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INTRODUCTION

We had the great honor of organizing the ICFAR 2024. It was truly a great pleasure for us togreet a lot of participants from many different countries attending ICFAR 2024! We firmly believe that the conference will become an important international event in the field of cross-industry discussion about innovations in Academic Studies.

ICFAR 2024 was organized by All Science Academy located in Konya, Turkey.

Three cooperating organizations supported the four-day conference. There were 430 papers accepted for presentation at ICFAR 2024, contributed from different countries. We had plenary speeches and several well-known scientists and experts, to give invited talks at differentsessions.

The purpose of ICFAR 2024 was to provide a forum for the participants to report and review innovative ideas, with up-to-date progress and developments, and discuss novel approaches to the application in the field of their own research areas and discuss challenges of doing science.

We sincerely hope that the exchange of ideas on doing research, science and improving education will help the participants, and international cooperation sharing the common interest will be enhanced.

On behalf the Organization Committee of ICFAR 2024, we would like to heartily thank our cooperating organizations for all they have done for the conference. We would also like to thank the authors for their contribution to the proceedings; the participants and friends of ICFAR 2024, for their interest and efforts in helping us to make the conference possible; and the Editorial boards for their effective work and valuable advice, especially the ICFAR 2024 secretariat and the ICFAR 2024 staff, for their tireless efforts and outstanding services in preparing the conference and publishing the Proceedings.

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88	DÜNYA KUPASINA KATILACAK MODERN PENTATLON SPORCULARININ SPORTMENLİK YÖNELİMİNİN VE SPORCU RUH SAĞLIĞI DÜZEYLERİNİN İNCELENMESİ	Serhan Sabri HAMAT, Belgin GÖKYÜREK	Turkey, Turkey	Submission 1173
89	Study of electrical resistivity of hafnium in the wide temperature range using classical and quantum mechanical methods	Zafer Doğan, Tural Mehmetoğlu	Turkey, Turkey	Submission 1175
90	Study of specific heat capacities of aluminum boron nitride (AlBN2) using Einstein-Debye approximation	Zafer Doğan, Tural Mehmetoğlu	Turkey, Turkey	Submission 1176
91	Consumer perception on use of food processing waste in preparation of functional food: A review	Tusneem Kausar, Ashiq Hussain	Pakistan, Pakistan	Submission 1179
92	Efficient Replication Strategy for Mobile CHORD with Reduced Network Overhead	Hamza Khemliche, Meriem Messaoudi, Ouafia Belgherbi, Samah Boudour, Leila Lamiri, Fayçal Medjili	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1181
93	Computational study of the inclusion of a local anesthetic in cavities of two cyclodextrins	Nourredine Meddah-Araibi,Tefaha Fergoug, Mansour Azayez, Youcef Bouhadda	Algeria, Algeria, Algeria, Algeria	Submission 1186
94	ENERJİ DEPOLAMA SİSTEMLERİ	Nurullah AKGÜN, Serdal DAMARSEÇKİN	Turkey, Turkey	Submission 1189
95	Flow and Thixotropic Parameters for Rheological Analysis of Cosmetic Moisturizing Cream	Fouzia Benoudjit, Hassina Boussak	Algeria, Algeria	Submission 1190
96	Insight into structural, electronic, elastic and magnetic properties of full Heusler alloys by DFT investigation	Righi AYA, Bendahma FATIMA, Labdelli ABESS, Mechehoud KHEDIDJA,Mana MOHAMED, Achir Bilel	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1193

97	A Deep Based Approach for Pre-Classifying Skin Diseases With Using Artificial Intelligence Techniques	Ali Berkan URAL	Turkey	Submission 1194
98	Parasitically Coupled F-Shaped Microstrip Antenna for 2.4 GHz Wi-Fi Applications	Yağız Haktan Gözkaman, Recep Taha Cansuyu, Rozerin Turan, Merih Palandöken	Turkey, Turkey, Turkey, Turkey	Submission 1196
99	Effect of biofertiliser on the variation in polyphenol content of aqueous extracts from tomato leaves (Lycopersicon esculentum Mill)	Amara Nacira, Amara Sabrina, Chaib Selma, Drai Wissem	Algeria, Algeria, Algeria, Algeria	Submission 1199
100	A different set of methods was utilized to calculate the Urbach energy and optical gap energy of Zn-doped NiO thin films formed by spray pyrolysis	Maghni Cherif, Zaouche Chouaieb, Dahbi Laid	Algeria, Algeria, Algeria	Submission 1202
101	From short dry spells to very long dry spells – case study of Shkodra city	Tanja Porja, Klaudio Peqini	Albania, Albania	Submission 1206
102	Effect of Temperature on Bioethanol Production from Liquid Waste Generated after Extraction	FERROUDJ Nawal, BENSEFIA Chaima, KAHALERRAS Fatma	Algeria, Algeria, Algeria	Submission 1207
103	Global dynamics and mathematical study for a heroin hybrid model	Zirar Imane Hana, Lakmeche Abdelkader, Touaoula Mohamed Tarik, Helal Mohamed, Bensid Yazid	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1209
104	Öğretmenlerin Bilinçli Farkındalık Düzeyleri ile Psikolojik Sağlamlık Düzeyleri Arasındaki İlişkinin İncelenmesi	Mücahit DURSUN	Turkey	Submission 1210
105	Comparative Analysis of Time Series and Machine Learning Forecasting Methods: Effectiveness and Applicability Across Domains	Selin SARAÇ GÜLERYÜZ	Turkey	Submission 1220
106	Blowing-up solutions for time-fractional differential equations	Abdelatif Boutiara	Algeria	Submission 1223
107	Kolaviron isolated from Garcinia kola seed inhibits snake venom phosphodiesterase activity	Azubuike Ikechukwu Okafor	Nigeria	Submission 1224
108	Comprehensive Characterization of Eco-Friendly marine Algae based Composites	Hafssa Atlas, Boukhlifi Fatima	Morocco, Morocco	Submission 1225
109	Green Alternatives for Dye Removal: Comparative Study of Seaweed and Sugarcane Bagasse	Hafssa Atlas, Smail Imame, Hafssa El-Idrissi, Khaoula Loukili, Boukhlifi Fatima	Morocco, Morocco, Morocco, Morocco, Morocco	Submission 1226
110	Analyzing the Existence of Solutions for Caputo Fractional q-Differential Equations with Variable Order	Zineb Bellabes, Naima Boussekkine	Algeria, Algeria	Submission 1228
111	optimization for high-efficient and more stable RbGeI3 perovskite solar cells	Abdelkader Bouhenna, Kada BOUALEM, Nabil Beloufa, Soufi Hadjer	Algeria, Algeria, Algeria, Algeria	Submission 1229
112	Effects of Salt Stress on Germination and Seedling Growth of Sweet Corn	Birgul Guden	Turkey	Submission 1231
113	Characteristic study of the morphology, electronic conductivity and thermal degradation of PLA biopolymer and its ZnO composites	Noudjoud HOUAS, Delloula LAKHDARI, Hanane TOUHAMI	Algeria, Algeria, Algeria	Submission 1232
114	Types of Misconceptions and Diagnostic Instruments Used to Identify Students Misconceptions in Chemistry Subject	Yam Pui Mun, Corrienna Abdul Talib	Malaysia, Malaysia	Submission 1233
115	Frontiers in Soil Science: Integrating Optical and Radar Remote Sensing for Superior Soil Moisture Estimation in Kairouan, Tunisia	Mohamed Rajhi, Endre Dobos	Hungary, Hungary	Submission 1234
116	Effect of the Temperature Regime Variations on Heat Treatment Process of Nanocrystalline-based Magnetic Cores	Taylan Günes	Turkey	Submission 1236
117	Preparation and study of the effect of Nd substitution on structural and microstructural properties of La0.7-xNdxBa0.2Sr0.1MnO3 (x=0.00 and x=0.05) manganite compounds	Fatih DENBRI, Nabil MAHAMDIOUA, Sadek BOUFLIGHA	Algeria, Algeria, Algeria	Submission 1239
118	Quasistatic Contact with Wear in Electro-Elasto-Viscoplastic Solids with Damage	Laldja Benziane, Nemira Lebri	Algeria, Algeria	Submission 1244
119	Fractional p-Laplacian in Singular Elliptic Problem with Discontinuous Nonlinearity	H. Achour, S. Bensid	Algeria, Algeria	Submission 1245
120	Contribution to the study of antioxidant activity of Aqueous extract of Thymus vulgaris	Mohamed Khiari, Zine Kechrid	Algeria, Algeria	Submission 1246
121	Fabrication Of Flexible Thin Film Substrates By The Extraction Of CNCs From Cellulosic Materials	Abdul Basit, Hafeez Anwar	Pakistan, Pakistan	Submission 1249
122	Language, Culture, and Ecology: Investigating ECLA Levels at Graduate-Level Education	Vesna Prodanovska-Poposka	North Macedonia	Submission 1250
123	The shortening structures following the Mw 7.6 Elbistan (Türkiye) 2023 Earthquake	Mehmet Köküm	Turkey	Submission 1253
124	Introduction to Artificial Intelligence and Machine Learning Algorithms: A Review	Muhammad Umer Karimi, Sardar Muhammad Abubakar, Shiekh Junaid Mustafa, Burhan Ahmad	Pakistan, Pakistan, Pakistan, Pakistan	Submission 1261
125	Characteristic study of the morphology, optical capacity and thermal degradation of PLA biopolymer	Noudjoud HOUAS, Delloula LAKHDARI, Hanane TOUHAMI	Algeria, Algeria, Algeria	Submission 1265

	and its ZnO composites			
126	The Contribution of Greenhouse Gas Emission Mitigation of Recycling Waste	Faruk KOÇAK, Zeynep EREN	Turkey, Turkey	Submission 1268
127	Effects of cannabis on multiple visual parameters and self-perceived eyesight: A cross-sectional study in cannabis users in Morocco	Karima Raoui, El Mehdi Wakrim, René J. Combe , Mohamed Cherkaoui, Abderrahman Chait	Morocco, Morocco, Morocco, Morocco, Morocco	Submission 1272
128	Experimental Assessment of Parameter Identification Techniques for Leroy-Somer Emerson Permanent Magnet Synchronous Motors (PMSM)	Aissa Redhouane Harkat, Linda barazan, Larabı Abdelkader, Abdelouadoud Loukriz, Abderrahim Zemmıt	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1273
129	Elimination of Gentian violet in water using Barbary fig seeds as bio-coagulant	MOKHATI Aya, AISSOUS Bochra, FERROUDJ Nawal, BENALIA Abderrezzaq, DERBAL Kerroum	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1274
130	Functional properties of bioactive compounds from Spirulina sp.	Saada zakia, charef nassira, Tamer fatma zohra, Belaid Bouthaina, Nasri hichem	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1275
131	Optimizing Physical and Photocatalytic Performance of ZnO Thin Films Through Varying Thickness in SILAR Deposition	Hadjer Barkat, Yousra Khadraoui, Elhachmi Guettaf Temam, Rahmane Saâd	Algeria, Algeria, Algeria, Algeria	Submission 1276
132	Effect of film thickness on the electrical properties of pure Zinc oxide thin films	Hadjer Barkat, Yousra Khadraoui, Elhachmi Guettaf Temam, Rahmane Saâd	Algeria, Algeria, Algeria, Algeria	Submission 1277
133	Photogrammetry Through the Luma AI Application and the Possibilities of its Use in Education	Gergely Kocsis, Ondrej Takáč	Slovakia, Slovakia	Submission 1283
134	Modeling of soil consolidation around the tunnels	Ibrahim MAHROUG, Abdelhafid MAHROUG	Algeria, Algeria	Submission 1284
135	Iron doped Zinc Oxide: optical and structural properties	Abdelhafid MAHROUG, Ibrahim MAHROUG, Samia MEDJENAH	Algeria, Algeria, Algeria	Submission 1285
136	Solutions of (1+1)-dimensional Dirac equation with for some models of symmetric PT potentials and position-dependent mass by using SUSY QM approach	Samia MEDJENAH	Algeria	Submission 1286
137	The optoelectronic properties of novel Lithium tetrafluoroaurate (III) LiAuF4: First-principles calculations	Ishak Mebarkia	Algeria	Submission 1288
138	Grey Wolf Optimization and Particle Swarm Optimization- Support Vector Regression Approach for Predicting HLB of Surfactant	Nada Boukelkal, Soufiane Rahal, Redha Rebhi, Mabrouk Hamadache	Algeria, Algeria, Algeria, Algeria	Submission 1289
139	Durability of Mortars Prepared with Addition of glass powder, Slag, and natural pozzolan	Boubakeur Seddik Elbahi, Leila Zeghichi, Fodil Dif, Bachir Elbahi	Algeria, Algeria, Algeria, Algeria	Submission 1290
140	Determination of the Effect of Progressive Muscle Relaxation Exercises on the Perceived Stress Level of Nursing Students Before the Clinical Practice of Mental Health and Diseases Nursing Course	Ozden Yuvalı, Berna Bayır	Turkey, Turkey	Submission 1293
141	Evaluating Mechanical and physical properties of recycled HD-PE Biocomposites reinforced with Esparto grass and natural Pozzolan.	Bouchra Achour, Abdelkader Ziadi, Lahcen Belarbi, Allel Mokaddem, Abdelkader Lousdad	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1297
142	Preparation and effect of 10% Sn substitution for Mn on La0.7(Ca,Ba)0.3MnO3 compound's structural and electrochemical corrosion behavior in 3 wt. % NaCl solution	Sadek Boufligha, Nabil Mahamdioua, Fatih Denbri, Benzaid Roumaissa, Belhour Amina	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1298
143	Using the AHP to Identify Priority Bridges for Seismic Resilience Enhancement	Mohammed Abdellaoui, Mohamed Badaoui, Mahmoud Ben saibi, Said koriga	Algeria, Algeria, Algeria, Algeria	Submission 1299
144	Comparative Study of Optimization of Phenolic Compounds Using ANN and RSM Models	BENMANSEUR Anfel, HAB Fatma Zahra, DERGUINE Rania, TACHOUR Rechda Amel, TACHERFIOUT Mustapha, KHETTAL Bachra, REZGUI Abdelmalek, SOBHI Widad	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1300
145	Destructive and Non-Destructive Evaluation to study of Plastic Waste Aggregate Mortar	N. Latroch, A.S. Benosman, A. Badache, M.Hacini, M. Mouli, O. Safer	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1302
146	Unlocking the Power of Artificial Intelligence: Building Digital Twins with Classification Algorithms for Optimized Geothermal Drilling	Orkun TEKE	Turkey	Submission 1303
147	OPTIMIZING EMOTION RECOGNITION: MULTIMODAL ANALYSIS OF TEXT AND AUDIO WITH METAHEURISTIC ALGORITHMS	G. Janaki, R. L. Jasmine	India, India	Submission 1304
148	Effectiveness of the Geneious Prime Software in High Throughput Sequencing Data Analysis of Plant Viruses	Serkan Önder	Turkey	Submission 1309
149	Combining CNN with hand-crafted features for Diabetic retinopathy classification	Abderaouf Moustari, Youcef Brik, Bilal Attallah	Algeria, Algeria, Algeria	Submission 1310
150	Deep neural networks for an accurate palmprint recognition system across multiple instances	Nadir Cheyma, Attallah Bilal, Brik Youcef	Algeria, Algeria, Algeria	Submission 1311

151	Investigating the QCD Equation of State at Finite Temperature and Chemical Potential	Amal Ait El Djoudi, Rokaya Djida, Faiza Ramdani	Algeria, Algeria, Algeria	Submission 1312
152	Low-temperature sol-gel synthesis of mullite precursor powder: characterization, sintering behavior, mechanical properties	Ahcen Keziz, Meand Heraiz	Algeria, Algeria	Submission 1314
153	A scoping review on games-based learning approaches in chemistry education	Wan Nor Azlina Wan Abdullah, Corrienna Abdul Talib	Malaysia, Malaysia	Submission 1316
154	Challenges and Approaches to Motivate Students in Learning Chemistry: A Scoping Review	Syaida Ab Manaf, Corrienna Abdul Talib	Malaysia, Malaysia	Submission 1317
155	A Review of AI-Based Approaches against Wormhole and Blackhole Attacks in AODV Protocol	Zainab Bashar Ibrahim, Mayada Faris Ghanim	Iraq, Iraq	Submission 1323
156	Impact of Thermal Aging and Water Absorption on the Mechanical Properties of 18/30 kV XLPE-Insulated Cables	Hani Terfa, Saâd Chouch, Younes Hamache, Sayah Merazi	Algeria, Algeria, Algeria, Algeria	Submission 1326
157	Detection of Diabetic Retinopathy Using a Pre-trained Inception-v3 Model	Ishaq Aiche, Youcef Brik, Bilal Attallah	Algeria, Algeria, Algeria	Submission 1327
158	Scoping review: non-traditional approaches to enhancing student learning in chemistry education	Li Lefan, Corrienna binti Abdul	Malaysia, Malaysia	Submission 1328
159	Promoting Energy Efficiency and Sustainability in High-Rise Buildings: A Critical Review	Emaan Ishaq, Burhan Ahmad	Pakistan, Pakistan	Submission 1330
160	Machine Learning Techniques for Material Property Prediction: ZnO and Zn-ion Battery Material Case Studies	Amine bayoud, Raidou abderrahim	Morocco, Morocco	Submission 1332
161	Enhancing Energy Efficiency of Existing High-Rise Buildings: A Comprehensive Review	Emaan Ishaq, Burhan Ahmad, Muhammad Ayyaz Haider Bhatti	Pakistan, Pakistan, Pakistan	Submission 1333
162	Structural Insulated Panels (SIPs) in Construction; Energy Efficiency, Seismic Performance and Sustainability: A Review	Emaan Ishaq, Burhan Ahmad	Pakistan, Pakistan	Submission 1334
163	Numerical Study on the Coupled Effect of Particles Concentration and Flow Velocity on Their Transport and Deposition in Saturated Fractured Media	Bouragaa Kheira, Bennacer Lyacine, Ahfir Nasre-dine	Algeria, Algeria, Algeria	Submission 1336
164	Sequential Approach for Landfill Leachate Treatment: Coagulation-Flocculation and Advanced Oxidation Processes Activated by UV/Ultrasound	Hamza Bellouk, Imane El Mrabet, Karim Tanji, Mostafa Nawdali, Hicham Zaitan	Morocco, Morocco, Morocco, Morocco, Morocco	Submission 1337
165	Numerical Analysis on the Effect of Bar Diameter on Bond Stress-Slip Behavior in ABAQUS	Sana Shaukat	Pakistan	Submission 1342
166	Response Surface Optimization of Bioactive Phenolic Compound Extraction from Orange Peels	Sid Ahmed El Khalil AHED MESSAOUD , Khedidja BENOUIS, Anes GHAZI, Marwa Lamise HAMEL, Sabrina OULAD BRAHIM	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1344
167	Flaxseed (Linum usitatissimum L) as a Natural Coagulant for Urban Wastewater treatment: Optimizing Colloidal Matter Removal using Response Surface Methodology	Anes GHAZI, Khedidja BENOUIS, Sid Ahmed El Khalil AHED MESSAOUD, Sabrina OULAD BRAHIM, Marwa Lamise HAMEL	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1345
168	Visible-Light Driven Photocatalytic Degradation of Congo Red with Zinc Oxide : Process Optimization using Box-Behnken Design	Sabrina OULAD BRAHIM , Khedidja BENOUIS, Marwa Lamise HAMEL, Anes GHAZI, Sid Ahmed El Khalil AHED MESSAOUD	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1346
169	Mean-field study of magnetic properties in a bilayer graphene Ising system	Mohammed Salama, Nabil Hachem, Elbachir Dahbani, El Bouâzzaoui Choubabi	Morocco, Morocco, Morocco, Morocco	Submission 1347
170	Enhanced Visible-Light Photocatalytic Degradation of Methylene Blue with Copper (II) Oxide: Process Optimization using Box-Behnken Design	Marwa Lamise HAMEL, Khedidja BENOUIS, Sabrina OULAD BRAHIM, Sid Ahmed El Khalil AHED MESSAOUD, Anes GHAZI	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1348
171	Weyl–Dirac Equation in Fractional-Dimensional Space: GRAPHENE IN THE PRESENCE OF AN ELECTROMAGNETIC FIELD	Asma MERAD, Souheib MERAD	Algeria, Algeria	Submission 1349
172	Characterization of TiO2 nanoparticles synthetized by modified co-precipitation method	S. Hadjab, F. Boufelgha, N. Brihi1, R. Zellagui, MC. Benachour, F. Labreche, M. khiat	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1351
173	Study of an in depth characterization of discharges from the exploitation of iron ore cae of the El‘Ouenza mine	BOUZERIBA Hadjer, BOUZIDI Nedjima, IDRES Abdelaziz, LAALA Imen	Algeria, Algeria, Algeria, Algeria	Submission 1352
174	CHARACTERIZATION OF PHOSPHATE REJECTS OBTAINED FROM THE PHOSPHATE ORE TREATMENT OF DJEBEL ONK (TEBESSA NE ALGERIA)	LAALA Imen, BOUZIDI Nedjima, ELICHE-QUESADA Dolores, BOUZERIBA Hadjer	Algeria, Algeria, Spain, Algeria	Submission 1353
175	Coordination and electronic structure of monometallic complexes: DFT investigation	MERAD Sara, Aimene Nadjet, Mecheri Sabri, Zaiter Abdellah, Zouchoune Bachir, BOUAICHA Abderrachid, HADJADJ Mekki	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1354
176	Common fixed point theorem for multi-valued generalized contractive mappings in b-metric spaces	Merad Souheib	Algeria	Submission 1355

177	Formulation of Curcuminoid-Based Dental Films for Treating Oral Cavity Ulcerations	MERZOUGUI Besma, MIDOUN Sarah, GUENDOUZ Souhila	Algeria, Algeria, Algeria	Submission 1356
178	Implantable Catheter Chamber: Selection and Recommendations.	MERZOUGUI Besma, CHELGHOUM Mustapha	Algeria, Algeria	Submission 1357
179	Thermal and Mechanical Characterizations of Improved Polyimide Insulation for High voltage Applications	Abdur Rahman, Gul Rukh, Nafees Ahmed, Hamdullah Jan, Muhammad Ismail, Zeeshan Ahmad	Pakistan, Pakistan, Pakistan, Pakistan, Pakistan, Pakistan	Submission 1358
180	Perils of Presidentialism?	Özhan Demirkol	Turkey	Submission 1360
181	Advances in Molecular Genetics and Optimization of Antidiabetic Drugs: Towards More Effective Therapies	Hassina Fisli, Mohamed Lyamine Chelaghmia	Algeria, Algeria	Submission 1362
182	Coal Quality and Petrographic Features of Middle Miocene İlyaslı coalfield in the Uşak-Güre Basin (W. Türkiye)	Rıza Görkem Oskay, Ali İhsan Karayiğit, Yakup Çelik	Turkey, Turkey, Turkey	Submission 1364
183	Investigation of various ropes in different water medium as forensic evidence	Hümeyra Durmuş, Soner Kızıl	Turkey, Turkey	Submission 1365
184	Effects of Rotational Speed/Traverse Speed Ratio on AA2024 Alloy Microstructure and Macrostructure in Friction Stir Processing	Aykut Batinli, Fatih Kahraman	Turkey, Turkey	Submission 1366
185	Çimento Hamurunun Priz Süresi ve Erken Yaş Performansına Plastik Tozunun Etkisi	Melek Akgül, Serkan Etli	Turkey, Turkey	Submission 1371
186	PMSM Design for Real-World Electric Vehicle Applications: Performance Suitability and Efficiency Assessment	Hani Terfa, Saâd Chouch, Younes Hamache, Sayah Merazi	Algeria, Algeria, Algeria, Algeria	Submission 1372
187	Composition analysis and influence of secondary phases on sprayed Cu2ZnSnS4 thin film	MENADI Widad, KERMADI Salim, ZOUGAR Lyes, SALI Samira	Algeria, Algeria, Algeria, Algeria	Submission 1374
188	Characterization of polypyrrole copper, electrocatalyst for ethanol degradation in alkaline medium	SEID Lamria, BELGHERBI Ouafia, AROUI Linda, CHOUDER Dalila	Algeria, Algeria, Algeria, Algeria	Submission 1378
189	Crimes omissions: A psycho-sociological perspective	Nino Kitoshvili, Beka Dadeshkeliani	Georgia, Georgia	Submission 1380
190	Structural, optical and photoluminescence properties of Eu3+ doped ZnO films	Tiour Faiza, Zougar Lyes, Sali Samira, Boulahdjel Sara, Toumi Yassin, Kermadi Salim, Ayachi Messaouda, Chaib Zoubir	Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1383
191	Özel Eğitim Öğretmenlerinin Cinsel İçerikli Problem Davranışlarla Başa Çıkma Stratejilerinin ve Yeterliliklerinin Belirlenmesi	Mert Can KAYA, Bestami Buğra ÜLGER	Turkey, Turkey	Submission 1389
192	Make Science Visible through Numerical Methods in Computer Graphics. Water Wave Equation through Graphical Bezier Solution	Alma Sheko, Shkelqim Hajrulla, Robert Kosova, Vasil Lino, Leonard Bezati	Albania, Albania, Albania, Albania, Albania	Submission 1390
193	Kapsayıcı Eğitime İlişkin Öğretmen Görüşleri	İdris GÜLTEKİN, Emin Tamer YENEN	Turkey, Turkey	Submission 1391
194	Discrete fractional numerical analysis on the shallow water wave theory	Shkelqim Hajrulla, Alma Sheko, Robert Kosova, Loubna Ali, Ozen Ozer	Albania, Albania, Albania, Germany, Turkey	Submission 1392
195	Effective Degradation of Basic Yellow 28 Dye via a Novel Visible Light-Mediated Chlorine Photolysis Process	STAMBOULI Walid, Noureddine Nasrallah, Aymen Amin Assadi	Algeria, Algeria, Saudi Arabia	Submission 1393
196	Contribution of the acoustic emission technique to assess mechanical damage in the -case of eco-concretes-	Bouchenak Khelladi Hadjer, Marouf Hafida, Dahou Zohra	Algeria, Algeria, Algeria	Submission 1394
197	GRANULOMETRIC ANALYSIS OF SULPHIDE ZINC ORES FROM THE CHAABET EL-HAMRA MINE (SETIF, ALGERIA)	SI TAYEB Nor El Houda, CHAFI-SOUICI Zahia	Algeria, Algeria	Submission 1396
198	Structural, microstructural study of nanostructured Fe70Si25Cr5 developed by powder metallurgy	Ali Mameri, Ismail Daoud, Khalil benabderzak	Algeria, Algeria, Algeria	Submission 1397
199	Applications of Artificial Intelligence in Structural Engineering: A Review	Sardar Muhammad Abubakar, Muhammad Umer Karimi, Shiekh Junaid Mustafa, Burhan Ahmad	Pakistan, Pakistan, Pakistan, Pakistan	Submission 1400
200	KATILIM BANKALARININ SUKUK İHRACI UYUM DÜZEYİNİN ANALİZİ	Atiqullah Hakimi, Yavuz DEMİRDÖĞEN	Turkey, Turkey	Submission 1401
201	HUMAN SUPPORT AND NON-HUMAN SUPPORT IN ASSOCIATION WITH PSYCHOLOGICAL WELL-BEING OF UNIVERSITY STUDENTS	Aliza Zafar, Rabia Muzaffar	Pakistan, Pakistan	Submission 1406
202	Review of Intraocular Lens Utilization	MERZOUGUI Besma, CHELGHOUM Mustapha	Algeria, Algeria	Submission 1408
203	Microscopic Insights into Failure Mechanisms and Mechanical Properties of a PLA Biocomposite with Plant Fiber Reinforcement	Khalil Benabderazag, Zouheyr Belouadah, Moussa Guebailia	Algeria, Algeria, Algeria	Submission 1413
204	How to Establish MIT-Standard Institutions in Türkiye and Pakistan?	Syed Arif Kamal	Pakistan	Submission 1414
205	Mechanical Characterization of a Lygeum spartum	Khalil Benabderazag, Moussa	Algeria, Algeria,	Submission 1416

	fibers/PLA Biocomposite Using Flexural Testing and Impulse Excitation Technique	Guebailia, Zouheyr Belouadah	Algeria	
206	Implementing rule-based reasoning for effective maintenance of radiology equipment	Mawloud Titah	Algeria	Submission 1417
207	DEVELOPMENT OF CHARACTERISTIC PROPERTIES OF TiO2 THIN FILMS FOR SOLAR CELL APPLICATIONS	Ertürk TÜRKER, Saadet YILDIRIMCAN, Selma ERAT, Samed ÇETİNKAYA	Turkey, Turkey, Turkey, Turkey	Submission 1418
208	Entrepreneurship and innovation in Algeria: an overview	Yasmine Hariti, Nacira Boukhezer-Hammiche	Algeria, Algeria	Submission 1419
209	Novel material designed as an additive to enhance cement manufacturing efficiency and performance	Boukhamla Yousra, Nettour Djamel, Chettibi Mohamed, Derrardjia Nesrine, Aichouri Imene	Algeria, Algeria, Algeria, Algeria, Algeria	Submission 1420
210	Feedback Control over Response in the Cavity Quantum Electromagnetic Sensor	Sergey Borisenok	Turkey	Submission 1421
211	Enhancing Diabetic Retinopathy Detection Using a Hybrid Framework Integrating Machine Learning Classifiers and Advanced Feature Extraction Techniques	Tawfiq Beghriche, Mohamed Djerioui, Youcef Brik	Algeria, Algeria, Algeria	Submission 1422
212	DIGITAL PRACTICES IN SUSTAINABLE AGRICULTURE	Daniela PELIVANOSKA DAMESKA, Blagojche NAJDOVSKI	North Macedonia, North Macedonia	Submission 1424
213	Physical And Functional Characteristics of Ebony Fruits Flour Assorted Products	Leticia Touh Yamga, Anusha MB	Ghana, India	Submission 1427
214	Comparison of Multifocal ERG Responses between Retinitis Pigmentosa Patients and Healthy Individuals	Aykut Oruç, Kadriye Yağmur Oruç, Hakkı Oktay Seymen	Turkey, Turkey, Turkey	Submission 1428
215	Modelling of two well-known SPD methods (ECAP and MDF) and comparison with a numerical analysis method	Seher KAPLAN, Mehmet ŞAHBAZ	Turkey, Turkey	Submission 1431
216	SIMULATING THE OPTIMAL IRRIGATION DATE AND AMOUNT OF ONION USING THE FAO CROPWAT MODEL IN ADANA	Yusuf Sadi Ibrahim, Burak Sen	Turkey, Turkey	Submission 1433
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BCH Codes, Implementation of (15, 7)-BCH code

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Abstract **–** In this paper, BCH codes are considered a family of powerful cyclic codes and are a generalization of Hamming codes for error correction. Initially, linear codes were studied by focusing on a larger subset of them, cyclic codes. In addition, the mathematical structure of BCH codes, their characteristics and applications have also been studied.
Encryption and decryption techniques are also identified, as well as the error detection and correction capabilities of the BCH code.
Theoretical examples of BCH code are implemented in two well-known programming environments: MATLAB and Python.

Keywords – BCH codes, encoding, decoding, implementation, MATLAB, Python

I. INTRODUCTION

In a world where information is precious and data transmission is error-corrected, the theory of linear codes ensures data integrity and corrects errors that may occur during transmission.

Coding Theory began to be considered as part of Mathematics in the middle of the 20th century, precisely in 1948 when Claude Shannon published a scientific article entitled "A Mathematical Theory in Communication". Coding Theory has found applications in various fields, where we can mention: basic data systems, communication systems, computer science, engineering applications, etc. Before this theory takes a vital place in applications it is a perfect application of algebra, geometry, and combinatorics.

Linear codes are a significant field in coding theory and can find and correct errors during message transmission in a noisy channel. Linear codes are essential in modern communications such as cellular telephones, internet and satellite transmissions. Among the most important classes of linear codes are cyclic codes, where their security is greater and their application is simpler.

The Bose Chaudhuri and Hocquenghem (BCH) codes form a special case of cyclic codes for error-correction. This class of codes is constructed using polynomials over a finite field F_q and is a remarkable generalization of the Hamming codes for multiple-error correction. Binary BCH codes were discovered by Alexis Hocquenghem in 1959 and independently by Ray Chandra Bose and D. K. Ray-Chaudhuri in 1960.

One of their main features is that during code design, there is precise control over the number of errors that the code corrects. BCH codes are used in applications such as satellite communications, DVDs, CDs, USB drives, etc.

II. MATERIALS AND METHODS

A. Binary BCH codes

For any positive integers $m \geq 3$ and $t < 2^{m-1}$, there exists a binary BCH code with the following parameters:

Block length $n = 2^m - 1$

Number of information bits in a codeword $k \geq n - mt$

Number of parity-check digits $n - k \leq mt$

Minimum distance $d_{min} \geq 2t + 1$.

This code is called a t error-correcting BCH code. [2]

B. Design of BCH codes

Let be α a primitive element of $GF(2^m)$. The generator polynomial $g(x)$ of the $t$error-correcting BCH code of length $n = 2^m - 1$ is the lowest-degree polynomial over $GF(2)$ that has $\alpha,\ \alpha^2,\ \alpha^3, \dots, \alpha^{2t}$ as its roots.

Let $\varphi_i(x)$ be the minimal polynomial of α^i, then the generator polynomial $g(x)$ must be the least common multiple (LCM) of $\varphi_1(x),\ \varphi_2(x), \dots, \varphi_{2t}(x)$, that is: $g(x) = LCM\ \{\varphi_1(x),\ \varphi_2(x), \dots, \varphi_{2t}(x)\}$.

Table 1: Minimal polynomials of the elements in GF(2^4) generated by polynomial $x^4 + x + 1$

Conjugate roots	Minimal polynomials
0	x
1	$x + 1$
$\alpha, \alpha^2, \alpha^4, \alpha^8$	$x^4 + x + 1$
$\alpha^3, \alpha^6, \alpha^9, \alpha^{12}$	$x^4 + x^3 + x^2 + x + 1$
α^5, α^{10}	$x^2 + x + 1$
$\alpha^7, \alpha^{11}, \alpha^{13}, \alpha^{14}$	$x^4 + x^3 + 1$

C. Encoding of BCH codes

BCH encoding is the process of finding some polynomial that has the generator as a factor. BCH codes can be encoded using two encoding methods:

- Non-systematic encoding:

Let be $g(x)$ the generator polynomial of the BCH code and $m = (m_0, m_1, \dots, m_{k-1})$ vector of information symbols. We consider information symbols as coefficients of a polynomial, starting from its highest degree, so we get the polynomial:

$$m(x) = m_0 x^{n-1} + m_1 x^{n-2} + \cdots + m_{k-1} x^{n-k}.$$

Thus, the transmitted codeword will be: $c(x) = m(x) \cdot g(x)$.

- Systematic encoding: The message as a prefix

Let be $g(x)$ the generator polynomial of the BCH code and $m = (m_0, m_1, \dots, m_{k-1})$ vector of information symbols. We consider information symbols as coefficients of a polynomial, starting from its highest degree, so we get the polynomial:

$$m(x) = m_0 x^{n-1} + m_1 x^{n-2} + \cdots + m_{k-1} x^{n-k}.$$

We take our message polynomial $m(x)$ and multiply it by x^{n-k} and if we divide it by $g(x)$ (using Euclid's division algorithm), we get: $m(x)x^{n-k} = q(x)g(x) + r(x)$.

The polynomial $q(x)g(x)$ is a valid BCH codeword, thus, the transmitted codeword will be: $c(x) = m(x)x^{n-k} - r(x) = q(x)g(x) \in < g(x) >$, where $\deg\big(r(x)\big) < \deg(g(x)) = n - k$.

D. Decoding of BCH code

There are many algorithms for decoding BCH codes but, decoding can be broken down into three separate steps:

1. Calculating the syndromes

2. Solving the key equation

3. Finding the error locations

For BCH codes that correct one or two errors, step number 2 can be omitted.

1. Calculating the syndromes

Let be $c(x) = c_0 + c_1 x + \cdots + c_{n-1} x^{n-1}$ the transmitted polynomial, $r(x) = r_0 + r_1 x + \cdots + r_{n-1} x^{n-1}$ the received polynomial and $e(x) = e_0 + e_1 x + \cdots + e_{n-1} x^{n-1}$ the error polynomial. So, $r(x) = c(x) + e(x)$.

Calculate the syndromes, as

$$S_j = \sum_{i=0}^{n-1} r_i \alpha^{i-j} = \sum_{i=0}^{n-1} (c_i + e_i)\alpha^{i-j} = \sum_{i=0}^{n-1} c_i \alpha^{i-j} + \sum_{i=0}^{n-1} e_i \alpha^{i-j}$$

where $1 \le j < 2t$. By the definition of BCH code $\sum_{i=0}^{n-1} c_i \alpha^{i-j} = 0$, thus

$$S_j = \sum_{i=0}^{n-1} e_i \alpha^{i-j}$$

The syndromes S_j depends only on the error polynomial $e(x)$, so if no errors occur, the syndromes will be zero.

2. Solving the key equation

Let be $\sigma(x) = \sigma_0 + \sigma_0 x + \sigma_t x^t$ the error location polynomial. The relationship between the syndromes and the coefficients σ_j is given by [11]:

$$\sum_{j=0}^{t} S_{t+i-j}\sigma_j = 0$$

for $i = 1,2, \dots t$ and the roots of $\sigma(x)$ give the error positions.

The coefficients of $\sigma(x)$ can be calculated by different methods, such as Berlekamp-Massey Algorithm (BMA) [12], Peterson-Gorenstein-Zieler algorithm (PGZ) [11] or Euclid's algorithm [13].

The error location polynomial $\sigma(x)$ is generated (using the BMA algorithm), by the following set of recursive equations:

$$d_n = \sum_{i=0}^{t} \sigma_i^n \cdot S_{2n-i+1}$$

$$\sigma^n(x) = \sigma^{n-1}(x) - d_p^{-1} \cdot d_n \cdot \beta^n(x)$$

$$bsel = \begin{cases} 0, & d_n = 0 \; ose \; n < l_n \\ 1, & d_n \neq 0 \; ose \; n \geq l_n \end{cases}$$

$$\beta^{n+1}(x) = \begin{cases} x^3 \cdot \beta^n(x), & bsel = 0 \\ x^2 \cdot \sigma^{n-1}(x), & bsel \neq 0 \end{cases}$$

$$l_{n+1} = \begin{cases} l_n, & bsel = 0 \\ 2 * l_n - l_n + 1, & bsel \neq 0 \end{cases}$$

$$d_p = \begin{cases} d_{p-1}, & bsel = 0 \\ d_n, & bsel \neq 0 \end{cases}$$

$$n = n + 1$$

for $n = 1, \dots, t-1$.

A circuit implementing the BMA algorithm is given in the figure below:

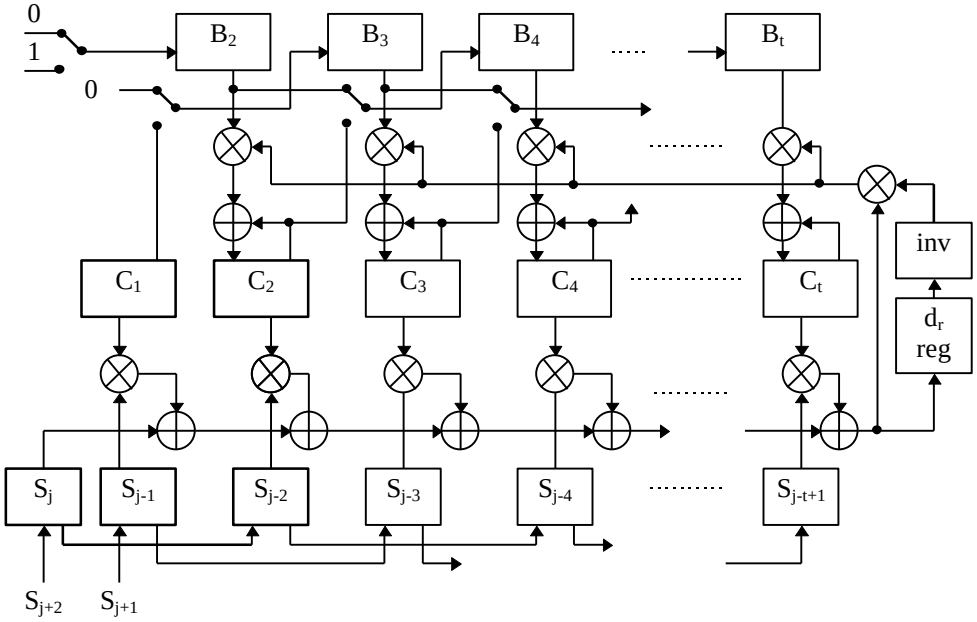

Figure 1: Berlekamp Massey Algorithm with inversion

3. Finding the error locations

The third step in decoding BCH codes is to find the error location numbers. These values are the reciprocals of the roots of $\sigma(x)$ and may be found by substituting $1, \alpha, \alpha^2, \dots, \alpha^{n-1}$ into $\sigma(x)$. A method of achieving this has been presented by Chien [14], where the sum $\sigma_0 + \sigma_1\alpha^j + \sigma_2\alpha^{2j} + \cdots + \sigma_t\alpha^{tj}$ for $j = 0,1, \dots, k-1$ is evaluated every clock.

If $\sigma(\alpha^j) = 0$, the received bit r_{n-1-j} is corrupted. Therefore if for clock cycle j the sum equals zero the received bit r_{n-1-j} should be corrected.

III. RESULTS

A. (15, 7)-BCH code

Let be consider the (15,7)-BCH code, where $n = 2^m - 1 = 15 \Rightarrow m = 4$, and $k \geq n - mt \Rightarrow$ (15,7)-BCH code is 2 error-correcting code.

Let α be a primitive element of $GF(2^4)$, then the generator polynomial of (15,7)-BCH code will be:

$g(x) = LCM\{\varphi_1(x), \varphi_2(x), \varphi_3(x)\}$, where $\varphi_1(x) = \varphi_2(x) = x^4 + x + 1$ and $\varphi_3(x) = x^4 + x^3 + x^2 + x + 1$ (from *Table 1*). Then:

$$g(x) = LCM\{\varphi_1(x), \varphi_2(x), \varphi_3(x)\} = LCM\{\varphi_1(x), \varphi_3(x)\} = \varphi_1(x) \cdot \varphi_3(x) = x^8 + x^7 + x^6 + x^4 + 1$$

Let's encode the message $m = (1101001)$

a) using the non-systematic encoding:

We get the polynomial with coefficients and the information symbols:

$m(x) = x^6 + x^5 + x^3 + 1$. The encoded message will be

$$c(x) = m(x) \cdot g(x) = (x^6 + x^5 + x^3 + 1) \cdot (x^8 + x^7 + x^6 + x^4 + 1) = x^{14} + x^8 + x^5 + x^4 + x^3 + 1$$

Thus, the transmitted codeword is $c = (100000100111001)$.

b) using the systematic encoding:

We get the polynomial with coefficients the information symbols:

$m(x) = x^6 + x^5 + x^3 + 1 \Rightarrow m(x)x^{n-k} = x^8(x^6 + x^5 + x^3 + 1) = x^{14} + x^{13} + x^{11} + x^8$.

If we divide it by $g(x)$ we get

$$x^{14} + x^{13} + x^{11} + x^8 = (x^6 + x^4)(x^8 + x^7 + x^6 + x^4 + 1) + x^6 + x^4$$

$\Rightarrow x^{14} + x^{13} + x^{11} + x^8 - x^6 - x^4$ will be the encoded message.

Thus, the transmitted codeword is $c = (110100101010000)$.

B. Implementation of (15,7)-BCH code in MATLAB

The MATLAB (MATrix LABoratory) program is capable of working with BCH codes of large sizes, analyzing and evaluating their performance, and improving the efficiency of the work of engineers and data scientists. [15], [16]

We have implemented the encoding and decoding of a message using the (15,7)-BCH code in MATLAB:

```
%=========================================================================
% Example: Transmitting a message, encoding it with (15,7)-BCH code
% 3rd ICENSOS
% Tedis Ramaj & Daniela Bardhi
%=========================================================================
clc;
clear all;
close all;
m=4;
n=2^m-1;  % Codeword length
k=7;      % Message length
M=input('Give the message M='); % The user gives the message to send
msg=gf(M);
disp('The message will we encode is msg=');
disp(' msg=');
disp(msg);
disp('The generator polynomial and error correction capability for (15,7)-BCH code
are:')
[genpoly,t]=bchgenpoly(n,k)  % genpoly is the generator polynomial of (n,k)-BCH
%code and t is the error correction capability
code=bchenc(msg,n,k);        % Encoding the message
disp('Encoded message is c=');
c=gf(code);
disp(c);
receivedCode=code+randerr(1,n,1:t);  % Received message
disp('Received word is receivedCode=');
disp(receivedCode);
[newmsg,err,ccode]=bchdec(receivedCode,n,k);  % Decoding the received message
disp('Decoded message is newmsg=');
disp(newmsg);
if msg==newmsg
disp('Message is decoded correctly.')
else
disp('Errors occurred during message decoding');
end
```

The result of above code is:

Give the message M=[1 0 0 0 1 0 1]

The message will we encode is msg=

1×7 gf array with properties:

[1 0 0 0 1 0 1]

The generator polynomial and error correction capability for (15,7)-BCH code are:

genpoly = GF(2) array.

Array elements =

1 1 1 0 1 0 0 0 1

t =

2

Encoded message is c=

1×15 gf array with properties:

[1 0 0 0 1 0 1 1 1 0 1 1 1 1 1]

Received word is receivedCode=

1×15 gf array with properties:

[1 0 0 0 1 0 0 1 1 0 1 1 1 1 1]

Decoded message is newmsg=

1×7 gf array with properties:

[1 0 0 0 1 0 1]

Message is decoded correctly.

C. Implementation of (15,7)-BCH code in Python

Python is a high-level programming language that offers various ways to analyze and visualize data. It is used to evaluate the performance and to display the results of BCH code in a nice way. [19]

We have implemented encoding and decoding of a message using the (15,7)-BCH code in Python.

```
# Example: Transmitting a message, encoding it with (15,7)-BCH code
# 3rd ICENSOS
# Tedis Ramaj & Daniela Bardhi

from pyfinite import ffield
import pyfinite


m = 4
n = 2**m - 1  # Codeword length
k = 7         # Message length

M = int(input('Give the message M = ').strip())  # The user gives the
message to send
msg = ffield.FField(m).Ex(M)
print('The message will we encode is msg =', msg)

print('The generator polynomial and the error correction capability for
(15,7)-BCH code are:')
genpoly, t = matfuncs.bchgenpoly(n, k)  # genpoly is the generator
```

```
polynomial of (n,k)-BCH code and t is the error correction capability
print('genpoly =', genpoly)
print('t =', t)

code = matfuncs.bchenc(msg, n, k)  # Encoding the message
print('Encoded message is c =', code)

import random
import numpy as np

receivedCode = code + np.array([random.randint(0, 1) for _ in range(n)],
dtype=int)  # Received message
print('Received word is receivedCode =', receivedCode)

newmsg, err, ccode = matfuncs.bchdec(kodiImarre, n, k)  # Decoding the
received message
print('Decoded message is newmsg =', newmsg)

if msg == newmsg:
    print('Message is decoded correctly.')
else:
    print('Errors occurred during message decoding')
```

IV. CONCLUSION

This paper discusses BCH codes and examines the implementation of the (15,7) code. An easier method for determining these codes and their constituent elements has been observed through MATLAB and Python. It turns out that these programming languages are particularly helpful, especially for large-scale codes. It turns out that these programming languages are particularly helpful, especially for large-scale codes. Future work should continue to determine which specific codes these programs work effectively with.

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Bir Eğitim Binasında Isıtma ve Soğutma Sistemlerinin Bakım, İşletme ve Maliyet Bakımından Enerji Performanslarının İncelenmesi

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Özet – Konut ve ticari binalarda kullanılan ısıtma ve soğutma sistemlerinin çalıştırılması için ilk enerji kaynağı olarak ya fosil yakıtlar veyahut fosil yakıtlardan üretilen elektrik enerjisi kullanılmaktadır. İklimlendirme cihazları, geçmişten günümüze insanoğlunun geliştirmek için çok fazla uğraş gösterdiği sistemlerdir. Günümüzde birçok ısıtma ve soğutma sistemi bulunmaktadır. Bu sistemler hem soğutma sistemi hem de ısı pompası olarak kullanılabilmektedir. Bu özelliği sayesinde aynı anda farklı hava şartları gereken okul, hastane, alışveriş merkezleri ve otel gibi birçok binalarda kullanımı öne çıkmaktadır. Ayrıca, aynı anda hem ısıtma hem de soğutma yapabilmesi enerji tasarrufu açısından da katkı sağlamaktadır.
Bu sistemlerin diğer bir önemli avantajı ise tek bir dış ünite ile birden fazla iç ünitenin çalışabilmesidir. Bu zamanda enerji verimliliği ve enerjinin etkin kullanılmasının önemine vurgu yaparak VRF ve Fancoil klima sistemlerinin performanslarını inceleyeceğiz. Bu nedenle, enerjiyi üretmek kadar, verimli kullanmakta oldukça önemlidir. Ülkemiz, gelişen sanayisiyle birlikte, enerji gereksinimi gün geçtikçe artmaktadır. Bu kapsamda, enerji verimliliğine yönelik gerçekleştirilen çalışmalarla büyük oranda tasarruf elde edilmektedir.

Ülkemizde ve dünyada enerji verimliliği konusunda çeşitli standartlar getirilmiş ve gelişen teknoloji ile bu standartlar güncellenmektedir. Isıtma-soğutma sistemleri endüstride yaygın olarak kullanılmakta ve enerji sarfiyatında önemli bir yere sahiptir. Sistemlerin tasarlanması sürecinde ve pazarlanma safhasında en önemli parametrelerden bir tanesi de kurulum maliyetinin yanı sıra işletme maliyetidir. Bunun için, sistemin sağladığı enerji verimliliği önem arz etmektedir. Tasarımı yapılan sistemlerin işletme maliyetinin azlığı, enerjiyi verimli kullanması, faaliyet gösterdiği işletme adına da ciddi avantaj sağlamaktadır. Ayrıca, ülke ekonomisine de artı bir katma değer katmaktadır. Bu proje çalışmasında, ısıtma ve soğutma sistemi olarak geniş bir kullanım alanı olan VRF ve Fancoil sistemleri, ortalama bir bina için projelendirilip, yatırım ve işletme maliyetleri açısından performansları karşılaştırılacaktır. Ayrıca iki sistem, konfor şartları, gürültü düzeyleri, işletme kolaylığı gibi parametreler açısından da değerlendirilecektir. Yapılan çalışma ile VRF sistemlerinin en verimli çalışma koşulları ve en az ekserji kaybını sağlayan soğutucu akışkanlar belirlenmiştir. Yapılan analiz neticesinde, VRF sistemlerinin eş zamanlı ısıtma ve soğutma yaptığı durumun en verimli çalışma koşulu olduğu izah edilmiştir.

Anahtar Kelimeler: Vrf Sistemleri, Fancoil Sistemleri, Isıtma, Soğutma, Enerji Verimliliği

1. GİRİŞ

Kainatta müşahede ettiğimiz veyahut edemediğimiz her türlü oluşum da enerji den söz etmemiz mümkündür. İnsanlar asırlardır, enerjisiz veya yakıtsız çalışan makine yapmaya çalışsa da netice alamamıştır. Bu da fen ve mühendislik ilmine göre, mümkün olmadığı görülmüştür. Hayatımızın bir

parçası olan enerji aynı zamanda bir ülkenin gelişme kriterleri arasında büyük önem arz etmektedir. Bu gelişme üzerinde enerjinin güvenilir, yeterli ve kesintiye uğramadan sağlanarak, bu amaca yönelik her aşamasında verimliliğin ve etkin bir şekilde kullanımının arttırılarak sağlanması ile mümkün olabilir. Dünya üzerinde her geçen gün enerji talepleri artarken enerji kaynaklarının ise hızla tükendiğini görmekteyiz. En başta gelen sorunlardan biriside yeni enerji kaynakları elde etmenin yanı sıra enerji üretiminde kaynak çeşitliliğinin sağlanmasıdır.

İnsanoğlunun büyük bir bölümünü kapalı ortamda geçirdiği için yıllar boyunca konforlu ortamın sağlanmasının arayışı içinde olunmuştur. Günümüzde gelişen teknoloji ile birlikte uygun sıcaklık değerleri ve hava kalitesi sağlanabilirken aynı zamanda otomatik kontrolü de yapılabilmektedir. Ancak artık ısıtma-soğutma sistemlerinin enerji verimliliği de önem kazanmış ve çalışmalar bu yönde de ilerlemektedir.

VRF "Değişken Debili Soğutucu Akışkan" anlamında kullanılan ve İngilizce olarak Variable Refrigerant Flow tabir edilen sistemin genel adıdır. VRF klima sistemleri esas itibariyle, evaporatörün mahal içinde, kondenserin de mahal dışında bulunduğu direkt genleşmeli bir soğutma sistemidir. Ancak diğer tip direkt genleşmeli sistemlerden ayıran özelliği bu sistemde bir dış üniteye çok sayıda iç ünite bağlanabilir. (1) Birçok yerde VRV ve VRF sistemleri aynı anlamda kullanılmaktadır. İki isim de aynı teknolojinin farklı isimle kısaltmasından oluşup temelde aynıdır. VRV (Variable Refrigerant Volume) ismi, aslında sistemin kurucusu olan Daikin firmasının patent aldığı bu sistemin adıdır. Aynı anlamda kullanılsa da diğer firmalar tarafından VRF (Değişken Debili Akışkan) ismi ile kullanılmaktadır ve bu isimle adlandırılmaktadır. Burada da sistemin adından bahsedilirken genel kullanım olan VRF kısaltması kullanılmıştır.[2] VRF merkezi bir iklimlendirme sistem olduğu için hem ısıtma hem soğutma yapabilen bir ısı pompası şeklinde çalışır. İlk kullanılmaya başlanılması 1982 yılına dayanmaktadır. VRF sisteminde tıpkı split klimalarda olduğu gibi soğutkan gazlar kullanılır. Soğutucu akışkan suya göre daha fazla ısı transferi yetisine sahip bir akışkandır. Bu sayede sistem verimli olarak çalışmaktadır.[3]

Fancoil sistemi ise daha eski bir merkezi iklimlendirme sistemidir. Sulu ısıtma-soğutma sistemi olarak çalışır. Bir ısıtıcı kaynakta ısıtılan su, fan coil denilen bir fan ile bakır ya da alüminyumdan borudan oluşan bir sarmal boru içerisinden geçirilerek ortam şartlandırılır. Soğutma periyodunda ise chiller adı verilen soğutucu ünite kullanılarak coil' den bu sefer soğutulan su geçirilir. İki sistem arasındaki temel fark ise, VRF sisteminde dolaşan akışkan fan coil sisteminde olduğu gibi su değil daha verimli bir soğutkan gaz oluşudur. Soğutkan gaz sayesinde fan coil sistemine göre daha küçük çapta borular kullanılmaktadır. İki sistem arasındaki diğer önemli fark ise VRF sisteminde dış ünite ısı pompası gibi çalışarak hem ısıtma, hem soğutma yapabilmekte iken, fan coil sisteminde ise ısıtmayı kazan gibi bir ısı üreticisi ile soğutmayı ise ayrı bir soğuk su üreticisi ile yapmasıdır.

Isıtma-soğutma sistemleri tasarlanırken genelde yatırımcının istekleri ve kullanıcıların ihtiyaçları temel alınsa da, tasarımdaki diğer önemli unsur sistemin verimli olmasıdır. Isıtma soğutma sistemlerinin enerji tüketimlerini hesaplamak ve bu hesabı ilk yatırım maliyeti ile birlikte değerlendirmek en doğru sistemi seçmek konusunda yol gösterecektir. Bu çalışmada da bir eğitim binasında VRF ve Fancoil sistemlerinin yatırım maliyetleri ve işletme maliyetleri hesaplama yönteminden yola çıkarak sistemin verimlilik analizinin karşılaştırılması amaçlanmıştır.

2. AMAÇ VE YÖNTEM

Bu çalışmada, ısıtma soğutma sistemi olarak geniş kullanım alanı olan Fancoil sistem ile VRF sistemi yaklaşık 7000 m^2 kapalı alana sahip bir binada ayrı ayrı projelendirilmiştir. Projesi tasarımı yapılan VRF ve Fancoil sistemlerinin yatırım maliyetleri, yaz ve kış dönemleri için işletme maliyetleri hesaplanarak karşılaştırılmıştır. Ayrıca iki sistem, konfor şartları, gürültü düzeyleri, işletme kolaylığı, montaj ve devreye alma gibi konularda da incelenerek sistemlerin artı ve eksi yönleri gösterilmiştir.

Bina aşağıdaki şekilde Autocad programı ile 2 boyutlu olarak çizilmiştir. 2. Bodrum kat, 1. Bodrum kat, Zemin kat, 1. Kat ve 2. Kat olmak üzere toplamda 5 kattır. Binanın 2. Bodrum katı, 1. Bodrum katı ve Zemin katı aynı ölçülerde olup 1. Kat ve 2. Katta bir kısım teras mahali olarak ayrılmıştır. Şekil de projesi yapılan binanın arka giriş görünüşü verilmiştir.[4]

Şekil 1. Tasarımı yapılan binanın servis giriş görünüşü.

Binada iç duvarlar ve dış duvarlarda 19 cm kalınlığında gaz beton kullanılmıştır. Gaz betonun ısı yalıtımının mevcut diğer inşaat malzemelerine göre daha iyi olması nedeni ile bu seçim yapılmıştır. Isı yalıtımı için ise 5 cm kalınlığında taş yünü kullanılmıştır. Bina duvarlarında 2 cm kaba sıva, 1 cm kalınlığında ise saten kullanılmıştır. Dış duvarlarda ise 3 cm kaba sıva, binanın dış cephesinde ise pre-cast denilen dış cephe kaplaması bulunmaktadır. Binada asma tavan olarak 60x60 cm taş yünü esaslı karolaj adı verilen sistem yer almaktadır. Bu sistem sayesinde kullanılan iç ünitelere erişim daha rahat olmakta ve montaj işlemi yine daha rahat yapılmaktadır. Binadaki mahaller; amfiler, derslikler, ofis odaları, kütüphane, toplantı salonları, tuvaletler ve holler olarak ayrılmıştır. Bodrum katta sığınak bulunmaktadır. Binada taze hava için mekanik olarak bir sistem kullanılmamıştır, havalandırma doğal olarak sağlanmaktadır.

Binanın ısı kaybından söz edecek olursak binanın ısı kayıp hesapları TS 2164 " Binalarda Isıtma Sistemi Projelendirmesine Esas Isı Gereksinimi Hesabı" kapsamında yapılmıştır. Binanın mimari projesinde tüm mahallerin alanları, ne amaçla kullanılacağı, kat yükseklikleri, dış duvar malzemeleri ve kalınlıkları, iç duvar malzemeleri ve kalınlıkları, teras döşeme, yer döşeme malzemeleri, dış duvar yalıtım malzemesi gibi veriler bulunmaktadır.
Isı kaybı hesaplarında yapılan kabuller TS 2164 standartlarına göre alınmıştır. Bu standartlarda Yalova ili 2. Bölgede bulunduğundan dış hava sıcaklıkları ve diğer şartlar aşağıdaki tabloda gösterilmiştir.

Tablo 1. Tasarım dış hava sıcaklık değerleri (T_d).

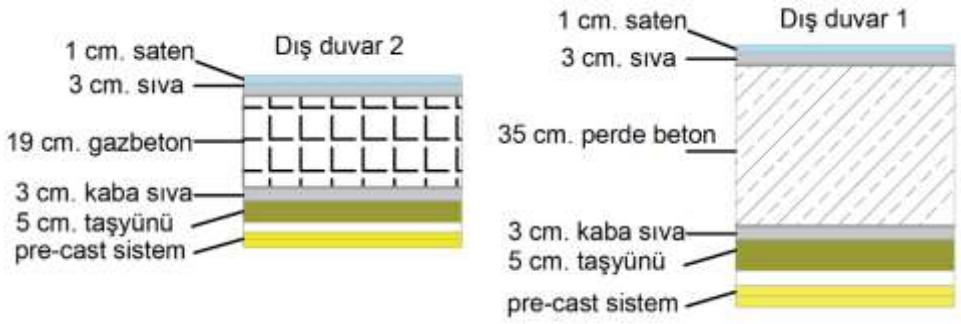
İl	Yaz Kuru Termometre Sıcaklığı (ºC)	Yaz Yaş Termometre Sıcaklığı (ºC)	Kış Sıcaklığı	Rüzgar Durumu
Yalova	32 ºC	23 ºC	-2 ºC	R

Binada yapılmış ısı kazancı ve ısı kaybı hesaplarında oda mahalleri aşağıdaki tabloda verilen sıcaklıklarına göre yapılmıştır.

Tablo 2. Mahallerin tasarım sıcaklık değerleri (T_i).

Mahal adı	Tasarım Sıcaklık Değeri (T_i)
Derslikler, kütüphane, ofis odaları	21 ºC
Duş ve Banyolar	23 ºC
WC'ler	16 ºC
Antre ve Merdiven boşlukları	19 ºC
Yangın merdivenleri	10 ºC

Yapılarda kullanılan çimento, kum, tuğla kireç, taş, cam, demir ahşap gibi malzemeler yapı malzemeleridir. Bunların bazılarının birbirlerine belirli oranlarda karıştırılması ile beton, harç ve sıva gibi farklı özellikte yeni malzemeler elde edilir. Aşağıdaki Şekil de dış duvarlara ait malzeme cinslerini ve kalınlıkları gösterilmiştir. [5]



Şekil 2. Dış duvarların yapı malzeme kalınlıkları.

Isı kayıplarının hesaplandığı binada öncelikle her yapı elemanı için ısı geçirgenlik katsayılarının bilinmesi gerekir. Bu değerler belirlendikten sonra, ısı transferinin iletim, taşınım ve hava sızıntısı ile olan miktarları hesaplanır. Elde edilen değerler watt ya kcal/saat olarak mahale verilmesi gereken saatlik ısı miktarını gösterir. Aşağıda gösterilen denklem de yapı elemanının yüzeylere bakan kısımlarında taşınım ile, yüzey görmeyen kısımlarında ise iletim ile ısı transferinin olduğunu ifade eder. Toplam ısı geçirgenlik katsayısı "U" Denklem ile bulunur.[6]

3. BULGULAR VE TARTIŞMA

Bir binanın ısı kayıplarının hesaplanması ısıtma tesisatında mahallere gereken ısı yüklerini bulmamızı sağlar. Yıllık enerji ihtiyacının hesaplanmasında iç iklim şartları, iç ısı kazanç kaynakları ve güneş enerjisi gibi parametreleri de hesaba katmak gereklidir. Bu yüzden TS 825 de belirtilen standartlara göre yıllık ısıtma enerjisi hesabı yapılacaktır. Tek hacimli bir bina için yıllık ısıtma enerjisi ihtiyacı aşağıdaki eşitlik ile hesaplanır.

$$Q_{yıl} = \Sigma\, Q_{ay}$$

$$Q_{ay} = [\, H\,(\theta_i - \theta_e) - \eta_{ay}\,(\phi_{i,ay} + \phi_{s,ay})\,] \,.\, t$$

$Q_{yıl}$: Yıllık ısıtma enerjisi ihtiyacı ……..(Joule)
Q_{ay} : Aylık ısıtma enerjisi ihtiyacı……(Joule)
H : Binanın özgül ısı kaybı ……..(W/K)
θ_i : Aylık ortalama iç sıcaklık ……...…(^oC)
θ_e : Aylık ortalama dış sıcaklık……(^oC)
η_{ay} : Kazançlar için aylık ortalama kullanım faktörü……...…(birimsiz)
$\phi_{i,ay}$: Aylık ortalama iç kazançlar (sabit alınabilir)……(W)
$\phi_{s,ay}$: Aylık ortalama güneş enerjisi kazancı……..(W)
t : Zaman, saniye olarak……(s)

Öncelikle binanın özgül ısı kaybının hesabı yapılır. Binanın özgül ısı kaybı (H) için, iletim ve taşınım yoluyla gerçekleşen ısı kaybı (H_T) ile havalandırma yoluyla gerçekleşen ısı kaybının (H_v) toplanır. İletim ve taşınım yoluyla gerçekleşen ısı kaybı hesabı için aşağıdaki denklem kullanılır. Bu eşitlikte yapı elemanlarının bünyesinden iletilen ısı kaybına, varsa ısı köprülerinden iletilen ısı kayıpları eklenir. Isı köprüsü, bitişik yüzeye göre farklı yapıya sahip, ısı kaybı binanın ortalama ısı kaybından daha yüksek olan, kışın kararlı durumlarda iç yüzey sıcaklığının daha düşük olduğu bölümlerdir.
Binadan iletim ve taşınım ile olan ısı kaybı H_T ile gösterilir ve aşağıdaki denklem ile hesaplanır.

Havalandırma ile olan ısı kaybı yukarıdaki denklemler ile hesaplanacaktır. Binada havalandırma sistemi doğal olarak karşılanacağı için mekanik havalandırma ısı kaybı yapılmayacaktır.

Isı kazançları hesabında ısı kayıp hesaplarında olduğu gibi standart bulunmamaktadır. Hesaplar MMO' nun "Klima Tesisatı Kitabı" doğrultusunda hesaplanacaktır. Isı kazancı bileşenleri aşağıdaki şekilde sırayla hesaplanacaktır. [8]

Isı kazançları, dış ısı kazançları ve iç ısı kazançları olmak üzere iki şekilde ayrı ayrı hesaba katılır. Dış ısı kazançlarında güneşin çatılardan duvarlardan ve pencerelerden olan ısı iletim ve taşınım ile olan ısı kazancının yanında radyasyonla olan ısı kazançları hesaplanır. İçi ısı kazançlarında ise insanlardan, aydınlatma araçlarından ve elektrikli cihazlardan gelen ısı kazançları hesaba katılır.

Dış ısı kazançları binadaki herhangi bir mahalin dış ortam ile temas eden her yapı bileşeninden kazanılan ısı kazançlarının toplamından oluşur. Bu yöntemde tüm dış yüzeylere ışınım ve taşınım ile gelen ısının iletim ile mahale giren kısmı hesaplanmaktadır. Pencereler, dış duvarlar, tavanlar ve döşemeler ısı kazançlarının olduğu yapı elemanlarıdır.

$$q = U \cdot A \cdot (CLTD)$$

formülü ile hesaplanır.

q : soğutma yükü, (W)

U : toplam ısı geçiş katsayısı, ($W/m^2.K$)

A : yüzey alanı, (m^2)

CLTD : soğutma yükü sıcaklık farkı, (K)

Yapı elemanları için ısı geçiş değerleri ısı kayıp hesaplarında hesaplanmıştı. Bu yönteme adını koyan parametrelerden birisi olan CLTD değeri soğutma şartları için tanımlanmış, dış yüzeylerde taşınım ve ışınım etkilerini birlikte göz önüne alan ve yapı elemanlarının ısı depolama etkilerini de içeren bir eşdeğer sıcaklık farkı tanımlamasıdır. CLTD değerleri tablolardan alınarak hesaplama yapılır.
Pencerelerden güneş ışınımı ile oluşan soğutma yükü hesabı

$q = A \bullet (SC) \bullet (SCL)$

eşitliği ile hesaplanır.

q : güneş ışınımından kaynaklanan soğutma yükü, (W)

A : yüzey alanı, (m^2)

SC : gölgeleme katsayısı

SCL : güneş soğutma yükü (W/m^2)

SCL (Solar Cooling Load) değeri, pencere etrafında herhangi bir gölgeleme elmanı olmaması durumunda referans pencere yüzeyinin birim alanı başına, birim zamandaki güneş ışınımından olan soğutma yükü anlamına gelir. Bu değerler ilgili tablolardan seçilerek denklemde yerine yazılır.
İç ısı kaynakları insanlar, aydınlatma cihazları ve elektrikli ısı kaynaklarıdır. Projede hesabın pratik olması açısından tablodan değerler seçilmiştir.

İnsanlar için genel aktivite durumları ve giyime uygun olarak çevreye yaydıkları ısı ile ilgili bazı pratik değerler aşağıdaki tablo verilmiştir. Genellikle insanlardan kaynaklanan duyulur (nefesle mahale verilen) ve gizli (deri yüzeyinden buharlaşan) ısı kazançları toplam yük içinde önemli bir yüzdeyi kapsar. İnsan tarafından neden olunan gizli ısı kazancı, ani soğutma yükü olarak göz önünde bulundurulabilir. Ancak toplam duyulur ısı kazancı doğrudan soğutma yüküne çevrilemez. Işınımla yayılan miktar ilk olarak etraftaki cisimler tarafından emilir, daha sonra odanın karakteristiğine bağlı olarak ortama iletilir

Kapalı bir ortamda bulunan insanların, sahip oldukları aktivite derecesine göre iç ortama verdiği duyulur ve gizli ısı miktarları tablolar halinde verilmiştir. Bu değerler, hesap anında mahalde bulunan kişi sayısı ile çarpılarak ısı kazanç değerleri hesaplanmış olur.

Duyulur ısı kazancı;

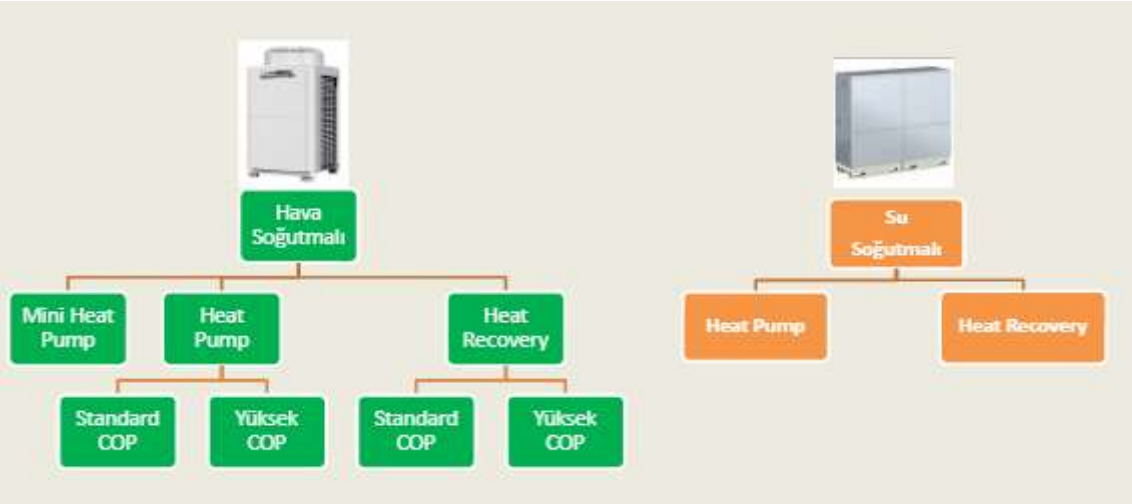
$q_{duyulur} = N \times$ duyulur ısı kazancı (W)

Gizli ısı kazancı ;

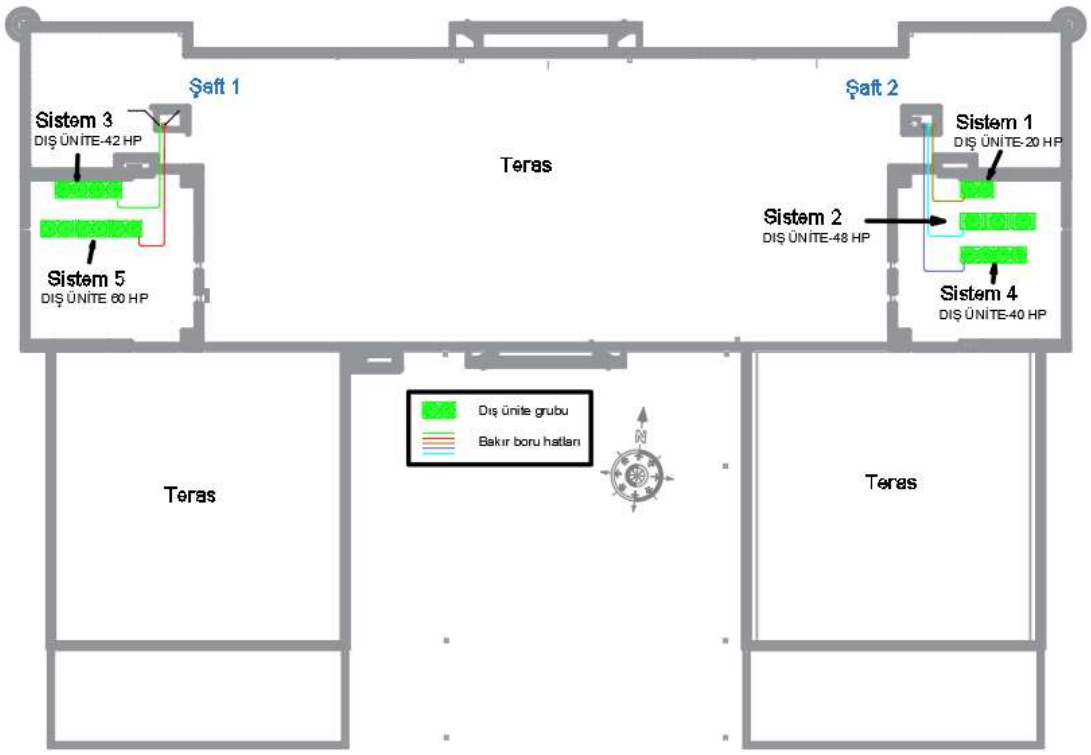
$q_{gizli} = N \times$ gizli ısı kazancı (W)

N : insan sayısı

Dış üniteler şekilde görüldüğü gibi hava ve su soğutmalı olarak kısımlara ayrılmıştır.



VRF klima tesisatında kullanılan dış ünite gruplarının teras katındaki konumları ve HP değeri olarak soğutma kapasiteleri Aşağıdaki Şekiller de gösterilmiştir.



Şekil 3. Projede kullanılan dış ünitelerin teras katındaki konumları.

Tablo 3. Projede kullanılan iç ünitelerin kapasite değerleri

İç ünite gücü	Sayısı	Toplam gücü
2,5 Hp (7,1 kW) dört yöne üflemeli kaset tipi	10	37,5 HP
3,2 Hp (9 kW) dört yöne üflemeli kaset tipi	9	16 HP
4,0 Hp (11,2kW) dört yöne üflemeli kaset tipi	23	104 HP
0,8 Hp (2,2 kW) dört yöne üflemeli kompakt kaset tipi	17	18,4 HP
1,0 Hp (2,8 kW) dört yöne üflemeli kompakt kaset tipi	17	9 HP
1,25 Hp (3,6 kW) dört yöne üflemeli kompakt kaset tipi	5	7,5 HP
1,7 Hp (4,5 kW) dört yöne üflemeli kompakt kaset tipi	8	11,9 HP
2,0 Hp (5,6 kW) dört yöne üflemeli kompakt kaset tipi	10	14 HP
Toplam	**99 adet**	**218,9 HP**

İç üniteler havayı eşit olarak dört yöne verimli vermesi için dört yöne üflemeli kaset tipi olarak seçilir. Kaset tipi seçilmesinin bir diğer önemli tarafı da kanallı cihazlara göre daha kolay montajı olması ve önünde kanallardan yapılan üfleme kutusunun yapılma mecburiyetinin olmamasıdır. Ayrıca kanallı tip cihazlarda menfez konulması gerekliliği vardır. Aşağıdaki tabloda projede kullanılan kaset tipi cihazların adetlerini ve kapasitelerini göstermektedir.

Kapasitesi nispeten düşük olan iç üniteler klima üreticileri tarafından daha küçük boyutlarda üretilmekte ve buna kompakt iç ünite adı verilmektedir. 60cmx60cm boyutlarında üretilebilmektedir. Bu projede de 2,2 kW, 2,8 kW, 3,6 kW, 4,5 kw ve 5,6 kW soğutma kapasitesindeki iç üniteler kompakt tiptir. Diğer yüksek kapasiteli iç üniteler ise 90x90 cm boyutlarına sahiptir.

Fan coil projesinde ısı üreticisi olarak bir adet yer tipi yoğuşmalı kazan, bir adet soğuk su üreticisi olarak chiller, toplamda 101 adet fan coil iç ünitesi bulunmaktadır. Metrajı yapılacak olan sistemlerde boru, vana, pislik tutucu çekvalf, genleşme tankı, emniyet ventili, boru yalıtımı, hava tüpleri gibi elemanların sayı ve uzunlukları hesaplanır.

Daha önce hesaplandığı gibi sistemde 460 kW (80-60 ^{o}C) gücünde bir adet yer tipi premiks brülörlü yoğuşmalı kazan ve 611kW (7-12 ^{o}C) gücünde soğutucu ünite (chiller) seçilmişti. Projede ısı kayıp ve kazanç hesaplarına göre mahallere konulan fan coil iç ünitelerin kapasiteleri bulunduktan sonra toplam adetleri hesaplanmıştır. Aşağıdaki tabloda kapasitelere göre fan coil adetleri verilmiştir.

Tablo 4. Katlara göre FanCoil iç ünite tipleri ve sayıları.

Fan coil tipi	Soğutma Kapasitesi (kw)	Isıtma Kapasitesi (kw)	2. Bodrum Kat	1. Bodrum Kat	Zemin Kat	1. Kat	2. Kat	Toplam Adet
Tip 1	3	6,8	4	-	-	27	2	34
Tip 2	3,7	8,6	-	-	2	4	-	6
Tip 3	4,5	10,3	-	-	-	4	3	7
Tip 4	5,7	16,4	2	3	-	-	2	7
Tip 5	7	19,6	2	3	4	4	1	14

Tip 6	8,2	23,5	-	4	-	-	4	8
Tip 7	10,4	29,8	8	8	8	-	-	24
			15	**19**	**14**	**39**	**12**	**99**

Projede her iç üniteye ait odanın büyüklüğüne göre termostatlar yer alır. Her fancoil bağımsız olarak kontrol edilebileceğinden toplamda 101 adet de oda termostatı bulunmalıdır.

Fancoil projesinde hesaplanan çelik boru chiller grubundan kazan dairesindeki pompalara ve sistem pompalarından fan coil iç ünitelerine kadar olan çelik borulardan ve kazan dairesindeki kollektör gruplarına gelen dönüş borularından oluşur. Sistemde bulunan değişen çaplarda çelik borular anti pas ile boyanmalı ve üzerine uygun çaplarda ısı yalıtım malzemesi kaplanmalıdır. Aşağıdaki tabloda projede kullanılan toplam boru metrajı çaplara göre verilmiştir.

Tablo 5. Projedeki çelik boru metrajı.

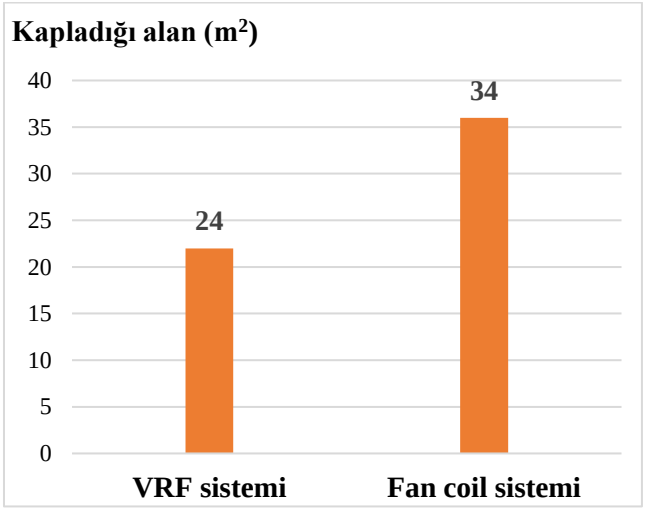
Çelik boru çapı (inç)	**Uzunluk (metre)**
1/2 "	20
3/4 "	88
1 "	320
1 1/4 "	245
1 1/2 "	135
2 "	142
2 1/2 "	160
3 "	80
4"	75
5"	95
6 "	170
8"	112
10 " (Kollektör için)	15

Sirkülasyon pompaları sistemde toplamda 9 adet bulunmaktadır. Bu pompaların chiller grubuna basan hattında iki adet asıl bir adet yedek pompa bulunmaktadır. Sisteme basan hatlar toplamda iki adet olduğundan her hatta iki asıl bir de yedek pompa bulunmaktadır.

Buraya kadar yapılan işlemlerde iki sistemin karşılaştırılması için öncelikle projenin yapılacağı binanın mimari özellikleri tanıtıldı ve binada kullanılan yapı malzemeleri tespit edildi. Projelerin hazırlanması için ısı kaybı ve ısı kazancı hesaplandı bunun için de dış duvar, pencere, kapı ve iç duvar gibi yapı elemanlarının ısı iletim katsayıları bulundu. Daha sonra iki sistemin de kış dönemi ısıtma periyodunda işletme maliyetinin hesaplanması için binanın yıllık ısı ihtiyacı hesaplandı.

Yapılması tasarlanan ısıtma-soğutma sistemlerinin mimari projeye göre uygun seçilmesi önemlidir. Çoğu zaman yatırımcılar mahalleri verimli kullanmak için mekanik sistemlerin az yer kaplamasını talep ederler. Bu nedenle tasarımcılar tecrübelerini kullanarak yatırımcıların taleplerini karşılayan sistemler seçmek zorunda kalır. Projesi yapılan VRF ve fan coil sistemlerinin binada kapladığı yer bakımından aralarında

ciddi fark bulunmaktadır. VRF sisteminde dış üniteler sadece teras katında bulunmakta ayrıca bir kazan dairesine gerek duyulmamaktadır. Oysa fan coil sisteminde kazan dairesi bulunmak zorunda ve sirkülasyon pompaları, genleşme tankları, çekvalf ve pislik tutucu gibi birçok yardımcı elemana ihtiyaç duyulmaktadır. VRF sisteminde dış üniteler içi sadece teras kat kullanılmıştır. Sistem hava soğutmalı olduğu için atmosfere açık alanın kullanımı zorunlu olmaktadır. Sistemin dış ünitelerinin boyutları chiller ünitesine göre daha kompakt, daha taşınabilir olmaktadır. VRF sistemi dış üniteleri teras katta toplam 22 m^2 yer kaplamaktadır. Fan coil sistemi ise teras katta chiller ünitesi teras katta 16 m^2 yer kaplamakta ancak kazan dairesine ihtiyaç duymakta ve kazan, pompa ve diğer yardımcı elemanlar için toplam minimum 20 m^2 mahale gerek duyulmaktadır. Toplamda chiller ünitesi ve kazan dairesi ihtiyaç duyulan alanı 36 m^2 olmaktadır. Fan coil sistemi dış ünitelerinin ihtiyaç duyduğu alan VRF sistemine göre %39 daha fazla olmaktadır. Ağırlık bakımından karşılaştırıldıklarında fan coil sistemi elemanları VRF sistemine göre daha ağırdır. Sadece soğutucu ünite olan chiller yaklaşık 4500 kg ağırlığındadır. Oysa projede kullanılan tüm VRF dış ünitelerinin toplam ağırlığı yaklaşık 3650 kg dır. Şekil 6.1'de iki sistemin dış ünitelerinin kapladığı alan bakımından karşılaştırması gösterilmiştir.



Şekil 4. VRF ve fan coil sisteminin dış ünitelerinin kapladığı alanlar.

İklimlendirme sistemlerinde işletmenin kolay ve ekonomik olması ayrıca servis hizmetlerinin hızlı ve erişilebilir olması kullanıcılar için oldukça önemlidir. Fan coil sisteminde çok daha fazla eleman olduğundan birçok firmadan ürünlerin sistemde yer alması kaçınılmaz olmaktadır. Örneğin chiller ünitesi firması ile yoğuşmalı kazan firması ve sirkülasyon markaları genelde farklıdır. Bu nedenle birçok markadan servis hizmeti beklenmek zorunda kalınmaktadır. VRF sisteminde ise bütün sistem tek bir marka tarafından yapılıp devreye alındığından bu konuda fan coil sistemine göre servis ulaşımı konusunda daha avantajlıdır.

Sistemin işletme kolaylığı genelde yatırımcılar tarafından göz ardı edilse de aslında kullanıcılar için çok önemlidir. Bu iki sistem bu konuda karşılaştırıldığında açık ara VRF sisteminin işletmesi çok daha kolay olmaktadır. Çünkü fan coil sisteminde ısıtma ünitesi olan kazan doğalgaz ile çalışmakta kazanın ve sirkülasyon pompalarının bulunduğu sistemin ayrı ayrı bakımı gerekmektedir. Ayrıca genleşme deposu, pislik tutucu, vana vb. elemanların periyodik bakımı gerekmektedir. Kısaca fan coil sistemi daha çok elemandan oluştuğundan daha işletmesi VRF sistemine göre daha zordur. VRF sistemi ise bir dış üniteler ve iç ünitelerden oluştuğundan, sistemi meydana getiren parçaların azlığı nedeni ile daha kolay bir işletmeye sahiptir.

VRF sisteminde her dış üniteye belli sayıda iç ünite bağlanarak sistem kısım kısım çalıştırılabilmektedir. Örneğin projesi yapılan binada beş ayrı sistem bulunmaktadır. İç ünite ya da dış ünitenin birinde meydana gelen herhangi bir arızada sistemin tamamını devreden çıkarmadan sadece arıza olan sisteme müdahale etmek mümkün olmaktadır. Bu sayede kullanıcıların sadece bir kısmı bu durumdan etkilenmektedir.

Ayrıca VRF klima sisteminde eş yaşlandırma denilen bir sistem bulunmaktadır. Bu sistemde dış ünitelerin hepsi tam kapasitelerde çalışmadığı zamanlarda kompresörler sıra ile ilk çalışmayı yapmaktadır. Bu sayede sürekli aynı kompresör ilk devreye giren olmadığından kompresörler hemen hemen aynı süre çalışmış olur eşit şekilde yaşlanmış olurlar. Fan coil sisteminde ise chiller tek başına bir dış ünite görevi gördüğünden yedeklenmesi mümkün değildir. Herhangi bir arıza durumumda sistem tamamen kapatılmakta ve kullanıcıların tamamı bundan etkilenmektedir.

Bakım maliyetleri karşılaştırıldığında VRF sistemi daha az elemandan oluştuğundan daha avantajlıdır. Fan coil sisteminde ısıtma ve soğutma ünitelerinin ayrı oluşu ve sistem parçalarının çok oluşu nedeni ile bakım maliyetleri VRF sistemine göre daha fazladır.

İki sistemin de iç ünitelerinin bakım maliyetleri ortalama olarak aynıdır. İki sistemde de iç üniteler kaset tipi olduğundan genelde bakım iç üniteye ait hava filtresinin temizliği olmaktadır. Ancak fan coil iç ünitesine ait su giriş küresel vana ve iki yollu vanaların ve pislik tutucuların bakımı maliyeti artırmaktadır. Fan coil sisteminde chiller ünitesinin parça maliyetleri de VRF sistemi dış ünitelerine göre daha maliyetli olmaktadır.

Fan coil sisteminde kullanılan borular çelik borulardır. Çelik boruların nispeten daha ağır oluşu sistemin ağırlığını artırmakta ve montaj sürelerini de uzatmaktadır. VRF sisteminde ise, hem sistemin kısımlara ayrılması hem de bu sistemin kendi özelliğinden dolayı en büyük bakır boru çapları 2 inç' ten daha küçük çaptadır. Bu durum hem sistemi hafifletmekte hem de montaj kolaylığı sağlamaktadır. Ayrıca fan coil sisteminde kullanılan çelik borularının izolasyonu VRF sitemine göre daha uzun montaj süresi gerektirmektedir. VRF siteminde çapların fan coil sistemine göre küçük oluşu bakır borularının izolasyonlu olarak piyasada bulunabilme imkanı sağlamakta ve bu da montaj süresini kısaltmaktadır.
Fan coil sisteminde kazan, chiller ünitesi, pompa grupları, iç üniteler, doğalgaz gibi devreye alınması gereken birçok sistem bulunmaktadır. Bu durum sistemi devreye alma işlemlerini uzatmaktadır. VRF sisteminde ise sistem dış ve iç ünitelerden oluştuğundan fan coil sistemine göre daha kolay ve kısa montaj süreleri olmaktadır.

Eğitim binasının ısıtma ve soğutma sistemlerinin kullanımıyla ilgili bilgiler ve enerji verimliliği ve kamuda enerji tasarrufu tedbirleri kapsamında sistemlerinin çalışma saatleri ve kullanım talimatlarına değinecek olursak [9]:

- Isıtma Sistemleri her yılın 15 Ekim tarihinde açılır, 15 Nisan tarihinde kapatılır.
- Soğutma sistemleri her yılın 15 Mayıs tarihinde açılır, 15 Eylül tarihinde kapatılır.
- Isıtma, kombi ve fancoil motor sistemi ile yapılmaktadır.
- Soğutma chiller ve fancoil motor sistemi ile yapılmaktadır.
- Isıtma sistemi normal şartlarda saat: 06:30 ile 17:00 zaman aralıklarında çalışır vaziyettedir. (Hava şartlarında anormal durumlar yaşandığında otomasyon sistemi güncellenebilir.) (Açık öğretim ve ÖSYM sınavlarının yapıldığı tarihlerde hafta sonu ısıtma sistemi açık vaziyettedir.)
- Chiller-fancoil soğutma sistemi 07:30-17:00 saatleri arasında otomasyon sistemi açıktır. Belirtilen saatlerde kullanım olup olmamasına göre termostatlı kontrol panelinden tekrardan açılma özelliği mevcuttur.

- Binalarda Fancoil ısıtma sisteminin otomasyonu her katın ayrı olup Kombi kaskad sistemi ile eş zamanlı çalışma yapılmaktadır. (Bina kullanıcıları otomasyonları manuel modda çalıştırmamalıdır.)

- Ofislerin güneş alma konumu aynı olmadığı için bireysel kullanıcılar radyatörlerde bulunan termostatlı vanalar aracılığı ile oda sıcaklığını ayarlayabilirler.

- Hafta sonu ve resmî tatiller ile dini bayramlarda ısıtma ve soğutma sistemi kapatılmaktadır.

- Kombi sistemine bağlı dış hava sensörlü aracılığı ile sıcak havalarda ısıtma sistemi kendini devre dışı bırakır. (Dış hava sensörünün konumuna göre sıcaklık değeri 19-21 derece arasında ayarlanmaktadır.)

- Kombi-radyatör aracılığı ile ısıtma sağlanmaktadır. Merkezi klima kullanımı gerekli olmadıkça kullanılmamalıdır.

4. SONUÇ

Karşılaştırılan her iki sistem göz önüne alındığında, VRF sistemi tesisatında soğutucu akışkan, fan coil sisteminde ise su bulunmaktadır. Soğutucu akışkanın kilogram başı verdiği ısı miktarı sudan fazladır [10]. Buradan başlanırsa, VRF sisteminin suya göre daha az akışkan sirküle ederek, aynı ısı miktarını verebildiği görülmektedir. Bu durum daha küçük boru çapları kullanma şansını doğurmuştur. Ayrıca sistemde dolaşan akışkan için daha az pompa gücü gerektirmektedir.

Isıtma soğutma sistemlerinin kolay uygulanabilir olması ve binada az yer yer tutması hem kullanıcı hem de yatırımcılar için istenen bir durumdur. Bu bakımdan incelendiğinde VRF klima sisteminin kazan dairesi zorunluluğunun olmaması ve daha kolay taşınabilir olması nedeni ile avantajlı olduğu görülmektedir.

İklimlendirme sistemlerinde işletmenin kolay yapılabilmesi ve ekonomik olması ayrıca servis hizmetlerinin hızlı ve erişilebilir olması kullanıcılar için oldukça önemlidir. Fan coil sisteminin VRF sistemine göre daha fazla ekipmana sahip olması hem işletme hem de servis yükü açısından daha maliyetli hale getirmektedir. Yine arıza durumunda sistemler incelendiğinde, fan coil sisteminde servislerin çeşitli markalardan ve daha fazla sayıda olması işletme esnasında VRF sistemine göre daha fazla yük ve maliyet getirecektir. Bu durum bakım ve parça giderlerini artıracaktır.

Mekanik sistemlerin ilk yatırım maliyetleri yatırımcılar için oldukça önemlidir. Bir sistem çok verimli ancak yapım maliyeti ve bakım maliyeti çok ise bu sistem doğru sistem olmayabilir. Doğru sistemi seçmede değerlendirmenin sağlıklı yapılabilmesi için, binanın kullanım amacından mimari özelliklerine, yapılması tasarlanan sistemlerin işletme maliyetlerinden bakım maliyetine kadar hatta kullanıcıların eğitim düzeyine kadar bütün parametreler birlikte göz önünde bulundurulmalıdır. Son yıllarda sistem seçimleri daha doğru temellere oturmuş olsa da, bazı projelerde yatırım maliyeti ucuz olanların ya da alışılmış ve bilinen sistemlerin uygulandığı görülmektedir. Bu durum, ilerleyen yıllarda işletme giderlerinin artmasına ve yatırım maliyeti düşük sistemlerinin daha büyük işletme maliyeti getirmesine neden olmaktadır.

Fan coil sisteminin avantajlı olarak görüldüğü özellik, mevsim geçişlerindeki konfor düzeyidir. Ülkemizde dört mevsim yaşandığından, mevsim geçişleri bazı mahallerde ısıtma ihtiyacı doğururken bazı mahallerde ise soğutma ihtiyacı doğurmaktadır. Fan coil sistemi dört borulu olarak tasarlandığında iki ayrı serpantini sayesinde bu konforu sunmaktadır. VRF sisteminde ise yeni üç borulu olarak tasarlanan

sistemler olsa da, pahalı ve henüz yaygın değildir. Ayrıca VRF sistemlerinde sıfırın altındaki sıcaklıklarda oluşan defrost işlemi konfor şartlarını bozan özellik olarak karşımıza çıkmaktadır. Isıtmanın devamlılığı için klimalar, dış ünitede dolaşmakta olan akışkanın sıcaklığını, daima dış havadan düşük tutmak zorundadır. Buzlanma arttıkça ısı transferi güçleştiğinden verim düşer. Dış ünitenin, üzerindeki buzu çözebilmek için klima zaman zaman ters çevrimde çalışır. Bu işleme "defrost" denir. Defrost işlemi sırasında üniteler fan çalışmasını durdurur. Isıtmaya kısa bir süre ara verilmiş olur. Kaliteli markalarda bu durum kullanıcılar tarafından hissedilmez ancak bazı markaların sistemlerinde defrost işlemi konforu bozan özellik olarak karşımıza çıkmaktadır. Fan coil sisteminde ise ısıtma periyodunda yakıt olarak doğalgaz kullanıldığından defrost gibi konfor bozabilecek durumlar oluşmamaktadır.

Sistemlerin ilk yatırım maliyetleri karşılaştırıldığında VRF sisteminin yaklaşık %20 daha ekonomik olduğu görülmüştür. Bu durumun oluşmasında temel nedenin fan coil sistemini oluşturan elemanların VRF sistemine göre daha fazla oluşudur. VRF sistemi aynı dış üniteden hem ısıtma hem soğutma yapabilme özelliğine sahipken, fan coil sistemi soğutma periyodunda chiller dış ünitesine, ısıtma periyodunda ise doğalgaz gaz ile çalışan kazana ihtiyaç duymaktadır.

Sonuç olarak Fancoil soğutma sistemleri endüstriyeller için daha ideal olduğu anlaşılmaktadır. Ancak Ofis, derslikler ve iş yerleri gibi mekanlar da ise VRF klima sistemlerini tercih etmek gereklidir. Bu yüzden üniversite gibi kurum binalarında VRF soğutma sistemlerinin kullanılmasının daha verimli olduğunu belirtmekteyiz.

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Obtaining Smarandache Curves of Mannheim Pair Curves in terms of the Frenet frame of Curve-Surface Pair of a Curve in Euclidean 3-Space

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Abstract **–** In this document presents we obtain the Smarandache Curves of Manheim Curve Couple according to the Frenet vectors of the partner curve of Manheim curve in terms of the Frenet vectors of the curve-surface pair (α, M) in Euclidean 3-space.

Keywords – Curve-surface pair, Manheim Curve, Manheim partner curves, Smarandache curves

I. INTRODUCTION

There are a lot of special curves in the curve theory. One of them is Smarandache curves. Smarandache curves have been studied by some scientists in Differential Geometry. Ahmad T.Ali investigated Smarandache curves with Frenet invariants in the Euclidean space (e.g. [1]). Muhammed Çetin , Yılmaz Tunçer and Kemal Karacan studied special Smarandache curves according to Bishop frame in Euclidean 3-Space (e.g. [5]). Süleyman Şenyurt and Abdüssamet Çalışkan studied special Smarandache curves in terms of Sabban frame of spherical indicatrix curves and some characterization of Smarandache curves are given by them (e.g. [4]). Özcan Bektaş and Salim Yüce investigated some special Smarandache curves according to Darboux Frame in E^3 (e.g. [2]). Some special Smarandache curves in E_1^3 are investigated by Nurten Bayrak, Özcan Bektaş and Salim Yüce (e.g. [3]). Smarandache TB_2 curves in E_1^4 are studied by Melih Turgut and Süha Yılmaz (e.g. [10]).

A specific feature is Curve-surface pair that belong to a curve. When we observe the curve-surface pair, in actually we observe the curve. H. Hilmi Hacısalihoğlu and Arif Sabuncuoğlu observed firstly curve-surface pair of the curve in 1975. After, Sadık Keleş studied his pHd thesis on curve-surface pairs in 1982 (e.g. [13-19]).

The purpose of this paper is obtaining Smarandache Curves of Manheim Curve Couple according to the Frenet vectors are demonsrated in terms of the Frenet vector fields of the curve-surface-pair. For this study in this paper, we did a similar study to Süleyman Şenyurt and Abdussamet Çalışkan's paper in reference [e.g. [12]. But we study Smarandache curve $\beta_{T^*N^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve.

II. PRELIMINARIES

Definition 1**.** Let M and α be a surface in E^3 and a curve in $M \subset E^3$. We define a surface element of M is the part of a tangent plane at the neighbour of the point. The locus of these surface element along the curve α is called a curve-surface pair and is shown as (α, M).

Definition 2**.** Let $\{T, N, B\}$ and $\{\xi, \eta, \zeta\}$ be the curve and curve-surface pair's vector fields of curve. The curve-surface pair's tangent vector field, normal vector field and binormal vector field is given by $T = \xi$, $\zeta = N$ and $\eta = \zeta \wedge \xi$ (e.g. [13]). These vectors are taken as position vectors. The formulae of the Frenet vector fields, curvatures of a differentiable curve $\alpha(t)$ are given as follows (e.g. [15],[16]);

$$T = \frac{\alpha'}{\|\alpha'\|}, N = B \wedge T = \frac{(\alpha' \wedge \alpha'') \wedge \alpha'}{\|\alpha' \wedge \alpha''\| \|\alpha'\|}, B = \frac{\alpha' \wedge \alpha''}{\|\alpha' \wedge \alpha''\|}, \tag{1}$$

$$\kappa = \frac{\|\alpha' \wedge \alpha''\|}{\|\alpha'\|^3}, \quad \tau = \frac{\det(\alpha', \alpha'', \alpha''')}{\|\alpha' \wedge \alpha''\|^2}$$

$$T' = \kappa N, \; N' = \kappa T + \tau B, \; B' = -\tau N.$$

II.1. Curvatures of the curve-surface pair and Curvatures of the Curve

Let $k_n = -b, k_g = c, t_r = a$ and $\{\xi, \eta, \zeta\}$ be the normal curvature, the geodesic curvature, the geodesic torsion of the strip and the curve-surface pair's vector fields on α (e.g. [13], [17]-[19]).

Then we have following equations.

$$\begin{aligned} \xi' &= c\eta - b\zeta \\ \eta' &= -c\xi + a\zeta \\ \zeta' &= b\xi - a\eta. \end{aligned} \tag{2}$$

We know that a curve α has two curvatures κ and τ. A curve has a strip and a strip has three curvatures k_n, k_g and t_r. Let k_n, k_g and t_r be the $-b, c$ and a. We have following equalities.

$$\begin{aligned} T &= \xi, \\ N &= \cos\varphi\eta + \sin\varphi\zeta, \\ B &= -\sin\varphi\eta + \cos\varphi\zeta. \end{aligned} \tag{3}$$

From last equations we have $\xi' = c\eta - b\zeta$. If we substitude $\xi = T$ in last equation, we obtain the equaillities

$$\xi' = \kappa N \tag{4}$$

and,

$$\begin{aligned} b &= -\kappa\sin\varphi \\ c &= \kappa\cos\varphi \end{aligned}. \tag{5}$$

(e.g.[18]). From last two equations we obtain,

$$\kappa^2 = b^2 + c^2. \tag{6}$$

This equation is a relation between the curvature κ of a curve α and normal curvature and geodesic curvature of a curve-surface pair.

By using similar operations, we obtain a new equation as follows

$$\tau = a + \frac{b'c - bc'}{b^2 + c^2}, \tag{7}$$

(e.g. [18]).

This equation is a relation between τ (torsion or second curvature of α and curvatures of a curve-surface pair that belongs to the curve α). And also we can write

$$a = \varphi' + \tau . \tag{8}$$

II.2. Mannheim pair

Definition 3 : Let $\alpha : I \to E^3$ and $\alpha^* : I \to E^3$ be the C^2 – class differentiable unit speed two curves and let $\{T, N, B\}$ and $\{T^*, N^*, B^*\}$ be the Frenet frames of the curves α and α^*, respectively. If the principal normal vector N of the curve α is linearly dependent on the binormal vector B of the curve α^*, then the curves α and α^* are called Mannheim curve and Mannheim partner curve α. The curve pair (α, α^*) is called as Mannheim pair (e.g. [7],[8],[12]). The following equalities are the relations between the Frenet frames $\{T, N, B\}$ and $\{T^*, N^*, B^*\}$.

$$\begin{cases} T^* = \cos\phi T - \sin\phi B, \\ N^* = \sin\phi T + \cos\phi B, \\ B^* = N. \end{cases} \tag{9}$$

$$\begin{cases} \cos\phi = \dfrac{ds^*}{ds}, \\ \sin\phi = \rho\tau^* \dfrac{ds^*}{ds}, \end{cases} \tag{10}$$

where ϕ is the angle between T and T^* (e.g. [7],[8],[12]).

Remark **:** The angle ϕ is equal to the angle φ. So we have to take one of them.

III. OBTAINING T^*N^* – SMARANDACHE CURVES OF MANNHEIM PAIR CURVES IN TERMS OF FRENET VECTORS OF CURVE-SURFACE PAIR OF A CURVE

Definition 4 : (e.g. [12]) Let (α, α^*) be a Mannheim pair curves in E^3 and $\{T^*, N^*, B^*\}$ be the Frenet frame of Manheim partner curve α^* at $\alpha^*(s)$. T^*N^*-Smarandache curve is defined by following equation.

$$\beta_{T^*N^*} = \frac{1}{\sqrt{2}}(T^* + N^*). \tag{11}$$

By substituting T^* and N^* from (9), we obtain T^*N^*-Smarandache curve $\beta_{T^*N^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α is as follows.

$$\begin{aligned}
\beta_{T^*N^*} &= \frac{1}{\sqrt{2}}\left[(\cos\phi T - \sin\phi B) + (\sin\phi T + \cos\phi B)\right] \\
&= \frac{1}{\sqrt{2}}\left[(\cos\phi\xi - \sin\phi(-\sin\varphi\eta + \cos\varphi\zeta)) + (\sin\phi\xi + \cos\phi(-\sin\varphi\eta + \cos\varphi\zeta))\right] \\
&= \frac{1}{\sqrt{2}}\left[\cos\varphi\xi + \sin^2\phi\eta - \sin\varphi\cos\varphi\zeta + \sin\varphi\xi - \sin\varphi\cos\varphi\eta + \cos^2\varphi\zeta\right] \\
&= \frac{1}{\sqrt{2}}\left[(\cos\varphi + \sin\varphi)\xi + (\sin^2\phi - \sin\varphi\cos\varphi)\eta + (\cos^2\varphi - \sin\varphi\cos\varphi)\zeta\right]
\end{aligned} \tag{12}$$

In actually, our purpose is to find above equation (12), but if we want to find the invariants of T^*N^*-Smarandache curve $\beta_{T^*N^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α of the T^*N^* Smarandache curve $\beta_{T^*N^*}$, then we obtain following equality.

If we take the derivative of the T^*N^*-Smarandache curve $\beta_{T^*N^*}$, then we obtain following equality.

$$\beta'_{T^*N^*} = \frac{1}{\sqrt{2}}\begin{bmatrix}(-\varphi'\sin\varphi + \varphi'\cos\varphi)\xi + (\cos\varphi + \sin\varphi)\xi' + (2\sin\varphi\cos\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi)\eta \\ + (\sin^2\varphi - \sin\varphi\cos\varphi)\eta' \\ + (-2\varphi'\cos\varphi\sin\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi)\zeta + (\cos^2\varphi - \sin\varphi\cos\varphi)\zeta'\end{bmatrix}, \tag{13}$$

By substituting Frenet vectors ξ', ξ' and ξ' in the equality (2.5), then we have following equality.

$$\beta'_{T^*N^*} = \frac{1}{\sqrt{2}}\begin{bmatrix}(-\varphi'\sin\varphi + \varphi'\cos\varphi)\xi + \kappa(\cos\varphi + \sin\varphi)N + (2\sin\varphi\cos\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi)\eta \\ + (\sin^2\varphi - \sin\varphi\cos\varphi)(-c\xi + a\zeta) \\ + (-2\varphi'\cos\varphi\sin\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi)\zeta + (\cos^2\varphi - \sin\varphi\cos\varphi)(b\xi - a\eta.)\end{bmatrix}, \tag{14}$$

$$\beta'_{T^*N^*} = \frac{1}{\sqrt{2}}\begin{bmatrix}(-\varphi'\sin\varphi + \varphi'\cos\varphi + b\cos^2\varphi - b\sin\varphi\cos\varphi - c\sin^2\varphi + c\sin\varphi\cos\varphi)\xi \\ + (2\sin\varphi\cos\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi - a\cos^2\varphi + a\sin\varphi\cos\varphi + \kappa\cos^2\varphi + \kappa\sin\varphi\cos\varphi)\eta \\ + (-2\varphi'\cos\varphi\sin\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi + a\sin^2\varphi - a\sin\varphi\cos\varphi + \kappa\cos\varphi\sin\varphi + \kappa\sin^2\varphi)\zeta\end{bmatrix}, \tag{15}$$

By substituting (5) in (15), then we get the equation is as follows.

$$\beta'_{T^*N^*} = \frac{1}{\sqrt{2}}\begin{bmatrix}(-\varphi'\sin\varphi + \varphi'\cos\varphi - \kappa\sin\varphi\cos^2\varphi + \kappa\sin^2\varphi\cos\varphi - \kappa\cos\varphi\sin^2\varphi + \kappa\sin\varphi\cos^2\varphi)\xi \\ + (2\sin\varphi\cos\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi - (\varphi' + \tau)\cos^2\varphi + (\varphi' + \tau)\sin\varphi\cos\varphi \\ + \kappa\cos^2\varphi + \kappa\sin\varphi\cos\varphi)\eta \\ + (-2\varphi'\cos\varphi\sin\varphi - \varphi'\cos^2\varphi + \varphi'\sin^2\varphi + (\varphi' + \tau)\sin^2\varphi - (\varphi' + \tau)\sin\varphi\cos\varphi \\ + \kappa\cos\varphi\sin\varphi + \kappa\sin^2\varphi)\zeta\end{bmatrix}. \tag{16}$$

Similarly, by taking the 2nd and 3rd derivatives and computing Frenet vector fields, curvatures of this T^*N^*-Smarandache curve $\beta_{T^*N^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α can calculated by using the necessary formulas from (1).

IV. OBTAINING N^*B^* – SMARANDACHE CURVES OF MANNHEIM PAIR IN TERMS OF FRENET VECTORS OF CURVE-SURFACE PAIR OF A CURVE

Definition 5: (e.g. [12]) Let (α,α^*) be a Mannheim pair curves in E^3 and $\{T^*,N^*,B^*\}$ be the Frenet frame of Manheim partner curve α^* at $\alpha^*(s)$. N^*B^* – Smarandache curve is defined by following equation.

$$\beta_{N^*B^*}=\frac{1}{\sqrt{2}}(N^*+B^*). \tag{17}$$

By substituting N^* and B^* (from (9)) in (17), we obtain N^*B^* – Smarandache curve $\beta_{N^*B^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α is as follows.

$$\begin{aligned}\beta_{N^*B^*}&=\frac{1}{\sqrt{2}}((\sin\phi T+\cos\phi B)+N)\\&=\frac{1}{\sqrt{2}}(\sin\varphi\xi+\cos\varphi(-\sin\varphi\eta+\cos\varphi\zeta)+(\cos\varphi\eta+\sin\varphi\zeta))\\&=\frac{1}{\sqrt{2}}(\sin\varphi\xi-(\sin\varphi\cos\varphi+\cos\varphi)\eta+(\sin\varphi+\cos\varphi)\zeta\end{aligned} \tag{18}$$

In actually, we reached our purpose for finding above equation (18), but if we want to find the invariants of N^*B^* – Smarandache curve $\beta_{N^*B^*}$ of Mannheim pair curves obtaining in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α of the N^*B^* – Smarandache curve $\beta_{N^*B^*}$, then we obtain following equality.

$$\begin{aligned}\beta'_{N^*B^*}&=\frac{1}{\sqrt{2}}(\varphi'\cos\varphi\xi+\sin\varphi\xi'+\varphi'\sin^2\varphi\eta+\varphi'\cos^2\varphi\eta+(\sin\varphi\cos\varphi+\cos\varphi)\eta' \\&+\cos\varphi\zeta-\sin\varphi\zeta+(\sin\varphi+\cos\varphi)\zeta'),\\&=\frac{1}{\sqrt{2}}(\varphi'\cos\varphi\xi+\kappa\sin\varphi N+\varphi'\sin^2\varphi\eta+\varphi'\cos^2\varphi\eta+(\sin\varphi\cos\varphi+\cos\varphi)(-c\xi+a\zeta)\\&+\cos\varphi\zeta-\sin\varphi\zeta+(\sin\varphi+\cos\varphi)(b\xi-a\eta.)),\\&=\frac{1}{\sqrt{2}}(\varphi'\cos\varphi\xi+\kappa\sin\varphi(\cos\varphi\eta+\sin\varphi\zeta)+\varphi'\sin^2\varphi\eta+\varphi'\cos^2\varphi\eta\\&+(\sin\varphi\cos\varphi+\cos\varphi)((\varphi'+\tau)\zeta)+\cos\varphi\zeta-\sin\varphi\zeta+(\sin\varphi+\cos\varphi)(-(\varphi'+\tau)\eta.)),\\&=\frac{1}{\sqrt{2}}((\varphi'\cos\varphi-\kappa\sin\varphi\cos^2\varphi-\kappa\cos^2\varphi-\kappa\sin^2\varphi-\kappa\sin\varphi\cos\varphi)\xi\\&+(\kappa\sin\varphi\cos\varphi+\varphi'\sin^2\varphi+\varphi'\cos^2\varphi-\varphi'\sin\varphi-\varphi'\cos\varphi-\tau\sin\varphi-\tau\cos\varphi)\eta\\&(\kappa\sin^2\varphi+\tau\sin\varphi\cos\varphi+\tau\cos\varphi+\cos\varphi-\sin\varphi)\zeta.\end{aligned} \tag{19}$$

Similarly, by taking the 2nd and 3rd derivatives and computing Frenet vector fields, curvatures of this obtaining N^*B^* – Smarandache curve $\beta_{N^*B^*}$ of Mannheim partner curve in terms of the Frenet vector fields which belong to the curve-surface pair of the curve α can be calculated by using the necessary formulas from (1).

V. OBTAINING T^*B^* – SMARANDACHE CURVES WITH MANNHEIM PAIR IN TERMS OF FRENET VECTORS OF CURVE-SURFACE PAIR OF A CURVE

Definition 6 : (e.g. [12]) Let (α,α^*) be a Mannheim pair curves in E^3 and $\{T^*,N^*,B^*\}$ be the Frenet frame of Manheim partner curve α^* at $\alpha^*(s)$. T^*B^*-Smarandache curve is defined by following equation.

$$\beta_{T^*B^*}=\frac{1}{\sqrt{2}}(T^*+B^*). \tag{20}$$

By substituting T^* and B^* from (2.3), we obtain,

$$\begin{aligned}\beta_{T^*B^*}&=\frac{1}{\sqrt{2}}((\cos\phi T-\sin\phi B)+N),\\&=\frac{1}{\sqrt{2}}(\cos\varphi\xi+(\sin\varphi(-\sin\varphi\eta+\cos\varphi\zeta))+(\cos\varphi\eta+\sin\varphi\zeta)),\\&=\frac{1}{\sqrt{2}}(\cos\varphi\xi+(-\sin^2\varphi+\cos\varphi)\eta+(\sin\varphi\cos\varphi+\sin\varphi)\zeta.\end{aligned} \tag{21}$$

If we take the derivative of the T^*B^* – Smarandache curve $\beta_{T^*B^*}$, then we obtain following equality.

$$\begin{aligned}\beta'_{T^*N^*}&=\frac{1}{\sqrt{2}}(-\varphi'\sin\varphi\xi+\cos\varphi\xi'-2\varphi'\cos\varphi\sin\varphi\eta-\varphi'\sin\varphi\eta+(-\sin^2\varphi+\cos\varphi)\eta'\\&+\varphi'\cos^2\varphi\zeta-\varphi'\sin^2\varphi\zeta+(\sin\varphi\cos\varphi+\sin\varphi)\zeta'),\\&=\frac{1}{\sqrt{2}}(-\varphi'\sin\varphi\xi+\kappa\cos\varphi N-2\varphi'\cos\varphi\sin\varphi\eta-\varphi'\sin\varphi\eta+(-\sin^2\varphi+\cos\varphi)(-c\xi+a\zeta)\\&+\varphi'\cos^2\varphi\zeta-\varphi'\sin^2\varphi\zeta+(\sin\varphi\cos\varphi+\sin\varphi)(b\xi-a\eta)),\\&=\frac{1}{\sqrt{2}}(-\varphi'\sin\varphi\xi+\kappa\cos\varphi(\cos\varphi\eta+\sin\varphi\zeta)-2\varphi'\cos\varphi\sin\varphi\eta-\varphi'\sin\varphi\eta+(-\sin^2\varphi+\cos\varphi)(-\kappa\cos\varphi\xi+(\varphi'+\tau)\zeta)\\&+\varphi'\cos^2\varphi\zeta-\varphi'\sin^2\varphi\zeta+(\sin\varphi\cos\varphi+\sin\varphi)(-\kappa\sin\varphi\xi-(\varphi'+\tau)\eta)),\\&=\frac{1}{\sqrt{2}}((-\varphi'\sin\varphi+\kappa\sin^2\varphi\cos\varphi-\kappa\sin^2\varphi\cos\varphi)\xi,\\&+(\kappa\cos^2\varphi-2\varphi'\cos\varphi\sin\varphi-\varphi'\sin\varphi-\varphi'\sin\varphi\cos\varphi-\varphi'\sin\varphi-\tau\sin\varphi\cos\varphi-\tau\sin\varphi)\eta\\&+(\kappa\cos\varphi\sin\varphi-\varphi'\sin^2\varphi+\varphi'\cos\varphi-\tau\sin^2\varphi+\tau\cos\varphi+\varphi'\cos^2\varphi-\varphi'\sin^2\varphi)\zeta,\\&=\frac{1}{\sqrt{2}}((-\varphi'\sin\varphi)\xi,+(\kappa\cos^2\varphi-3\varphi'\sin\varphi\cos\varphi-2\varphi'\sin\varphi-\tau\sin\varphi\cos\varphi-\tau\sin\varphi)\eta\\&+(\kappa\cos\varphi\sin\varphi-2\varphi'\sin^2\varphi+\varphi'\cos\varphi-\tau\sin^2\varphi+\tau\cos\varphi+\varphi'\cos^2\varphi)\zeta.\end{aligned} \tag{22}$$

By taking the 2nd and 3rd derivatives and computing Frenet vector fields, curvatures of this T^*B^*-Smarandache curve $\beta_{T^*B^*}$ is demonsrated in terms of from Frenet vector fields which belong to the curve-surface pair of the curve α can calculated by using the necessary formulas from (1).

VI. OBTAINING $T^*N^*B^*$ – SMARANDACHE CURVES OF MANNHEIM PAIR CURVES IN TERMS OF FRENET VECTORS OF CURVE-SURFACE PAIR OF A CURVE

Definition 7: (e.g. [12]) Let (α,α^*) be a Mannheim pair curves in E^3 and $\{T^*,N^*,B^*\}$ be the Frenet frame of Manheim partner curve α^* at $\alpha^*(s)$. $T^*N^*B^*-$Smarandache curve is defined by following equation.

$$\beta_{T^*N^*B^*}=\frac{1}{\sqrt{2}}(T^*+N^*+B^*). \tag{23}$$

By substituting N^* and B^* from (9), we obtain,

$$\begin{aligned}
\beta_{T^*N^*B^*}&=\frac{1}{\sqrt{2}}((\cos\phi T-\sin\phi B)+(\sin\phi T+\cos\phi B)+N),\\
&=\frac{1}{\sqrt{2}}((\sin+\cos\phi)T+N+(\cos\phi-\sin\phi)B)),\\
&=\frac{1}{\sqrt{2}}((\sin\varphi+\cos\varphi)\xi+(\cos\varphi\eta+\sin\varphi\zeta)+(\cos\varphi-\sin\varphi)(-\sin\varphi\eta+\cos\varphi\zeta)),\\
&=\frac{1}{\sqrt{2}}((\sin\varphi+\cos\varphi)\xi+(\cos\varphi-\sin\varphi\cos\varphi+\sin^2\varphi)\eta+(\sin\varphi+\cos^2\varphi-\sin\varphi\cos\varphi)\zeta)
\end{aligned} \tag{24}$$

If we take the derivative of the $T^*N^*B^*-$Smarandache curve $\beta_{T^*N^*B^*}$, then we obtain following equality.

$$\begin{aligned}
&\beta'_{T^*N^*B^*}=\frac{1}{\sqrt{2}}(\varphi'\cos\varphi-\varphi'\sin\varphi)\xi+(\sin\varphi+\cos\varphi)\xi'\\
&+(-\varphi'\sin\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi+2\varphi'\sin\varphi\cos\varphi)\eta+(\cos\varphi-\sin\varphi\cos\varphi+\sin^2\varphi)\eta'\\
&(\varphi'\cos\varphi-2\varphi'\sin\varphi\cos\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi)\zeta+(\sin\varphi+\cos^2\varphi-\sin\varphi\cos\varphi)\zeta',\\
&==\frac{1}{\sqrt{2}}(\varphi'\cos\varphi-\varphi'\sin\varphi)\xi+\kappa(\sin\varphi+\cos\varphi)N\\
&+(-\varphi'\sin\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi+2\varphi'\sin\varphi\cos\varphi)\eta+(\cos\varphi-\sin\varphi\cos\varphi+\sin^2\varphi)(-c\xi+a\zeta)\\
&(\varphi'\cos\varphi-2\varphi'\sin\varphi\cos\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi)\zeta+(\sin\varphi+\cos^2\varphi-\sin\varphi\cos\varphi)(b\xi-a\eta.),\\
&=\frac{1}{\sqrt{2}}((\varphi'\cos\varphi-\varphi'\sin\varphi)\xi+\kappa(\sin\varphi+\cos\varphi)(\cos\varphi\eta+\sin\varphi\zeta)\\
&+(-\varphi'\sin\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi+2\varphi'\sin\varphi\cos\varphi)\eta+(\cos\varphi-\sin\varphi\cos\varphi+\sin^2\varphi)(-\kappa\cos\varphi\xi+(\varphi'+\tau)\zeta)\\
&(\varphi'\cos\varphi-2\varphi'\sin\varphi\cos\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi)\zeta+(\sin\varphi+\cos^2\varphi-\sin\varphi\cos\varphi)(-\kappa\sin\varphi\xi-(\varphi'+\tau)\eta),\\
&=\frac{1}{\sqrt{2}}((\varphi'\cos\varphi-\varphi'\sin\varphi-\kappa\cos^2\varphi+\kappa\sin\varphi\cos^2\varphi-\kappa\sin^2\varphi\cos\varphi-\kappa\sin^2\varphi-\kappa\sin\varphi\cos^2\varphi-\kappa\sin^2\varphi\cos\varphi)\xi\\
&+(\kappa\sin\varphi\cos\varphi+\kappa\cos^2\varphi-\varphi'\sin\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi+2\varphi'\sin\varphi\cos\\
&-\varphi'\sin\varphi-\varphi'\cos^2\varphi+\varphi'\sin\varphi\cos\varphi-\tau\sin\varphi-\tau\cos^2\varphi+\tau\sin\varphi\cos\varphi))\eta\\
&+(\kappa\sin^2\varphi+\kappa\cos\varphi\sin\varphi+\varphi'\cos\varphi-\varphi'\sin\varphi\cos\varphi+\varphi'\sin^2\varphi+\tau\cos\varphi\\
&-\tau\sin\varphi\cos\varphi+\tau\sin^2\varphi+\varphi'\cos\varphi-2\varphi'\sin\varphi\cos\varphi-\varphi'\cos^2\varphi+\varphi'\sin^2\varphi)\zeta
\end{aligned} \tag{25}$$

Similarly, by taking the 2nd and 3rd derivatives and computing Frenet vector fields, curvatures of this $T^*N^*B^*-$Smarandache curve $\beta_{T^*N^*B^*}$ Manheim Curve Couple according to the Frenet vectors of the partner curve of Manheim curve are taken as the position vectors in terms of Frenet vectors of the curve-surface pair (α,M) of the curve α can be calculated by using the necessary formulas from the equality (1).

VII. CONCLUSION

In this paper we obtain the Smarandache Curves of Manheim Curve Couple according to the Frenet vectors taken as the position vectors in terms of Frenet vectors of the curve-surface pair (α, M) in Euclidean 3-space.

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THE VILLAGE OF VITHKUQ, A BIZANTINE SETTLEMENT

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Abstract - The village of Vithkuq, is situated in South Albania. Nowadays, there remain few churches, and some dozen of houses. Although there are many ruins, the picturesque village seems very important in the past historical archives, and monuments of culture. To understand these layers of culture is quite important and it can be possible to study the layers in order to preserve the remaining heritage and also to create a link with the past in an adequate way. Also, it is important to think of sustainable tourism. Another issue, which can be of importance is to improve the settlement also by acupuncture interventions. The study focuses on the historical monuments, including churches and byzantine settlements, typology of houses, etc. Another issue of importance is the role of agritourism in improving the economic condition of the village. This study proposes a methodology for improvement of the village conditions, and possible business for its inhabitants. Also, its important to mention the Monasteries of Saint Peter and Saint Paul, which are at the hill of the village of Vithkuq were built on the ruins of pagan temple. The mixture of byzantine architecture and traditional materials need further observation and attention. Although before XVIII there are no documents, which can provide a clear understanding of creation of the settlement, this is not a village that has started in that period. There were at about 20 churches in Vithkuq, many of which were completed with elaborate work of stonemasons, masters, carpenters, byzantine fresco and painting artists and wood crafting. The study will focus on some of the most important shiny aspects of the Byzantine village of Vithkuq.

Keywords – Byzantine settlement, monuments, regeneration, local material, traditional architecture

I. INTRODUCTION

About 26 kilometers distant from Korce, in the vicinity of the same-named mountains, lies the mountain settlement of Vithkuqi. We are attempting to emphasize some of the relationships in the domains of economy, society, and culture between the two medieval centers, Vithkuqi and Voskopoja, based on a variety of sources. Chronologically, the first reference about the settlement of Vithkuqi dates at the Byzantine period, and it must be an integral development together with Moschopolis. (Rembeci, Çunga,, 2019)

Over the course of hundreds of years, these two communities nearly assume the characteristics of a binomial, experiencing nearly identical situations and nearly identical variables up till the loss of municipal physiognomy. Cities having a large population, referred to as "politie" in this context include Voskopoja and Vithkuqi. Additionally, it seems from their material and spiritual cultures that these two places, particularly in the 18th century, reached a good level of economic and cultural growth. Residential architecture, cult constructions and decorations with artistic value, intellectual movement along with the rapid development of crafts and trade, items that were preferred even beyond the sea. As social and

economic groups of professionals, dealers, and artisans, guilds have long been significant in Vithkuq and Voskopoja. Despite being practically the same distance apart geographically, they have grown commerce with Korça as well as with each other. They had markets with many of stores and lodgings for the regional bazaars and the caravans that traveled between these regions, serving as important craft-commercial hubs. They sold groceries, cattle, and agricultural items during their weekly bazaars. The so-called "Albanian merchants" were able to expand their trade ties not only with major European and Balkan commercial hubs like Venice, but also with Shkodër, Durrës, Kostur, and Manastir as their economic dominance increased.

Located on a hill northeast of Vithkuq village lies the Monastery of Saint Peter and Saint Paul. It was constructed atop the remnants of an ancient temple that once housed a fort that is still standing. Dhionis Mantuka, the metropolitan of Kosturi, claims that a codex of St. Peter and St. Paul from the monastery was discovered in 1908. The codex bears the following inscription: Codex of the Holy Monastery of the Apostles in Vithkuq, given in 1739 from the birth of Christ by the humble Kostur metropolitan, Lord Krisanth. The codex states that the monastery was constructed between 1709 and 1710, 1736, and 1759 and 1764. In 1709, the monastery was established. Thanas Rimara, an archon, was the founder. In the third phase, which coincides with the years 1759-1764, the church of Saint Peter and Saint Paul was built. The church was built by master craftsman Gjike Lena and craftsmen Dhimo Dukasi, Hari Venetiku, Dine Krekasi, Merkur Saraqi, Zoto Lihasi, Bitri Maxhari, Vaso Sumbulla, Kule Deti and Pepo Rredhi. Of the monastery's buildings, only the church of St. Peter and St. Paul remains, because the inns of the monastery were destroyed during the Second World War.

Both of these churches are decorated with miraculous murals from the famous Albanian painters, the brothers Kostandin and Athanas Zografi. Their mural paintings can be really observed from 1744 until 1783, so for 24 years, according to Rozela Dhimgjini. (Dhimgjini, 2018)

The nave and portico in front of the main entrance make up the monastery church. With a dome, it is a three-sided basilica that is 16.10 by 10.50 meters in size. The monastery on the east side is closed by the church volume. Two rows separate the nave into three longitudinal naves, each with four columns. The eastward set of columns holds the iconostasis. The artists Kostandin and Athanas Zografi painted the chapel in 1764. The picture cost about 700 grosch, which the monastery's abbot, Tarasi, bought from Hungary. An inscription within the chapel above the northern entrance attests to the monastery's building date. It is critical to acknowledge Vithkuq's significance.

II. Materials and Method

The traditional houses in Vithkuq, are 2 stories with a balcony, they are built with material mainly stone (called çmërs, massively found in this village) and red marble stone. The roof was covered with black stone slabs, today tiles are used. The wood used is (beech, pine, fir, poplar and oak) found massively in this village. These were used in the construction of roofs, internal stairs and for laying floors, also wooden belts, mainly beech or oak, were placed as belts inside the walls of the house.

Today, few houses have preserved this style and construction method. After the 70s, the "L"-shaped 1-story style prevailed, but the materials have remained the same. The traditional apartment has 4 rooms, 2 corridors and 1 balcony in the middle. The rooms have dimensions of 4×4 m, while the corridors are 4×3 m, the ascent to the second floor is made through the stairs found in the corridor. The stairs are arched and the space created under the stairs is used as a warehouse.

Situated within a massive forest consisting of pine, fir, beech, and oak trees sits Vithkuq. Although there are other plants, "Vidhi i kuq" is the principal one, which is how this town received its name, Vithkuq. There is a wide variety of medicinal plants, including aspen, mountain tea, primrose, thistle, and others, among the abundant flora and wildlife.

There is no shortage of wild creatures, including bears, wolves, jackals, and endangered raccoons. Archaeological finds and three ancient forts (Leshnje, Roshanji, and Bellovode) attest to the fact that Vithkuqi was an Illyrian settlement that existed in the third and fourth century BC. The monastery of St. Peter, which was constructed on the remains of a pagan temple, also has the remnants of a fortress. Over the ages, the Vithkuqi people have seen many significant displacements. The first is believed to have occurred during the Ottoman invasion of the Balkans in 1390, during which the Vithkuqis and a few Permet households established the city of Kozan. The 17th and 18th centuries saw the height of Vithkuqi's growth, coinciding with the new neighbor Voskopoje. The route that went through the city of Berat and connected it to places like Voskopoja, Korca, and Ohrid was responsible for the growth of Vithkuqi; portions of this road are still standing today.

The trade of cattle products, dairy products, woollen goods, tapestries, and—most importantly—precious stones and multicolored marble, which are abundant in this region, employed some of the area's principal inhabitants.

“Ornament is Crime” would write Adolf Loos at the beginning of the 20 Century. (Loos, 1962) These quote so much misinterpreted during the modernist architecture, since the real value of architecture he was inspired was from the land of Schyros. Natural materials are really important for architecture and therefore it is important to observe the traditional materials.

Because clay is abundant in many forms, there is also no scarcity of ceramic goods. Based on the findings, it appears that the dwellings were covered with native tiles rather than stone slabs. Church roofs were the only structures made of slate. Medium-sized cobblestones, mostly red and white, are used to pave the roadways. The water could be drained because of the cobblestone's central slope.

Despite the abundance of resources, the topography prevents the city from having enough water supply, thus the locals coordinated the installation of public taps using stone canals and ceramic pipes (cork). Fejasi is the primary source and the one with the largest yearly flows. This source was used to build the first aqueduct in Albania, connecting the Italian Shaqeria to the city of Korce. In 1936, the first hydroelectric plant in Albania was constructed, providing energy to Vithkuq and Korce.

In a brief period of time, Vithkuqi as a city has seen three significant destructions. Refugee camps have been established both inside and outside the Balkans, reaching as far as Ukraine, after the huge migration.

The southern regions of Albania, including Himara, the Muzeqese region, and Korcen, were inhabited by a multitude of additional people. Only the Ura e Zotos, which is believed to have been constructed in the 17th century, has remained among the other ancient bridges that once stood in Vithkuqi. Although the toponyms of Vithkuq are unique, they are still in Slavic, a language from the time of the Bulgarian domination.

The cultural and economic development of Vithkuqi is inseparable from that of Moschopolis and that is why its Churches will be viewed as part of these in Moschopolis according to Ralitsa Rousseva. (Rousseva, 2011) The Monastery of St. Peter and St. Paul Church of silversmiths Kozma and Damian, Saint Thanasi 1162, is the oldest church in Vithkuqi, and it is still operational today. Since it was demolished under the communist government, it has been reconstructed today.

- Saint Nicholas Monastery
- Panagia Theotokos Church (Fig. 1)
- Evangelization Church
- Saint Constantine
- Church of Archangel Michael and Gabriel (Fig. 2)
- Saint Nicodemus
- Saint Paraskhevia
- Church of the prophet Ilia
- Saint George (Fig. 3)

- Saint Pandelimon (Fig. 5)

Fig. 1 Panagia Theotokos Church, (Source: Authors)

Fig. 2 Church of Archangel Michael and Gabriel, (Source: Authors)

Fig. 3 Church of St. George, (Source: Authors)

Fig. 4 of Monasteries of St. Peter and St. Paul, (Source: Authors)

Fig. 5 Church of St. Pandeleimonit, (Source: Authors)

III. RESULTS

Villages and cities coexist during a whole period of time. The arable land is very important as providing the city with food. Agriculture importance can not be neglected and is precisely the arable area that is important for the sustainable development of cities and territories.

Although something that looks natural for the Middle Ages, or preindustrial times or even early 20th century, it seems forgotten nowadays, and it is very important to understand that although technology can lead to easier work, it does not mean that it provides for more sustainability.

Man, and machine get closer and according to Le Corbusier “A house is a Machine for Living in”. (Le Corbusier, 1931) Thinking of a ubiquitous modernist settlement, can perhaps lead to urbanisation and losing of local values, as we know from late 20th century. A return to “traditional architecture” can it be seen as a more sustainable approach especially for peripherical areas.

Vithkuq is taken as a case study in regenerating the cultural monuments and byzantine churches, houses, tavernas, creating patterns of local or food production of vital importance for historical settlements. The village can be considered as a model for other case studies.

IV. DISCUSSION

The are several ways to regenerate the Vithkuq, and one of the main objectives is to return, the citizens and other tourists and to regenerate the village economically from one side but also to preserve the byzantine monuments and natural environment on the other side.

A. *Churches*

Revitalization of byzantine churches, needs to follow the restoration pattern, which includes the materials that the church needs according to byzantine canons, including restoration and usage of original materials, stone or brick, wood and painting of frescos. Frescos need also to be painted according to byzantine canons. What is important, is also lighting, libraries and other environments.

B. *Itineraries*

Itineraries of Vithkuq, could be revitalized by using the old itineraries and improving the paved or natural path in order to connect with destination points. Destination points could be agriculture or touristic destinations. Proper signalling, could be installing, with natural materials in order to let the tourists to the right destination. Also, it could be combined with agritourist or camping sites, including simple outdoor sheds which could be used for recreation and summer camping.

C. *Village street*

Village streets are the ones that can be restored according to traditional patterns and materials. If you take into consideration the cobble stones patterns and composition but also water channels and sidewalks. Restauration is important to be done with local materials.

D. *Houses*

Houses need to be improved with cheap and local materials. Preserving the typology, natural materials and traditional structure of the house is a primary strategy. In this regard, architects shall focus on the traditional characterises such balcony, roof, terraces, gardens, chardac or any other feature including passive heating and cooling.

E. *Tavernas*

Tavernas are characteristic of Korca in general where usually people go for eating or drinking. The specifics of tavernas are its interior, local materials, gardens and intimate interior space. Preserving local cuisine is also important.

F. *Transportation.*

Although Vithkuq is very close to Korca, it would be highly effective to establish a multiconnection, public transportation that includes minibuses, off-road cars, and horse ride tracks. Connections of to itineraries could be improved with alpine off-road cars.

V. CONCLUSION

One of the main issues, is to regenerate the village that it preserves the identity on one side but also to generate economic development, and add possibilityy for bringing more tourists in the region.

Another issue is to preserve the territorial resources which are in the area and its connection with Korca, in order to promote itineraries for sightseeing and landscape.

A general recommendation has to do with ways to improve the village of Vithkuq which from one side preserves the byzantine heritage, and on the other side it creates the options to regenerating the village in order to adapt it in creating a living village.

Some of the principles and recommendations are the following:

- Restoration of Byzantine Churches including buildings, Icons, and auxiliary buildings such as libraries, museums or pilgrimage rooms.
- Improving itineraries and village streets
- Preserving the characteristics of the village houses, typologies including materials, facades and traditional passive or active heating, cooling.
- Fostering and enriching tavernas and/or culinary, vineyard traditions.
- Improving transportation, off-road transportation and alpine itinerates.

Regeneration of the village of the byzantine village of Vithkuq can become a model for regeneration of other villages in Korca or similar areas.

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Soil Relationship of Some Macrophyte Communities in Karakuyu reeds (Afyonkarahisar-Turkey)

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Abstract – Karakuyu Marshes are located in the upstream of the Büyük Menderes River upper basin, within the borders of Dinar district of Afyonkarahisar province, and are also known as "Karakuyu Lake", "Çapalı Lake" and "İncesu Lake". The lake, which is connected to the Burdur Basin in the south, the Uluborlu Plain in the east and the Büyük Menderes Basin in the west, has the coordinates of 38° 15. north, 30° 52. east and an altitude of 950 m. The study area is located within the borders of Afyonkarahisar province in the Aegean Region Inner Western Anatolia and is located within the B3 square according to the quadrature system determined by Davis (1965-1988). The region has a "semi-arid Mediterranean Bioclimate" and an "Eastern Mediterranean type" rainfall regime. In the region, there are mostly Alluvial Soils, Hydromorphic Alluvial Soils, Colluvial and Brown Large Soil groups and reeds-swamps as land types. The majority of the research area is covered by Quaternary land. Nearly 100 vascular plants were identified in the study area located within the Iran-Turan floristic region. "Flora of Turkey and the Eastern Aegean Islands", "List of Plants of Turkey (Vascular Plants)", (Flora of Turkey (Vascular Plants) Checklist)" and Afyon Kocatepe University herbarium (AKÜ) were also used to identify the plants. According to Braun-Blanquet (1932), 6 plant communities were identified in the research area. These are *Phragmites australis* (Cav.) Trin. ex Steud., *Eleocharis palustris* (L.) Roem. & Schult., *Schoenoplectus litoralis*(Schrader) Palla, *Schoenoplectus lacustris* (L.) Palla, *Typha latifolia* L., *Typha angustifolia* L. To carry out the research, plant communities along with their soils were collected, analyzed and evaluated. In order to find out the relationship between these plant communities, soil samples taken from 0-30 and 30-60 cm depths and their physical-chemical analyzes were determined primarily by soil structure, pH, salt, lime and organic matter, determined by the Ankara Soil Fertilizer and Water Resources Central Research Institute. It was interpreted according to the methods.

Keywords – Karakuyu Reeds and marshlands (Afyonkarahisar), aquatic macrophytes, aquatic macrophytes and soil features, coastal ecosystem

I. INTRODUCTION

Karakuyu Marshes are located in the upstream of the Büyük Menderes River upper basin, within the borders of Dinar district of Afyonkarahisar province, and are also known as "Karakuyu Lake", "Çapalı Lake" and "İncesu Lake". The lake, which is connected to the Burdur Basin in the south, the Uluborlu Plain in the east and the Büyük Menderes Basin in the west, has the coordinates of 38° 15. north, 30° 52. east and an altitude of 950 m. The study area is located within the borders of Afyonkarahisar Province, in Mid-Western Anatolia, Aegean Region, and falls into B3 square according to the gryd system (Fig. 1). So far, Afyonkarahisar's close near, Sultan Mountains [1], Köroğlubeli Vegetation [2], Vegetation of Afyon Başkomutan Historic National Park [3], Akdağ Flora and Vegetation [4], Türkiye Geothermal Inventory [5], Akarçay Basin Hydrogeology [6], The Steppe Vegetation of Emir Mountain [7], Kumalar Mountain Flora [8], Ahır Mountain Flora [9], Emir Mountain Northern half of Flora [10], Emir Mountains South

Half Flora [11], [12], Eber Lake (Afyonkarahisar) Flora [13], Evaluation of Eber Lake (Afyonkarahisar) Macrophytes in Terms of Restoration Ecology [14], and so on, have been found in such studies.

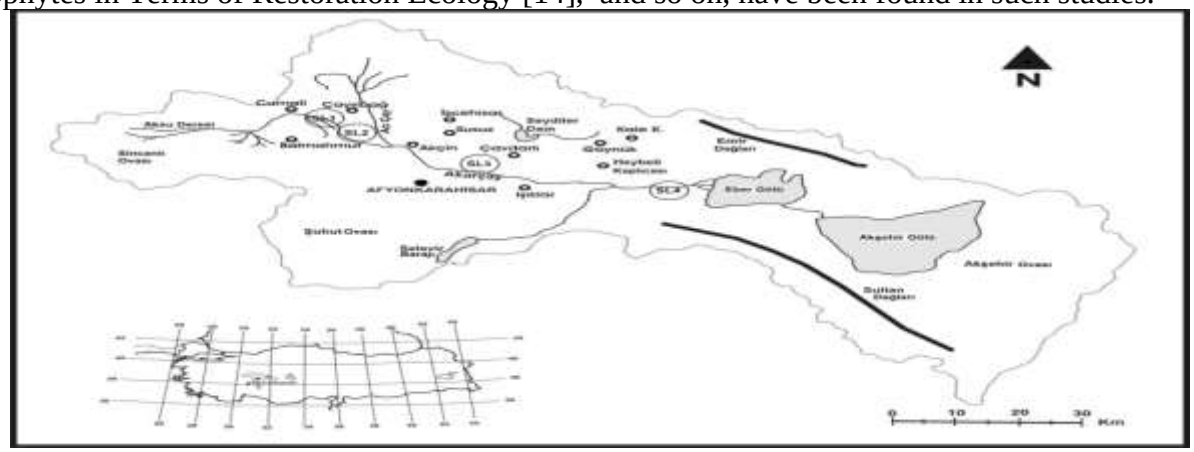

Fig. 1 Study area

II. Materials and Method

Nearly 100 vascular plants were identified in the study site, situated in the Irano-Turanian floristic region. Identification of the plants was based on "Flora of Turkey and the East Aegean Islands" [15]-[17] and "Türkiye Bitkileri Listesi (Damarlı Bitkiler)" (A checklist of the Flora of Turkey (Vascular Plants))" [18], and the herbarium of Afyon Kocatepe Üniversitesi (AKÜ) was also utilized. Most of the study area is covered by Quaternary lands. Bioclimate of the area is a combination of semi-arid - cold Mediterranean climates. The precipitation regime shows the characteristic of eastern Mediterranean. Most of the study area has alluvial soils, hydromorphic alluvial soils, colluvial soils, brown soils with reeds-marshs of land type. Floristic region of the area is a Irano-Turanian type and about 100 vascular plant types have been identified. 6 plant communities are identified regarding to [19] in the research area. These are *Phragmites australis* (Cav.) Trin. ex Steud., *Eleocharis palustris* (L.) Roem. & Schult., *Schoenoplectus litoralis*(Schrader) Palla, *Schoenoplectus lacustris* (L.) Palla, *Typha latifolia* L., *Typha angustifolia* L.

Table 1. Analysis of the soil results

Plant Com. Num.	Depth cm	Water Saturation	Texture Class	EC ds/m	Total Salt %	Water Saturation at Soil pH	Organic Matter %	Phosphorus (P_2O_5) Kg/da	Potassium (K_2O) Kg/da	Lime $CaCO_3$ %
1	0-30	155	C	17,41	1,24	7,6	13,23	12,45	133,43	26,22
1	0-60	159	C	17,82	1,28	7,5	15,41	17,56	128,55	25,94
2	0-30	177	C	9,16	0,55	7,4	12,88	8,91	144,38	30,21
2	0-60	171	C	10,32	0,69	7,9	14,61	9,89	129,71	29,36
3	0-30	168	C	8,64	0,32	7,8	14,44	19,65	144,65	27,48
3	0-60	162	C	10,10	0,50	7,7	16,22	22,91	167,33	26,29
4	0-30	167	C	5,72	0,29	7,3	14,51	14,36	198,42	25,89
4	0-60	188	C	5,86	0,30	7,6	13,65	18,82	187,67	26,73
5	0-30	181	C	15,43	0,70	7,8	13,72	14,16	192,56	28,47
5	0-60	175	C	15,80	0,89	7,1	12,97	13,03	182,32	29,92
6	0-30	169	C	18,70	1,32	7,2	15,49	26,64	176,29	26,55
6	0-60	171	C	19,61	1,54	7,4	16,51	23,49	164,99	30,25

[1] *Phragmites australis*, [2] *Eleocharis palustris*, [3] *Schoenoplectus litoralis*, [4] *Schoenoplectus lacustris*, [5] *Typha latifolia*, [6] *Typha angustifolia*

III. RESULTS

To find the relation of the plant community with soils, 12 soil examples which have a high capability of representation were taken from the deepness of 0-30 and 0-60 cms and their physical and chemical analysis were done in Ankara Toprak Gübre ve Su Kaynakları Merkez Araştırma Enstitüsü (Ankara Soil Fertilizer and Water Resources Central Research Institute) laboratories according to the methods determined by Reference [20] (Table 1). The area has “Mediterranean Bioclimate with low precipitation”. “Eastern Mediterranean type” precipitation is recorded in the area [21], [22]. To reflect the climate values of the region, a climate diagram was drawn for the nearest meteorological stations, Dinar (Afyonkarahisar) [23]- [25] (Fig. 2). If the climate data of Dinar (Afyonkarahisar) meteorological station is applied to the climate classification formula of Reference [26], Dinar (Afyonkarahisar) show a "semi-arid, cold Mediterranean bioclimate" [27].

It mostly contains the major soil types as alluvial soils, hydromorphic alluvial soils, colluvial soils, and brown soils [28]. Nearly 100 vascular plants were identified in the study site, situated in the Irano-Turanian floristic region.

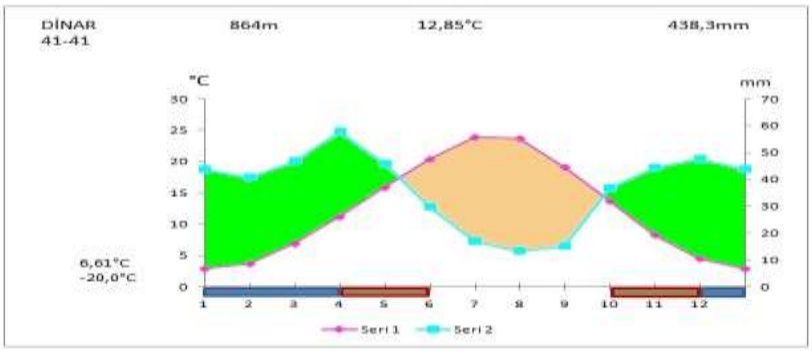

Fig 2. Walter climate diagrame

IV. DISCUSSION

To accomplish the research the communities of plant have been pulled up with their soil and the analysed and evaluated. To find the relationship with this plant communities 0-30 and 30-60 cm soil samples retrieved from the depths and their physical (In percent clay, silt, sand, texture, water saturation, field capacity, wilting point) - chemical [cations (Me/100 gr), anions (Me/100 gr), pH, $CaCO_3$ %, total salt %, EC, organic matter %, changable Na (Me/100 gr), changable K (Me/100 gr), SAR (Me/100 gr), B ppm] analyses and commented. According to the findings, the results vary as follow. In the group, cover of the vegetation is 50 %- % 90 and the number of species in the group is about 6-10. In the group’s study field, Hydromorpic Alluvial exist in the soils. Soils are in clayey structure. The soil samples taken from the group are slightly salty to very salty, highly calcareous, organic material in the samples are high and phosphorus in the samples vary from moderate to very high with too much level of potassium. Soils are characterised by very slightly alkali with respect to pH.

V. CONCLUSION

In this study, the relationship of 6 plant communities with soil taken from depths of 0-30 and 30-60 cm was investigated. It is very important to have information about the ecology of these plant communities found in various places, especially about soil properties. Reaching the results of the same ecological conditions in nature without analysis constitutes the essence of the research. Similar studies to be conducted in the future will contribute to plant ecology.

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Effect of the integration of EVCS on the distribution network parameters in the presence of DGs

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Abstract – Recently, the scarcity of traditional fossil fuels alongside the rising greenhouse gas emissions has driven a shift from conventional gasoline-powered vehicles to electric vehicles (EV). Breakthroughs in renewable energy technologies have significantly enhanced the practicality of EVs, resulting in their widespread acceptance on a global scale. Nevertheless, the rapid expansion of EVs has posed challenges such as inadequate charging infrastructure, uneven availability, high expenses, and limited charging points, which have become increasingly obstacles.

Despite these hurdles, a growing number of public electric vehicle charging stations (EVCS) are being installed as more people embrace EVs. Ongoing research is concentrated on pinpointing the most suitable sites for EVCSs to promote the electrification of transportation systems and address the mounting demand for EVs. This review delves into various optimization strategies considering the impact of EV charging loads on the distribution system (DS), environmental consequences, and economic implications.

By analysing ten different scenarios using a standard IEEE 33-bus radial distribution system (RDS) , the study aims to present the individual and combined benefits of identifying optimal locations for integrating EV charging stations in the presence of different renewable energy sources in order to mitigate the impact of EVCS on the RDS

Keywords – radial distribution system- Electrical vehicles- electric vehicle charging stations- renewable energy- power loss profile

I. INTRODUCTION

In the modern era, the emergence of alternative energy sources and their widespread adoption has received great attention around the world, and this is reflected in the increasing popularity of electric cars [1], as EVs play a decisive role in the shift towards environmentally friendly renewable sources and offer a potential solution to get rid of the concerns associated with dependence on energy sources. Traditional such as fossil fuels [2] , and recent years have witnessed a noticeable increase in demand for electric vehicles, and this is due to their ability to reduce greenhouse gas emissions compared to internal combustion engines [3]. Also, compared to traditional diesel engines, electric vehicles are characterized by lower fuel and operating costs [4]. By the end of 2024, the global electric vehicle market is expected to be worth 623.3 $ billion. Looking ahead, the market is expected to grow at a CAGR (Compound Annual Growth Rate 2024-2028) of 9.82%, eventually leading to a projected market size of 906.7$ billion by 2028. In addition, electric vehicle sales are expected to reach 17.07 million units by 2028.

Looking at the market in 2024, the volume-weighted average price of the EV market is expected to be US 52.9$ k. From an international perspective, it is clear that China will generate the highest revenue, which is expected to reach US319,000$ million in 2024. This demonstrates the significant presence of the EV market in the Chinese market segment. On the other hand, EV adoption is growing rapidly across the globe, with countries such as Norway leading the way in terms of market share. [5] Some studies indicate that by 2030, electric vehicles could contribute to reducing carbon dioxide emissions into the atmosphere by 28% [6].

The accelerated trend in relying on EVs has led to a collision with two basic factors that could affect the expansion process in this field, which are the high costs of electric vehicles, especially in terms of the primary resources used in producing storage batteries [7], and secondly, the lack of infrastructure, represented by charging stations EVCS is sufficient in residential areas [1].

The Integrating EVCS into the electrical distribution network poses many challenges in light of the increasing demand for EVs and the resulting steady and unexpected increase in demand for energy at peak times. This leads to a number of technical problems facing operators of current distribution systems, such as overstraining traditional power production stations. And transformers, imbalances in power distribution, increased energy losses, as well as imbalance in the voltage profile, all of these negative effects affect the dynamics of the RDS network's work. Here the importance of optimal connectivity of EVCS stations in RDS is evident as a focal point in this research [8] and here scientists propose integrating renewable energy production stations. DG in the distribution network as a potential solution [9] and as a support element in light of the great pressure in energy demand. This integration of DG addresses the increasing demand for energy at peak times and also reduces the carbon footprint associated with EV charging [1] and lays the foundations for a cleaner and more sustainable environmental system, which also stimulates the continued development of renewable energy technologies.

The main work in this paper focuses on the importance of optimal connection of EVCS charging systems in the IEEE 33 RDS distribution network in G2V operating mode, as well as determining the optimal location and sizing for connecting DG renewable energy generation systems in RDS in order to reduce active power loss and improve the voltage profile, as The distribution network was divided into three regions to enable consumers' access to EVCS charging stations and ensure the establishment of a highly reliable energy system.

II. Materials and Method

A. Level-1 Problem formulation

The widespread proliferation of Electric Vehicle Charging Stations (EVCS) resulting from the growing adoption of electric vehicles can exert a notable influence on the Distribution Grid System (RDS). This influence is particularly pronounced due to the haphazard and inappropriate installation of these stations, which results in heightened power dissipation, voltage instability, and a considerable additional burden on the distribution system. To mitigate these technical challenges, Distributed Generation (DG) equipment has been incorporated as a means of counterbalancing the effects of integrating EV charging stations (EVCS) into the RDS to mitigate power dissipation and optimize the voltage profile. Consequently, the primary aim of this study is to underscore the ramifications and significance of optimizing the placement of EVCS charging stations in the presence of DG plants within the distribution network.

B. Level-2 Mathematical modelling of power flow analysis in radial distribution networks.

B.1- power flow analysis

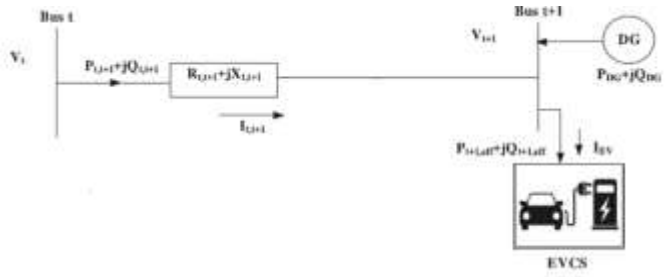

Fig. 1 Single line of RDS with DG and EVCS

the typical power flow analysis methods are inadequate for accurately analyzing line flows and voltages within RDS. To resolve this issue, the study used the DLF approach to evaluate power losses and voltage values at each system branch [10],The simplicity, speed, and less memory requirement for processing One of the most important advantages of this method, as well as the computational and robust convergence in the RDS solution, are the essential features of this power flow analysis resulting in a more exact assessment of power distribution within the system. Fig.1 depicts the sample distribution system with proposed method .The voltage magnitude at node t+1 can be calculated using the following equation.

$$V_{t+1} = V_t - I(R_{t,t+1} + jX_{t,t+1}) \quad (1)$$

The voltage at node t+1 is represented by V_{t+1}, while the voltage at node t is represented by V_t. The reactance and resistance of the connection between nodes t and t+1 are denoted $X_{t,t+1}$ respectively and $R_{t,t+1}$, respectively.

The division current I is determined as:

$$I = [BIBC][\mathrm{i}] \quad (2)$$

where *BIBC* indicated the Bus Current Injection to Branch Current matrix.

$$i_{t+1} = \frac{\left(P_{t+1} + jQ_{t+1}\right)^*}{V_t} \quad (3)$$

The third equation articulates the real and reactive power consumption at node t+1, denoted as Q_{t+1} and P_{t+1} respectively, along with the electrical current injected at node t+1, symbolized as i_{t+1}.

The following equations (4) and (5) are used to determine the actual and reactive power losses in a system, as given below.

$$P_{loss}(t,t+1) = \left(\frac{P_{(t,t+1)}^2 + Q_{(t,t+1)}^2}{|V_t|^2} \right).R_{(t,t+1)} \quad (4)$$

$$Q_{loss}(t,t+1) = \left(\frac{P_{(t,t+1)}^2 + Q_{(t,t+1)}^2}{|V_t|^2} \right).\mathrm{X}_{(t,t+1)} \quad (5)$$

The real and imaginary power flows between t and t+1 are represented by $P_{t,t+1}$ & $Q_{t,t+1}$, respectively.

the sum of branch power losses provides a comprehensive measure of the total losses of the system It is calculated using the following expression:

$$P_{T,loss} = \sum_{t=1}^{n} P_{loss}(t, t+1) \quad (6)$$

where n is the number of branches.

B.2- *Modelling of EVCS*

EVCS add an additional electrical requirement to the RDS. To calculate the overall RDS load, taking into account the integration of EVCSs, the total load can be determined using Equation (7)

$$P_{load} = \sum_{t=1}^{n} P_{avil,t+1} + P_{EVCS,t+1} \quad (7)$$

Within the given context, P_{load} signifies the total load present in the system. $P_{avil,t+1}$ denotes the existing load at time t+1, whereas $P_{\mathrm{EVCS},t+1}$ indicates the load generated by electric vehicle charging stations linked to the same power bus. The necessary data for determining the energy demand for charging EVCS is drawn from reference [1]. The energy needed for recharging the batteries is calculated through the utilization of equations (8). Following sections will detail the different models for electric vehicle charging stations.

$$P_{\mathrm{EVCS},t+1} = n.B_c.S_c \quad (8)$$

Where n represent The number of electric vehicles EVs, Bc is the Battery rating in kWh. and Sc represent the Desired charging amount specified as state of charge. The total consumed by the electric car during the charging process at each station is 966 kW, for a total of 2898 kW.[1]

B.3- *Modelling of EVCS*

Deploying distributed energy resources (DERs) like renewable energy units and identifying their optimal placement within the distribution grid delivers multiple advantages. These benefits encompass reductions in energy wastage, enhancements to voltage stability, and increased overall profits, particularly in the context of electric vehicle charging stations. To specify actual and reactive power flow when integrating DERs at bus i+1, we can define it as:

$$P_{loss}(\mathrm{t}, \mathrm{t}+1) = \left(\frac{P_{t+1}^2 + Q_{t+1}^2}{|V_{t+1}|^2} \right) R_{\mathrm{t},\mathrm{t}+1} + \left(\frac{P_{DG}^2 - 2P_{t+1}P_{DG}}{|V_{t+1}|^2} \right) R_{\mathrm{t},\mathrm{t}+1} + \left(\frac{Q_{DG}^2 - 2Q_{t+1}Q_{DG}}{|V_{t+1}|^2} \right) .R_{\mathrm{t},\mathrm{t}+1} \quad (9)$$

III. RESULTS

The load and line parameters are obtained from the authoritative source [11], specifically for the IEEE 33-bus system as shown in Figure 2. Within this system, the active and reactive power requirements are quantified at 3.72 MW and 2.3 MVAR, correspondingly, while the line voltage registers at 12.66 kV. The inherent power losses in the system, devoid of any compensation, are computed at 210.98 kW utilizing the RDS methodology. To delineate the fundamental bus voltages and power allocation across the network lines in the test setup, we utilize the direct approach distribution load flow technique expounded in reference [10].

This work was divided into three scenarios to study the impact of the combination of EVCS and DG on the distribution system:

Scenario 1: in the normal case without the integration of EVCS and DG.

Scenario 2: In the presence of 3 EVCS, they were randomly assigned in to the RDS (G2V)

Scenario 3: in the presence of 3 EVCS and their integration into optimal locations in to the RDS (G2V)

Scenario 4: With EVCS & 1DG (Only Solar)

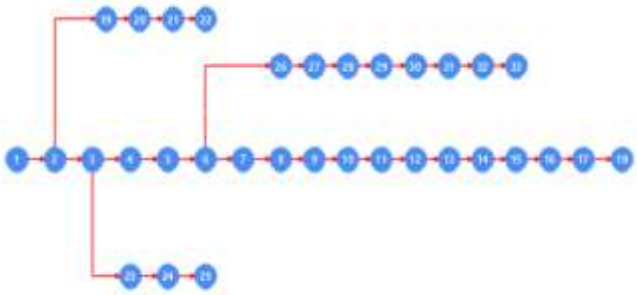

Fig. 2 IEEE 33-bus test system.

Table 1. Performance of the IEEE 33 bus system in a variety of scenarios.

Scenarios	Vmin(p.u)	Ploss (KW)	Qloss (KVAR)	EVCS location	DG location And size (KW)
Scenario 1	0.9038	210.9897	143.13	-	-
Scenario 2	0.7919	995.1125	693.4556	966 (9)	-
				966 (18)	
				966 (32)	
Scenario 3	0.8960	266.4862	169.2299	966 (2)	-
				966 (19)	
				966 (23)	
Scenario 4	0.9401	138.8424	94.1804	966 (2)	2100 (6)
				966 (19)	
				966 (23)	

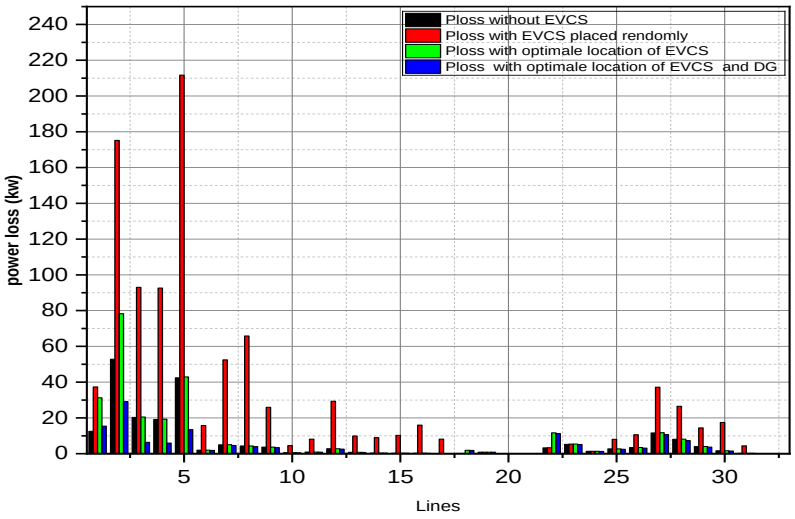

Fig. 3 Comparison of the real values of the power losses with the different scenarios in each branch.

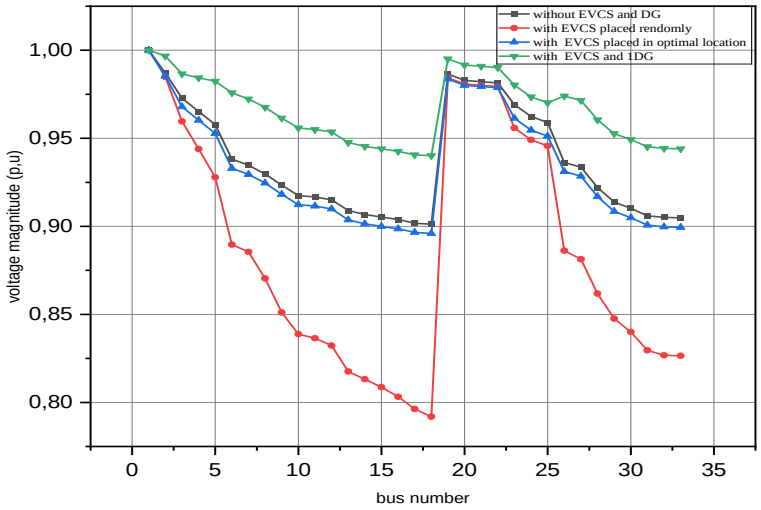

Fig. 4 Comparison of voltage profile results for IEEE 33 bus system with different scenarios.

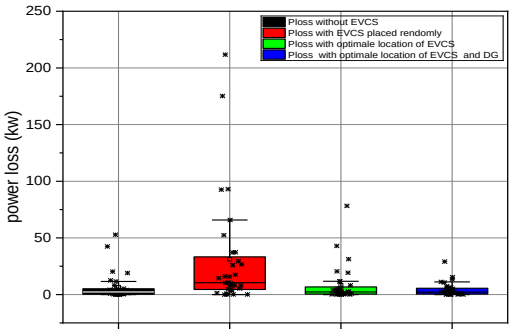

Fig. 5 Box plot of real power loss with scenario.

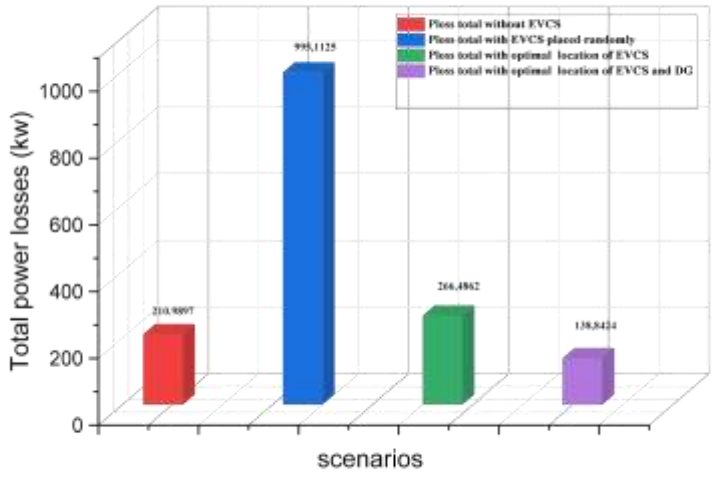

Fig. 6 Comparison of the real values of the total power losses with the different scenarios in each branch.

IV. DISCUSSION

Scenario 1: *without the integration of EVCS and DG.*

The Power flow analysis was performed for RDS in the absence of EVCS and DG, where the active and reactive power loss values were 210.98 KW and 143.1382 KVAR, respectively. The lowest voltage value was determined as 0.903741 (p.u) in JB 18, as shown in Table 1.

Scenario 2:

The 3 EVCS were randomly integrated into the RDS in G2V mode with a additional total load of 2898 KW. This led to an increase in the value of active and reactive power losses to 995.1325 KW and 693.4556 KVAR respectively as shown in Figure 6, in addition to a voltage value of Vmin = 0.7919 (p.u) in Bus 18 as shown in Table 1 and in Figure 4.

Scenario 3:

The 3 EVCS were connected to the RDS distribution network, and was determined the optimal location to integrate these stations, which was on the following buses [2/19/23] as shown in Figure 7, where the value of active and reactive power losses reached 266.4821 KW and 169.2299 KVAR , respectively, an increase of 20.82406% over scenario 1. A decrease of 73.2214% compared to scenario 2, as shown in Figures 5 and 6, with a value of Vmin = 0.8960 (p.u), as shown in Figure 4, All results for this scenario are shown in Table 1.

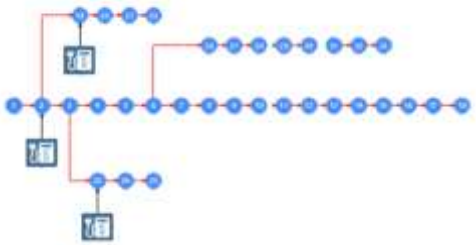

Fig. 7 Diagram line of the 33 bus system with the optimal location of the three EVCS

Scenario 4:

In this scenario, an energy production station (photovoltaic) with a production capacity of 2.1 MW was integrated in its optimal location, (bus 6), as shown in Figure 8, with 3 EVCS connected strategically, as shown in scenario 3.

Where the value of active and reactive power losses reached 138.8424 KW and 94.1804 KVAR, respectively, an decrease of 34.1917% over scenario 1. And decrease of 47.898% compared to scenario 3,

as shown in Figures 5 and 6, and with a value of Vmin = 0.9401(p.u), as shown in Figure 4, All results for this scenario are shown in Table 1.

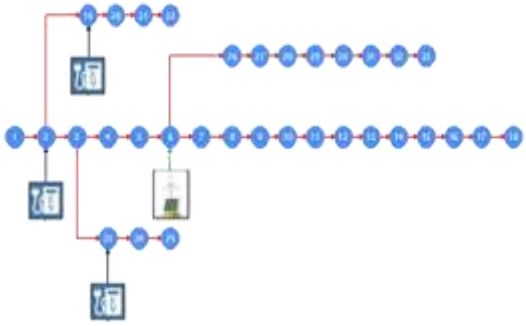

Fig. 8 Diagram line of the 33 bus system with the optimal location of the three EVCS and 1DG

The results obtained for each of the 4 scenarios were compared, and this was highlighted in relation to the voltage changes in Figure 4. As for the active power loss in each line, it is shown in Figure 3 and the box plot (Figure 6), and Figure 7 shows the total active power loss for each scenario.

V. CONCLUSION

The integration of electric vehicle charging stations (EVCS) into distribution systems (RDS) represents a pivotal step in revolutionizing transportation infrastructure and increasing the popularity of electric vehicles. However, this transition is not without challenges, as this increase is offset by the mandatory expansion of the number of charging stations in the distribution network and will have a detrimental impact on Ds, so the smooth integration of EVCS into RDS requires careful consideration of various factors, including Infrastructure compliance, network capacity, and energy management.

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Investigating The Impact of Soil-Structure Interaction on Raft Foundation Design

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Abstract **–** Determining the interaction between soil and structure accurately is great importance for structural analyses. Most structural analysis programs use a single parameter related to the soil during building analyses, which is the coefficient of subgrade reaction. Many different formulas have been proposed in the literature for calculating the coefficient of subgrade reaction. The value of the coefficient of subgrade reaction calculated from these formulas varies according to the foundation size and soil parameters. Moreover, there are significant differences in the values of the coefficient of subgrade reaction calculated from the formulas recommended in the literature for foundations with the same size and soil properties. This situation causes confusion for design engineers. In this study, analyses were conducted on a five-story symmetrical building. The coefficient of subgrade reaction values to be used for the building's foundation were calculated from the formulas recommended in the literature. Seven different analyses were performed with the calculated coefficient of subgrade reaction for the five-story building. The analyses resulted in no significant changes in parameters related to the building's superstructure. However, significant changes were observed in parameters related to the building's raft foundation. In summary, the value of the subgrade reaction coefficient is crucial for the building's raft foundation.

Keywords – coefficient of the subgrade reaction, raft foundation, rebar quantity, settlement

I. INTRODUCTION

Soil-foundation interaction has become one of the challenging issues in both geotechnical and structural engineering over the last two centuries. The complexity of soil behavior has contributed to the emergence of this problem. The subgrade in soil-structure interaction problems is represented by a much simpler model to simplify the current problem. For this reason, the Winkler method is one of the most preferred and simplest methods for finite element programs used in structural engineering. The main principle of this model is to represent the soil medium as an independent, discrete, and linearly elastic system of springs. Thus, the ratio between the contact pressure, P, at a specific point and the displacement, y, at that point can be determined by the coefficient of subgrade reaction (Ks) at that point. The geometry and dimensions of the foundation and soil profile are considered the most significant influential parameters on Ks [1]. In addition, this method gives higher contact pressure than actual values because it is derived by disregarding the effect of lateral pressures of soil masses [2].

Limited space in large cities has led to an increase in the construction of tall buildings with complex architectural designs. The foundations of these buildings pose a challenge related to soil-structure interaction in order to achieve the most suitable design that meets safety and serviceability requirements. Collaboration between geotechnical and structural engineers is essential for a successful design. The coefficient of subgrade reaction represents the relationship between these two disciplines and depends on factors such as soil conditions, load level, and structural rigidity. While the Winkler Theory is used to calculate this coefficient, it does not consider soil-structure interaction [3]. However, many structural analysis programs favor Winkler method for resolving soil-foundation issues. In addition to this, the primary challenge lies in determining the coefficient of subgrade reaction, which can vary based on factors such as soil properties, foundation rigidity, loads, and more [4].

One way to analyze an elastic raft foundation is by treating it as an elastic plate. For instance, a square flexible raft foundation exemplifies this approach effectively. For analyzing elastic raft foundations, some researchers have utilized a boundary element method based upon the Winkler method. Nevertheless, settlements derived from this method may lack reliability because they heavily depend on a single soil parameter that is called as the coefficient of subgrade reaction. This parameter can be obtained from either plate load tests or indirect methods [5-10]

In geotechnical engineering, it is known to be important to interpret different methods of calculating soil parameters and obtain reliable results. The value of Ks is generally calculated using field loading tests, laboratory experiments, and various empirical relationships. However, Ks values obtained using either different methods or empirical relationships can vary significantly. Hence, determination of the Ks value frequently lack precision, leading to considerable discrepancies among outcomes derived from different methodologies. This discrepancy affects the realistic determination of the Ks. The value of Ks depends on parameters such as soil settlement, elasticity modulus and consequently Poisson's ratio, soil type, unit weight values, seismic velocities, and soil safety stresses. Accurately determining these parameters is important for the safety and durability of structural systems. Therefore, the calculation and interpretation of the subgrade reaction coefficient should be carefully considered in engineering applications [11].

In this study, the effect of some formulas developed in the literature for Ks has been investigated on the superstructure. Within the scope of the study, the superstructure was designed on a soil with a ZC local soil class consisting of dense sand according to Turkish Building Earthquake Code (TBEC,2018) [12]. A 5-story building was analyzed as the structure. As a result of the analyses conducted, earthquake forces acting on the building, maximum foundation pressure, displacement, and period and displacement values under earthquake effects were obtained.

II. MATERIALS AND METHOD

The information regarding both the soil and the superstructure used in the analyses has been detailed under subtitles.

II.A. Ks Value of Some Formulas Developed in Literature

Soil-structure interactions are typically assessed using a constant coefficient of subgrade reaction in foundation design, regardless of soil displacement. However, the coefficient of subgrade reaction is actually dependent on soil deformation and varies based on soil type and foundation dimensions. Analyzing these factors reveals that the coefficient of subgrade reaction increases with soil internal friction angle and foundation depth, while decreasing with soil displacement. This coefficient is crucial for determining internal forces in structural systems. Therefore, a more reliable approach involves determining coefficient of subgrade reaction values that decrease with deformation, considering factors like foundation depth, dimensions, internal friction angle, and soil elasticity modulus [13].

Throughout history, many scientists have conducted research and developed some formulas to calculate the value of Ks. Firstly, Biot (1937) employed an infinite beam carrying a concentrated load and a three-dimensional elastic soil in his hypothesis. A correlation between the continuum elastic theory and the Winkler model was developed by Biot (1937), in which the maximum moments in the beam are equalized [14].

Terzaghi conducted studies on Ks. As a result of these studies;

- Vertical and horizontal subgrade reaction theories conform to Hooke's law,
- It is based on the simplifying assumptions that every point of the subgrade on a rigid base loaded horizontally has the same value.

While some recommendations were made by Terzaghi regarding the Ks values for a 1x1 foot rigid plate placed on a soil medium, no application or procedure was specified by Terzaghi for calculating or using Ks values for a larger plate [15].

Research on Ks continued after Terzaghi. Vesic (1961) utilized the maximum displacements of the beam in two different models to develop the Ks value. Thus, he formulated the Ks equation for spring constants in the Winkler model [16]. Additionally, the Ks value obtained from the formula proposed by Vesic yields more consistent results for soft soil models (Sadrekarimi and Akbarzad, 2009)

Meyerhof and Baike (1963) reported that the values of Ks obtained from triaxial experiments on sands were consistent with the average coefficients derived from loading tests. Using these coefficients, they determined the theoretical ultimate load of curved sheets supported by an elastic medium [17].

Selvadurai (2013) reported that a formula has been developed utilizing the foundation width, soil's modulus of elasticity, and the soil's Poisson ratio to calculate the subgrade modulus [18].

Similar to earlier researchers, the formula for the coefficient of subgrade reaction is somewhat more straightforward and useable.

The formulas of the subgrade reaction coefficient used in this study are given in Table 1.

Table 1. Some of the subgrade reaction coefficient equations developed by researchers

Researcher	Suggested Formula
Biot (1937)	$k_s = \frac{0.95 * E_s}{B * (1-\nu_s^2)} \left[\frac{E_s * B^4}{(1-\nu_s^2) * E_b * I}\right]^{0.108}$
Terzaghi (1955)	$k_s = k_{s,plate} \left[\frac{B+B'}{2B}\right]^2$
Vesic (1961)	$k_s = \frac{0.65 * E_s}{B * (1-\nu_s^2)} \sqrt[12]{\frac{E_s * B^4}{E_b * I}}$
Meyerhof and Baike (1963)	$k_s = \frac{E_s}{B * (1-\nu_s^2)}$
Selvadurai (1985)	$k_s = \frac{0.65 * E_s}{B * (1-\nu_s^2)}$
Kloppe and Glock	$k_s = \frac{2 * E_s}{B * (1+\nu_s)}$

The soil used in the analyses consists of a dense sand layer throughout the depth of influence. The parameters related to the dense sand layer are detailed in Table 2 [19].

Tablo 2. The parameters of dense sand layer (Das, 2018)

Parameters	Values
Elasticity Modulus, E (MPa)	34,5
Poisson Ratio, *ν*	0,3
Subgrade Reaction Values, k0,3 (MN/m3)	125

The value of Ks is directly influenced by both the soil parameters and the foundation width. The curves in Figure 1 are obtained by using the soil parameters from Table 2 and foundation width in the formulas provided in Table 1.

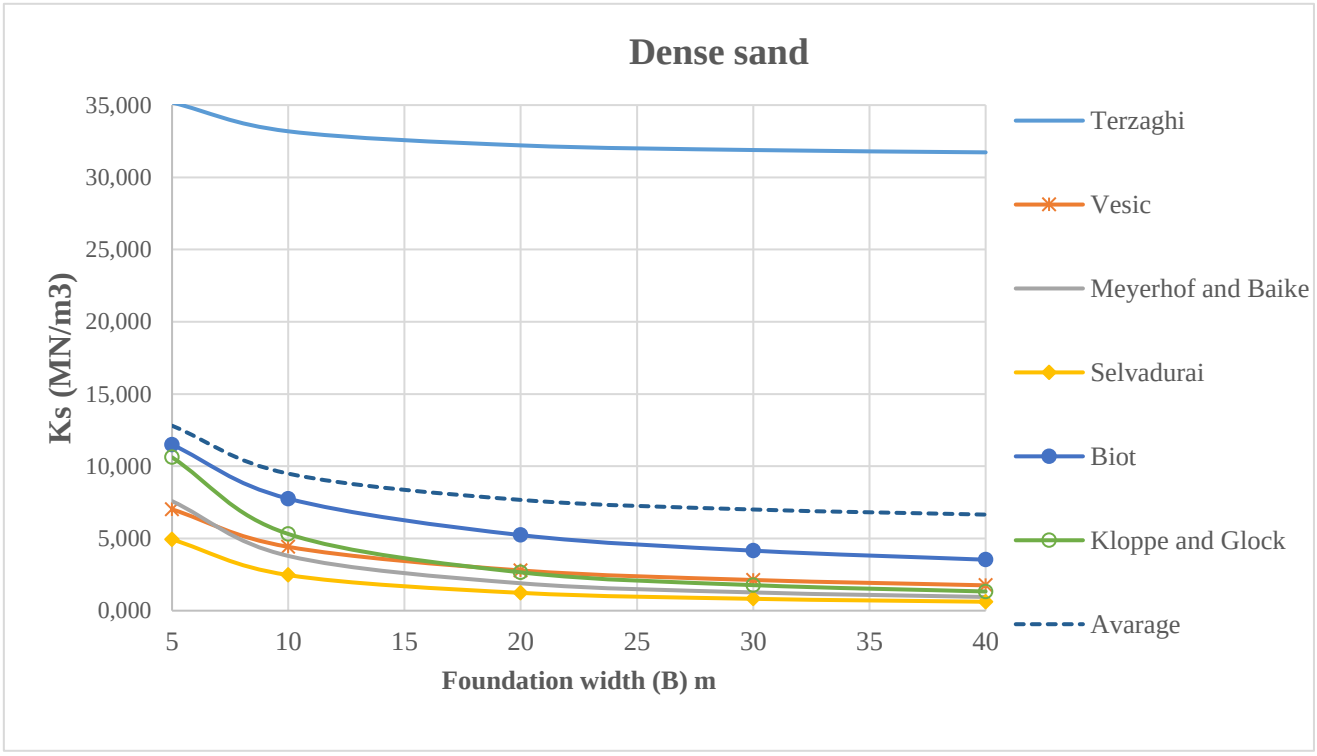

Figure 1. The curves of Ks calculated from the formulas developed in the literature

As the foundation width increases, the values of Ks decrease gradually. However, after exceeding a foundation width of 20 meters, the decrease in values of Ks follow an almost horizontal trend.

According to the curves in Figure 1, the values of Ks calculated from the formula proposed by Terzaghi much higher results compared to the Ks values calculated from other formulas. Except for the formula proposed by Terzaghi in this study, the values of Ks calculated from other proposed formulas are closer to each other.

II.B. The Parameters of Building Analyzed in This Study

In this study, a 5-story building was analyzed on a layer with ZC local soil class according to TBEC 2018.

An analysis was conducted for a 5-story building of three different sizes designed on a raft foundation with a thickness of 50 cm. Both the floor plan and 3-D of the building is shown in Figure 2. The analyses were performed using the Sta4cad software.

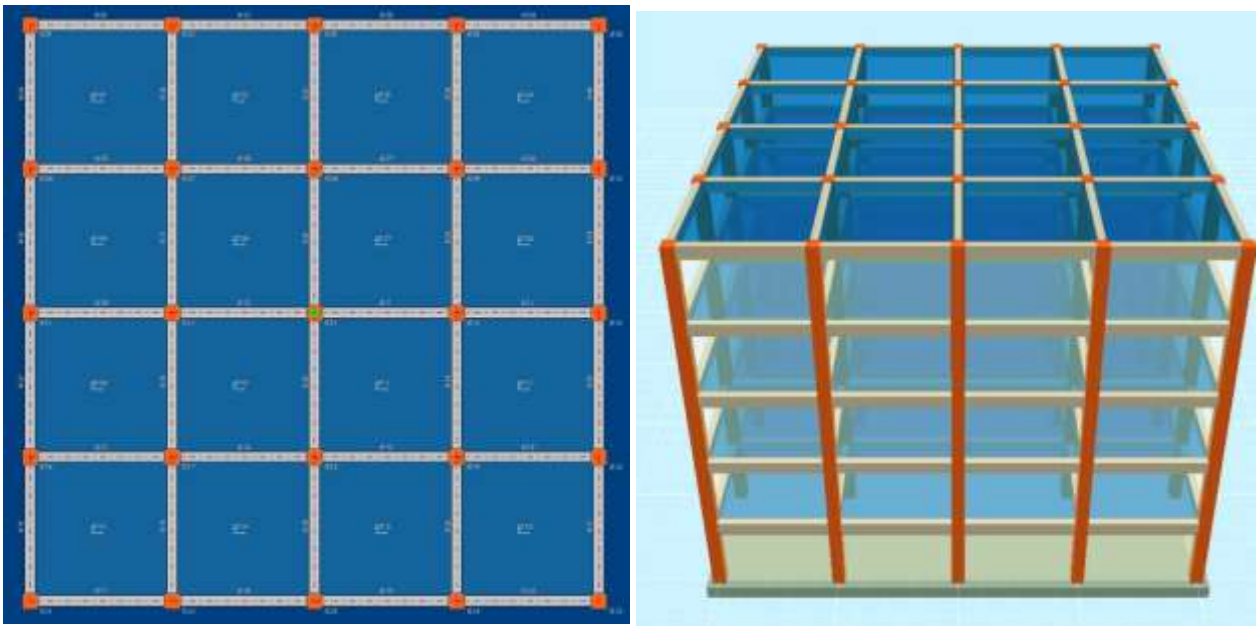

Figure 2. Both the floor plan and 3-D of the building

The other parameters of the building are given in Table 3.

Table 3. Analysis parameters of the building

Number of Story	5	**Beam Dimensions (m)**	40 x 60
Story Height (m)	3	**Slab Thickness (m)**	0.15
Structure Height (m)	15	**Dead Load (t/m2)**	0.250
Span X-Y (m)	5	**Live Load (t/m2)**	0.350
Buildıng Dimensions (m)	34.5 x 34.5	**Concrete Class**	C25/30
Analysis Type	Vertical+Earthquake	**Reinforcement**	S420a
Column Dimensions (m)	60 x 60	**Building coordinates (latitude/longitude)**	37.17947°/36.73259°
Local spectral acceleration coefficient S_S/S_1	1.153/0.305	**Design spectral acceleration coefficient (S_{ds}/S_{d1})**	1.384/0.458

III. Results

The natural vibration period of the structure, earthquake forces acting on each floor of the building, and displacements on each floor of the building have been examined, as a result of the analyses conducted. Additionally, the mat foundation of the structure has been performed. The results of the mat foundation analysis include comparisons of maximum stress, settlement, and the amount of reinforcement in the raft foundation.

III.A The Natural Vibration Period of The Structure

The natural vibration period (Px and Py) in both the X and Y directions of the building has been found to be the same since the structure is symmetric. The natural vibration period values of the structure obtained from the analyses are shown in Figure 3.

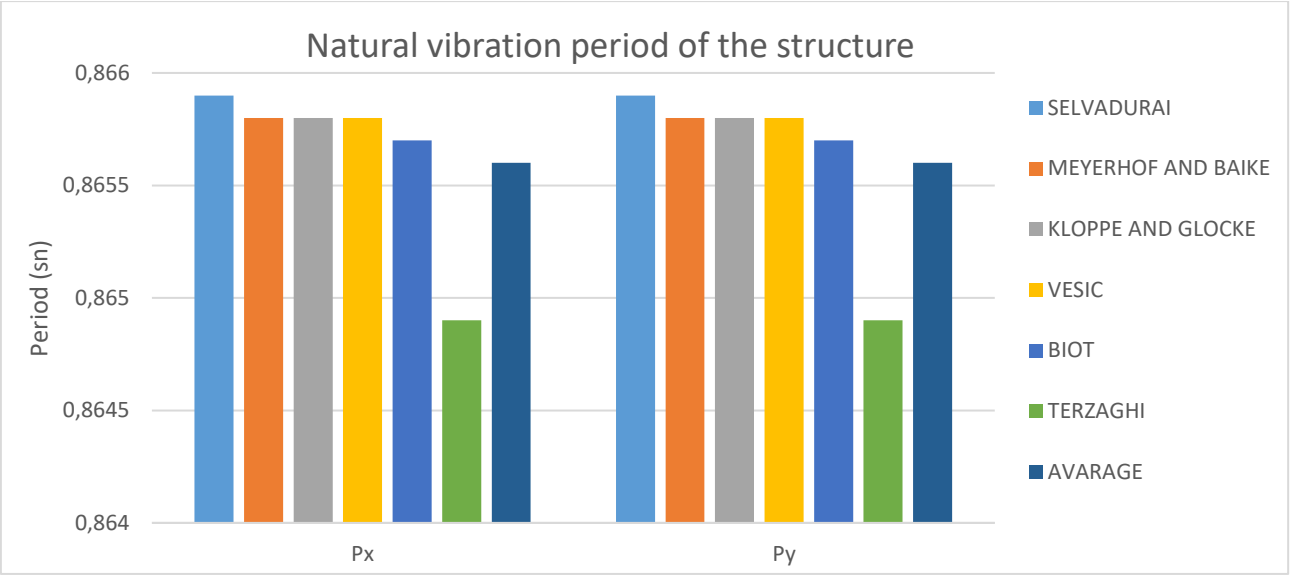

Figure 3. The Natural Vibration Period of The Structure

The natural vibration period values of the structure, determined through analyses with seven different subgrade reaction coefficients, have been found to be approximately 0.865 seconds. As the Ks value increases, the natural vibration period of the structure decreases. However, despite the Ks value increasing by a factor of 26, the decrease in the natural vibration period of the structure remains at approximately one-thousandth level.

III.B. Earthquake Loads

The earthquake forces acting on the building in both the x-direction and the y-direction have been calculated to be the same due to the symmetry of the building. The calculated earthquake forces acting on the building are given in Table 4.

Table 4. The earthquake forces acting on the building

Ks value	**Earthquake forces X or Y direction (ton)**				
	1ST floor	**2nd floor**	**3rd floor**	**4th floor**	**5th floor**
Selvadurai	11,128	22,257	33,385	44,513	45,858
Meyerhod and Baike	11,131	22,263	33,394	44,525	45,84
Kloppe and Glock	11,132	22,264	33,395	44,527	45,842
Vesic	11,132	22,264	33,395	44,527	45,842
Biot	11,133	22,267	33,4	44,533	45,848
Terzaghi	11,143	22,285	33,428	44,57	45,886
Avarage	11,133	22,267	33,4	44,533	45,848

As seen in Table 2, the earthquake forces acting on the 1st, 2nd, 3rd, 4th, and 5th floors of the building are approximately calculated in all solutions as 11.1 tons, 22.2, 33.4, 44.5, and 44.8, respectively. The earthquake forces acting on the building are not significantly affected by changes in the Ks value. In other words, the Ks value has no effect on the earthquake force.

III.C. Translation

The translation occurring in the building during an earthquake are one of the important outputs of the analyses. The translation occurring at each floor of the building according to the Ks values are provided in Table 5.

Table 5. The translation occurring in the building during an earthquake

Ks value	**Translation X or Y direction (mm)**				
	1ST floor	**2nd floor**	**3rd floor**	**4th floor**	**5th floor**
Selvadurai	3,700	9,184	14,254	18,084	20,402
Meyerhod and Baike	3,700	9,185	14,256	18,087	20,457
Kloppe and Glock	3,700	9,185	14,256	18,087	20,457
Vesic	3,700	9,185	14,256	18,087	20,457
Biot	3,700	9,185	14,256	18,087	20,457
Terzaghi	3,679	9,164	14,239	18,074	20,395
Avarage	3,700	9,185	14,256	18,087	20,403

The displacement values calculated at each floor of the building with different Ks values vary with a precision of one-thousandth of a millimeter. The lowest displacement values are calculated from the Ks value obtained from the Terzaghi formula. As the Ks value increases, the displacement value decreases. However, the decrease in displacement according to the Ks value is negligible.

III.D. Raft Foundation

The building designed on a raft foundation has been analyzed with different Ks values. Some parameters of raft foundation that are maximum settlement (s_{max}), maximum foundation pressure (σ_{max}), and rebar quantities of the building's raft foundation (T) have been calculated and evaluated with respect to these analyzes (Table 6).

Table 6. Some parameters of raft foundation obtained from analyzes

Ks value	σ_{max} $(\frac{t}{m^2})$	s_{max} (mm)	T (ton)
Selvadurai	18,24	14,805	31,57
Meyerhod and Baike	20,88	10,440	29,66
Kloppe and Glock	20,88	10,440	29,66
Vesic	22,49	8,474	29,35
Biot	27,3	5,219	29,03
Terzaghi	49,51	1,537	23,96
Avarage	30,67	4,000	29,03

Changes in the Ks value directly affect the parameters of the raft foundation. Firstly, the maximum stress value affecting the raft foundation increases significantly as the Ks value increases. The settlement values occurring in the raft foundation decrease significantly as the Ks value increases. Finally, the rebar quantities related to the raft foundation decrease gradually as the Ks value increases.

IV. Conclusion

In this study, a five-story building designed on a raft foundation has been analyzed using different Ks values. Through the conducted analyses, several parameters of the building have been calculated, including the natural vibration period of the building, earthquake forces acting on each floor of the building, displacements occurring in each floor due to the earthquake, and some parameters related to the building's raft foundation. The analysis results have been compared, and the following outputs have been obtained:

- Ks value tends to decrease as the foundation dimensions increase. The decrease in the Ks value varies according to the formulas found in the literature. Additionally, the highest Ks value in the literature is calculated from the formula derived by Terzaghi.
- Changes in the Ks value affect parameters related to the superstructure of the building. However, the variations in parameters such as the natural vibration period of the building, earthquake forces acting on each floor of the building, and translations are negligible concerning the superstructure.
- As the Ks value increases, the calculated rebar quantity for the raft foundation gradually decreases.

- Changes in the Ks value significantly affect calculations related to the building's raft foundation. As the Ks value increases, the maximum pressure exerted on the building's raft foundation increases, while the settlement value occurring in the raft foundation decreases.

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Numerical Calculation Second Virial Coefficient over HFDHE2 Potential

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Abstract – The thermodynamic property of fluid can be investigated based on the second virial coefficient with HFDHE2 potential. The suggested numerical method for the second virial coefficient is calculated using Mathematica 10.0 Software program. We compare our numerical results with the literatures data. Satisfactory agreement has been obtained between our and literature data.

Keywords – Virial equation of state, Second virial coefficient, HFDHE2 potential

I. INTRODUCTION

Determining the thermodynamic properties, transport properties and interaction potentials of atoms and molecules plays an important role in scientific and technological research. To accurately explain the thermodynamic properties of molecules, a full understanding of the nature of the intermolecular interaction potential is required. Therefore, many equations of state have been proposed to examine such properties of atoms and molecules. The most important of these equations of state is the virial equation of state. The virial equation of state has an important feature that determines the interdependent changes of temperature, pressure, volume, and potential energy of fluids. Virial equation of state is defined following form:

$$\frac{P}{k_B T} = \rho + B_2(T)\rho^2 + B_3(T)\rho^3 + B_4(T)\rho^4 + \ldots \quad (1)$$

Here, $B_2(T), B_3(T), B_4(T)$ are second, third, fourth virial coefficient, respectively (Hirschfelder et al., 1954). Virial coefficients play a fundamental role in many aspects, including the deviation of a gas from the ideal state to the real state and the determination of intermolecular interactions over various temperature ranges. (Kihara et al., 1956; McQuarrie et al., 1997; Widom, 2002; Boltachev and Baidakov, 2006). At the same time, virial coefficients have an important place in the examination of the thermodynamic properties of gases (such as internal energy, enthalpy, heat capacity at constant volume, heat capacity at constant pressure, Joule-Thomson coefficient, speed of sound). (Hirschfelder et al., ark., 1954).

As can be understood, virial coefficients must be calculated precisely to examine fluid according to the virial equation. In this study, the numerical method is created for the second virial coefficient using the HFDHE2 potential. The calculation results were compared with the literature.

Materials and Method

Second virial coefficient

$$B_2(T) = -2\pi N_A \int_0^{\infty} \left(e^{u(r_{12})/k_B T} - 1 \right) r_{12}^2 dr_{12} \quad (2)$$

where N_A is Avagadro constant $u(r_{12})$ is intermolecular interaction energy, k_B Bolztmann constant, and T is temperature (Hirschfelder et al., 1954). HFDHE2 potential is written following as (Mosameh et al., 2014):

$$V(r) = \varepsilon V^*(x)$$

$$V^*(r) = Aexp(-\alpha x) - \left\{ \frac{C_6}{x^6} + \frac{C_8}{x^8} + \frac{C_{10}}{x^{10}} \right\} F(x) \quad (3)$$

Here F(x):

$$F(x) = \begin{cases} \exp\left[-\left\{ \frac{D}{x} - 1 \right\}^2 \right], & x \le D \\ 1, & x < D \end{cases} \quad (4)$$

Here, $x = r/rm$. Substituting equation 3 into equation 2, we get numerical formula for second virial coefficient.

II. RESULTS

Numerical calculations for second virial coefficient have performed using Mathematica 10.0 Software program. The obtained results are compared with available literature data (Mosameh et al., 2014) and it shows approximately agreement in the literature data. The potential parameters given in Table 1.

Table 1. The HFDHE2 potential parameters

	$\varepsilon/k_B(K)$	$r_m A^0$	D	A	α	C_6	C_8	C_{10}
^4He	10.8	2.98	1.24	0.554x10^6	13.35	1.373	0.425	0.178

The obtained results of the reduced second virial coefficient are given in Table 2. As can be seen in Table 2, the results are approximately good agreement with literature data.

Table 2. Second virial coefficient for HFDHE2

T(K)	This work	(Mosameh et al., 2014)
4	-343.98	–343.97
4.5	-264.053	–264.05
5	-211.601	–211.60
5.5	-174.87	–174.87
6	-147.863	–147.86
6.5	-127.246	–127.24
7	-111.029	–111.03

7.5	-97.9635	–97.96
8	-87.2247	–87.22
8.5	-78.2508	–78.25
9	-70.6454	–70.64
9.5	-64.1216	–64.12
10	-58.4669	–58.47

III. DISCUSSION

In this paper, we have presented numeric method for second virial coefficient with HFDHE2 potential. The suggested numeric method is general and free of any restriction on its applications to fluids.

IV. CONCLUSION

A numeric method for evaluating second virial coefficient of fluids is presented, in this study. The correct and precision of results show that the presented numeric method is applicable to fluid at a wide range of temperatures.

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Calculation of Using Third Virial Coefficient over Hard-Core-Lennard-Jones Potential

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Abstract – Hard-core Lennard-Jones potential has preferred to calculate the third virial coefficient of real gases. In this study, the numeric method has been suggested for calculating the third virial coefficient over hard-core Lennard-Jones potential. The accuracy of the numeric method has been tested by application to reduced third virial coefficient. Also, obtained results are compared with the obtained results than Lennard-Jones potential. It was seen in this work that the obtained results for reduced third virial coefficient are approximately agreement with available the literature.

Keywords – Third virial coefficient, Hard-core Lennard-Jones potential, Thermodynamic properties

I. INTRODUCTION

The thermodynamic properties of real gases have been examined with theoretically and experimentally methods [1-5]. Many authors have been presented theoretical method to evaluate the thermodynamic properties of real gases [6-8]. The virial equation state, that is consist of virial coefficient, is one of these methods. The virial coefficient of imperfect gases can be calculated accurately and precisely in certain temperature and pressure ranges [8]. Here, the intermolecular interaction potentials are very important to calculate according to virial coefficients. Therefore, intermolecular interaction potentials, which are selected according to the structure of the molecule, are Lennard-Jones (12-6), Yukawa, and Keesom potentials, etc [9]. The advantage of hard-core Lennard-Jones potential is a better defined of the thermodynamic and transport properties of complex fluids.

In this work, the reduced third virial coefficient over hard-core Lennard-Jones potential was calculated in different temperature. The results obtained were compared with available other method in the literature.

Materials and Method

Second virial coefficient

The third virial coefficient is defined in the following form [8]

$$C(T) = -\frac{N_A^2}{3}\iiint f\left(r_{12}\right) f\left(r_{13}\right) f\left(r_{23}\right) dr_{12} dr_{13} \quad . \tag{1}$$

Here, $f\left(r_{ij}\right) = exp\left(u\left(r_{ij}\right)/k_B T\right) - 1$ is Mayer functions and N_A is Avogadro's constant. In Mayer function, $u\left(r_{ij}\right)$ is the intermolecular potential, T is temperature and k_B is the Boltzmann constant [8].

For evaluating of the third virial coefficient, we presented numeric method following form:

$$C^*(T^*) = 12\sigma^{-6}\int_0^\infty\int_0^\infty r^2\left(1-e^{\frac{4}{T^*}\left(\left(\frac{\sigma-2a}{r-2a}\right)^{12}-\left(\frac{\sigma-2a}{r-2a}\right)^{6}\right)}\right)t^2\left(1-e^{\frac{4}{T^*}\left(\left(\frac{\sigma-2a}{t-2a}\right)^{12}-\left(\frac{\sigma-2a}{t-2a}\right)^{6}\right)}\right)drdt -$$
$$6\sigma^{-6}\int_0^\infty\int_0^\infty\int_{-1}^1 r^2\left(1-e^{\frac{4}{T^*}\left(\left(\frac{\sigma-2a}{r-2a}\right)^{12}-\left(\frac{\sigma-2a}{r-2a}\right)^{6}\right)}\right)t^2\left(1-\right.$$
$$\left.e^{\frac{4}{T^*}\left(\left(\frac{\sigma-2a}{t-2a}\right)^{12}-\left(\frac{\sigma-2a}{t-2a}\right)^{6}\right)}\right)\left(e^{\frac{4}{T^*}\left(\left(\frac{\sigma-2a}{\sqrt{r^2+t^2-2rtz}-2a}\right)^{12}-\left(\frac{\sigma-2a}{\sqrt{r^2+t^2-2rtz}-2a}\right)^{6}\right)}\right)drdtdz \qquad (2)$$

where, $C^*\left(T^*\right)=C\left(T^*\right)\big/b_0^2$, $b_0=2\pi N_A\sigma^3/3$, and $T^*=k_BT/\varepsilon$. The hard-core Lennard-Jones potential in Eq. (2) [10]:

$$u(r)=4\varepsilon\left(\left(\frac{\sigma-2a}{r-2a}\right)^{12}-\left(\frac{\sigma-2a}{r-2a}\right)^{6}\right)$$
(3)

Here, a=0 gives Lennard-Jones potential. The substituting Eq. (3) into the Eq. (2), we have calculated third virial coefficient. The reduced third virial coefficient calculation results obtained at different temperature ranges are given in Table 1.

II. RESULTS

Numerical calculations for third virial coefficient have performed using Mathematica 7.0 Software program. The obtained results are compared with available literature data [10] and it shows approximately agreement in the literature data.

The obtained results of the reduced third virial coefficient are given in Table 1. As can be seen in Table 1, the results are approximately good agreement with literature data. In consequence, the certain temperature range of the used numeric method offers the advantage of the correct calculation of the third virial coefficient.

Table 1. Reduced third virial coefficient.

$T(K)$	This work	For a=0 [10]	Lennard-Jones potential [10]
0.7	-0.0287951	-3.37602	-3.37602
0.8	0.00374126	-0.848386	-0.848386
0.9	0.0137837	0.0773667	0.0773667
5	0.00898234	0.315059	0.315059
10	0.00858588	0.286068	0.286068
20	0.0076614	0.246413	0.246413
30	0.00696859	0.219512	0.219512
40	0.00645225	0.200101	0.200101
50	0.00605031	0.185277	0.185277
60	0.0057258	0.173471	0.173471
100	0.00485673	0.142536	0.142536
200	0.00381586	0.106819	0.106819
300	0.00329188	0.0894545	0.0894545
400	0.00295805	0.0786384	0.0786384

III. DISCUSSION

In this paper, we have presented numeric method for third virial coefficient over hard-core Lennard-Jones potential. The suggested numeric method is general and free of any restriction on its applications to real gases.

IV. CONCLUSION

A numeric method for evaluating third virial coefficient of imperfect gases is presented, in his work. The accuracy and precision of results demonstrate that the suggested numeric method is applicable to imperfect gases at a certain range of temperatures.

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On Some New m-Difference Double Sequence Spaces Defined by Orlicz Functions

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Abstract – In this article, the author defines the generalized difference double paranormed sequence spaces $c^2(\Delta_m, M, p, q, s)$, $c_o^2(\Delta_m, M, p, q, s)$ and $l_\infty^2(\Delta_m, M, p, q, s)$ defined over a seminormed sequence space (X, q). The author also studies their properties and inclusion relations between them.

Keywords – P-convergent, Difference sequence, Orlicz function, seminorm,

I. INTRODUCTION

Let l_∞, c and c_o be the Banach spaces of bounded, convergent and null sequences $x = (x_k)$ with the usual norm $\|x\| = \sup_k |x_k|$. Kizmaz [1] introduced the notion of difference sequence spaces as follows:

$$X(\Delta) = \{x = (x_k) : (\Delta x_k) \in X\}$$

for $X = l_\infty, c$ and c_o. Later on, the notion was generalized by Tripathy and Esi [15] as follows:

$$X(\Delta_m) = \{x = (x_k) : (\Delta_m x_k) = (x_k - x_{k+m}) \in X, \text{for } m \in N\}$$

for $X = l_\infty, c$ and c_o,

Subsequently, difference sequence spaces were studied by Esi [3], Esi and Tripathy [4], Tripathy et.al [5] and many others.

An Orlicz function M is a function $M: [0, \infty) \to [0, \infty)$, which is continuous, convex, nondecreasing function define for $x > 0$ such that $M(0) = 0$, $M(x) > 0$ and $M(x) \to \infty$ as $x \to \infty$.If convexity of Orlicz function is replaced by $M(x + y) \leq M(x) + M(y)$ then this function is called the modulus function and characterized by Ruckle [6]. An Orlicz function M is said to satisfy $\Delta_2 - condition$ for all values u, if there exists $K > 0$ such that $M(2u) \leq KM(u), u \geq 0$.

Remark. An Orlicz function satisfies the inequality $M(\lambda x) \leq \lambda M(x)$ for all λ with $0 < \lambda < 1$.

Lindenstrauss and Tzafriri [7] used the idea of Orlicz function to construct the sequence space

$$l_M = \left\{(x_k) : \sum_{k=1}^{\infty} M\left(\frac{|x_k|}{r}\right) < \infty, \text{for some } r > 0\right\},$$

which is a Banach space normed by

$$\|(x_k)\| = \inf\left\{r > 0: \sum_{k=1}^{\infty} M\left(\frac{|x_k|}{r}\right) \leq 1\right\}.$$

The space l_M is closely related to the space l_p, which is an Orlicz sequence space with $M(x) = |x|^p$, for $1 \leq p < \infty$.

In the later stage different Orlicz sequence spaces were introduced and studied by Tripathy and Mahanta [8], Esi and Et [9], Parashar and Choudhary [10] and many others.

Let w^2 denote the set of all double sequences of complex numbers. By the convergence of a double sequence we mean the convergence on the Pringsheim sense that is, a double sequence $x = (x_{k,l})$ has Pringsheim limit L (denoted by $P - limx = L$) provided that given $\varepsilon > 0$ there exists $N \in \mathbb{N}$ such that $|x_{k,l} - L| < \varepsilon$ whenever $k, l > N$ [11]. We shall describe such an $x = (x_{k,l})$ more briefly as "$P - convergent$". We shall denote the space of all $P - convergent$ sequences by c^2. The double sequence $x = (x_{k,l})$ is bounded if and only if there exists a positive number M such that $|x_{k,l}| < M$ for all k and l. We shall denote all bounded double sequences by l_∞^2.

II. DEFINITIONS

In this presentation our goal is to extend a few results known in the literature from ordinary (single) difference sequences to difference double sequences.

Definition 2.1. Let M be an Orlicz function and $p = (p_{k,l})$ be a factorable double sequence of strictly positive real numbers and $s \geq 0$ is a real number. Let X be a seminormed space over the complex field $\mathbb{C}$ with the seminorm q. We now define the following new generalized difference double sequence spaces:

$$[c^2(M, \Delta_m, p, q, s)]_{\square} = \begin{Bmatrix} x = (x_{k,l}) \in w^2: P - \lim_{k,l} (kl)^{-s} \left[M\left(\frac{q(\Delta_m x_{k,l} - L)}{\rho}\right)\right]^{p_{k,l}} = 0, \\ \text{for some } \rho > 0 \text{ and } L \end{Bmatrix},$$

$$[c_o^2(M, \Delta_m, p, q)]_{\square} = \begin{Bmatrix} x = (x_{k,l}) \in w^2: P - \lim_{k,l} (kl)^{-s} \left[M\left(\frac{q(\Delta_m x_{k,l})}{\rho}\right)\right]^{p_{k,l}} = 0, \\ \text{for some } \rho > 0. \end{Bmatrix},$$

and

$$[l_\infty^2(M, \Delta_m, p, q)]_{\square} = \begin{Bmatrix} x = (x_{k,l}) \in w^2: \sup_{k,l} (kl)^{-s} \left[M\left(\frac{q(\Delta_m x_{k,l})}{\rho}\right)\right]^{p_{k,l}} < \infty, \\ \text{for some } \rho > 0. \end{Bmatrix},$$

where $\Delta_m x = (\Delta_m x_{k,l}) = (x_{k,l} - x_{k+m,l+m})$.

III. MAIN RESULTS

Theorem 3.1. Let $p = (p_{k,l})$ be bounded. The classes of $c^2(\Delta_m, M, p, q, s)$, $c_o^2(\Delta_m, M, p, q, s)$ and $l_\infty^2(\Delta_m, M, p, q, s)$ are linear spaces over the complex field $\mathbb{C}$.

Proof. We give the proof only $l_\infty^2(\Delta_m, M, p, q, s)$. The others can be treated similarly. Let $x = (x_{k,l}), y = (y_{k,l}) \in l_\infty^2(\Delta_m, M, p, q, s)$. Then we have

$$\sup_{k,l}(kl)^{-s}\left[M\left(\frac{q(\Delta_m x_{k,l})}{\rho_1}\right)\right]^{p_{k,l}} < \infty, \text{for some } \rho_1 > 0 \text{ and } s \geq 0 \qquad (3.1)$$

and

$$\sup_{k,l}(kl)^{-s}\left[M\left(\frac{q(\Delta_m y_{k,l})}{\rho_2}\right)\right]^{p_{k,l}} < \infty, \text{for some } \rho_2 > 0 \text{ and } s \geq 0. \qquad (3.2)$$

Let $\alpha, \beta \in \mathbb{C}$ be scalars and $\rho = \max(2|\alpha|\rho_1, 2|\beta|\rho_2)$. Since M is non-decreasing convex function, we have

$$\left[M\left(\frac{q\left(\Delta_m(\alpha x_{k,l}+\beta y_{k,l})\right)}{\rho}\right)\right]^{p_{k,l}}$$

$$\leq D\left\{\left[M\left(\frac{q(\Delta_m x_{k,l})}{2\rho_1}\right)\right]^{p_{k,l}} + \left[M\left(\frac{q(\Delta_m y_{k,l})}{2\rho_2}\right)\right]^{p_{k,l}}\right\}$$

$$\leq D\left\{\left[M\left(\frac{q(\Delta_m x_{k,l})}{\rho_1}\right)\right]^{p_{k,l}} + \left[M\left(\frac{q(\Delta_m y_{k,l})}{\rho_2}\right)\right]^{p_{k,l}}\right\},$$

where $D = \max(1, 2^H)$, $H = \sup_{k,l} p_{k,l} < \infty$. Now, from (3.1) and (3.2), we have

$$\sup_{k,l}(kl)^{-s}\left[M\left(\frac{q\left(\Delta_m(\alpha x_{k,l}+\beta y_{k,l})\right)}{\rho}\right)\right]^{p_{k,l}} < \infty.$$

Therefore $\alpha x + \beta y \in l_\infty^2(\Delta_m, M, p, q, s)$. Hence $l_\infty^2(\Delta_m, M, p, q, s)$ is a linear space.

Theorem 3.2. The double sequence spaces $c^2(\Delta_m, M, p, q, s), c_o^2(\Delta_m, M, p, q, s)$ and $l_\infty^2(\Delta_m, M, p, q, s)$ are seminormed spaces, seminormed by

$$f\left(\left(x_{k,l}\right)\right) = \sum_{k=1}^{m} q\left(x_{k,1}\right) + \sum_{l=1}^{m} q\left(x_{1,l}\right) + \inf\left\{\rho > 0: sup_{k,l} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right) \leq 1\right\}.$$

Proof. Since q is a seminorm, so we have $f\left(\left(x_{k,l}\right)\right) \geq 0$ for all $x = \left(x_{k,l}\right)$; $f(\theta^2) = 0$ and $f\left(\left(\lambda x_{k,l}\right)\right) = |\lambda| f\left(\left(x_{k,l}\right)\right)$ for all scalars λ.

Now, let $x = \left(x_{k,l}\right)$, $y = \left(y_{k,l}\right) \in c_o^2(\Delta_m, M, p, q, s)$. Then there exist $\rho_1, \rho_2 > 0$ such that

$$sup_{k,l} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho_1}\right)\right) \leq 1 \text{ and } sup_{k,l} M\left(q\left(\frac{\Delta_m y_{k,l}}{\rho_2}\right)\right) \leq 1.$$

Let $\rho = \rho_1 + \rho_2$. Then we have,

$$sup_{k,l} M\left(q\left(\frac{\Delta_m(x_{k,l}+y_{k,l})}{\rho}\right)\right)$$

$$\leq \left(\frac{\rho_1}{\rho_1+\rho_2}\right) sup_{k,l} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho_1}\right)\right) + \left(\frac{\rho_1}{\rho_1+\rho_2}\right) sup_{k,l} M\left(q\left(\frac{\Delta_m y_{k,l}}{\rho_2}\right)\right) \leq 1.$$

Since $\rho_1, \rho_2 > 0$, so we have,

$$f\left((x_{k,l}) + (y_{k,l})\right)$$

$$= \sum_{k=1}^{m} q(x_{k,1} + y_{k,1}) + \sum_{l=1}^{m} q(x_{1,l} + y_{1,l}) + \inf\left\{\rho = \rho_1 + \rho_2 > 0 : sup_{k,l} M\left(q\left(\frac{\Delta_m(x_{k,l}+y_{k,l})}{\rho}\right)\right) \leq 1\right\}$$

$$\leq \sum_{k=1}^{m} q(x_{k,1}) + \sum_{l=1}^{m} q(x_{1,l}) + \inf\left\{\rho_1 > 0 : sup_{k,l} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho_1}\right)\right) \leq 1\right\}$$

$$+ \sum_{k=1}^{m} q(y_{k,1}) + \sum_{l=1}^{m} q(y_{1,l}) + \inf\left\{\rho_2 > 0 : sup_{k,l} M\left(q\left(\frac{\Delta_m y_{k,l}}{\rho_2}\right)\right) \leq 1\right\}$$

$$= f\left((x_{k,l})\right) + f\left((y_{k,l})\right).$$

Therefore f is a seminorm.

Theorem 3.3. Let (X, q) be a complete seminormed space. Then the spaces $c^2(\Delta_m, M, p, q, s), c_o^2(\Delta_m, M, p, q, s)$ and $l_\infty^2(\Delta_m, M, p, q, s)$ are complete seminormed spaces seminormed by f.

Proof. We prove the theorem for the space $c_o^2(\Delta_m, M, p, q, s)$.The other cases can be establish following similar technique. Let $x^i = \left(x_{k,l}^i\right)$ be a Cauchy sequence in $c_o^2(\Delta_m, M, p, q, s)$.Let $\varepsilon > 0$ be given and for $r > 0$, choose x_o fixed such that $M\left(\frac{rx_o}{2}\right) \geq 1$ and there exists $m_o \in \mathbb{N}$ such that

$$f\left(\left(x_{k,l}^i - x_{k,l}^j\right)\right) < \frac{\varepsilon}{rx_o}, \text{for all } i, j \geq m_o$$

By definition of seminorm, we have

$$\sum_{k=1}^{m} q\left(x_{k,1}^i\right) + \sum_{l=1}^{m} q\left(x_{1,l}^j\right) + \inf\left\{\rho > 0 : \sup_{k,l} M\left(q\left(\frac{\Delta_m x_{k,l}^i - \Delta^r x_{k,l}^j}{\rho}\right)\right) \leq 1\right\} < \frac{\varepsilon}{rx_o} \quad (3.3)$$

This shows that $q\left(x_{k,1}^i\right)$ and $q\left(x_{1,l}^j\right)$ $(k, l \leq r)$ are Cauchy sequences in (X, q). Since (X, q) is complete, so there exists $x_{k,1}, x_{1,l} \in X$ such that

$$\lim_{i\to\infty} q\left(x_{k,1}^i\right) = x_{k,1} \text{ and } \lim_{j\to\infty} q\left(x_{1,l}^j\right) = x_{1,l} \ \ (k, l \leq m).$$

Now from (3.3), we have

$$M\left(q\left(\frac{\Delta_m\left(x_{k,l}^i - x_{k,l}^j\right)}{f\left(\left(x_{k,l}^i - x_{k,l}^j\right)\right)}\right)\right) \leq 1 \leq M\left(\frac{rx_o}{2}\right), \text{for all } i,j \geq m_o. \tag{3.4}$$

This implies

$$q\left(\Delta_m\left(x_{k,l}^i - x_{k,l}^j\right)\right) \leq \frac{rx_o}{2}.\frac{\varepsilon}{rx_o} = \frac{\varepsilon}{2}, \text{for all } i,j \geq m_o.$$

So, $q\left(\Delta_m\left(x_{k,l}^i\right)\right)$ is a Cauchy sequence in (X,q). Since (X,q) is complete, there exists $x_{k,l} \in X$ such that $\lim_i \Delta_m\left(x_{k,l}^i\right) = x_{k,l}$ for all $k,l \in \mathbb{N}$. Since M is continuous, so for $i \geq m_o$, on taking limit as $j \to \infty$, we have from (3.4),

$$M\left(q\left(\frac{\Delta_m\left(x_{k,l}^i\right) - \lim_{j\to\infty} \Delta_m^r x_{k,l}^j}{\rho}\right)\right) \leq 1 \Rightarrow M\left(q\left(\frac{\Delta_m\left(x_{k,l}^i\right) - x_{k,l}}{\rho}\right)\right) \leq 1.$$

On taking the infimum of such $\rho's$, we have

$$f\left(\left(x_{k,l}^i - x_{k,l}\right)\right) < \varepsilon, \text{for all } i \geq m_o.$$

Thus $\left(x_{k,l}^i - x_{k,l}\right) \in c_o^2(\Delta_m, M, p, q, s)$. By linearity of the space $c_o^2(\Delta_m, M, p, q, s)$, we have for all $i \geq m_o$,

$$\left(x_{k,l}\right) = \left(x_{k,l}^i\right) - \left(x_{k,l}^i - x_{k,l}\right) \in c_o^2(\Delta_m, M, p, q, s).$$

Thus $c_o^2(\Delta_m, M, p, q, s)$ is a complete space.

Proposition 3.4.(a) $c^2(\Delta_m, M, p, q, s) \subset l_\infty^2(\Delta_m, M, p, q, s)$,

(b) $c_o^2(\Delta_m, M, p, q, s) \subset l_\infty^2(\Delta_m, M, p, q, s)$.

Proof. It is easy, so omitted.

Theorem 3.5. The double spaces $c^2(\Delta_m, M, p, q, s)$ and $c_o^2(\Delta_m, M, p, q, s)$ are nowhere dense subsets of $l_\infty^2(\Delta_m, M, p, q, s)$.

Theorem 3.6. (a) If $0 < \inf_{k,l} p_{k,l} \leq p_{k,l} < 1$, then $Z^2(\Delta_m, M, p, q, s) \subset Z^2(\Delta_m, M, q, s)$,

(b) If $1 < p_{k,l} \leq \sup_{k,l} p_{k,l} < \infty$, then $Z^2(\Delta_m, M, q, s) \subset Z^2(\Delta_m, M, p, q, s)$,

where $Z^2 = c^2$, c_o^2 and l_∞^2.

Proof. The first part of the result follows from the inequality

$$(kl)^{-s} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right) \leq (kl)^{-s}\left[M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right)\right]^{p_{k,l}}$$

and the second part of the result follows from the inequality

$$(kl)^{-s}\left[M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right)\right]^{p_{k,l}} \leq (kl)^{-s} M\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right).$$

Theorem 3.7. Let M_1 and M_2 be Orlicz functions satisfying Δ_2 −condition. If $\beta = \lim_{t\to\infty} \frac{M_2(t)}{t} \geq 1$, then $Z^2(\Delta_m, M_1, p, q, s) = Z^2(\Delta_m, M_2 o M_1, p, q, s)$,where $Z^2 = c^2$, c_o^2 and l_∞^2.

Proof. We prove it for $Z^2 = c^2$ and the other cases will follows on applying similar techniques. Let $x = (x_k) \in c^2(\Delta_m, M_1, p, q, s)$, then

$$P - \lim_{k,l}(kl)^{-s}\left[M_1\left(q\left(\frac{\Delta_m x_{k,l}}{\rho}\right)\right)\right]^{p_{k,l}} = 0.$$

Let $0 < \varepsilon < 1$ and δ with $0 < \delta < 1$ such that $M_2(t) < \varepsilon$ for $0 \leq t < \delta$.Let

$$y_{k,l} = M_1\left(q\left(\frac{\Delta^m x_{k,l}}{\rho}\right)\right)$$

and consider

$$\left[M_2(y_{k,l})\right]^{p_{k,l}} = \left[M_2(y_{k,l})\right]^{p_{k,l}} + \left[M_2(y_{k,l})\right]^{p_{k,l}} \tag{3.6}$$

where the first term is over $y_{k,l} \leq \delta$ and the second is over $y_{k,l} > \delta$. From the first term in (3.6), using the Remark

$$(kl)^{-s}\left[M_2(y_{k,l})\right]^{p_{k,l}} < (kl)^{-s}[M_2(2)]^H\left[(y_{k,l})\right]^{p_{k,l}} \tag{3.7}$$

On the other hand, we use the fact that

$$y_{k,l} < \frac{y_{k,l}}{\delta} < 1 + \frac{y_{k,l}}{\delta}.$$

Since M_2 is non-decreasing and convex, it follows that

$$M_2(y_{k,l}) < M_2\left(1 + \frac{y_{k,l}}{\delta}\right) < \frac{1}{2}M_2(2) + \frac{1}{2}M_2\left(\frac{2y_{k,l}}{\delta}\right).$$

Since M_2 satisfies Δ_2 −condition, we have

$$M_2(y_{k,l}) < \frac{1}{2}K\frac{y_{k,l}}{\delta}M_2(2) + \frac{1}{2}K\frac{y_{k,l}}{\delta}M_2(2) = K\frac{y_{k,l}}{\delta}M_2(2).$$

Hence, from the second term in (3.6)

$$(kl)^{-s}\left[M_2(y_{k,l})\right]^{p_{k,l}} \leq \max(1, (KM_2(2)\delta^{-1})^H)(kl)^{-s}\left[(y_{k,l})\right]^{p_{k,l}} \tag{3.8}$$

By (3.7) and (3.8), taking limit in the Pringsheim sense, we have $x = (x_k) \in c^2(\Delta_m, M_2 o M_1, p, q, s)$. Observe that in this part of the proof we did not need $\beta \geq 1$. Now, let $\beta \geq 1$ and $x = (x_k) \in c^2(M_1, \Delta_m, q, p)$. Since $\beta \geq 1$ we have $M_2(t) \geq \beta t$ for all $t \geq 0$. It follows that $x = (x_{k,l}) \in c^2(\Delta_m, M_2 o M_1, p, q, s)$ implies $x = (x_{k,l}) \in c^2(\Delta_m, M_1, p, q, s)$. This implies $c^2(\Delta_m, M_2 o M_1, p, q, s) = c^2(\Delta_m, M_1, p, q, s)$.

Theorem 3.8. Let M, M_1 and M_2 be Orlicz functions, q, q_1 and q_2 be seminorms and s, s_1 and s_2 be positive real numbers. Then

(i) $Z^2(\Delta_m, M_1, p, q, s) \cap Z^2(\Delta_m, M_2, p, q, s) \subset Z^2(\Delta_m, M_1 + M_2, p, q, s)$,

(ii) $Z^2(\Delta_m, M, p, q_1, s) \cap Z^2(\Delta_m, M, p, q_2, s) \subset Z^2(\Delta_m, M, p, q_1 + q_2, s)$,

(iii) If q_1 is stronger than q_2, then $Z^2(\Delta_m, M, p, q_1, s) \subset Z^2(\Delta_m, M, p, q_2, s)$,

(iv) If $s_1 \leq s_2$, then $Z^2(\Delta_m, M, p, q, s_1) \subset Z^2(\Delta_m, M, p, q, s_2)$,

where $Z^2 = l_\infty^2, c^2$ and c_o^2.

Proof. (i) We establish it for only $Z^2 = c_o^2$. The rest cases are similar. Let $x = \left(x_{k,l}\right) \in c_o^2(\Delta_m, M_1, p, q, s) \cap c_o^2(\Delta_m, M_1, p, q, s)$. Then

$$P - \lim_{k,l} (kl)^{-s} \left[M_1 \left(q \left(\frac{\Delta_m x_{k,l}}{\rho_1} \right) \right) \right]^{p_{k,l}} = 0 \text{ for some } \rho_1 > 0,$$

$$P - \lim_{k,l} (kl)^{-s} \left[M_2 \left(q \left(\frac{\Delta_m x_{k,l}}{\rho_2} \right) \right) \right]^{p_{k,l}} = 0 \text{ for some } \rho_2 > 0.$$

Let $\rho = \max(\rho_1, \rho_2)$. The result follows from the following inequality

$$(kl)^{-s} \left[(M_1 + M_2) \left(q \left(\frac{\Delta_m x_{k,l}}{\rho} \right) \right) \right]^{p_{k,l}}$$

$$\leq D \left\{ (kl)^{-s} \left[M_1 \left(q \left(\frac{\Delta_m x_{k,l}}{\rho_1} \right) \right) \right]^{p_{k,l}} + (kl)^{-s} \left[M_2 \left(q \left(\frac{\Delta_m x_{k,l}}{\rho_2} \right) \right) \right]^{p_{k,l}} \right\}.$$

The proofs of (ii), (iii) and (iv) follow obviously.

The proof of the following result is also routine work.

Proposition 3.9. If $q_1 \cong (equivalent\ to)\ q_2$, then $Z^2(\Delta_m, M, p, q_1, s) = Z^2(\Delta_m, M, p, q_2, s)$,where $Z^2 = l_\infty^2, c^2$ and c_o^2.

III. DISCUSSION

Difference sequence spaces were first introduced in the literature by H.Kızmaz in 1981. Since then, different structures of difference sequence spaces have been studied by various authors. In this study, we employ a new type of difference sequence spaces..

IV. CONCLUSION

The aim of this study is to define new types of double difference sequence spaces by using Orlicz function and to examine various properties of these spaces.

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Sliding Mode Position Control Application for a DC Motor on Simulink External Mode with Raspberry Pi

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Abstract – In this study, a Simulink-based Sliding Mode Control application was made for a brushed DC motor. The system is controlled by the Raspberry Pi 4B board. The block diagram for Raspberry Pi was prepared using MATLAB's *Simulink Support Package for Raspberry Pi Hardware* tool and loaded onto the board. Thanks to the prepared control panel, all data can be monitored by providing a real-time connection to the Raspberry Pi card via Simulink External Mode. Additionally, it is possible to choose between PID and SMC methods and adjust controller coefficients via the control panel. The system was tested on the experimental setup and successful results were observed.

Keywords – DC motor, Raspberry Pi, Simulink, External mode, Sliding mode control.

I. INTRODUCTION

Direct Current (DC) motors are pivotal components in modern electrical engineering, known for their versatility, reliability, and ease of control. These motors convert electrical energy from a direct current source into mechanical energy, producing rotational motion. This fundamental principle has enabled DC motors to become integral in a diverse array of applications, from small household appliances and toys to larger industrial machines and electric vehicles. DC motors operate based on the principles of electromagnetism. When an electric current passes through the windings of a DC motor, it generates a magnetic field that interacts with the field produced by permanent magnets or additional windings within the motor. This interaction creates a force that causes the motor's rotor to turn, thereby generating mechanical motion. One of the most compelling advantages of DC motors is their ease of speed and torque control. By simply varying the voltage or using pulse-width modulation (PWM) techniques, users can achieve precise control over the motor's performance. This flexibility makes DC motors particularly suitable for applications requiring variable speed and fine control, such as in robotics, precision tools, and automation systems [1–3].

Sliding Mode Control (SMC) is a sophisticated control strategy in the realm of control engineering, renowned for its robustness and ability to handle system uncertainties and external disturbances effectively. Developed initially for variable structure systems, SMC employs a discontinuous control law that forces the system states to reach and then remain on a predetermined sliding surface. This unique approach ensures that the system exhibits desired dynamic behavior even in the presence of model inaccuracies and external perturbations [4,5]. At its core, SMC operates by dividing the control process into two distinct phases: the reaching phase and the sliding phase. During the reaching phase, the control input drives the system state trajectories toward the sliding surface. Once the trajectories intersect this surface, the sliding phase commences, where the control law ensures that the states remain on the surface, effectively nullifying the effects of system uncertainties and external disturbances. This phase is characterized by the system's reduced-order dynamics, which are defined solely by the sliding surface [6].

Simulink is a leading simulation and model-based design environment developed by MathWorks, widely utilized in engineering and scientific fields. As an extension of MATLAB, Simulink provides an intuitive, graphical interface for modeling, simulating, and analyzing multidomain dynamic systems. Its versatile toolset and user-friendly design make it an indispensable resource for engineers and researchers engaged in the development and testing of complex systems [7–11].

Simulink External Mode is a powerful feature within the Simulink environment, enabling real-time interaction and monitoring of models running on external hardware. This capability is particularly valuable for engineers and researchers working on embedded systems and real-time applications, where it is essential to test and tune algorithms directly on the target hardware [12–14]. In External Mode, Simulink establishes a communication link between the host computer (where the Simulink model is developed) and the target hardware (such as microcontrollers, DSPs, or FPGAs). This link allows users to execute their Simulink models on the hardware while maintaining the ability to observe and modify parameters in real-time. The primary benefit of this approach is the ability to validate and fine-tune system performance under actual operating conditions, bridging the gap between simulation and practical implementation [12,15].

The Raspberry Pi, initially introduced as a low-cost, versatile single-board computer, has evolved into a popular choice for a myriad of applications, including its use as a microcontroller. Leveraging its powerful processing capabilities, extensive I/O options, and robust ecosystem, the Raspberry Pi offers a compelling platform for both hobbyists and professionals to develop and implement a wide range of projects that traditionally relied on dedicated microcontrollers [16,17]. One of the key advantages of using the Raspberry Pi as a microcontroller is its extensive General-Purpose Input/Output (GPIO) pins, which allow for direct interfacing with sensors, actuators, and other peripheral devices. This makes it suitable for projects involving home automation, robotics, and IoT (Internet of Things). The GPIO pins, coupled with the vast array of available interfaces like I2C, SPI, and UART, provide the flexibility needed to handle a wide range of hardware components and communication protocols [18,19].

II. DC Motor Position Control System

Voltage, back electromotive force (EMF) and torque equations of DC motor are given in Eq. (1), Eq. (2) and Eq. (3), respectively [20].

$$V_a = E_c + I_a R_a \tag{1}$$

$$E_c = K_1 \phi_f \omega \tag{2}$$

$$T_o = \frac{P_o}{\omega} \tag{3}$$

Where V_a denotes supply voltage, E_c is back EMF, I_a is the current, R_a is the armature resistance, K_1 is a constant, ϕ_f is the field flux, ω is the angular speed and P_o is the mechanical output power.

Block diagram of the Raspberry Pi based DC motor position control system is presented in Fig. 1.

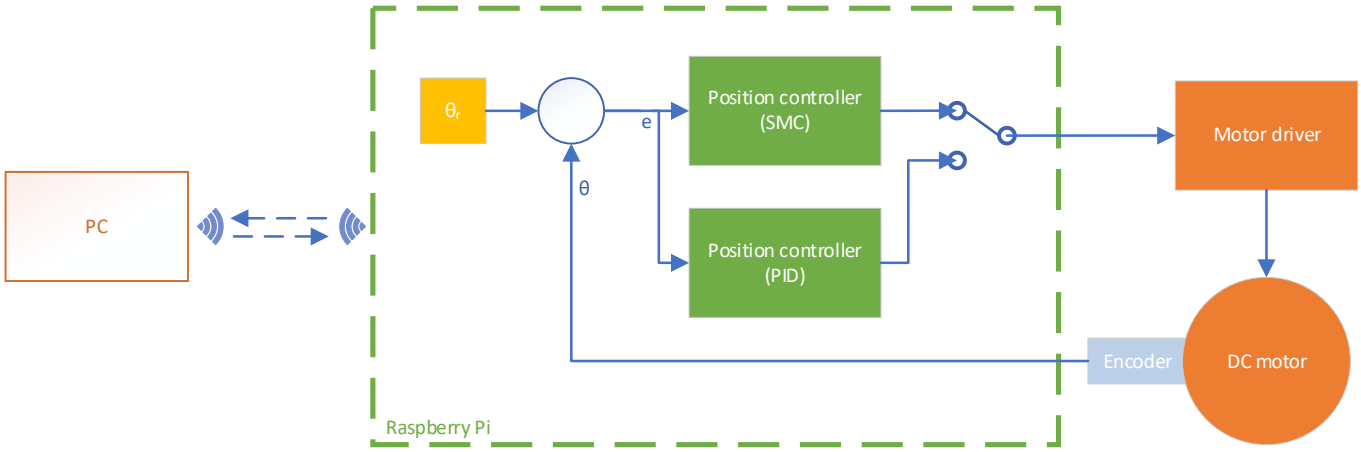

Fig. 1 Block diagram of the system.

In Fig. 1, θ is the actual position, θ_r is the reference position and e is the position error. In this system, PID and SMC position controllers can be selected via switch. PID and SMC controller block diagrams are illustrated in Fig. 2 and Fig. 3, respectively.

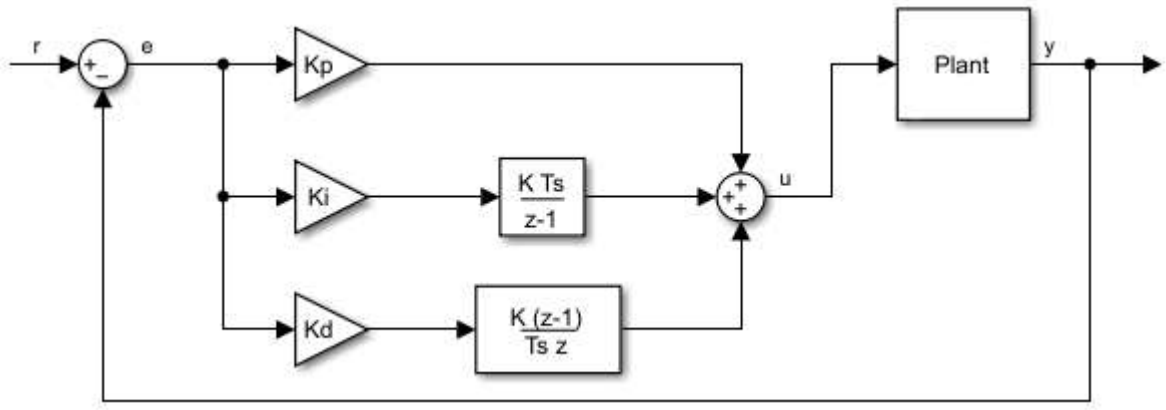

Fig. 2 PID block diagram.

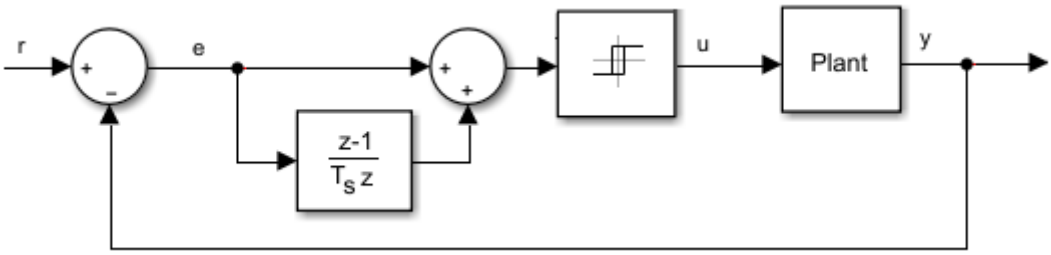

Fig. 3 SMC block diagram.

Here K_p, K_i and K_d are the PID controller gains. e is the error, u is the control signal, y is the output of the plant, r is the reference signal. The experimental setup of the system is presented in Fig. 4. The setup consists of a 12 V brushed DC motor with encoder, a motor driver, a DC power supply and a Raspberry Pi 4B board. A Simulink block diagram is prepared for Raspberry Pi to control the position of DC motor. This block diagram is illustrated in Fig. 5. *Simulink Support Package for Raspberry Pi Hardware* tool of MATLAB is used in this design. Also, a control panel is designed for real-time monitoring and data logging. The designed control panel is given in Fig. 6. h parameter in Fig. 6 represents the hysteresis band gain of SMC.

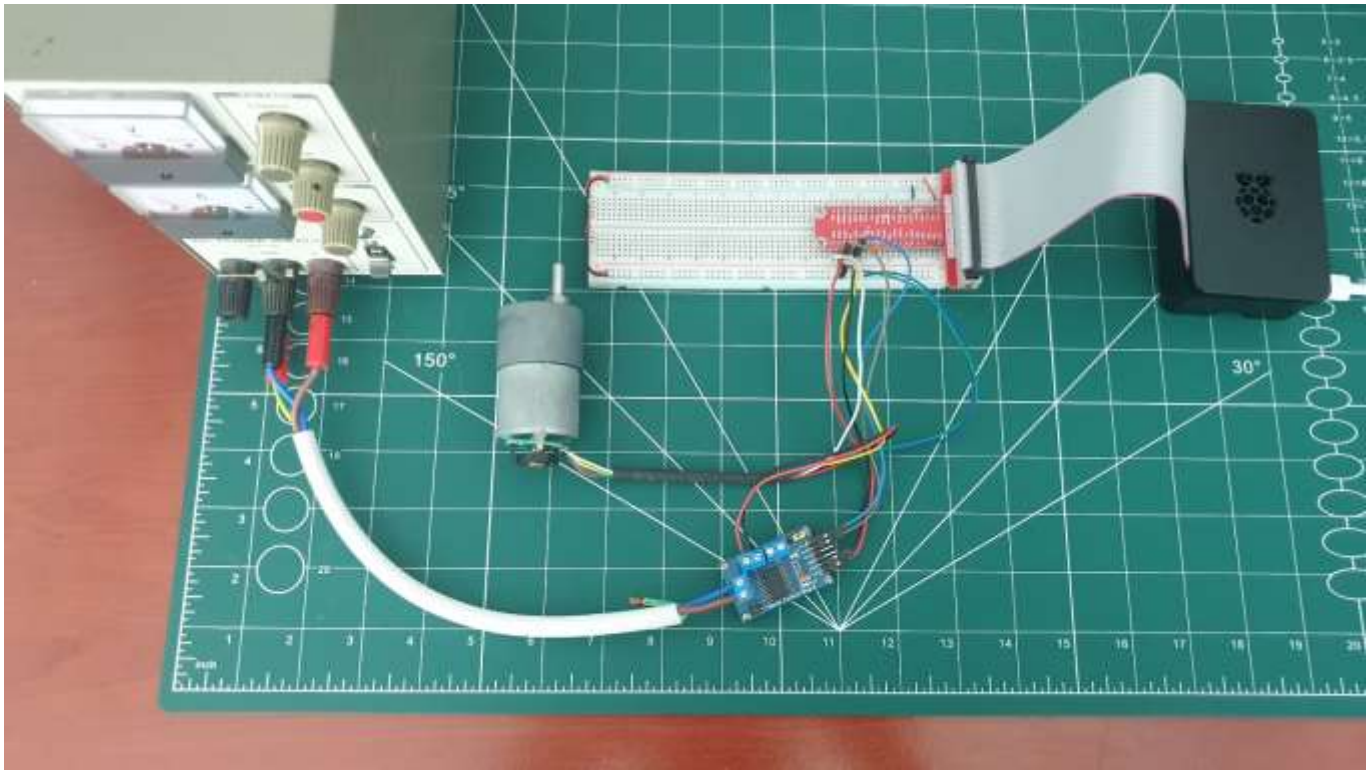

Fig. 4 Experimental setup.

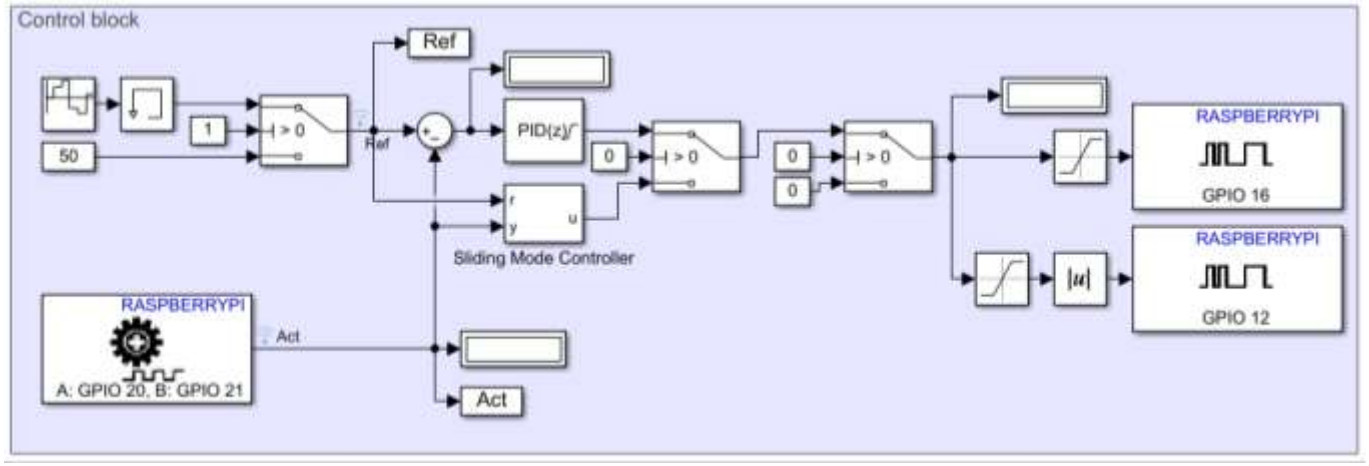

Fig. 5 Simulink block diagram for Raspberry Pi.

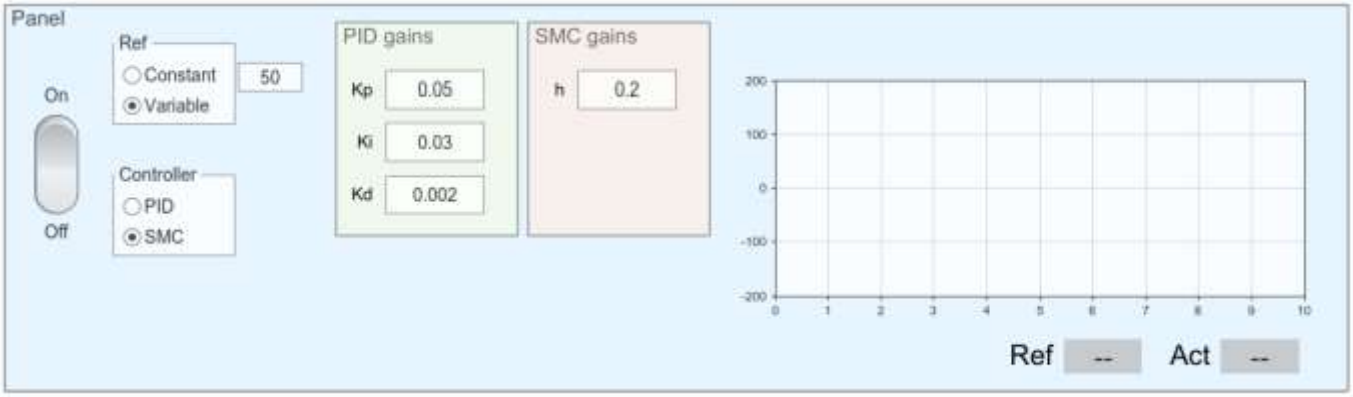

Fig. 6 DC motor position control panel.

III. RESULTS

DC motor position control system is tested on the experimental setup with Simulink external mode. The measured and the reference positions are displayed on dashboard scope. PID and SMC gains can be adjusted on this screen in real-time. Test results are presented in Fig. 7.

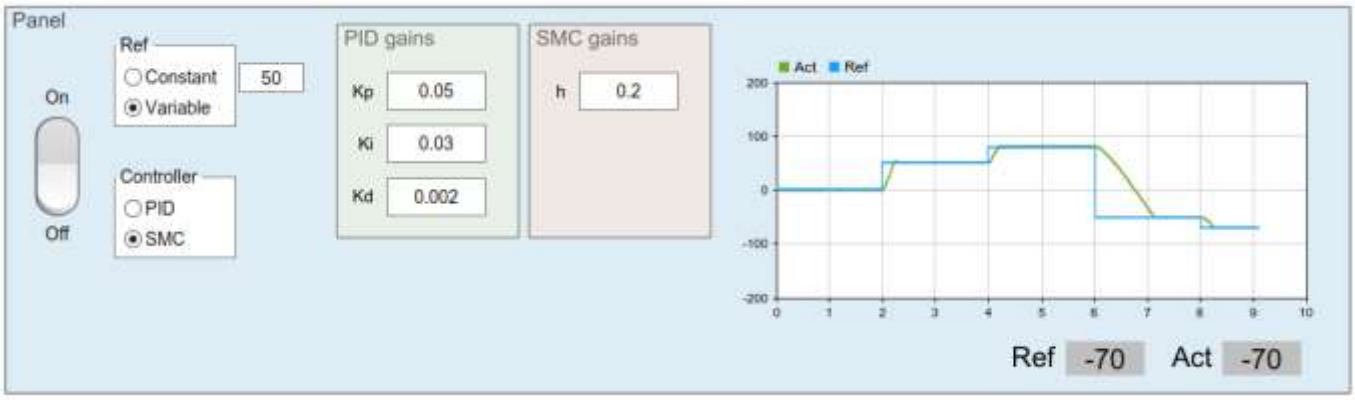

Fig. 7 Test results.

IV. CONCLUSION

In this study, the position of a DC motor is controlled by PID and SMC methods. Raspberry Pi 4B board is used in experimental studies. *Simulink Support Package for Raspberry Pi Hardware* tool of MATLAB is used for preparation of the Raspberry Pi codes. A block diagram and control panel are prepared in the Simulink environment to control and real-time monitor the system. The measured and the reference positions are displayed on dashboard scope. PID and SMC gains can be adjusted on this screen in real-time. The system is tested in Simulink External Mode and the results are seen to be successful.

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Light Gradient Boosting Machine (LGBM) for Daily Solar Radiation Prediction Using Claude3

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Abstract – The goal of this project is to forecast daily sun radiation using the Claude3 platform's Light Gradient Boosting Machine (LGBM) method. Climate modeling and solar energy generation are two examples of applications where solar radiation prediction is essential. To forecast daily sun radiation, a complete dataset of meteorological factors is subjected to the excellent performance and efficiency of the LGBM algorithm. The obtained findings show that LGBM is a very accurate and low-resource computational method for estimating solar radiation. The study advances the fields of climate modeling and renewable energy by demonstrating the utility of LGBM in generating accurate solar radiation forecasts.

Keywords – Light Gradient Boosting Machine (LGBM), daily solar radiation prediction, Claude3 platform, large datasets, solar energy generation, climate modeling.

I. INTRODUCTION

Daily sun radiation prediction is essential for many uses, such as climate modeling, agricultural planning, and solar energy forecasts. Precise forecasts contribute to solar energy optimization and improve photovoltaic system performance. The efficacy and resilience of machine learning approaches, especially Light Gradient Boosting Machines (LGBM), in managing extensive datasets and intricate interactions, have garnered significant interest. This literature review investigates the use of LGBM in daily solar radiation prediction and evaluates its efficacy compared to alternative techniques.

In this work, we investigate the use of the Claude3 platform to use LGBM for daily solar radiation forecast. Claude3 is a complete software framework for precise weather forecasting that combines many modeling methods and meteorological data. The goal of the Claude3 platform's LGBM algorithm is to increase the precision and effectiveness of daily solar radiation forecasts.

This study's main goal is to assess how well LGBM predicts daily solar radiation in relation to climatic factors such temperature, humidity, wind speed, and cloud cover. We train the LGBM model to understand the intricate interactions between these factors and solar radiation by utilising historical meteorological data. There are several benefits of using LGBM to anticipate daily sun radiation. First off, long-term meteorological data analysis is a good fit for LGBM because of its reputation for handling massive datasets with ease. In addition, compared to conventional linear regression models, LGBM can capture non-linear correlations and interactions among variables, enabling more accurate predictions.

Furthermore, by integrating LGBM into the Claude3 platform, other meteorological modelling tools may be seamlessly integrated, improving forecasting capabilities overall. This integration provides a thorough examination of solar radiation patterns and makes it easier to use other meteorological factors.

This discovery aids in the optimisation of solar energy output by precisely forecasting daily sun radiation. These forecasts can help solar power facilities schedule maintenance for times of less solar radiation or modify panel orientation to maximise efficiency. Furthermore, precise estimates of solar radiation improve

climate modelling, enabling researchers to get a deeper understanding of how solar radiation affects different environmental processes. [1] – [3]

II. OVERVIEW

On this work, we examine the daily sun radiation forecast using the Light Gradient Boosting Machine (LGBM) method, which is implemented on the Claude3 platform. In many applications, such as solar energy generating and climate modelling, solar radiation is essential. To estimate daily sun radiation, the Claude3 platform applies the high-performing and efficient LGBM algorithm to a large dataset of meteorological factors. [4]

The main goal of this study is to evaluate how well and accurately LGBM predicts daily sun radiation. The LGBM model gains an understanding of the intricate correlations between solar radiation and many meteorological variables, including temperature, humidity, wind speed, and cloud cover, by using past meteorological data. The Claude3 platform's integration of LGBM offers a smooth and thorough investigation of solar radiation patterns. The purpose of the study is to illustrate the benefits of daily solar radiation forecast using LGBM. First off, long-term meteorological data analysis is a good fit for LGBM because of its reputation for handling massive datasets with ease. In addition, compared to conventional linear regression models, LGBM can capture non-linear correlations and interactions among variables, providing more accurate predictions. [14]

There are other advantages of using LGBM in the Claude3 platform. It improves overall forecasting skills through smooth interaction with other meteorological modelling systems. This integration makes it possible to use more meteorological factors and makes it easier to analyse solar radiation patterns in-depth.

Reliable daily estimates of solar radiation have applications in solar energy production and climate modelling. Based on these forecasts, solar power plants may schedule maintenance for times of less solar radiation and optimise their operations by changing the orientation of their panels. Moreover, precise projections of solar radiation enhance climate modelling, offering a clearer picture of how solar radiation affects different environmental processes. [5]

Important Characteristics of LGBM

- *Histogram-based Decision Tree Learning*: By discretizing continuous features into a set number of bins, this method lowers the complexity involved in determining the best split points.
- *Leaf-wise Growth Strategy*: Grows trees by investigating the leaf with the best loss reduction, leading to deeper trees and perhaps greater accuracy for particular datasets.
- *Efficiency*: It is suited for large-scale data since it is optimised for both speed and memory utilisation.

A. APPLICATIONS OF LGBM IN SOLAR RADIATION PREDICTION

1. *Predictive Accuracy and Computational Efficiency*:
    - It has been demonstrated that LGBM performs better in prediction accuracy and computational efficiency than conventional machine learning models like decision trees and linear regression. For example, compared to support vector machines and neural networks, LGBM performed better in forecasting daily solar radiation and required a substantially shorter training period, according to a research by Liu et al. (2018).
2. *Managing Non-linear connections*:
    - A variety of climatic factors can have an impact on the non-linear connections that are frequently seen in solar radiation data. LGBM is an effective method for predicting solar radiation because it can capture these intricate relationships. According to a research by Yang et al. (2020), cloud cover, temperature, humidity, and solar radiation non-linear relationships were all well-modeled by LGBM.
3. *Robustness to Missing Data*:
    - Handling missing or partial data is a problem in the prediction of solar radiation. Due to its internal handling of missing data and lack of need for significant preprocessing, LGBM is renowned for its resilience to missing values. This property was highlighted in a Zhang et al. (2019) comparative research, where LGBM was trained on datasets with considerable missing values, and nevertheless maintained good accuracy.

4. *Integration with Real-time Systems*:
    - Because of LGBM's efficiency, real-time solar radiation forecasting systems may effectively integrate it. In a project by Kim and Park (2021), for instance, the application of LGBM in a real-time prediction model for a solar farm was proven. Quick and precise forecasts were made, which aided in the optimisation of energy production and storage.

III. Analysis Of Comparative Performance

1. *LGBM vs. more Boosting Algorithms*: XGBoost and CatBoost are two more boosting algorithms that have been examined in studies with LGBM. In general, LGBM has been seen to provide comparable or even better performance, especially when it comes to speed and memory economy. Across a variety of solar radiation datasets, LGBM routinely surpassed XGBoost in terms of training time and predicted accuracy in a thorough study conducted by Chen et al. (2022). [4]

2. *LGBM vs. Deep Learning Models*: Deep learning models, such recurrent neural networks (RNNs) and convolutional neural networks (CNNs), have demonstrated promise in the prediction of solar radiation, however they frequently necessitate significant computing resources and extended training periods. However, LGBM offers an excellent trade-off between accuracy and efficiency, which makes it the better option in many real-world scenarios. According to a research by Huang et al. (2023), LGBM had a far reduced computational cost while achieving accuracy levels equivalent to CNNs. [5]

IV. METHODOLOGY

1. **Data collection**: Get a thorough dataset of historical weather conditions, such as sun radiation, wind speed, humidity, temperature, and cloud cover. These variables ought to cover a long enough time frame to record yearly and seasonal fluctuations.
2. **Preparing data**: Take care of outliers, inconsistent data, and missing values to clean up the dataset. Extraction of pertinent characteristics, including the day and time of day and the weather patterns, is the first step in feature engineering. To make sure that every variable has a same scale, normalise the data.
3. **Dividing the Collection**: Separate the training and testing sets from the dataset. The LGBM model will be trained on the training set, and its performance will be assessed on the testing set.
4. **Model Training**: Use the Claude3 platform to apply the LGBM algorithm. Utilising the training dataset and the climatic variables as input and sun radiation as the target variable, train the LGBM model. To enhance the model's performance iteratively, apply the gradient boosting approach.
5. **Model Validation**: Use the testing dataset to assess the trained LGBM model. To evaluate the model's predictive accuracy for daily solar radiation, calculate performance measures such as mean absolute error (MAE), root mean square error (RMSE), and coefficient of determination (R-squared).
6. **Model Optimisation**: To maximise the model's performance, adjust its hyperparameters. To experiment with alternative combinations of hyperparameters, such learning rate, maximum tree depth, and number of boosting rounds, use strategies like grid search or random search.
7. **Model Deployment**: After optimisation, make the LGBM model available for usage in the Claude3 platform. This makes it possible to anticipate daily sun radiation in real time by entering climatic data.
8. **Performance Evaluation**: Track the deployed LGBM model's performance over time. Make regular comparisons between estimated and measured solar radiation to evaluate its accuracy and dependability.
9. **In contrast to baseline models**: To assess the LGBM model's superiority in daily solar radiation prediction, compare its performance with alternative baseline models, such as support vector regression or linear regression.
10. **Sensitivity Analysis**: To determine how different climatic factors affect the forecast of solar radiation, do sensitivity analysis. Identify the variables that most significantly affect the LGBM model's accuracy.
11. **Interpretation and Visualisation**: Analyse the LGBM model's output and see how the estimated values of solar radiation correspond to the actual data. This facilitates comprehension of the daily solar radiation patterns and trends as well as how they relate to meteorological factors.

12. **Robustness Testing**: To assess the model's performance in various circumstances, such as severe weather or alterations in the quality of the data, do robustness testing. Examine if the LGBM model continues to be accurate and reliable in difficult circumstances. [9] – [11]

With this approach, we can efficiently forecast daily sun radiation using the Claude3 platform's LGBM algorithm. For a variety of applications in solar energy generation and climate modelling, the combination of LGBM's high performance and efficiency with Claude3's extensive analytical capabilities guarantees accurate and dependable forecasts.

A. MATHEMATICAL MODELING OF LGBM

1) Framework for Light Gradient Boosting: A class of machine learning methods known as gradient boosting machines (GBMs) constructs an ensemble of decision trees in a sequential manner. Every tree makes an effort to fix the mistakes made by its predecessors. [1]
The prediction function F(x) is built in a stage-wise manner:

$$F(x) = F_M(x) = \sum_{m=1}^{M} f_m(x)$$

Where **fm(x)** is a weak learner (decision tree) at stage m**m**, and M**M** is the total number of trees.

2) Objective Function: The goal of regression tasks is to reduce the loss function, which is frequently the Mean Squared Error (MSE):

$$L(y, F(x)) = \frac{1}{n} \sum_{i=1}^{n} (y_i - F(x_i))^2$$

where y_i is the true value, and $F(x_i)$ is the predicted value for instance i.

Gradient Descent: In each iteration mm, a new tree fm(x) is added to the model to reduce the residuals (errors):

$$F_m(x) = F_{m-1}(x) + \gamma_m f_m(x)$$

where γm is the learning rate, a small constant that controls the contribution of each tree.
The new tree fm(x) is fit to the negative gradient of the loss function:

$$r_{im} = - \left[\frac{\partial L(y_i, F(x_i))}{\partial F(x_i)} \right]_{F(x)=F_{m-1}(x)}$$

B. PSEUDOCODE

The pseudocode provides a basic framework for implementing LGBM for daily solar radiation prediction. Adjustments can be made based on the specific dataset and requirements.

```
# Import necessary libraries
import lightgbm as lgb
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error

# Load the dataset
data = pd.read_csv('solar_radiation_data.csv')

# Preprocess the data
# Assuming the dataset contains columns: 'temperature', 'humidity', 'cloud_cover', 'historical_radiation',
'solar_radiation'
features = ['temperature', 'humidity', 'cloud_cover', 'historical_radiation']
target = 'solar_radiation'

X = data[features]
y = data[target]

# Split the data into training and testing sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)

# Create the LightGBM dataset
train_data = lgb.Dataset(X_train, label=y_train)
test_data = lgb.Dataset(X_test, label=y_test, reference=train_data)

# Set the parameters for LGBM
params = {
    'objective': 'regression',
```

```
    'metric': 'rmse',
    'boosting_type': 'gbdt',
    'num_leaves': 31,
    'learning_rate': 0.05,
    'feature_fraction': 0.9
}

# Train the model
num_round = 100
bst = lgb.train(params, train_data, num_round, valid_sets=[test_data], early_stopping_rounds=10)

# Make predictions on the test set
y_pred = bst.predict(X_test, num_iteration=bst.best_iteration)

# Calculate the mean squared error
mse = mean_squared_error(y_test, y_pred)
rmse = np.sqrt(mse)
print(f'Root Mean Squared Error: {rmse}')

# Save the model
bst.save_model('lgbm_solar_radiation_model.txt')

# Load the model (for future predictions)
bst = lgb.Booster(model_file='lgbm_solar_radiation_model.txt')

# Predict on new data
new_data = pd.DataFrame({
    'temperature': [25.0],
    'humidity': [60.0],
    'cloud_cover': [20.0],
    'historical_radiation': [500.0]
})
new_prediction = bst.predict(new_data)
print(f'Predicted Solar Radiation: {new_prediction[0]}')
```

1. **Import Libraries:** Import the necessary libraries for data handling (pandas, numpy), model training (lightgbm), and evaluation (sklearn).
2. **Load Dataset:** Load the dataset which contains historical data on solar radiation and other relevant meteorological features.
3. **Preprocess Data:** Select the features and target variable. In this case, features might include temperature, humidity, cloud_cover, and historical_radiation.
4. **Train-Test Split:** Split the data into training and testing sets to evaluate the model's performance.
5. **Create LightGBM Dataset:** Convert the training and testing data into LightGBM dataset format.
6. **Set Parameters:** Define the parameters for the LightGBM model. These include the objective (regression), metric (RMSE), boosting type (GBDT), number of leaves, learning rate, and feature fraction.
7. **Train Model:** Train the LightGBM model using the training data. Use early stopping to prevent overfitting.
8. **Make Predictions:** Predict the solar radiation on the test set and calculate the Root Mean Squared Error (RMSE) to evaluate the model.
9. **Save and Load Model:** Save the trained model for future use. Demonstrate loading the model and making predictions on new data.

C. INPUT

Fig.1. Climatic Data Chart -1

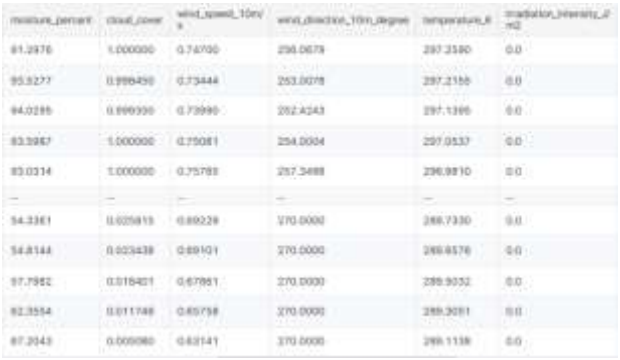

Fig.2. Climatic Data Chart -2

rainfall_m	wind_speed_100m/s	wind_direction_100m_degree
9.933500e-03	1.1432	270.0000
9.142200e-03	1.2091	269.8118
9.114800e-03	1.1972	269.2202
9.496700e-03	1.1258	270.0000
9.933500e-03	1.0141	270.0000
...	...	...
0.000000e+00	0.0000	270.0000
0.000000e+00	0.0000	270.0000
4.280000e-77	0.0000	270.0000
8.020000e-77	0.0000	270.0000
7.750000e-77	0.0000	270.0000

Fig.3. Climatic Data Chart -3

D. OUTPUT

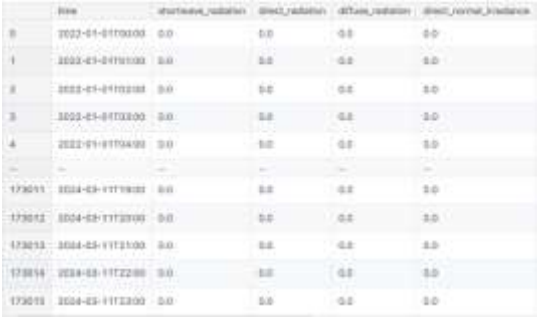

Fig.4. Radiation Analysis

Fig.5. Positional Radiation Result

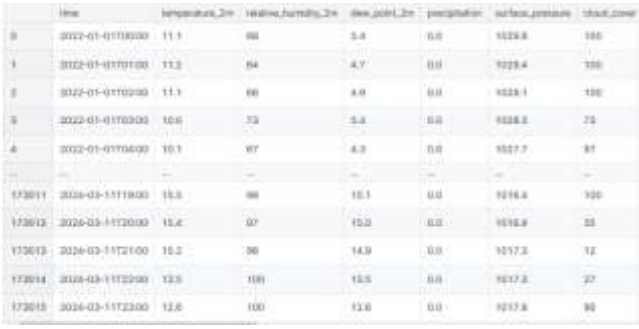

Fig.6. Time and Climatic Condition Result - 1

Fig.7. Time and Climatic Condition Result – 2

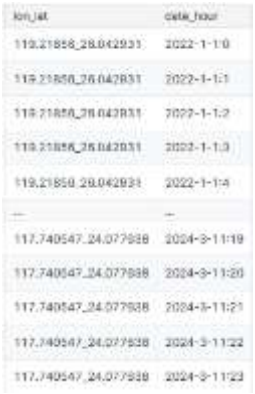

Fig.8. Time and Radiation Position Result

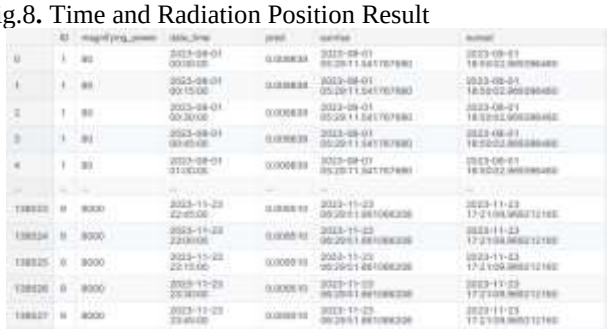

Fig.9. Sunrise and Sunset Prediction Data

V. CONTRIBUTION

The science of solar energy forecasting has benefited greatly from the application of Light Gradient Boosting Machines (LGBM) for daily solar radiation prediction. Here are a few significant contributions made in this article for LGBM in this regard:

1. Increased Accuracy: When it comes to daily solar radiation prediction, LGBM outperforms conventional machine learning algorithms. Predictions have become more accurate and dependable as a result of its capacity to manage large-scale information, handle non-linear connections, and recognise intricate patterns in the data.
2. Meteorological Variable Integration: The forecast model can incorporate a range of meteorological data, including wind speed, humidity, temperature, and cloud cover, thanks to LGBM. By taking

into account these variables, LGBM improves the prediction accuracy of solar radiation by capturing the impact of meteorological circumstances on solar radiation levels.

3. Effective Feature Selection: The most pertinent meteorological variables for prediction may be automatically identified thanks to an inbuilt feature selection process in LGBM. More accurate predictions are produced as a result of this feature selection process, which also lowers dimensionality, boosts model efficiency, and removes superfluous or unnecessary information.
4. Scalability and Speed: Large-scale datasets are easily handled by LGBM, which makes it appropriate for processing large-scale solar radiation data sets. Its parallel computing capabilities and optimisation methods allow for quicker model inference and training, which makes it possible to estimate solar radiation in real-time or almost real-time.
5. Practical Applications: Predicting daily sun radiation using LGBM has practical ramifications for a number of industries. It facilitates effective energy production and grid integration by helping to optimise the planning and operation of solar energy installations. Furthermore, it facilitates decision-making procedures in the management of renewable energy, allowing for improved resource allocation and energy yield calculation.

LGBM has made significant contributions to the field of solar energy forecasting by offering scalable, accurate, and efficient models for predicting daily solar radiation. The accuracy and application of solar radiation predictions have improved due to its integration of climatic factors and feature selection capabilities, which has eventually supported the development and use of solar energy as a dependable and sustainable power source.

VI. CHALLENGES

There are a number of benefits to using the Light Gradient Boosting Machine (LGBM) algorithm in the Claude3 platform to anticipate daily sun radiation, but there are definite drawbacks as well. Among these difficulties are:

1. **Data Quality**: The quality of the input data has a major impact on the accuracy and dependability of forecasts made about solar radiation. Meteorological data that is inadequate or inaccurate might have a negative impact on the LGBM model's performance. To overcome this difficulty, it is imperative to implement thorough data cleaning and validation procedures to ensure data quality.
2. **Variable Interactions**: A number of meteorological factors, including temperature, humidity, wind speed, and cloud cover, can affect solar radiation. It is difficult to comprehend the intricate relationships and interdependence between these factors. The LGBM algorithm makes an effort to capture these interactions; nevertheless, in order to maximise its effectiveness, meticulous feature engineering and model tweaking are required.
3. **Generalisation**: To effectively estimate solar radiation in data that has not yet been seen, the LGBM model must have good generalisation. One possible issue is overfitting, which occurs when the model performs well on training data but badly on fresh data. To guarantee the model's capacity for generalisation, regularisation strategies including early halting, feature selection, and hyperparameter adjustment are essential.
4. **Computing Resources**: LGBM is a strong algorithm that effectively manages big datasets. On the other hand, the more computer resources needed, the larger and more complicated the dataset. To train and run the LGBM model on the Claude3 platform, a sufficient amount of processing power is required, particularly when working with large amounts of historical meteorological data.
5. **Interpretability**: Although LGBM is quite good at making predictions, it might not be as interpretable as more straightforward models like linear regression. It might be difficult to understand the underlying causes of the forecasts. Although there may be a trade-off between interpretability and accuracy, methods like feature significance analysis and partial dependency plots can be useful in gaining understanding of the behaviour of the model.
6. **Model Maintenance**: To guarantee that the LGBM model's functioning is dependable throughout time, constant observation and upkeep are necessary. For the model to remain accurate and efficient, it might need to be updated and retrained on a regular basis as new data becomes available and the environment changes.

A multidisciplinary strategy integrating knowledge of software engineering, meteorology, and machine learning is needed to address these issues. Through comprehension and surmounting these obstacles, the utilisation of LGBM in the Claude3 platform for the purpose of daily solar radiation forecasting may produce precise and significant understandings for solar energy production and climate modelling.

VII. CONCLUSION

In summary, there is great potential for renewable energy and climate modelling with the application of the Light Gradient Boosting Machine (LGBM) algorithm in the Claude3 platform for daily solar radiation forecast. We are able to anticipate daily solar radiation with high accuracy by utilising the power of LGBM and historical meteorological data. This allows for enhanced solar energy generation and a deeper comprehension of the environmental effects of solar radiation. We have demonstrated via this research the benefits of LGBM in effectively managing vast and complicated datasets. It differs from conventional linear regression models in that it may capture non-linear connections and interactions among meteorological variables. Through the integration of LGBM into the Claude3 platform, we can easily add more meteorological modelling tools and improve forecasting performance overall. We must, however, also be aware of the difficulties this strategy presents. Among the most important things to take care of, are data quality assurance, comprehension of variable interactions, preservation of generalisation, and computing resource management. The trade-off between interpretability and accuracy might also make it difficult to comprehend the underlying causes of the forecasts.

Notwithstanding these difficulties, there is a lot of room for advancement in solar energy generating and climate modelling with the use of LGBM in Claude3. Precise forecasts of solar radiation for each day enable solar power plants to operate at maximum efficiency, producing more electricity. Additionally, it aids in climate modelling efforts by shedding light on how different environmental processes are affected by solar radiation.

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Prospective Middle School Mathematics Teachers' Experiences of Verbal Description for Students with Visual Impairments

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Abstract – in the current study, prospective middle school mathematics teachers' experiences of verbally describing mathematical expressions to students with visual impairments are examined. The participants of the study designed in the case study were eight prospective middle school mathematics teachers. The participants prepared presentations on the identified mathematics learning outcomes and carried out teaching practices on an online educational platform designed for students with visual impairments. The results indicated that the participants demonstrated inadequate abilities to verbally describe mathematical symbols, lacked awareness of the necessity to describe the Latin alphabet, and exhibited difficulties in describing equations. Furthermore, it was established that the participants' verbal describing skills of the relationship between problem comprehension, interpretation and strategy selection were enhanced by the provision of feedback from the researcher and individuals with visual impairments. Therefore, the results obtained are as follows: symbol description difficulties, inadequate description, caesura, detailed description, and simple description. According to the results of the research, suggestions are presented to mathematics teachers and prospective mathematics teachers about verbal describing mathematical expressions with a focus on mathematical contents.

Keywords – Students with visual impairments; Prospective middle school mathematics teachers; Verbal description; Audio description

I. INTRODUCTION

Students with visual impairments are subject to educational assistance practices and inclusive education according to criteria such as their level of impairment, disability and educational background [1]. The design and implementation of inclusive practices take place in teachers' professional knowledge and skills [2]. These differentiations include designing tactile materials for students with visual impairments, adjusting font style or size, and appealing to senses other than sight, and description [3]. The verbal description can take place simultaneously with the tactile materials or only with screen reader programs or audio recordings. It is important to describe content with discourses, especially in educational practices where hybrid learning environments are gaining importance. Indeed, the increasing prevalence of multimedia presentations and textbooks in classrooms is a growing barrier to accessibility for students with visual impairments [4]. Also, in contexts with symbolic and visual elements, such as mathematics, discourses require the mathematical language to be presented accurately and comprehensibly [5]. Thus, the skill of mathematics teachers to describe mathematical expressions by considering variables such as alphabets (Latin and Braille), symbols and equations becomes increasingly important. The conventional response to this issue is to furnish a description of the visual component [6]. Indeed, to provide a mathematical description, it is necessary to utilise a mathematical language that is capable of representing symbols (such as fractions), graphs and diagrams [7].

According to [8], audio description "should be clear, objective and concise, directand appropriate language according to the target audience(children, young, adult)" (p.10). To fully comprehend and appreciate these events, it is essential to consider the role of visual input and the ability to integrate visual, auditory, and tactile information alongside cognitive skills. One method of enhancing the experience of visual events for the blind or visually impaired population is the use of audio descriptions. Audio description allows blind or visually impaired individuals to access visual content such as movies, television shows, and museum exhibitions. The audio description process begins with the delivery of a descriptive narration, which is a spoken account provided alongside the existing soundtrack or dialogue of a visual event. However, verbal description is arguably the most ancient and pervasive method of facilitating access to the world for individuals who are visually impaired [9].

In this context, teachers of students who are visually impaired should describe items in the classroom, describe what they are doing as they teach a lesson, and describe illustrations in textbooks they are reading aloud. Unfortunately, the lack of formal methods or standard techniques means that few teachers are able to instruct their students on how to describe in such a way. It is imperative that a set of guidelines for formal description be established for the purpose of providing a framework for the development of formal curricular material. Therefore, this study examines the prospective middle school mathematics teachers' experiences of verbally describing mathematical expressions to students with visual impairments. Accordingly, the research question is as follows: "How do prospective middle school mathematics teachers describe mathematical content to students with visual impairments?"

II. MATERIALS AND METHOD

The participants of the study designed in the case study were eight prospective middle school mathematics teachers. Each participant represents a case in this study, with the cases involving the analysis of discourses in the context of their descriptive experiences [10]. Participants were determined based on the criteria of being a senior student, achieving the Teaching Practice I, Special Education and Inclusion and mathematical concept teaching courses. The participants prepared presentations on the identified mathematics learning outcomes and carried out teaching practices on an online educational platform designed for students with visual impairments. The practices were carried out simultaneously with the participation of students with visual impairments and were recorded. The participants were tasked with designing two individual presentations on the subject of rational numbers, exponents and radicals. These presentations were to include content on the definition of the concepts in question, as well as information on the properties and problem-solving techniques associated with them. Once the participants had completed their presentations, the researcher proceeded to provide explanations for the symbolic descriptions and to review each mathematical expression in the presentations with the participants. Each presentation was delivered as synchronous distance education via an online platform for two hours. The presentations designed by the participants and the video recordings were the data collection tools of the study and were analysed by content analysis. Examples for content analysis are presented in Table 1.

Table 1. Examples of data analyses

Theme	Explanation	Example
caesura	a break in the flow of sound usually in the middle of a line of verse; a pause	brief silence in the description to emphasise transitions between terms and line differences in the symbolic structure (such as numerator and denominator, exponential and radical expressions)
Detailed description	Provide an explanation of the visually delimited terms associated with mathematical symbols, as well as their written representation in lines.	it is necessary to specify/describing the degree of the root and the radicand, beginning and end, numerator-denominator-fraction vinculum for rational numbers

Each participant was observed for a total of four courses. The transcripts were presented to the participants for their approval. In addition, the participants' statements were extensively included in the text, with the aim of providing a detailed and comprehensive account of the transfer of findings. This methodology was employed in order to enhance the trustworthiness of the research [11].

III. RESULTS

The most striking results related to exponential expressions were collected under the theme of the *symbol description difficulties*. The participants encountered difficulties in symbolically describing the concepts of base and exponent in exponential expressions.

P1: In the case of an exponential expression, the exponent is written in the upper right corner of the base.

As in P1's discourse, it was determined that P1 did not include descriptions such as the size of the base and exponent font size or the upper corner of a number. In addition, P1, P4 and P7 did not describe and skipped these examples during the lesson despite the examples of powers of negative rational numbers in the presentation. P2 did not describe the brackets when he described $(-11)^0$.

P6 had difficulty in describing examples where the exponent is negative and although the students asked questions, she described only two example expressions and avoided solving different examples. Instead, P6, while describing the properties of exponents, i.e. generalisations, frequently stated that he could describe them better with examples and described examples with numbers. Therefore, the participants' *symbol description difficulties* led to a tendency to avoid descriptions.

The most striking finding is that P1 did not include discourses such as the beginning and end of the exponential expression in his discourse about exponential expression. While presenting only the expression $1^{-14}=1$ as an example, he included the expression 'end of exponential expression'. Thus, the theme of *inadequate description* is another frequent conclusion. As a result of P1's inadequate description of exponential expressions, a student with visual impairment asked the question "Are we multiplying denominators here?" in example $3^4.5^4=15^4$. Thus, it was revealed that the student did not understand the symbolic structure and terms of base and exponent in exponential expressions.

Inadequate description of terms related to exponential expressions without giving details such as beginning and end makes it difficult to understand some problems. For example, since P8 did not describe the exponent expression for problem $5.3^{15}-2.3^{15}=?$ in such a way as to indicate that the exponent only affects the number 3 or did not cease, the students first gave an incorrect answer. After the second description, the students determined the correct answer. Here, the *caesure* is noteworthy as a tendency to emphasise the transition between terms by silencing for a second in the description. However, some participants did not follow the principles of description when describing the exponential expression as '2 [caesure] in the exponent of 3'.

The *inadequate description* is also the main result for radical expressions. P2 frequently forgot the descriptions of 'the beginning of the root' and 'the degree (index) of the root' while describing examples related to radical expressions and started to describe them again. Furthermore, P2 frequently made errors in the order of the beginning of the root and the degree of the root. P1, on the other hand, employed discourses such as 'inside-outside' for the radicands. However, this description was not perceived by the students. In P5's description "it is the degree we write on the upper left part of the root", symbolic writing was not perceived by the students because it was not described. P7's practices based on *inadequate description* caused significant misconceptions and difficulty in comprehension for students. For example; 'x over m and degree n in the root' and then describing the degree of the root caused misconceptions and difficulties for students. The fact that P7 did not include the expression 'end of the root' in descriptions caused them not to perceive the expression $b.\sqrt[n]{a} + c$. Students who could not understand the degree had the idea that 2 was a multiple, despite the description 'square root' for the expression $\sqrt[2]{3}$ almost at the end of the lesson. Students warned P7 by emphasising that they had different perceptions due to the lack of description of multiplication or inadequate description in the radical expression.

The *symbol description difficulties* were also determined for the participants in the radical expressions. P4 had difficulty in describing the relationship between the exponent of radicand and the degree of the root.

For example; P4 could not explain the expression $\sqrt[5]{-32} = -2$ and therefore had the *symbol description difficulties*.

The general difficulty of some of the participants in the practices related to rational numbers is the *inadequate description* for the numerator and denominator descriptions. P2 while describing the numerator and denominator in division with exponents, 'the exponent of the lower number was passing as minus to the upper number' was far from symbolic language and remained meaningless. Furthermore, P2 did not specify the numerator and denominator when describing rational numbers, only the fraction line. Since the numerator and denominator descriptions were not made for the problem of $\frac{\sqrt{2}-\frac{1}{\sqrt{2}}}{\sqrt{2}+\frac{1}{\sqrt{2}}}$ =?, students thought that simplification could be done directly. In this case, the students asked her to describe it again. P1 did not draw attention to the numerator and denominator discourses while describing the rational number.

Detailed descriptions were a theme that emerged frequently, especially in the second round of participants' courses. Both positive and negative reflections of *detailed description*s on the comprehension of students with visual impairments were determined. *Detailed descriptions* were useful in the steps of understanding symbolic language and understanding problems. However, in the examples where the number of symbols increased, i.e. the number of terms increased, students had difficulty in memorising the terms due to the descriptions. For example, in the course of P3, who encountered similar student difficulties, discourses such as 'fraction beginning-end' or 'numerator and denominator' were abandoned and descriptions were made with the discourse 'a divided by b' based on *simple descriptions*. However, P3 used his voice as a means of emphasis between each term and for the numerator and denominator. Nevertheless, *simple descriptions* led to errors in complex problems. For example, while P3 continued to describe the expression as decided together with the students, it was revealed that 'numerator and denominator' should be specified for the expression $\frac{7}{\frac{4}{3}}$. Because the students thought that the denominator of the whole number in the numerator was not described or they forgot it. Similarly, students wrote the mathematical expression $\left(\frac{3}{4}-\frac{5}{2}\right)\times\left(\frac{-3}{4}\right)\div\frac{1}{2}$ and considered $\frac{1}{2}$ as the denominator of the fraction with *simple descriptions*. In this case, P3 had to emphasise that there is no fraction vinculum.

IV. DISCUSSION

Inadequacies and difficulties were identified in prospective middle school mathematics teachers' description skills for students with visual impairments. However, it can be said that they improve in these skills with simple experiences and feedback. As a result of the feedback given for the description of the symbols in the presentations of the prospective mathematics teachers and the guidance of the students with visual impairments, productive courses were continued. In the context of the scope of the research, the results regarding the description skills of prospective mathematics teachers were symbol description difficulties, inadequate descriptions, caesura, detailed descriptions, and simple descriptions. These results point to two key points: the detailed descriptions of the mathematical language and the use of simple language in the descriptions.

It is clear that mathematical language is a complex set of symbols for individuals with visual impairments (see [5]). According to the results, it is important to describe this symbolic structure in detail, to increase the emphasis with caesure and to prefer a simple expression in the description. Prospective middle school mathematics teachers had difficulty in achieving these requirements for the concepts of radical and exponential expressions. These difficulties are the result of their lack of experience. However, fundamentally this result is the product of the prospective mathematics teachers' failures to analyse which qualities should be emphasised when describing symbols or the students' inability to comprehend the description. Indeed, the results frequently revealed symbol description difficulties and inadequate description.

Conclusions for rational numbers are the necessity of caesura, detailed description, and simple description due to intertwined operations and symbolic structures. Indeed, in rational numbers, it is important to comprehend the broad perspective through simplification as well as detailed description (see [7]).

Therefore, different strategies can be employed when describing stepped operations such as rational numbers or mathematical expressions with a lot of terms. According to the strategies used by prospective middle school mathematics teachers, detailed descriptions can be provided or a simple language can be used as a result of the agreement to be reached with the students (such as not including numerator and denominator discourses in rational numbers). However, when employing the second strategy, for example with a lot of terms or when dealing with an example different from the familiar examples, the detailed descriptions followed by the simple descriptions may increase comprehension.

The caesura is important for recognising transitions between terms in all mathematical expressions regardless of concept, for indicating the terms affected by degrees in exponential or radical numbers, for distinguishing multiple structures in rational numbers. These results are among the description criteria frequently emphasised in the literature (see [5], [7]). In addition, it can be suggested that prospective mathematics teachers and teachers should master the description of mathematical symbols for students with visual impairments, make practices and focus on student feedback to achieve a simple and powerful expression in the description.

V. CONCLUSION

The main conclusions of the study can be categorised as problems and improved qualities in prospective middle school mathematics teachers' description skills as follows: symbol description difficulties, inadequate description, caesura, detailed description, and simple description. According to these results, prospective mathematics teachers need to describe symbols, use language based on detailed and simple narratives, and increase emphasis via the caesura.

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The Harmful Values Framing Mathematical Concept Definitions

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Abstract – The aim of this study is to reveal the harmful values that prospective middle school mathematics teachers adopt when constructing mathematical concepts. The participants of the study, which was designed in accordance with the phenomenological design, were five prospective middle school mathematics teachers. The individual interviews with the participants were recorded on camera and the data were subsequently obtained. During the interviews, the participants were questioned about fundamental concepts such as fractions, sets, triangles, and polygons, and their informal explanations regarding the various representations of these concepts. The most frequently identified harmful values in the participants' understanding of concept definitions and misconceptions are mathematical representations, mathematical terms, relevance with daily life, and pre-knowledge. The elements that need to be eliminated in the shaping of mathematical concepts were revealed based on the harmful values that were revealed in the results. Thus, the suggestions were provided as a framework for teaching practices in the construction of mathematical concept knowledge.

Keywords – Harmful values, Mathematical concept definitions, Prospective middle school mathematics teachers

I. INTRODUCTION

The mathematics educational values influence the cognitive structuring of individuals, as well as their affective responses [1]. The values adopted by individuals can influence their interest in mathematics, their well-being, and the learning process. The performance of this role entails the involvement of cultural, institutional, teacher and student values and decision-making processes [2]. Therefore, the comprehension of mathematical concepts, problem-solving, discussion, or relevance to daily life emerge as outcomes of mathematical values. However, the outcomes considered valuable or values adopted by individuals may lead to challenges or misconceptions in the structuring of conceptual knowledge and the individual's comprehension. These values, defined as harmful values, are implicit values that have deep roots in mathematical understanding and skills [3].

The values are defined as any core beliefs, standards, principles, or norms that an individual has judged to be important or worthy in their life [4]. In this study, values are adopted as encompassing all beliefs about the importance and worth of mathematics education. Indeed, [1] highlighted the conative structure of values at the intersection of cognition, affect and behavior. In this sense, values are regarded as factors that play key roles in generating better actions. In fact, research and theories on values and valuing tend to positive relationships, relationship importance and perceptions [5]. Therefore, it can be seen that negative values are not highlighted in the literature except for a few studies (see [6], [3], [7], [8]). [6] evaluated the negative expressions of participants for each value category indicator as not belonging to this category. [8] regarded negative affective features as indicators of negative values. Therefore, bad and harmful values were emphasized as social and ethical values and drew attention to values such as discrimination and prejudice that are harmful to society [9]. It is therefore important to remember that the values that emerge in the classroom are not always positive [10]. The harmful values that arise in the process of learning

concepts and that affect comprehension are the best examples of these negative values. Therefore, the current study aims to determine the harmful values that prospective middle school mathematics teachers have when constructing definitions and representation types of mathematical concepts. In this context, the research question is 'What are the harmful values underlying the prospective middle school mathematics teachers' comprehension of mathematical concepts?'

II. Materials and Method

This research that aims to examine the participants' conceptions and thoughts was designed as a phenomenological design [11]. The participants of the study were five prospective middle school mathematics teachers. Participants were selected using a criterion sampling approach. Accordingly, the participants had completed the Fundamentals of Mathematics I and II courses and the Communication in the Mathematics Classroom course. Thus, they possess a rudimentary understanding of the definitions and representation types of mathematical concepts. In this way, it is possible to obtain a rich source of information from the participants on the phenomena being studied. The individual interviews with the participants were video-recorded and the data were subsequently analysed. During the interviews, the participants were questioned about fundamental concepts such as fractions, sets, triangles, and polygons, and their informal explanations regarding the various representations of these concepts. The data were analysed using the content analysis method. The study by [3] was considered when determining the indicators of harmful values from the participants' statements. Accordingly, an example of data analysis is presented in Table 1.

Table 1. Examples of data analysis

Values	**Codes**	**Indicators from Participant's Discourse**
Mathematical representation	Graphical representation	P2: a straight line to infinity […]
Pre-knowledge	Sub-concept	P4: Triangle hmm such as a right triangle, an obtuse triangle or an isosceles triangle.

Each participant was interviewed for approximately one hour. The transcripts were presented to the participants for their approval. In addition, the participants' statements were extensively included in the text; accordingly, an attempt was made to achieve a thick description of the transfer of findings. Thus, these procedures increased the trustworthiness of the research (see [12]).

III. Results

The harmful values that emerged when the participants examined the definitions of mathematical concepts are listed as *mathematical representations*, *mathematical terms*, *relevance with daily life*, and *pre-knowledge*. As the participants were directly queried about the definitions of concepts, it was established that their responses were based on the meanings of the terms, with a particular focus on *mathematical terms*:

P1: In this context, the term 'line' is used to refer to a straight line, or a direct line.

P3: We usually learnt concepts by drawing. I always remember the diagram, not the definition.

As can be understood from P3's statement, when participants were expected to express their thoughts about the concept instead of the concept definitions, it was determined that they focused on *mathematical representations*. It was determined that the participants who focused on the representation types of concepts gave importance to graphical representations or symbolic representations of basic concepts instead of their definitions. For example, it was found that participants focused on the graphical representation of the concept of angle rather than its definition, shaping their understanding through the graphical representation:

P5: It is formed by the intersection of two line segments. This is the angle (drew the inner region of the angle, see Figure 1).

P1: It's a combination of two rays. We need to name the vertice. Like this, $\hat{A}$.

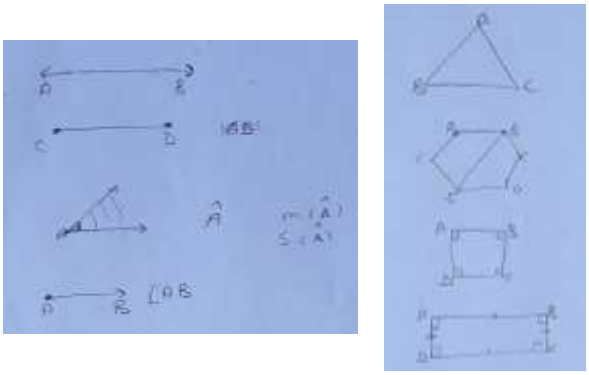

Fig. 1 Participants' representations

Therefore, it is clear that the importance given by participants to graphical and symbolic representations affects their comprehension. However, rather than presenting the definitions of concepts, the participants allowed for the types of representations of these concepts and the descriptions of these representations, which can be attributed to their focus on the qualities and pre-knowledge of mathematical concepts. For instance, when the concept of a circle was queried, it was established that the participants typically drew a circle with a compass and indicated the centre of the circle, the perimeter angles, the radius and the diameter lengths. Accordingly, rather than defining the circle, participants focus on the concept's attributes, the type of representation and pre-knowledge. Similarly, when polygons were analysed, participants focused on their representation types and pre-knowledge by drawing prototypes (see Figure 1). *Mathematical representation* and *pre-knowledge* values such as number of sides, naming of vertices, symbolic representation, side length, and area formula were revealed by drawing prototypes of regular polygons. Also, when the angle concept was questioned, the participants focused on types of angles such as acute and obtuse angles. When the triangle concept was asked, they focused on classifications such as the right triangle or isosceles triangle. This focus indicates the importance attributed to *mathematical representations* and *pre-knowledge*, such as prototypes, which are graphical representations of the participants. Finally, it was determined that the participants gave concrete examples by associating them with *daily life* instead of paying attention to the definitions of the concepts. This was exemplified by the use of a door to illustrate the angle concept or by comparing the concepts of circle.

IV. DISCUSSION

This study contributes to the existing literature by examining the relationship between individual mathematics educational values and the comprehension of mathematical concepts. It also explores the impact of negative effects on the construction of concept definitions, offering a novel perspective on the subject. Indeed, there are studies that examine the inadequacy of individuals' mathematics educational values (see [6], [7], [8]) or the negative effects of harmful values on mathematical skills (see [3]). However, the harmful values related to concept definitions, which are essential for concept knowledge and teacher professional skills, have been introduced to the literature by the present research.

The results of the study revealed that prospective middle school mathematics teachers gave importance to representation types such as graphical and symbolic representation, term meanings and qualities rather than formal definitions of concepts in their comprehension of concepts. These results indicate that the values of *mathematical representations*, *mathematical terms* and *pre-knowledge* prevent focusing on formal definitions of concepts. Therefore, these values, which were frequently reflected in the thoughts of prospective mathematics teachers, were determined as harmful values. In contrast to the results of [3], this result emphasised the harmful consequences of positive mathematics educational values. Consequently, although informal and formal explanations, representation types and pre-knowledge are considered together in the concept learning process, it is necessary to determine priorities in teaching practices. Accordingly, formal definitions of concepts should be emphasised in teaching practices. Then the types of representation

for the concepts should be constructed. Furthermore, pre-knowledge and examples from daily life emphasised in the construction of concepts should not override their formal definitions. It is important to note that practices reflecting these values should be regarded as a means for learners to comprehend, rather than as an end in themselves. For example, it is necessary to emphasise the formal definition of the circle based on set representation, then the focus should be on the representation types and qualities of the concept. While the formal definition of the angle concept is discussed in detail, the graphical representation should be a tool, it should not be intended as a concept definition.

V. CONCLUSION

Harmful values that prevent prospective middle school mathematics teachers from constructing formal definitions or causing misconceptions in the process of learning basic mathematical concepts are *mathematical representations*, *mathematical terms*, *relevance with daily lif*e, and *pre-knowledge*. This result emphasises that the type of representation, pre-knowledge and relevance to daily life, which are important in the comprehension of mathematical concepts, may have negative effects on the construction of the formal definition.

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Logic-Based Approach for Modifying Mean Prompt Using Gemma-LLM

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Abstract – This research presents a logic-based method employing Gemma-LLM (Logic Language Model) for adjusting mean prompts in natural language processing (NLP) tasks. The problem of changing a prompt's meaning without affecting its syntactic structure is solved by applying logical reasoning skills. Gemma-LLM uses inference processes and logical principles to allow for exact and controlled changes to the prompt's meaning. The method provides a systematic and ethical means of modifying prompts, resulting in more acceptable replies for the given setting. The outcomes of the experiments showcase the efficiency and possibilities of the logic-based method, indicating its usefulness in augmenting the versatility and pliability of language models in natural language processing assignments. This study seeks to promote more research and advancement in logic-based natural language processing methods for adjusting average prompts.

Keywords –Modifying Mean Prompt, Semantic Modification, Controlled Modifications, Contextual Appropriateness, Versatility, Gemma-LLM.

I. INTRODUCTION

Natural language processing (NLP) has made great strides in producing human-like replies using massive language models in recent years. Modifying the mean prompt, or changing a text prompt's intended meaning without changing its syntactic structure, is one of the domain's problems. A logic-based strategy that makes use of the Gemma-LLM (Logic Language Model) has emerged as a viable answer to this problem.

Gemma-LLM is a complex language model with logical reasoning built into its framework. It makes use of inference procedures and logical principles to change the meaning of a prompt without compromising its structural integrity. Because of its logic-based methodology, the prompt may be precisely and carefully modified while still guaranteeing that the produced replies reflect the intended semantic changes. [4]

This work aims to present and investigate the use of Gemma-LLM to apply a logic-based technique for altering mean prompts in natural language processing tasks. This method allows for more nuanced and contextually relevant replies by manipulating the meaning of prompts in a principled and systematic manner through the application of logical reasoning techniques.[9]

This essay will examine the fundamental ideas and workings of Gemma-LLM and describe the useful use of logical rules to successfully change the meaning of prompts. We will also go over the advantages and possible uses of this logic-based method in a variety of NLP tasks, including language generation models, conversation systems, and question-answering systems.

In addition, we will showcase the merits and limitations of the logic-based approach using Gemma-LLM by presenting experimental findings and comparisons with other techniques that are already in use. By means of these studies, we hope to illustrate the efficacy and promise of this methodology in augmenting language models' versatility and adaptability in producing answers that correspond with intended semantic adjustments.

To sum up, the logic-based method that makes use of Gemma-LLM presents a viable way to change the mean prompts in NLP tasks. This technique allows for more accurate and controlled changes to the prompt meaning by including logical reasoning skills into language models, which improves the flexibility and contextual relevance of generated replies. The purpose of this work is to present a thorough overview of this method and to encourage more study and advancement in the area of logic-based natural language processing.[1] – [3]

II. Overview

With the use of Gemma-LLM (Logic Language Model), a sophisticated logic-based method for altering mean prompts, one may precisely and carefully alter the intended meaning of a given text prompt while maintaining its syntactic structure. This methodology provides a systematic and principled technique to manage prompts in natural language processing (NLP) by integrating logical reasoning skills. [8]

This method is based on the Gemma-LLM language model, which combines inference methods with logical principles. The model may successfully change the meaning of prompts while preserving the original text's structural integrity thanks to these logical criteria. The method guarantees that the produced replies are consistent with the intended semantic modifications by utilising logical reasoning techniques.

Applications of the logic-based method in NLP tasks include language generation models, dialogue systems, and question-answering systems. It provides the flexibility to modify and personalise replies in accordance with certain contextual needs. The method improves language models' adaptation and flexibility by changing mean prompts, resulting in output that is more nuanced and contextually relevant. [11]

The efficacy of the logic-based method employing Gemma-LLM is demonstrated by experimental findings and comparisons with other existing techniques. It demonstrates how to modify semantics precisely while preserving grammatical coherence, which improves the relevance and quality of produced replies. This strategy has potential to address the problem of mean prompt modification in NLP tasks.

All things considered, the logic-based method of altering mean prompts using Gemma-LLM provides a methodical and ethical way to improve language models' ability to produce contextually relevant answers. This method creates new opportunities for customisation and adaptation in the field of natural language processing by integrating logical reasoning techniques. [6]

A. Logic-Based Approaches in NLP Heading

In Natural Language Processing (NLP), logic-based methods refer to the use of formal logic frameworks and logical reasoning techniques to a range of activities and problems. These methods seek to give natural language processing (NLP) a more organised, methodical approach that will enable accurate, logical analysis and manipulation of natural language.

Semantic parsing and comprehension is a typical use case for logic-based techniques in natural language processing. Through the use of logical formalisms like higher-order or first-order logic, these methods facilitate the derivation of meaning from phrases in natural language. They facilitate activities such as information extraction, knowledge representation, and question answering by offering a framework for expressing and reasoning about sentence semantics. [2]

Opinion mining and sentiment analysis are two other fields where logic-based techniques have shown to be beneficial. These methods enable the recognition and categorization of sentiment or opinion statements in text by using logical rules and inference procedures. By capturing the logical connections between words, sentences, and attitudes, logical frameworks aid in precise sentiment analysis and opinion extraction.

Conversational agents and discourse systems likewise heavily rely on logic-based techniques. Formal logic and logical reasoning are used in these methods to allow systems to converse coherently and contextually relevantly. Logical frameworks facilitate the modelling of conversation flow, query handling for users, and suitable answer generation through the application of logical principles and inference. [12]

B. Modifying Mean Prompts

Changing a text prompt's intended meaning without changing its syntactic structure is known as "modifying mean prompts." This job is important for natural language processing (NLP) because it improves the flexibility of language models and gives more exact control over the produced answers.

In NLP, there are several ways to change mean cues. Semantic editing is a popular technique that involves changing or replacing particular words or phrases in the prompt to accomplish the intended meaning change. To guarantee that the intended meaning is correctly communicated, this method necessitates a comprehensive examination of the prompt's semantics and the anticipated adjustments. [5]

Using logical reasoning approaches to alter mean prompts is another strategy. Formal logic and knowledge graphs are two examples of logical frameworks that are used to express the meaning of the prompt and allow for methodical changes. The prompt's meaning can be changed while preserving its syntactic structure and logical coherence by using logical rules and inference methods.

Machine learning methods can also be used to change mean prompts. Using this method, models are trained on sizable datasets that provide examples of prompt alterations together with the intended meanings for each. More automatic and data-driven changes are made possible by the trained models' ability to produce altered prompts based on discovered patterns and relationships. [3]

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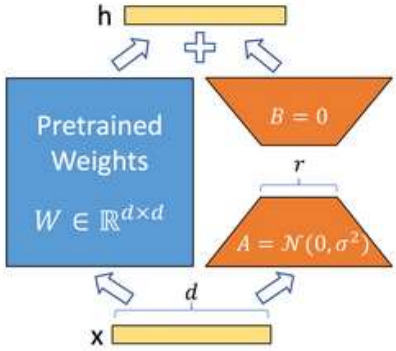

Fig. 1 Gemma-LLM Process

III. Integration of Gemma-LLM with Logic-Based Modification

In natural language processing (NLP), the combination of logic-based modification approaches with Gemma-LLM provides a potent and sophisticated method for adjusting mean prompts. As a logic language model, Gemma-LLM offers the framework for adding logical thinking skills to the modification process, allowing for more accurate and regulated modifications to the prompt's meaning.

The logic-based modification technique improves the contextuality and flexibility of rapid changes by utilising Gemma-logical LLM's rules and inference processes. The ability to reason logically enables a systematic and principled manipulation of the prompt, guaranteeing that the generated replies correspond with the intended semantic modifications.

There are many processes involved in integrating logic-based modification approaches with Gemma-LLM. First, the fundamental semantics of the prompt are captured by representing it using logical formalisms such higher-order or first-order logic. Subsequently, inference methods and logical principles are used to alter the prompt's representation while maintaining its syntactic structure. In order to make sure that the intended meaning changes are appropriately represented in the amended prompt, these logical rules can be tailored to accommodate certain semantic adjustments. The ability of Gemma-LLM to think logically is essential to this integration. They guarantee that the changes preserve logical coherence and consistency by allowing the model to reason about the logical links between words, sentences, and concepts inside the prompt. The process of modification is guided by logical principles and inference processes, which enable accurate alterations to the prompt's meaning. [11]

There are several advantages of integrating logic-based modification approaches with Gemma-LLM. In order to guarantee that the generated replies are appropriate for the given context and consistent with the intended semantics, it offers a methodical and ethical approach to prompt change. Furthermore, the capacity to think logically improves the interpretability and explainability of the modification process, enabling more transparent and intelligible changes.

It is crucial to remember that research on the combination of Gemma-LLM and logic-based modification methods is currently ongoing. Additional refining and investigation are required to maximise this

approach's efficacy and performance. The full potential of logic-based alterations in NLP activities may be unlocked by further developing and improving the integration, which will result in more advanced and precise language processing systems. [18]

IV. Application And Benefits

In natural language processing (NLP), there are several advantages of utilising Gemma-LLM to apply the logic-based method of changing mean prompts.

Conversational agents and dialogue systems are two important areas of application. The method makes it possible to respond to discussions in a more comprehensible and contextually relevant way by utilising Gemma-logic LLM's reasoning skills. The user experience may be improved overall by enabling customised and pertinent interactions through the logical precision with which mean prompts can be modified.

As further significant use is in question-answering systems. The prompt may be precisely changed using the logic-based technique, which guarantees that the produced solutions appropriately answer the intended query. This increases the system's utility for information retrieval tasks by improving the relevance and accuracy of the responses it provides.

Furthermore, language generation models using the logic-based method may be used for tasks like text creation and text summarization. Through the use of Gemma-logical LLM's rules and inference processes, the method allows for controlled interpretation changes of the prompt meaning, leading to more coherent and contextually relevant output content. [15]

The following are some advantages of utilising Gemma-LLM's logic-based mean prompt modification approach:

1. *Precision*: The method provides a methodical and ethical means of modifying prompt meanings, guaranteeing that the desired semantic modifications are faithfully conveyed in the revised prompt.
2. *Contextual Appropriateness*: The method facilitates the creation of more contextually suitable solutions by utilising logical thinking abilities. As a result, the resulting output is more pertinent and helpful for a wider range of NLP jobs.
3. *Coherence*: Gemma-LLM's integrated logical rules and inference techniques guarantee that the prompt's alterations preserve both syntactic and logical coherence. As a result, the replies are clearer and more comprehensible.
4. *Flexibility*: The method offers an adaptable structure for adjusting mean prompts, enabling customised modifications according to particular contextual needs. This improves language models' flexibility and customisation in NLP tasks.
5. *Enhanced Performance*: The outcomes of the experiments show how successful the logic-based method is and how it can be used to improve language models' performance. The changes made with this method result in output that is produced that is of higher quality and more relevance.

All things considered, the logic-based method of changing mean prompts using Gemma-LLM has many useful applications and advantages in NLP. The technique improves the performance, flexibility, and adaptability of language models, resulting in more accurate and contextually relevant replies, by fusing logical reasoning abilities with exact alterations.

V. METHODOLOGY

Imagine in an LLM, we have a pre-trained dense layer, represented by a $\boldsymbol{d}\times\boldsymbol{d}$ weight matrix, denoted as $\boldsymbol{W0}$. We then initialize two additional dense layers, labeled as $\boldsymbol{A}$ and $\boldsymbol{B}$, with shapes $\boldsymbol{d}\times\boldsymbol{r}$ and $\boldsymbol{r}\times\boldsymbol{d}$, respectively. Here, r denotes the rank, which is typically *much smaller than* $\boldsymbol{d}$. Prior to LoRA, the model's output was computed using the equation $output=\boldsymbol{W0}\cdot x+\boldsymbol{b0}$, where x represents the input and $\boldsymbol{b0}$ denotes the bias term associated with the original dense layer, which remains frozen. After applying LoRA, the equation becomes $output=(\boldsymbol{W0}\cdot x+\boldsymbol{b0})+(\boldsymbol{B}\cdot\boldsymbol{A}\cdot x)$, where A and B denote the trainable rank-decomposition matrices that have been introduced.

A number of crucial phases are included in the logic-based strategy for changing mean prompts using Gemma-LLM to guarantee accurate and controlled changes that preserve logical coherence. An outline of the process is provided below:

1. Clearly state the precise semantic adjustments that must be made to the mean prompt in order to achieve the intended improvements. This might entail changing the general context, adding or eliminating material, or changing the meaning of specific words or phrases.
2. Explain the prompt with the use of logical formalisms: Create a logical representation of the mean prompt by using formal logical languages like higher-order or first-order logic. The fundamental semantics of the prompt are captured in this form.
3. Create logical rules: Formulate a collection of rules that make sense and direct the intended changes. These guidelines ought to direct the process of modification, guaranteeing that the desired adjustments are reflected in the semantic changes. The links and dependencies between words, sentences, and concepts in the prompt should be reflected in the logical rules.
4. Use methods for logical inference: Apply the created logical rules to the logical representation of the prompt by using logical inference methods. In order to ensure coherence and consistency, this stage allows the system to reason about the logical linkages and make systematic changes to the prompt.
5. Create modified prompt: Create the updated prompt that represents the intended semantic modifications by using the logical rules and inference methods. The revised prompt should incorporate the logical changes while retaining the original prompt's syntactic structure.
6. Assess and improve: Check that the updated prompt still makes the desired changes, is logical, and is acceptable for the given context. Refine the logic-based strategy and make any required changes in light of the evaluation's findings.

Logical reasoning skills of Gemma-LLM serve as the basis for logical rules and inference mechanisms to be incorporated into the modification process throughout the approach. With the help of these functions, the system is able to reason about the logical linkages and make accurate adjustments that correspond with the intended semantics.

It is crucial to remember that the approach is an iterative process that has to be adjusted and refined according to the particular application and area. To maximise the accuracy and efficacy of the logic-based method for changing mean prompts using Gemma-LLM, ongoing assessment and development are required.

A. CODING

```
IMPORT OS
OS.ENVIRON["KERAS_BACKEND"] = "JAX" # YOU CAN ALSO USE TENSORFLOW OR TORCH
OS.ENVIRON["XLA_PYTHON_CLIENT_MEM_FRACTION"] = "1.00" # AVOID MEMORY FRAGMENTATION ON JAX BACKEND.

IMPORT KERAS
IMPORT KERAS_NLP

IMPORT NUMPY AS NP
IMPORT PANDAS AS PD
FROM TQDM.NOTEBOOK IMPORT TQDM
TQDM.PANDAS() # PROGRESS BAR FOR PANDAS

IMPORT PLOTLY.GRAPH_OBJS AS GO
IMPORT PLOTLY.EXPRESS AS PX
FROM IPYTHON.DISPLAY IMPORT DISPLAY, MARKDOWN
CLASS CFG:
  SEED = 42
  DATASET_PATH = "INPUT/LLM-PROMPT-RECOVERY"
  PRESET = "GEMMA_INSTRUCT_2B_EN" # NAME OF PRETRAINED GEMMA
  SEQUENCE_LENGTH = 512 # MAX SIZE OF INPUT SEQUENCE FOR TRAINING
  BATCH_SIZE = 1 # SIZE OF THE INPUT BATCH IN TRAINING
  EPOCHS = 1 # NUMBER OF EPOCHS TO TRAIN

# `LLM PROMPT RECOVERY - SYNTHETIC DATASTORE DATASET`
DF1 = PD.READ_CSV("INPUT/LLM-PROMPT-RECOVERY-SYNTHETIC-DATASTORE/GEMMA1000_W7B.CSV")
DF1 = DF1[["ORIGINAL_TEXT", "REWRITE_PROMPT", "GEMMA_7B_REWRITTEN_TEXT_TEMP0"]]
DF1 = DF1.RENAME(COLUMNS={"GEMMA_7B_REWRITTEN_TEXT_TEMP0":"REWRITTEN_TEXT"})
DF1.HEAD(2)

# `3000 REWRITTEN TEXTS - PROMPT RECOVERY CHALLENGE`
```

```
DF2 = PD.READ_CSV("INPUT/3000-REWRITTEN-TEXTS-PROMPT-RECOVERY-CHALLENGE/PROMPTS_0_500_WIKI_FIRST_PARA_3000.CSV")
DF2.HEAD(2)

# MERGE ALL DATASETS
DF = PD.CONCAT([DF1, DF2], AXIS=0)
DF = DF.SAMPLE(2000).RESET_INDEX(DROP=TRUE) # TO REDUCE TRAINING TIME WE ARE ONLY USING 2K SAMPLES
DF.HEAD(5)
```

B. INPUTS AND OUTPUTS

	original_text	rewrite_prompt	rewritten_text
0	Story highlights New findings suggest sperm al...	Turn this into a programmer's code.	```python\n# Code to summarize the text\n\nspe...
1	Glasgow's Needy is a non-registered charity or...	Make this a formal apology letter to a customer.	[Your Name]\n[Your Address]\nGlasgow, Scotland...
2	Pune: In a bizarre case, a parrot accused of "...	Convert this into a technique to be used.	**Technique:**\n\n**Step 1: Gather evidence.**...
3	Berrya is a genus of evergreen trees with fibr...	Convert the text into the layout of a classic ...	## Level Layout: Berrya Forest\n\n**Background...
4	The Libertarian Party of Oregon is a political...	Recast it as the backstory for a mysterious an...	In the shadows of the Evergreen State of Orego...

Fig. 2 Sample Input and Output of Data

VI. CONTRIBUTIONS

Gemma-LLM's logic-based method for changing mean prompts has numerous important benefits for the natural language processing (NLP) community.

7. Accuracy and Control: The logic-based method provides a methodical and ethical means of changing prompt meanings while maintaining syntactic integrity. The method enables exact and controlled updates by utilising Gemma-LLM's logical reasoning skills, guaranteeing that the desired semantic changes are correctly represented in the amended prompt. The accuracy and applicability of the produced replies are improved by this degree of control and precision.
8. Contextual Appropriateness: The logic-based method produces contextually suitable replies because to Gemma-logical LLM's principles and inference processes. The method makes sure that the changes are consistent with the intended semantics by taking into account the logical connections and dependencies included in the prompt. This enhances the overall quality of NLP systems by producing outputs that are more meaningful and contextually relevant.
9. Coherence and Consistency: Gemma-LLM's capacity for logical reasoning guarantees that the changes made to the mean prompts preserve coherence and consistency in logic. The method produces altered prompts that follow the fundamental logical structure of the original prompt by abiding by logical norms and principles. As a consequence, the user experience is improved and the replies are more comprehensible and coherent.
10. Flexibility and Personalisation: The logic-driven methodology enables customised adjustments according to certain situational needs. The technique may be tailored to manage diverse semantic changes and adapt to different domains or linguistic settings by including logical rules and inference processes. This adaptability increases NLP systems' versatility and usefulness across a broad variety of applications.
11. Progress in Logic-Based Methods: The development of logic-based methods in NLP is aided by the combination of Gemma-LLM and logic-based modification techniques. The method broadens the scope of language models and creates new opportunities for accurate and regulated language processing by investigating the use of logical reasoning to alter mean prompts. The development of logic-based NLP approaches and their general comprehension are both aided by this study.

In conclusion, Gemma-LLM's logic-based method for changing mean prompts makes significant advances to NLP. This method improves the accuracy, relevance, and flexibility of natural language processing (NLP) systems by offering precision, contextual appropriateness, coherence, adaptability, and the advancement of logic-based approaches. As a result, NLP systems perform better overall and are more helpful.

VII. CHALLENGES AND FUTURE DIRCTIONS

Although there are several advantages to the logic-based method of changing mean prompts using Gemma-LLM, there are drawbacks as well as potential future possibilities for its advancement and use in natural language processing (NLP).

The difficulty of creating and putting into practice logical rules and inference processes that precisely capture the intended adjustments is one of the challenges. It can be difficult and time-consuming to create an extensive collection of logical rules that encompass a variety of semantic modifications. Another issue that needs further research is making sure these principles are resilient and flexible enough to work in many linguistic situations and domains.

The interpretability of the logic-based method presents another difficulty. Although Gemma-LLM's logical reasoning skills offer a consistent foundation for changing mean prompts, it can be difficult to comprehend and justify the changes the system makes. Efforts should be made to create strategies that increase the transparency and interpretability of the logic-based adjustments, allowing users to have a better grasp of the reasons behind the changes.

Additionally, there may be scalability issues when integrating logic-based modification approaches with Gemma-LLM. The computing resources needed for effective adjustments may become limited as the models get larger and more complex. Future studies should concentrate on enhancing the logic-based approach's scalability and efficiency to guarantee that it can be effectively used to more complex NLP jobs.

One potential avenue for future research is the integration of external knowledge sources with Gemma-LLM. The quality of the changes may be improved and logical reasoning abilities can be strengthened by incorporating domain-specific or background information. Further study may be interestingly directed towards investigating methods for autonomously learning logical rules and inference processes from data.

The assessment and benchmarking of the logic-based method is another avenue for future research. The development of standardised assessment criteria and datasets designed expressly for logic-based adjustments can aid in evaluating and contrasting the effectiveness of various strategies. In the NLP community, this would promote the development and use of logic-based modification approaches.

Overall, resolving the issues and considering potential avenues for development in the logic-based method for adjusting mean prompts using Gemma-LLM will help to improve and expand the use of this strategy. We can realise the approach's full potential in enabling more accurate, contextually relevant, and coherent alterations in NLP tasks by improving its interpretability, scalability, and performance.

VIII. CONCLUSION

To sum up, the logic-based method of changing mean prompts using Gemma-LLM provides a useful and sophisticated way to make exact and controlled changes in natural language processing (NLP). Through the use of Gemma-LLM's logical reasoning skills, the method offers a methodical and ethical framework for changing prompt meanings without affecting their syntactic structure.

The logic-based method advances natural language processing in a number of ways. It allows for accuracy and control over the changes, guaranteeing that the changed prompt appropriately reflects the desired semantic changes. The method additionally improves the produced replies' contextual appropriateness by taking into account the prompt's logical connections and linkages.

Moreover, the logic-based method guarantees consistency and coherence in the changes, leading to more comprehensible and logical answers. It provides flexibility and personalisation, enabling customised adjustments according to certain domains and contextual needs. Furthermore, the methodology advances logic-based approaches in NLP, increasing language models' capacities and stimulating more study in this field.

The logic-based method with Gemma-LLM offers substantial advantages in terms of accuracy, contextuality, coherence, and flexibility, even if there are obstacles and potential directions to take into account, such as the difficulty of creating logical rules and guaranteeing scalability.

Overall, the accuracy, relevance, and performance of NLP systems are improved by the logic-based method of changing mean prompts utilising Gemma-LLM. The logic-based approach advances NLP

research and applications by offering a regulated and systematic method for altering prompts, hence enhancing language processing and communication quality.

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Producing Hydrogen: Utilizing the Chlor-Alkali Method for $ZnCl_2$ Salt Hydrogen Production

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Abstract – The hydrogen production of $ZnCl_2$ salt via the chlor-alkali method was investigated at 20°C and under 5 volts of cell voltage conditions. The central structure of the reactor was crafted from derlin polymer via CNC machining. Anode and cathode sections were partitioned by a Nafion 212 membrane, with carbon rod electrodes employed in each section. According to the experimental results, $ZnCl_2$ produced 10 mL, 20 mL, and 30 mL of hydrogen in 11,2 min, 22,52 min, and 34,09 min, respectively, with a constant current density of 0.11 A.

Keywords – Hydrogen, Chlor – Alkali Reactor, Electrolysis, Energy, Sustainable Energy,

I. INTRODUCTION

Hydrogen's role in advancing sustainable energy systems is pivotal due to its eco-friendly characteristics. Being a versatile energy carrier, hydrogen shows promise in decarbonizing sectors like transportation, industry, and power generation. Its significance lies not just in reducing greenhouse gas emissions but also in facilitating the integration of renewable energy sources and enabling energy storage, thus promoting a more resilient, low-carbon future. In an experimental investigation, hydrogen generation from NaCl, KCl, and $CaCl_2$ solutions using an electrochemical approach in a chlor-alkali reactor was explored. A lab-scale reactor, featuring distinct anode and cathode compartments separated by a cation exchange membrane, was employed. Multiple parameters such as cell voltage, temperature, and electrolyte flow rate were examined. Although active chlorine gas contamination in the anode section impeded expected chlorine gas output, notable hydrogen production was observed at the cathode. Hydrogen generation rates varied from 37.23 mL/h to 437.72 mL/h under different conditions, with $CaCl_2$ at 0.4 g/s and 3 V, and KCl at 1.2 g/s and 5 V yielding the lowest and highest rates, respectively [1,4]. Another investigation explores how electrode surface area, electrode gap, electrolyte temperature, mass flow rate, and bubble formation influence current density in a membrane cell chlor-alkali reactor. The chlor-alkali process involves the electrolysis of brine to produce chlorine gas, sodium hydroxide, and hydrogen. Sequential experiments indicate that enlarging the electrode surface area enhances current density, while increasing the distance between electrodes diminishes it. Elevated electrolyte temperatures notably increase current density, whereas augmenting the mass flow rate has a limited impact. The presence of air bubbles accumulated on the electrodes impedes the electric field, leading to a gradual reduction in current density over time [2]. The chlor-alkali process generates three essential outputs: chlorine gas, sodium hydroxide (caustic soda), and hydrogen gas—typically with minimal carbon emissions, rendering it vital for renewable energy-driven industrial applications. Experimentally, the highest hydrogen production was observed with a KCl solution, while the lowest was with $CaCl_2$. Increasing operational temperature, cell voltage, and mass flow rate enhanced hydrogen production, with cell voltage exerting the most significant influence and mass flow rate the least. The minimum hydrogen

production was 27.36 mL/h with a $CaCl_2$ solution at 0.3 g/s and 2.5 V, while the maximum production was 295.68 mL/h with a KCl solution at 0.7 g/s and 3.5 V, yielding respective energy and exergy efficiencies of 10.81% and 8.47%, and 23.78% and 17.63% [3,5].

Taking into account the insights gleaned from these three sources, it's clear that the chlor-alkali process presents a promising avenue for hydrogen production in renewable energy contexts. Despite facing challenges such as active chlorine gas contamination and electrode bubbling, notable hydrogen outputs were attained, showcasing varying efficiencies influenced by factors like solution composition, operational conditions, and reactor configuration. Collectively, these studies underscore the significance of fine-tuning process parameters to elevate hydrogen production rates and optimize energy efficiency in sustainable industrial settings.

II. Materials and Method

Fig. 1 illustrates the schematic diagram of the membrane cell chlor-alkali reactor utilized in the experimental configuration. The experimental setup consists of the chlor-alkali reactor unit itself, vessels for electrolyte provision, containers for managing electrolyte waste disposal, a graduated measuring cylinder, a direct current (DC) power source, and peristaltic pumps.

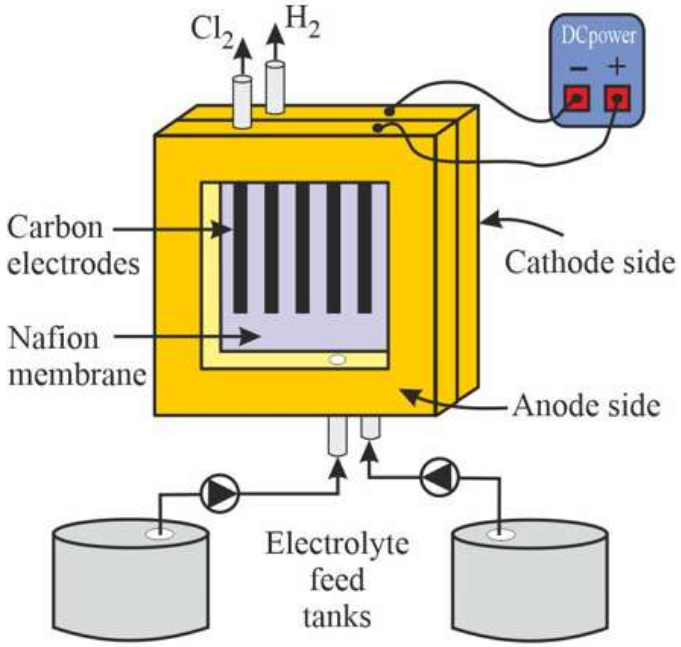

Fig. 1. portrays the schematic depiction of the experimental arrangement.

III. Results and Discussion

The hydrogen production of $ZnCl_2$ salt via the chlor-alkali method was investigated at 20°C and under 5 volts of cell voltage conditions. The central structure of the reactor was crafted from derlin polymer via CNC machining. Anode and cathode sections were partitioned by a Nafion 212 membrane, with carbon rod electrodes employed in each section. When examining hydrogen production, it is observed that the reactor operates under a constant current when working with $ZnCl_2$. Additionally, it is noted that the amount of hydrogen produced is directly proportional to time.

Table 1. The Hydrogen production of the chlor-alkali reactor utilizing $ZnCl_2$

	$ZnCl_2$		
Hydrogen Production (mL)	**Minutes**	**Ampere**	**Voltage**
10	11.2	0,11	5
20	22.52	0,11	5
30	34.09	0,11	5

IV. CONCLUSION

The chlor-alkali reactor stands as a cornerstone in chemical processing, boasting a plethora of industrial applications. This reactor facilitates the synthesis of critical chemicals, including chlorine gas, sodium hydroxide (caustic soda), and hydrogen. Chlorine gas finds utility across various industries, from PVC plastics manufacturing to water treatment facilities. Sodium hydroxide, a fundamental chemical compound, serves diverse sectors, spanning from the paper industry to detergent production. Meanwhile, hydrogen emerges as a pivotal raw material in an array of industrial processes, such as fuel cell technology, petrochemical synthesis, and metallurgical applications. Additionally, chlor-alkali reactors play a pivotal role in energy-intensive sectors, renowned for their notable energy efficiency. When integrated with clean and renewable energy sources, these reactors hold the promise of mitigating carbon emissions and fostering the evolution of sustainable industrial practices.

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Learning the Generative Design Tools for Architecture Projects: An Experience from a Student-Design Workshop

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Abstract – Generative architecture is a branch of architectural design that is currently gaining popularity all over the world. Parametric design has become one of the most important components of contemporary architectural education; however, its learning and practice require an extraordinary effort from the students. Students need to learn new component-based design tools and change their mindset from object-oriented to algorithm-oriented. This study presents an evaluation of the new parametric design approach by a team of architecture students. During the workshop, the students learned the basic principles of Grasshopper for Rhino software and applied them to practice by designing the twisting tower. At the end of the workshop, students completed the survey, aiming to compare conventional and parametric modeling. The results show that architecture students prefer to use standard 3D modeling software since they understand the modeling process better and can directly see the building volume, while the parametric approach is more difficult to use. The participants agreed that all types of 3D modeling should be used more intensively during the architectural classes since it helps to understand the building volumes, to produce accurate models, to transfer from the basic concept to the design solution, and to increase the level of creativity and imagination.

Keywords – Parametric Modeling, Twisting Tower, Architectural Education, Generative Design

I. INTRODUCTION

Parametric design (PD) is a branch of computer-aided design, which allows the architects to create volumes based on the execution of the algorithms rather than on the three-dimensional compositional works. It allows the nonstandard and complex geometries using the rule-based scripting activities [1]. During the process of coding, the architects design the modeling workflow which is defined by the set of rules rather than the final object. The resulting script can be easily manipulated; thus, designers can produce an infinite number of solutions without spending a lot of effort modeling the entire object from the beginning [2]. Parametric design requires to study the basics of geometry and mathematics including the form definition, shape grammar, transformation rules, data management and coordinate systems [3]. In addition, the infinite possibilities for shape generation require developing a set of evaluation criteria and optimization tools, which can facilitate the decision-making process. Fabrication methods and material constraints are considered directly at the design stage; therefore, the resulting object can be easily constructed [4].

Sutherland conducted the first research focusing on computer-aided drawing using the graphical interface with a defined set of rules in 1963 [5]. Until the end of the twentieth century, parametric architecture remained a field of scientific research rather then a widely applied architectural style [6]. Parametricism as architectural style gained its popularity after the publication of P. Schumacher's manifesto in 2009 [7]. Since then, parametric design has started to appear in architectural schools, with

the aim of solving advanced modeling, simulation, automatization, and digital fabrication tasks. PD is an architectural response towards the growing influence of the digital culture, application of mathematical skills in the field of applied arts and common use of the freeform shapes [8]. PD classes have been implemented during the Descriptive Geometry and Advanced Modeling lectures, elective courses, and workshops [9]. Students in the first year do not have a lot of motivation in learning of generative design, but the end of the study graduates acquire a huge interest in parametric design, digital fabrication, and scripting [10]. Currently PD is envisioned to become one of the main sources of inspiration for the future designs, which can boost the creative architects skills, offer more freedom for the form generation and reduce the errors, which are associated with the traditional way of construction [11].

Students of architecture are not supposed to be trained in programming or have a deep knowledge of mathematics and algorithms. Conventional architectural education uses sketching, drawing, and modeling as primary tools for design and research, while the main challenge of PD is to enable students to think parametrically, which goes far beyond the simple knowledge of the interface and commands [12]. PD is introduced using visual programming languages by creating flow charts explaining the main steps of the modeling process and further perfecting the script to reduce the number of operations and entities [13]. Visual programming allows the users to break the process of model making into the simple components, to copy and paste the definitions from the other sources and to produce multiple variations of design within one workspace [14].

PD training is usually composed of two parts, where the first one is a set of lectures introducing general approaches towards generative design and the basics of software, while the second part is the design activity, allowing students to apply the received knowledge and experiment with the geometry [15]. Digital fabrication can be a last step of PD course, which makes the students to be familiar also with the building materials and construction techniques [16]. The design process is organized in several steps, starting from the development of conceptual model, and continuing with its analysis and identification of the main parameters defining the object. Further, the students select the parametric design approach, such as slicing, sectioning, use of attractors, component population, subdivision, transformation, and so on, and analyze its application to the first shape. Finally, they execute a script, create a digital model, and explore the possibilities of its fabrication [17]. PD exercises allow students to control the parameters, to interact with the object at any design stage and to make an infinite number of design alternatives, or ‘family of forms’ [18]. Being able to generate multiple design variations, students feel more creative, and they are more satisfied by the end model [19]. At the same time the whole design process should be easily dividable into the small subsystems enabling the students to understand the complex task step by step [20]. Analysis, evaluation and reconstruction of the existing buildings using the parametric tools is a method, which allows students of the first year to understand the generative design and to apply the mathematical rules towards the form finding [21]. The PD course should offer students a certain level of form complexity, which is difficult to achieve using standard 3D modeling software, motivating them to study further and explore different parametric tools [22]. Parametric approach goes along with an opportunity to create more sustainable and environmentally friendly architecture by implementing simulation techniques that optimize the structural design, thermal performance, indoor lighting, natural ventilation and testing the building components, which are unified in shape and materials and easily recyclable [23]. On the other side, the factors, such as architectural and urban context, site history, social context, aesthetic values, are hard to incorporate into the script [24]. Furthermore, during the education PD can be visualized using augmented reality tools, helping students to experience their models being superimposed on the real world [25].

This paper introduces an output of the parametric design workshop, which was organized at the premises of the University Metropolitan Tirana. During the one-day event, the group of the students of architecture of various years got a task to design a concept, execute a model, and present a conceptual project of the twisted tower. At the beginning of the event, students received a series of lectures introducing the main approach towards parametric design and digital fabrication. Further they got detailed instructions and assistance in the algorithmic modeling process. Students were able to select the shape, to modify the height, scale, twisting angle, and to apply the modular components on the building façade. At

the end, students completed the survey focusing on the differences between the conventional and parametric modeling.

II. Materials and Method

The design workshop, which lasts between 1 and 3 days, is a method that has been widely applied to teach parametric architecture design to students who have no experience in programming [9], [10], [13], [20], [26], [27]. The parametric tower is selected to be the theme of the workshop due to several factors. Firstly, skyscrapers are built recently throughout the world, and they are called as innovative buildings using the latest achievements in design and construction. Second, most of them can be considered as products of parametric design since they use the widely the rotation, shifting and component population as key design principles. Third, parametric modeling of the twisting tower is performed using some basic commands, which can be easily understood by beginners, allowing them to produce an impressive conceptual shape in just a few steps. The aim of the workshop is to introduce innovative design techniques to the students and to motivate them for further studies in the field of parametric design.

Grasshopper for Rhino is selected as a major tool of design, as it is a visual programming language, which does not require specific skills to operate and can be used intuitively by architects and designers to produce complex non-linear geometries [28]. Grasshopper has an extended range of plug-ins offering a wide variety of modeling operations, and a developed community, which has a big archive of discussions, solved questions, and examples of scripts. Master students of architecture commonly study Grasshopper to be used for diploma projects and thesis research. During the Twisting Tower Workshop, students have learned some basic commands, such as Move, Rotate, and Scale. They also got familiar with the idea of braking of the modeling process into six steps (Figure 1), such as designing of the building base, repetition of floors to elevate the building, rotation of each floor, scaling the floors using the profile curve and population of components onto the façade surface and export of model into Rhino.

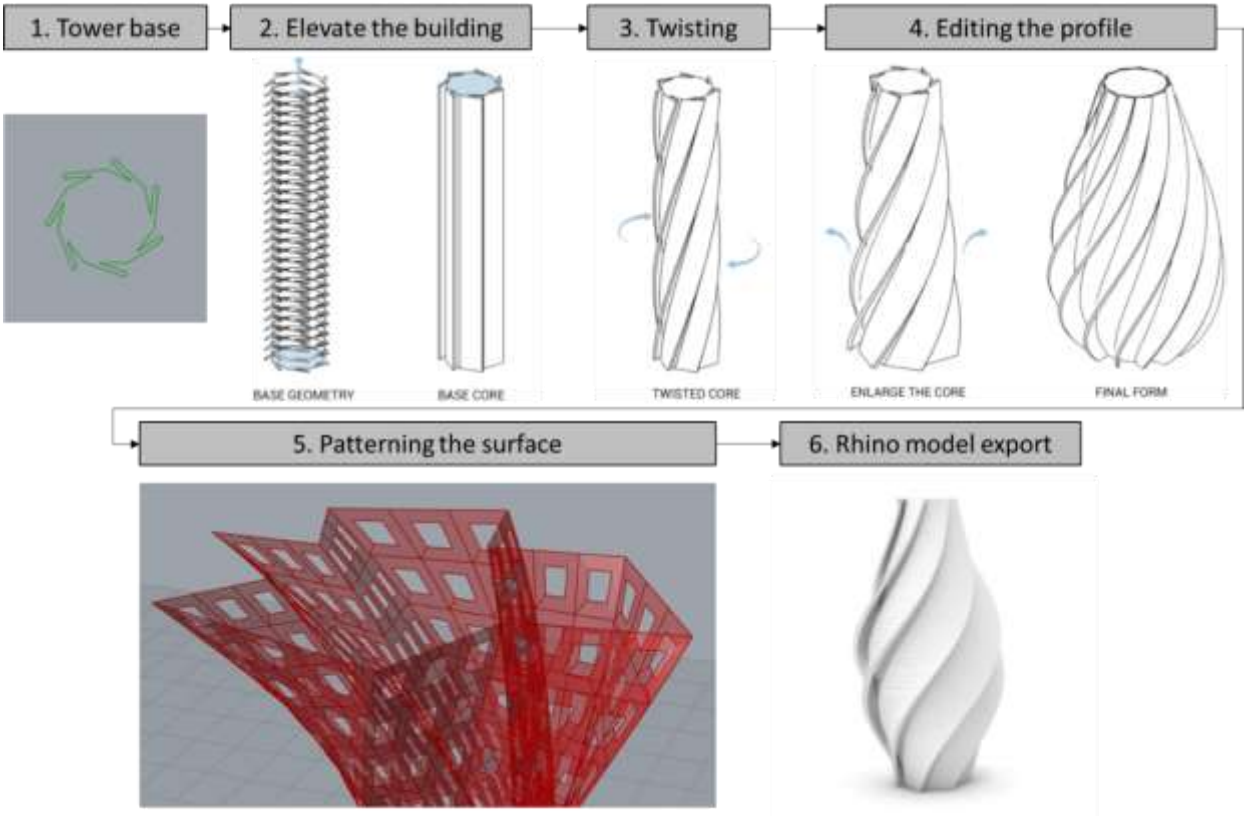

Fig. 1 Twisting tower design steps

The workshop was conceptualized as guided instruction. Students received detailed step by step explanations of the algorithmic modeling process. They received direct support during the application of

the demonstrated commands using Grasshopper for Rhino. Figure 2 shows the final script of the twisting tower. The components are grouped according to the main design steps and all the variables are indicated by text panels in order to facilitate the understanding of the process.

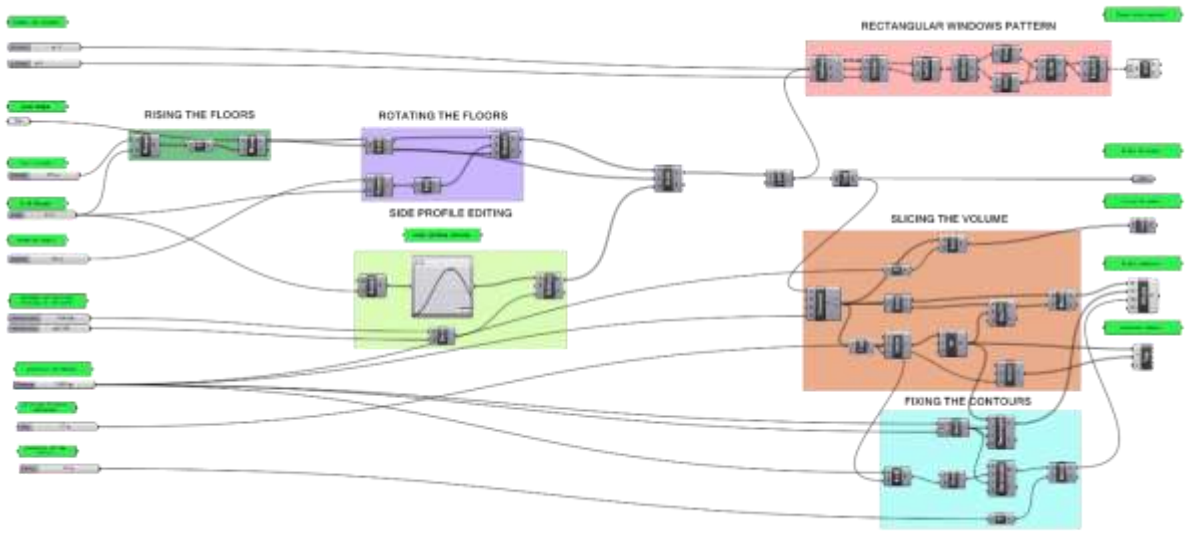

Fig. 2 Twisting tower visual script

For the final projects students were divided into small groups. Each group was asked to design a tower, study its main parameters, such as height, number of floors, twisting angle, and profile curve, and prepare a poster and to present it to the class. Two surveys were taken prior to the beginning and at the end of the workshop.

III. RESULTS

A. Design exercise

Fig. 3 Design alternatives

At the end of the workshop, each group presented a poster explaining the design concept (Figure 3). Students were able to understand the main steps of the parametric design, to use the script at the basic level, to play with the parameters, to explore multiple alternative designs, and to present the final solution.

B. *Survey results*

Before the workshop, 88.2% of students had been familiar with the 3D modelling (3DM), and 75% have tried to use the parametric design for their projects. The majority have practiced AutoCAD since it is taught from the beginning of school and SketchUp, as the simplest 3DM tool (Figure 4). Fewer senior students use Revit and 3DsMax for their projects, while Rhinoceros is not included in the curriculum therefore it is not well-known. 30% of students learned software during the classes, but 94% of students have stated, that they needed to study more and identified the self-learning as a main tool in mastering the 3D modelling skills. 17.6% took private modelling courses.

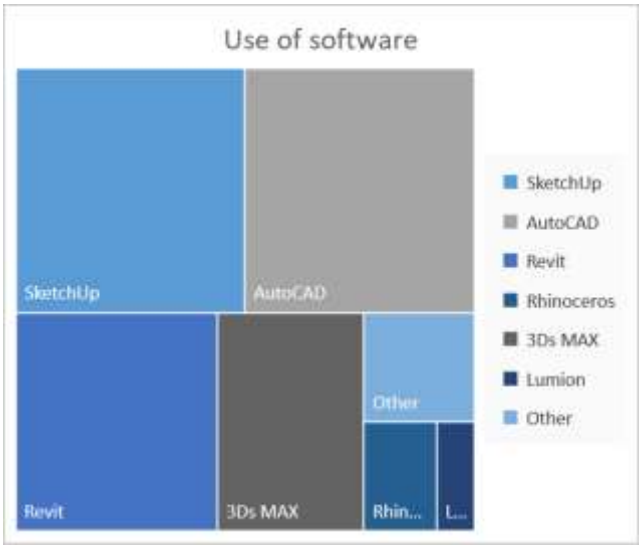

Fig. 4 Use of software

Students have used the 3DM software primarily for the conceptual design and for the modelling of final product and rendering (Figure 5). Fewer number have used 3DM as a tool, which is useful at all stages of design and just some were familiar with Building Information Modelling (BIM) software.

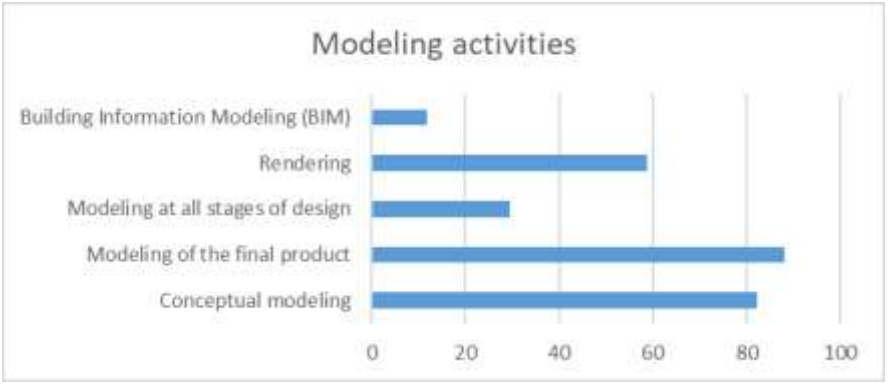

Fig. 5 Modelling activities

Further set of questions aims to compare the conventional 3D modelling and parametric modelling and to find the technique, which is the most preferred by students. 3DM is easier to practice in comparison with the PM and it is believed to have better tools for production of the architectural models (Figure 6).

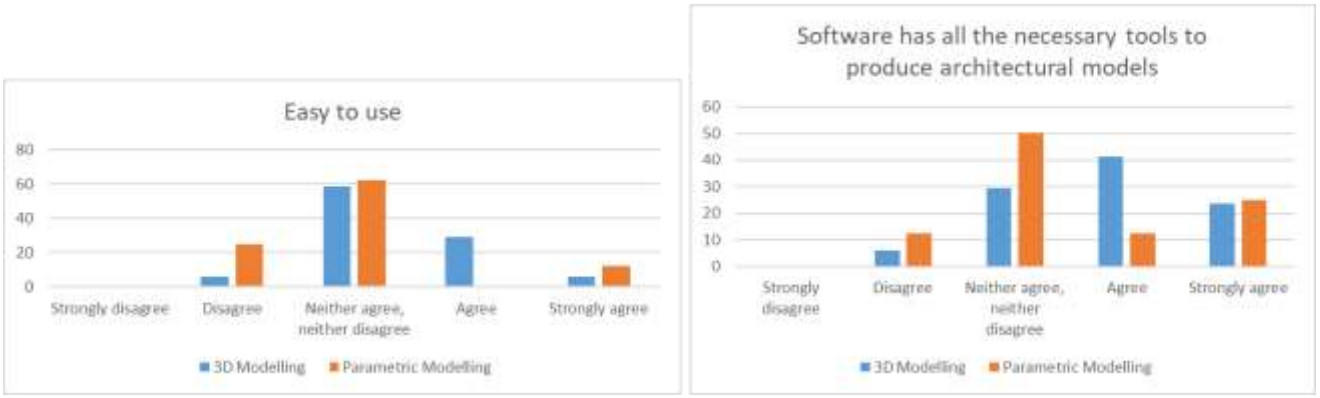

Fig. 6 Easiness in use (left) and tools (right)

Conventional 3DM software help students in better understanding of the building volumes, while parametric modelling is more suitable for production of the complex geometries (Figure 7).

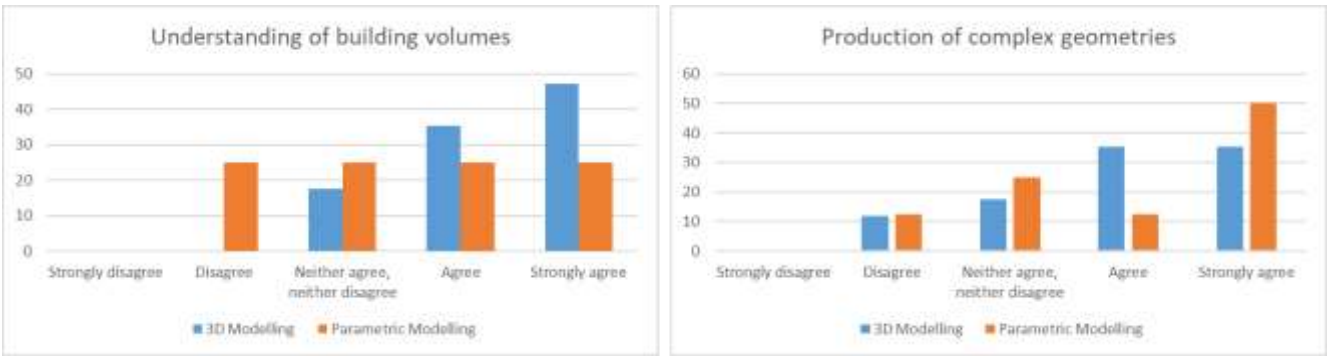

Fig. 7 Understanding of building volumes (left) and production of complex geometries (right)

PM is evaluated as better medium for development of three-dimensional thinking and imagination while conventional modelling is more suitable for fostering the students' creativity and innovation (Figure 8).

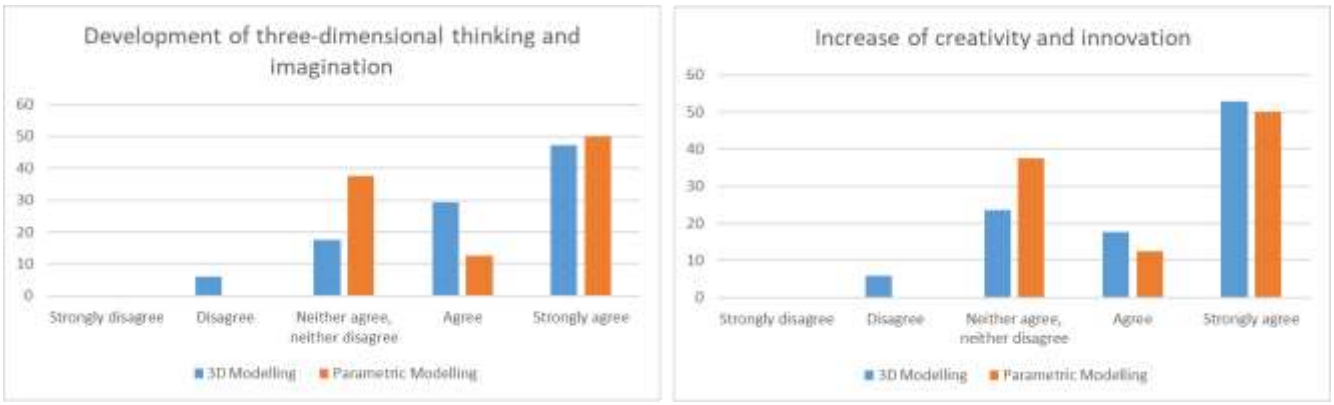

Fig. 8 Development of three-dimensional thinking and imagination (left) and increase of creativity and innovation (right)

3DM gives more support in designing the architectural projects, while PM is more suitable for the development of multiple design alternatives (Figure 9).

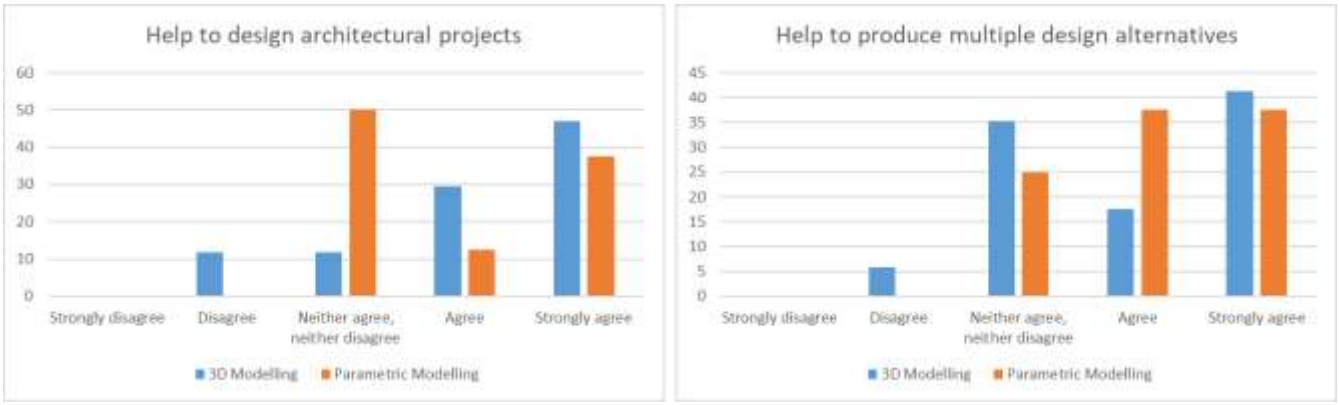

Fig. 9 Project design (left) and production of design alternatives (right)

Students agreed that both types of modelling are suitable for making the artistic, clean and aesthetically good-looking models. There is also a demand to use more intensively 3DM and PM during the architectural classes (Figure 10).

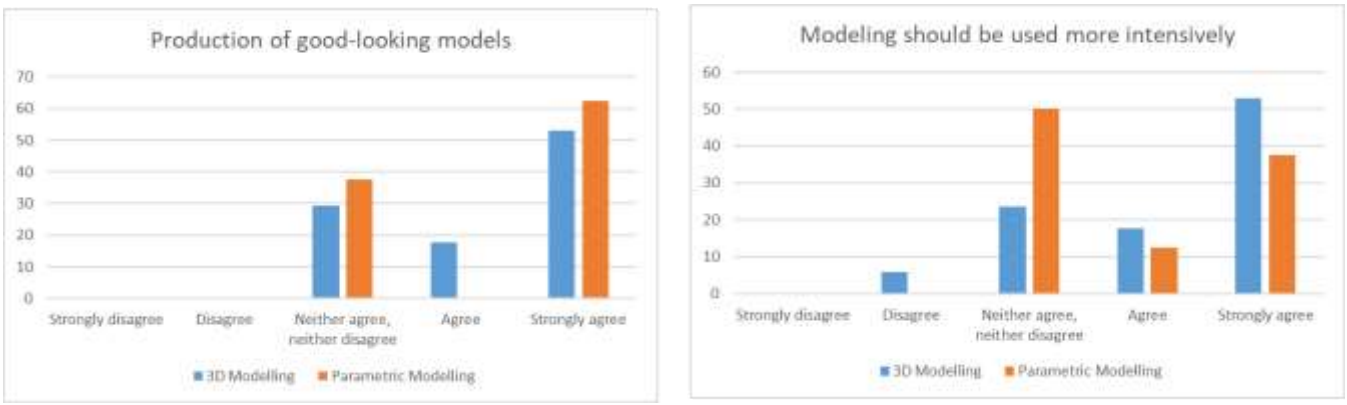

Fig. 10 Model making (left) and use during the class (right)

IV. DISCUSSION

Twisting Tower parametric workshop allowed students to design a skyscraper using the innovative modelling tools. Students have learned the basic principles of algorithmic modelling and applied them in practice. The results of the questionnaire show that students do not make a big differentiation between 3DM and PM. They evaluated both modelling techniques rather in positive way, highlighting several areas, such as complex geometry production, design of alternative solutions, and aesthetic qualities of the models, where the PM is more suitable. Students noted the similar technical problems, such as software crushing and laptop overloading. At the end of the workshop the students were able to apply the basic tools of parametric modelling and to design an object, which is simple by modelling process but complex by appearance.

Limited timeframe, such as one day, affected the depth of learning, complexity of design and the quality of final presentation. Similar parametric design workshops, which are aimed at beginners, generally last from 2 to 7 days, giving more space for introduction of the software, mastering the script, and designing of the final product. Often the longer design workshop is combined with the model fabrication. The workshop may include the production of the small-scale models designed by the participants using the laser cutting or 3D printing techniques, or it can be oriented towards the construction of the large-scale experimental structure, such as pavilion, urban furniture, or abstract sculpture.

Fabrication of parametrically designed models seems to be an important stage, which gives students more motivation in future learning of the software. Students do not see the examples of PM application in their daily architectural practice; therefore, they do not like to give an extra effort in learning this mainly theoretical field of study. Even using the digital tools in various aspects of their life, they don’t envision the necessity in coding for architectural design.

The parametric design workshop as a teaching medium cannot replace regular classes due to limited time. It can be suitable for deepening the knowledge, for studying a single modelling, simulation, or fabrication technique, for learning a new plug-in or software. However parametric approach is not a compulsory knowledge for architectural students. It can be offered rather as an elective course at the master level and be addressed to students who make a conscious choice since they are truly interested in visual programming, advanced design, and digital fabrication.

V. CONCLUSION

This study describes an experience in teaching of the parametric design to the students of architecture without any knowledge in parametric modelling. Parametricism as an architectural style is gaining its popularity, but conventional architectural education does not offer a wide range of modelling tools that allow students to practice it easily. The study revealed that the one-day workshop is not sufficient for students to understand advanced PM. They do not distinguish it from conventional 3D modelling as well. However, the students agree that the PM design workshop helps them expand their creativity by designing complex forms with multiple model variations. For the better results the workshop should be extended, and digital fabrication activities should be included into the program. It is an appropriate medium to teach the specific topics to the experienced students, while the basics of parametric modelling should be given during the regular classes.

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Successful Roadmaps for the Managerial Maze and Manager's Dilemmas

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Abstract **–** Managers in organizations face a range of challenges, from building relationships with stakeholders to managing change and conflict. Although the effort to balance priorities in seemingly impossible tasks and conflicting situations can be daunting, it is not without its prescriptions. In addition to individual efforts, some organizational practices also make the job of management easier. From the moment they metaphorically step into the managerial maze, it becomes possible to successfully continue this challenging process with resources that help them develop and grow. In this study, individual resources (e.g., developing personal awareness, increasing relationships with key stakeholders, providing regular checks) and organizational resources (e.g., cross-training, management by exception, job shadowing, management consultancy etc.) that help managers in the process of continuous learning turn their experiences or difficulties into opportunities are presented from a holistic perspective. By presenting examples from organizations where the culture of success is established and from various types of managers (e.g., overly critical, disorganized), factors (e.g., developing socio-emotional intelligence, increasing technological communication skills, training and prioritizing development, creating a completely positive working environment) that make the journey of the difficult maze fun and successful and shed light on the way out are listed. Although the management journey is challenging, it should not be forgotten that it should be considered as an opportunity as it creates a continuous learning process. Being able to take a safe step in the maze is for managers who are talented and have an inspired life. Finally, as a result of this study, road maps that will make the organization successful have been drawn in the light of systematic literature review.

Keywords – Management, Managerial Maze (Labyrinth), Road Map.

I. INTRODUCTION

Working life and business management include questions, problems and dilemmas, just like a maze (or winding/labyrinth) and are full of uncertainties in this context. Since some of the moments experienced in it are not transparent, the manager must be talented in many issues in order to establish dominance over and outside stakeholders and to direct the business correctly. His ability is to predict the future or to feel what will happen. The development of this ability is possible by acquiring certain efforts.

Nevertheless, everything is not visible [1]. Considering that informal structure and self-elements conceal themselves, in other words, emotions and feelings in interpersonal relationships affect the relationships, the manager's work becomes increasingly difficult. In fact, it is seen that situations such as negative attitudes adopted and some negative perceptions about the organization put the manager more difficult. In the managerial maze, both roads and endings are more than one. In this study, the manager made suggestions regarding the guidance of some techniques or approaches in order for the manager to be out of this maze with a positive end.

II. MANAGER'S INDIVIDUAL RESOURCES

The journey of management involves a new challenge or obstacle encounter every turn or turning. Managers can progress successfully and fearlessly in the maze with the right guidance and preparation process. Individual resources that help them can be summarized as follows [2-4]:

- ✓ Personal awareness development (individually strong and weaknesses should be identified),
- ✓ Socio-emotional intelligence development (the manager should be able to understand, manage the feelings of both himself and others and communicate with the external environment without any problems),
- ✓ Interactive communication (should listen to open and effective communication first, then communication with regular feedback should be made dynamic)
- ✓ Developing relationships with key stakeholders (relationship with all stakeholders should be established to achieve common goals),
- ✓ Authority transfer (employees should be directed to take the transfer of authority and responsibility),
- ✓ Management with the leadership of mentor or idol (a leader who will be a guide or inspired),
- ✓ Care for education and development (continuous educational policy in developing needed knowledge and skills),
- ✓ Creating a working environment in prosperity (a business where is peaceful and pleasant),
- ✓ The policy of balancing expectations (finding the sensitive balance between the expectations of the administration and the needs of employees),
- ✓ Managing conflicts (taking responsibility for the results of the team and instilling the sense of unity),
- ✓ Avoiding being an expert in every field (the manager's role is not to know everything, but the understanding of bringing and supporting the necessary expertise team members),
- ✓ Creating a culture of collaborative knowledge sharing (in the light of learning mentality, utilization of the team's various knowledge, skills and experiences).

III. MANAGER'S ORGANIZATIONAL RESOURCES

Organizational resources that assist managers can be summarized as follows [2, 5]:

- ✓ Job shadowing (an on-the-job training program in which a manager who wishes to specialize in a different field observes the in-house activities of someone experienced in that field),
- ✓ Cross training (increasing the new manager's knowledge and skills on all aspects of the job by working in different areas),
- ✓ Challenging tasks (directing the new manager to accomplish a challenging task)
- ✓ 360 degree feedback (collecting information about the new manager from all stakeholders within the organization)
- ✓ Management consultancy (receiving support from competent people who have already been involved in the managerial maze, in other words, who have previously experienced the management phenomenon)
- ✓ Management by exception (delegating daily tasks and frequently repeated decisions in the organization to subordinates

IV. RECOMMENDATIONS FOR DIFFERENT DIFFICULT MANAGER TYPES AND FEATURES

The types of managers who make the business environment more complicated with the policies they implement and their suggestions are also among the sources that help to get out of the maze [6]. There are five types of difficult managers that can often be encountered in businesses: disorganized, micro, unresponsive, bully and overly critical. It is recommended that *disorganized managers,* who like chaos and constantly postpone the fulfillment of responsibilities without paying attention to the deadlines of important tasks, should first create a planned and programmed system, accelerate information sharing by using technology, prefer open communication with regular checks, and estimate mandatory needs and priority tasks. *Micromanagers* who are obsessed with constant supervision and detailed scrutiny are advised to research ways to reduce anxiety, trust their employees, take care to establish constructive

relationships with their environment, and find alternative ways to avoid excessive supervision. For *unresponsive managers* who are often unapproachable, it is suggested that they should be encouraged to proactively evaluate their employees, review their performance, prepare documentation to prove every improvement, and establish strong communication ties with their stakeholders. It should be reminded that for *bully managers* who use fear to defend their authority and enjoy a toxic work environment, disrespect will not be tolerated, records of mistreatment will be kept and the future repercussions will be negative, and the turnover rate will increase for these reasons. Finally, for *overly critical managers* who are constantly dissatisfied and focus especially on the negativities, it is recommended that they not approach events personally, look for the sources of the decrease in motivation, and turn to methods such as supporting mediators. Even though the difficulties are based on mental or organizational resources, it should not be forgotten that they offer helpful opportunities to the person in his/her learning journey. Increasing one's resilience and learning from adversities seem to be beneficial in professionalizing working life.

V. THE SYMBOLIC ROAD MAP OF THE MANAGER IN THE MANAGERIAL MAZE

In the light of the above explanations, a symbolic visual for the manager's roadmap was presented in the managerial maze (Figure 1).

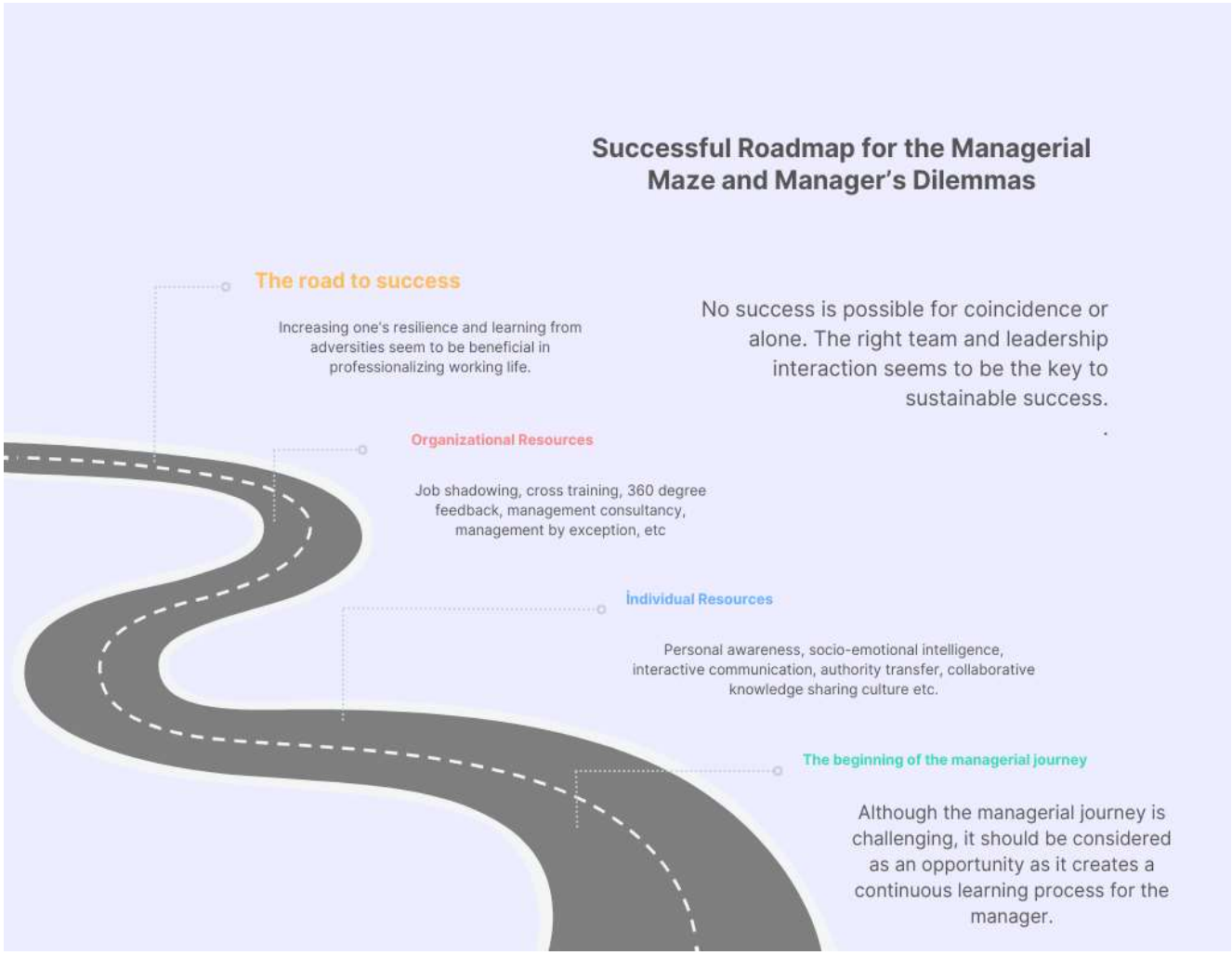

Figure 1. Successful Roadmap for the Managerial Maze and Manager's Dilemma

VI. DISCUSSION

The managerial maze is a continuous learning journey that has difficulties but creates an opportunity for growth. There are many individual and organizational resources that will help him if he wishes. It is

thought that the awareness of these resources summarized in this study will guide them. However, no success is possible for coincidence or alone. The right team and leadership interaction seems to be the key to sustainable success.

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The Changing Face of Business Administration with Industry 5.0 and Multidisciplinary Approaches

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Abstract – As we approach the second half of the 2020s, the changing job characteristics and workforce qualifications have led to an increase in the concerns of leaders, with the competitive environment beginning to be reshaped as a red, blue, green and yellow world. The value of strategic human resources has become increasingly important in creating a Super Smart Society (Industry 5.0) and the accompanying business world. Furthermore, in these scenarios where the rules of fair living are being rewritten, it seems inevitable that business managers will benefit from technology-oriented multidisciplinary approaches in solving problems instead of looking from a single perspective. In this context, this study plans to prepare for the future business world of the 2030s by touching on the contributions of multidisciplinary fields such as meta management, neuro management, data mining, horizon scanning, lean six sigma, retro and green management. In this universe, which is becoming increasingly chaotic with the structures and systems it contains, the process of change and transformation is possible with the right steps taken in acquiring and interpreting information. Abandoning the shallow mindset and having a high-level governance mechanism will become possible by researching, learning and applying the new from different scientific perspectives. When discussing the subject, it is beneficial to take the human system as an example, to consider technology-oriented initiatives and philosophies, and to be inspired by different scientific paradigms. This approach will prepare us for the future. It is believed that this study will raise awareness for future business research.

Keywords – Industry 5.0, Meta Management, Neuro Management, Data Mining, Horizon Scanning, Lean Six Sigma, Retro Management, Green Management.

I. INTRODUCTION

In consideration of the future, business life is a dynamic phenomenon encompassing all environmental changes, including human resources and managerial skills on an internal level and technology on an external level. As a result of these changes, business life is continually reshaped. In the current era, characterized by the dissolution of traditional rationality paradigms, there is a pressing need to redesign businesses and implement novel management techniques in order to ensure a sustainable future.

As the perception of humanity shifts with the advent of the Industrial Revolution and the ascendance of human- and information-oriented societies, it appears that the driving force of capitalism has been supplanted by technology and information [1]. This shift in mindset prompted businesses to adopt novel approaches, particularly those that integrated multiple disciplines. The Super Smart Society (Industry 5.0) facilitates the integration of human, knowledge and technology, thereby preparing businesses for a sustainable future. Firstly, the advent of mechanized production (1.0) led to the advent of mass production (2.0), which in turn gave rise to automation of production (3.0), industrial technology integration (4.0), and finally the intelligent digital information and production technology interaction (5.0), which requires

the multidimensional science windows. In this context, this study sought to interpret the impact of certain multidisciplinary approaches to business administration.

II. Importance of Multidisciplinary Approaches in Business Administration

This section will present a discussion of the multidisciplinary approaches that are subject to this study.

A. Meta Management

Political science-based meta-management represents one of the emerging coordination-based management styles in the business world. This style of management has become increasingly complex due to the implementation of new policies. It encompasses efforts to coordinate the combination of hierarchical, market and network management styles. In light of the evolving social landscape, the necessity for democratic decision-making processes in businesses is becoming increasingly apparent as problems deepen and interactions and negotiations between stakeholders intensify. The objective is to guarantee the coordination of disparate collective actions, providing effective direction to all stakeholders, networks, and partners. As a consequence of increased autonomy, a management style that reduces instability and increases self-organisation capacity, but is non-interventionist, is adopted through dynamic interaction and negotiations between networks, based on the foundations of complexity theory. Furthermore, the role of mediator in pursuing common goals in reducing conflict is also included. Also, it facilitates the development of network actors' identities through techniques such as storytelling, which enables consensus to be reached. Moreover, meta-management practices exhibit considerable variation. The aforementioned approach is designed to achieve the goals of inclusive policy practices, including the framing, facilitation and mediation of the task of organising on networks. This is achieved through the use of tools such as network design, network framing, network management and network participation [2].

B. Neuro Management

Neuro-management is “an approach that investigates managerial and behavioural problems through mental processes and brain activity” [3]. It employs neuroimaging practices to observe neural actions and thus interprets the relationship between human decisions and actions. This approach, which is founded on the basic sciences of medicine and psychiatry, measures mental, psychological and emotional processes that affect the actions and decisions of employees and managers. Examples of neuroimaging tools include the use of electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (FMRI), eye-tracking, galvanic skin response (GSR), and facial action coding system (FACS) allows for the interpretation of leadership and management effectiveness. The analysis of managerial problems enables the examination of employees at work and the evaluation of their behaviours and organizational processes, thereby facilitating the generation of inferences.

C. Data Mining

Data mining, which actually emerged in the 1960s to solve data analysis problems, is a technology that helps businesses focus on extremely important information in their data warehouses and reveals intelligent information [4]. As it turns out, it also includes disciplines such as statistics, artificial intelligence, mathematics and management information systems. It is mostly used in businesses in areas such as customer services, sales forecasts, stock determinations, quality control analyses, optimization of production processes and risk management [5]. Thanks to techniques such as statistical methods, memory-based methods, artificial neural networks and decision trees, business managers benefit from this approach when analysing information and making decisions through data warehouses that provide integration between databases and other information sources.

D. Horizon Scanning

Horizon scanning is “a policy tool that collects a wide range of information about emerging issues and trends in the political, economic, social, technological or ecological environment of the business [6]”. It serves as an early warning system as businesses have an effective foresight system to prepare for the future, thus promoting a culture of organizational foresight [7]. Identifying emerging opportunities and

possible threats provides great convenience for scenario planning and precautions. They include a process similar to the PDCA cycle (by Deming) used by businesses in quality control processes. It includes 4 basic stages: The first phase of scanning is the *discovery* phase, where problems are identified and priorities are evaluated, the *evaluation* phase, where evidence on the subject is presented and its effects on the business are evaluated, the *implementation* phase, which is foresight - creating a strategy, implementing it, reviewing its impact on decision making, and the *maintenance* phase, which is defined as maintaining the mechanism that supports the information management and decision-making processes of the business. It uses many data collection tools such as hand scanning, text mining, WIKI and similar collective platforms, surveys prepared by experts, conferences, and social media tools. It is not insignificant that the forecasting system, which is a signal about the future, serves as a policy tool for businesses.

E. Lean 6 Sigma

Inspired by the Japanese culture, and with the understanding of getting rid of all kinds of waste that creates waste (muda), with the simple six sigma, the development of lean processes that create value in enterprises is improved both to improve quality and to improve the speed in business processes. The first step in lean six sigma applications begins with the identification of customer value. The element that reduces customer value is considered as error or waste. The belief that the exploration manager will adopt this approach, the creation of the team, the accuracy of the project-work match, the integration of training programs, the acceptance of financial responsibilities, the information sharing in the whole of the enterprise, the customer loyalty and change management is created with a better and lower cost. And ultimately, there is an increase in customer value and profitability and a cultural change is felt [9]. With this approach, the fact that businesses reach their production to 3.4 error rates per million brings them one step closer to the future on the way to perfection.

F. Retro Management

Longing for previous historical periods, and in this context, nostalgia, has always included itself in conversations with various connotations. For several decades, these conversations have been reflected in the products and services offered by businesses. It is the re-launch of products and/or services that emerged in previous years, the reminder of the years and memories of their debut with similar packaging, and the implementation of retro management approaches, especially retro marketing in the marketing discipline, in businesses. Such a retrospective management approach in businesses is like taking time travel to the present. Even though postmodern business life prevails, the ties of the future and the past are not severed with this approach. While the "otherness" of the past is always sought in different disciplines such as anthropology, history and psychology, the combination of today's “ordinary” and the “curiosity” of the future has created a signal for businesses to reconsider their management approach. Especially businesses with dominant marketing activities have offered the purchasable version of this desire by keeping nostalgia alive with pictures, scents or objects. Remembering and reminding the past, sometimes with individual experiences, sometimes with environmental and cultural influences, and sometimes with scenarios, has connected the customer and the business and made them share their feelings. Retro marketing and management approach is one of the important strategic tools to “wake up sleeping brands” and “make existing brands emphasize their deep-rooted history” [10].

G. Green Management

Businesses must first change their perspective on dealing with environmental problems and fulfilling their environmental responsibilities. With this change in mentality, it is possible to wisely use natural resources, which are one of the most important inputs, especially production activities, and ultimately to make it possible to return the created outputs to nature both without harming the nature and to a large extent, thanks to the correct awareness. In this context, every technical and organizational process that involves minimizing the negative effects on nature of every activity produced or offered by businesses is evaluated within the scope of green management. Greening business activities is actually possible with the integration of more than one discipline. It is important to benefit from the philosophies and practices

of disciplines such as economy, environment and health together while moving towards the ultimate common goal of sustainable development. While green management is adopted in businesses, it is seen that they move away from tradition and adopt an environmentally focused green culture, focus on environmentally focused design instead of price reasons, seek ways to live in harmony with nature and reduce waste, and give more importance to long-term growth and safety and security issues [11-13].

III. DISCUSSION

This study, which provides examples of applications that help the business world, which has become more complex through various managerial models, aims to raise awareness to solve today's business management problems. In the face of these different perspectives, the importance of stakeholders' knowledge and awareness level has become more central. With the fact that the role of everyone is always important, windows that offer collaborative and conciliatory approaches to preparing for the future seem rational. Hybrid, or in other words, crossbreed structures, offer a window that adds more value to the whole. Although a few of them have been presented in this study, it does not seem possible to present all interdisciplinary approaches at once. However, given the changing face of businesses with smart digital technologies and information interaction, awareness and differentiation seem essential. Matching the right workforce, the right position and the right business is also important at this point. Because catching the future is only possible with the effective use of talented workforce.

Finally, it is thought that the business world will be divided into four worlds in these days when we approach the 2030s [14]. In the *yellow world*, people are prioritized and lead to justice and social benefits and direct enterprises to make business successful in the market. In the *green world*, a strong need for a strong social conscience is important and consumers show loyalty to the environment that respect the environment. In the *blue world*, global and institutional companies have settled in the center and each stakeholder performance is oppressive ruthless. In the *red world*, the rules of innovation are dominant, and a market of niche purpose is competing to serve the needs of individuals and strong interest groups. Although this work world scenarios are seen as imaginary at the time of preparation, it almost coincides with our perspectives. It is possible to say that the red and blue world is more dominant as realism. On the other hand, the yellow world, which focuses on social good, seems to soon destroy its existence from a pessimistic perspective. Technology and artificial intelligence seem to be the biggest power by sitting at the center of businesses.

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Petrography of the Keban Overthrust Zone

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Abstract **–** The Early-Middle Triassic Keban metasediments comprise metamorphosed products of carbonate and pelitic origin. Although they underwent metamorphism under greenschist facies conditions, in some areas where dislocation metamorphism is observed, it can be said that metamorphic conditions advanced to the amphibolite facies. The polysynthetic twinning and kink band structures in calcite minerals indicate that tectonic deformation caused plastic deformation at temperatures exceeding 200°C. The presence of metallic mineralizations, silica lenses, and veins suggests the infiltration of hydrothermal fluids into the overthrust zone..

Keywords – Hidrothermal metamorphism, Skarn, Dislocation, Milonite, Elazığ

I. INTRODUCTION

Since the Eastern Taurus Mountains have been subjected to a compressional regime since the Upper Cretaceous, they contain numerous thrusts. The Bitlis-Pütürge thrust and the Keban overthrust zone, which are widespread around Elazığ and its surroundings, are two such examples. The oldest unit of the region, the metamorphic basement, is best exposed in Keban and its vicinity. The units composing the Keban metasediments, which are vertically and laterally transitional with each other, present a complex stratigraphy. This metamorphic basement has been previously studied by many researchers [1-8], and the term 'Keban Metamorphics' was introduced by Özgül [7]. This unit was included in the Alanya Unit of the Western Taurus by researchers such as and Yazgan [9], Perinçek and Özkaya [10], In their study around Tunceli-Ovacık, Özgül and Turşucu [8] described the Keban Metamorphics as consisting of recrystallized limestone-calcschist, marble and meta-conglomerate, calcschist, and calcphyllite units from bottom to top, and included Jurassic-Cretaceous aged limestones in this formation, naming the metamorphic sequence the Keban Unit. In this study, the term Keban Metamorphics will be used.

The age of the Keban Metamorphics, represented by platform-type carbonates and clastic rocks that underwent regional metamorphism in the greenschist facies, is known as Permo-Triassic/Permo-Carboniferous based on fossils from the Glomospira and Ammodiscus families, which are estimated to be of Permian age. However, a study by Kaya [11] indicates that the Nimri Formation, representing the middle levels of the Keban Metamorphics, contains trace fossils such as Rhizocorallium, Planolites, and Thalassinoides on the upper surfaces of the Gogodere layered dolomitic-crystalline limestone member, suggesting an Early-Middle Triassic (Scythian-Anisian) age.

This study aims to determine the structural deformation traces, mineralogical and petrographic characteristics of rock types, and metamorphic conditions within the Keban Overthrust Zone, which developed along the contact between the Keban Metamorphics and the Elazığ Magmatics.

II. Materials and Method

In order to determine the petrographic characteristics of the rocks in the study area, a total of 25 rock samples were prepared as thin sections in the Mineralogy Laboratories at Pamukkale University. Mineral examinations were conducted using a Leica DM 2500 P polarizing microscope in the laboratories of the Department of Geological Engineering at Fırat University, and photographic images were taken.

A. Geology

In the study area, the fault zone between the Keban Metamorphics and the Elazığ Magmatics is clearly delineated by widespread quartz veins. The allochthonous Keban Metamorphics comprise three nappes overlying each other. The first and lowest nappe is the Early Triassic-Jurassic aged Nimri Formation. The middle nappe consists of the Middle-Late Devonian aged Keban recrystallized carbonates and the Late Devonian aged Delimehmet Formation. The uppermost nappe is the Early Carboniferous aged pelites known as the Süleymanlı Formation. Green metadiabase interlayers are observed at the middle and upper nappe levels (Kaya, 2016).

In the study area, amphibolites are observed at the contact between the Elazığ magmatics, which consist of quartz diorite, diorite, gabbro, granodiorite, and granite rocks, and the Keban Metamorphics (Figure 1). These amphibolites, which outcrop as independent masses within the zone, are located to the northeast of Keban-Çakmak village and Şeyhan neighborhood. The presence of amphibolites indicates an increase in temperature from greenschist facies to amphibolite facies metamorphism

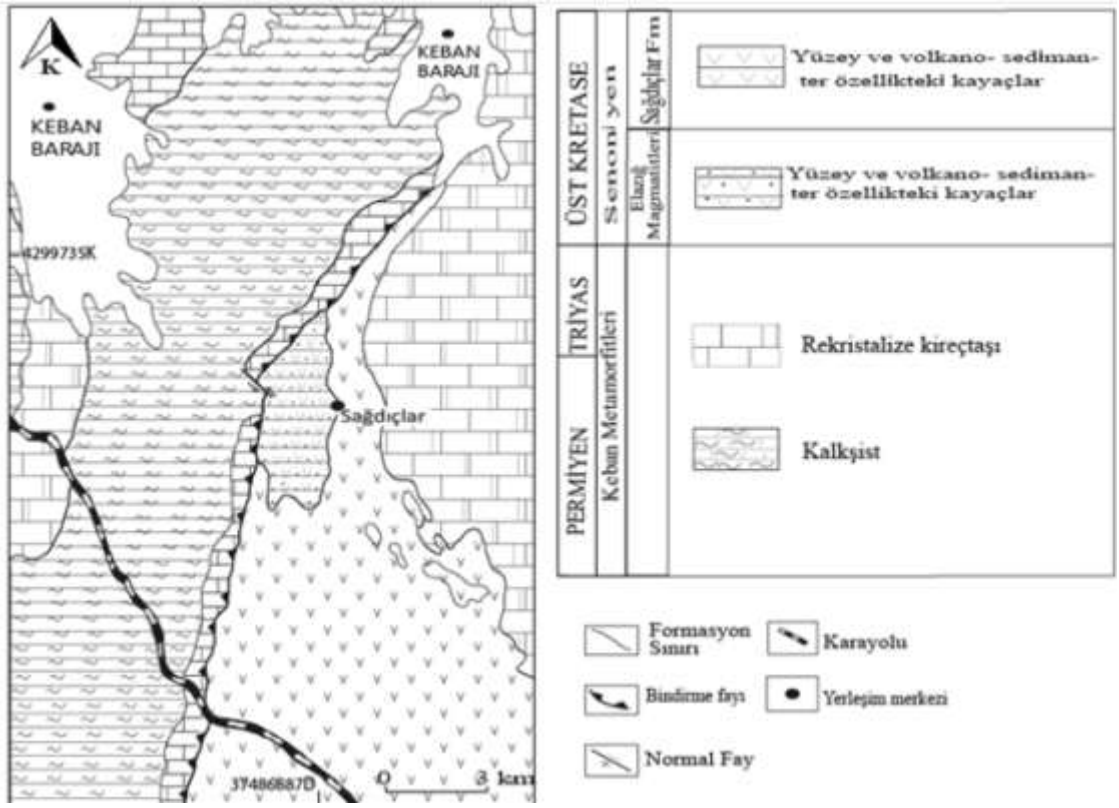

Fig. 1. Geological map of investigated area (from changed Herece 1992)

The Keban Metamorphics are represented by marble, metaconglomerate, calcschist, and calcphyllite rocks (Figure 2).

Fig. 2 Rock samples of Keban metamorphite and Elazığ magmatites

B. Mineralogy and Petrography

The Keban Metamorphics consist of recrystallized limestone, calcphyllite, sericite-chlorite schist, and metaconglomerate. These metamorphics, formed by the regional metamorphism of shallow marine sediments, are observed in intrusive or tectonic contact with magmatics (Figure 1). From bottom to top, the rock types include calcschist, calcphyllite, sericite-chlorite schist, and recrystallized limestone (Figure 3).

Fig. 3 Rocks belong to Keban Metamorphite

The Keban Metamorphics in the study area comprise levels of metaconglomerates laterally transitioning with calcschists and interbedded recrystallized limestone. Recrystallized limestones may have been deposited in a shallow environment during the Permian [3.13,14]. However, Asutay [15] suggests that these rocks were initially derived from carbonate sandstone. The Keban Metamorphics were originally platform-type limestones deposited on a continental shelf.

Calcite crystals, exhibiting a mosaic texture, along with quartz grains displaying ripple marks, are the main minerals constituting marble. Polysynthetic twinning and king band structures in calcite minerals carry the effects of tectonic deformation. These structures, formed as a result of plastic deformation at temperatures exceeding 200°C, are characteristic of thrust zones (Figure 4).

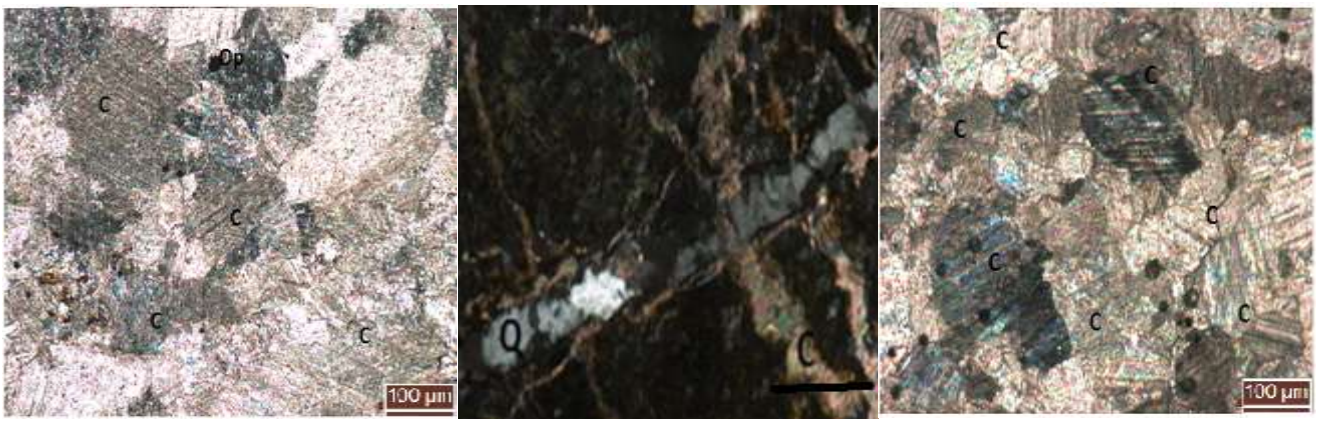

Fig. 4. Birefringence view of marbles and an example of skarn zone

Figure 3 shows calcites and quartzes. In this sample, calcites are larger in size compared to other minerals, while quartzes are smaller, euhedral to subhedral, and generally contain rounded crystals. Additionally, pressure twinning is more pronounced in quartzes, and silicification is widespread. Although manganese is not common, it is particularly developed along fractures. Quartz crystals, although small and rare throughout the rock, are concentrated as large crystals in only a small portion of the thin section. Furthermore, zone differences in the rock are observed along fractures. One side of the fracture is muscovitized. Flow structures can be observed between sericite-chlorite schist and marble. The calcschists, characterized by their greyish color and excellent schistosity, contain calcite, phyllosilicate, quartz, and graphite and exhibit granolepidoblastic texture.

III. DISCUSSION AND CONCLUSIONS

The study area located 30 km northwest of Elazığ province in the Eastern Taurus, situated within the Southeast Anatolian Orogenic Belt, was formed as a result of the collision between the Arabian and Eurasian plates following the closure of the southern Tethys ocean during the Cretaceous-Miocene period [1,2, 11, 13]. In this belt, the lower nappe zone comprises ophiolitic units, while the upper nappe zone consists of the Malatya-Keban Metamorphic massifs [2,12]. The thrust zone located between the Keban Metamorphics and the Elazığ Magmatics is a thrust fault developed within the DAF zone due to compressional forces. Thrust zones formed between the Arabian Plate and the Eurasian Plate from south to north, such as the Maden Complex-Pütürge Metamorphics, the Elazığ Magmatics with the Kömürhan Ophiolites, and the Elazığ Magmatics with the Keban Metamorphics, are observed. This section includes the Hazar Basin, Mastar Mountains, and Elazığ Basin. The main reason for this is the continuous compression regime that the region has been under since the Upper Cretaceous. The most significant factor contributing to this regime is the subduction of the Arabian Plate beneath the Eurasian Plate and its approximately northward compression. The Keban metamorphics have been identified as Early-Middle Triassic (Scythian-Anisian) in age [11].

It is highly probable that the Keban carbonates were metamorphosed during the Turonian-Lower Maastrichtian interval. Considering the structural compatibilities with granitic rocks, this interval could potentially extend up to the Coniacian-Lower Maastrichtian. The Lower Maastrichtian marks a period when the regional tectonic style underwent a complete change. Data obtained from samples collected along the Keban Thrust Zone indicate that the temperature and pressure conditions increase towards the northwest. The pressure effective in the formation of minerals associated with the Keban Thrust Zone is determined to be approximately within the range of 2-4 kbar. The obtained temperature and pressure values indicate conditions of low-grade dynamic metamorphism, which can only be explained by retrograde pressure-temperature conditions. Mineralogical data obtained from samples taken from the Keban Thrust Zone indicate high-pressure-low-temperature conditions. The presence of a mylonitic zone where rock compositions remain unchanged but significant textural changes occur, along with widespread components such as quartzite and aragonite, suggests dynamic metamorphic conditions. Within the thrust zone, a skarn

zone has developed between recrystallized limestone and diorites. The skarn zone observed within the thrust zone is highly fractured and faulted. Metallic mineralizations, including ilmenite, hematite, limonite, chalcopyrite, pyrite, and magnetite, have developed. The mineral parageneses indicate the presence of a metamorphic condition ranging from greenschist facies to amphibolite facies[16]. The thrust zone located between the Keban Metamorphics and the Elazığ Magmatics has formed as a result of continuous compression since the Upper Cretaceous. This compression is due to the subduction of the Arabian Plate beneath the Eurasian Plate and its approximate northward compression.

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Numerical Analysis of the Effects of Different Flow Rates and Pipe Diameter Selection on Fluid Behavior in Crossflow Heat Exchangers

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Abstract – In this study, the flow behavior in a heat exchanger with rectangular channels, containing six pipe bundles with water flowing inside as the fluid and crossflow outside these pipe bundles, has been examined. Despite each pipe having a different fluid temperature, a constant fluid inlet velocity of 0.001 m/s was assumed for all. To investigate the effect of pipe diameter on flow behavior, analyses were conducted within a diameter range of 20-30 mm. The rectangular channel is thermally insulated from the surroundings and the k-omega SST turbulence model, commonly used in heat exchangers, was chosen to examine the resulting turbulence. Water at 300 K was selected as the crossflow fluid and a parametric analysis was conducted with an fluid inlet velocity range of 0.002-0.004 m/s. The Central Composite Design method was chosen for the parametric study. For this purpose, 13 flow analyses were conducted for copper pipe material. These finite element analyses were performed using commercial software for computational fluid dynamics. The results of the analyses were defined in a commercial experimental design program and the effects of pipe diameter, crossflow inlet velocity parameters on the fluid velocity and temperature distribution were presented as a response surface in three-dimensional space. Through this study, the thermal flow inside and outside the pipes in the heat exchanger was numerically modeled and detailed comprehensively. The results provide extensive information for crossflow heat exchangers.

Keywords – Cross flow, Heat exchanger, CFD, Thermal analysis, Central composite

I. INTRODUCTION

In today's world, with the rapid depletion of our natural resources, the emergence of global energy bottlenecks and the continuously rising energy costs, it has become imperative to use energy efficiently and conservatively. Therefore, minimizing losses and reclaiming waste heat has become crucial wherever energy is consumed or produced. In industrial and similar applications, it is often necessary to discharge heat either in the fluid or gas phase. As such, it is evident that this waste heat, when viewed holistically, constitutes a significant proportion. In locations where energy losses are observed, it is essential to design and implement appropriate energy recovery systems to reclaim lost energy and reduce costs.

The objective of waste heat recovery systems is to transfer as much energy as possible to incoming fresh and unloaded fluids before expelling an energy-loaded fluid, thereby reducing the energy consumption of new fluids in subsequent processes and lowering costs. The general working principle of crossflow heat exchangers is such that, while hot fluid passes through one of the parallel plates, cold fluid advances in a cross (perpendicular) manner through the other plate. Desired heat transfer occurs during this flow, thereby achieving thermal gain. Heat exchangers can be classified in various ways according to the mode of heat exchange, different fluids, heat transfer methods, flow structure, and design features. Numerous theoretical and experimental studies have been conducted on crossflow heat exchangers.

Cadavid et al. developed a calculation algorithm by formulating the necessary energy equations for a heat exchanger unit made of aluminum, designed for compact heat recovery units [1]. Saha et al. presented a method for designing a counterflow heat exchanger with rectangular channels and performed CFD analyses using a thermally equivalent parallel plate heat exchanger [2]. Yang et al. conducted a 3D numerical simulation of a tubular heat exchanger using four different modeling approaches and validated their results with experimental data. They found that periodic models, porous models and complete models showed high accuracy in predicting heat transfer, while unit models demonstrated relatively lower accuracy [3]. Sekulic examined the energy conversion of a heat exchanger according to the second law of thermodynamics, observing the efficiency of the exchanger in relation to various parameters such as the inlet temperature ratio and liquid flow capacity [4]. Van Den Bulck optimized the design of a crossflow heat exchanger, determining the optimal distribution of the transfer area for maximum heat efficiency [5]. Oğulata et al. developed a crossflow plate heat exchanger operating with unmixed fluids and analyzed it using balanced crossflow. They established an experimental setup to determine the validity of the heat exchanger and tested it by measuring temperature, airspeed and pressure losses in the system [6].

Quadir et al. numerically analyzed the performance of a triple concentric pipeheat exchanger under different flow arrangements, using the finite element method for both insulated and non-insulated conditions. They utilized hot water, cold water and tap water as the three liquids, making various observations [7]. Vali et al. developed a steady-state two-dimensional numerical model to study heat transfer in an environmental heat recovery system with two heat exchangers, each combining parallel plate or membrane counterflow and crossflow [8]. Vaitekunas proposed a general model for crossflow heat exchangers suitable for dynamic process simulation, using the finite difference method to formulate energy solutions for arbitrary transitions in combined flow with temperature and pressure drops [9]. Taler et al. developed a numerical model to determine the effect of the fouling factor on steam temperatures and flue gas in crossflow heat exchangers with complex flow arrangements [10]. Inan et al. examined fluid behavior in single-segment baffle shell and pipeheat exchangers at different flow rates and baffle spacings. Using water, they investigated the effects on pressure drop, heat transfer rate and shell-side heat transfer coefficient. The results indicated that varying the distance between baffles affected fluid behavior and heat transfer performance [11].

Dhangar et al. investigated factors affecting heat transfer in automotive radiators. They analyzed the effects of different materials (aluminum, brass and copper) and varying mass flow rates (180-500 kg/h) on heat transfer in finned and finless radiators using a computational fluid dynamics (CFD) model. They also evaluated the impact of airspeed through the radiator (3-6 m/s) on heat transfer [12]. Bhavesh et al. designed a mini-channel heat exchanger considering different inlet temperatures, cold water inlet temperatures and mass flow rates. This compact heat exchanger was designed for cooling electronic devices such as microprocessors [13]. Bhanuchandrarao et al. conducted analyses using Ansys Fluent software and found that fouled exchangers performed less efficiently and that parallel flow exchangers exhibited different performance from counterflow exchangers [14]. Zena et al. conducted CFD studies to determine the temperature difference in a smooth and low integral finned pipecrossflow heat exchanger. They used air as a cooling fluid passing through the test pipeat speeds of 1-4 m/s. The results showed that the finned pipeheat exchanger had a higher temperature difference and heat transfer coefficient than the smooth pipeheat exchanger [15].

Ocłoń et al. experimentally obtained the flow behavior inside a heat exchanger pipe and simulated these experimental results using various turbulence models in a CFD simulation program. They found that the k-omega SST turbulence model provided the most accurate results when comparing the experimental data with the CFD analysis results [16]. Kılıc et al. performed CFD analyses of a crossflow heat exchanger used for cooling electronic systems in unmanned aerial vehicles. They observed that changing the Reynolds number (6000-12000) increased the Nusselt number by 44.65% and increasing the air inlet speed (30-90 m/s) increased the Nusselt number by 6.96%. They also found that comparing different nanofluids showed that Cu-H2O nanofluid increased the Nusselt number by 6.63% compared to H2O nanofluid [17]. Singh et al. examined a heat exchanger where hot water flowed inside the pipe and cold water flowed outside the pipe. They conducted their analyses using the CFD technique and k-epsilon turbulence model

and validated the CFD analysis results with experimental data. They demonstrated that the CFD method is a reliable approach for designing and optimizing heat exchangers [18]. Kang et al. proved that heat transfer varied when the material of a micro heat exchanger was changed in their study on micro heat exchangers [19]. Petrik et al. investigated the heating performance of a radiator used in the automotive industry. They analyzed different airflow speeds and fin models, observing that different fin models affected the heat transfer coefficient and heating performance [20]. Meral et al. conducted experimental research and CFD analyses on a micro-channel and crossflow heat exchanger. They compared the experimental and CFD results, finding them consistent. However, they noted differences in pressure values [21].

In this study, the thermal and hydrodynamic characteristics of crossflow within an insulated rectangular channel were examined. The cooling of a fluid with a constant inlet speed and different temperatures passing through the pipe was numerically investigated and simulated. To thoroughly elucidate the cooling process, the thermal behavior induced by crossflow heat transfer was analyzed by introducing a counterflow with a constant temperature and varying inlet speeds. Systematic combinations were analyzed using an numerical design model to model the behavior resulting from different inlet speeds and fluid temperatures and the fluid temperature behavior and outlet velocity inside the pipe were numerically modeled through regression analysis.

II. MATHEMATICAL MODEL

CFD (Computational Fluid Dynamics) analyses are used to examine the performance of crossflow heat exchangers in a more detailed and accurate manner. These analyses enable the acquisition of critical data for the design and optimization of heat exchangers. Through this, it is possible to obtain more precise data that is difficult to achieve using experimental methods and the behavior of fluids can be simulated using numerical methods. CFD analyses are widely used to study the velocity distribution, temperature distribution and heat transfer coefficients of fluids in three dimensions. The FEM (Finite Element Method) is utilized for numerical solutions. FEM is a numerical solution method commonly used in CFD analyses. The purpose of this method is to divide large and complex geometries into simpler and smaller elements. By using this method, each element, which is divided into small and simple parts for analysis, can be examined by solving the continuity, momentum, and energy conservation equations respectively for each element. The following equations have been used to analyze the effect and flow behavior of the crossflow within the control volume in this study.

Continuity equation:

$$\frac{\partial \mathrm{Ux}}{\partial \mathrm{x}} + \frac{\partial \mathrm{Uy}}{\partial \mathrm{y}} + \frac{\partial \mathrm{Uz}}{\partial \mathrm{z}} = 0 \quad (1)$$

Momentum equation for the X-axis:

$$\rho_{hnf}\left[U_x \frac{\partial U_x}{\partial x} + U_y \frac{\partial U_x}{\partial \mathrm{y}} + U_z \frac{\partial U_x}{\partial \mathrm{z}}\right] = -\frac{\partial \mathrm{P}}{\partial \mathrm{x}} + \mu_{hnf}\left[\frac{\partial^2 U_x}{\partial \mathrm{x}2} + \frac{\partial^2 U_x}{\partial y^2} + \frac{\partial^2 U_x}{\partial z^2}\right] \quad (2)$$

Momentum equation for the Y-axis:

$$\rho_{hnf}\left[U_x \frac{\partial U_y}{\partial x} + U_y \frac{\partial U_y}{\partial \mathrm{y}} + U_z \frac{\partial U_y}{\partial \mathrm{z}}\right] = -\frac{\partial \mathrm{P}}{\partial \mathrm{x}} + \mu_{hnf}\left[\frac{\partial^2 U_y}{\partial x^2} + \frac{\partial^2 U_y}{\partial y^2} + \frac{\partial^2 U_x}{\partial z^2}\right] \quad (3)$$

Momentum equation for the Z-axis:

$$\rho_{hnf}\left[U_x \frac{\partial U_z}{\partial x} + U_y \frac{\partial U_z}{\partial \mathrm{y}} + U_z \frac{\partial U_z}{\partial \mathrm{z}}\right] = -\frac{\partial \mathrm{P}}{\partial \mathrm{x}} + \mu_{hnf}\left[\frac{\partial^2 U_z}{\partial x^2} + \frac{\partial^2 U_z}{\partial y^2} + \frac{\partial^2 U_z}{\partial z^2}\right] \quad (4)$$

Energy conservation equation:

$$\rho_{hnf}\, Cp_{hnf}\left[U_x\frac{\partial T}{\partial x}+U_y\frac{\partial \mathrm{T}}{\partial \mathrm{y}}+U_z\frac{\partial \mathrm{T}}{\partial \mathrm{z}}\right]=k_{hnf}\left[\frac{\partial^2 \mathrm{T}}{\partial x^2}+\frac{\partial^2 \mathrm{T}}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right] \quad (5)$$

$$k_{hnf}\left[\frac{\partial^2 \mathrm{T}}{\partial x^2}+\frac{\partial^2 \mathrm{T}}{\partial y^2}+\frac{\partial^2 T}{\partial z^2}\right]=0$$

III. PHYSICAL MODELING

The control volume where crossflow behavior will be examined consists of a well-insulated rectangular channel. In the narrow section of the channel, there are six circular pipe bundles through which hot fluid flows. The pipes are parallel and equidistant from each other, with diameters of a minimum of 20 mm and a length of 500 mm. For the parametric study, pipe diameters have been selected to range between 20 mm and 30 mm. The geometries of the flow area and the pipe bundle were created using the DesignModeler design program within Ansys Fluent software. The isometric view and geometric dimensions of the rectangular flow volume and the pipe bundle inside it are shown in Figure 1.

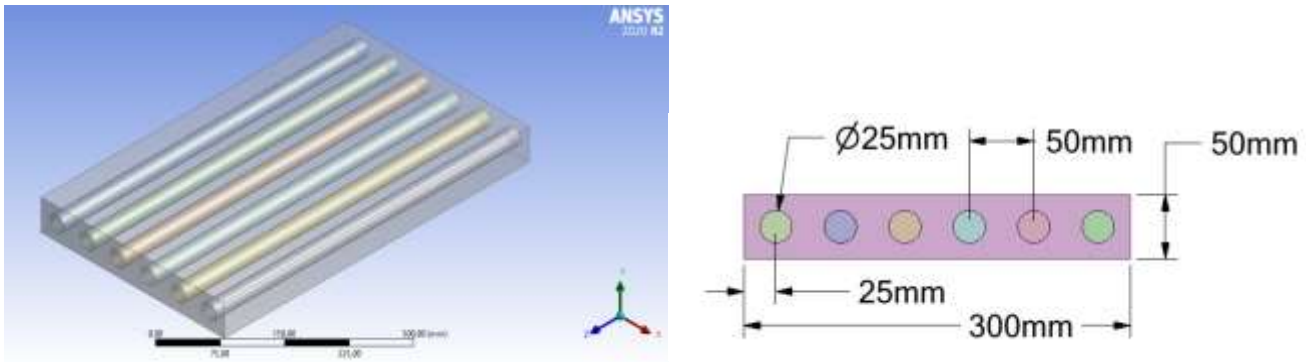

Figure 1. Crossflow control volume and geometric dimensions

Material

The inlet velocity of the hot fluid passing through the pipebundle is 0.001 m/s and is constant. Water, which serves as the hot fluid, is used, and its physical properties are provided in Table 1. From the side cross-section of the rectangular channel, water with the same physical properties and at a temperature of 300 K flows perpendicularly and crosswise to the pipebundles. The inlet velocity value for the crossflow is selected from the minimum and maximum speed range initially established, and the thermal and hydrodynamic effects of this velocity on the flow behavior are examined. Copper metal, known for its high thermal conductivity and low cost, was chosen as the material type for the pipebundle through which the fluid flows. The physical properties of the copper metal used in the analyses are provided in Table 1.

Table 1. Physical properties of the fluid and the copper tube

	Hot Fluid	**Cross Cold Fluid**	**Copper**
Temperature (K)	400-450	300	
Density (kg/m³)	998.2	998.2	8978
Viscosity (kg/m·s)	0.001003	0.001003	
Velocity (m/s)	0.001	0.002-0.004	
Specific Heat (J/kg·K)	4182	4182	381
Thermal Conductivity (W/m·K)	0.6	0.6	387.6

Boundary Conditions

Thermal conduction occurs as a result of the contact between the fluid to be cooled and the surface of the pipe with the crossflow fluid. The rectangular channel, designed for analyzing velocity and pressure behavior, is insulated from its surroundings and represents a volume capable of demonstrating turbulent behavior. The control volume has two flow inlets: one through the inside of the pipe bundle and the other from outside the pipe bundle (crossflow). The visual representations of these flow volumes are provided in Figure 2. The velocity and temperature values are defined as inlet boundary conditions for these flows. The defined ranges for these velocity and temperature values are provided in Table 2.

Table 2. Velocity and temperature range values

Variables	In-PipeFlow	Cross Flow
Velocity (m/s)	0.001	0.002-0.004
Temperature (K)	400-450	300

Figure 2. In-Pipe and Cross Flow Volume.

The hot fluid to be cooled passes through the pipe bundle. The fluid temperature in the first pipe is 400 K and it is arranged such that the temperature increases by 10 K increments in the adjacent tubes, reaching 450 K in the last tube. The inlet velocity of the hot fluid is constant at 0.001 m/s. Fluids exiting the control volume are defined as open to the atmosphere. The crossflow entering the control volume has a temperature of 300 K and its inlet velocity varies between 0.002 and 0.004 m/s. The k-omega SST turbulence model, frequently used in heat exchangers for hydrodynamic and thermal behavior, was chosen [16]. A total of 1000 iterations were performed to monitor convergence results. The copper pipes are numbered from one to six, with the pipe closest to the crossflow inlet labeled as '1'. Results were taken for the cross-section at the pipe outlet, and the term 'outlet temperature 1' refers to the outlet temperature at the outlet of pipe '1'. The same notation applies to the velocity at the outlet cross-section of the tube. For comparing cooling performance, the minimum temperature values at the outlet pipe cross-sections were taken as references. Conversely, maximum velocity values were used for the experimental design. The boundary conditions for the physical model are shown in Figure 3.

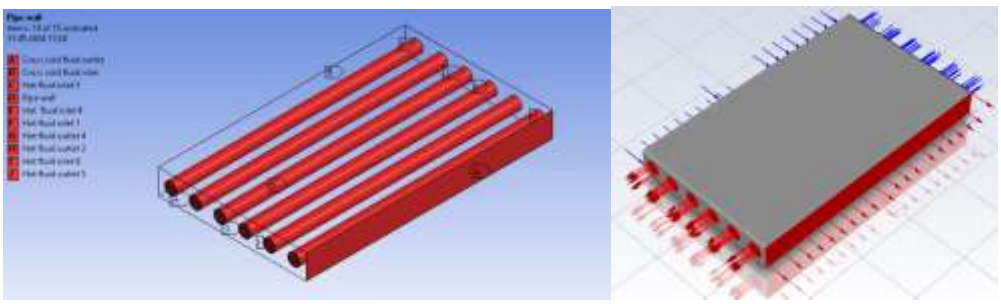

Figure 3. Boundary conditions of the physical model.

Mesh Structure

A mesh structure is required to model the turbulent behavior occurring in the crossflow area and the hot flow area. In the meshing process, a hexahedral element structure was used and the control volume consists of 105,200 elements and 116,251 nodes. The mesh structure of the model is shown in Figure 4 and the Orthogonal Quality table for the created mesh elements is provided in Figure 5.

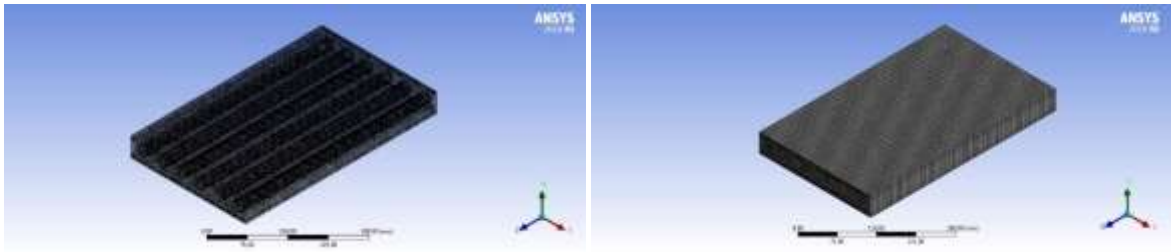

Figure 4. View of the mesh structure of the model

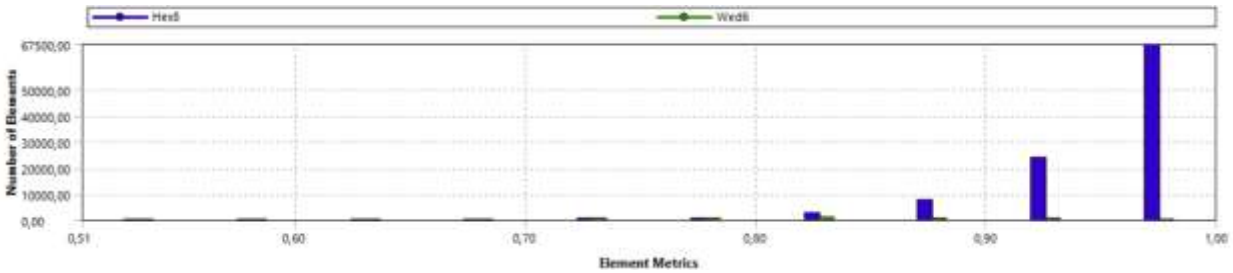

Figure 5. Orthogonal quality table

IV. FINDINGS

In this study, the effects of pipe diameter and crossflow inlet velocity on the fluid outlet velocity and flow temperature within the pipes in hydrodynamic systems were systematically examined. Regression models were used to mathematically investigate the effects of independent variables on dependent variables. By performing regression analysis with the findings from the analysis, mathematical models were obtained. Determining the optimum parameters for the physical model within the control volume is crucial for system design and performance optimization. The accurate selection of pipe diameter and crossflow inlet velocity parameters in this study has improved system efficiency and reduced design costs.

The mentioned regression analyses were conducted using the Design Expert software. Thirteen analyses were performed using the central composite method, yielding the mathematical equations provided below. The regression coefficient (R^2) being 0.97 indicates that a highly accurate mathematical model was obtained. (A: Diameter, B: Inlet velocity)

According to the findings, it was observed that the cooling performance improved with a decrease in the diameter of the copper pipes. The minimum diameter of 20 mm exhibited the best cooling performance, while the 30 mm diameter provided the least cooling. Conversely, an increase in the crossflow fluid velocity enhanced cooling. The highest cooling was observed at the maximum velocity of 0.04 m/s. This desired condition is represented by the peak point in the 3D result graph provided by the Design Expert software, as clearly shown in Figure 6.

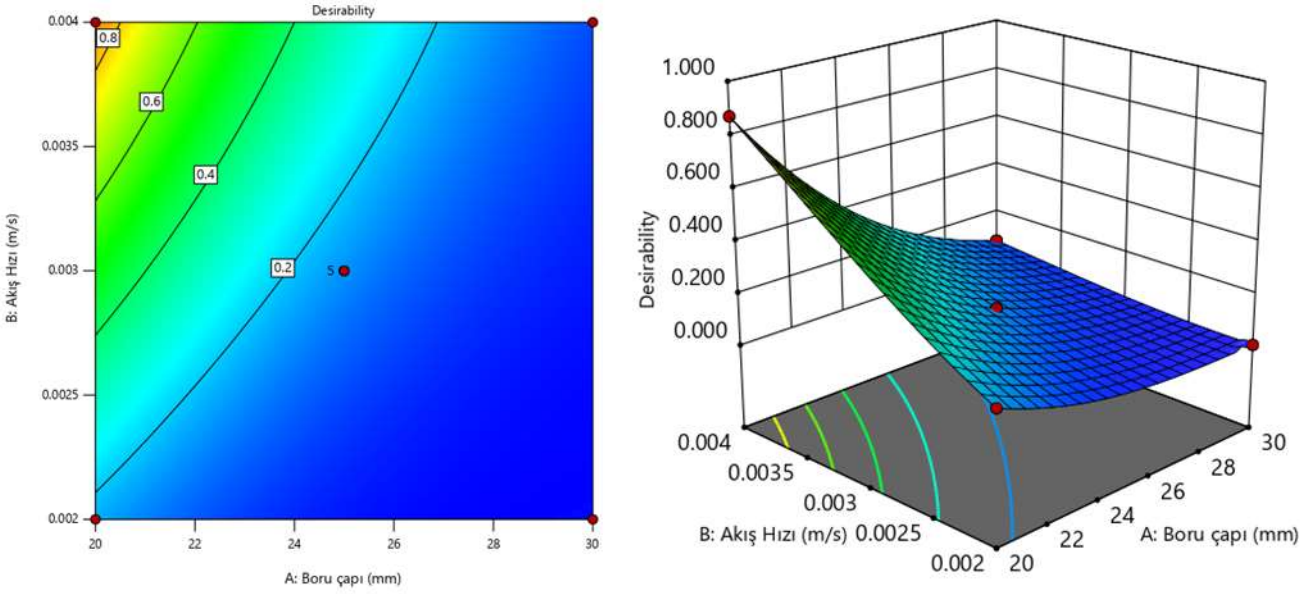

Figure 6. Two and Three-Dimensional analysis optimum result graphs.

Outlet Temperature

First Pipe: Generally, lower outlet temperatures were observed with smaller pipe diameters. However, at a specific pipe diameter of 25 mm, the maximum outlet temperature was reached at low flow velocities. When the pipe diameter is 25 mm, the exit temperatures are generally stable and around 390.699 K. However, when the flow velocity is 0.00158579 m/s, the outlet temperature reaches its maximum value of 392.126 K. At low flow velocities (0.0015 - 0.002 m/s), exit temperatures are typically high. Specifically, when the pipe diameter is 25 mm and the flow velocity is 0.00158579 m/s, the outlet temperature reaches the highest level at 392.126 K. In contrast, at high flow velocities (0.004 - 0.0045 m/s), outlet temperatures remain lower. For example, when the pipe diameter is 20 mm and the flow velocity is 0.004 m/s, the outlet temperature drops to 388.738 K.

Second Pipe: At the maximum pipe diameter (32.0711 mm), the outlet temperature is 399.825 K. When the pipe diameter is at its minimum (20 mm) and the flow velocity is also at its minimum (0.002 m/s), the outlet temperature is 396.655 K. If the flow velocity is at its maximum (0.004 m/s), the outlet temperature is 394.842 K. When the pipe diameter is 20 mm (minimum) and the flow velocity is 0.004 m/s (maximum), the outlet temperature drops to 394.842 K. Conversely, when the pipe diameter is 25 mm and the flow velocity is 0.00158579 m/s, the outlet temperature reaches a high level of 398.650 K.

Third Pipe: At the maximum pipe diameter, the outlet temperature is 408.547 K. At the minimum pipe diameter, outlet temperatures range between 405.142 K and 403.209 K. A notable point is that at a diameter of 30 mm and a flow velocity of 0.002 m/s, the outlet temperature reaches the maximum value of 409.076 K. When the flow velocity is at its maximum and the pipe diameter is 20 mm (minimum), the outlet temperature drops to 403.209 K.

Fourth Pipe: The minimum and maximum outlet temperatures are observed between 411.798 K and 418.180 K. When the pipe diameter is at its highest (32.0711 mm), the outlet temperature is 417.298 K. When the pipe diameter is at its minimum and the flow velocity is 0.002 m/s, the outlet temperature is 413.802 K; as the flow velocity increases to 0.004 m/s, the temperature reaches 411.798 K. Another point is that when the pipe diameter is 25 mm and the flow velocity is 0.00441421 m/s, the outlet temperature drops to 413.089 K, approaching the minimum temperature value.

Fifth Pipe: The minimum temperature value of 420.326 K is reached at the minimum pipe diameter and maximum velocity. Conversely, the temperature reaches a maximum of 427.173 K. When the pipe diameter is 25 mm, the outlet temperatures are generally around 422.343 K. However, when the flow velocity is 0.00158579 m/s, the outlet temperature rises to 424.528 K.

Sixth Pipe: At the highest pipe diameter (32.0711 mm), the outlet temperature is observed to be 435.221 K. This indicates that larger pipe diameters experience less friction and energy loss for the fluid. Outlet temperatures range between 432.817 K and 430.623 K. As the flow velocity increases, the outlet temperature decreases. When the pipe diameter is 25 mm and the flow velocity is 0.00441421 m/s, the outlet temperature drops to 433.175 K. At medium pipe diameters (25 mm), the outlet temperature is generally clustered around a constant value (434.082 K). These comments and comparisons are consistent with the mathematical equations obtained from the regression analysis results shown in Table 3.

Table 3. Coefficient table of the mathematical model for outlet temperature

	Intercept	**A**	**B**	**AB**	**A^2**	**B^2**
Outlet Temperature 1	390.699	**0.893971**	**-0.75468**	0.08825	**-0.202062**	0.100938
Outlet Temperature 2	396.923	**1.45228**	**-0.81973**	0.1785	**0.641938**	0.156688
Outlet Temperature 3	405.306	**1.6861**	**-0.873126**	0.1805	**0.759625**	0.247125
Outlet Temperature 4	414.04	**1.78866**	**-0.940329**	0.17175	**0.789938**	0.288438
Outlet Temperature 5	422.343	**1.85223**	**-1.00962**	0.201	**1.1575**	0.346
Outlet Temperature 6	434.082	**1.72189**	**-0.973135**	0.1725	**-0.967625**	0.179875

.

Generally, as the pipe diameter increases, the outlet temperature also increases. This is an undesirable situation for cooling. As the crossflow velocity increases, the outlet temperature tends to decrease. However, this decrease is less pronounced compared to the effect of pipe diameter. The lowest outlet temperature is 390 K for the first pipe and the highest outlet temperature is 435 K for the sixth pipe. When comparing outlet temperatures within each analysis:

Outlet Temperature 1 and 2: The effects of pipe diameter and flow velocity on outlet temperature are more pronounced. The results show that outlet temperature 2 is more sensitive to pipe diameter compared to outlet temperature 1 and exhibits higher temperature increases.

Outlet Temperature 3 and 4: The effect of pipe diameter is significant, while the effect of flow velocity is less pronounced. Outlet temperature 4 is more responsive to changes in pipe diameter and shows higher temperature increases. For outlet temperature 3, as the pipe diameter increases from 20 mm to 30 mm, the temperature reaches 408 K. For outlet temperature 4, the temperature reaches 418 K. This indicates that outlet temperature 4 is more sensitive to pipe diameter.

Outlet Temperature 5 and 6: The effect of pipe diameter is significant, while the effect of flow velocity is minimal. For outlet temperature 5, as the pipe diameter increases from 20 mm to 30 mm, the temperature reaches 426 K. For outlet temperature 6, the temperature reaches 435 K. This shows that outlet temperature 6 is more sensitive to pipe diameter. These observations are consistent with the outlet temperature graphs shown in Figure 7.

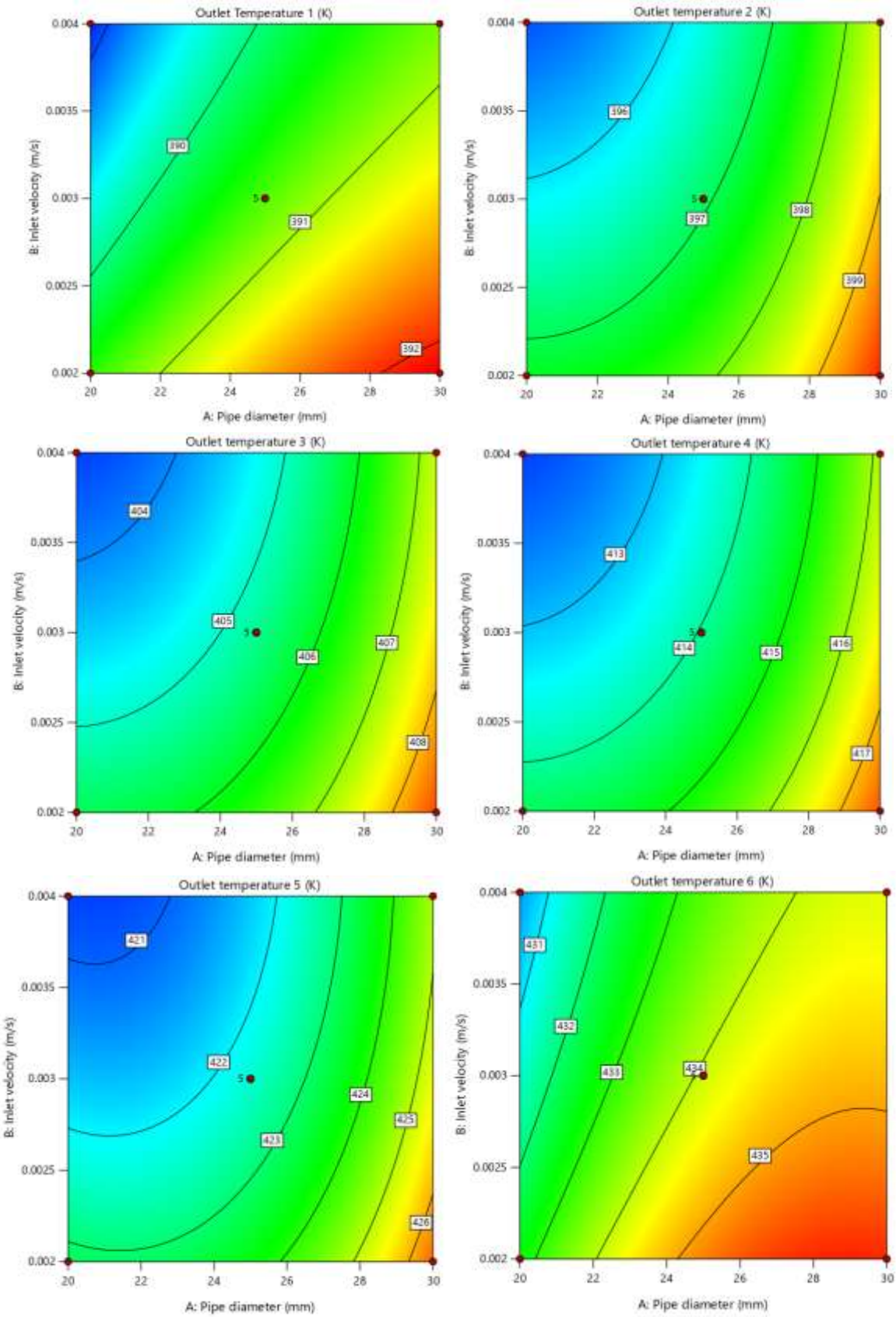

Figure 7. Outlet temperature result contours by pipe sequence.

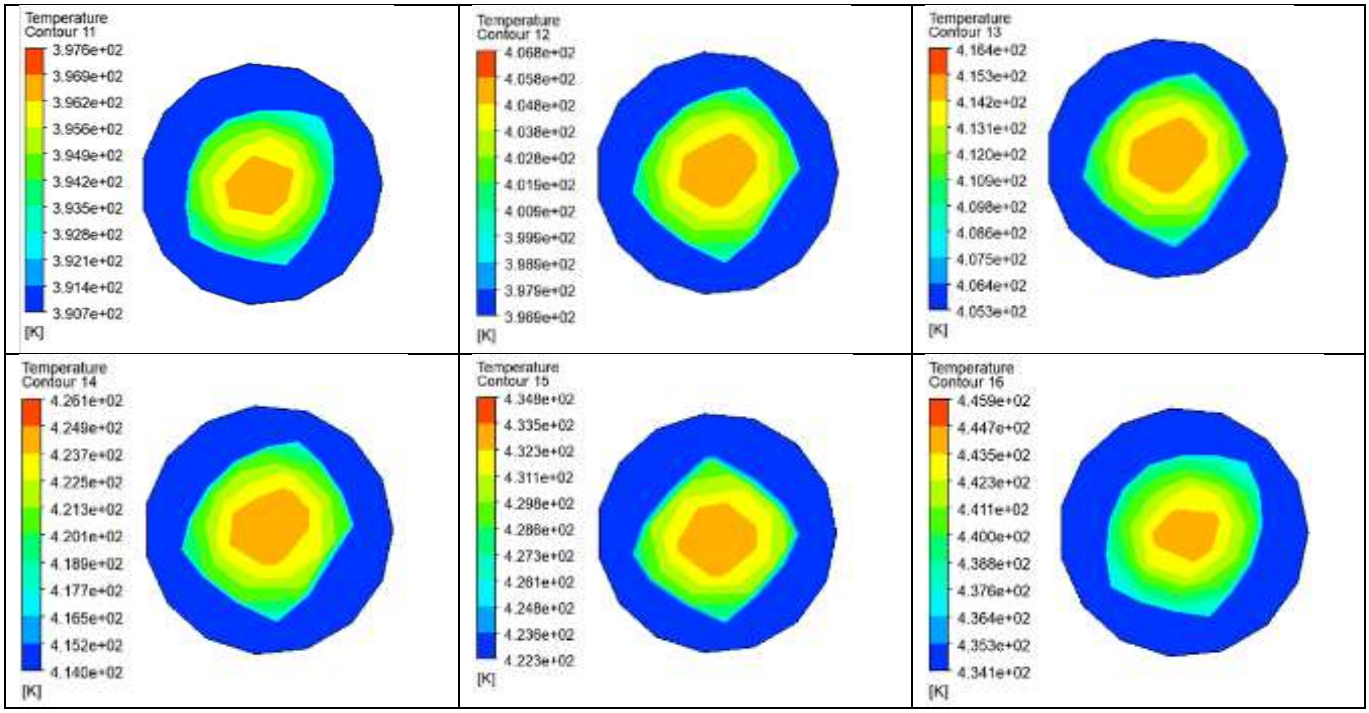

Figure 8. Outlet temperature distribution result visuals by pipe sequence.

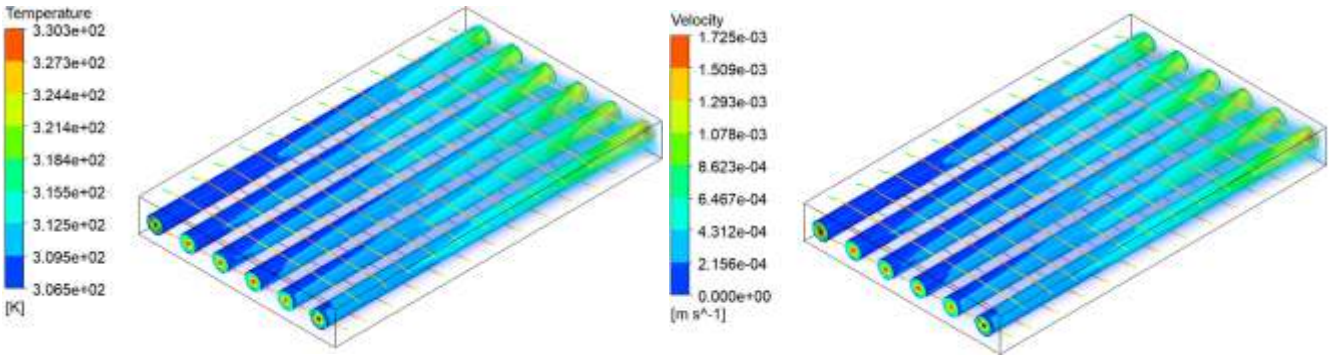

Figure 9. Temperature and velocity outlet result visual.

Outlet Velocity

Generally, pipe diameter and crossflow velocity have less impact on the fluid's outlet velocity compared to the outlet temperature. For low crossflow velocities (0.0015 - 0.002 m/s), the in-pipe outlet velocities are generally lower. Specifically, when the pipe diameter is 25 mm and the flow velocity is 0.00158579 m/s, the outlet velocity reaches a maximum of 0.00118907 m/s. For medium flow velocities (0.003 m/s), the in-pipe outlet velocities are generally stable and cluster around a predictable value. At this velocity, changes in pipe diameter and flow velocity have a limited effect on the outlet velocity. When high flow velocities (0.004 - 0.0045 m/s) are applied, the in-pipe outlet velocities are at higher levels. This indicates that as the flow velocity increases, the outlet velocity also increases. These comments and comparisons are consistent with the mathematical equations obtained from the regression analysis results shown in Table 4.

Table 4. Coefficient table of the mathematical model for outlet velocity

	Intercept	A	B	AB	A^2	B^2
Outlet velocity 1	0.00118907	**4.17068E-06**	-1.41054E-19	2.80509E-19	**-7.985E-06**	1.005E-06
Outlet velocity 2	0.00117861	**9.6066E-06**	-1.55274E-19	3.04699E-19	**-5.69E-06**	1.1E-07
Outlet velocity 3	0.00117861	**1.01315E-05**	-8.67075E-20	1.69693E-19	**-6.2625E-06**	3.125E-07
Outlet velocity 4	0.00117861	**9.34765E-06**	-1.09266E-19	2.13736E-19	**-4.76875E-06**	-1.8375E-07
Outlet velocity 5	0.00115908	**9.99819E-06**	-2.55858E-19	5.10168E-19	**6.71375E-06**	2.49875E-06
Outlet velocity 6	0.00118907	**8.01707E-06**	-1.71217E-19	3.37302E-19	**-6.35187E-06**	-8.24375E-07

When low flow velocities and medium pipe diameters are applied to the design, maximum outlet velocity is achieved. For example, a pipe diameter of 25 mm and a flow velocity of 0.003 m/s are ideal for achieving high outlet velocities. In the case of high flow velocities and large pipe diameters (30 mm), high outlet velocity is also achieved.

Low Flow Velocities: At low flow velocities, the outlet velocity is more sensitive to the pipediameter and increases significantly. In all graphs, as the pipediameter increases at low flow velocities, the outlet velocity increases. This indicates that the effect of pipediameter on outlet velocity is more pronounced at low flow velocities.

Medium Flow Velocities: At medium flow velocities, the outlet velocity is sensitive to the pipediameter, but the increase is more limited. In all graphs, as the pipediameter increases at medium flow velocities, the outlet velocity increases. However, this increase is less pronounced compared to low flow velocities. For example, in Figure 10, while the outlet velocity remains constant as the pipediameter increases from 25 mm to 30 mm in Outlet Velocity 1, this increase is more pronounced in other graphs.

High Flow Velocities: At high flow velocities, the outlet velocity is less sensitive to the pipediameter and remains approximately constant. In all graphs, as the pipediameter increases at high flow velocities, the outlet velocity remains constant or increases slightly.

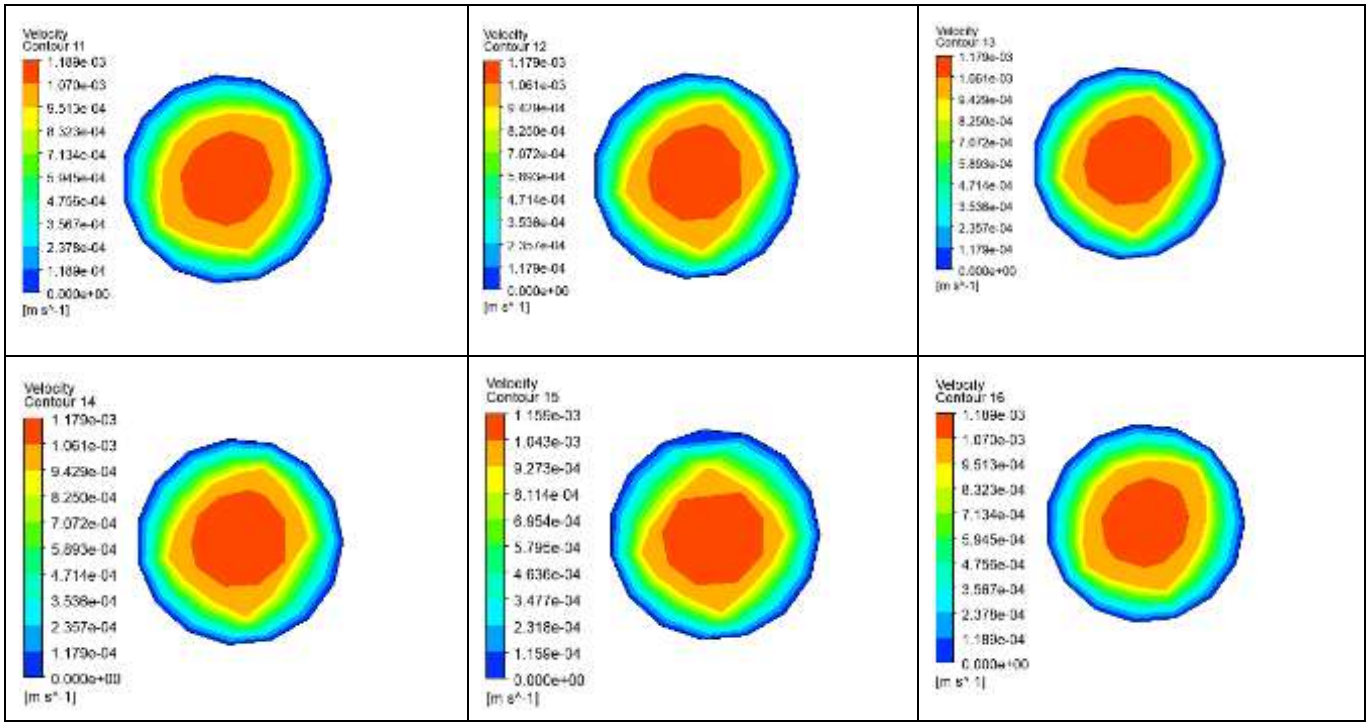

Figure 10. Outlet velocity distribution result visuals by pipe sequence.

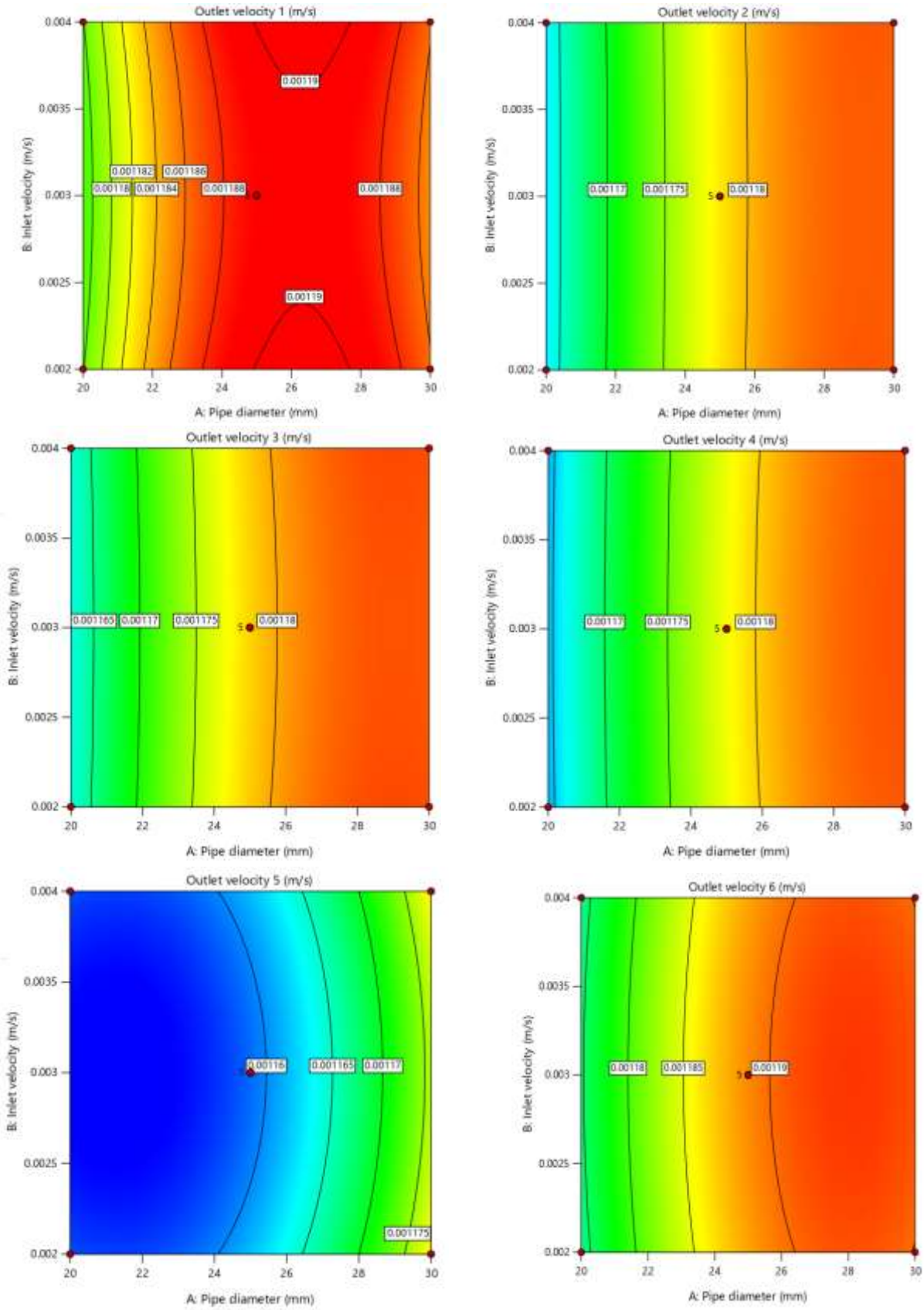

Figure 11. Outlet velocity result contours by pipe sequence

V. DISCUSSION

This study examines the effects of diameter (A) and inlet velocity (B) variables on outlet velocity and flow temperature. The analysis data allow us to better understand the relationships between the interaction of pipe diameter and inlet velocity with outlet velocity and flow temperature. The regression models in this study provided significant information and correlations for the optimization process of crossflow cooling performance. The research findings demonstrate that careful optimization of diameter and inlet velocity is critical to improving system performance in the design of hydrodynamic systems. In particular, optimizing the combinations of diameter and inlet velocity in industrial applications such as water distribution systems and oil and gas pipe lines can reduce energy costs and extend system life. Based on analyses conducted considering the design parameters and boundary conditions, adhering to the following recommendations will provide advantages in terms of thermal performance and system cost;

High Heat Requirement: If high outlet temperatures are required in a system, for example, 435 K or higher, the pipe diameter should be at least 25 mm and the flow velocity should be kept low (around 0.003 m/s).

Low Heat Requirement: If low outlet temperatures are needed, for example, around 430 K, the pipe diameter can be smaller (20 mm) and the flow velocity can be increased (0.004 m/s).

VI. CONCLUSIONS

This detailed analysis shows how diameter and inlet velocity variables affect the performance of hydrodynamic systems and demonstrates that careful optimization of these parameters is critical to improving system performance. Energy efficiency in hydrodynamic systems is critical to reducing operational costs and minimizing environmental impacts. Determining the optimal combinations of diameter and inlet velocity can enhance energy efficiency. These findings can be used to develop more efficient and cost-effective solutions in engineering applications. For instance, a combination of a 30 mm diameter and a 0.004 m/s inlet velocity provides high outlet velocity and energy efficiency. While increasing the inlet velocity boosts the outlet velocity, very high velocities can cause turbulence and wear in the pipe system, which can negatively affect the system's life span and reliability. These combinations offer sustainable engineering solutions by reducing energy consumption. Maximum heat transfer can be achieved by using larger pipe diameters at low flow velocities. However, the pipe diameter must also be maintained at an optimum level; very large pipe diameters can increase costs.

This comparison examines the effects of pipe diameter and flow velocity on outlet velocity in depth. The correct combination of pipe diameter and flow velocity can enhance energy efficiency and optimize system performance. In various industrial applications, careful evaluation and optimization of these parameters will provide cost-effective and high-performance solutions. Such analyses are crucial in the design and development of heat transfer systems and should be supported by continuous research and development efforts.

Future studies and practical applications can expand on these findings to develop more efficient, sustainable and cost-effective hydrodynamic systems. More comprehensive analyses can be performed by including not only diameter and inlet velocity but also other factors such as fluid type, pipe material and environmental conditions in the model.

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İdealist/Liberal Uluslararası İlişkiler Kuramı Bağlamında Türkiye'nin Filistin Sorununa Yaklaşımı

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Özet – Türkiye Cumhuriyeti yeni kurulduğunda, kurucu Mustafa Kemal Atatürk'ün ifadesiyle simgeleşen "Yurtta Sulh, Cihanda Sulh" ilkesini dış politikasının temeli olarak kabul etmiştir. Söz konusu ilke, güç mücadelesinin uluslararası hukuk aracılığıyla dizginlenebileceği ve çıkar mücadelesine girişmek yerine herkesin çıkarına olacak şekilde ortak bir güvenlik sistemi kurulabileceği inancını ifade eden liberal uluslararası ilişkiler kuramına denk düşmektedir. Yıllar geçtikçe, söz konusu ifade temelinde şekillenen idealist/liberal yaklaşım ilke olarak sürmekle beraber Türkiye, karşılaştığı dış politika sorunlarını çoğunlukla güç, şiddet, ulusal çıkar, güvenlik ve devlet merkezlilik gibi realist kuramın kavramları çerçevesinde ele almış ve realizme uygun şekillerde çözmeye meyilli olmuştur. Yüz yıllık dış politika geçmişi çoğunlukla realizme yakın olmakla birlikte Türkiye, İsrail-Filistin sorununda, uluslararası toplumun ve barışın öncelendiği, önemi Soğuk Savaş'ın ardından demokrasilerin yayılması ve dünya ekonomilerinin küreselleşmesi sürecinde artan liberal uluslararası ilişkiler kuramına uygun söylem ve eylemlere yönelmiştir. Bu bağlamda Türkiye, liberal uluslararası kuram araçlarından demokrasi ve kamuoyunu, uluslararası hukuk ve adaleti, uluslararası örgütleri, ortak güvenlik rejimini ve insan haklarını Filistin sorununun temeline yerleştirmiştir. Türkiye'nin bu konudaki tutumu, bölgesel barışın sağlanması ve uluslararası iş birliğinin artırılması yönünde atılan adımlarla örtüşmektedir. Liberal uluslararası ilişkiler kuramı doğrultusunda Türkiye, Filistin sorununun çözümüne katkıda bulunmayı amaçlamıştır. Bu adımlar, uluslararası hukukun üstünlüğü odağında, Birleşmiş Milletler (BM) kararları gereğince 1967 sınırları özelinde başkenti Doğu Kudüs olan bir Filistin'in kurulması ve iki devletli çözümün uygulanmasını sağlamak; Filistin'in sorunun bir aktörü olarak kabul edilmesini sağlamak amacıyla BM gözlemci üyesi olarak kabul edilmesine çalışmak, uluslararası kamuoyunu harekete geçirmek için özellikle Birleşmiş Milletler Genel Kurulu'nda Cumhurbaşkanı Recep Tayyip Erdoğan tarafından gerçekleştirilen konuşmada uluslararası toplumun aktif rol alması içi çağrı yapmak; yine Erdoğan'ın 2021 yılında Papa Francis ile yaptığı görüşmesinde, İsrail'in Filistin topraklarında uyguladığı şiddetin sona erdirilmesi ve Kudüs'ün statüsünün korunması için uluslararası toplumun daha etkin bir rol oynaması gerektiğini ifade etmek; dönemin Dışişleri Bakanı Mevlüt Çavuşoğlu tarafından Avrupa Birliği'ni proaktif olmaya çağırmak gibi örnekler Türkiye'nin uluslararası toplumu ve barışı önceleyen eylemlerine ve liberal uluslararası ilişkiler kuramına uygun açıklamalarına birkaç örnek teşkil etmektedir. Bu çalışma, Türkiye'nin İsrail-Filistin sorununun çözümü için liberal uluslararası ilişkiler kuramının araçlarını kullandığını öne sürmekte ve bu araçları kullanırken neyi amaçladığını ortaya koymayı hedeflemektedir. Bu hedef doğrultusunda bu çalışmada, liberal kuramın temel özellikleri ve uluslararası politika ile olan bağlantısı genel hatlarıyla ortaya konulmuş, Türk diplomat ve bürokratların söylemleri üzerinde kısaca durulmuş ve Türkiye'nin İsrail-Filistin sorununa yönelik adımlarının uluslararası hukuk ve politikaya yönelik etkileri, etik, pratik ve politik sorunlar başlığı altında incelenmiş ve etkileri analiz edilmiştir. Nihai olarak tespit edilen bulgular sistematik bir şekilde derlenerek tartışılmıştır.

Anahtar Kelimeler – Uluslararası İlişkiler Kuramları, Liberalizm, İsrail-Filistin Sorunu, Türk Dış Politikası, Kamu Diplomasisi

I. GİRİŞ

Türkiye Cumhuriyeti yeni kurulduğunda, Atatürk'ün "Yurtta Sulh, Cihanda Sulh" vecizesiyle özdeşleşen bir dış politika izlemeye yönelmiştir. Bu bağlamda 1932 yılında Milletler Cemiyeti'ne üye olunmuş, 1934 yılında Yunanistan, Yugoslavya ve Romanya ile *Balkan Antantı*; İran, Irak ve Afganistan ile *Sadabat Paktı* yapılmış, 1937 yılında Hatay Sorunu'nun çözümü için *Milletler Cemiyeti* yetkili kılınmıştır. [1] Genç cumhuriyetin dış politikası, güç mücadelesinin uluslararası hukuk aracılığıyla dizginlenebileceği ve çıkar mücadelesine girişmek yerine herkesin çıkarına olacak şekilde ortak bir güvenlik sistemi kurulabileceği inancını ifade eden[2] liberal uluslararası ilişkiler kuramı ile büyük benzerlikler taşımaktadır. Yıllar geçtikçe, söz konusu ifade temelinde şekillenen idealist/liberal yaklaşım ilke olarak sürmekle beraber Türkiye, karşılaştığı dış politika sorunlarını çoğunlukla güç, şiddet, ulusal çıkar, güvenlik ve devlet merkezlilik gibi realist kuramın kavramları çerçevesinde ele almış ve realizme uygun şekillerde çözmeye yönelmiştir.[3] Dış politikası realizme yakın olmakla birlikte Türkiye, İsrail-Filistin sorununda uluslararası toplumun ve barışın öncelendiği, önemi Soğuk Savaş'ın ardından demokrasilerin yayılması ve dünya ekonomilerinin küreselleşmesi sürecinde artan [4] liberal uluslararası ilişkiler kuramına uygun söylem ve eylemlerde bulunmuştur. Uluslararası bir toplum vardır varsayımından hareketle Türkiye, liberal uluslararası kuram araçlarından demokrasi ve kamuoyunu, uluslararası hukuk ve adaleti, uluslararası örgütleri, ortak güvenlik rejimini ve insan haklarını [3] Filistin sorununun temeline yerleştirmiştir. Türkiye'nin bu konudaki tutumu, bölgesel barışın sağlanması ve uluslararası iş birliğinin artırılması yönünde atılan adımlarla örtüşmektedir. Liberal uluslararası ilişkiler kuramı doğrultusunda Türkiye, Filistin sorununun çözümüne katkıda bulunmayı amaçlamıştır.

II. BULGULAR

Türkiye, İsrail-Filistin sorununa, 1948 Mayıs'ında ilan edilen İsrail Devleti'ni aradan bir yıl geçmeden 1949 Mart'ında tanıyarak neredeyse başından beri dahil olmuştur. Benzer şekilde Türkiye, İsrail tarafındaki ilk resmi temsilciliğini de 7 Ocak 1950'de açmıştır. Filistin Kurtuluş Örgütü (FKÖ) ile 1975 yılından itibaren ilişki kuran Türkiye, 1988 Kasım'ında ilan edilen Filistin Devleti'ni de tanıyan ilk ülkeler arasında yer almıştır. 2005 yılından itibaren de Türkiye'nin Kudüs Başkonsolosluğu'na büyükelçi atanmış ve Filistin tarafındaki Türk Büyükelçisi olarak görev yapmıştır. Türkiye Cumhuriyet Dışişleri Bakanlığı web sitesinin Türkiye-Filistin Siyasi İlişkileri başlığında yer verdiği bilgilere göre "*Türkiye, Filistin-İsrail ihtilafına iki devletli çözüme yönelik yerleşik BM parametreleri temelinde ve müzakereler yoluyla adil, kapsamlı ve kalıcı bir çözüm getirilmesini, bu çerçevede 1967 sınırları temelinde başkenti Doğu Kudüs olan, coğrafi bütünlüğe sahip, bağımsız ve egemen Filistin Devleti'nin kurulmasına yönelik çabaları desteklemektedir*" denilmektedir. [5]

Türk Dışişleri'nin açıklamasından anlaşıldığı kadarıyla Türkiye, uluslararası hukukun üstünlüğü temelinde, Birleşmiş Milletler kararları gereğince 1967 sınırları özelinde başkenti Doğu Kudüs olan bir Filistin Devleti'nin kurulması ve iki devletli çözümün uygulanmasını sağlamayı amaçlamaktadır. Bunu mümkün kılabilmek adına da, Filistin'in sorunun bir aktörü olarak kabul edilmesini sağlamak amacıyla BM gözlemci üyesi olarak kabul edilmesine çalışmakta, uluslararası kamuoyunu harekete geçirmek için özellikle Birleşmiş Milletler Genel Kurulu'nda Cumhurbaşkanı Recep Tayyip Erdoğan tarafından gerçekleştirilen konuşmada uluslararası toplumun aktif rol alması için çağrı yapmakta; yine Erdoğan'ın 2021 yılında Papa Francis ile yaptığı görüşmesinde, İsrail'in Filistin topraklarında uyguladığı şiddetin sona erdirilmesi ve Kudüs'ün statüsünün korunması için uluslararası toplumun daha etkin bir rol oynaması gerektiğini ifade etmekte ve dönemin Dışişleri Bakanı Mevlüt Çavuşoğlu Avrupa Birliği'ni proaktif olmaya çağırmaktadır. Yukarıdaki gibi örnekler Türkiye'nin uluslararası toplumu ve barışı önceleyen eylemlerine ve liberal uluslararası ilişkiler kuramına uygun açıklamalarına birkaç örnek teşkil etmektedir.

III. TARTIŞMA

Liberal uluslararası ilişkiler kuramının uluslararası hukukun ve uluslararası örgütlerin önemini ve etkisini öncelemesi, anlaşmazlıkların barışçıl yollardan çözülmesine yönelik uygulamaları teşvik etmesi ve küresel iş birliğini öne çıkarması [6] Türkiye'nin İsrail-Filistin sorununda liberal kuram doğrultusunda hareket etmesini gerektirmiştir. Yalnızca son 7 Ekim Saldırıları sonrasında yaşananlar bile bunun göstergesidir. Bu bağlamda ilk olarak, Türk Cumhurbaşkanı Recep Tayyip Erdoğan, saldırıların hemen ertesi gününe denk

gelen 8 Ekim'de yaptığı açıklamada, Türkiye'nin İsrail ve Filistin güçleri arasındaki çatışmaları yatıştırmak için diplomatik çabaları artırmaya kararlı olduğunu söylemiş, bununla birlikte bölgesel barışı sağlamanın tek yolunun iki devletli çözüm olduğunu da sözlerine eklemiştir.[7] Böylece sorunun taraflarından biri olan Filistin'in bir devlet olarak tanınmadığı sürece sorunun çözümünün mümkün görünmediğini ifade etmiştir.

Benzer şekilde yine Erdoğan, Kazakistan'ın başkenti Astana'da düzenlenen Türk Devletleri Örgütü (TDÖ) zirvesinde yaptığı konuşmada İsrail-Filistin sorununa değinmiştir. İsrail'in Gazze'ye yönelik orantısız saldırılarına atıfta bulunarak, "7 Ekim'den bu yana şahit olduklarımızı haklı çıkaracak hiçbir şey yoktur" demiş [8] ve Türk Devletleri Örgütü nezdinde İsrail-Filistin sorununu gündeme getirmiştir. Erdoğan'ın iki açıklamasının da uluslararası kamuoyunun dikkatini çekmek, sorunun çözümü için barışçıl yolları öne çıkarmak ve aracılık etmek üzerine inşa edildiği anlaşılmaktadır.

Benzer şekilde, Dışişleri Bakanı Hakan Fidan da İsrail-Filistin sorununun çözümü için benzer adımlar atmıştır. Bir Filistin devletinin kurulmasını ve Türkiye'nin de aralarında bulunduğu bölge ülkelerinin anlaşmanın uygulanması için garantör olmasını içeren bir formül önermesini sorunun hukuksal çözümü için bir çaba olarak değerlendirmek mümkündür. [9] Liberal kuram uyarınca arabuluculuk veya sorunların uluslararası toplum aracılığıyla çözülmesi de benzer düşüncelerin bir tezahürü olarak değerlendirilebilir.

Bir başka örnek olarak, liberal uluslararası ilişkiler kuramına göre uluslararası ekonomik ilişkiler savaşların önleyicisi olarak görülmüştür[6]. Ekonomik karşılıklı bağımlılık arttıkça savaşın maliyeti de artacağı için devletlerin savaştan kaçınacağı varsayılmıştır. Bu ilke doğrultusunda Türkiye, 2024 yılının Nisan ayında uyguladığı ekonomik kısıtlamaları Mayıs ayında tüm ürünlere yayarak İsrail ile ticareti kesmiştir. *İsrail hükümeti Gazze'ye kesintisiz ve yeterli insani yardım akışına izin verene kadar yeni tedbirleri kesin ve kararlı bir şekilde uygulayacaktır* [10] şeklinde kendini ifade ederek de ticari ilişkilerin İsrail-Filistin sorununda bir çözüm olarak kullanılmasını amaçlamıştır.

Ayrıca, Dışişleri Bakanı Hakan Fidan, Türkiye'nin Güney Afrika'nın İsrail'e karşı Uluslararası Adalet Divanı'nda (UAD) açtığı soykırım davasına katılacağını ifade ederek [11] uluslararası örgüt ve mahkemeler kanalıyla sorunu uluslararasılaştırmaya ve dünya kamuoyunun dikkatini çekmeye çalışmaktadır.

Yalnızca 7 Ekim Saldırıları sonrasında değil, söz konusu saldırılardan önce de Türkiye, Filistin konusunda öncü ülke olmuş ve adımlar atmıştır. Bunun belki de en belirgini, ABD Başkanı Trump'ın Kudüs'ü İsrail'in başkenti kabul eden ve Amerikan büyükelçiliğini Kudüs'e taşıyan kararının ardından İstanbul'da İslam İşbirliği Teşkilatı'nın toplanılması olmuştur. Zirvede, Filistin Devlet Başkanı Mahmud Abbas da bir konuşma yaparak, zirveyi "*gerçekleşmiş en önemli ve başarılı zirve*" olarak nitelendirmiş ve katkıları nedeniyle Erdoğan'a teşekkür etmiştir.[12]

SONUÇ

Türkiye, özellikle terörle mücadele konusunda realist uluslararası ilişkiler kuramı doğrultusunda hareket eder ve dış politikasını bu minvalde şekillendirirken İsrail-Filistin sorununun çözümünde liberal uluslararası ilişkiler kuram doğrultusunda hareket etmektedir. Bunda şüphesiz ki birçok neden bulunmaktadır. Bu nedenlerden belki de en belirgini, İsrail-Filistin sorununun ABD ve Batı dünyası için farklı algılanmışıdır. Batı dünyası sorunu İsrail'in varoluşu ile alakalı görmekte ve İsrail'e destek vermektedir. Hal böyle olunca da Türkiye hem askeri hem de ekonomik olarak "baş edemeyeceği" diğer devletlerle karşı karşıya gelmek yerine, yukarıda anlatılan yollara yönelmektedir. Bir başka neden İsrail-Filistin sorununun doğrudan Türk dış politikası ile ilgisinin bulunmamasıdır. Nihayetinde ne İsrail ne de Filistin Türkiye'nin sınır komşusudur. Hal böyle olunca da Türkiye, terörle mücadelede başvurduğu realist yollara başvurmaktan ziyade liberal kuram doğrultusunda hareket etmektedir. Türkiye'nin bu konuya ilgisinin nedeni olarak, eski Osmanlı toprağı olarak gördüğü coğrafyadaki etkisini sürdürmek ve İslam dünyasında güç kazanmak söylenebilir. Elbette sorunun insani bir boyutu da bulunmaktadır ve Türkiye'nin mazlumların yanında bulunduğu da gözden kaçırılmamalıdır.

Son olarak İsrail-Filistin sorununda ABD ve Batılı devletlerin çifte standartları Türkiye'ye atfedilen çeşitli sorunlarda Türkiye'nin eline koz vermektedir. PKK ile mücadeleyi eleştiren ülkelere İsrail'in eylemlerini örnek gösterirken insan haklarını dile getiren ülkelere de Filistinliler için neden sessiz kaldıkları sorulmaktadır.

Sonuç olarak ülkeleri yönetenler duygusal davransa da ülkelerin politikaları rasyonel olmak zorundadır. Türk dış politikasını yönlendiren ve karar alanlar da İsrail-Filistin sorununu değerlendirebilecekleri en doğru kuramla ele almış bu bağlamda hareket ediyor görünmektedir.

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ADÖLESAN FUTBOLCULARDA YALNIZLIĞIN ÖFKE ÜZERİNE ETKİSİ

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Özet **–** Bu çalışmanın amacı adölesan futbolcuların yalnızlık durumunun öfke üzerindeki etkisini araştırmaktır. Araştırmaya yaşları ortalaması 16,20 ± 1,28 yıl, boyları ortalaması 171,28 ± 6,48 cm, vücut ağırlıkları ortalaması 61,22 ± 4,76 kg olan 174 amatör erkek futbolcu gönüllü olarak katılmıştır.
Araştırmada futbolcuların öfke ve yalnızlık düzeylerine ilişkin veriler toplanmıştır. Araştırmada futbolcuların yalnızlık düzeylerini belirlemek için Yalnızlık Ölçeği (UCLA-LS) ve öfke düzeylerini belirlemek için Sürekli Öfke-Öfke İfade Tarzı Ölçeği (SÖÖTÖ) kullanılmıştır. Elde edilen bulgular neticesinde, yalnızlık ile sürekli öfke, öfke içe vurum ve öfke dışa vurum arasında zıt yönde anlamlı bir ilişki olduğu tespit edilirken, yalnızlık ile öfke kontrolü arasında anlamlı bir ilişki olmadığı tespit edilmiştir. Yalnızlık değerinde meydana gelen bir birimlik değişimin sürekli öfkeyi 0,12 oranında, öfke içe vurumu 0,1 oranında ve öfke dışa vurumu 0,1 oranında etkilediği tespit edilmiştir.
Sonuç olarak, yalnızlığın sürekli öfke, öfke içe vurum ve öfke dışa vurum değerlerini etkilediği görülürken, yalnızlığın öfke kontrolünü etkilemediği tespit edilmiştir. Yalnızlığın en çok sürekli öfke alt boyutu üzerine etkisi olduğu, öfke içe vurum ve öfke dışa vurum alt boyutlarını aynı oranda etkilediği görülmüştür. Araştırma sonucunda yalnızlık seviyesinin optimal düzeyde tutulmasının futbolcuların performansını olumlu yönde etkileyeceği düşünülmektedir.

Anahtar Kelimeler – Futbol, Adölesan, Yalnızlık, Öfke

I. GİRİŞ

İnsan yaşamında sosyal ilişkilerin yeri oldukça önemlidir. Doğumdan itibaren kişi çevresindeki diğer kişilerle etkileşim halinde olarak iletişim kurmaya başlamaktadır. Kişi diğer insanlarla iletişim kurarak öncelikli olarak fiziksel ihtiyaçları, daha sonra güvenlik, sevilme ve sayılma gibi ihtiyaçlarını karşılar. Bu yüzden insan sosyal bir varlıktır. İnsanın çevresiyle kurduğu iletişim ve etkileşime bağlı olarak kişisel özellikleri gelişme sağlamaktadır. Günümüzde teknoloji hızlı bir gelişim göstermekte ve endüstrileşme oranı da buna bağlı olarak artmaktadır. Bu da insanların sosyal yaşamlarını olumsuz etkileyerek insanları ilişki kuramaz duruma getirmektedir [1]. Spor, dünyada meydana gelen bu değişim ve gelişmelere en hızlı karşılık veren kavramlardan biri olmuştur. İnsanlar yalnızca hareket etmek için spor yapma ihtiyacı duymazlar. İnsanların sağlıklı yaşam amacıyla yaptıkları spor ne kadar önemliyse, yalnız kalırım

duygusunun meydana getirdiği korku, insanlarla etkileşim halinde olmak ve sosyalleşmek amacıyla yapılan sporda o kadar önemlidir [2].

Genel olarak yalnızlık, insanlar arası ilişkinin ve sosyal bağın zayıf olmasından kaynaklanan ruh hali olarak ifade edilmektedir. Ayrıca bireyin kendi istediğiyle yaşadığı ve çevresindeki insanlarla olan etkileşimini azaltarak yaşadığı duygu durumudur [3]. Yalnızlık, gündelik yaşam esnasında yapılan seçimlerle ilgilidir. Bu durum insanın diğer kişilerle arasına mesafe koyma tercihidir. İnsanlar yaşadığı dünyada farklılık oluşturarak, kabul görerek ve ait olduğunu hissederek var olmak ister. Yalnızlık samimiyetsiz davranışların sergilendiği ortamlarda daha fazla görülmektedir.

İnsanınların birbirleriyle etkileşim halinde olması ve iletişim kurması, insanın var oluşundan beri vardır. Ancak insanlar arasındaki bu etkileşim ve iletişim bazen risk altındadır. Bu riskler insanın acı çekmesi, reddedilmesi ya da hayal kırıklığına uğraması şeklinde görülmektedir. Riskleri ortadan kaldırmak için insanların birbirlerine yardımcı olmasıyla sağlanabilir ve yalnızlık duygusunun üstesinden gelinebilir [4].

Spor, belirlenmiş kurallar dahilinde gerçekleştirilen olay ve sosyal bir durumdur. Spor, öncelikle kişinin kendisine, ardından çevresindeki doğal yaşama, içerisinde bulunduğu zamana karşı ve çevresindeki diğer kişilere yönelik bedensel ve ruhsal aktivitelerle sürekli aktif olarak kaldığı bir mücadele yöntemidir. Spor, insanın yalnızca içinde bulunduğu çevreden dışında, ayrıca küresel sorunları da içeren ve yansıtan bir ayna görevindedir [5]. Spor faliyetleri bilimsel olarak zihinsel, sosyal ve bedensel yetenekleri geliştirmesinden dolayı insanların sportif faliyetlere katılım arzusunu da olumlu yönde etkilemektedir [6].

Öfke duygular içerisinde önemli bir yere sahiptir. Öfkenin ortaya çıkışı genellikle iş, aile, yasal problemler ve sağlıkdan dolayı olur. Öfke süreklilik ve şiddet yönünden farklılık gösterir. Yanlış bir davranışa maruz kalma ya da duygusal bir yükselme gibi durumlarla bağlantılı olan olumsuz bir duygu durumu olarak belirtilmektedir [7] .

Yapılan bir çok araştırmada öfke durumunda sergilenen davranışlar deneysel ortamlarda gerçekleştirilirken, spor faliyetleri, bu davranış biçimlerinin ortaya çıkarılması için doğal bir ortam konumundadır. Bunun sebebi ise spor faliyetleri gerçekleştirilirken sardırganlığa ve öfkeye neden olabilecek engellemelerin sürekli olarak gerçekleştirilmesidir. Spor aktivitelerinde rakip amaca yönelik yapılan tüm hareketleri engellemeye çalışır. Sportif ortamın öfke ve saldırganlık bakımından bir diğer özelliği ise sergilenen öfkeli ya da saldırgan davranışın model olarak alınıp taklit edilmesi, başka bir ifadeyle öfkeli veya saldırgan bir davranışın öğrenilmesine sebep olmasıdır [8, 9]. Dolayısıyla bu araştırmada amatör futbol oyuncularında yalnızlık durumunun öfkeyi etkileme düzeyinin araştırılması amaçlanmıştır.

II. MATERYAL VE YÖNTEM

Araştırmaya yaşları ortalaması 16,20 ± 1,28 yıl, boyları ortalaması 171,28 ± 6,48 cm, vücut ağırlıkları ortalaması 61,22 ± 4,76 kg olan 174 amatör erkek futbolcu gönüllü olarak katılmıştır. Araştırmada futbolcuların yalnızlık düzeylerini belirlemek için Yalnızlık Ölçeği (UCLA-LS) ve öfke düzeylerini belirlemek için Sürekli Öfke-Öfke İfade Tarzı Ölçeği (SÖÖTÖ) kullanılmıştır.

Bu çalışma yerel etik kurul kararına uygun olarak yapılmıştır. Ayrıca tüm katılımcılar, etik kurul tarafından onaylanan prosedürler hakkında ve Helsinki Bildirgesi'ne uygun olarak bilgilendirildikten sonra bu çalışmaya katılmak için yazılı bilgilendirilmiş onamlarını verdi.

A. UCLA Yalnızlık Ölçeği

Bireyin genel olarak yalnızlık düzeyini tespit etmek için kullanılan UCLA yalnızlık ölçeği likert tipinde kendini değerlendirme ölçeğidir. Ölçeğin orijinalinde gözden geçirilen formun 10 maddesi olumlu yani anlamsal olarak yalnızlık içermeyen, diğer 10 maddesi olumsuz yani anlamsal olarak yalnız bireyleri belirlemeye yönelik toplam 20 maddelik " Tamamen Katılıyorum" (1) ile "Tamamen Katılmıyorum" (4) arasında derecelemeye sahiptir Ölçekten alınabilecek en yüksek puan 80, en düşük puan ise 20'dir. Alınan yüksek puanlar bireylerin daha fazla yalnızlık yaşadığına işaret etmektedir. Ülkemizde ölçeğin geçerlik ve güvenirlik çalışmaları Demir [10] tarafından yapılmıştır. Demir [10]'in yaptığı çalışmada ölçeğin iç tutarlılığı ile ilgili analizler toplam 72 kişi üzerinde hesaplanmış ve cronbach alfa iç tutarlılık katsayısı .96 olarak hesaplanmıştır. Ölçeğin beş hafta ara ile yapılan test tekrar test güvenirlik katsayısı .94 olarak bulunmuştur. Ölçeğin özgün formu Russell ve arkadaşları tarafına aittir [11].

B. Sürekli Öfke-Öfke İfade Tarzı Ölçeği (SÖÖTÖ)

Bu araştırmada kullanılan SÖÖTÖ toplam 34 maddedir ve Sürekli Öfke (ilk 10 madde) ve Öfke İfade Tarzı (24 madde) bölümlerinden oluşmaktadır. 34 maddelik 4'lü likert tipi bir ölçektir. Hiç (1 puan), Biraz (2 puan), Oldukça (3 puan) ve Tümüyle (4 puan) olarak değerlendirilir. Ölçeğin, ilk 10 maddesi sürekli öfkeyi, sonraki 24 maddesi öfke ifade tarzlarını ölçmektedir. Sürekli öfke, kişinin genelde kendini nasıl hissettiğini, ne derece öfke yaşadığını ifade etmektedir. Sürekli Öfke ölçeğinden alınabilecek en düşük puan 10, en yüksek puan 40'tır. Öfke İfade Tarzı Ölçeği, öfke içe vurumu (13, 15, 16, 20, 23, 26, 27 ve 31. maddeleri), öfke dışa vurumu (12, 17, 19, 22, 24, 29, 32 ve 33. maddeleri) ve öfke kontrolü (11, 14, 18, 21, 25, 28, 30 ve 34. maddeleri) olmak üzere üç alt boyuttan oluşmaktadır. Öfke içe vurumu, öfke dışa vurumu ve öfke kontrolü alt ölçeklerinden alınabilecek en düşük puan 8, en yüksek puan 32'dir. Orjinal ölçeğin Cronbach Alfa değeri .77 ile .88 arasındadır. Ölçeğin Türkçe'ye uyarlanması Özer [12] tarafından yapılmış olup cronbach alfa değerleri "öfke kontrolü" boyutu için .84; "öfke dışa vurumu" boyutu için .78 ve "öfke içe vurumu" boyutu için .62 olarak bulunmuştur [12].

C. *Verilerin Analizi*

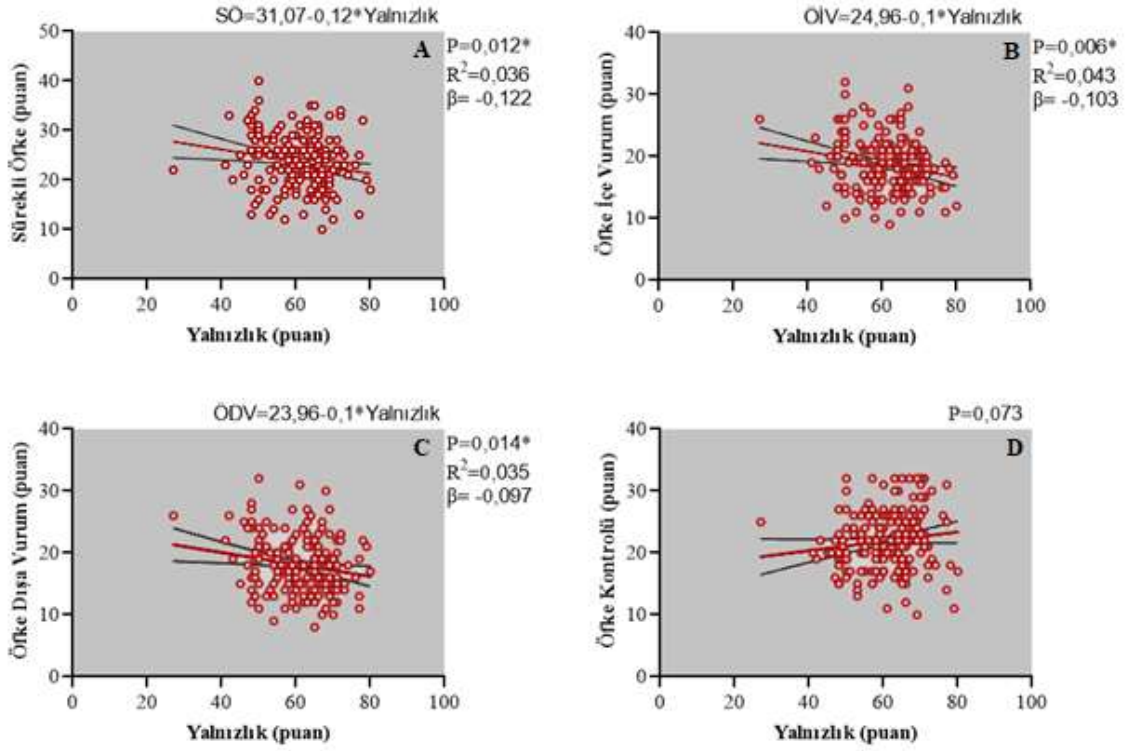
Verilerin düzenlenmesi ve hesaplanmasında SPSS IBM 27 paket program kullanılmıştır. Veriler ortalama ve standart sapmalar verilerek özetlenmiştir. Verilerin normallik dağılımı One-Sample Kolmogorov Smirnov testi ile test edilmiş olup verilerin normal dağılım gösterdiği tespit edilmiştir. Sürekli öfke, öfke içe vurumu, öfke dışa vurumu ve öfke kontrolü ile yalnızlık arasındaki ilişkinin tespiti için Pearson korelasyon testi yapılmıştır. Yalnızlığın, sürekli öfke, öfke içe vurumu, öfke dışa vurumu ve öfke kontrolünü etkileme düzeyini belirlemek için ise Linear Regression testi kullanılmıştır. Bu çalışmada elde edilen veriler 0,95 güven aralığında test edilmiştir.

III. BULGULAR

Tablo 1. Araştırmada yer alan katılımcılara ilişkin fiziksel özellikler (N=174)

Değişkenler	**Ortalama**	**Standart sapma**
Yaş (yıl)	16,20	1,28
Boy (cm)	171,28	6,48
Vücut Ağırlığı (kg)	61,22	4,76

Tablo 1 incelendiğinde, araştırmaya katılan deneklerin yaşları ortalaması 16,20 ± 1,28 yıl, boyları ortalaması 171,28 ± 6,48 cm, vücut ağırlıkları ortalaması 61,22 ± 4,76 kg olarak bulunmuştur.



Grafik 1. A: Sürekli öfke ile yalnızlık arasındaki ilişki, B: Öfke içe vurum ile yalnızlık arasındaki ilişki, C: Öfke dışa vurum ile yalnızlık arasındaki ilişki, D: Öfke kontrolü ile yalnızlık arasındaki ilişki.

Grafik 1.A incelendiğinde, araştırmaya katılan deneklerin sürekli öfke değerleri ile yalnızlık değerleri arasında zıt yönde anlamlı düzeyde bir ilişki olduğu tespit edilmiştir (P<0,05). Yalnızlık değerlerinin sürekli öfke değerlerini % 3,6 oranında açıkladığı görülmüştür. Yalnızlık değerlerindeki bir birimlik değişim sürekli öfke değerlerini 0,12 oranında etkilemektedir. Yalnızlık değerinin bir birim artması sürekli öfke değerini 0,12 oranında olumlu etkilerken, bir birim azalması sürekli öfke değerini 0,12 oranında olumsuz etkilemektedir.

Grafik 1.B incelendiğinde, araştırmaya katılan deneklerin öfke içe vurum değerleri ile yalnızlık değerleri arasında zıt yönde anlamlı düzeyde bir ilişki olduğu tespit edilmiştir (P<0,05). Yalnızlık değerlerinin öfke içe vurum değerlerini % 4,3 oranında açıkladığı görülmüştür. Yalnızlık değerlerindeki bir birimlik değişim öfke içe vurum değerlerini 0,1 oranında etkilemektedir. Yalnızlık değerinin bir birim artması öfke içe vurum değerini 0,1 oranında olumlu etkilerken, bir birim azalması öfke içe vurum değerini 0,1 oranında olumsuz etkilemektedir.

Grafik 1.C incelendiğinde, araştırmaya katılan deneklerin öfke dışa vurum değerleri ile yalnızlık değerleri arasında zıt yönde anlamlı düzeyde bir ilişki olduğu tespit edilmiştir (P<0,05). Yalnızlık değerlerinin öfke dışa vurum değerlerini % 3,5 oranında açıkladığı görülmüştür. Yalnızlık değerlerindeki bir birimlik değişim öfke dışa vurum değerlerini 0,1 oranında etkilemektedir. Yalnızlık değerinin bir birim artması öfke dışa vurum değerini 0,1 oranında olumlu etkilerken, bir birim azalması öfke dışa vurum değerini 0,1 oranında olumsuz etkilemektedir.

Grafik 3.1.D incelendiğinde, araştırmaya katılan deneklerin öfke kontrolü değerleri ile yalnızlık değerleri arasında anlamlı bir ilişki olmadığı tespit edilmiştir. Yalnızlık değerlerindeki değişimin öfke kontrolünü etkilemediği görülmüştür (P>0,05).

IV. TARTIŞMA

Adölesan futbolcuların yalnızlık durumunun öfkeyi etkileme düzeyini tespit etmek amacıyla yapılan bu araştırmada, yalnızlık ile sürekli öfke, öfke içe vurum ve öfke dışa vurum arasında zıt yönde anlamlı bir ilişki olduğu tespit edilirken, yalnızlık ile öfke kontrolü arasında anlamlı bir ilişki olmadığı tespit edilmiştir. Yalnızlık değerinde meydana gelen bir birimlik değişimin sürekli öfkeyi 0,12 oranında, öfke içe vurumu 0,1 oranında ve öfke dışa vurumu 0,1 oranında etkilediği tespit edilmiştir.

Yapılan bir araştırmada takım sporcularının öfke seviyeleri incelenmiş olup, sporcuların spor yapma yılı bakımından öfke alt boyutlarında istatistiksel olarak anlamlı bir farklılık olduğu belirlenmiştir [13]. Sporcuların öfke durumlarının incelendiği bir araştırmada yaşanılan yere göre öfke puanlarında farklılıklar olduğu tespit edilmiştir [14].

Amatör ve profesyonel futbolcularda öfke durumlarının araştırıldığı bir çalışmada, futbolcuların oynadığı lige göre öfke düzeylerinde istatistiksel olarak anlamlı farklılık olduğu belirlenmiştir [15] (Kaya 2019). Üzüm ve ark [16] profesyonel ve amatör sporcuların öfke seviyelerini incelemiştir. Profesyonel ve amatör sporcuların öfke puanlarınında anlamlı farklılık olduğu görülmüştür. Benzer bir araştırmada futbolcuların profesyonel ve amatör ligde oynama durumlarına göre öfke seviyelerinde farklılık olduğu tespit edilmiştir [9]. Yapılan bir araştırmada futbolcuların saldırganlık düzeyleri ile öfke düzeyleri arasındaki ilişkiyi incelemek için çoklu regresyon analizi yapılmıştır. Sürekli öfke puanı ile edilgen saldırganlık alt boyutu arasında anlamlı negatif bir ilişki olduğu belirlenirken, sürekli öfke puanıyla atılgan saldırganlık alt boyutu arasında pozitif bir ilişki olduğu ifade edilmiştir [17].

Morgan [18] bireysel ve takım sporcularının yalnızlık seviyelerini incelediği çalışmada, bireysel ve takım sporcusu olmanın yalnızlık ve kişilik özellikleri üzerinde istatistiksel olarak anlamlı farklılıklar olduğu görülmüştür. Ayrıca takım sporcularına kıyasla bireysel spor yapanların kişillik özelliklerinin daha pozitif olduğu belirlenmiştir. Hanci [5] yapmış olduğu araştırmada, farklı branştaki sporcuların yalnızlık düzeyleri incelenmiştir. Sporcuların branşlarına göre yalnızlık seviyeleri arasında istatistiksel olarak anlamlı farklılıklar olduğu tespit edilmiştir.

V. SONUÇLAR

Sonuç olarak yalnızlığın sürekli öfke, öfke içe vurum ve öfke dışa vurum değerlerini etkilediği görülürken, yalnızlığın öfke kontrolünü etkilemediği tespit edilmiştir. Yalnızlığın en çok sürekli öfke alt boyutu üzerine etkisi olduğu, öfke içe vurum ve öfke dışa vurum alt boyutlarını aynı oranda etkilediği görülmüştür. Araştırma sonucunda yalnızlık seviyesinin optimal düzeyde tutulmasının futbolcuların performansını olumlu yönde etkileyeceği düşünülmektedir.

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On $\mathcal{J}$-Statistical Convergence of sequences in Neutrosophic 2-Normed Spaces

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Abstract **–** This paper investigates the notion of $\mathcal{J}$-statistical convergence within the framework of neutrosophic 2-normed spaces. Additionally, the concept of $\mathcal{J}$-statistical Cauchy sequences is introduced, alongside an exploration of their fundamental properties. This study contributes to the understanding of convergence concepts in neutrosophic 2-normed spaces, offering insights into their theoretical foundations and practical implications.

Keywords – Neutrosophic 2-normed spaces, $\mathcal{J}$-statistical convergence, $\mathcal{J}$-statistical Cauchy sequences

I. INTRODUCTION

Fast [1] first introduced the concept of statistical convergence of sequences, extending the notion of ordinary convergence. Kostyrko et al. [2] later expanded on this by introducing $\mathcal{J}$-convergence, based on the ideal $\mathcal{J}$, which is a subset of natural numbers. This concept has since been widely applied in various scientific and technological fields by numerous researchers [3-10].

Following the introduction of fuzzy set theory by Zadeh [11], extensive efforts have been made to apply and develop fuzzy analogues of classical theories in various branches of engineering and science. This theory has evolved into several extensions, such as intuitionistic fuzzy sets [12], interval-valued intuitionistic fuzzy sets [13]. As a further generalization, Smarandache [14] introduced the concept of neutrosophic sets, which extends crisp, fuzzy, intuitionistic fuzzy, and Pythagorean fuzzy sets. Recently, Kirişci and Şimşek [15] introduced neutrosophic normed spaces. Various summability methods, such as statistical convergence [15], ideal convergence [16], lacunary statistical convergence [17], have been explored by numerous researchers.

In 2023, Murtaza et al. [18] introduced neutrosophic 2-normed spaces, extending the concept of neutrosophic normed spaces, and explored statistical convergence and statistical completeness within this framework. In this paper, we further extend the concept of ideal statistical convergence in neutrosophic 2-normed spaces and discuss some of its fundamental properties.

II. PRELIMINARIES

In this section, we recall some basic definitions and notations.

Definition 2.1. ([2]) A family $\mathcal{J}$ of subsets of a non empty set $\mathcal{X}$ is said to be an ideal in $\mathcal{X}$ if the following conditions hold:

1. $\emptyset \in \mathcal{J}$;
2. $A, B \in \mathcal{J}$ implies $A \cup B \in \mathcal{J}$;

3. $A \in \mathcal{J}$ and $B \subseteq A$ implies $B \in \mathcal{J}$.

An ideal $\mathcal{J}$ is called non trivial if $X \notin \mathcal{J}$ and $\mathcal{J} \neq \emptyset$.

Definition 2.2. ([2]) A non trivial ideal $\mathcal{J} \subseteq 2^X$ is called admissible if $\{\{x\}: x \in X\} \subseteq \mathcal{J}$.

Definition 2.3. [2] A non empty family F of subsets of a non empty set X is called a filter in X if the following properties hold:

1. $\emptyset \notin F$;
2. $A, B \in F$ implies $A \cap B \in F$;
3. $A \in F$ and $A \subseteq B$ implies $B \in F$.

If $\mathcal{J} \subseteq 2^X$ is a non trivial ideal then the class $F(\mathcal{J}) = \{X/A : A \in \mathcal{J}\}$ is a filter on X which is called filter associated with the ideal $\mathcal{J}$.

Definition 2.4. ([2]) An admissible ideal $\mathcal{J} \subseteq 2^{\mathbb{N}}$ is said to satisfy the condition (AP) if for every countable family of mutually disjoint sets $\{A_1, A_2, \dots\}$ belonging to $\mathcal{J}$ there exists a countable family of sets $\{B_1, B_2, \dots\}$ such that the symmetric difference $A_i \Delta B_i$ is finite for each $i \in \mathbb{N}$ and $\bigcup_{i=1}^{\infty} B_i \in \mathcal{J}$.

Definition 2.5. ([1]) Let $\mathcal{K} \subset \mathbb{N}$. Then the natural density of $\mathcal{K}$, denoted by $\delta(\mathcal{K})$, is defined as

$$\delta(\mathcal{K}) = \lim_{n \to \infty} \frac{1}{n} |\{k \leq n: k \in \mathcal{K}\}|$$

provided the limit exists, where the vertical bars denote the cardinality of the enclosed set.

Definition 2.6. ([19]) A binary operation $\Theta: [0,1] \times [0,1] \to [0,1]$ is named to be a continuous t-norm if the following conditions hold.

(1) Θ is associative and commutative;

(2) Θ is continuous;

(3) $x\Theta 1 = x$ for all $x \in [0,1]$;

(4) $x\Theta y \leq z\Theta w$ whenever $x \leq z$ and $y \leq w$ for each $x, y, z, w \in [0,1]$.

Definition 2.7. ([19]) A binary operation $\Delta: [0,1] \times [0,1] \to [0,1]$ is named to be a continuous t-conorm if the following conditions are satisfied.

(1) Δ is associative and commutative;

(2) Δ is continuous;

(3) $x\Delta 0 = x$ for all $x \in [0,1]$

(4) $x\Delta y \leq z\Delta w$ whenever $x \leq z$ and $y \leq w$ for each $x, y, z, w \in [0,1]$.

Example 2.1. ([20]) The following are the examples of t-norms:

(1) $x\Theta y = \min\{x, y\}$

(2) $x\Theta y = x.y$

(3) $x\Theta y = \max\{x + y - 1,0\}$. This t-norm is known as Lukasiewicz t-norm.

Example 2.2. ([20]) The following are the examples of t-conorms:

(1) $x\Delta y = \max\{x, y\}$

(2) $x\Delta y = x + y - x \cdot y$

(3) $x\Delta y = \min\{x + y, 1\}$. This is known as Lukasiewicz t-conorm.

Lemma 2.1. ([21]) If Θ is a continuous t-norm, Δ is a continuous t-conorm, $r_i \in (0,1)$ and $1 \leq i \leq 7$, then the following statements hold:

(1) If $r_1 > r_2$, there are $r_3, r_4 \in (0,1)$ such that $r_1 \Theta r_3 \geq r_2$ and $r_1 \geq r_2 \Delta r_4$

(2) If $r_5 \in (0,1)$, there are $r_6, r_7 \in (0,1)$ such that $r_6 \Theta r_6 \geq r_5$ and $r_5 \geq r_7 \Delta r_7$.

Now we recall the notions of 2-normed space and neutrosophic 2-normed space.

Definition 2.8. ([22]) Let Y be a real vector space of dimension d, where $2 \leq d < \infty$. A 2-norm on Y is a function $\|.\|: Y \times Y \to \mathbb{R}$ which satisfies the following conditions:

(1) $\| x, y \| = 0$ if and only if x and y are linearly dependent in Y;

(2) $\| x, y \| = \| y, x \|$ for all x, y in Y;

(3) $\| \alpha x, y \| = |\alpha| \| x, y \|$ for all α in $\mathbb{R}$ and for all x, y in Y;

(4) $\| x + y, z \| \leq \| x, z \| + \| y, z \|$ for all x, y, z in Y.

Example 2.3. ([5]) Let $Y = \mathbb{R}^2$. Define $\|\cdot,\cdot\|$ on $\mathbb{R}^2$ by $\| x, y \| = |x_1 y_2 - x_2 y_1|$, where $x = (x_1, x_2), y = (y_1, y_2) \in \mathbb{R}^2$. Then $(Y, \|\cdot,\cdot\|)$ is a 2 -normed space.

Definition 2.9. ([18]) Let $\mathcal{W}$ be a vector space and $\mathcal{N}_2 = \{< (e,f), \mathcal{R}(e,f), \mathcal{S}(e,f), \mathcal{T}(e,f) \rangle : (e,f) \in \mathcal{W} \times \mathcal{W}\}$ be a 2 -normed space such that $\mathcal{N}_2 : \mathcal{W} \times \mathcal{W} \times \mathbb{R}^+ \to [0,1]$. Suppose Θ and Δ be continuous t-norm and t-conorm respectively. Then the four tuple $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$ is named to be neutrosophic 2-normed space $(N2 - NS)$ if the following conditions hold for all $e, f, g \in X, \eta, \zeta > 0$ and $\beta \neq 0$.

(1) $0 \leq \mathcal{R}(e,f;\eta) \leq 1, 0 \leq \mathcal{S}(e,f;\eta) \leq 1$ and $0 \leq \mathcal{T}(e,f;\eta) \leq 1$ for every $\eta > 0$;

(2) $\mathcal{R}(e,f;\eta) + \mathcal{S}(e,f;\eta) + \mathcal{T}(e,f;\eta) \leq 3$

(3) $\mathcal{R}(e,f;\eta) = 1$ iff e, f are linearly dependent;

(4) $\mathcal{R}(\beta e, f;\eta) = \mathcal{R}\left(e, f; \frac{\eta}{|\beta|}\right)$ for each $\beta \neq 0$;

(5) $\mathcal{R}(e,f;\eta) \Theta \mathcal{R}(e,g;\zeta) \leq \mathcal{R}(e, f+g; \eta+\zeta)$;

(6) $\mathcal{R}(e,f;\cdot): (0,\infty) \to [0,1]$ is a non-increasing function that runs continuously;

(7) $\lim_{\eta \to \infty} \mathcal{R}(e,f;\eta) = 1$;

(8) $\mathcal{R}(e,f;\eta)=\mathcal{R}(f,e;\eta)$

(9) $\mathcal{S}(e,f;\eta)=0$ iff e,f are linearly dependent;

(10) $\mathcal{S}(\beta e,f;\eta)=\mathcal{S}\left(e,f;\frac{\eta}{|\beta|}\right)$ for each $\beta\neq 0$;

(11) $\mathcal{S}(e,f;\eta)\Delta\mathcal{S}(e,g;\zeta)\geq\mathcal{S}(e,f+g;\eta+\zeta)$;

(12) $\mathcal{S}(e,f;\cdot):(0,\infty)\to[0,1]$ is a non-increasing function that runs continuously;

(13) $\lim_{\eta\to\infty}\mathcal{S}(e,f;\eta)=0$

(14) $\mathcal{S}(e,f;\eta)=\mathcal{S}(f,e;\eta)$

(15) $\mathcal{T}(e,f;\eta)=0$ iff e,f are linearly dependent;

(16) $\mathcal{T}(\beta e,f;\eta)=\mathcal{T}\left(e,f;\frac{\eta}{|\beta|}\right)$ for each $\beta\neq 0$;

(17) $\mathcal{T}(e,f;\eta)\Delta\mathcal{T}(e,g;\zeta)\geq\mathcal{T}(e,f+g;\eta+\zeta)$

(18) $\mathcal{T}(e,f;\cdot):(0,\infty)\to[0,1]$ is a non-increasing function that runs continuously;

(19) $\lim_{\eta\to\infty}\mathcal{T}(e,f;\eta)=0$

(20) $\mathcal{T}(e,f;\eta)=\mathcal{T}(f,e;\eta)$

(21) If $\eta\leq 0,\mathcal{R}(e,f;\eta)=0,\mathcal{S}(e,f;\eta)=1,\mathcal{T}(e,f;\eta)=1$.

In this case, $\mathcal{N}_2=(\mathcal{R},\mathcal{S},\mathcal{T})$ is called neutrosophic 2 -norm on $\mathcal{W}$.

Definition 2.10. ([18]) Let $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ be a sequence in a $2-NS\ X=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$. Choose $\sigma\in(0,1)$ and $\mathfrak{Z}>0$. Then $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ is named to be convergent if there exists a $p_0\in\mathbb{N}$ and $\alpha\in\mathcal{W}$ such that $\mathcal{R}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})>1-\sigma,\mathcal{S}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})<\sigma$ and $\mathcal{T}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})<\sigma$ for all $p\geq p_0$ and $t\in\mathcal{X}$ which can be said that $\lim_{p\to\infty}\mathcal{R}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})=1,\lim_{p\to\infty}\mathcal{S}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})=0$ and $\lim_{p\to\infty}\mathcal{T}(\mathfrak{r}_p-\alpha,t;\mathfrak{Z})=0$. In this case we write $\mathcal{N}_2-\lim_{p\to\infty}\mathfrak{r}_p=\alpha$ or $\mathfrak{r}_p\overset{\mathcal{N}_2}{\to}\alpha$ and α is called $\mathcal{N}_2$-limit of $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$.

Definition 2.11. ([18]) Let $\{\mathfrak{r}_k\}_{k\in\mathbb{N}}$ be a sequence in a $2-NS\ X=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$. Choose $\sigma\in(0,1)$ and $\mathfrak{Z}>0$. Then $\{\mathfrak{r}_k\}_{k\in\mathbb{N}}$ is said to be statistically convergent to α if the natural density of the set $\mathcal{A}(\sigma,\mathfrak{Z})=\{k\leq n:\mathcal{R}(\mathfrak{r}_k-\alpha,t;\mathfrak{Z})\leq 1-\varepsilon$ or $\mathcal{S}(\mathfrak{r}_k-\alpha,t;\mathfrak{Z})\geq\varepsilon$ and $\mathcal{T}(\mathfrak{r}_k-\alpha,t;\mathfrak{Z})\geq\varepsilon\}$ is zero for every $t\in\mathcal{X}$ i.e. $\delta(\mathcal{A}(\sigma,\mathfrak{Z}))=0$.

Definition 2.12. ([18]) Let $\{\mathfrak{r}_k\}_{k\in\mathbb{N}}$ be a sequence in a $N2-NS\ X=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta),\sigma>0$ and $\mathfrak{Z}>0$. Then $\{\mathfrak{r}_k\}_{k\in\mathbb{N}}$ is named to be statistical Cauchy if there exists $k_0\in\mathbb{N}$ such that $\lim_{p\to\infty}\frac{1}{p}\left|\{k\leq p:\mathcal{R}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\leq 1-\sigma\right.$ or $\left.\mathcal{S}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\geq\sigma,\mathcal{T}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\geq\sigma\}\right|=0$ for every $t\in\mathcal{X}$ or equivalently the natural density of the set

$$\mathcal{A}(\sigma,\mathfrak{Z})=\{k\leq p:\mathcal{R}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\leq 1-\sigma \text{ or } \mathcal{S}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\geq\sigma,\mathcal{T}(\mathfrak{r}_k-\mathfrak{r}_{k_0},t;\mathfrak{Z})\geq\sigma\}$$

is zero, i.e., $\delta(\mathcal{A}(\sigma,\mathfrak{Z}))=0$.

III. MAIN RESULTS

Throughout this section $\mathcal{J}$ denotes an admissible ideal of $\mathbb{N}$. Unless otherwise specified, $\mathcal{Y}, \mathcal{N}_2$ and $\mathcal{X}$ refer to a 2-norm, a neutrosophic 2-norm, and a neutrosophic 2-normed space, respectively. First, we introduce the concept of $S(\mathcal{J})$-convergence in neutrosophic 2-normed spaces.

Definition 3.1. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a $N2-NS\ \mathcal{X}=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$ Then, $\{\aleph_p\}_{p\in\mathbb{N}}$ is termed $S(\mathcal{J})$-convergent to $\alpha\in\mathcal{W}$ if for each $\sigma\in(0,1),\delta>0$ and $\beth>0$ the set $\mathcal{A}(\sigma,\delta,\beth)=\left\{u\in\mathbb{N}:\frac{1}{u}\left|\{p\le u:\mathcal{R}(\aleph_p-\alpha,t;\beth)\le 1-\sigma \text{ or } \mathcal{S}(\aleph_p-\alpha,t;\beth)\ge\sigma,\mathcal{T}(\aleph_p-\alpha,t;\beth)\ge\sigma\}\right|\ge\delta\right\}\in\mathcal{J}$ for all $t\in\mathcal{X}$. In this context, we denote $S(\mathcal{J})(\mathcal{N}_2)-\lim_{p\to\infty}\aleph_p=\alpha$ or $\aleph_p\overset{S(\mathcal{J})(\mathcal{N}_2)}{\to}\alpha$ and α is referred to as the $S(\mathcal{J})(\mathcal{N}_2)$-limit of $\{\aleph_p\}_{p\in\mathbb{N}}$.

Example 3.1. Let $\mathcal{W}=\mathbb{R}^2$ and $(\mathbb{R}^2,\|.,.\|)$ be a 2-normed space with 2-norm defined as in Example 2.3. We take t-norm and t-conorm as $a\Theta b=ab$ and $a\Delta b=\min\{a+b,1\}$ for $a,b\in[0,1]$. Let $\mathcal{J}$ be a collection of subsets of $\mathbb{N}$ such that natural density of each subsets is zero. Then $\mathcal{J}$ becomes a non trivial admissible ideal on $\mathbb{N}$. Now choose $\sigma\in(0,1),\delta>0$ and $x,y\in\mathcal{W},\beth>0$ with $\beth>\|x,y\|$. We consider $\mathcal{R}(x,y;\beth)=\frac{\beth}{\beth+\|x,y\|},\mathcal{S}(x,y;\beth)=\frac{\|x,y\|}{\beth+\|x,y\|},\mathcal{T}(x,y;\beth)=\frac{\|x,y\|}{\beth}$. Thus, $\mathcal{N}_2=(\mathcal{R},\mathcal{S},\mathcal{T})$ is a neutrosophic 2-norm on $\mathcal{W}$ and the four tuple $\mathcal{X}=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$ forms a neutrosophic 2-normed space.

Now choose $\{\aleph_p\}_{p\in\mathbb{N}}\in\mathcal{X}$ by

$$\aleph_p=\begin{cases}(1,0), & \text{if } p=s^2(s\in\mathbb{N})\\ (0,0), & \text{otherwise.}\end{cases}$$

For $t\in\mathcal{X}$ and $\alpha=(0,0)$,

$$\mathcal{A}(\sigma,\delta,\beth)=\left\{u\in\mathbb{N}:\frac{1}{u}\left|\{p\le u:\mathcal{R}(\aleph_p-\alpha,t;\beth)\le 1-\sigma \text{ or } \mathcal{S}(\aleph_p-\alpha,t;\beth)\ge\sigma,\mathcal{T}(\aleph_p-\alpha,t;\beth)\ge\sigma\}\right|\ge\delta\right\}=\{s\in\mathbb{N}:p=s^2\}\mathcal{A}(\sigma,\delta,\beth)=\{s\in\mathbb{N}:p=s^2\}.$$

Since $\delta(\{s\in\mathbb{N}:p=s^2\})=0$, we obtain $\mathcal{A}(\sigma,\delta,\beth)\in\mathcal{J}$.

Theorem 3.1. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X}=(\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$. For each $\sigma\in(0,1),\delta>0,\beth>0$ and for every $t\in\mathcal{X}$ the following statements are equivalent.

(1) $S(\mathcal{J})(\mathcal{N}_2)-\lim_{p\to\infty}\aleph_p=\alpha$,

(2)

$$\left\{u\in\mathbb{N}:\frac{1}{u}\left|\{p\le u:\mathcal{R}(\aleph_p-\alpha,t;\beth)\le 1-\sigma\}\right|\ge\delta\right\}\in\mathcal{J},$$

$$\left\{u\in\mathbb{N}:\frac{1}{u}\left|\{p\le u:\mathcal{S}(\aleph_p-\alpha,t;\beth)\ge\sigma\}\right|\ge\delta\right\}\in\mathcal{J},$$

$$\left\{u\in\mathbb{N}:\frac{1}{u}\left|\{p\le u:\mathcal{T}(\aleph_p-\alpha,t;\beth)\ge\sigma\}\right|\ge\delta\right\}\in\mathcal{J},$$

(3)$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \alpha, t; \beth) > 1 - \sigma \text{ and } \mathcal{S}(\aleph_p - \alpha, t; \beth) < \sigma, \mathcal{T}(\aleph_p - \alpha, t; \beth) < \sigma\}\right| < \delta\right\} \in \mathcal{F}(\mathcal{J})$;

(4)

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \alpha, t; \beth) > 1 - \sigma\}\right| < \delta\right\} \in \mathcal{F}(\mathcal{J}),$$

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{S}(\aleph_p - \alpha, t; \beth) < \sigma\}\right| < \delta\right\} \in \mathcal{F}(\mathcal{J}),$$

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{T}(\aleph_p - \alpha, t; \beth) < \sigma\}\right| < \delta\right\} \in \mathcal{F}(\mathcal{J}),$$

(5) $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathcal{R}(\aleph_p - \alpha, t; \beth) = 1$ and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathcal{S}(\aleph_p - \alpha, t; \beth) = 0$, $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathcal{T}(\aleph_p - \alpha, t; \beth) = 0$.

Theorem 3.2. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a $N2 - NS\ \mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\aleph_p = \alpha$, then $S(\mathcal{J})(\mathcal{N}_2)$-limit of $\{\aleph_p\}_{p\in\mathbb{N}}$ is unique.

Proof. If possible, let $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} = \xi$ and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} = \alpha$ with $\xi \neq \alpha$. For a given $\sigma \in (0,1)$, choose $\beta \in (0,1)$ such that $(1-\beta)\Theta(1-\beta) > 1-\sigma$ and $\beta\Delta\beta < \sigma$. Then, for every $, \beth > 0$ and $t \in \mathcal{X}$, the sets

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \xi, t; \beth) \leq 1 - \beta \text{ or } \mathcal{S}(\aleph_p - \xi, t; \beth) \geq \beta, \mathcal{T}(\aleph_p - \xi, t; \beth) \geq \beta\}\right| \geq \delta\right\} \in \mathcal{J}$$

and

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \alpha, t; \beth) \leq 1 - \beta \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \beth) \geq \beta, \mathcal{T}(\aleph_p - \alpha, t; \beth) \geq \beta\}\right| \geq \delta\right\} \in \mathcal{J}.$$

Let

$$\begin{aligned}\mathcal{B}_{\mathcal{R}1}(\sigma, \delta, \beth) &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{R}\left(\aleph_p - \xi, t; \frac{\beth}{2}\right) \leq 1 - \beta\right\}\right| \geq \delta\right\}; \mathcal{B}_{\mathcal{R}2}(\sigma, \delta, \beth) \\ &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) \leq 1 - \beta\right\}\right| \geq \delta\right\};\end{aligned}$$

$$\begin{aligned}\mathcal{B}_{\mathcal{S}1}(\sigma, \delta, \beth) &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{S}\left(\aleph_p - \xi, t; \frac{\beth}{2}\right) \geq \beta\right\}\right| \geq \delta\right\}; \mathcal{B}_{\mathcal{S}2}(\sigma, \delta, \beth) \\ &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{S}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) \geq \beta\right\}\right| \geq \delta\right\};\end{aligned}$$

$$\begin{aligned}\mathcal{B}_{\mathcal{T}1}(\sigma, \delta, \beth) &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{T}\left(\aleph_p - \xi, t; \frac{\beth}{2}\right) \geq \beta\right\}\right| \geq \delta\right\}; \mathcal{B}_{\mathcal{T}2}(\sigma, \delta, \beth) \\ &= \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{T}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) \geq \beta\right\}\right| \geq \delta\right\}.\end{aligned}$$

Then, according to the Theorem 3.1, we have all of

$$\mathcal{B}_{\mathcal{R}1}(\sigma,\delta,\mathfrak{z}),\mathcal{B}_{\mathcal{R}2}(\sigma,\delta,\mathfrak{z}),\mathcal{B}_{\mathcal{S}1}(\sigma,\delta,\mathfrak{z}),\mathcal{B}_{\mathcal{S}2}(\sigma,\delta,\mathfrak{z}),\mathcal{B}_{\mathcal{T}1}(\sigma,\delta,\mathfrak{z}),\mathcal{B}_{\mathcal{T}2}(\sigma,\delta,\mathfrak{z}) \in \mathcal{J}.$$

Let,

$$\mathcal{B}_{\mathcal{R},\delta,\mathcal{T}}(\sigma,\delta,\mathfrak{z}) = [\mathcal{B}_{\mathcal{R}1}(\sigma,\delta,\mathfrak{z}) \cup \mathcal{B}_{\mathcal{R}2}(\sigma,\delta,\mathfrak{z})] \cap [\mathcal{B}_{\mathcal{S}1}(\sigma,\delta,\mathfrak{z}) \cup \mathcal{B}_{\mathcal{S}2}(\sigma,\delta,\mathfrak{z})] \cap [\mathcal{B}_{\mathcal{T}1}(\sigma,\delta,\mathfrak{z}) \cup \mathcal{B}_{\mathcal{T}2}(\sigma,\delta,\mathfrak{z})].$$

Then $\mathcal{B}_{\mathcal{R},\delta,\mathcal{T}}(\sigma,\delta,\mathfrak{z}) \in \mathcal{J}$. Then $\mathcal{B}^{c}_{\mathcal{R},\delta,\mathcal{T}}(\sigma,\delta,\mathfrak{z}) \in \mathcal{F}(\mathcal{J})$. So, let $k \in \mathcal{B}^{c}_{\mathcal{R},\delta,\mathcal{T}}(\sigma,\delta,\mathfrak{z})$. Three possible cases arise. If $k \in \mathcal{B}^{c}_{\mathcal{R}1}(\sigma,\delta,\mathfrak{z}) \cap \mathcal{B}^{c}_{\mathcal{R}2}(\sigma,\delta,\mathfrak{z})$, then we obtain

$$\mathcal{R}(\xi-\alpha,t;\mathfrak{z}) \geq \mathcal{R}\left(\mathfrak{r}_k-\xi,t;\frac{\mathfrak{z}}{2}\right) \theta \mathcal{R}\left(\mathfrak{r}_k-\alpha,t;\frac{\mathfrak{z}}{2}\right) > (1-\beta)\theta(1-\beta) > 1-\sigma.$$

Since $\sigma > 0$ is arbitrary, we have $\mathcal{R}(\xi-\alpha,t;\mathfrak{z}) = 1$ which yields $\xi-\alpha = 0$ i.e. $\xi = \alpha$.

If we take $k \in \mathcal{B}^{c}_{\mathcal{S}1}(\sigma,\delta,\mathfrak{z}) \cap \mathcal{B}^{c}_{\mathcal{S}2}(\sigma,\delta,\mathfrak{z})$,

$$\mathcal{S}(\xi-\alpha,z;\eta) \leq \mathcal{S}\left(\mathfrak{r}_k-\xi,t;\frac{\mathfrak{z}}{2}\right) \Delta \mathcal{S}\left(\mathfrak{r}_k-\alpha,t;\frac{\mathfrak{z}}{2}\right) < \beta \Delta \beta < \sigma.$$

Since $\sigma > 0$ is arbitrary, we get $\mathcal{S}(\xi-\alpha,t;\mathfrak{z}) = 0$ which yields $\xi-\alpha = 0$ i.e. $\xi = \alpha$.

For $k \in \mathcal{B}^{c}_{\mathcal{T}1}(\sigma,\delta,\mathfrak{z}) \cap \mathcal{B}^{c}_{\mathcal{T}2}(\sigma,\delta,\mathfrak{z})$,

$$\mathcal{T}(\xi-\alpha,t;\mathfrak{z}) \leq \mathcal{T}\left(\mathfrak{r}_k-\xi,t;\frac{\mathfrak{z}}{2}\right) \Delta \mathcal{T}\left(\mathfrak{r}_k-\alpha,t;\frac{\mathfrak{z}}{2}\right) < \beta \Delta \beta < \sigma.$$

Since $\sigma > 0$ is arbitrary, we get $\mathcal{T}(\xi-\alpha,t;\mathfrak{z}) = 0$ which gives $\xi-\alpha = 0$ i.e. $\xi = \alpha$. This contradicts the fact $\xi \neq \alpha$, therefore the $S(\mathcal{J})(\mathcal{N}_2)$-limit of $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ is unique.

Theorem 3.3. Let $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ be a sequence in a $N2-NS$ $\mathcal{X} = (\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$. If $\mathfrak{r}_p \overset{\mathcal{J}(\mathcal{N}_2)}{\to} \alpha$, then $\mathfrak{r}_p \overset{S(\mathcal{J})(\mathcal{N}_2)}{\to} \alpha$.

Proof. The proof is obvious.

Remark 3.1. The converse of Theorem 3.3 is not true. If we take the same neutrosophic 2-normed space $\mathcal{X}$ defined as in Example 3.1 and a sequence $\{\mathfrak{r}_p\}_{p\in\mathbb{N}} \in \mathcal{X}$ given by

$$\mathfrak{r}_p = \begin{cases} (p,0), & \text{if } p = u^2, (u \in \mathbb{N}) \\ (0,0) & \text{if not.} \end{cases}.$$

Then $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})(\mathcal{N}_2)$-convergent to $(0,0) \in \mathcal{X}$ but it is not $\mathcal{J}$-convergent with respect to $\mathcal{N}_2$ on $\mathcal{W}$.

Theorem 3.4. Let $\mathcal{W}$ be a real vector space. Let $\{\mathfrak{r}_p\}_{p\in\mathbb{N}}$ and $\{\lambda_p\}_{p\in\mathbb{N}}$ be two sequences in a $N2-NS$ $\mathcal{X} = (\mathcal{W},\mathcal{N}_2,\Theta,\Delta)$. Then we have

(1) If $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathfrak{r}_p = \alpha$ and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\lambda_p = \lambda$, then $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathfrak{r}_p + \lambda_p = \alpha + \lambda$.

(2) If $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\mathfrak{r}_p = \alpha$, then $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty}\beta\mathfrak{r}_p = \beta\alpha$ for each $\beta \neq 0$.

Proof. (1) For a given $\sigma \in (0,1)$, choose $\beta \in (0,1)$ such that $(1-\beta)\Theta(1-\beta) > 1-\sigma$ and $\beta\Delta\beta < \sigma$. Since $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$ and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \lambda_p = \lambda$, then for every $\daleth > 0$ and $t \in \mathcal{X}$, the sets

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \le 1-\beta \text{ or } \mathcal{S}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \ge \beta, \mathcal{T}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\} \in \mathcal{J}$$

and

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \le 1-\beta \text{ or } \mathcal{S}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \ge \beta, \mathcal{T}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\} \in \mathcal{J}.$$

Let,

$$\mathcal{A}_{\mathcal{R},\mathcal{S},\mathcal{T}}(\sigma,\delta,\daleth) = [\mathcal{A}_{\mathcal{R}1}(\sigma,\delta,\daleth) \cup \mathcal{A}_{\mathcal{R}2}(\sigma,\delta,\daleth)] \cap [\mathcal{A}_{\mathcal{S}1}(\sigma,\delta,\daleth) \cup \mathcal{A}_{\mathcal{S}2}(\sigma,\delta,\daleth)] \cap [\mathcal{A}_{\mathcal{T}1}(\sigma,\delta,\daleth) \cup \mathcal{A}_{\mathcal{T}2}(\sigma,\delta,\daleth)],$$

where

$$\mathcal{A}_{\mathcal{R}1}(\sigma,\eta) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \le 1-\beta\right\}\right| \ge \delta\right\},$$

$$\mathcal{A}_{\mathcal{R}2}(\sigma,\eta) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \le 1-\beta\right\}\right| \ge \delta\right\},$$

$$\mathcal{A}_{\mathcal{S}1}(\sigma,\delta,\daleth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\},$$

$$\mathcal{A}_{\mathcal{S}2}(\sigma,\delta,\daleth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\},$$

$$\mathcal{A}_{\mathcal{T}1}(\sigma,\delta,\daleth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\},$$

$$\mathcal{A}_{\mathcal{T}2}(\sigma,\delta,\daleth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: \mathcal{R}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) \ge \beta\right\}\right| \ge \delta\right\}.$$

By Theorem 3.1, we get $\mathcal{A}_{\mathcal{R},\mathcal{S},\mathcal{T}}(\sigma,\delta,\daleth) \in \mathcal{J}$. Then $\mathcal{A}^c_{\mathcal{R},\mathcal{S},\mathcal{T}}(\sigma,\delta,\daleth) \in \mathcal{F}(\mathcal{J})$ and hence $\mathcal{A}^c_{\mathcal{R},\mathcal{S},\mathcal{T}}(\sigma,\delta,\daleth) \neq \emptyset$. So, let $p \in \mathcal{A}^c_{\mathcal{R},\mathcal{S},\mathcal{T}}(\sigma,\delta,\daleth)$. Then, we have

$$\mathcal{R}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \daleth) \ge \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \Theta \mathcal{R}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) > (1-\beta)\Theta(1-\beta) > 1-\sigma;$$

$$\mathcal{S}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \daleth) \le \mathcal{S}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \Delta \mathcal{S}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) < \beta\Delta\beta < \sigma$$

and

$$\mathcal{T}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \daleth) \le \mathcal{T}\left(\aleph_p - \alpha, t; \frac{\daleth}{2}\right) \Delta \mathcal{T}\left(\lambda_p - \lambda, t; \frac{\daleth}{2}\right) < \beta\Delta\beta < \sigma.$$

This shows that

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \leq 1-\sigma \text{ or } \mathcal{S}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \geq \sigma, \mathcal{T}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \geq \sigma\}\right| \geq \delta\right\} \subset \mathcal{A}_{\mathcal{R},\delta,\mathcal{T}}(\sigma, \delta, \beth).$$

Consequently

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \leq 1-\sigma \text{ or } \mathcal{S}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \geq \sigma, \mathcal{T}(\aleph_p + \lambda_p - (\alpha+\lambda), t; \beth) \geq \sigma\}\right| \geq \delta\right\} \in \mathcal{J}.$$

Therefore $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p + \lambda_p = \alpha + \lambda$.

(2) Since $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$, then for every $\sigma \in (0,1), \beth > 0$ and $t \in X$ the set

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \leq u: \mathcal{R}\left(\aleph_p - \alpha, t; \frac{\beth}{|\beta|}\right) \leq 1-\sigma \text{ or } \mathcal{S}\left(\aleph_p - \alpha, t; \frac{\beth}{|\beta|}\right) \geq \sigma, \mathcal{T}\left(\aleph_p - \alpha, t; \frac{\beth}{|\beta|}\right) \geq \sigma\right\}\right| \geq \delta\right\} \in \mathcal{J},$$

i.e.

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\beta\aleph_p - \beta\alpha, t; \beth) \leq 1-\sigma \text{ or } \mathcal{S}(\beta\aleph_p - \beta\alpha, t; \beth) \geq \sigma, \mathcal{T}(\beta\aleph_p - \beta\alpha, t; \beth) \geq \sigma\}\right| \geq \delta\right\} \in \mathcal{J}.$$

Therefore $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \beta\aleph_p = \beta\alpha$.

Now we proceed with the notion of $S(\mathcal{J}^*)$-convergence in a neutrosophic 2 -normed space X.

Definition 3.2. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. Then $\{\aleph_p\}_{p\in\mathbb{N}}$ is termed $\mathcal{J}^*$-statistical convergent to $\alpha \in \mathcal{X}$ with regards to $\mathcal{N}_2$ if there exists a set $\mathcal{K} = \{p_1 < p_2 < \cdots < p_k < \cdots\} \subset \mathbb{N}$ such that $\mathcal{K} \in \mathcal{F}(\mathcal{J})$ and $S(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_{p_k} = \alpha$. In this case, we write $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$ or $\aleph_p \overset{S(\mathcal{J}^*)(\mathcal{N}_2)}{\to} \alpha$ and α is called $S(\mathcal{J}^*)(\mathcal{N}_2)$-limit of $\{\aleph_p\}_{p\in\mathbb{N}}$.

Theorem 3.5. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a $N2-NS\ \mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$, then $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$.

Proof. Since $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$, there exists a set $\mathcal{K} = \{p_1 < p_2 < \cdots < p_k < \cdots\} \subset \mathbb{N}$ such that $\mathcal{K} \in \mathcal{F}(\mathcal{J})$ and $S(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_{p_k} = \alpha$, i.e. for every $\sigma \in (0,1), \beth > 0$ there exists $p_k \in \mathbb{N}$ such that

$$\lim_{u\to\infty} \frac{1}{u}\left|\{p_k \leq u: \mathcal{R}(\aleph_{p_k} - \alpha, t; \beth) \leq 1-\sigma \text{ or } \mathcal{S}(\aleph_{p_k} - \alpha, t; \beth) \geq \sigma, \mathcal{T}(\aleph_{p_k} - \alpha, t; \beth) \geq \sigma\}\right| = 0.$$

So, for any $\delta > 0$,

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p_k \leq u: \mathcal{R}(\aleph_{p_k} - \alpha, t; \beth) \leq 1-\sigma \text{ or } \mathcal{S}(\aleph_{p_k} - \alpha, t; \beth) \geq \sigma, \mathcal{T}(\aleph_{p_k} - \alpha, t; \beth) \geq \sigma\}\right| \geq \delta\right\} \in \mathcal{J}$$

since $\mathcal{J}$ is an admissible ideal.

Now, let $\mathcal{H} = \mathbb{N} \setminus \mathcal{K}$.

Then we have

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \alpha, t; \daleth) \leq 1 - \sigma \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \daleth) \geq \sigma, \mathcal{T}(\aleph_p - \alpha, t; \daleth) \geq \sigma\}\right| \geq \delta\right\} \subset$$
$$\subset \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p_k \leq u: \mathcal{R}(\aleph_{p_k} - \alpha, t; \daleth) \leq 1 - \sigma \text{ or } \mathcal{S}(\aleph_{p_k} - \alpha, t; \daleth) \geq \sigma, \mathcal{T}(\aleph_{p_k} - \alpha, t; \daleth) \geq \sigma\}\right| \geq \delta\right\} \in \mathcal{J}.$$

This shows that $S(\mathcal{J})(\mathcal{N}_2) - \lim_{p\to\infty} \aleph_p = \alpha$.

Remark 3.2. In general, the converse of Theorem 3.5 is not true which can be illustrated by the following example.

Example 3.2. We consider the neutrosophic 2-normed space defined as in Example 3.1. Let $\mathbb{N} = \bigcup_i \mathcal{D}_i$ be a decomposition of $\mathbb{N}$ such that for any $p \in \mathbb{N}$ each $\mathcal{D}_i$ contains infinitely many $i's$ where $i \geq p$ and $\mathcal{D}_i \cap \mathcal{D}_p = \emptyset$ whenever $i \neq p$. Let $\mathcal{J}$ be the class of all subsets of $\mathbb{N}$ which intersects only a finite number of $\mathcal{D}_i's$. Then $\mathcal{J}$ becomes a non trivial admissible ideal of $\mathbb{N}$. Now we define a sequence $\{\aleph_k\}_{k\in\mathbb{N}} \in \mathcal{X}$ by $\aleph_k = \left(\frac{1}{k}, 0\right)$ if $k \in \mathcal{D}_k$. Now for $t = (t_1, t_2)$ and $\alpha = (0,0)$ we have

$$\mathcal{R}(\aleph_k - \alpha, t; \daleth) = \frac{\daleth}{\daleth + \|\aleph_k, t\|} = \frac{\daleth}{\daleth + |t_2|\frac{1}{k}} \longrightarrow 1$$

$$\mathcal{S}(\aleph_k - \alpha, t; \daleth) = \frac{\|\aleph_k, t\|}{\|\aleph_k, t\| + \daleth} = \frac{|t_2|\frac{1}{k}}{\daleth + |t_2|\frac{1}{k}} \longrightarrow 0$$

$$\mathcal{T}(\aleph_k - \alpha, t; \daleth) = \frac{\|\aleph_k, t\|}{\daleth} = \frac{|t_2|\frac{1}{k}}{\daleth} \longrightarrow 0$$

as $k \to \infty$. Since $\mathcal{J}$ is an admissible ideal, therefore $S(\mathcal{J})(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_k = \alpha$.

Now, if possible, let $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_k = \alpha$. Then, there exists a set $\mathcal{K} = \{k_1 < k_2 < \cdots < k_m < \cdots\} \subset \mathbb{N}$ such that $\mathcal{K} \in \mathcal{F}(\mathcal{J})$ and $S(\mathcal{N}_2) - \lim_{m\to\infty} \aleph_{k_m} = \alpha$. Since $\mathcal{K} \in \mathcal{F}(\mathcal{J})$, there is $\mathcal{M} \in \mathcal{J}$ such that $\mathbb{N} \setminus \mathcal{K} = \mathcal{M}$. Now by the construction of $\mathcal{J}$, there is $j \in \mathbb{N}$ such that $\mathcal{M} \subset \bigcup_{i=1}^{j} \mathcal{D}_i$. But then $\mathcal{D}_{j+1} \subset \mathcal{K}$ and therefore $\aleph_{k_m} = \left(\frac{1}{j+1}, 0\right)$ for infinitely many $k_m \in \mathcal{K}$ which contradicts $S(\mathcal{N}_2) - \lim_{m\to\infty} \aleph_{k_m} = \alpha$. Therefore $\{\aleph_k\}_{k\in\mathbb{N}}$ is not $S(\mathcal{J}^*)(\mathcal{N}_2)$-convergent to $\alpha \in \mathcal{X}$.

Theorem 3.6. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $\mathcal{J}$ satisfies the condition (AP) and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_k = \alpha$ then $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_k = \alpha$.

Proof. Suppose that $\mathcal{J}$ satisfies the condition (AP) and $S(\mathcal{J})(\mathcal{N}_2) - \lim_{k\to\infty} \aleph_k = \alpha$. Then, for each $\sigma \in (0,1), \delta > 0$ and $\daleth > 0$ the set

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \leq u: \mathcal{R}(\aleph_p - \alpha, t; \daleth) \leq 1 - \sigma \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \daleth) \geq \sigma, \mathcal{T}(\aleph_p - \alpha, t; \daleth) \geq \sigma\}\right| \geq \delta\right\} \in \mathcal{J}$$

for each $t \in \mathcal{X}$. Now, we define

$$\mathcal{A}_j = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: 1 - \frac{1}{j} \le \mathcal{R}(\aleph_p - \alpha, t; \beth) < 1 - \frac{1}{1+j} \text{ or } \frac{1}{j+1} < \mathcal{S}(\aleph_p - \alpha, t; \beth) \le \frac{1}{j}, \frac{1}{j+1} < \mathcal{T}(\aleph_p - \alpha, t; \beth) \le \frac{1}{j}\right\}\right| \ge \delta\right\}.$$

Clearly $\{\mathcal{A}_1, \mathcal{A}_2, \dots\}$ is countable and pairwise disjoint and each $\mathcal{A}_j \in \mathcal{J}$. Since $\mathcal{J}$ satisfies the condition (AP), there exists a countable family $\{\mathcal{B}_1, \mathcal{B}_2, \dots\}$ of subsets of $\mathbb{N}$ belonging to $\mathcal{J}$ and $\mathcal{A}_i \triangle \mathcal{B}_i$ is finite for each i and $\mathcal{H} = \bigcup_i \mathcal{B}_i \in \mathcal{J}$. Now from the associated filter of $\mathcal{J}$ there is $\mathcal{M} \in \mathcal{F}(\mathcal{J})$ such that $\mathcal{M} = \mathbb{N} \setminus \mathcal{H}$. It is sufficient to prove the theorem that the subsequence $\{\aleph_p\}_{p \in \mathcal{M}}$ is convergent to α with respect to $\mathcal{N}_2$. Let $\vartheta \in (0,1), \beth > 0$ and $t \in \mathcal{X}$. We choose $p_0 \in \mathbb{N}$ such that $\frac{1}{p_0} < \vartheta$. Then, clearly

$$\left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \alpha, t; \beth) \le 1 - \vartheta \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \beth) \ge \vartheta, \mathcal{T}(\aleph_p - \alpha, t; \beth) \ge \vartheta\}\right| \ge \delta\right\} \subset \left\{u \in \mathbb{N}: \frac{1}{u}\left|\left\{p \le u: 1 - \mathcal{R}(\aleph_p - \alpha, t; \beth) \le 1 - \frac{1}{p_0} \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \beth) \ge \frac{1}{p_0}, \mathcal{T}(\aleph_p - \alpha, t; \beth) \ge \frac{1}{p_0}\right\}\right| \ge \delta\right\} \subset \bigcup_{i=1}^{p_0+1} \mathcal{A}_i.$$

Since $\mathcal{A}_i \triangle \mathcal{B}_i, i = 1,2, \dots, p_0 + 1$ are finite, there is $w_0 \in \mathbb{N}$ such that

$$\left(\bigcup_{i=1}^{p_0+1} \mathcal{B}_i\right) \cap \{p \in \mathbb{N}: p \ge w_0\} = \left(\bigcup_{i=1}^{p_0+1} \mathcal{A}_i\right) \cap \{p \in \mathbb{N}: p \ge w_0\} \tag{3.1}$$

Now, if $p \ge w_0$ and $p \in \mathcal{M}, p \notin \bigcup_{i=1}^{p_0+1} \mathcal{B}_i$. So, by equation 3.1, $p \notin \bigcup_{i=1}^{p_0+1} \mathcal{A}_i$. Therefore, for every $p \ge w_0$ and $p \in \mathcal{M}$ we get $\mathcal{R}(\aleph_p - \alpha, t; \beth) > 1 - \vartheta, \mathcal{S}(\aleph_p - \alpha, t; \beth) < \vartheta$ and $\mathcal{T}(\aleph_p - \alpha, t; \beth) < \vartheta$ for every $t \in \mathcal{X}$. Since $\vartheta \in (0,1)$ is arbitrary, we have $S(\mathcal{J}^*)(\mathcal{N}_2) - \lim_{k \to \infty} \aleph_k = \alpha$. This completes the proof.

Definition 3.3. Let $\{\aleph_p\}_{p \in \mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$ and $\sigma \in (0,1), \delta > 0$ and $\beth > 0$. Then $\{\aleph_p\}_{p \in \mathbb{N}}$ is named to be $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$ if there exists $p_0 = p_0(\sigma, \delta) \in \mathbb{N}$ such that the set

$$\mathcal{A}(\sigma, \delta, \beth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \aleph_{p_0}, t; \beth) \le 1 - \sigma \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \beth) \ge \sigma, \mathcal{T}(\aleph_p - \alpha, t; \beth) \ge \sigma\}\right| \ge \delta\right\} \in \mathcal{J}$$

for every $t \in \mathcal{X}$.

Definition 3.4. Let $\{\aleph_p\}_{p \in \mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. Then $\{\aleph_p\}_{p \in \mathbb{N}}$ is named to be $S(\mathcal{J}^*)$-Cauchy with regards to $\mathcal{N}_2$ if there exists a set $\mathcal{K} = \{p_1 < p_2 < \cdots < p_k < \cdots\} \subset \mathbb{N}$ such that $\mathcal{K} \in \mathcal{F}(\mathcal{J})$ and the subsequence $\{\aleph_{p_k}\}$ is an statistically Cauchy sequence with regards to $\mathcal{N}_2$.

Theorem 3.7. Let $\{\aleph_p\}_{p \in \mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $\{\aleph_p\}_{p \in \mathbb{N}}$ is $S(\mathcal{J}^*)$-Cauchy with regards to $\mathcal{N}_2$ then $\{\aleph_p\}_{p \in \mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$.

Theorem 3.8. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $\mathcal{J}$ satisfies the condition (AP) and $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$ then $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J}^*)$-Cauchy with regards to $\mathcal{N}_2$.

The Theorem 3.7 and Theorem 3.8 can be proved in the line of Theorem 3.5 and Theorem 3.6 respectively. So, we omit details.

Now we proceed with the investigations of relation ship between $S(\mathcal{J})$-Cauchy sequence and $S(\mathcal{J})$-convergence with respect to the neutrosophic 2 -norm $\mathcal{N}_2$.

Theorem 3.9. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-convergent with regards to $\mathcal{N}_2$, then $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$.

Proof. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-convergent to $\alpha \in X$ and $\sigma \in (0,1)$ be given. Choose $\beta \in (0,1)$ such that $(1-\beta)\Theta(1-\beta) > 1-\sigma$ and $\beta\Delta\beta < \sigma$. Then, for every $\zeta > 0$ and $t \in \mathcal{X}$, the set

$$\mathcal{A}(\beta,\delta,\zeta) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \alpha, t; \zeta) \le 1-\beta \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \zeta) \ge \beta, \mathcal{T}(\aleph_p - \alpha, t; \zeta) \ge \beta\}\right| \ge \delta\right\} \in \mathcal{J}.$$

Then $\mathcal{A}^c(\beta,\delta,\zeta) \in \mathcal{F}(\mathcal{J})$. So $\mathcal{A}^c(\beta,\delta,\zeta) \neq \emptyset$. Then, there is $p_0 \in \mathcal{A}^c(\beta,\delta,\zeta)$. Now, we define

$$\mathcal{B}(\sigma,\delta,\zeta) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \aleph_{p_0}, t; \zeta) \le 1-\sigma \text{ or } \mathcal{S}(\aleph_p - \aleph_{p_0}, t; \zeta) \ge \sigma,\ \mathcal{T}(\aleph_p - \aleph_{p_0}, t; \zeta) \ge \sigma\}\right| \ge \delta\right\} \in \mathcal{J}.$$

It is sufficient to prove the theorem that $\mathcal{B}(\sigma,\delta,\zeta) \subset \mathcal{A}(\beta,\delta,\zeta)$. Let $k \in \mathcal{B}(\sigma,\delta,\zeta)$. Then we get

$$\mathcal{R}(\aleph_k - \aleph_{p_0}, t; \zeta) \le 1-\sigma \text{ or } \mathcal{S}(\aleph_k - \aleph_{p_0}, t; \zeta) \ge \sigma, \mathcal{T}(\aleph_k - \aleph_{p_0}, t; \zeta) \ge \sigma$$

Case-i: We consider $\mathcal{R}(\aleph_k - \aleph_{p_0}, t; \zeta) \le 1-\sigma$. We show $\mathcal{R}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) \le 1-\beta$. If possible, let $\mathcal{R}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) > 1-\beta$. Then we have $1-\sigma \ge \mathcal{R}(\aleph_k - \aleph_{p_0}, t; \zeta) \ge \mathcal{R}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right)\Theta\mathcal{R}\left(\aleph_{p_0} - \alpha, t; \frac{\zeta}{2}\right) > (1-\beta)\Theta(1-\beta) > 1-\sigma$, which is not possible. So we have $\mathcal{R}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) \le 1-\beta$. Hence $k \in \mathcal{A}(\sigma,\delta,\zeta)$, i.e. $\mathcal{B}(\sigma,\delta,\zeta) \subset \mathcal{A}(\beta,\delta,\zeta)$.

Case-ii: We consider $\mathcal{S}(\aleph_k - \aleph_{p_0}, t; \zeta) \ge \sigma$. We show $\mathcal{S}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) \ge \beta$. If possible, let $\mathcal{S}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) < \beta$. Then we have $\sigma \le \mathcal{S}(\aleph_k - \aleph_{p_0}, t; \zeta) \le \mathcal{S}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right)\Delta\mathcal{S}\left(\aleph_{p_0} - \alpha, t; \frac{\zeta}{2}\right) < \beta\Delta\beta < \sigma$, which is not possible. So we have $\mathcal{S}\left(\aleph_k - \alpha, t; \frac{\zeta}{2}\right) \ge \beta$. Hence $k \in \mathcal{A}(\beta,\delta,\zeta)$, i.e. $\mathcal{B}(\sigma,\delta,\zeta) \subset \mathcal{A}(\beta,\delta,\zeta)$.

Case-iii: If we consider $\mathcal{T}(\aleph_k - \aleph_{p_0}, t; \zeta) \ge \sigma$ then in the similar way as Case-ii we can show that $\mathcal{B}(\sigma,\delta,\zeta) \subset \mathcal{A}(\beta,\delta,\zeta)$. Hence $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$.

Theorem 3.10. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ be a sequence in a N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$. If $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$, then $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-convergent with regards to $\mathcal{N}_2$.

Proof. Let $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$ but not $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-convergent to $\xi \in X$ with regards to $\mathcal{N}_2$. Then for $\sigma \in (0,1)$ and $\beth > 0$ there exists $p_0 = p_0(\sigma) \in \mathbb{N}$ such that $\mathcal{A}(\sigma,\delta,\beth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \aleph_{p_0}, t; \beth) \le 1-\sigma \text{ or } \mathcal{S}(\aleph_p - \aleph_{p_0}, t; \beth) \ge \sigma,\ \mathcal{T}(\aleph_p - \aleph_{p_0}, t; \beth) \ge \sigma\}\right| \ge \delta\right\} \in \mathcal{J}$ for every $t \in \mathcal{X}$. And, $\mathcal{B}(\sigma,\delta,\beth) = \left\{u \in \mathbb{N}: \frac{1}{u}\left|\{p \le u: \mathcal{R}(\aleph_p - \alpha, t; \beth) > 1-\sigma \text{ or } \mathcal{S}(\aleph_p - \alpha, t; \beth) < \sigma, \mathcal{T}(\aleph_p - \alpha, t; \beth) < \sigma\}\right| < \delta\right\} \in \mathcal{J}$. So, $\mathcal{B}^c(\sigma,\delta,\beth) \in \mathcal{F}(\mathcal{J})$. Since, $\mathcal{R}(\aleph_p - \aleph_{p_0}, t; \beth) \ge 2\mathcal{R}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) > 1-\sigma$ and $\mathcal{S}(\aleph_p - \aleph_{p_0}, t; \beth) \le 2\mathcal{S}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) < \sigma, \mathcal{T}(\aleph_p - \aleph_{p_0}, t; \beth) \le 2\mathcal{T}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) < \sigma$ if $\mathcal{R}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) > \frac{1-\sigma}{2}$ and $\mathcal{S}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) < \frac{\sigma}{2}, \mathcal{T}\left(\aleph_p - \alpha, t; \frac{\beth}{2}\right) < \frac{\sigma}{2}$. This implies $\mathcal{A}^c(\sigma,\delta,\beth) \in \mathcal{J}$ which leads to a contradiction because $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-Cauchy with regards to $\mathcal{N}_2$. Therefore, $\{\aleph_p\}_{p\in\mathbb{N}}$ is $S(\mathcal{J})$-convergent with regards to $\mathcal{N}_2$.

Definition 3.5. A N2-NS $\mathcal{X} = (\mathcal{W}, \mathcal{N}_2, \Theta, \Delta)$ is named to be $S(\mathcal{J})$-complete with regards to $\mathcal{N}_2$ if every $S(\mathcal{J})$-Cauchy sequence is $S(\mathcal{J})$-convergent with regards to $\mathcal{N}_2$.

Remark 3.3. In the light of Theorem 3.9 and 3.10, we see every neutrosophic 2-normed space is $S(\mathcal{J})$-complete.

IV. CONCLUSION

In conclusion, this paper has delved into the concept of $\mathcal{J}$-statistical convergence and $\mathcal{J}$-statistical Cauchy sequences within neutrosophic 2-normed spaces. Through our exploration, we have illuminated the theoretical underpinnings of convergence in these spaces, shedding light on their intricate properties. By introducing and analyzing these novel concepts, we have enriched the theoretical framework of neutrosophic 2-spaces, paving the way for further research and applications in various fields. Our findings not only deepen our understanding of convergence in neutrosophic spaces but also have potential practical implications in areas such as fuzzy logic, decision-making, and data analysis. Moving forward, future studies can build upon this work to explore more advanced concepts and extend the applicability of neutrosophic 2-normed spaces in diverse domains.

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Berezin Yarıçapı için Üst Sınırlar

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Özet – Fonksiyonel Hilbert uzaylarındaki doğrusal operatörleri için çeşitli norm ve Berezin yarıçap eşitsizliklerini kanıtlıyoruz. Özellikle, A fonksiyonel bir Hilbert uzayında lineer bir doğrusal operatör ise,

$$ber^2(\mathfrak{Z}) \leq \frac{1}{2}\left(ber(|\mathfrak{Z}^*||\mathfrak{Z}|) + \|\mathfrak{Z}\|_{ber}^2\right)$$

sağlanır. Burada $ber(\mathfrak{Z})$, $\|\mathfrak{Z}\|_{ber}$ ve $|\mathfrak{Z}|$, sırasıyla Berezin yarıçapı, Berezin normu ve $\mathfrak{Z}$'nın mutlak değeridir.

Anahtar Kelimeler –Berezin sembolü, Berezin yarıçapı; Operatör norm; Konveks fonksiyon; Pozitif operatör

I. GİRİŞ

$\mathbb{B}(\mathbb{H})$'nin, iç çarpımı $\langle .,. \rangle$ ve ilişkilendirilmiş norm $\|.\|$ ile norm-trivial kompleks Hilbert uzayı $\mathbb{H}$ üzerinde çalışan tüm sınırlı doğrusal operatörlerin $C^* -$ cebirini belirttiğini varsayalım. $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ için, $\omega(\mathfrak{Z})$ ve $\|\mathfrak{Z}\|$ sırasıyla $\mathfrak{Z}$ 'nın sayısal yarıçapı ve operatör normunu belirtir. $\omega(\mathfrak{Z}) = \sup_{x\in\mathbb{H},\|x\|=1}|\langle \mathfrak{Z}x, x\rangle|$ ve $\|\mathfrak{Z}\| = \sup_{x\in\mathbb{H},\|x\|=1}\|\mathfrak{Z}x\|$ olduğunu hatırlayalım. Eğer $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ ve f, $[0,\infty]$ üzerinde artan ve negatif olmayan bir fonksiyon ise, o zaman $\|f(|\mathfrak{Z}|)\| = f(\|\mathfrak{Z}\|)$ olduğu iyi bilinmektedir. Burada $|\mathfrak{Z}|$, pozitif operatörü $(\mathfrak{Z}^*\mathfrak{Z})^{\frac{1}{2}}$ olarak belirtir.

Sayısal yarıçap eşitsizlikleri ve uygulamaları hakkında bazı sonuçlar için [16, 17, 19]'ya bakılabilir.

Θ 'nın boş olmayan bir küme olduğunu varsayalım. Fonksiyonel bir Hilbert uzayı $\mathbb{H}(\Theta)$, her $\varrho \in \Theta$ için fonksiyon değerlemelerinin sürekli olduğu anlamında kompleks değerli fonksiyonların bir Hilbert uzayıdır. Riesz temsili teoremi, her $\varrho \in \Theta$ için $\mathbb{H}(\Theta)$ üzerinde her f için $f(\varrho) = \langle f, k_\varrho \rangle$ olacak şekilde benzersiz bir eleman $k_\varrho \in \mathbb{H}(\Theta)$ olduğunu garanti eder. $\{k_\varrho : \varrho \in \Theta\}$ kümesine, $\mathbb{H}(\Theta)$ uzayının yeniden üretim çekirdeği denir. Eğer $\{e_n\}_{n\geq 0}$, fonksiyonel bir Hilbert uzayı $\mathbb{H}(\Theta)$ için bir ortonormal baz ise, $\mathbb{H}(\Theta)$ 'nin yeniden üretim çekirdeği $k_\varrho(\gamma) = \sum_{n=0}^{+\infty} \overline{e_n(\varrho)}e_n(\gamma)$ şeklinde verilir (bkz. [10]). $\varrho \in \Theta$ için, $\mathbb{H}(\Theta)$ 'nin normalleştirilmiş yeniden üretim çekirdeği $K_\varrho = \frac{k_\varrho}{\|k_\varrho\|}$ olsun.

$\mathbb{H}(\Theta)$ üzerinde sınırlı bir doğrusal operatör $\mathfrak{Z}$ 'nın Berezin sembolü, ilk olarak Berezin [1] tarafından tanıtılmış ve Θ üzerinde $\widetilde{\mathfrak{Z}}$ fonksiyonu olarak tanımlanmıştır:

$$\widetilde{\mathfrak{Z}}(\varrho) := \langle \mathfrak{Z}K_\varrho, K_\varrho \rangle.$$

Operatör $\mathfrak{Z}$'nın Berezin kümesi ve Berezin sayısı sırasıyla şu şekilde tanımlanır

$$Ber(\mathfrak{Z}) := \{\langle \mathfrak{Z}K_\varrho, K_\varrho \rangle \ : \ \varrho \in \Theta\} \text{ ve } \mathrm{ber}(\mathfrak{Z}) := \sup\{|\langle \mathfrak{Z}K_\varrho, K_\varrho \rangle| \ : \ \varrho \in \Theta\}.$$

Berezin sembolü $\widetilde{\mathfrak{Z}}$'nın, Θ üzerinde değerleri $\mathfrak{Z}$ operatörünün sayısal aralığında yer alan sınırlı bir fonksiyon olduğu açıktır ve dolayısıyla herhangi bir $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ için,

$$\mathrm{Ber}(\mathfrak{Z}) \subset W(\mathfrak{Z}) \text{ ve } \mathrm{ber}(\mathfrak{Z}) \leq w(\mathfrak{Z}).$$

Berezin sembolü ve Berezin sayısı hakkında daha fazla bilgi için okuyucuyu [3, 7]'ye yönlendiriyoruz.

Huban vd. [12]'de, $\mathrm{ber}(\mathfrak{Z}) \leq \|\mathfrak{Z}\|$ eşitsizliğini geliştirerek aşağıdaki sonucu elde etmişlerdir:

$$\mathrm{ber}(\mathfrak{Z}) \leq \frac{1}{2}\||\mathfrak{Z}| + |\mathfrak{Z}^*|\|_{\mathrm{ber}} \leq \frac{1}{2}\left(\|\mathfrak{Z}\|_{\mathrm{ber}} + \|\mathfrak{Z}^2\|_{\mathrm{ber}}^{\frac{1}{2}}\right). \tag{1.1}$$

Ayrıca, aşağıdaki tahmini göstermişlerdir ki bu, (1.1)'den daha güçlüdür:

$$ber(\mathfrak{Z}) \leq \frac{1}{2}\||\mathfrak{Z}| + |\mathfrak{Z}^*|\|_{ber}. \tag{1.2}$$

Başka bir iyileştirme, [11, Sonuç 3.3]'de kurulmuştur. Bu iyileştirme, eğer $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ ise,

$$ber^2(\mathfrak{Z}) \leq \frac{1}{2}\||\mathfrak{Z}|^2 + |\mathfrak{Z}^*|^2\|_{ber}. \tag{1.3}$$

Aynı makalede, yazarlar ayrıca şu sonucu kanıtlamışlardır:

$$\frac{1}{4}\||\mathfrak{Z}|^2 + |\mathfrak{Z}^*|^2\|_{ber} \leq ber^2(\mathfrak{Z}). \tag{1.4}$$

Son zamanlarda, birçok matematikçi fonksiyonel Hilbert uzayı operatörlerinin çeşitli Berezin yarıçapı eşitsizliklerini elde etmiştir, ilgilenen okuyucular [6, 8, 9, 18, 20] ve oradaki referanslara bakabilirler. Burada, [14] makalesinden ilham alarak, fonksiyonel Hilbert uzayı operatörlerinin Berezin yarıçapı için birkaç yeni eşitsizlik elde ediyoruz. Burada elde edilen sınırlar mevcut sınırları geliştirir.

II. MATERYAL VE YÖNTEM

Analizimizde aşağıdaki yardımcı teoremler gerekecektir.

Yardımcı Teorem 1. *([2]) $a, \mathscr{b}, c \in \mathbb{H}$ olsun. O zaman*

$$|\langle c, a\rangle||\langle c, \mathscr{b}\rangle| \leq \frac{\|c\|^2}{2}(|\langle a, \mathscr{b}\rangle| + \|a\|\|\mathscr{b}\|)$$

sağlanır.

[5]'te, aşağıdaki eşitsizlik, daha önce M.L. Buzano tarafından [2]'de farklı bir şekilde elde edilmiştir.

Yardımcı Teorem 2. *$a, \mathscr{b}, c$ $\mathbb{H}$ 'de vektörler olsun ve $\|c\| = 1$ olsun, o zaman*

$$\frac{1}{2}(\|a\|\|\mathscr{b}\| + |\langle a, \mathscr{b}\rangle|) \geq |\langle a, c\rangle\langle c, \mathscr{b}\rangle| \tag{2.1}$$

sağlanır.

Aşağıdaki yardımcı teoremler de devamında faydalıdır.

Yardımcı Teorem 3. *([4, eq. (2.26)]) $a, \mathscr{b}, c \in \mathbb{H}$ olsun. O zaman*

$$|\langle c,a\rangle|^2+|\langle c,b\rangle|^2\le\|z\|^2(|\langle a,b\rangle|+\max(\|a\|^2,\|b\|^2))$$

sağlanır.

Yardımcı Teorem 4. *([15])* $\mathfrak{Z}\in\mathbb{B}(\mathbb{H})$ *ve* $x,y\in\mathbb{H}$ *herhangi bir vektör olsun.* f,g $[0,\infty)$ *üzerinde negatif olmayan sürekli fonksiyonlar olsun ve* $f(t)g(t)=t,\ (t\ge 0)$ *koşulunu sağlasınlar. O halde*

$$|\langle\mathfrak{Z}x,y\rangle|\le\|f(|\mathfrak{Z}|)x\|\|g(|\mathfrak{Z}^*|)y\|$$

sağlanır.

Özellikle,

$$|\langle\mathfrak{Z}x,y\rangle|\le\sqrt{\langle|\mathfrak{Z}|^{2(1-v)}x,x\rangle\langle|\mathfrak{Z}^*|^{2v}y,y\rangle},\quad(0\le v\le 1)$$

sağlanır.

III. BULGULAR

İlk sonucumuz aşağıdaki biçimde takdim edilir.

Teorem 1. *Eğer* $\mathfrak{Z}\in\mathbb{B}(\mathbb{H})$ *ise bu durumda*

$$ber^2(\mathfrak{Z})\le\frac{1}{2}\left(\left(\int_0^1\|(1-v)|\mathfrak{Z}|^2+v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2+ber(\mathfrak{Z}^2)\right)\tag{3.1}$$

sağlanır.

İspat. Yardımcı Teorem 1 kullanarak, logaritmik-ortalama ve Young eşitsizliği ile,

$$\begin{aligned}
&|\langle\mathfrak{Z}K_\varrho,K_\varrho\rangle|^2\\
&\le\frac{1}{2}(\|\mathfrak{Z}K_\varrho\|\|\mathfrak{Z}^*K_\varrho\|+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|)\\
&\le\frac{1}{2}\left(\left(\int_0^1\|\mathfrak{Z}K_\varrho\|^{1-v}\|\mathfrak{Z}^*K_\varrho\|^v dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)\\
&=\frac{1}{2}\left(\left(\int_0^1\langle|\mathfrak{Z}|^2K_\varrho,K_\varrho\rangle^{\frac{1-v}{2}}\langle|\mathfrak{Z}^*|^2K_\varrho,K_\varrho\rangle^{\frac{v}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)\\
&=\frac{1}{2}\left(\left(\int_0^1\left(\langle|\mathfrak{Z}|^2K_\varrho,K_\varrho\rangle^{1-v}\langle|\mathfrak{Z}^*|^2K_\varrho,K_\varrho\rangle^{v}\right)^{\frac{1}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)\\
&\le\frac{1}{2}\left(\left(\int_0^1\left((1-v)\langle|\mathfrak{Z}|^2K_\varrho,K_\varrho\rangle+v\langle|\mathfrak{Z}^*|^2K_\varrho,K_\varrho\rangle\right)^{\frac{1}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)\\
&=\frac{1}{2}\left(\left(\int_0^1\langle((1-v)|\mathfrak{Z}|^2+v|\mathfrak{Z}^*|^2)K_\varrho,K_\varrho\rangle^{\frac{1}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)\\
&\le\frac{1}{2}\left(\left(\int_0^1\|(1-v)|\mathfrak{Z}|^2+v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right).
\end{aligned}$$

Bu, şunu ima eder:

$$|\langle\mathfrak{Z}K_\varrho,K_\varrho\rangle|^2\le\frac{1}{2}\left(\left(\int_0^1\|(1-v)|\mathfrak{Z}|^2+v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2+|\langle\mathfrak{Z}^2K_\varrho,K_\varrho\rangle|\right)$$

ve

$$\sup_{\varrho\in\Theta}|\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle|^2 \le \frac{1}{2}\sup_{\varrho\in\Theta}\left(\left(\int_0^1 \|(1-v)|\mathfrak{Z}|^2 + v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2 + |\langle \mathfrak{Z}^2K_\varrho, K_\varrho\rangle|\right).$$

Dolayısıyla, şunu çıkarıyoruz:

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}\left(\left(\int_0^1 \|(1-v)|\mathfrak{Z}|^2 + v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2 + ber(\mathfrak{Z}^2)\right).$$

Sonuç 1. *Eğer* $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ *ise bu durumda*

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}\left(\|\mathfrak{Z}\|^2 + ber(\mathfrak{Z}^2)\right) \tag{3.2}$$

sağlanır.

İspat. Şimdi, (2.1)'de $e = K_\varrho$, $a = \mathfrak{Z}K_\varrho$ ve $b = \mathfrak{Z}^*K_\varrho$ olarak seçin. O zaman şunu elde ederiz:

$$\frac{1}{2}\left(\|\mathfrak{Z}K_\varrho\|\|\mathfrak{Z}^*K_\varrho\| + |\langle \mathfrak{Z}K_\varrho, \mathfrak{Z}^*K_\varrho\rangle|\right) \ge |\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle|^2. \tag{3.3}$$

(3.3)'de supremum'u $\varrho \in \Theta$ üzerinde alarak, istenen eşitsizliği (3.2) çıkarıyoruz.

Usual operator norm için üçgen eşitsizliğini kullanarak,

$$\left(\int_0^1 \|(1-v)|\mathfrak{Z}|^2 + v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2 \le \|\mathfrak{Z}\|^2,$$

şunu elde ederiz:

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}\left(\left(\int_0^1 \|(1-v)|\mathfrak{Z}|^2 + v|\mathfrak{Z}^*|^2\|^{\frac{1}{2}}dv\right)^2 + ber(\mathfrak{Z}^2)\right)$$
$$\le \frac{1}{2}\left(\|\mathfrak{Z}\|^2 + ber(\mathfrak{Z}^2)\right)$$

ve bu da (3.1) eşitsizliğimizin (3.2) eşitsizliğinden bir iyileştirme olduğunu ima eder.

Berezin yarıçapı için farklı bir üst sınır aşağıdaki teoremde verilmiştir.

Teorem 2. $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ *ve* $0 \le t \le 1$ *olsun. O zaman*

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}\left(ber\left(|\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}\right) + \max\left(\|\mathfrak{Z}\|^{4t}, \|\mathfrak{Z}\|^{4(1-t)}\right)\right)$$

sağlanır.

İspat. $0 \le t \le 1$ olsun. Yardımcı Teorem 3 de $x = |\mathfrak{Z}|^{2t}K_\varrho$, $y = |\mathfrak{Z}^*|^{2(1-t)}K_\varrho$ ve $z = K_\varrho$ olarak alalım. O zaman

$$\langle |\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle^2 + \langle |\mathfrak{Z}^*|^{2(1-t)}K_\varrho, K_\varrho\rangle^2$$
$$\le \left(|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle| + \max\left(\||\mathfrak{Z}|^{2t}K_\varrho\|^2, \||\mathfrak{Z}^*|^{2(1-t)}K_\varrho\|^2\right)\right)$$

sağlanır.

Diğer yandan, Yardımcı Teorem 4 tarafından,

$$2\left|\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle\right|^2 \le 2\langle |\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\langle |\mathfrak{Z}^*|^{2(1-t)}K_\varrho, K_\varrho\rangle$$
$$\le \langle |\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle^2 + \langle |\mathfrak{Z}^*|^{2(1-t)}K_\varrho, K_\varrho\rangle^2$$

sağlanır.

Böylece,

$$\left|\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle\right|^2$$
$$\le \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \max\left(\left\||\mathfrak{Z}|^{2t}K_\varrho\right\|^2, \langle |\mathfrak{Z}^*|^{2(1-t)}K_\varrho\rangle^2\right)\right)$$
$$= \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \max\left(\langle |\mathfrak{Z}|^{4t}K_\varrho, K_\varrho\rangle, \langle |\mathfrak{Z}^*|^{4(1-t)}K_\varrho, K_\varrho\rangle\right)\right)$$
$$\le \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \max\left(\|\mathfrak{Z}\|^{4t}, \|\mathfrak{Z}\|^{4(1-t)}\right)\right).$$

Bu, şunu ima eder:

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}\left(ber\left(|\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}\right) + \max\left(\|\mathfrak{Z}\|^{4t}, \|\mathfrak{Z}\|^{4(1-t)}\right)\right)$$

sağlanır.

Aşağıdaki sonuç, Teorem 2'nin doğrudan bir sonucudur.

Sonuç 2. *Eğer* $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ *ise bu durumda*

$$ber(\mathfrak{Z}) \le \sqrt{\frac{1}{2}(ber(|\mathfrak{Z}^*||\mathfrak{Z}|) + \|\mathfrak{Z}\|^2)}$$
$$\le \sqrt{\frac{1}{2}(\||\mathfrak{Z}^*||\mathfrak{Z}|\| + \|\mathfrak{Z}\|^2)}$$
$$= \sqrt{\frac{1}{2}(\|\mathfrak{Z}^2\| + \|\mathfrak{Z}\|^2)}$$
$$\le \|\mathfrak{Z}\|$$

sağlanır.

Son sonucumuz aşağıdaki şekilde ifade edilir.

Teorem 3. Eğer $\mathfrak{Z} \in \mathbb{B}(\mathbb{H})$ *ve* $0 \le t \le 1$ *ise bu durumda*

$$ber^2(\mathfrak{Z}) \le \frac{1}{2}ber\left(|\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}\right) + \frac{1}{4}\left\||\mathfrak{Z}|^{4t} + |\mathfrak{Z}^*|^{4(1-t)}\right\|.$$

İspat. $0 \le t \le 1$ olsun. Yardımcı Teorem 3'de $x = |\mathfrak{Z}|^{2t}K_\varrho$, $y = |\mathfrak{Z}^*|^{2(1-t)}K_\varrho$ ve $z = K_\varrho$ olarak alalım. O zaman

$$\langle |\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\langle |\mathfrak{Z}^*|^{2(1-t)}K_\varrho, K_\varrho\rangle$$
$$\le \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \left\||\mathfrak{Z}|^{2t}K_\varrho\right\|\left\||\mathfrak{Z}^*|^{2(1-t)}K_\varrho\right\|\right).$$

Bu nedenle, Yardımcı Teorem 4 tarafından, şunu çıkarırız:

$$\left|\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle\right|^2 \le \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \left||\mathfrak{Z}|^{2t}K_\varrho\right|\left||\mathfrak{Z}^*|^{2(1-t)}K_\varrho\right|\right).$$

Böylece,

$$
\begin{aligned}
&\left|\langle \mathfrak{Z}K_\varrho, K_\varrho\rangle\right|^2 \\
&\leq \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \left||\mathfrak{Z}|^{2t}K_\varrho\right||\mathfrak{Z}^*|^{2(1-t)}K_\varrho|\right) \\
&= \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \sqrt{\langle |\mathfrak{Z}|^{4t}K_\varrho, K_\varrho\rangle\langle |\mathfrak{Z}^*|^{4(1-t)}K_\varrho, K_\varrho\rangle}\right) \\
&\leq \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \frac{1}{2}\left(\langle |\mathfrak{Z}|^{4t}K_\varrho, K_\varrho\rangle + \langle |\mathfrak{Z}^*|^{4(1-t)}K_\varrho, K_\varrho\rangle\right)\right) \\
&= \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \frac{1}{2}\left\langle \left(|\mathfrak{Z}|^{4t} + |\mathfrak{Z}^*|^{4(1-t)}\right)K_\varrho, K_\varrho\right\rangle\right) \\
&\leq \frac{1}{2}\left(\left|\langle |\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}K_\varrho, K_\varrho\rangle\right| + \frac{1}{2}\left||\mathfrak{Z}|^{4t} + |\mathfrak{Z}^*|^{4(1-t)}\right|\right),
\end{aligned}
$$

bu da şu anlama gelir:

$$ber^2(\mathfrak{Z}) \leq \frac{1}{2}ber\left(|\mathfrak{Z}^*|^{2(1-t)}|\mathfrak{Z}|^{2t}\right) + \frac{1}{4}\left||\mathfrak{Z}|^{4t} + |\mathfrak{Z}^*|^{4(1-t)}\right|.$$

Uyarı 1. *Teorem 3'de* $t = 1/2$ *almak, şu sonuca varır:*

$$ber^2(\mathfrak{Z}) \leq \frac{1}{2}ber(|\mathfrak{Z}^*||\mathfrak{Z}|) + \frac{1}{4}||\mathfrak{Z}|^2 + |\mathfrak{Z}^*|^2|$$

ki bu da [13, Sonuç 2.11]'in sonucudur.

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Eğitimde Bulut Bilişim Teknolojisinin Değerlendirilmesi Üzerine Bir İçerik Analizi

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Özet **–** Bulut bilişim, eğitim alanında büyük bir potansiyele sahip bir teknolojidir. Öğrencilere ve eğitmenlere her yerden erişilebilir, maliyet etkin bir platform sunmaktadır. Öğrencilerin ve öğretmenlerin ders materyallerine uygulamalarına ve diğer eğitim kaynaklarına cihazdan kolayca erişebilme imkânı sunmaktadır. Bulut bilişim sistemleri öğrencilere ve öğretmenlere çeşitli avantajlar sunmaktadır. Öğrencilere zaman tasarrufu ve kişiselleştirilmiş öğrenme ortamı sunarken öğretmenlere ise etkili analiz ve verimliliğin artacağı konusunda avantajlar sunmuştur. Bu çalışmanın amacı bulut bilişim teknolojisinin eğitim alanındaki uygulamalarını ve etkilerini derinlemesine incelemektir. Bu analiz bulut bilişim teknolojisinin eğitimde nasıl kullanıldığını bu teknolojinin öğretim ve öğrenme sürecini nasıl katkı sağladığını ve hangi zorluklarla karşılaşıldığını anlamayı hedeflemektedir. Bulut bilişim teknolojisinin eğitimdeki rolünü ve önemini vurgulayarak bu alandaki gelebilecek çalışmalar için temel oluşturmayı amaçlamaktadır. Bu nedenle bu çalışma eğitim teknolojisi alanında bulut bilişim teknolojisinin değerlendirilmesi konusunda önemli bir katkı sağlamaktadır. Bu amaç doğrultusunda YÖK Tez veri tabanında "bulut bilişim, eğitim, bulut bilişim sistemleri, eğitimde bulut, dijital dönüşüm" anahtar kelimeleri ile tarama yapılmıştır. Bu taramada 47 adet tez incelenerek tezlerden 10 tanesi amaca göre uygun oluğu için seçilmiştir. Seçilen tezler veri tabanlarından belirlenen kaynakları sistematik bir şekilde incelenmesi ve analiz edilmesi yoluyla toplanmıştır. Amaca uygun olarak seçilen makaleler "yıllara göre dağılımı, araştırma desenine göre dağılımı ve katılımcıların eğitim düzeyine göre dağılımı" bakımından incelenmiştir.

Anahtar Kelimeler – bulut bilişim, eğitim, bulut bilişim sistemleri, eğitimde bulut, dijital dönüşüm

I. GİRİŞ

Bulut bilişim birçok alanda yeniden şekillendirilmiş devrim niteliğinde bir teknolojidir. Bu teknoloji performanslarını arttırma ve maliyet azaltmak için çok sayıda kişiye bağlı seçenek sunmaktadır. Öğrencilere eğitmenlere kolaylık sunmak için farklı işlem modelleri aracılığıyla katkıda bulunur. Öğrencilere zaman ve emek tasarrufu sağlamanın yanında laboratuvarları modernleştirmek için de kullanılır. Bulut bilişim kullanıcılarının nerede ve hangi cihazla bağlandıklarını önemsemez Servislerini sağlamaya devam eder. kullanıcı havuzunda verilerin paylaşılmasını sağlar. Öğrencilerin farklı ihtiyaçlarını tamamını karşılayabilir niteliktedir. Bulut bilişimde kullanılan kadar ödeme yapılır. Buluttaki uygulamalar kullanılarak geliştirilebilir ve altyapı oluşturma süresinde tasarruf yapmasının yanı sıra lisanslama maliyetlerini de ortadan kaldırır [10]. Bulut bilişimin yayılmasını önündeki kolaylaştırıcı ve engelleri anlamak için öğrenme ortamı değerlendirilmeye alınmıştır. Öğrencilerin öğrenme deneyimini kolaylaştırdığı ve iş yerlerini dönüştürebilir geleceği, öğrencilerin deneyimini gel geliştirmek için araştırma ve öğretim yoluyla bulut bilişimin ilişkili yeniliklerde bulunduğu ve bunun da yararlı olduğu belirtilmiştir [7].

Öğrencilerin bulut bilişimi müfredatlarının bir parçası olarak düşünmelidir. Bunu göz önünde bulundurarak oluşturulan bir çalışmada davranışsal niyetle ilgili olarak bulut bilişimin kullanıcı kontrolüne odaklanmaktadır. Öğrencileri temel alan bu çalışma müfredatlarının bir parçası olarak bulut bileşimi benimsemeye motive etme amacı taşımaktadır. Kaygı, algılanan risk, algılanan endişe ve kültürel gibi faktörlerin bağlam ve harici depolamanın kullanılması üzerinde olumsuz bir etkisi olduğu belirtilmiştir. öğrencinin bulut bilişimi benimseme niyetinde bu tür düşüncelerin önemli bir rol oynadığı ve öğrencilerin eğitimlerinin bir parçası olarak bulut bilişimi benimsemelerinin önemli olduğu vurgulanmıştır [6].

Yapılan bir çalışmada Windows Azure platform üzerinde bulut bilişim temelli eğitim portalı geliştirilmiştir. Eğitim sürekli gelişmekte ve değişmekte olan teknolojiye ayak uydurmaktadır. Bu doğrultuda eğitim gibi sürekli gelişen alanlarda hizmet kalitesini artırmak amacıyla bulut bilişim modelinin kullanımı etkin bir çözüm olmaktadır. Türkiye'nin ilk uygulama özelliğini taşıyan Windows Azure bulut platformu üzerine kurulmuştur. Bu bileşim sunduğu olanaklarla sistem kullanımında artış de azalışlar otomatik olarak birden fazla sunucu ya dağıtılır hizmet aksamadan ve performans kaybı olmadan iş deyişini sürdürülmesine olanak sağlamaktadır [9].

Taher (2013) yaptığı bir çalışmada bulut bilişim ve sanallaştırma teknolojileri incelenmiş web tabanlı sanal bir laboratuvar geliştirilmiştir. Üniversite öğrencisi ve diğer kişiler üstünde yapılan bu çalışmada MATLAB, SPSS, AutoCAD, 3D gibi uygulamalarını Kullanmaları ve farklı bir işletim sistemine ihtiyaç duyulduğunda geleneksel bir bilgisayar laboratuvarı kullanılması önerilmiştir. Bunun sebebi kişilerin bilgisayarlarının yüksek özelliklere sahip olmadığından kaynaklanmaktadır. Kullanıcılar platform hizmetini çalıştırmadan ofis yazılımlarını internet sayfası üzerinden yazılım hizmeti olarak kullanabilmektedir. bu çalışmanın mali açıdan bakışı ise web tabanlı sanal laboratuvarın gelecekte daha da gelişerek üniversitede bulunan bilgisayar laboratuvarı ihtiyaçlarını daha da azaltacağı yöndedir. Üniversite laboratuvarları yüksek maliyet ve yüksek performanslı bilgisayar donanımlarının ihtiyacını birlikte getirmektedir. Web tabanlı sanal laboratuvar ile bu gereksinim ortadan kalkacak ve bilgisayarın üzerinde sadece bir web tarayıcısı bulunması yeterli olacağı belirtilmiştir [10].

Bilgin (2020), çalışmasında bulut tabanlı öğrenme ortamının öğrencilerin bilişsel yüklerine ve başarılarına etkisi incelenmiştir. Bu bağlamda öğrencilerin eğitimde başarı durumları ölçülerek etkili olduğu belirtilmiştir. Kalıcılık test sonuçlarında ise kalıcılığın devam ettiği belirtilmiştir. Grupların bilişsel yük ve başarı arasında anlamlı ilişkileri ise bulunamamıştır. Deney grubuna yapılan ölçek sonuçlarına dayanarak öğrencilerin 100 yüze, çevrimiçi ve harmanlanmış öğrenme ortamlarına verdikleri cevapların fazla olumlu görüşe sahip olduğu belirtilmiştir. Öğrencilerin bulut bilişim sayesinde ders içeriklerine istedikleri zaman istedikleri yerde çevrim içi olarak ulaşabileceklerini ayrıca yaptıkları etkinlikleri ve ödevleri öğretmenlere sistem üzerinden rahatlıkla gönderildikleri vurgulanmıştır. Sınavların sistem üzerinden yapılması ile sınav sonuçlarına yine sistem üzerinden kolaylıkla ulaşabildikleri belirtilmiştir [2].

Bulut tabanlı e-kitap ortamına göre öğrenenler platformu farklı amaçlarda soru sora bildikleri öğretici ve diğer öğretmenlerin sorularına da cevap verdiklerini belirtmişlerdir. Bunların yanı sıra kitap içeriği tasarımı platform özellikleri ve süreç hakkında kişisel fikir ve çıkarımlarda bulunduklarını da belirtmişlerdir. Öğrencilerin kendi düşüncelerini rahat bir şekilde paylaşması sunulan ortamın etkili olduğunu göster gösterdiği vurgulanmıştır. Öğrencilerin açık ve uzaktan öğrenme ortamlarında ihtiyaç duyulan çok yönlü iletişim ve etki iletişime kolaylıkla ulaşılabilirliğinin sağlandığı belirtilmiştir. Böylelikle öğrenciler pasif katılımdan aktif katılıma geçmişlerdir. Eğitici içerik üzerindeki hataların bulunması hatta içeriğin geliştirilmesi yönünde platforma destek çıktı belirtilmiştir. Canlı dersler ve tartışma formlarına kıyasla kitap üzerinden iletişim kurmayı sağlayan farklı bir boyut öne çıkarılmıştır. İletişim sürecinde ne söylediğinden ziyade nasıl söylendiği defa fark yaratan unsurlardan biri olduğu öne çıkmıştır [4].

Bulut bilişim işlemlerin bilgisayarlar ile başka bilgisayarlarda bundan yazılımlar aracılığıyla bir ağ üzerinden paylaşımının yapılmasıdır. Dünyanın her yerinde bilgisayarlar veya sunucunun kapasitesi kullanılarak veriler saklanabilmektedir. Bulut bilişimi teknolojilerinin en bilinen tedarikçileri ise Google Drive, Dropbox, Apple I Cloud, One Drive veya Amazon Drive'dır. Türkiye'de ise Turkcell, Türk Telekom ve koç sistemi tedarikçi olarak görev yapmaktadır. Bu tedarikçiler sayesinde telefonlar, bilgisayarlar gibi teknolojik araçlarla veriler kolaylıkla saklanabilir ve depolanan bilmektedir. Uygulamalara yüklenen veriler internet erişimi olan her yerden erişebilmek de değiştirilmekte ve kaydedilmektedir. Teknolojik cihazlarda meydana gelen arızalarda ise verilerin kurtarılması olası bir durumdur. Bulut bilişim teknolojisi kurulum gerektirmemesi ve web tabanlı uygulamalar ile her yerden ulaşım sağlanması yönünden hayata kolaylık sağlamaktadır [8].

Bulut bilişim destekli internet tabanlı programların öğrencilerin akademik başarılarına ve iş birlikli öğrenmeye karşı tutumlarını inceleyen bir çalışmada 12 haftalık bir çalışma süreci gerçekleştirilmiştir. Araştırmaya katılan öğrencilerin akademik başarı düzeylerini belirlemek amacıyla yapılan sınavlardan aldıkları önceki ve sonraki puanlar arasında anlamlı bir fark olduğu belirtilmiştir. Bulut bilişim desteği alan öğrencilerin destek almayan öğrencilere göre daha başarılı olduğu vurgulanmıştır. Böylelikle bulut bilişimin öğrencilerin akademik başarı düzeylerini artırmada etkili olduğu gözlemlenmiştir. Yine bulut bilişim desteği alan öğrencilerin bulut bilişim desteği alamayan öğrencilere kıyasla iş birlikli öğrenmeye karşı tutumlarında benzer seviyede olduğu bulunmuştur. Bu durumda bul bilişim destekli eğitimlerin iş birlikli öğrenme yönetimleriyle birlikte kullanılabileceği ortaya çıkarılmıştır [8].

Bulut bilişim sistemlerinde öğretmenin rolü internet tabanlı öğrenme ortamında öğrenciler arası iş birliği meydana getirmektir. bu kapsamda öğretmen bulut bilişim sistemlerini kullanarak öğrencilere liderlik etmektedir. Öğretim etkinlikleri öğretmenin rolünün etkili öğrenmeyi gerçekleştirmek için öğrencilere çeşitli materyaller hazırlamak, sisteme yüklemek, öğrencilere rehberlik etmek, öğrencilerden gelen geri bildirimleri almak ve iletmek şeklinde değerlendirilmektedir. Bulut bilişim sistemlerinde öğrencinin rolü ise çevrim içi derslere aktif olarak katılarak bulut üzerinde oluşan sınavları yapma, ödevleri teslim etme ve projelere katılma rollerinin olduğu söylenebilmektedir. Öğrenci ders takibi yapmak, sisteme yüklenen materyalleri etkin bir şekilde kullanmak, etkinliklere aktif bir şekilde katılmak, arkadaşlarıyla iş birliği içerisinde çalışmak ve bu süreçte öğrenmelerini gerçekleştirmek olarak belirtilmektedir [5].

Yapılan bir çalışmada dijital okur yazarlık ölçeğine göre öğrencilerin tutum, teknik, bilişsel ve sosyal tüm alanlarda puan ortalamaları uygulama sonunda anlamlı bir yükselme gösterdiği belirtilmiştir. fakat istatistiksel olarak bakıldığı zaman anlamlı olmadığı vurgulanmıştır. bu bulgulardan hareketle bulut bilişim teknolojisi uygulamalarının kullanımının öğrencilerin dijital okur yazarlık becerilerini geliştirdiği ortaya koyulmuştur. Diğer taraftan alan yazın taramasında yapılan araştırmada dijital araçlarla desteklenmiş öğrenme sürecinde öğrenciler teknolojik araçları kullanmanın dijital okuryazarlık becerileri üzerine etkisinin olduğunu vurgulamışlardır. Sonuç olarak öğrencilerin materyallere erişimi, materyal paylaşımı, ders aktif katılımı, uygulamaları etkin kullanımı gibi kategorilerde başarılı oldu belirtilmiştir [5].

Eğitim alanındaki kaynakların maliyetinin azaltılması için IoT teknolojisi araştırmaya başlanmıştır. Carnegie Mellon Üniversitesi'nde yapılan bir çalışmada IoT en popüler uygulamalar arasına girmiştir. Eğitim alanında kullanımının ardından; öğretmenden eğitim alabilmek, belli bir zaman diliminde öğretmek, stratejik bir eğitim sürecine odaklanabilmek, özel ve maliyet içeren kaynaklarla öğretmek, verilerden anlam çıkarmayı göstermek öngörülmüştür. İngiltere de Açıköğretim Üniversiteleri bilgisayar bilimlerine giriş dersinde "My Dijital Life" yapısını kullandı ve bu tasarımın yeniden yapılandırılarak IoT temelli derslerin deneyimlerini amaçlamışlardır. Bu ders sayesinde dünya ile duygusal bir bağlantı oluştuğu vurgulanmıştır ve böylelikle IoT teknoloji isimli bir yenilik üretildiği belirtilmiştir [7].

Yapılan bir çalışmada öğretmenlerin teknolojik yeterlilikleri nasıl algıladığı üzerine çalışma gerçekleştirilmiştir. Bu çalışmada öğretmenlere cinsiyetleri, yaşları, eğitim düzeyleri, çalışma ortamı, kaç yıldır eğitim verdikleri ve ne kadar zaman geçirdikleri gibi değişkenlerle etkiyi belirlemek amaçlanmıştır. 5'li likert ölçeğiyle tasarlanan bu çalışmada sonuç olarak öğretmenlerin cinsiyetlerinin, yaşlarının, kaç yıldır öğretmenlik yaptıklarının ve hangi seviyede olduklarının önemli olmadığı belirtilmiştir. Fakat elektronik ortamlarda ne kadar zaman geçirdikleri ve çalışma ortamlarının algılanan teknoloji yeterliliklerini etkilediği vurgulanmıştır. Teknoloji yeterliliği algısının artması için elektronik ortamlarda fazla zaman geçirmeleri ve özel okullarda çalışmanın teknoloji yeterliliği algısının arttırılabileceği vurgulanmıştır [3].

Fadhil (2020), yaptığı çalışmasında öğrenciler arasında bulut bilişimin kullanılmasını etkileyen faktörleri incelemiştir. Araştırmada öğrencilerin bulut bilişim hakkında bilgi düzeyleri, bulut bilişim sistemlerine olan erişim imkanları gibi değişkenlerle bulut bilişim teknolojilerini kullanma eğilimine ağırlık vermiştir. Öğrencilerin cinsiyetinin, yaşının, bölümünün, bilgisayar ve internet kullanma durumlarının, bulut bilişim hakkında bilgi düzeylerinin etkilediğini belirtmiştir. Bulut bilişim kullanma eğilimini etkileyen bu faktörlerin, eğitim politikalarını ve öğrenci eğitimi programlarının geliştirilmesinde dikkate alınması gerektiğini vurgulamıştır. Bulut bilişim teknolojisinden en iyi şekilde yararlanılması için stratejilerin geliştirilmesi gerekliliğini belirtmiştir [6].

Ahmad (2021) yaptığı çalışmada Irak Üniversite üzerinde bulut bilişim temelli e öğrenim sistemlerinin kullanılmasını etkileyen faktörler araştırmıştır. Çalışmada öğrencilerin bilgisayar ve interneti kullanma becerileri bulut bilişim hakkındaki bilgi düzeyleri ve bulut bilişim temelli e öğrenim sistemlerine erişim olanakları gibi değişkenleri incelemiştir. Öğrencilerin bilgisayar ve internet kullanma becerilerinin bulut bilişim hakkındaki bilgi düzeylerinin ve bulut bilişim temelli e öğrenme sistemlerine erişim olanaklarının bu sistemi kullanma eğilimlerini etkilediğini belirtmiştir [1].

II. MATERYAL VE YÖNTEM

Eğitimde bulut bilişim sistemlerinin kullanımının incelendiği bu çalışma, içerik analizi yöntemi kullanılarak gerçekleştirilecektir. Bu yöntem eğitimle bulut bilişim sistemlerinin değerlendirilmesine mevcut literatürdeki desenlerin ve temaların belirlenmesine olanak sağlayacaktır.

Araştırmanın Tasarımı

Bu araştırma, nitel araştırma aşamalarından içerik analizi yöntemi kullanılarak oluşturulacaktır. Çalışmada alan yazın taraması için kullanılan akademik veri tabanı YÖK Tez olarak belirlenecektir.

Veri Kaynakları/Örneklem

Çalışmada YÖK Tez veri tabanında bulunan tezler bilgi eğitimde bulut bilişim sistemlerinin kullanımı bakımından filtrelenmiş ve filtrelenen çalışmaların amaca uygunluğu kontrol edilecektir. Çalışmaların taranması için YÖK Tez veri tabanında gelişmiş tarama seçenekleri kullanılacaktır. YÖK Tez veri tabanında "Bulut Bilişim, Eğitim" anahtar kelimeleri ile tarama yapılacaktır. Bu taramada 47 adet tez incelenerek tezlerden 10 tanesi amaca göre uygun olduğu için incelenecektir.

Verilerin Toplanması

Araştırma, seçilen veri tabanlarından belirlenen kaynakları sistematik bir şekilde incelenmesi ve analiz edilmesi yoluyla toplanacaktır. Amaca uygun olarak seçilen makaleler "yıllara göre dağılımı, araştırma desenine göre dağılımı, katılımcıların eğitim düzeyine göre dağılımı" bakımından incelenecektir.

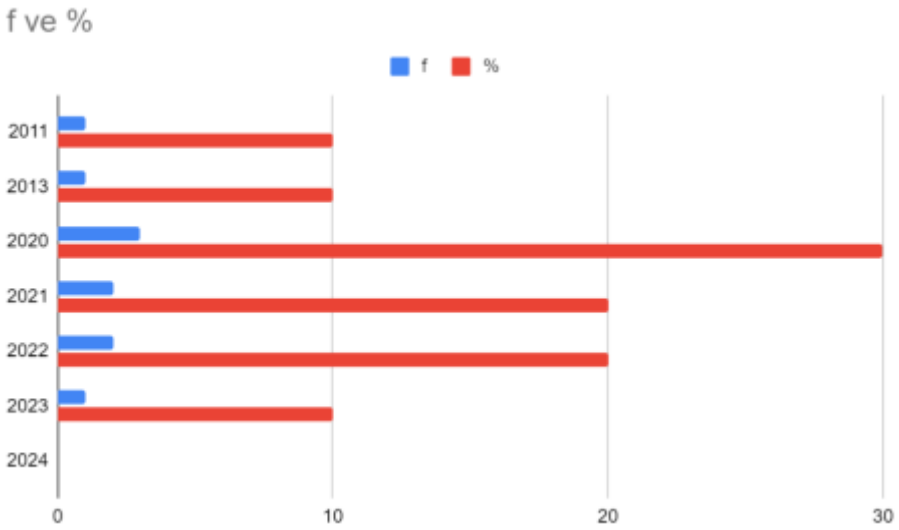
Verilerin Analizi

Eğitimde bulut bilişim sistemlerinin kullanımının değerlendirilmesine yönelik bu çalışma 2024 yılı Mayıs ayında yapılmış olup tarama çalışmaları 2011 yılından bu zamana kadar olan 13 yıllık süreç içinde bulunan çalışmaları kapsayacaktır. Tezler incelenerek amaç bağlamında belirlenen kodlamalar sağlanmış ve kodlamalar tamamlandıktan sonra ilgili tema altında frekans ve yüzdeler hesaplanıp elde edilen bulgular grafik ve tablo kullanılarak sunulacaktır.

III. BULGULAR

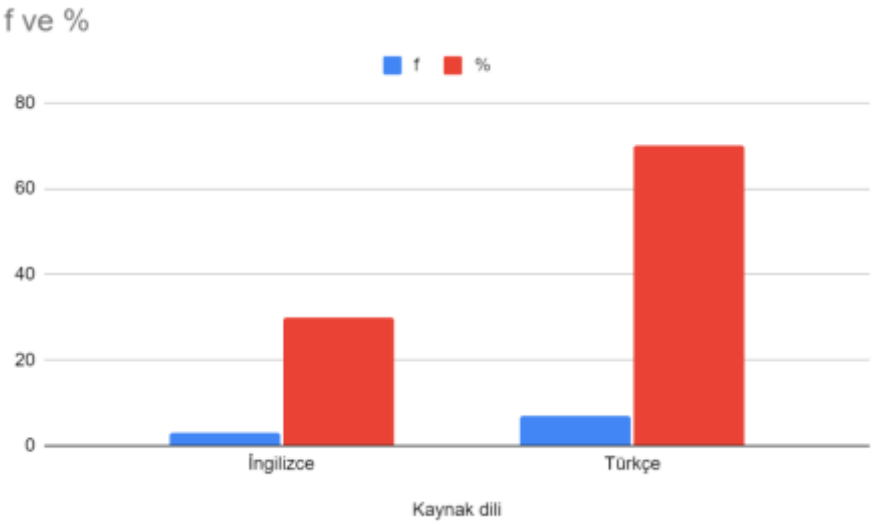
Bu bölümde eğitimde bulut bilişim sistemlerinin kullanımın değerlendirilmesi konusunda yapılmış 10 adet tez çalışmasının çeşitli ölçütlere göre içerik analizinden elde edilen bulgular yer almaktadır.

Kaynakların Yıllara, Yayın Diline ve Eğitim Düzeylerine Göre Dağılımı



Şekil 1. Kaynakların Yıllara Göre Dağılımı

Şekil 1. incelendiği zaman 2011-2024 yılları arasında ilgili makale sayıları belirtilmiştir.2011, 2013 ve 2023 yılına ait %10 ile 1 kaynak incelenmiştir. 2021 ve 2022 yıllarına ait %20 ile 2 kaynak incelenirken kaynakların en fazla ve yoğun olduğu 2020 yılına ait %30 oranla 3 kaynak incelenmiştir. En fazla kaynak 2020 yılında bulunmaktadır.



Şekil 2. Kaynaklara Göre Yayın Dili

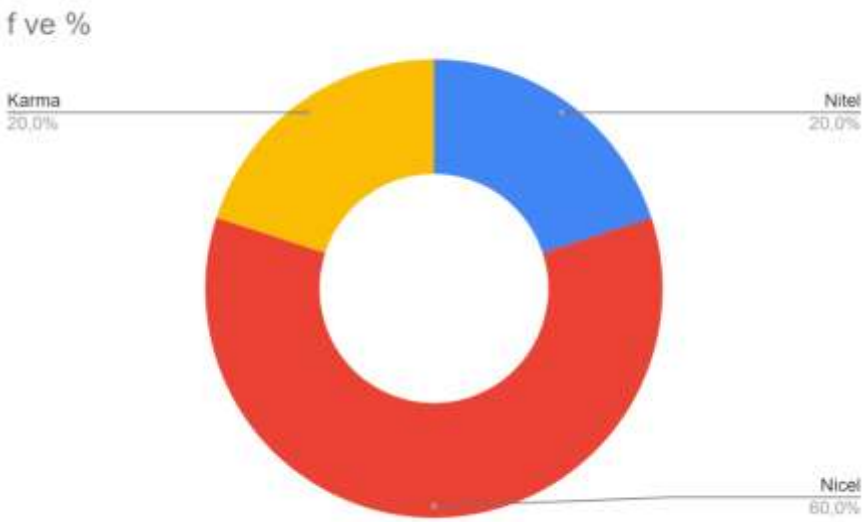
Şekil 2. incelendiğinde YÖK Tez'de çalışma yapılan tezlerin %70'inin Türkçe ve %30'unun İngilizce olduğu incelenmiştir. Yayın dili en çok Türkçe kullanılmıştır.

Tablo 1. Eğitim Düzeyine Göre Dağılımı

Katılımcıların Eğitim Düzeyi	f	%
Öğrenci	6	60
Eğitmen	2	20
Belirtilmemiş	2	20

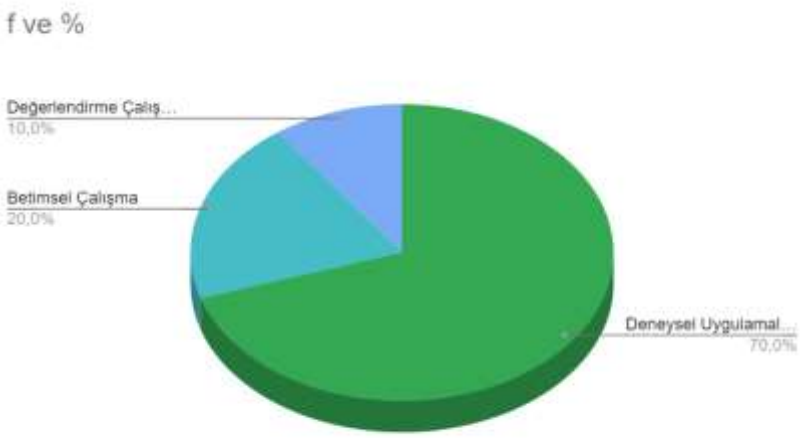
Tablo 1. İncelendiğinde belirlenen çalışmaların %60'ının öğrencilere yapıldığı gözlemlenmiştir. %20 tanesi eğitmenlere uygulanmıştır ve %20'lik bir kısmının ise katılımcı eğitim düzeyi belirtmediği incelenmiştir.

Kaynakların Araştırma Yöntemine, Türüne Göre Dağılımı



Şekil 3. Araştırma Yöntemine Göre Dağılımı

Şekil 3. İncelendiğinde araştırma yapılan tezlerin çoğunluğunun nicel araştırma yöntemi belirlediği gözlemlenmiştir. %20 si nitel olan çalışmaların ise yine %20'li kısmı karma araştırma yöntemi belirlemiştir.



Şekil 4. Araştırma Türüne Göre Dağılımı

Şekil 4. İncelendiğinde araştırılan tezlerin çoğunluğunun deneysel uygulamalı çalışma gerçekleştirdiği incelenmiştir. %20 betimsel çalışma gerçekleştirilen tezlerde %10 oranında değerlendirme çalışması gerçekleştirilmiştir.

IV. TARTIŞMA

Bu çalışmanın bulguları bulut bilişimin eğitimde birçok faydaya sahip olduğunu ortaya koymaktadır. Bulut bilişim öğrencilere zaman ve emek tasarrufu sağlarken laboratuvarları modernleştirebilir, kişiselleşmiş öğrenme ortamı ortaya koyabilir, iletişimi kolaylaştırabilir, iş birliği ve erişilebilirliği artırabilir. Bulut bilişim öğretmenlerin verimliliğini de arttırmada önemli rol oynamaktadır. Yeni öğretim yöntemleri sunarak iş birliği ve iletişimi kolaylaştırabilir ve veri toplama ile analizini geliştirebilir. ancak bulut bilişim kullanımıyla alakalı bazı zorluklar bulunmaktadır. Veri güvenliği ve gizlilik endişeleri bu zorlukların arasında bulunsa da internet erişimine ihtiyaç duyulması ve öğrenciler ile öğretmenler için gerekli becerilerin eksikliği de yer almaktadır.

Eğitimcilerin bulut bilişimin sunduğu avantajlardan yararlanabilmesi için zorlukların ele alınması önemlidir. Bunun için de veri güvenliği ve gizliliğini sağlamak için çeşitli politikalar ve prosedürler geliştirilmeli, internet erişiminin sağlanması ve gerekli becerilere sahip olmalarını sağlamak için de gerekli eğitimler verilmelidir.

V. SONUÇLAR

Bulut bilişim teknolojisi eğitim alanında önemli bir dönüşüm potansiyeli sunmaktadır bu teknolojiyi öğrencilere ve eğitmenlere her yerden erişebilir, kısa maliyet etkin ve ölçülebilir bir platform sunmaktadır [5]. Öğretmenler bulut bilişim sistemlerini kullanarak öğrencilere liderlik ederken öğretmenler de çevrimiçi derslere aktif olarak katılarak bulut üzerinde oluşan sınavları yapma, ödevleri teslim etme ve projelere katılma rollerini üstlenir [5]. Ayrıca bulut bilişim eğitim kurumlarının altyapılarını yöneltme ve sürdürme maliyetlerini azaltabilir [7]. Bu okulların daha fazla kaynağa doğrudan öğretim ve öğrenmeye yönlendirmelerini sağlar [7]. Bununla birlikte bulut bilişimi eğitiminde kullanımı, veri güvenliği ve gizlilik konularında bazı endişeleri de beraberinde getirir [6]. Eğitim kurumları öğrenci bilgilerinin korunması ve yasal uyumluluk konularında dikkatli olmalıdır [1]. Sonuç olarak bulut bilişim teknolojisi eğitimde büyük bir potansiyele sahip olmasına rağmen bu teknolojinin etkin bir şekilde kullanılabilmesi için bazı zorlukların üstesinden gelinmesi gerekmektedir [3]. Bu eğitim kurumlarının bulut bilişim çözümlerini uygularken dikkatli bir planlama ve strateji geliştirmelerini gerekmektedir [6].

TEŞEKKÜR

Bu araştırmayı tamamlamamda bana yardımcı olan bir çok kişiye teşekkür etmek isterim. Başta danışmanım Doç. Dr. Hatice Yıldız Durak'a verdiği rehberlik ve desteği için teşekkür ederim. Bu süreçte beni destekleyen aileme de gösterdikleri sabır ve anlayışlarından ötürü teşekkür ederim.

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Proposed Model for Improving Quality in the Hotel Industry in the Republic of North Macedonia

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Abstract **–**The problem investigated in this paper refers to the state and improvement of the business processes in organizations from the hotel industry in the R. N. Macedonia and determining the level of maturity in relation to the strategy of TQM (Total Quality Management), which represents a new approach in management, in the direction of continuous improvement of the quality of all activities of the organizations. The research itself was realized through the analysis of the existing situation in the hotel industry, determination of the possibilities for the improvement of business processes and a model for their improvement was proposed. Basic prerequisites for the introduction of the TQM system in the hotel enterprise are: marketing orientation of the hotel; existence of a quality program and readiness of all subjects in the enterprise for its introduction; establishing an organization of operations that enables the introduction of such a system; and electronic operation of the hotel.

Keywords – business processes, model, TQM (Total Quality Management),

INTRODUCTION

Large hotel systems and hotel groups, due to the need to introduce an integrated service management system in all facilities, regardless of the different areas in which they are located, initially decide to introduce a quality system. Its introduction is achieved through: continuous improvement of the hotel service; strengthening the company's competitive abilities and market power; increasing the satisfaction ng reasons: The organizational structure of small hotels is simpler, because the number of employees is much smaller; to a smaller number of employees, it is easier to explain the essence and benefits of the introduction of the TQM system and to gain confidence for its introduction; the largest number of employees is involved in all stages of creation and delivery of services; it is simpler to organize the training; the cooperation of management and employees is permanent; unnecessary inventory is kept to a minimum; shortcomings and weaknesses are quickly noticed; and the procedure for resolving guest complaints is much simpler and faster. Smaller hotels are more flexible, which allows them to adapt more easily and quickly to market conditions and market demands, the possibility of faster resolution of objections and fewer decision-making levels [2], [3].

Disadvantages that can often be manifested during the introduction of the total quality management system in smaller hotels are: managers and owners of these hotels often lack a vision and strategy for the market, so they accept the TQM system with reservations; managers and owners very often expect quick results, which this system does not provide in a short time period; very often, due to ignorance, there is resistance to the introduction of this system; employee training is organized rarely due to the small number of employees and there is a problem of replacing them during training; and due to the small number of employees there is a risk that one or two employees will prevent the changes if they fear that it will mean more work and responsibilities [4], [5].

The knowledge, education, culture and readiness of the owners of the small hotels to introduce the quality system are determining elements that dominate the total management of them. It is up to them, together with the management, to create such a climate in which employees will be interested, think independently and have personal responsibility. In order to adopt this philosophy, managers - owners of small hotels must have integrity, ability, flexibility, exceptional communication skills, willingness and will to work on themselves and motivate others to work.

Through the research within this paper, the management models of the business processes in the hotel industry in the Republic of North Macedonia have been analyzed and based on the findings a proposed model for a management system in the hotel industry is offered [6].

LITERATURE REVIEW

At the basis of many scholars' explanation of maturity in business process management is the claim that a company's overall performance can be improved by adopting a process approach to business. The adoption of a process approach actually leads to the management of business processes, which results from the realization that processes have their own development cycle, which can be defined, directed, measured and controlled over time [1], [7].

Businesses are constantly looking for new ways to improve their performance, their business, striving for excellence. Achieving excellence in a dynamic, global environment is very challenging, and for that reason many authors have developed and proposed maturity models of business processes with the intention of facilitating their gradual improvement, guided by process orientation [8], [9].

Higher levels of development, in fact, are higher levels of maturity of the process, which results in increased predictability of the course and results of the process, increased effectiveness in achieving the set goals, as well as increasing the ability of managers to define new, higher goals in the conditions of execution [1], [11], [12].

In order to be able to analyze the maturity of the process and later the models for managing the maturity process, it is necessary to first explain the concept of maturity itself. In that manner, it can be indicated that the maturity of the process means that everything the company does is done in an adequate way, which is documented and subject to verification and measurement and that everyone in the company knows what is expected of the process, what and how it should work. This means that the increase in the level of maturity can in no way be associated with the heroic deeds of dominant individuals, but only with the systematic application of an appropriate methodology and following pre-defined procedures. When all this is implemented at the process level, it means that it can be discussed about the maturity of individual processes. But when all of the above mentioned is implemented at the company level, then it can be discussed about the maturity in managing the processes of an entire enterprise [14], [15].

Based on the results of the research on the Austrian tourist market - a synonym for quality development of the services offered in sports resorts for winter tourism, a process approach to the creation of a quality tourist product and its application has been determined. The areas for tourist services in Austrian winter sports destinations are divided into seven categories: boarding and lodging; sports potential (except skiing); entertainment and cultural activities; accessible transportation (resort accessibility and resort transportation); hiking activities; protection of nature, landscape and environment and shopping and related services. For each given area, a quality management system consisting of seven elements has been established: safety and protection; freedom, privacy, sociability; aesthetics; trust and honesty; variety and entertainment; accuracy and reliability and ease of communication and availability of information. Measuring the satisfaction of service users on a continuous basis helps to determine the gap between the expectations of the guests and what the Austrian tourism sector projects and implements. This represents a good basis for building or correcting a system for managing the quality of the tourist product. The following is an analysis of the situation in the hotel sector in R. N. Macedonia.

The purpose of the research within this paper is to obtain a realistic picture of the business process management models in the hotel industry, in order to obtain useful guidelines for the development of a model proposal that will contribute to the improvement of organizational performance, measures will be

defined that will lead to the realization of sustainable business systems, thereby encouraging innovation and contributing to strengthening the links between the hotel industry, research and innovation.

MATERIALS AND METHOD

The specific goal of this research is to create a proposed model for the improvement of business processes in the hotel industry, as well as proposing measures to improve it by determining the maturity in the management of business processes in the hotel sector in R. N. Macedonia.

The subject of the research are 32 hotels with 3, 4 and 5 stars in R. N. Macedonia and the same will be in the direction of determining the level in the management of business processes as well as proposing a model for their advancement.

According to the latest statistics, there is a relatively well-developed hotel accommodation offer in North Macedonia, which according to the Ministry of Economy (2023), in 2023 (as of February 1, 2023), a total of 174 hotels of all categories were registered, as shown in Table 1.

Table 1. Structure of categorized hotels in R.N. Macedonia as of February 1, 2023

Type of hotel	Number	%
Superior 5* hotel	16	9%
5* hotel	3	2%
Superior 4* hotel	10	6%
4* hotel	52	30%
3* superior hotel	9	5%
3* hotel	46	26%
Superior 2* hotel	2	1%
2* hotel	31	18%
1* hotel	4	2%
It has not been categorized	1	1%
Total:	**174**	**100%**

Source: Ministry of Economy, Tourism and Hospitality Sector.
Overview of the categorized hotels (2023)

The research was conducted on a convenient sample of 32 respondents (N=32) who have senior positions and decision-making power in 32 hotels on the territory of the Republic of North Macedonia. The low response rate obtained (N=32) is satisfactory, taking into account the conditions of the Covid-19 pandemic and in scientific research of this type, it ranges between the limits of 16% to 25%, which in our case, it is considered as relevant.

The same source states that most rules of statistical inference require that the sample number a minimum of 30 cases, although for descriptive research, practice dictates that 100 cases shall be treated as a minimum. Considering that the research used inferential statistics, the sample of 32 hotels is small, but it is quite satisfactory, as is shown in Table 2.

Table 2: Distribution of responses by type of hotel in percentages

Type of hotel	Number	%
5* hotel	6	18.8%
4* hotel	11	34.4%
3* hotel	15	46.9%
Total:	**32**	**100%**

In order to determine the maturity in the improvement of business processes in the hotel industry, a direct method was used - a survey questionnaire. This research used a convenience sample that was reached through a combined approach of online questionnaires via Google Forms, in person, and via e-mail.

The questionnaire was composed of three parts.

In the first part, answers were sought about the demographic characteristics of the respondents (11 questions).

In the second part, the questions referred to the management systems implemented by the hotel, as well as questions related to describing the business environment in the hotel where the respondents work - for each of the listed factors of managing the management systems (9 questions).

In the third part, issues related to the organizational structure and management of the business processes were addressed through thirteen aspects related to: strategy, leadership, process management, employee management, information technology, communication, customer focus, external supplier relations, employee skills, reward system, continuous improvement, methods and techniques, defect-free operation, as well as performance measures.

The collected data were analyzed using the statistical software tool IBM SPSS Statistical Package for the Social Sciences - 22, and the analysis used descriptive statistics and Spearman's correlation coefficient, as well as the $\chi 2$ test and the cross-tabulation method. During the statistical processing, descriptive statistics were applied, i.e., frequencies, percentages, rank, arithmetic mean and standard deviation. A five-point Likert scale (from 1 to 5) is used, with an impact factor of very low (1 – 1.80), low (1.81 – 2.60), medium (2.61 – 3.40), high (3.41 – 4.20) and very high (4.21 – 5.00).

As statistical indicators for determining maturity in the management of business processes and competitiveness factors of hotels, the following are used: information technology, process management (including methods and techniques for flawless operation), employee management, strategic approach, organizational or business culture) and competitiveness (market share) of the hotel.

Table 3 provides the general demographic data for the respondents and basic data for the organizations in which they work.

Table 3: Demographic data for respondents (managers/owners) and general data for organizations (hotels)

	Category	**Frequency (n)**	**Percentage**
Gender	Men	*21*	*66.6*
	Women	*11*	*34.4*
Work experience in the hotel	1-5 years	*17*	*53.1*
	over 5 years	*15*	*46.9*
Age	36-40 years	*12*	*37.5*
	41-45 years old	*8*	*25*
	46-50 years	*5*	*15.5*
	over 55 years	*7*	*22*
Form of the hotel ownership	Independent/individual hotel	*30*	*93.8*
	Hotel as part of a chain	*2*	*6.2*
Function of the surveyed person	Manager	*23*	*71.9*
	Owner	*9*	*28.1*
Hotel category	5 star hotel	*6*	*18.8*
	4 star hotel	*11*	*34.4*
	3 star hotel	*15*	*46.9*
Number of employees	Up to 25	*8*	*25*
	26-50	*16*	*50*
	Over 51	*8*	*25*

Table 4 presents the general characteristics and management systems used in the researched hotels that made up the research sample.

Table 4: General characteristics and used management systems of the organizations that make up the research sample

Management systems	Answer	Frequency (n)	Percentage (%)
What is the organizational structure of the organization?	Functional	*19*	*59.4*
	Divisional/Sectoral	-	-
	Matrix/project	-	-
	Process oriented	*13*	*40.6*
Does the hotel you work in possess a quality management system certificate - ISO 9001:2015?	Yes	*13*	*40.6*
	No	*19*	*69.4*
Does the hotel you work in possess an ISO 14001:2015 environmental management system certificate?**	Yes	*8*	*29.6*
	No	*19*	*70.4*
Does the hotel you work in possess an ISO 45001:2018 occupational health and safety management systems certificate?***	Yes	*14*	*46.7*
	No	*16*	*53.3*
Does the hotel you work in possess an ISO 22000:2018 food safety management system certificate?	Yes	*19*	*59.4*
	No	*13*	*40.6*
Does the hotel you work in possess a HACCP hazard analysis and critical control point system implemented?	Yes	*28*	*87.5*
	No	*4*	*12.5*
Does the hotel you work in apply the ISO 26000:2010 Social Responsibility guideline?	Yes	*13*	*40.6*
	No	*19*	*59.4*
Does the hotel you work in apply multiple management systems combined as an integrated system?	Yes	*7*	*21.9*
	No	*25*	*78.1*

** 5 respondents did not answer this question

***2 respondents did not answer this question

From Table 4, it can be concluded that 59.4% of hotels operate according to a functional approach and 40.4% are process-oriented organizations. The sample did not include organizations with semi-adaptive ways of functioning, i.e., those that practice a divisional/sector approach and a matrix/project system.

As can be seen from the Table 4, the majority of the hotels, i.e., 87.5%, have implemented HACCP, the system for hazard analysis and critical control points. 59.4% of the respondents declared that the organization in which they work possess a certificate for food safety management systems ISO 22000:2018. Here, it is important to indicate that HACCP (Hazard Analysis and Critical Control Point) is a system with the help of which the identification, assessment and control of hazards that are significant for food safety are implemented. In the Republic of North Macedonia, the implementation of HACCP food quality standards is regulated by the Law on Food Safety adopted in 2004. Furthermore, 46.7% of the hotels in the sample possess an ISO 45001:2018 certificate for safety management systems and workplace protection, but two respondents did not answer the question. 40.6% of the hotels in the sample possess an ISO 9001:2015 certificate for quality management systems and the same percentage (40.6%) apply the social responsibility guideline ISO 26000:2010. Furthermore, less than a third of the hotels in

the sample, or 29.6%, possess the certificate for environmental management systems ISO 14001:2015. Finally, only 21.9% of the hotels apply two or more management systems in business process management.

DISCUSSION

From the general characteristics and used management systems of the organizations that comprise the research sample, shown in Table 4, it can be concluded that in more than half of the hotels the organizational structure is functional. In terms of management systems, the majority of hotels possess ISO 22000:2019, HACCP certificates, whereas for the rest hotels, these numbers are lower. This indicates that towards excellence, it is necessary to increase the awareness of business processes among hoteliers, strict compliance with the legal regulations and the appointment of responsible persons who will monitor the introduction of the management systems until they are fully implemented.

The maturity model with management of business processes allows identifying the level of maturity in the functioning of the organization, i.e., the degree of representation of the process approach. The level of maturity is determined by elements and factors that are critical for successful implementation in business process management. A higher level of implementation of these critical factors and their continuous improvement indicates a higher level of maturity in the functioning of the organization itself. This research has the task of determining to what level the hotels are familiar with and use these critical factors that are included in the sample of this research. Table 5 provides an overview of the impact factors related to business process maturity and competitiveness.

Table 5. Impact factors related to business process maturity and competitiveness

	Very low	**Low**	**Medium**	**High**	**Very high**
Information technology				*3.66*	
Performance measures			*3.09*		
Process management			*3.22*		
Methods and techniques for flawless operation			*3.03*		
Management of employees				*3.72*	
Strategy				*3.72*	
Business culture				*3.50*	
Competitiveness			*3.22*		

Legend:
Impact factor

1 – 1.80 Very low	1.81 – 2.60 Low	2.61 – 3.40 Medium	3.41 – 4.20 High	4.21 – 5.00 Very high

Table 6 presents the descriptive statistics related to the independent variables, which are related to the maturity of business processes and the dependent variable competitiveness.

Table 6. Descriptive statistics for the independent variables related to business process maturity and the dependent variable competitiveness

	N	Min	Max	M	SD	Skewness	Kurtosis
Information technology	*32*	*2*	*5*	*3.66*	*.865*	*-.518*	*-.196*
Performance measures	*32*	*2*	*5*	*3.09*	*1,027*	*.183*	*-1,447*
Process management	*32*	*2*	*5*	*3.22*	*1,099*	*.313*	*-1.234*
Methods and techniques for flawless operation	*32*	*1*	*5*	*3.03*	*1,636*	*-.100*	*-1,739*
Management of employees	*32*	*3*	*5*	*3.72*	*.683*	*.423*	*-.736*
Strategy	*32*	*3*	*5*	*3.72*	*.581*	*.096*	*-.415*
Business culture	*32*	*2*	*5*	*3.50*	*.984*	*-.108*	*-.931*
Competitiveness	*32*	*2*	*5*	*3.22*	*.86*	*.050*	*-1,375*

Legend: N – number of respondents; M – arithmetic mean; SD – standard deviation, Min – minimum achieved result; Max – maximum achieved result.

After reviewing the descriptive statistics, shown in Table 6, it is determined that all process management maturity factors have an arithmetic mean in the interval between 3 and 4, which is higher than the middle of the scale. Higher maturity factors with business process management are: strategy, employee management, information technology and business culture.

On the other hand, most attention is focused on the following factors: performance measures, process management and methods and techniques for flawless operation. But if one looks at the standard deviation values of these three factors, it is noted that they are the three highest values in the table for this statistic (between 1.03 and 1.64).

The above mentioned means that according to the answers to these three factors (performance measures, process management and methods and techniques for defect-free operation), it is noticeable that there is a greater dispersion of the answers, which would mean that the organizations that have been examined, approach them completely differently to the listed factors.

In continuation a proposed model follows for improving quality in the hotel industry in R.N. Macedonia, which will contribute to the improvement of organizational performance and measures will be defined that will lead to the realization of sustainable business systems.

CONCLUSION

Analyzing the different management systems for quality management that are predominantly applied in the management of hotels in the Republic of North Macedonia, it can be concluded that above all it is important to respect the principles of quality management, which are composed of appropriate complex and basic rules and beliefs used to manage and direct an organization. Proposed model for improving quality in the hotel industry in R. N. Macedonia aims to continuously improve performance related to the needs of customers and other business partners in the long term. The condition for an organization to remain successful is possible by continuously identifying the wants and needs of all interested parties and constant improvements.

Analyzing the directions in which direction the hotels in the Republic of North Macedonia should move, it can be indicated that managing the hotels by applying the principles of process orientation and process approach, the management manages the entire value chain of its products and services. By focusing and relying on the way of actual performance of the work, applying a logical order of activities in the processes, a more reliable picture of the business is obtained and the managerial work becomes more rational and clearer.

In this section it is important to mention one of the most important foundations on which the model rests, which is "orientation towards the client". Organizations depend on their customers, so they must understand their current and future needs, meet their demands and work to exceed customer expectations. Customers play a key role in the future profitability of an organization. In order to retain customers, organizations must understand current and future customer needs. A key role is played by leadership, which creates the unity of the entire organization. Leaders should create an internal environment and atmosphere of the organization so that employees can be fully involved in achieving the goals of the organization. Based on the results of the research, there are recommendations that hotel managers in Macedonia should focus on the new approach to quality, which requires new activities in the field of employee education, the introduction of standardization of all processes, the introduction of statistical process control for the purpose of flawless operation, such as the new approach to cost analysis. The participation of the employees in all the functions of the hotel is very important and the creative energy of the Macedonian citizens who are brought into the work in case of mobilization should be taken into account.

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Kolonların CFRP ile Güçlendirilmesinde Uygulama Detayları

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Özet **–** Türkiye'de mevcut yapı stokunun önemli ve büyük bir çoğunluğu betonarme yapılardan oluşmaktadır. Son yıllarda meydana gelen depremlerin etkisiyle mevcut yapı stoku incelenmiş ve mevcut yapı stoku içerisinde yer alan bu yapıların büyük çoğunluğunun deprem güvenliği bulunmadığı ve yapıda hasarlar ve yıkımların olduğu tespit edilmiştir. Deprem konusunda yeterli performansa sahip olmayan bu yapıların onarım ve güçlendirme gereksinimi ortaya çıkmaktadır. Güçlendirme, yapıların yük taşıma kapasitesinin ve servis ömrünün artırılması için yapılan işlemlerdir. Yapısal hasarların giderilmesi, yapının kullanım alanının değişmesi, sismik iyileştirme, yapının yük taşıma kapasitesinin ve servis ömrünün artırılması için güçlendirme yapılır. Betonarme yapıların güçlendirilmesinde çeşitli güçlendirme teknikleri bulunmaktadır. Bu işlemlerin arasında günümüzde en yaygın olan yöntemlerden biri Karbon Fiber Takviyeli Polimer (CFRP) malzemeler ile güçlendirme işlemleridir. Mevcut yapılarda meydana gelen yapısal hasarların giderilmesi ve yapının performansının artırılması için CFRP kullanılmaktadır. CFRP olarak isimlendirilen bu malzemelerin avantajları; kolay şekil alması, hafif olması, yapıya ilave yük getirmemesi, kolay ve hızlı uygulanabilmesi, yüksek bir yapısal dayanım sağlamasıdır. Ayrıca diğer güçlendirme yöntemlerine göre alandan ve zamandan tasarruf sağlar. Bu çalışmada yapısal elemanlardan biri olan kolon elemanlarının CFRP malzemeler ile güçlendirilmesi ve bu güçlendirme işleminin uygulamaya yönelik detayları ele alınmıştır.

Anahtar Kelimeler – Kolonların güçlendirilmesi, epoksi, CFRP kumaşlar

I. GİRİŞ

Ülkemizde en fazla can ve mal kaybına neden olan doğal afetlerin başında deprem gelmektedir. Ülkemizdeki depremlerin yıkıcı etkisi göz önüne alındığında; 1939 Erzincan Depremi, 1999 İzmit Depremi,1999 Düzce Depremi, 2023 Kahramanmaraş Pazarcık ve 2023 Kahramanmaraş Elbistan depremleri ilk sırada yer almaktadır. Yaşanan bu depremlerde tespit edilen yapı hasarlarının ve kayıpların; mevcut tasarım standartlarının ve inşaat kalitesinin yetersizliğinden, bilgi eksikliğinden, yapım hatalarından veya yönetmelik kurallarına uyulmayışından kaynaklandığını göstermektedir. Yaşanan bu depremler yapıların depreme dayanıklı tasarım ilkelerine ilişkin birikimlerini artırırken, hasara uğrayan yapıların onarılması ve mevcut yapıların güçlendirilmesini pek çok ülkede hızla büyüyen bir mühendislik alanı haline getirmiştir [1].

Mevcut betonarme yapıların çoğunda; beton basınç dayanımı projelendirme sırasında öngörülen değerden düşük, enine boyuna donatılar günümüz yönetmelikleri tarafından öngörülen şartları sağlamaktan uzaktır. Bu eksiklikler düşey taşıyıcı elemanların eksenel yük, kesme kuvveti, eğilme momenti ve taşıma kapasiteleri ile sünekliklerini olumsuz etkilemekte, bunun sonunda yaşanan deprem karşısındaki davranışı öngörülenden çok daha dayanıksız olabilmektedir. Lifli polimerlerle yapısal güçlendirme havacılık ve uzay sanayiden yapı sektörüne geçen bir teknolojidir. İlk örnekleri 80'li yılların sonlarında ABD'de başlayan bu teknoloji, özellikle 1999 depremlerinden sonra ülkemizde de yaygın olarak kullanılmıştır [2]. Yetersiz

betonarme kolonların potansiyel plastik mafsal bölgelerinde lifli polimer sargılama ile deformasyon kapasitelerinin artırılması son yıllarda oldukça sık kullanılan bir güçlendirme tekniğidir. Deprem etkisi altındaki kolonlarda CFRP sargılama, kolon yanal rijitlik ve yanal yük kapasitesinde fazla bir artış olmadan yer değiştirme istemlerini karşılayabilme imkânı vermektedir. Bu nedenle CFRP sargılama oldukça etkin bir yöntemdir. Sismik performans açısından yetersiz binalarda genellikle tüm güçlendirme metotları uygulanmakla birlikte, CFRP sargılama metodu ile sargı yetersizliği bulunan kolonların deformasyon kapasitelerinin artırılması alternatif bir güçlendirme yöntemidir [3]. Betonarme binaların ayakta durmasını sağlayan en önemli yapı elemanı kolondur. Düşey yüklerin yanı sıra binanın maruz kaldığı dinamik yükleri de temele aktaran elemanlardır. Kolonlara zarar veren etkiler kesme kuvveti, eğilme ve burkulma momentidir. CFRP'ler kolonlarda güçlendirme amaçlı kullanılabilecek etkili bir malzemedir. Eğilme momentinin ve rijitliğin artırılması için kumaş sargı yönüne dik, kesme kuvvetinin, sünekliğin, basınç kuvvetinin ve sismik dayanımın artması içinse kumaş sargı yönüne paralel uygulanır. Yapılan testlerde CFRP sargılı kolonların artan sismik ve tekrarlı yüklere karşı daha fazla deplasman yaparak enerji sönümlediği görülmüştür [4].

Bu çalışmada kolonların CFRP ile güçlendirilme işleminin uygulanmasında hazırlık çalışmaları, güçlendirme işlemi yapılacak elemanın yüzey hazırlıkları, kullanılacak epoksi malzemesi ve uygulanması ve CFRP uygulama işlemlerine ait detaylar araştırılmıştır.

II. KOLONLARIN CFRP İLE GÜÇLENDİRİLMESİ

CFRP, ingilizcede Carbon Fiber Reinforced Polymers (CFRP) kelimesinin kısaltılması olarak bilinen bir güçlendirme malzemesidir. Karbon fiber çeşitlerinden olan karbon elyaf, çelikten 14 kat daha fazla gerilmeye sahip ve çeliğin ağırlığının beşte biri oranındadır. Ayrıca uygulandığı yapıda yapı elemanının yük taşıma kapasitesi ve eğilme dayanımını artırır, yorulma direncini de yükseltir. Diğer güçlendirme yöntemlerine karşı alandan ve zamandan tasarruf sağlar. CFRP ile kolonların çevresine, lifler enine donatılara paralel olacak şekilde sarılması ve yapıştırılması ile sargılama sağlanır. CFRP sargısı ile betonarme kolonların süneklik kapasitesi, kesme ve basınç dayanımları ile boyuna donatı bindirme boyunun yetersiz olduğu durumlarda donatı kenetlenme dayanımı arttırılır. CFRP sargılama ile yapılan güçlendirmelerde tam sargı (tüm kesit çevresinin sarılması) yöntemi kullanılmalı ve sargı sonunda en az 200 mm bindirme yapılmalıdır. CFRP sargısı dikdörtgen kolonlarda kolon köşelerinin en az 30 mm yarıçapında yuvarlatılması ile uygulanabilir. CFRP ile kolonların eksenel basınç dayanımlarının arttırılabilmesi için, kolon kesitinin uzun boyutunun kısa boyutuna oranı iki buçuktan fazla olmamalıdır. Kolonların enkesitleri dikdörtgenden elipse dönüştürülerek CFRP'nin etkinliği arttırılabilir. Elips kesitlerde uzun boyutun kısa boyuta oranı en fazla üç olabilir. CFRP sargılama ile kolonların sünekliğinin arttırılabilmesi için, kolon kesitinin uzun boyutunun kısa boyutuna oranı iki buçuktan fazla olmamalıdır. Elips kesitlerde uzun boyutun kısa boyuta oranı en fazla üç olabilir [5].

A. *Ürün Seçimi*

CFRP, yönlü mukavemet özelliklerine sahiptir; bu karbon fiber dağılımının yönüne ve karbon fiber/polimer oranına bağlı olduğu anlamına gelir. Dolayısıyla statik yük hesaplarına bağlı kalınarak tek veya çift yönlü, karbon fiber/polimer oranlarına ve plaka kalınlıklarına göre çözümleme yapılmalıdır (Üretim seçenekleri ve bahsedilen özellikler zamanla çeşitlendirilebilir fakat şu anda ülkemizde üretimi yapılan ve hem uygulamada kullanılıp hem de deneylerde kullanılan mevcut ürün özellikleri dikkate alınmıştır).

CFRP güçlendirme sisteminin fayda sağlaması için lifli polimer kumaşın epoksi yapıştırıcı ile kompozit hale getirilmesi bu uygulama türünün en kritik noktasıdır. Sistemin kompozit halde yani karbon fiber esaslı ürün (elyaf, plaka veya çubuk) ve iki bileşenli epoksi karışımının test sonuçlarının incelenmiş olması, yeterli düzeyde laminasyonun sağlandığından emin olunarak tercih edilmelidir.

B. *Malzeme Davranışı*

a. Yük Kapasitesi: CFRP güçlendirmesi, güçlendirilmemiş numunelerin neredeyse iki katı yük kapasitesiyle betonarme kolonların performansını önemli ölçüde artırmıştır.

b. Çekme Mukavemeti: Çoğu durumda CFRP kompozitler çekme gerilmelerinin etkili olduğu yerlerde bulunmaktadır.

c. Bükülme Kapasitesi: Ahşap kirişlerde yapılan çalışmalarda üç katmanlı karbon fiber ile güçlendirme durumunda sonuçlar, takviyesiz kirişlere kıyasla bükülme kapasitesinde %60,3'e kadar artış olduğunu göstermiştir.

d. Yer Değiştirme: İki katmanlı çift yönlü karbon fiber kumaşla güçlendirilmiş kolonların nihai yükü, tek katmanlı takviyeli kolonların nihai yüküne çok benzer davranış sergilemektedir. Donatılı kolonlarda yaşanan nihai yer değiştirme artmamaktadır.

e. Sıcaklık: Termal hasar, CFRP laminatların mukavemetini zayıflatan kritik faktörlerden biri olarak bilinmektedir. Yapılan çalışmada, sıcaktan etkilenmiş alan genişliğinin CFRP numunelerinin bükülme, çekme ve basınç mukavemeti üzerindeki etkisi niceliksel olarak değerlendirilmiştir. 1 mm CFRP için, bozulmaya en çok duyarlı olan bükülme mukavemetidir ve bunu basınç mukavemeti takip eder. Sıcaktan etkilenmiş alanın çekme mukavemetini zayıflatma etkisi nispeten daha azdır. Mekanik performansların zayıflamasının ana nedeni, sıcaktan etkilenmiş alan içindeki açıkta kalan karbon fiberin yükü taşıyamamasıdır.

Betonarme kolonların CFRP tipi şeritlerle güçlendirilmesinde güneşlenme etkisinin, betonarme ile CFRP bant arasındaki yapışkan bağlantısının camsı olmasına neden olabileceği gösterilmiştir. Yüksek sıcaklıklarda yapının yük taşıma kapasitesinde önemli bir azalma gözlenmiştir. Başarısızlığın nedeni yapışkan tabakadaki delaminasyondur. Yapıştırıcı ve CFRP matrisi polimerdir ve polimerler söz konusu olduğunda bu sıcaklık, yük taşıma kapasitesini, bireysel bileşenlerin gücünü ve dolayısıyla tüm yapıyı etkilemektedir.

f. Korozyon İlişkisi: CFRP levhalar ve reçine sisteminin, klorür iyonik difüzyonunu azalttığı ve kolonlardaki donatıların korozyon hızını azaltabileceği görülmüştür.

C. *CFRP Kumaşlar (Yüksek Çekme Dayanımına Sahip, Tek veya Çift Doğrultulu Karbon Lifli Kumaş)*

CFRP kumaşlar, yüksek çekme dayanımına sahip; tek doğrultulu 300gr/m^2, tek ve çift doğrultulu 600 gr/m^2 karbon fiber takviyeli lifli yapılardır. İplik şeklindeki karbon lifler ile dokunan CFRP kumaşlar, kolaylıkla şekil almakta ve özel epoksi reçinesi ile uygulandığında yapı elemanı rijit hale gelmektedir. Hafif, hızlı uygulanabilir ve esnek olması, zamandan ve alandan tasarruf sağlaması nedeniyle uygulamalarda sıklıkla tercih edilmektedir. Şekil 1'de CFRP kumaş verilmiştir.

Şekil 1. CFRP Kumaş Malzeme

Kullanım alanları; Betonarme kirişleri eğilme ve kesmeye, betonarme döşemeleri eğilmeye karşı güçlendirerek yük taşıma kapasitesinin artırılmasında, ahşap kirişlerin sünekliliğine karşı güçlendirilmesinde, betonarme kolonların sarılarak kesme ve basınç dayanımları ile sünekliliğinin artırılmasında, kargir (yığma) yapı elemanlarının güçlendirilmesinde, yerinde döküm ve prekast betonarme ve öngerilmeli beton elemanlarının güçlendirilerek yük taşıma kapasitelerinin artırılmasında kullanılır. Yapının çeşitli dış etkenler (deprem, araç çarpması vs.) nedeniyle yapısal olarak zarar görmesi sonucunda servis ömrünü artırmak için kullanılır.

Uygulama Yüzeyleri;

- Betonarme kolon
- Betonarme kiriş
- Betonarme döşeme
- Ahşap kiriş
- Kargir (yığma)yapı
- Prekast betonarme elemanlar

Ürünün avantajları;

- Tüm güçlendirme çalışmalarında kullanılabilir.
- Yüksek yorulma dayanımına sahiptir.
- Sünme değeri düşüktür.
- Düşük yoğunluğu sayesinde uygulanan yüzeye getirdiği ilave yük değeri azdır.
- Hafiftir.
- Kolay şekil alır ve uygulanır.

CFRP kumaşlardan beklenen çekme dayanımı, elastisite modülü, kopma uzama % değeri, birim genişlikteki rijitlik gibi belirli performans özellikleri bulunmaktadır. Bu özellikler Tablo 1'de verilmiştir.

Tablo 1. CFRP Kumaşlardan Beklenen Performans Özellikleri

ÖZELLİK	Alansal Ağırlık Tek Doğrultulu 300 gr/m^2	Alansal Ağırlık Tek Doğrultulu 600gr/m^2	Alansal Ağırlık Çift Doğrultulu 600 gr/m^2
Çekme Dayanımı (MPa)	4000-5000	4000-5000	4000-5000
Elastisite Modülü (MPa)	>235	>235	>235
Kopma Uzama (%)	~2	~2	~2
Birim Genişlikteki Rijitlik (kN/mm)	40	80	80

D. *Epoksi Esaslı Yapıştırıcı ve Laminasyon Reçineleri*

Uygulamada, kolonların güçlendirme işlemleri sırasında kullanılan CFRP plakaları yapıştırmak için epoksi esaslı çift bileşenli yapıştırıcılar kullanılırken, CFRP kumaşları yapıştırmak için ise epoksi esaslı çift bileşenli laminasyon reçineleri kullanılmaktadır. Epoksi esaslı yapıştırıcı ve epoksi esaslı çift bileşenli laminasyon reçinelerinin avantajları;

- ✓ Yüzeylere kolay bir şekilde uygulanabilmeleri,
- ✓ El ile doyurma işlemleri için kullanılmaları,
- ✓ Düşey ve yatay yüzeylerde kolaylıkla uygulanabilmeleri,
- ✓ Düşey ve yatay yüzeylerde iyi aderans sağlamaları,
- ✓ Yüksek mekanik özelliklere sahip olmaları,
- ✓ Solventsiz olmaları ve uygulandıkları yerlerde astar gerektirmemeleri,
- ✓ TS EN 1504-4 standartına uygun ve CE kalite belgesi bulunmaları şeklinde sıralanabilmektedir.

Yüzey hazırlığı işlemleri CFRP kumaş ve plaka ile güçlendirme işlemlerinde olduğu gibidir. Ancak birçok yönden benzerlik gösteren bu iki epoksi esaslı malzemelerin performans özellikleri birbirinden

farklılık göstermektedir. Tablo 2'de epoksi esaslı malzemeye dair performans özellikleri, Şekil 2'de epoksi esaslı çift bileşenli yapıştırıcı verilmiştir.

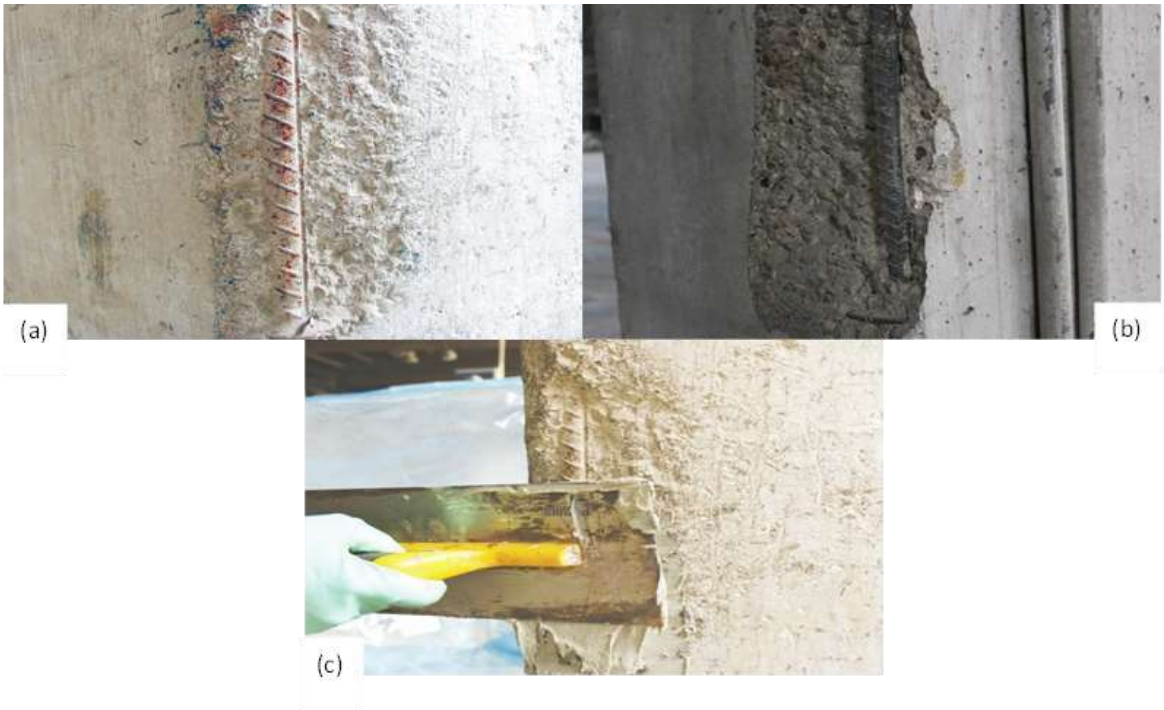
Tablo 2. Epoksi Esaslı Malzemelerden Beklenen Performans Özellikleri

Epoksi Esaslı Çift Bileşenli Laminasyon Reçinesi	
Basınç Dayanımı (MPa)	79
Kayma Dayanımı (MPa)	>6
Çekme Yapışma Dayanımı (MPa)	52

Şekil 2. Epoksi esaslı çift bileşenli laminasyon reçinesi

E. *Yüzey Hazırlıkları ve Tamiri*

Kolonların güçlendirilmesi işleminde yaygın olarak CFRP (Karbon Fiber Takviyeli Polimerler) kullanılmaktadır. Güçlendirme işlemleri yapılacak yüzeyin hazırlığının doğru yapılması çok önemlidir. Beton yüzeyi; yağ, kir, zayıf kısımlar, sıva ve boyalardan kumlama veya taşlama gibi mekanik yöntemlerden biri kullanılarak temizlenmelidir. Yüzeyi hazırlanmış betonarme yapı elemanında açıkta kalan donatılar var ise kir, toz ve pastan arındırılır. Donatılar hazır hale geldikten sonra yüzeyde bulunan gözenekler ve boşluklar belirlenir (Şekil 3.a). Demir ve çelik yüzeyler uygulama öncesi mutlaka kumlanmalıdır. Kumlanma sonrası 4 saat içerisinde yüzeye uygulanmalıdır. Uygulama kumlamadan sonraki 4 saat içerisinde yapılmayacaksa uygulamadan hemen önce tekrar kumlama yapılmalıdır (Şekil 3.b). Yapısal tamir harcı hazırlanmalı ve tamiratı yapılacak tüm yüzeylere uygulanmalı, sağlam olmayan yüzeylere uygulama yapılmamalıdır. Eski yüzeylerin sağlamlığı ve taşıyıcılığı uygulama işlemi öncesi kontrol edilmelidir. Uygulama sonrasında yüzey, perdah malası ile perdahlanmalıdır. Kurumuş epoksi esaslı tamir harcı temizliği, mekanik temizleme yolu ile yapılabilir. Uygulamadan hemen sonra kullanılan aletler; tiner, aseton, tolüen gibi çözücüler yardımıyla temizlenmelidir. Uygulama yüzeyi üzerindeki kürlenmemiş epoksi temizliği, nemli bir sünger ile yapılmalıdır. CFRP kumaşların zarar görmemesi için kolonların köşeleri ve kenarları pahlanarak en az 30 mm yuvarlatılmalı ve yüzey hazırlık işlemlerinin tamamlanmasının ardından uygulama işlemlerine geçilmelidir (Şekil 3.c).



Şekil 3. a) Yüzeyde bulunan gözenek ve boşlukların belirlenmesi, b) Demir ve çelik yüzeylerde kumlama işlemi, c) Yapısal tamir harcı uygulaması

F. *Uygulama*

Yapı kullanıcılarının veya sahiplerinin, yapının onarımı ve güçlendirilmesine yönelik talepleri oluşmaktadır. Teknik inceleme ile yapının projesi, zemin durumu ve fiziki hasarları tespit edilerek yapı performans analizleri yapılır. Teknik incelemeler sonucuna göre binanın güçlendirmeye uygun olduğu raporlanır ve karar vericiler tarafından değerlendirilir. Analizlere göre güçlendirme projesi oluşturularak planlaması yapılır. Güçlendirme işlemi sırasında kullanılacak CFRP kumaşların belirli mukavemete sahip olması gerekmektedir. CFRP kumaşların uygulama adımları uzman uygulayıcılar ve inşaat mühendisleri gözetiminde yapılması gerekmektedir. Uygulamada kullanılan CFRP malzemelerin özellikleri üretici firmalar tarafından temin edilmektedir. Uygulama şeklinin belirlenmesinin ardından yüzeyde kullanılacak ve CFRP malzemelere uygun, kimyasal bir yapıştırıcı olan epoksi malzemesinin seçimi gerçekleştirilmektedir. Epoksi, yüzeye uygulanmasının ardından belirli bir süre sonra sertleşen ve yüksek dayanımı olan bir kimyasal yapıştırıcı türüdür.

Yüzey hazırlık işlemlerinin tamamlanmasının ardından uygulama işlemlerine geçilmektedir. Uygulama sırasında, uygulama yapılacak yüzeyin geometrik özellikleri göz önünde bulundurularak CFRP kumaş parçaları maket bıçağı ile kesilerek hazır hale getirilmektedir. Hazırlanan epoksi esaslı reçineler aracılığı ile epoksi karışımı rulo yardımı ile betona sürülmekte ve daha sonra bu yüzeye çalışma yönü doğrultusunda CFRP kumaşlar gerilerek el ile yapıştırılmaktadır. Yapıştırılma işlemi sırasında beton yüzeyi ile CFRP kumaşların tamamen yapışmış olmasına dikkat edilmekte ve uygulama titizlikle gerçekleştirilmektedir. Yüzeyin ölçüsüne göre hazırlanan lifli kumaş, yüzey ve kumaş arasında hava kalmayacak şekilde lifler doğrultusunda 20m mm bindirme yapılarak uygulanır. Epoksinin CFRP malzeme içerisinde tamamen emilmesi ve tüm yüzeye homojen olarak yapışmasını sağlamak için kumaşta bulunan liflerin çalışma yönleri doğrultusunda rulo ile baskı uygulanmakta ve hava boşlukları bu şekilde alınmaktadır. Uygulama sırasında kumaş ile kolon güçlendirilme yüzeyinin arasında hava boşluğu kalmamasına dikkat edilmesi gerekmektedir. Yapıştırma sırasında hafif tırtıklı plastik rulolar aracılığı ile uygulama yüzeyinin üzerinden geçilmekte ve epoksinin kumaş içerisinde homojen dağılım göstermesi sağlanmaktadır. Uygulama işlemlerinin tamamlanmasının ardından bu yüzeylere sıva ve boya yapılması gerektiği durumlarda, sıvanın kumaşa yapışmasını sağlamak amacı ile son kat uygulanan epoksinin kurumasını beklemeden yüzeye kum serpme işlemi gerçekleştirilmektedir. Şekil 4. a'da laminasyon reçinesinin beton yüzeye doyurulması, 4.

b'de CFRP kumaşın el ile yapıştırılması, 4. c'de rulo ile CFRP kumaşa epoksi uygulanması işlemi ve 4. d'de yapışma aderansının artırılması için dişli kum serpilme işlemi verilmiştir.

Şekil 4. a) Laminasyon reçinesinin betona doyurulması, b) CFRP kumaşın el ile yapıştırılması, c) Rulo ile CFRP kumaşa epoksi uygulanması, d) Dişli kum serpilme işlemi

III. SONUÇLAR

Kolonların CFRP ile güçlendirilmesinde uygulama detaylarının ele alındığı bu çalışmanın sonucunda elde edilen bulgular aşağıda verilmiştir. Buna göre;

- Bir yapının güçlendirilmesi için hasar görmesi gerekmez. Yapıda hareketli yüklerde artışın meydana gelmesi, yapı kullanım amacının değişmesi, yönetmeliklerin revize edilmesi, yapı malzemesinin veya yapı elemanının servis ömrünü doldurması nedeniyle güçlendirme gereksinimi duyulabilir.
- Karbon liflerin oluşturduğu CFRP malzemeler, geleneksel güçlendirme malzemelerine göre çok daha yüksek mukavemete sahiptir. Ek olarak, CFRP malzemeler hafif oldukları için yapısal taşıyıcı elemanlara ilave yük getirmezler. Zamandan ve alandan tasarruf sağlarlar.
- Günümüzde yapılarda görülen en önemli sorunlardan biri korozyondur. Dış etmenlere karşı korunmamış, rutubetli ve asidik ortamlarda donatının korozyona uğradığı ve betonarme yapı elemanının taşıyıcı özelliğini kaybettiği görülmüştür. Uygulanan CFRP malzemesi, beton ve donatının hava ile teması keserek tüm bu etkilere engel olmaktadır.
- CFRP malzemeler, uygun epoksi reçineleri ile yapıştırılarak uygulanabilmektedir. Bu, güçlendirme işleminin hızlı ve kolay bir şekilde gerçekleştirilmesini sağlarken beklenen performans değerlerine ulaşılmasını da kolaylaştırmaktadır.
- CFRP ile güçlendirme işlemi, kolay ve hızlı uygulanabilir. Yapıya esneklik katar.
- CFRP ile güçlendirme yöntemleri tarihi ve ahşap yapılarda da uygulanabilmektedir.

- Ülkemizde meydana gelen hasarların büyük bölümü yanlış malzeme kullanımı, düşük kalitede işçilikten kaynaklanmaktadır. Bu nedenle güçlendirme yapılacak binada hasarlar teknik ekiplerle iyi yorumlanmalı ve onarım ve güçlendirmede deneyimli ekiplerle çalışılmalıdır.

TEŞEKKÜR

Kolonların CFRP ile güçlendirilmesi konulu bu bildiri çalışmasında KYK YAPI KİMYASALLARI tarafından temin edilen ürün bilgileri, özellikleri ve uygulama fotoğraflarından yararlanılmıştır. Katkıları için firmaya, firma yetkilileri Dr. Utku ÇAĞLAR ve Ömer GÜRSEL'e teşekkür ederiz.

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Finansal Teknolojilerin Gelişim Evreleri

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Özet **–** Araştırmanın temel amacı, finansal teknolojilerin bankacılık sektöründeki gelişimini ve yenilikçilikle olan ilişkisini incelemektir. Bu doğrultuda hedef kitle olarak bir kamu bankasında çalışan 150 personelin finansal teknolojilerin (FinTek) gelişimine katılımını ve yenilikçi faaliyetlerdeki rollerini incelemeyi planlamaktadır. Çalışma, rastgele örneklem yöntem ile çevrim içi anketler vasıtasıyla gerçekleştirilecek ve elde edilen veriler SPSS 21 istatistik program paketiyle analiz edilecektir.

Elde edilen bulgular, bankacılık sektöründeki etkilerini kapsamlı bir şekilde analiz edilecektir. Araştırma, bankacılık sektöründe çalışan personelin FinTek'e yönelik tutumlarını ve bu teknolojilerin benimsenme oranlarını araştırmayı hedeflemektedir. Literatür taramasının sonucunda konu ile ilgili bulunan sonuçlar Finansal Teknolojilerin günümüzde önemli bir rol oynadığını açıklamaktadır. FinTek ekosisteminin sunduğu yenilikçi, çevik ve müşteri odaklı ürünler, finans ve bankacılık sektörüne yeni bir bakış açısı getirerek, geleneksel iş modellerini değiştirmiştir. Özellikle ABD ve Avrupa'da, FinTek girişimleri ödeme sistemleri, fon toplama, borç verme, varlık yönetimi ve finansal analiz gibi alanlarda faaliyet göstermektedir. Bu girişimler, bankalardan daha hızlı ve maliyet etkin hizmet sunma kapasitesine sahiptir. FinTek'in kökenleri, 1970'lerdeki ATM'lerin yükselişi ile başlasa da, 2008 finansal krizi sonrası güvensizlik ortamı, bu girişimlerin hızla büyümesine zemin hazırlamıştır. Günümüzde, dijital para birimleri, mobil bankacılık ve otomatik yatırım danışmanlığı gibi yeniliklerle finansal hizmetlerdeki dijital dönüşüm sürmektedir. Bu çalışmada, Türkiye ve Avrupa ülkelerindeki FinTek sektörüne yapılan yatırımlar ve start-up sayıları incelenmiştir. Ayrıca, anket çalışmaları ile FinTek'in yenilikçilik eğilimine katkıları analiz edilmiştir.

Anahtar Kelimeler – FinTek, RegTech, Finansal Evreler, Finansal Gelişim, Bankacılık

I. GİRİŞ

Zaman değiştikçe modern finansal teknolojiler kapsamında sunulan finansal hizmetlerin kalitesi ve çeşitliliği de değişti. Söz konusu gelişmede finansal teknoloji ekosisteminin (FinTek) payı oldukça büyüktür. Küresel finansal teknoloji sektöründe faaliyet gösteren FinTek girişimlerinin sunduğu yenilikçi, çevik ve müşteri odaklı ürün ve hizmetler, finans ve bankacılık sektörüne yeni bir bakış açısı getirerek, finansal kurumların ve bankaların geleneksel iş modellerini değiştirdi.

Özellikle ABD ve Avrupa başta olmak üzere, son yıllarda gelişmiş teknolojilerin kullanımıyla küresel finans sektöründe ürün, hizmet ve iş modelleri sunan FinTek girişimlerinin sayısı artmaya başladı. Bankacılık ve Finans alanında sektöre hizmet veren FinTek girişimleri, ödeme sistemleri, fon toplama, borç verme, varlık yönetimi, finansal analiz ve danışmanlık gibi alanlarda faaliyet göstermektedir.

FinTek girişimleri çok hızlı ürün veya hizmet geliştirme yeteneğine sahip oldukları için bankaların bazı işlemlerini bankaların kendisinden çok daha hızlı, daha kolay ve daha ucuza yapabiliyorlar. Bir banka veya başka bir finans kurumu tarafından sunulan hemen hemen her hizmet ve ürün, bir veya daha fazla FinTek girişimi tarafından halihazırda sunulmaktadır veya yakın gelecekte sunulacaktır.

II. KAVRAMSAL ÇERÇEVE

Finansal teknoloji veya FinTek, 21. yüzyılın alacakaranlığında, geleneksel bankacılık ve finansal hizmetleri temelden dönüştürme misyonuyla ortaya çıkan bir harekettir [1]. FinTek, geniş bir yelpazede yenilikçi uygulamalar ve çözümler sunarak, finansal işlemlerin, yönetimin ve danışmanlık hizmetlerinin dijitalleşmesini sağlamıştır [2]. FinTek, finans sektöründe teknolojik yenilikleri ve müşteri odaklı yaklaşımları birleştirerek, kullanıcı deneyimini zenginleştirmeyi, operasyonel verimliliği artırmayı ve maliyet yapılarını optimize etmeyi amaçlar. Bu tanım altında, dijital bankalar, ödeme platformları, varlık yönetimi uygulamaları ve risk değerlendirme araçları gibi bir dizi uygulama gruplandırılmaktadır [3].

FinTek'in kökenleri, finansal işlemleri otomatize eden ilk bilgisayar sistemlerine ve 1970'lerin sonunda ATM'lerin yükselişine dayanır. İnternetin ticari olarak yaygınlaşmaya başladığı 1990'larda FinTek, özellikle e-ticaret ve çevrimiçi ödeme sistemleri alanında belirgin bir ivme kazandı [4]. 2008 finansal krizi sonrası ortaya çıkan güvensizlik ortamı, FinTek girişimlerinin hızla büyümesine zemin hazırlamıştır. Dijital para birimleri, mobil bankacılık ve otomatik yatırım danışmanlığı hizmetleri gibi yenilikler, 2010'lu yılların başında finansal teknolojinin sınırlarını zorlamıştır. Günümüzde, finansal hizmetlerdeki dijital dönüşümün ana itici güçleri arasında yer alan FinTek, sürekli gelişmekte olan düzenleyici çerçeveler ve güvenlik teknolojileri ile birlikte şekillenmektedir [5].

Modern FinTek ekosistemi, ödeme sistemleri, dijital cüzdanlar, çevrimiçi krediler, blockchain tabanlı işlemler ve kişisel finansal yönetim araçları gibi bir dizi anahtar kategori ve modeli içerir [6]. Bunların her biri, tüketici ve işletmelerin finansal hizmetlere erişim biçimini köklü bir şekilde değiştirmiştir. Bu yenilikler, özellikle finansal hizmetlerin dağıtımı ve erişilebilirliği konusunda devrim yaratmış, geleneksel finansal kurumların rolünü yeniden tanımlamıştır. Dijital ödeme sistemleri, günlük finansal işlemleri kolaylaştırırken, blockchain teknolojisi, finansal işlemlerin şeffaflığı ve güvenliğini artırarak yeni iş modellerinin doğmasını sağlamıştır [7].

2.1. FinTek Nedir?

FinTek, finans ve teknoloji kelimelerinin birleşiminden oluşuyor. Sözlükteki anlamı bakımından FinTek; Bankacılık ve finansal hizmetleri desteklemek veya etkinleştirmek için kullanılan bilgisayar programlarına ve diğer teknoloji uygulamalarına verilen addır [8]. Daha fazla bilimsel makale incelendikten sonra FinTek için en kapsamlı tanım şu şekilde sunulmaktadır: FinTek, finansal faaliyetleri geliştirmek için teknolojiyi kullanan yeni bir finans sektörüdür [9]. FinTek'in diğer tanımlarına göre; Cep telefonu, internet ve veri analizi gibi dijital teknolojilerin kullanımıyla geleneksel finansal hizmet anlayışını yıkmış, tam tersine yenilikçi bir yaklaşımla müşterilerin finansal hizmetlere ulaşmasını kolaylaştırmıştır [10].

2.2. FinTek Ekosistemi

FinTek ekosisteminin, FinTek inovasyonunda rekabet ve iş birliği konularında derinlemesine bir anlayışa sahip olması gerekmektedir. Bu nedenle, öncelikle FinTek ekosisteminin analiz edilmesi önem arz etmektedir. İstikrarlı ve esnek bir FinTek ekosistemi, FinTek sektörünün büyümesine katkı sağlamaktadır. Şekil 2'de bu ekosistemin detaylarına odaklanılmakta ve bu ekosistem beş temel unsurdan oluşmaktadır [11, 12].

Şekil 1 FinTek ekosistemi [12]

2.3. Finansal Teknolojilerin Gelişim Evreleri

Finansal teknolojilerin gelişimi, finansal hizmetleri basitleştirmek için kullanılan bir grup yeniliktir. Son yıllarda artan bir hızla gelişen FinTek, finans sektöründe önemli değişiklikleri beraberinde getiriyor ve bu değişimler hissedarlar üzerinde önemli etkiler yaratıyor [10]. FinTek'lerin gelişimi çeşitli aşamalardan geçmiştir. Her aşamada yeni iş modellerinin ortaya çıktığına tanık olduk. Solutions, yeni sorunlara başarılı bir şekilde çözüm sunmayı ve finansal hizmetleri eskisinden daha erişilebilir hale getirmeyi başardı [13].

2.3.1. FinTek 1.0

1866-1967 yılları finans sektörü açısından oldukça önemli dönemler olarak değerlendirilmektedir. Bu dönemde, insanlar finansal sistemlerin kullanımında manuel sistemlerden dijital sistemlere doğru bir dönüşüme tanık oldular. Önceleri finansal işlemler, kağıt ve insan aracılar kullanılarak manuel olarak gerçekleştiriliyordu. 1866 yılında telgrafın icadı, finansal dönüşümün başlangıç noktası olarak kabul edilmektedir çünkü telgraf, uzun mesafelerde daha hızlı iletişim kurmayı mümkün kılıyordu. Birinci Dünya Savaşı'ndan sonra gelişmiş ülkeler, verimli ve güvenilir iletişim sistemlerine duyulan ihtiyaçtan hareketle, bilgisayarlaşma ve telekomünikasyon ağları ile elektronik ödeme sistemleri gibi gerekli altyapıların oluşturulmasına büyük yatırımlar yapmaya başladılar [14].

2.3.2. FinTek 2.0

İnternet bankacılığının yeni dönemini ve 1967 ile 2008 arasındaki ilk dijital FinTek 2.0 yeniliğini kapsıyor. Bu evrim Barclay isimli bir kişinin ilk ATM'yi kurmasıyla başladı [15]. Bu dönüşümün 1971 yılında başlamasından 4 yıl sonra NASDAQ dünyanın ilk dijital borsası olarak faaliyet göstermeye başladı [16].

1970 yılı, SWIFT'in kurulduğu ve FinTek 2.0'ın büyümesinde değerli bir rol oynadığı diğer önemli yıllardan biridir[17]. Bankacılık sektöründe bu önemli adımın atılmasıyla, 1973 yılında bir endüstri standardı olarak tanıtılmış olmasına rağmen, 1977 yılına kadar 500'den fazla bankanın bu alana üye olması bekleniyordu [18]. 80'li yıllar e-ticaretin başlangıcıydı.

2.3.3. FinTek 3.0

FinTek 3.0 dönemi, finansal teknolojilerin hızla evrim geçirdiği ve finans sektöründe köklü değişikliklerin yaşandığı bir zaman dilimini kapsar. Bu dönem, yaklaşık olarak 2008 finansal krizinin ardından başlayıp 2010'ların sonlarına kadar devam etmiştir. FinTek 3.0, özellikle mobil teknolojilerin ve dijital ödeme sistemlerinin yükselişiyle belirginleşir[19].

Mobil cihazların ve akıllı telefonların yaygınlaşmasıyla, insanlar artık bankacılık işlemlerini, para transferlerini ve ödemelerini kolayca cep telefonları aracılığıyla gerçekleştirebiliyorlardı. Bu durum,

geleneksel banka şubelerine olan bağımlılığı azaltmış ve finansal işlemlerin daha erişilebilir hale gelmesini sağlamıştır.

2.3.4. FinTek 4.0

Bu alan, finansal hizmetlerin sağlanmasında ve finansal işlemlerin yönetilmesinde kullanılan yenilikçi teknolojileri kapsar. FinTek 4.0 dönemi ise, yapay zekâ, blokzincir, büyük veri analitiği ve bulut bilişim gibi yüksek teknolojik unsurların yaygın olarak benimsenmesi ve entegrasyonu ile karakterize edilir. Bu teknolojiler, finansal hizmetlerde devrim niteliğinde değişimlere yol açarak, geleneksel bankacılık ve finansal kurumlarının iş yapma şekillerini temelden değiştirmektedir [20]. Yapay zekâ, finansal karar alma süreçlerinde insan benzeri zekaya dayalı algoritmalar kullanarak daha hızlı ve daha doğru sonuçlar elde etmeyi sağlar. Blokzincir teknolojisi, finansal işlemlerin güvenli ve şeffaf bir şekilde kaydedilmesini ve izlenmesini sağlayarak, aracısız ve güvenilir bir ortam sunar. Büyük veri analitiği, büyük veri kümelerinden anlamlı bilgiler çıkarmayı ve finansal trendleri tahmin etmeyi mümkün kılar. Bulut bilişim ise, finansal hizmetlerin sunulmasını ve verilerin depolanmasını esnek ve ölçeklenebilir hale getirir [7]. Bu teknolojilerin bir araya gelmesi, FinTek 4.0'ın temelini oluşturur ve finansal sektörde devrim niteliğinde değişimlere yol açar [21].

FinTek'in en fazla geliştiği ülkeler arasında ABD, Çin, İngiltere, Singapur ve Almanya gibi büyük ekonomiler yer almaktadır. Bu ülkeler, geniş finansal altyapıları, gelişmiş teknoloji endüstrileri ve girişimcilik ekosistemleriyle FinTek inovasyonunu teşvik etmişlerdir [22].

Özellikle Almanya'da FinTek'in yükselişi dikkat çekicidir ve bu ülke, Avrupa'nın önde gelen FinTek merkezlerinden biridir. Hindistan ve Brezilya gibi gelişmekte olan ülkelerde de FinTek uygulamaları ve şirketleri hızla yayılmaktadır.

2.4. FinTek Türleri

Finansal teknolojilerin geniş yelpazesi, farklı FinTek türlerinin varlığını göstermektedir. Bu türler, finansal hizmetlerin çeşitli yönlerini dönüştürmek ve iyileştirmek için farklı teknolojilerin kullanılmasını içerir. FinTek, kavramları, teknolojileri, ürünleri ve hizmetleri kapsayan bir terim olup, sürekli olarak gelişen yeni teknolojilerle birlikte yeni FinTek türleri de ortaya çıkmaktadır.

Şekil 2 FinTek türleri

2.4.1. Blockchain ve Kripto Paralar

Popüler finansal teknoloji türleri arasında ilk sırada blockchain teknolojisi ve kripto para birimleri yer alıyor. Blockchain, finansal hizmetlerin büyümesine yönelik yeni emsaller oluşturmak için akıllı sözleşmelerin ve fikir birliği algoritmalarının gücünün yanı sıra Kişiler arası işlemleri mümkün kılabilir. Blockchain teknolojisinin kökenleri, Bitcoin'in temeli, 2008 yılında Satoshi Nakamoto takma adını kullanan bir kişi tarafından yayınlanan beyaz kağıda dayanmaktadır [23]. Bu beyaz kâğıt, merkezsiz olan bir dijital para birimi olan Bitcoin'in temellerini atmış ve blockchain teknolojisinin ilk kez tanıtımını yapmıştır. Blockchain, blokların birbirine zincirlenmiş bir şekilde organize edildiği, güvenli ve şeffaf bir veri tabanı yapısını tanımlar [24].

2.4.2. Düzenleyici Teknoloji

Dilimize Regülasyon Teknolojileri (Düzenleme Teknolojileri) olarak geçen Regulatory Technologies (RegTech), en genel tanımıyla giderek karmaşıklaşan uyum süreçlerinin yönetimi için geliştirilen teknolojilerin tamamını kapsayan bir kavramdır [25]. Bu alanda geliştirilen sistemler, uyum süreçlerinin takibi ve kolaylaştırılması için ilgili kullanıcıya destek sağlar, teknolojilerin ana kullanım alanını, uyum süreçlerinin oldukça hassas ilerlediği ve ihlal durumlarında ciddi cezalara maruz kalınan finans sektörü olarak görebiliriz. Bankacılık ve finans sektörlerinde regülasyon süreçleri için ayrı bir teknoloji ihtiyacını doğurdu. Tüm süreçlerle ilgili anlık veri akışına göre bilgi aktarımı sağlayan bu sistemlerle regülasyonlara uymayan süreç ve hareketlerin tespit edilerek gerekli aksiyonların alınması amaçlanır.

2.4.3. Sigorta Teknolojisi

Finans teknolojisi FinTek türleri arasında bir sonraki göze çarpan ekleme, sigorta teknolojisi veya InsurTech anlamına gelecektir. Sigorta sektörü, geçmişten bugüne kadar teknolojik gelişmelerin etkisiyle

önemli bir dönüşüm yaşamıştır. Önceleri, sigorta işlemleri genellikle kâğıt tabanlı ve manuel olarak gerçekleştirilirdi. 2000'li yılların başlarına kadar, sigorta şirketleri genellikle kendi iç ağlarında çalışırlar ve müşteri verilerini elle işlerlerdi [26]. Ancak, dijitalleşmenin ve internetin yaygınlaşmasıyla birlikte, sigorta işlemleri giderek çevrimiçi hale geldi. 2010'ların başlarında, sigorta teknolojisinin evrimi, çevrimiçi sigorta platformlarının ortaya çıkışıyla hız kazanmıştır. Bu platformlar, sigorta poliçelerinin çevrimiçi olarak satın alınmasını, yönetilmesini ve talep edilmesini kolaylaştırmıştır. Mobil uygulamaların ve dijital sigorta brokerlerinin yaygınlaşmasıyla birlikte, müşteriler artık sigorta işlemlerini cep telefonları aracılığıyla kolayca gerçekleştirebilmektedir [27].

2.4.4. Mobil Ödemeler

Geleneksel ödeme yöntemleri, nakit para, çekler ve fiziksel kredi kartları gibi araçlar üzerine kuruludur. Bu yöntemler, yüz yüze alışverişlerde ve mağaza işlemlerinde yaygın olarak kullanılmaktadır[28, 29]. Ancak, bu yöntemler zamanla sınırlamalarını ve dezavantajlarını ortaya koymuştur. Örneğin, nakit para taşıma riski, çalınma veya kaybolma ihtimali gibi sorunlara yol açabilir. Çeklerin kullanımı ise işlem süreçlerini uzatabilir ve dolandırıcılık riski taşıyabilir. Fiziksel kredi kartlarının kullanımı ise kart kopyalama ve sahtecilik gibi güvenlik endişeleri doğurabilir [30].

2.4.5. Kişiler Arası Borç Verme ve Borç Alma

Kişiler arası (P2P) borç verme ve borç alma, geleneksel finansal kurumlar aracılığıyla değil, doğrudan bireyler arasında gerçekleşen bir finansal işlem modelidir bu modelde, bir kişi diğerine doğrudan borç verir ve karşılığında belirli bir faiz veya geri ödeme anlaşması yapılır. Bu işlem genellikle çevrimiçi platformlar veya uygulamalar aracılığıyla organize edilir [31].

2.4.6. Kişisel Finans Yönetimi

Kişisel finans yönetimi, bireylerin mali durumlarını kontrol etmek, bütçe oluşturmak, tasarruf yapmak, borçları azaltmak ve yatırım yapmak gibi finansal hedeflerine ulaşmalarını sağlayan bir süreçtir. Bu süreç, mali kaynakların etkin ve verimli bir şekilde kullanılmasını sağlayarak mali refahı artırmayı amaçlar [32].

2.4.7. Kitle Finansmanı

Kitle finansmanı, genellikle büyük bir grup insanın küçük miktarlarda finansal katkıda bulunarak belirli bir projenin veya girişimin finansmanını sağladığı bir finansman modelidir. Bu model, genellikle bir çevrimiçi platform aracılığıyla gerçekleştirilir ve katılımcılar genellikle karşılığında bir kar payı, özel bir ayrıcalık veya projenin tamamlanmasında bir rol oynamak gibi bazı karşılıklar alabilirler [33].

2.4.8. Robot Tabanlı Tavsiye ve Hisse Senedi Ticareti

Gelişen FinTek endüstrisinde yapay zekâ ve makine öğreniminin önemini öğrenmiş olmalısınız. Robot tabanlı danışmanlar, finansal kararlarla ilgili öneriler sunan yapay zekâ ve makine öğrenimi tarafından desteklenen uygulamalardır. Finansal tavsiye için bir uzman tutmanın alternatifi sayılmaktadır. Hepsinden önemlisi, robot danışmanınız asla ara vermez ve 24 saat veri analizi yetenekleri sağlar [34].

2.4.9. FinTek Uygulamaları

Bilişim teknolojilerinin mobil uygulamalarla tüketicilere sunduğu imkanlar, sürekli artan tüketici taleplerine uygun hizmetlerin gelişiminde büyük bir rol oynuyor. FinTek girişimcileri, yeni neslin beklentilerine hitap eden finansal yazılımlar sayesinde, 21. yüzyıl tüketicisinin ihtiyaçlarını karşılayan mobil uygulamalar ve hizmetler sunuyor [35].

Tablo 2'de, FinTek girişimlerinin sunduğu dijital uygulamalar yer almaktadır. Bu dijital uygulamalar, "finansman, yatırım, finansal danışmanlık, ödemeler, sigortacılık, operasyon ve iletişim" başlıkları altında değerlendirilmektedir. Uygulamaların daha anlaşılır olması amacıyla, her bir dijital uygulama yönteminin karşısında ilgili uygulamaların tanımları ve örnekleri de ayrıntılı olarak sunulmaktadır.

Tablo 1 FinTek girişimlerinin sunduğu dijital uygulamalar

Dijital Uygulama	Tanım	FinTek Kurumları/ Dijital Platformlar/Start-ups Örnekler
Yatırım	Finansal araçların alım-satım işlemlerinin elektronik ortamda iki taraf arasında gerçekleştiği platformlardır.	Stock Sharp, Ninja Trader, robinhood, coinbase Quant Connect,
Finansman	Şirketlerin finansman ihtiyaçlarını karşılamak için sermaye ve bireyleri bir araya getiren çevrimiçi platformlardır.	Monexo, Kickstarter, Lending Club, Zelle, Prosper Marketplace, GoFundMe,
Finansal Danışmanlık	Finansal tüketicilere veya portföy yöneticilerine otomatik olarak yatırım tavsiyeleri sunan bilgisayar tabanlı sistemler veya yazılımlardır.	Schwab, Vanguard, Betterment, wealthfront, acorns
Ödemeler	Mobil cihazlarla yapılan ödemeleri kolaylaştıran programlardır.	Android Pay, Apple Pay, TransferWise, PayPal Mobile Express
Sigortacılık	Sigorta endüstrisinde yenilik getirebilecek ve düzenleyici politikaları etkileyebilecek nitelikteki yeni teknolojiye dayalı uygulamalardır.	Lemonade, Insurtech Hub, Cystellar, ThreatInformer, Oscar, Hippo
İletişim	Finansal müşterilerle etkileşimi artırmak için kullanılan yeni teknoloji temelli uygulamalardır.	Studio, Erica (Bank of America), Chatbots. Kasisto, Interface, EVA (HDFC Bank), Plum, Finn, Abe AI, mFino,
Operasyon	Risk yönetimi süreçlerini optimize etmek için tasarlanmış uygulamalardır.	Credissimo, Wolters Kluwer, Corlytics, Trunomi, ComplyAdvantage, Ascent, R-Sam Infosys,

2.5. Türkiyenin FinTek Alanında Avrupa ve ODKA Konumu

Pandeminin etkisiyle dijitalleşme hız kazanırken, finansal teknolojilere olan talep de artmıştır. Ancak, 2022 yılının ilk çeyreğiyle birlikte pandeminin etkilerinin azalmasıyla dijitalleşme ivme kaybetmiş ve küresel olarak para kıtlığı yaşanmıştır [36]. Bununla birlikte, Türkiye'de son dönemde girişim sermayesi yatırım fonları ve paya dayalı kitle fonlaması gibi araçlarla FinTek yatırımları yapılarak girişim ekosistemi canlandırılmıştır. Finansal açıdan güçlü konumda olan Türk FinTek girişimleri, uluslararası arenada adımlar atmak için yurt dışından satın almalar gerçekleştirmiştir. Bu satın almaların 2024 yılında artarak devam etmesi ve diğer FinTek girişimlerine ilham vermesi beklenmektedir. Bu gelişmelerin sonucunda, Türk FinTek şirketlerinin ve Türk unicorn adaylarının farklı klasmanlarda rekabet etmeye başlaması öngörülmektedir. Ayrıca, açık bankacılık, servis bankacılığı ve gömülü finans gibi alanlardaki düzenlemelerin 2023 sonu itibarıyla aktif olan 696 FinTek şirketi sayısını daha da artırması beklenmektedir [37].

Tablo 2 Türkiye'nin FinTek Sektöründeki Avrupa'daki Yeri

	Avrupa Ülkeleri	Milyar dolar	Start-pu sayısı
	İngiltere	24,3	1790
	Fransa	11,7	591
	Almanya	11	910
	İsveç	3,5	205
	İsviçre	3,4	325
	İspanya	3,4	356
	Hollanda	2,3	330
	Iranda	2,2	132
	İtalya	1,7	155
	Türkiye	1,6	300
	Estonya	1,5	100
	Finlandiya	1,3	124
	Belçika	1,2	96
	Norveç	1,2	84
	Avusturya	1,1	94
	Danimarka	1,1	102

2.5.1. Yıllara Göre Kurulan FinTek Sayisi

Son altı yıl içinde Türkiye'de toplam 409 FinTek girişimi kurulmuştur. Bu dönemde, bir yıl içinde en fazla FinTek girişiminin kurulduğu yıl, 90 FinTek girişimi ile 2018 yılı olmuştur. 2022 yılında ise 24 FinTek girişimi kurulmuştur. Bu veriler, Türkiye'nin FinTek ekosisteminin belirli dönemlerde hızlı bir büyüme kaydettiğini göstermektedir [38].

2.5.2. Lisansli FinTek Alanlari

Türkiye'de 2022 yılı itibarıyla Türkiye Cumhuriyet Merkez Bankası (TCMB), Sermaye Piyasası Kurulu (SPK), Bankacılık Düzenleme ve Denetleme Kurumu (BDDK) tarafından lisanslanmış toplam 100 FinTek şirketi bulunmaktadır. Bireysel Emeklilik ve Sigorta Yönetmeliği. Denetleyici Kurum (SEDDK). FinTek şirketlerinin 45 elektronik para kurumu, 29 ödeme kurumu, 8 kitlesel fonlama platformu, 5 sigorta teknolojisi, 5 ödeme sistemi, 4 dijital banka ve 1 aracı kurum olmak üzere devletten resmi lisansları bulunuyor [39, 40].

2.6. Finansal Teknolojilerin Geleceği ve Sürdürülebilirlik

Son yıllarda, finansal teknolojilere (FinTek) olan ilgi, profesyonel kariyer hedefleyen adaylar için büyük bir öncelik haline gelmiştir. FinTek, finansal hizmetlerle entegre edilebilen tüm teknolojileri kapsamakta ve finansal hizmetlerin kapsamını genişletmek amacıyla geliştirilen yeni teknolojiler bütünü olarak tanımlanmaktadır. FinTek alanı, yazılımlar, bulut uygulamaları, mobil ve web uygulamaları, özel kuruluşlar ve geleneksel bankacılık hizmetlerinin dijital uzantılarını içermektedir.

Örneğin, 1950'lerde kullanıma sunulan kredi kartları, FinTek'in finansal hizmetlere getirdiği önemli iyileştirmelerin en erken ve en belirgin örneklerinden biridir. Günümüzde FinTek'in çoklu uygulamaları, çeşitli FinTek kategorilerinin ortaya çıkmasına neden olmuştur. Bu kategoriler, bireysel müşterilere olduğu kadar start-up'lar, küçük işletmeler ve köklü şirketlere de önemli iyileştirmeler ve avantajlar sunmaktadır.

FinTek ayrıca devlet kurumları tarafından da arzu edilen değer avantajlarına ulaşmak amacıyla kullanılmaktadır. FinTek'in finansal hizmetler dünyasında yarattığı etki, çeşitli türlere ayrılmasına yol açmış ve bu türlerin her biri, finansal süreçleri daha verimli ve erişilebilir hale getirme potansiyeli

taşımaktadır. FinTek'in gelecekte sürdürülebilirliği, bu teknolojilerin devamlı olarak yenilikçi çözümler sunma kapasitesine ve genişleyen kullanıcı tabanına bağlıdır. Bu bağlamda, FinTek'in büyümesi ve sürdürülebilirliği hem teknolojik ilerlemeler hem de kullanıcı adaptasyonu ile doğrudan ilişkilidir.

III. MATERYAL VE YÖNTEM

Çalışmayı yaparken literatür taraması yapılmıştır. Avrupa'daki farklı ülkelerin ve Türkiye'nin FinTek sektörüne yatırım ve start-up sayıları grafiklerle belirtilmiştir. Anket çalışmaları da yapılarak FinTek çalışmalarının yenilikçilik eğilimine katkıları analiz edilecektir.

Araştırmanın amaçları:

1: Bir kamu bankası personellerine Yaratıcılık teknikleri konusunda eğitim verir mi?
2: Personellerin yenilikçi faaliyetlerde bulunması desteklenir mi?
3: Değişiklikleri ve yenilikleri sürekli takip eder ve bunları örgüte uyarlar mı?
4: Çevresel değişikliklere hızlı bir şekilde cevap verebilmenin başarıyı arttıracağına inanılır mı?
5: Yeni fikir üretenler ve yeniliklerin hayata geçirilmesinde aktif rol üstlenenler şirketiniz tarafından ödüllendirilir mi?
6: Personeller işleriyle ilgili ihtiyaç duyduğu bilgi ve kaynaklara kolay ulaşabilir mi?

Araştırmanın soruları:

1: Bir kamu bankası personellerine sunulan yaratıcılık teknikleri eğitiminin iş performansı üzerindeki etkisi nedir?

2: Banka personellerinin yenilikçi faaliyetlere katılımının desteklenmesi iş performansını nasıl etkiler?
3: Organizasyonun değişikliklere ve yeniliklere adaptasyonu iş performansına olan katkısını nasıl şekillendirir?
4: Çevresel değişikliklere hızlı yanıt verme kabiliyetinin iş performansı üzerindeki etkisi nedir?
5: Yenilikçi fikirleri üreten ve bu fikirleri hayata geçiren personelin ödüllendirilmesinin iş performansına etkisi nedir?
6: Personellerin ihtiyaç duydukları bilgi ve kaynaklara erişiminin kolaylığı iş performansını nasıl etkiler?

Araştırmanın hipotezleri:

1: Bir kamu bankasında personel tarafından alınan yaratıcılık teknikleri eğitimi, iş performansında olumlu bir iyileşmeye yol açar.
2: Banka içerisinde çalışanların yenilikçi faaliyetlere katılımının desteklenmesi, iş performansını artırır.
3: Değişikliklere ve yeniliklere hızlı adaptasyon sağlayan bir organizasyon yapısı, iş performansını olumlu yönde etkiler.
4: Çevresel değişikliklere proaktif bir şekilde yanıt verebilme yeteneği, iş performansının iyileşmesine katkıda bulunur.
5: Yenilikçi fikirler üreten ve bu fikirleri aktif olarak hayata geçiren personelin ödüllendirilmesi, genel iş performansını yükseltir.
6: Çalışanların işleriyle ilgili gerekli bilgi ve kaynaklara kolay erişebilmesi, iş performansının artmasını sağlar.

IV. SONUÇLAR

Bu çalışma, FinTek ekosisteminin finansal teknoloji sektöründe faaliyet gösteren FinTek girişimlerinin sunduğu yenilikçi, çevik ve müşteri odaklı ürün ve hizmetler, finans ve bankacılık sektörüne yeni bir bakış açısı getirerek, finansal kurumların ve bankaların geleneksel iş modellerini değiştirdi. Finansal hizmetler sektörüne getirdiği yenilikler ve bu yeniliklerin sektöre olan etkilerini derinlemesine incelemektedir. FinTek, geleneksel bankacılık ve finans hizmetlerinde köklü değişikliklere yol açan, yenilikçi ve müşteri

odaklı çözümler sunan bir ekosistem olarak karşımıza çıkmaktadır. FinTek şirketleri, daha hızlı, maliyet etkin ve erişilebilir finansal hizmetler sunarak sektörde önemli bir boşluğu doldurmaktadır. Bu sayede, ödeme sistemleri, fon toplama, borç verme, varlık yönetimi ve finansal analiz gibi alanlarda, bankalardan daha hızlı ve esnek çözümler sunma kapasitesine sahiptirler.

FinTek'in 1866-1967 yılları finans sektörü açısından oldukça önemli dönemler olarak değerlendirilmektedir. 1970'lerdeki ATM'lerin ortaya çıkışıyla daha önem kazanmıştır. Özellikle 2008 finansal krizi sonrasında hızla büyümüş ve genişlemiştir. Kriz sonrası dönemde oluşan güvensizlik ortamı, tüketicileri ve işletmeleri geleneksel finansal kurumların dışındaki alternatif çözümlere yöneltmiştir. Günümüzde, dijital para birimleri, mobil bankacılık, blok zinciri teknolojisi ve otomatik yatırım danışmanlığı gibi yenilikçi hizmetler, finansal hizmetlerde dijital dönüşümün öncüsü olmaktadır.

Türkiye ve Avrupa'daki FinTek sektörlerine yapılan yatırımlar ve start-up sayılarının incelenmesinde, bu alandaki büyüme potansiyelini ve yenilikçilik eğilimlerini gözler önüne sermektedir. Araştırmalar, FinTek'in finansal hizmetler sektöründe rekabeti artırarak, tüketicilere daha geniş ve çeşitli hizmet seçenekleri sunduğunu göstermektedir. Ayrıca, bu alanda yapılan anket çalışmaları, FinTek'in yenilikçilik ve kullanıcı deneyimini iyileştirme konusundaki katkılarını açıkça ortaya koymaktadır.

FinTek'in sunduğu yenilikler, bankacılık ve finans sektöründe dijital dönüşümün anahtarı olarak kabul edilmektedir. Bu dönüşüm, finansal hizmetlerin daha verimli, hızlı ve kullanıcı dostu olmasını sağlamaktadır. Gelecekte, FinTek'in sürdürülebilirliği, teknolojik ilerlemeler, regülasyonlar ve kullanıcı adaptasyonu ile doğrudan ilişkilidir. Özellikle blok zinciri ve yapay zekâ gibi ileri teknolojilerin entegrasyonu, FinTek'in potansiyelini daha da artıracaktır.

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Exploring Hydrogen Production Performance of Al_2Cl_3 Salt via Chlor-Alkali Method: An Experimental Study

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Abstract – The present study explores the hydrogen production efficiency of aluminum chloride (Al_2Cl_3) salt utilizing the chlor-alkali method under controlled conditions of 20°C and a cell voltage of 5 volts. The experimental setup comprised a reactor with a central structure fabricated from Derlin polymer via computer numerical control (CNC) machining. Anode and cathode compartments were delineated by a Nafion 212 membrane, with carbon rod electrodes employed within each compartment.

Experimental observations revealed that Al_2Cl_3 yielded varying volumes of hydrogen gas at specific time intervals. Specifically, 10 mL, 20 mL, and 30 mL of hydrogen were generated within time durations of 30.25 minutes, 61.04 minutes, and 93.09 minutes, respectively, maintaining a constant current density of 0.04 A.

These findings shed light on the hydrogen production potential of Al_2Cl_3 salt using the chlor-alkali method, demonstrating its feasibility under the specified experimental parameters. Further analysis and optimization of process conditions could enhance the efficiency and scalability of this hydrogen generation approach.

Keywords – Hydrogen, Chlor – Alkali Reactor, Electrolysis, Energy, Sustainable Energy.

I. INTRODUCTION

The Chlor-Alkali electrolysis method is widely used in industry for large-scale production of hydrogen. In this process, a salt solution such as sodium chloride (NaCl) is electrolyzed. During electrolysis, the electrolyte solution becomes ionized, leading to the formation of hydrogen and chlorine gases under the influence of an electric current. Hydrogen is produced through the reduction of water at the electrode surface, while chlorine is obtained from chloride ions (Cl^-) via oxidation. Additionally, hydroxyl ions (OH^-) and sodium ions (Na^+) are also generated during this process. The Chlor-Alkali electrolysis method enables the production of industrially significant by-products such as chlorine and sodium hydroxide alongside hydrogen. Despite its energy-intensive nature, this method is favored for industrial-scale hydrogen production and plays a pivotal role in the development of a sustainable energy economy [1,2].

Given its environmentally friendly attributes, hydrogen plays a crucial role in advancing sustainable energy systems. Its versatility as an energy carrier holds promise for decarbonizing various sectors including transportation, industry, and power generation. Beyond its capacity to reduce greenhouse gas emissions, hydrogen facilitates the integration of renewable energy sources and enables efficient energy storage, thus fostering a more resilient, low-carbon future.

In a recent experimental study, researchers investigated hydrogen generation from solutions of NaCl, KCl, and $CaCl_2$ using an electrochemical method in a chlor-alkali reactor. The study utilized a laboratory-scale reactor equipped with separate anode and cathode compartments, divided by a cation exchange membrane. Various parameters such as cell voltage, temperature, and electrolyte flow rate were meticulously analyzed.

Although the presence of active chlorine gas in the anode compartment hindered the anticipated chlorine gas output, significant hydrogen production was observed at the cathode. Hydrogen generation rates ranged from 37.23 mL/h to 437.72 mL/h under different experimental conditions. Notably, the lowest and highest rates were achieved with $CaCl_2$ at 0.4 g/s and 3 V, and KCl at 1.2 g/s and 5 V, respectively [3]

Studies regarding the chlor-alkali process have been conducted as documented by [4,5,6]. This process yields three primary outputs: chlorine gas, sodium hydroxide (commonly known as caustic soda), and hydrogen gas. These outputs are of paramount importance for renewable energy-oriented industrial applications, given their minimal carbon emissions. Experimentally, the study observed the highest hydrogen production when utilizing a potassium chloride (KCl) solution, while the lowest production was recorded with calcium chloride ($CaCl_2$). Noteworthy enhancements in hydrogen production were achieved by increasing operational parameters such as temperature, cell voltage, and mass flow rate. Among these parameters, cell voltage exerted the most pronounced influence, whereas the effect of mass flow rate was comparatively marginal. The study reported a minimum hydrogen production rate of 27.36 mL/h with a $CaCl_2$ solution at a mass flow rate of 0.3 g/s and a cell voltage of 2.5 V. Conversely, the maximum hydrogen production rate of 295.68 mL/h was attained using a KCl solution at a mass flow rate of 0.7 g/s and a cell voltage of 3.5 V. This resulted in respective energy and exergy efficiencies of 10.81% and 8.47% for the former condition, and 23.78% and 17.63% for the latter.

An additional study delves into the impact of electrode surface area, electrode gap, electrolyte temperature, mass flow rate, and bubble formation on current density within a membrane cell chlor-alkali reactor. The chlor-alkali process entails the electrolysis of brine to yield chlorine gas, sodium hydroxide, and hydrogen. Sequential experiments demonstrate that enlarging the electrode surface area amplifies current density, whereas widening the gap between electrodes diminishes it. Notably, heightened electrolyte temperatures correlate with increased current density, while augmenting the mass flow rate yields only a marginal effect. Accumulation of air bubbles on the electrodes hinders the electric field, resulting in a gradual decline in current density over time [7].

Given the escalating significance of renewable energy sources, the chlor-alkali process emerges as a promising avenue for hydrogen production. Nevertheless, several factors influence the efficacy of this process. Notably, challenges such as electrode damage and bubbling can impact process stability. However, research underscores that variables including solution composition, operational parameters, and reactor configuration are pivotal in dictating efficiency fluctuations in hydrogen generation.

Specifically, elements such as solution composition, electrode material and surface characteristics, operational conditions such as temperature and electric current, and reactor structural design all exert substantial influence on hydrogen yield. Rigorous control of these factors is imperative to bolster process efficiency and ensure consistent hydrogen output. Hence, meticulous adjustment of process parameters assumes paramount importance in augmenting hydrogen production and optimizing energy efficiency within sustainable industrial settings.

Consequently, acknowledging the chlor-alkali process as a key contender in the realm of renewable energy necessitates sustained enhancement and research endeavors. Efforts have been directed towards hydrogen production to enhance process efficiency and foster a more sustainable energy landscape. In this vein, fine-tuning process parameters holds critical significance in ramping up industrial-scale hydrogen production and warrants further exploration in forthcoming investigations.

II. Materials and Method

Figure 1 illustrates the schematic diagram of the membrane cell chlor-alkali reactor utilized in the experimental setup. The experimental arrangement comprises the chlor-alkali reactor unit itself, vessels employed for electrolyte provision, containers designated for electrolyte waste disposal, a graduated measuring cylinder for measurements, a direct current (DC) power supply, and peristaltic pumps. This apparatus is specifically engineered to facilitate the investigation of electrochemical reactions pertinent to the chlor-alkali process. The reactor unit is partitioned by a cation exchange membrane positioned between the anode and cathode compartments. This membrane facilitates ion passage while mitigating undesired reactions. The containers ensure the secure disposal of electrolyte waste, whereas peristaltic pumps regulate electrolyte flow to optimize reaction conditions. This experimental setup enables a comprehensive exploration of the chlor-alkali process and facilitates studies aimed at refining process parameters.

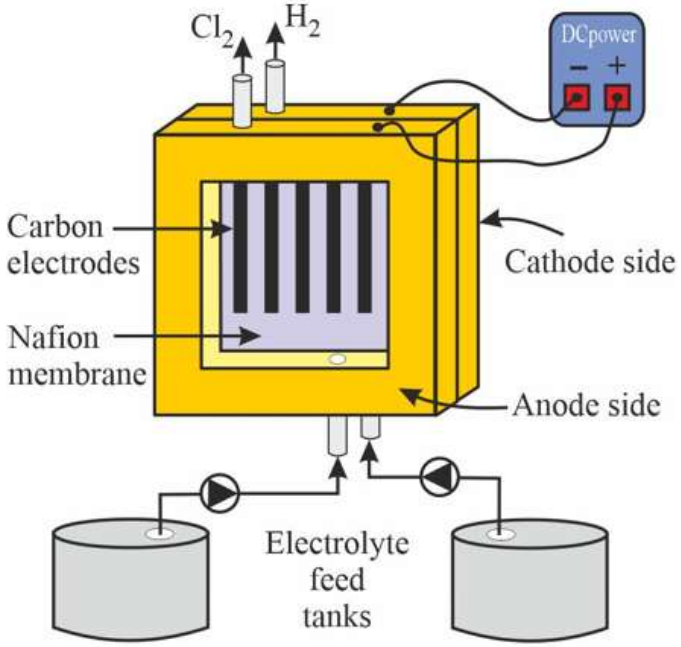

Fig. 1. illustrates the schematic representation of the experimental setup.

III. Results and Discussion

The hydrogen production from Al_2Cl_3 salt via the chlor-alkali method was investigated under conditions of 20°C temperature and 5 volts cell voltage. The central structure of the reactor was fabricated from derlin polymer using CNC machining, ensuring both high strength and chemical resistance. Separation of the anode and cathode compartments was achieved by employing a Nafion 212 membrane, with carbon rod electrodes utilized within each compartment. The membrane served the dual purpose of preventing undesired reactions while facilitating ion passage.

During the examination of hydrogen production, it was observed that the reactor operated under constant current conditions when utilizing Al_2Cl_3. Furthermore, the quantity of hydrogen produced was found to be directly proportional to time, suggesting a continuous process of hydrogen generation. These findings underscore the potential of Al_2Cl_3 salt as a viable source for hydrogen production via the chlor-alkali method. Nonetheless, further investigations are warranted to elucidate the underlying mechanism and optimize reaction conditions. Such research endeavors hold promise for advancing the development of alternative fuel sources to foster sustainable energy production.

Table 1. Hydrogen Production from the Chlor-Alkali Reactor Using Al_2Cl_3

	Al_2Cl_3		
Hydrogen Production (mL)	**Minutes**	**Ampere**	**Voltage**
10	30.25	0,04	5
20	61.04	0,04	5
30	93.09	0,04	5

IV. CONCLUSION

As a fundamental pillar of the chemical industry, the chlor-alkali reactor holds a pivotal position across numerous industrial sectors. This reactor serves as a facilitator for synthesizing crucial chemicals like chlorine gas, sodium hydroxide (caustic soda), and hydrogen, thereby supplying indispensable raw materials for a diverse array of industrial processes. Chlorine gas finds extensive utility ranging from PVC plastic manufacturing to water treatment facilities. Meanwhile, sodium hydroxide acts as a vital chemical constituent in various industries, spanning from the paper sector to detergent production. Conversely, hydrogen plays a vital role as a raw material in an array of industrial processes including fuel cell technology, petrochemical synthesis, and metallurgy.

With the inclusion of Al_2Cl_3 salt's impact on the chlor-alkali reactor, the significance of these reactors is further underscored. The incorporation of Al_2Cl_3 salt enhances the functionality and application scope of chlor-alkali reactors by contributing to hydrogen production. This broadens the horizon for diverse industrial applications while fostering integration with sustainable energy sources. Renowned for their notable energy efficiency, these reactors, when coupled with clean and renewable energy sources, make substantial strides toward carbon emission reduction and the advancement of sustainable industrial practices.

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Nimonic 50 Süperalaşımının Sürdürülebilir Koşullar Altında Frezelenmesinin Enerji Tüketimi Üzerine Etkileri

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Özet – Süperalaşımlar, özellikle yüksek sıcaklıklarda üstün mekanik ve kimyasal özellikler sergileyen ileri mühendislik malzemeleridir. Genellikle nikel, demir ve kobalt bazlı bileşimler içerirler ve yüksek sıcaklık dayanımı, korozyon direnci ve oksidasyon direnci gibi özelliklere sahiptirler. Süperalaşımlar, yüksek sıcaklıklarda mekanik dayanımlarını koruma yetenekleriyle bilinirler. Kimyasal bileşimleri, genellikle nikel, kobalt, krom, molibden, alüminyum ve titanyum gibi elementler içerir. Bu elementler, alaşımın yüksek sıcaklıklarda kararlı kalmasını ve oksidasyon ile korozyona karşı dirençli olmasını sağlar. Süperalaşımların işlenebilirliği, genellikle zorlu bir süreçtir ve bu malzemelerle çalışırken belirli zorluklar yaşanır. Yüksek mukavemet ve sertlik, işleme sırasında takım aşınmasını artırır ve işleme süresini uzatır. Bu nedenle, süperalaşımların işlenebilirliğini artırmak için özel kesme aletleri ve işleme stratejileri gereklidir. Kesme sıvıları, süperalaşımların işlenebilirliğini artırmak için kritik öneme sahiptir. Sürdürülebilir kesme sıvıları, çevresel etkileri minimize ederek ve çalışma ortamını iyileştirerek ek avantajlar sağlar. Sürdürülebilir kesme sıvıları, biyolojik olarak parçalanabilir ve toksik olmayan bileşenler içerir, bu da çevre dostu işleme süreçlerini destekler. Bu çalışmada Nimonic 50 süperalaşımı farklı kesme parametreleri ve farklı soğutma/yağlama stratejileri altında frezelenerek enerji tüketimi araştırılmıştır. Deneylerde üç kesme hızı (45-55-65 m/dak), üç ilerleme hızı (0.05-0.06-0.07 mm/dev) ve üç soğutma/yağlama ortamı (kuru-hava-MMY) seçilmiştir. Ayrıca deney sayısını ve maliyetleri azaltmak için Taguchi analizi uygulanmıştır. Sonuç olarak enerji tüketimi açısından en iyi seçeneğin minimum miktarda yağlama ortamı olduğu tespit edilmiştir. Ayrıca yapılan Taguchi analizi ile enerji tüketimi üzerindeki en etkili faktörün ilerleme hızı olduğu gözlenmiştir.

Anahtar Kelimeler – Nimonic-50 süperalaşımı, Frezeleme, Minimum miktarda yağlama (MMY), Enerji Tüketimi, Taguchi

I. GİRİŞ

Nikel tabanlı süperalaşımlar, yüksek sıcaklık koşullarında üstün mekanik ve kimyasal özellikler sergileyen ileri mühendislik malzemeleri olarak dikkat çekmektedir [1, 2]. Bu alaşımlar, 1940'lı yıllardan bu yana özellikle havacılık ve enerji üretim sektörlerinde, yüksek sıcaklık ve aşındırıcı ortamlara maruz kalan bileşenlerde kullanılmaktadır [3]. Nikel tabanlı süperalaşımlar, ısıl ve kimyasal stabiliteleri, yüksek mukavemetleri ve korozyon dirençleri ile bilinirler. Bu özellikler, onları jet motorları, gaz türbinleri, nükleer reaktörler ve petrokimya tesisleri gibi kritik uygulamalarda vazgeçilmez kılar [4]. Nikel tabanlı süperalaşımların kimyasal bileşimi genellikle nikelin yanı sıra krom, kobalt, molibden, tungsten, alüminyum ve titanyum gibi elementler içerir. Bu elementler, alaşımların mikro yapısını ve faz dengesini kontrol ederek, yüksek sıcaklıklarda mukavemet ve oksidasyon direncini artırır [5]. Nikel tabanlı süperalaşımların üretiminde, katı çözelti sertleşmesi, çökelme sertleşmesi ve tane sınırı mühendisliği gibi çeşitli mekanizmalar kullanılarak üstün performans elde edilir [6, 7]. Bu alaşımların üstün özellikleri, işlenebilirliklerini önemli ölçüde zorlaştırmaktadır. Yüksek sertlik ve mukavemet, işleme sırasında

takımların hızlı aşınmasına ve yüksek kesme kuvvetlerine neden olur. Bu nedenle, nikel tabanlı süperalaşımların işlenmesi, özel kesme aletleri, optimize edilmiş kesme parametreleri ve soğutma sıvıları gerektirir [8]. İşleme sürecinde sürdürülebilir kesme sıvılarının kullanımı, çevresel etkilerin azaltılmasına ve işleme verimliliğinin artırılmasına katkıda bulunur [9]. Nikel tabanlı süperalaşımlar, yüksek performans gerektiren uygulamalarda kritik bir rol oynamaktadır. Bu malzemelerin geliştirilmesi ve işlenmesi, ileri mühendislik bilgi ve tekniklerinin yanı sıra çevresel sürdürülebilirlik ilkelerini de gerektirir [10]. Bu bağlamda, nikel tabanlı süperalaşımların özelliklerinin ve işleme süreçlerinin derinlemesine anlaşılması, hem endüstriyel hem de akademik araştırmalar için büyük önem taşımaktadır [11].

Enerji tüketimi, işleme operasyonlarının verimliliğini ve sürdürülebilirliğini doğrudan etkileyen bir faktördür [12-14]. Süperalaşımların işlenmesi sırasında yüksek enerji gereksinimi, büyük ölçüde malzemenin sertliğinden ve mukavemetinden kaynaklanır [15]. Bu malzemeler, kesme kuvvetlerinin ve kesme sıcaklıklarının yüksek olmasına neden olur, bu da hem işleme süresinin uzamasına hem de takım aşınmasının hızlanmasına yol açar. Dolayısıyla, enerji tüketimini optimize etmek ve minimize etmek, süperalaşımların işlenmesi sırasında karşılaşılan başlıca teknik zorluklardan biridir [16]. İşleme sırasında enerji tüketimini etkileyen faktörler arasında kesme parametreleri (kesme hızı, ilerleme, kesme derinliği), takım malzemesi ve geometrisi, kesme sıvılarının kullanımı ve soğutma stratejileri yer alır [17-19]. Optimal kesme parametrelerinin belirlenmesi ve uygun kesme sıvılarının kullanımı, enerji tüketiminin azaltılmasında önemli rol oynar [20, 21]. Ayrıca, ileri imalat teknolojileri ve yenilikçi takım malzemeleri, enerji verimliliğini artırmak için sürekli olarak geliştirilmekte ve uygulanmaktadır [22]. Bu bağlamda, süperalaşımların işlenmesi sırasında enerji tüketiminin azaltılması, hem ekonomik hem de çevresel sürdürülebilirlik açısından büyük önem taşımaktadır [23]. Enerji verimliliği, üretim maliyetlerini düşürmenin yanı sıra, karbon ayak izini azaltarak çevresel etkileri de minimize eder. Bu nedenle, süperalaşımların işlenmesi üzerine yapılan akademik ve endüstriyel araştırmalar, enerji tüketimini optimize etmek ve daha sürdürülebilir işleme süreçleri geliştirmek amacıyla yoğun bir şekilde devam etmektedir.

Bu çalışmada Nimonic 50 süperalaşımının farklı kesme parametreleri ve farklı soğutma/yağlama stratejileri altında frezelenmesi sırasında harcanan enerji tüketimi araştırılmıştır. Bu amaçla üç kesme hızı (45-55-65 m/dak), üç ilerleme hızı (0.05-0.06-0.07 mm/dev) ve üç soğutma/yağlama ortamı (kuru-hava-MMY) seçilmiştir. Ayrıca deney sayısını ve maliyetleri azaltmak için Taguchi analizi uygulanmıştır.

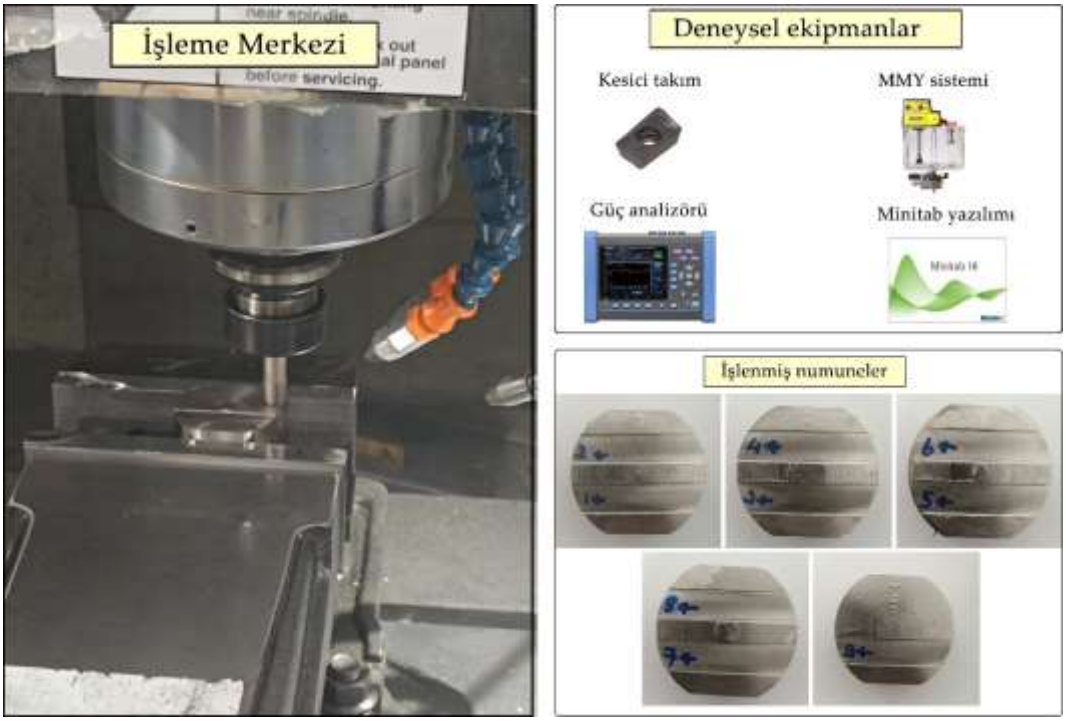
II. MATERYAL VE YÖNTEM

Deney malzemesi olarak endüstride birçok uygulamada sıklıkla kullanılan nikel esaslı bir süperalaşım olan Nimonic 50 seçilmiştir. Yüksek performans gerektiren ve aşırı koşullara maruz kalan endüstriler için kritik öneme sahip bu malzeme özellikle tercih edilmiştir. Deneyler üç eksenli bilgisayar kontrollü bir freze tezgahında yapılmıştır. Deneyler üç farklı kesme hızı (45-55-65 m/dak), üç farklı ilerleme hızı (0.05-0.06-0.07 mm/dev), tek kesme derinliği (0.3 mm) ve üç farklı soğutma/yağlama (kuru, hava ve MMY) stratejisi kullanılarak yapılmıştır. Ayrıca deney sayısını ve maliyetleri azaltmak amacıyla Taguchi L9 ortogonal dizisi kullanılmıştır. Taguchi analizi, kalite ve süreç iyileştirmesi için kullanılan bir tasarım ve analiz tekniğidir. Dr. Genichi Taguchi tarafından geliştirilen bu yöntem, üretim süreçlerindeki değişkenlikleri azaltmayı ve istenmeyen varyasyonları minimize etmeyi hedefler. Genellikle endüstride ürün ve süreç tasarımı, kalite kontrolü ve mühendislik uygulamalarında kullanılır. Taguchi analizi, deney tasarımı ve istatistiksel analiz prensiplerine dayanır. Temel olarak, bir ürün veya süreç için ana girdileri ve çıktıları tanımlar ve bu faktörlerin çeşitliliklerinin kalite üzerindeki etkisini değerlendirir. Tablo 1'de deney planı gösterilmektedir. Deneylerde kullanılan basınçlı hava bir kompresör (7 bar) yardımıyla kesme bölgesine ulaştırılmaktadır. Werte Micro STN-15 model bir cihaz ile MMY tekniği kullanılarak pülverize hale getirilen kesme sıvısı buhar şeklinde kesici takım ve iş parçası üzerine püskürtülmektedir. MQL tekniğinde nozul kesme bölgesine yaklaşık 40 cm mesafede konumlandırılarak püskürtme işlemi gerçekleştirilmektedir. Deneylerde kesici takım olarak AlTiN (Alüminyum Titanyum Nitrür) kaplanmış karbür uçlar kullanılmıştır. Bu karbür uçlar frezeleme işlemlerinde genellikle tercih edilmektedir [24]. Deneyler sırasında CNC freze tezgahından çekilen enerji miktarını belirlemek amacıyla HIOKI marka bir

güç analizörü kullanılmıştır. Güç analizörünün kabloları CNC freze tezgahının gerekli kablolarına monte edilmiştir. Cihazdan alınan veriler özel bir yazılımla hesaplanarak kayıt altına alınmıştır. Şekil 1'de işleme merkezi ve deneylerde kullanılan ekipmanlar gösterilmektedir.

Tablo 1. Deney tasarımı (Taguchi L_9) [24]

Deney No	Kesme hızı (m/dak)	İlerleme hızı (mm/dev)	Soğutma/Yağlama
1	45	0.05	Kuru
2	55	0.06	Kuru
3	65	0.07	Kuru
4	45	0.06	Hava
5	55	0.07	Hava
6	65	0.05	Hava
7	45	0.07	MMY
8	55	0.05	MMY
9	65	0.06	MMY

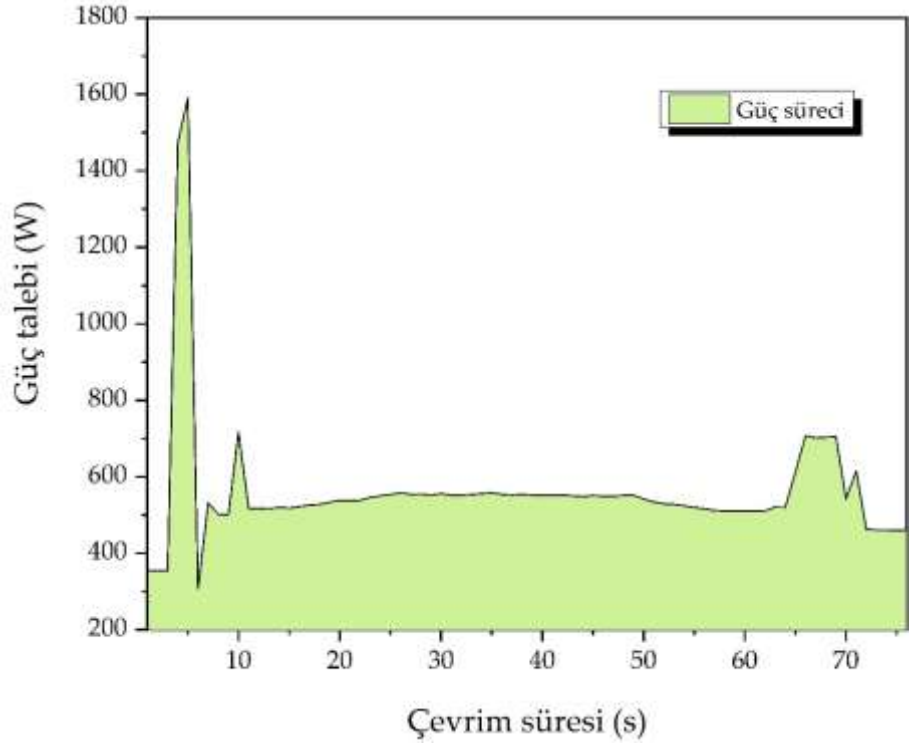


Şekil 1. Deneysel şema [24]

III. BULGULAR VE TARTIŞMA

Talaşlı imalat süreçlerinde enerji tüketimi, hem ekonomik maliyetler hem de çevresel sürdürülebilirlik açısından kritik bir öneme sahiptir [25]. Bu süreçlerde kullanılan enerji, doğrudan üretim maliyetlerini etkileyen temel unsurlardan biridir. Yüksek enerji tüketimi, üretim maliyetlerini artırarak rekabetçi piyasalarda dezavantaj yaratır. Bununla birlikte, enerji tüketiminin optimize edilmesi, üretim maliyetlerini düşürerek işletmelerin kârlılığını artırabilir [26]. Çevresel açıdan bakıldığında, talaşlı imalat süreçlerinde enerji verimliliği, karbon ayak izinin azaltılması ve çevresel etkilerin minimize edilmesi için hayati öneme sahiptir [27]. Geleneksel enerji kaynaklarının kullanımı, sera gazı emisyonlarına ve çevresel kirliliğe yol açarken, enerji tüketiminin azaltılması, sürdürülebilir üretim süreçlerinin geliştirilmesine katkıda bulunur [28]. Talaşlı imalat süreçlerinde enerji tüketimini etkileyen faktörler arasında kullanılan takım malzemeleri, kesme parametreleri, makine verimliliği ve soğutma stratejileri yer almaktadır. İleri imalat teknolojileri ve yenilikçi kesme sıvıları gibi çözümler, enerji tüketiminin optimize edilmesinde önemli rol oynamaktadır. Enerji verimliliğinin artırılması, sadece maliyetleri düşürmekle kalmaz, aynı

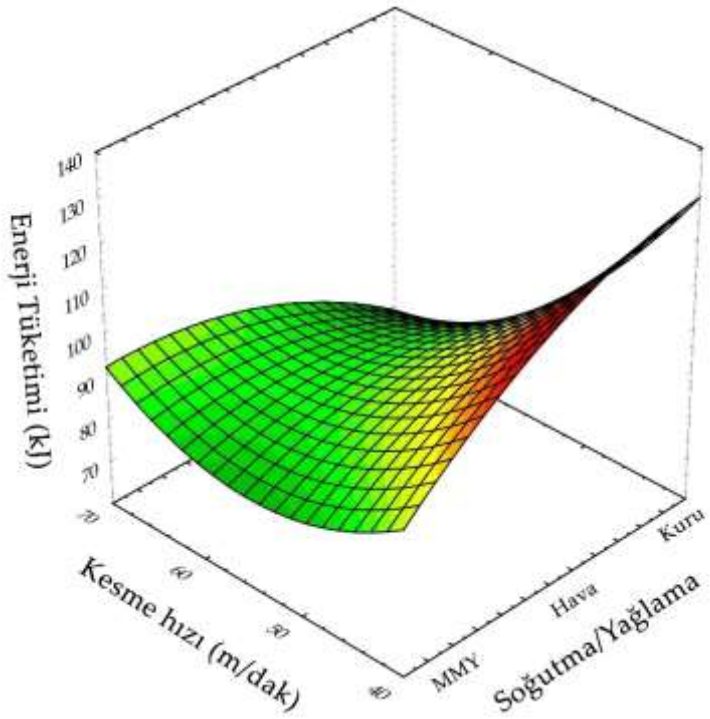
zamanda çevresel sorumlulukların yerine getirilmesini sağlar ve endüstriyel üretim süreçlerinde sürdürülebilirlik hedeflerine ulaşılmasına yardımcı olur. Bu bağlamda, talaşlı imalat süreçlerinde enerji tüketiminin detaylı analizi ve optimize edilmesi, hem akademik araştırmalar hem de endüstriyel uygulamalar için büyük bir öncelik taşımaktadır. Bu çalışmada farklı kesme parametrelerinin ve farklı soğutma stratejilerinin enerji tüketimi üzerindeki etkileri araştırılmıştır. Şekil 2'de 7 nolu deneyde harcanan güç miktarı grafiksel olarak verilmiştir.



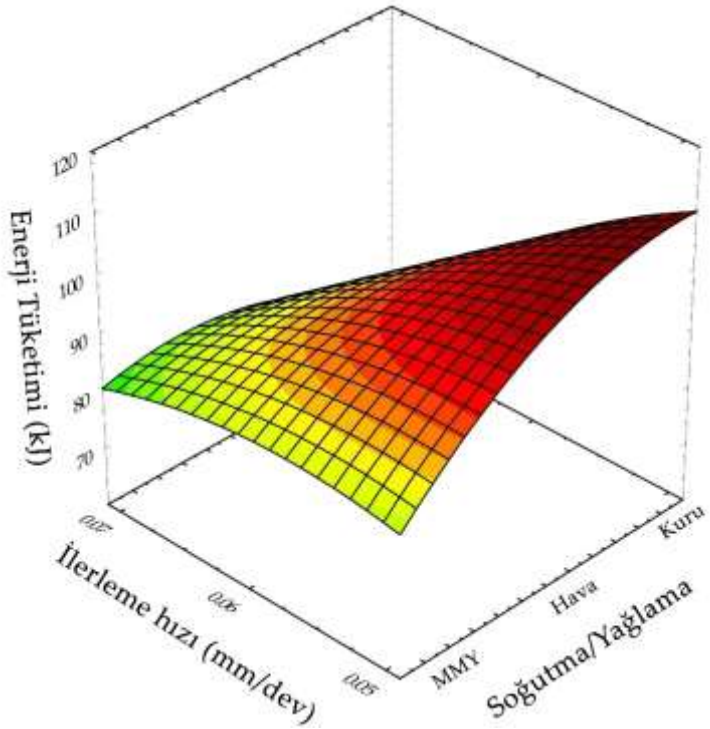
Şekil 2. 7 nolu deneyde harcanan güç miktarının grafiksel olarak gösterimi

Talaşlı imalat süreçlerinde kesme sıvılarının rolü, enerji tüketimini ve işleme verimliliğini önemli ölçüde etkileyen kritik bir faktördür [29]. Kesme sıvıları, işleme sırasında takımlar ve iş parçaları arasında soğutma, yağlama ve talaş taşıma işlevlerini yerine getirir. Bu işlevler, kesme kuvvetlerini ve sıcaklıklarını azaltarak takım ömrünü uzatır, yüzey kalitesini iyileştirir ve enerji tüketimini optimize eder. Kesme sıvılarının en önemli rollerinden biri, kesme işlemi sırasında oluşan ısının dağıtılmasını sağlamaktır. Yüksek kesme sıcaklıkları, takım aşınmasını hızlandırarak işleme verimliliğini düşürebilir ve enerji tüketimini artırabilir. Etkili soğutma, kesme bölgesindeki sıcaklığı kontrol ederek takım ömrünü uzatır ve kesme performansını artırır. Kesme sıvıları, kesme bölgesinde yağlayıcı bir film oluşturarak sürtünmeyi azaltır. Azalan sürtünme, kesme kuvvetlerini ve dolayısıyla enerji tüketimini azaltır. Daha düşük kesme kuvvetleri, hem işleme süresini kısaltır hem de takım aşınmasını ve talaş oluşumunu kontrol altında tutar. Kesme sıvıları, talaşların kesme bölgesinden etkin bir şekilde uzaklaştırılmasını sağlar. Talaşların hızlı ve etkili bir şekilde uzaklaştırılması, kesme kenarının temiz kalmasını ve dolayısıyla işleme kalitesinin korunmasını sağlar. Bu, enerji verimliliğini artıran bir diğer faktördür. Kesme sıvılarının seçimi ve kullanımı, enerji tüketimi ve çevresel sürdürülebilirlik açısından da büyük önem taşır. Geleneksel kesme sıvıları genellikle mineral yağ bazlıdır ve çevresel kirliliğe yol açabilir. Sürdürülebilir kesme sıvıları ise biyolojik olarak parçalanabilir ve toksik olmayan bileşenler içerir, bu da çevresel etkileri minimize eder ve enerji verimliliğini artırır. Kesme sıvılarının etkin kullanımı, talaşlı imalat süreçlerinde enerji tüketimini optimize etmek için temel bir stratejidir. Doğru kesme sıvısının seçimi, uygun konsantrasyon ve uygulama yöntemleri, işleme sırasında enerji verimliliğini artırarak hem maliyetleri düşürür hem de çevresel sorumlulukların yerine getirilmesini sağlar. Bu nedenle, kesme sıvılarının işleme süreçlerindeki rolü, enerji tüketimini ve genel işleme verimliliğini artırmada kritik bir

öneme sahiptir. Şekil 3 ve Şekil 4'te kesme parametrelerinin ve soğutma/yağlama ortamlarının enerji tüketimi üzerindeki etkileri 3B grafikler halinde verilmiştir.



Şekil 3. Kesme hızı ve soğutma/yağlama ortamının enerji tüketimi üzerindeki etkileri

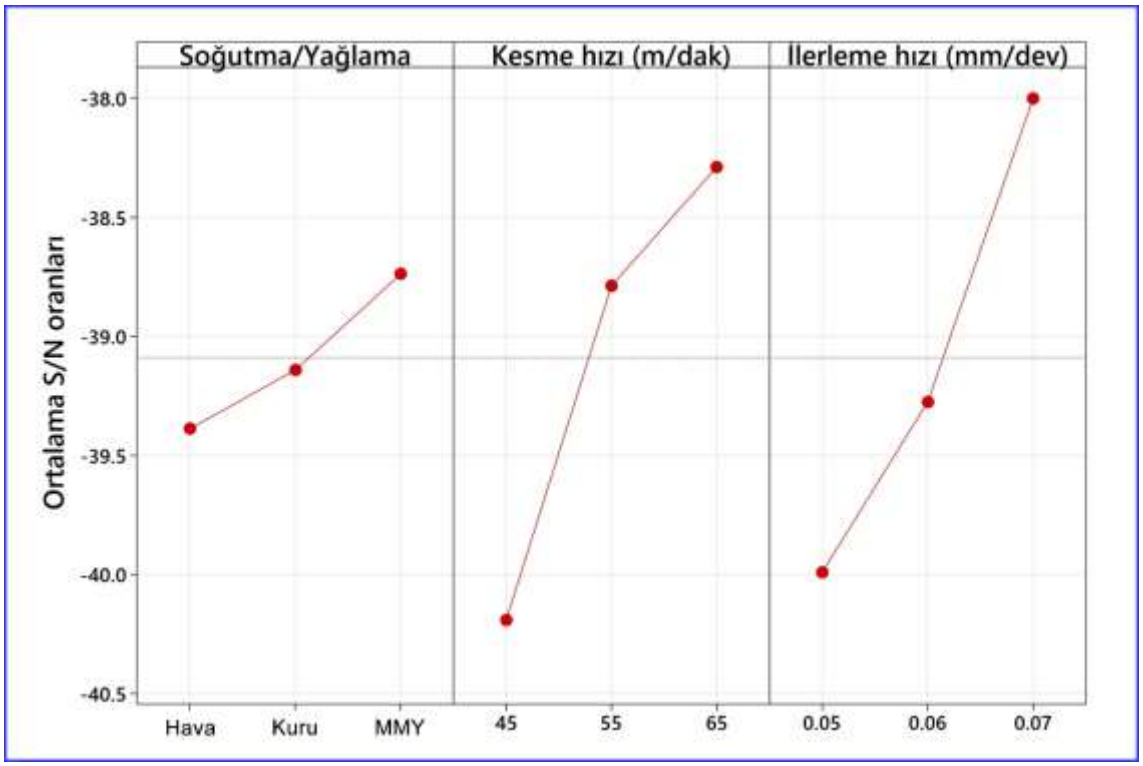


Şekil 4. İlerleme hızı ve soğutma/yağlama ortamının enerji tüketimi üzerindeki etkileri

Şekil 3 incelendiğinde kesme hızı arttıkça genel olarak enerji tüketiminin azaldığından söz edilebilir. Soğutma/yağlama performansı açısından değerlendirildiğinde minimum miktarda yağlama (MMY) ortamının enerji tüketiminde daha verimli olduğu söylenebilir. Bunun nedeni MMY sistemi ile kesme bölgesi hem soğutulmakta hem de takım talaş arayüzünde bir yağlama filmi oluşturularak sürtünme kuvveti azaltılmasına atfedilebilir. Kesme bölgesinde bir yağ filmi oluşumu sürtünmeyi azaltarak daha az

güç ile talaş kaldırma işleminin yapılmasına yardımcı olmaktadır. Şekil 4'te ise ilerleme hızı ve soğutma/yağlama ortamının enerji tüketimine etkileri gösterilmektedir. Grafik incelendiğinde en yüksek enerji tüketimi değerleri kuru işleme ortamında görülmektedir. Kuru işlemede kesici takımda artan yüksek sıcaklıklar ve plastik deformasyon takımın aşınmasına ve dolayısıyla kesici kenarın performansının azalmasına neden olmaktadır. Böylece aşınmış takım iş parçasını rahatlıkla kesemediği için güç tüketimini artırabilmektedir. Böylece kuru işlemede enerji ihtiyacı daha fazla olabilmektedir. İlerleme hızının enerji tüketimi üzerindeki etkisine bakacak olursak artan ilerleme hızları enerji tüketiminin azalmasına sebep olduğu görülmektedir. İlerleme hızının artmasıyla işleme için ayrılan toplam süre azalacağı için enerji tüketimin azalması olağan bir süreç olarak kabul edilmektedir.

Taguchi analizi, üretim ve mühendislik süreçlerinde kalite iyileştirmesi ve varyasyonların minimize edilmesi amacıyla kullanılan istatistiksel bir yöntemdir [30, 31]. Taguchi metodu, ürün ve süreç tasarımlarında performansı optimize etmek için kontrol edilebilen ve edilemeyen faktörlerin etkilerini sistematik olarak değerlendirir [32]. Bu yaklaşım, özellikle üretim süreçlerinde, çeşitli faktörlerin ana etkilerini ve etkileşimlerini inceleyerek, optimum koşulların belirlenmesini sağlar. Taguchi analizinde kullanılan ve faktörlerin bireysel etkilerini görselleştiren bir araçtır. Bu grafik, her bir faktör seviyesinin ortalama yanıtını gösterir ve hangi faktörlerin sonuçlar üzerinde en büyük etkiye sahip olduğunu belirlemeye yardımcı olur [33]. Ana etki grafiğinde, yatay eksen faktör seviyelerini, dikey eksen ise yanıt değişkeninin ortalama değerini temsil eder. Eğrinin eğimi, faktörün etkisinin büyüklüğünü gösterir; eğim ne kadar dikse, faktörün etkisi o kadar büyük demektir. Taguchi analizi ve ana etki grafiği birlikte kullanıldığında, süreç optimizasyonunda hangi faktörlerin kritik olduğunu ve bu faktörlerin hangi seviyelerde en iyi performansı sağladığını belirlemek mümkündür [34]. Bu yöntemler, maliyetlerin azaltılması, kalite iyileştirilmesi ve süreç verimliliğinin artırılması gibi hedeflere ulaşmada önemli katkılar sağlar. Şekil 5, giriş parametreleri olan soğutma/yağlama, kesme hızı ve ilerleme hızının çıkış parametresi olan enerji tüketimi üzerindeki etkilerini gösteren ana etki grafiklerini temsil etmektedir. Orta kısımda bulunan eksenin üs bölümü en iyi sonuçları göstermektedir. Örneğin en iyi soğutma/yağlama ortamı MMY, en iyi kesme hızı 65 m/dak ve en iyi ilerleme hızı 0.07 mm/dev olarak anlaşılmaktadır. Tablo 2'de deneylerden elde edilen sonuçlar ve sinyal/gürültü (S/N) oranları verilmiştir.



Şekil 5. Giriş parametrelerinin enerji tüketimi üzerindeki ana etki grafikleri

Tablo 2. Enerji tüketimi için deneysel sonuçlar ve S/N oranları

Deney No	Enerj Tüketimi (kJ)	Enerji Tüketimi için S/N (dB)
1	113.01	-41.0623
2	88.04	-38.8936
3	74.72	-37.4687
4	110.83	-40.8931
5	78.65	-37.9140
6	92.86	-39.3566
7	85.29	-38.6180
8	95.00	-39.5545
9	79.80	-38.0401

Taguchi analizi sürecinde ANOVA (Varyans Analizi), deneysel verilerin istatistiksel olarak değerlendirilmesinde kritik bir rol oynar. ANOVA, farklı faktörlerin ve bu faktörlerin etkileşimlerinin yanıt değişkeni üzerindeki etkilerini belirlemek amacıyla kullanılır. Taguchi metodunda, deney sonuçlarının varyasyonlarını analiz ederek, hangi faktörlerin istatistiksel olarak anlamlı olduğunu ve her bir faktörün varyansa ne kadar katkıda bulunduğunu belirlemek mümkündür. ANOVA'nın temel amacı, toplam varyansı, farklı faktörlerin neden olduğu varyans ve hatadan (residual) kaynaklanan varyans olarak ayrıştırmaktır. Bu analizde, her bir faktörün ana etkisi ve faktörler arası etkileşimler değerlendirilir. F-testi, faktörlerin ve etkileşimlerin anlamlılığını belirlemek için kullanılır; yüksek F-değerleri, ilgili faktörün veya etkileşimin yanıt değişkeni üzerinde önemli bir etkisi olduğunu gösterir. Tablo 3'te ANOVA sonuçları gösterilmektedir.

Tablo 3. ANOVA sonuçları

Kaynak	DF	Seq SS	Adj SS	Adj MS	F	P	Katkı oranı (%)
Enerji Tüketimi							
Soğutma/Yağlama	2	0.647	0.647	0.3235	3.02	0.249	5.053
Kesme Hızı	2	5.8398	5.8398	2.9199	27.22	0.035	45.611
İlerleme Hızı	2	6.1023	6.1023	3.0511	28.45	0.034	**47.661**
Hata payı	2	0.2145	0.2145	0.1073			1.675
Toplam	8	12.8035					100.000

ANOVA sürecinde, belirli bir güven düzeyinde (genellikle %95) faktörlerin etkisi değerlendirilir. Bu, belirli bir faktörün yanıt değişkeni üzerindeki etkisinin rastlantısal olup olmadığını belirlemek için kullanılır. Eğer bir faktörün P-değeri (olasılık değeri) belirlenen alfa seviyesinden (genellikle 0.05) düşükse, bu faktörün etkisi istatistiksel olarak anlamlı kabul edilir. ANOVA sonuçlarına göre enerji tüketimi üzerindeki en etkili faktörün ilerleme hızı olduğu görülmektedir. Daha sonraki etkili faktör ise ilerleme hızı olarak kaydedilmiştir. Dikkat edilecek olursa ilerleme ve kesme hızı faktörlerinin P değeri 0.05'ten küçüktür. Buradan yola çıkarak analizin anlamlı bir seviyede olduğunu söylemek mümkündür.

IV. SONUÇLAR

Bu çalışmada Nimonic 50 süper alaşımı farklı kesme parametreleri ve farklı soğutma/yağlama ortamlarında frezelenerek enerji tüketimi araştırılmıştır. Ayrıca Taguchi analizi yapılarak deney sayısı ve maliyetler azaltılmıştır. Sonuçlar aşağıdaki gibidir.

- Yapılan deneyler sonucunda kesme hızı ve ilerleme hızı parametrelerinin artmasıyla enerji tüketiminin azaldığı tespit edilmiştir.
- Sürdürülebilir bir soğutma/yağlama stratejisi olan MMY sisteminin enerji tüketimi açısından en iyi seçenek olduğu belirlenmiştir.
- Taguchi analizi sonucunda enerji tüketimi üzerindeki en etkili kontrol faktörünün ilerleme hızı olduğu anlaşılmıştır. Ayrıca yapılan istatistiksel analizin anlamlı olduğu ve % 95 güven seviyesinde gerçekleştiği tespit edilmiştir.

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Hidroklorik Asit Ortamında Bor Karbür Katkılı Epoksilerin Sıvı Emilim Davranışlarının Belirlenmesi

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Özet – Epoksi esaslı polimer malzemeler uygulamalarda farklı çalışma ve ortam koşullarına maruz kaldığı için yapısal, termal ve mekanik özelliklerinde birtakım bozunmalar meydana gelmektedir. Özellikle kimyasal maddelere maruz kaldığı durumda, agresif kimyasalların yıkıcı etkisi ile, epoksi malzemelerin yapısal bütünlüğü bozunmakta ve bunun sonucunda da epoksi malzemelerin dayanımı azalmaktadır. Sunulan bu çalışma, hidroklorik asit (HCl) çözeltisi ortamına maruz bırakılan epoksi numunelerin sıvı emilim davranışlarını belirlemeyi ve bor karbür nanopartikülü katkısıyla da sıvı emilim miktarını iyileştirmeyi amaçlamaktadır. Bu kapsamda yapılacak deneysel çalışmalar için, hem katkısız hem de 3-glycidyloxypropyl trimethoxysilane (GPS) bileşiği ile modifiye edilen bor karbür nanopartikülleri %0.5, %1 ve %2 oranlarında epoksi reçine içerisine takviye malzemesi olarak eklenmiş ve epoksi bulk numuneler üretilmiştir. Üretilen epoksi numuneler 50°C'de HCl çözeltisine 30 gün süre maruz bırakılmıştır. Katkısız ve farklı oranlarda bor karbür nanopartikülleri katkılı numunelerin HCl asit çözeltisi ortamında sıvı emilim miktarları ağırlık ölçümü ile belirlenmiştir. Çalışmadan elde edilen sonuçlar birbiriyle karşılaştırmalı olarak değerlendirildiğinde, bor karbür nanopartikülü katkısının sıvı emilimini azaltan bir etki ortaya koyduğu belirlenmiştir.

Anahtar Kelimeler – Epoksi kompozit, Bor karbür nanopartiküllü, Sıvı emilimi, Nanoteknoloji, Yapısal karakterizasyon

I. GİRİŞ

Epoksi esaslı polimer malzemeler, geniş bir uygulama alanına sahiptir ve birçok farklı çalışma ve ortam koşuluna maruz kalabilmektedirler. Bu koşullar arasında sıcaklık değişimleri, nem ve kimyasal etkileşimler gibi faktörler bulunmaktadır. Bu tür koşullar, epoksi polimerlerin yapısal ve mekanik özelliklerinde bozunmalara neden olabilmektedir [1-2].

Yüksek sıcaklıklara maruz kalan epoksi malzemelerde termal bozunmalar meydana gelmektedir. Bu durum ise, malzemenin mekanik özelliklerinde azalmaya neden olmakta ve çatlama veya kırılma ile sonuçlanmaktadır. Güneş ışığına veya diğer ultraviyole (UV) kaynaklarına maruz kalan epoksiler, UV radyasyonuna bağlı olarak bozunmaktadırlar. Bu durum sonucunda ise renk değişikliği, yüzeyde çatlaklar veya malzemenin fiziksel ve mekanik özelliklerinde değişimlere neden olmaktadır [3-5]. Korkmaz ve Gültekin tarafından yapılan bir çalışmada, bor nanopartikülleri katkılı polimer malzemeleri ve yapıştırma bağlantılarını farklı sürelerde UV maruz bırakmışlardır. Çalışmanın sonucunda, UV ışığı altında epoksi polimer malzemelerin bozunmaya uğradığını ancak bor nanopartikülleri katkısıyla yapıda meydana gelen değişim ve bozunmaların daha az oranda gerçekleştiği ifade edilmiştir [3]. Barkoula ve arkadaşları da yaptığı çalışmada [6], farklı epoksi malzemeleri UV ortamına maruz bırakmış ve UV maruziyeti sonrasında tüm epoksi sistemlerinin çekme dayanımlarında azalma meydana geldiğini ifade etmiştir.

Epoksi esaslı malzemeler, uzun süre nem veya sıvıya maruz bırakıldıklarında, bulunduğu ortamdan nem ve sıvı emmekte ve bu durum da epoksi esaslı malzemelerin yapısal bütünlüğünü etkilemektedir. Özellikle suyun nüfuz etmesi, malzemenin içinde çatlaklar oluşturmakta ve mekanik özelliklerde olumsuz etkiler ortaya çıkarmaktadır. Korkmaz ve Gültekin [7], 40°C sıcaklıkta su ortamına 20, 40 ve 60 gün süre boyunca maruz bıraktıkları katkısız ve bor nanopartikülleri katkılı epoksi malzemelerin mekanik özelliklerinde zamana bağlı olarak azalmalar meydana geldiğini, ancak nanopartikül katkılı numunelerde bu azalma oranlarının daha düşük olduğunu rapor etmişlerdir. Wang ve arkadaşları [8] tarafından yapılan bir çalışmada ise, karbon nanofiber katkılı ve katkısız epoksi malzemeleri 40°C sıcaklıkta 180 gün boyunca saf suya maruz bırakılmıştır. Saf su maruziyeti sonrası yapılan testler neticesinde, karbon nanofiber katkılı malzemelerin çekme mukavemetinin, katkısız numuneye kıyasla yaklaşık %18 oranında daha fazla olduğu ifade edilmiştir. Uthaman ve arkadaşları [9], ağırlıkça %0,5, %1,0, %1,5 ve %2 oranlarında çok duvarlı karbon nanotüp katkılı epoksi malzemeleri sıvı ortamına maruz bırakmış ve malzemelerin termal, mekanik ve su emme davranışlarını incelemişlerdir. Yapılan test ve analizler sonucunda çok duvarlı karbon nanotüp katkılı (ağırlıkça %1,5) epoksi malzemelerde sıvı emiliminin daha az oranda gerçekleştiği ve bu durum sonucunda ise mekanik özelliklerde daha iyi sonuçlar elde edildiği bildirilmiştir.

Kimyasal maddelere maruz kalan epoksi polimerler kimyasal bozunmaya uğramaktadırlar. Örneğin; asitler, bazlar veya çözücüler gibi agresif kimyasallar, malzemenin yapısını değiştirmekte ve mekanik özelliklerini azaltmaktadır [10]. Malzemelerin çeşitli çalışma şartları altında maruz kaldıkları kimyasal etkiler epoksi malzemelerin kullanım ömrünü sınırlamaktadır. Dolayısıyla, epoksi malzemelerin çeşitli kimyasal ortamlara maruz kaldığında mekanik performansını değerlendirme önem arz etmektedir. Gültekin ve Korkmaz [11], bor nitrür ve bor karbür nanopartikülleri katkılı epoksi malzemeleri sülfürik asit ortamına farklı sürelerde maruz bırakmış ve sülfürik asit ortamında malzemelerin yapısında ve mekanik özelliklerinde meydana gelen değişimleri incelemişlerdir. Asit ortamına maruz kalan malzemelerin tamamında, zamana bağlı olarak mekanik özelliklerinde azalmaların meydana geldiği, fakat bu azalmanın epoksi içerisine eklenen partikül türüne göre farklılık gösterdiği ve bor nanopartikülleri katkısı ile mekanik özelliklerde meydana gelen bozunmanın daha düşük oranda gerçekleştiğini ifade etmişlerdir. Kotnarowska [12] tarafından yapılan çalışmada da, sülfürik asit ortamına maruz bırakılan numunelerde benzer bozunmaların gerçekleştiği ifade edilmiştir. Amaro ve arkadaşları [13], alkali ve asit çözeltilerine maruz malzemelerin eğilme özellikleri üzerindeki etkisini inceledikleri çalışmada, malzemelerin sodyum hidroksit ve hidroklorik asit çözeltilerine 36 gün maruz bırakıldıktan sonra sonra eğilme dayanımının sırasıyla yaklaşık %22 ve %16 oranında azaldığını ifade etmişlerdir. Stamenoviç ve arkadaşları [14], alkali ve asit çözeltilerinin cam-polyester kompozitlerin mekanik özellikleri üzerindeki etkisini araştırdıkları çalışmada ise, alkali çözeltinin çekme mukavemeti ve modülünü azalttığı ve bu azalma eğiliminin çözeltinin pH değerinin artmasıyla birlikte arttığını ifade etmişlerdir.

Epoksi esaslı malzemelerin maruz kaldıkları çeşitli agresif ortamlarda yapısında meydana gelen bozunmaları azaltmak, fiziksel ve mekanik özelliklerini geliştirmek için genellikle epoksi içerisine mikro ve nano boyutlu takviye malzemeleri eklenmektedir. Bu doğrultuda yukarıda bahsedilen ve literatüre yer alan çalışmalar incelendiğinde, epoksi içerisine eklenen çeşitli takviye malzemelerinin bozunmayı önemli oranda azalttığı görülmektedir. Bu bilgiler ışığında sunulan bu çalışma, hidroklorik asit (HCl) çözeltisi ortamına maruz bırakılan epoksi numunelerin sıvı emilim davranışlarını belirlemeyi ve bor karbür nanopartikülü katkısıyla da sıvı emilim miktarını iyileştirmeyi amaçlamaktadır. Bu kapsamda yapılacak deneysel çalışmalar için, hem katkısız hem de 3-glycidyloxypropyl trimethoxysilane bileşiği ile foksiyonelleştirilen bor karbür nanopartikülleri %0.5, %1 ve %2 oranlarında epoksi reçine içerisine eklenerek numuneler üretilmiştir. Üretilen epoksi numuneler HCl çözeltisine 30 gün süre maruz bırakılmıştır. Katkısız ve farklı oranlarda (%0,5,%1 ve %2) bor karbür nanopartikülleri katkılı numunelerin asit ortamında sıvı emilimi ağırlık ölçümü ile belirlenmiştir. Çalışmadan elde edilen sonuçlar birbiriyle karşılaştırmalı olarak değerlendirildiğinde, bor karbür nanopartikülü katkısının sıvı emilimini azaltan bir etki ortaya koyduğu belirlenmiştir.

II. MATERYAL VE YÖNTEM

Yapılan çalışmada epoksi olarak, iki bileşenli Araldite 2011 epoksi yapıştırıcısı kullanılmıştır. Araldite 2011 epoksisine ait kürleşme koşulları ve bileşen oranı Tablo 1'de verilmiştir.

Tablo 1. Yapıştırıcının kürleşme koşulları ve bileşim oranı

Bileşen Oranı (Epoksi:A/Sertleştirici:B)	**Kürleşme Şartı (Zaman/Sıcaklık)**
A:B=1:0,8	75 dakika/60°C

Epoksi içerisine eklenecek takviye malzemesi olarak ise hegzagonal bor karbür (B_4C) nanopartikülü kullanılmıştır. Bor karbür, yüksek sıcaklıkta kimyasal ve termal stabiliteye sahiptir. Bu özellik, yüksek sıcaklık uygulamalarında dayanıklı malzeme olarak tercih edilmesini sağlamaktadır. Ayrıca, bor karbür, asitlere, bazlara ve çoğu çözücüye karşı dayanıklıdır ve kimyasal olarak inert kabul edilir. Bu özellikleri nedeniyle, bor karbür çeşitli endüstriyel uygulamalarda sıklıkla kullanılmaktadır. Çalışma kapsamında kullanıla bor karbür partikülüne ait elemantel analiz sonuçları Tablo 2'de verilmiştir.

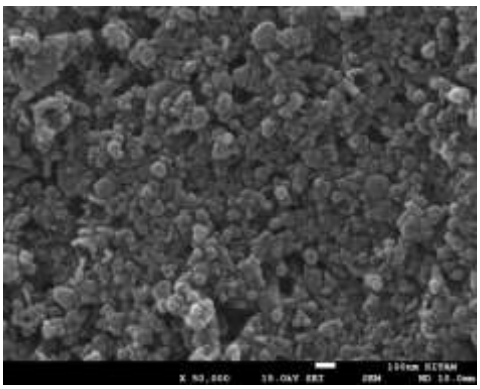
Tablo 2. Bor karbürün element analiz sonuçları [15-16]

B	**C**	**O**	**N**	**Si**	**Fe**	**Ni**
% 77,48	%21,52	%<0,1	% 0,08	% 0,1	% 0,1	% 0,01

Çalışmada kullanılan bor karbür nanopartikülün özellikleri Tablo 3'te, SEM görüntüsü ise Şekil 1'de verilmiştir.

Tablo 3. Bor nanopartikülünün özellikleri [17]

Kristal Faz	Hegzagonal
Saflık	%99,5
Partikül Boyutu	40-60 nm
Form	Toz
Yoğunluk	0,1 g/cm^3
Elastisite Modülü	445 GPa
Erime Noktası	2540 °C



Şekil 1. Bor nanopartikülünün SEM görüntüsü [18]

Nanopartiküllerinin yüzeylerinin fonksiyonelleştirmesi epoksi matris içerisinde dispersiyon stabilitesini artırmak ve matris ile iyi bir bağ kurmasını sağlamak için kullanılan bir yöntemdir. Bu yöntemde kullanılan bileşenler bağlayıcı ajanlar olarak isimlendirilmektedir. Sunulan çalışmada epoksi matris ve bor karbür arasındaki etkileşimi arttırmak amacıyla 3-(glycidyloxypropyl) trimethoxysilane silan bağlayıcı ajan kullanımı tercih edilmiştir.

Fonksiyonelleştirme işleminin ilk adımında, 0.5 gram bor karbür nanopartikülleri, saf su ve etil alkol karışımıyla hazırlanan 1:1 oranındaki çözeltiye eklenerek, 30 dakika boyunca ultrasonik karıştırıcıyla homojen bir şekilde karıştırılmıştır. Ardından, elde edilen karışıma 6 ml silan bileşiği eklenerek, çözeltinin pH değeri hacimce %10 oranında CH_3COOH kullanılarak 7'ye ayarlanmıştır. Hazırlanan çözelti, balon

içine alınıp, 40℃ sıcaklıkta 5 saat boyunca geri soğutma işlemine tabi tutulmuştur. Bu işlemin ardından, çözelti, santrifüj tekniği kullanılarak saf su ve etil alkol ile birkaç kez yıkanarak, silan bileşiklerinden arındırılmıştır. Son aşamada, bor karbür nanopartikülleri etüvde kurutulmuştur. Detaylı bilgiler ve tartışma önceki çalışmalarda yer almaktadır[16, 19].

Şekil 2. Bor karbür fonksiyonelleştirme işlemi

3-(glycidyloxypropyl) trimethoxysilane ile fonksiyonelleştirilen bor karbür nanopartiküllerinin epoksi matris içerisinde homojen bir dağılım gerçekleştirebilmesinin sağlanması oldukça önemlidir. Bu amaçla, ilk olarak, bor nanopartikülleri tartılarak bir beher kaba konulmuştur. Bor nanopartiküllerinin homojen bir şekilde dağılımını sağlamak amacıyla, üzerlerine aseton eklenip ultrasonik karıştırıcıda 15 dakika boyunca karıştırılmıştır. Daha sonra, belirlenen miktarlarda epoksi, aseton ve nanopartikül karışımı içine eklenmiştir. Hazırlanan karışım sırasıyla 30 dakika ultrasonik karıştırıcıda ve yüksek devirli mikserde karıştırılmıştır. Daha sonra, karışımdaki asetonun buharlaşması için karışım bir etüvde bekletilmiş ve asetonun buharlaşma durumu, belirli aralıklarla hassas bir terazi kullanılarak kontrol edilmiştir. Asetonun tamamen buharlaştığına emin olduktan sonra, karışıma epoksi/sertleştirici oranına uygun miktarda sertleştirici ilave edilerek 10 dakika boyunca elle karıştırılmıştır. Epoksilerin hazırlama işlemi sonrasında ise, üretilen epoksiler kalıba dökülerek kürleştirme işlemi uygulanmıştır. Bu amaçla ilk olarak kalıp bir yağlayıcı ile yağlanmış ve ardından üretilen epoksiler kalıba dökülmüştür. Kalıp daha sonra etüv içerisine yerleştirilerek kürleşme işlemi gerçekleştirilmiştir (Şekil 3).

Şekil 3. Epoksi numunelerin üretimi

Üretilen katkısız ve bor karbür katkılı epoksi numuneler %10 hidroklorik asit çözeltisine 30 gün süre boyunca maruz bırakılmıştır. Hazırlanan hidroklorik asit çözeltisin asitten etilenmeyen bir cam kap içerisine döküldükten sonra numuneler çözelti içerisine daldırılmıştır. Numunelerin içerisinde yer aldığı çözelti 30 gün boyunca etüv içerisinde bekletilmiştir.

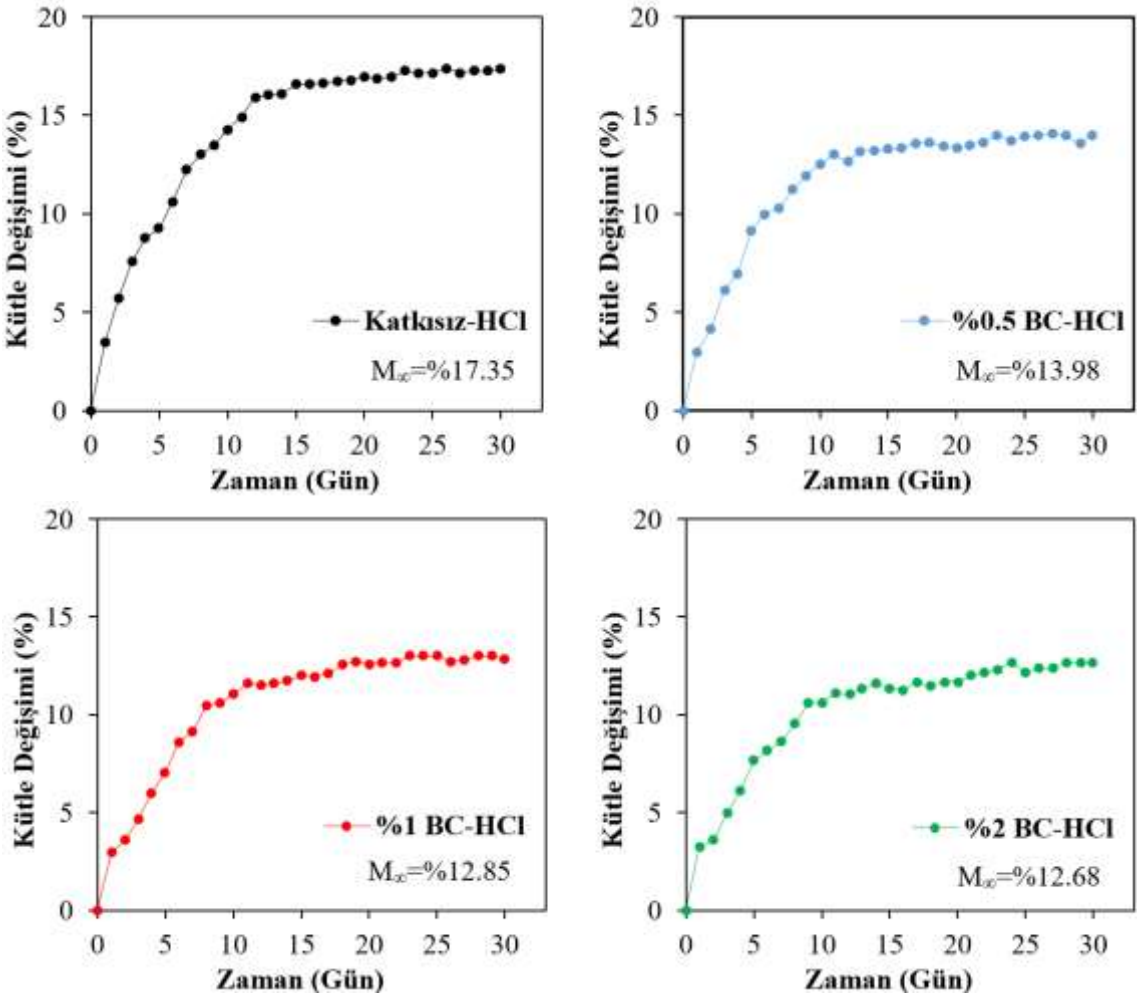
Üretilen numunelerin hidroklorik asit ortamına maruz kalmasıyla ilgili kütle değişim miktarları, periyodik olarak hassas terazi kullanılarak yapılan kütle ölçümleriyle belirlenmiştir. Tamamlanan ölçümler sonucunda, zamana bağlı olarak kütle değişimini gösteren grafikler elde edilmiştir. Bu grafikler, numunelerin ortamla etkileşime girdiği süre boyunca yaşadığı kütle değişimini ve bu değişimin zamanla

nasıl değiştiğini göstermektedir. Bu veriler, numunelerin belirli ortamlarda nasıl davrandığını ve çevresel koşullar altında nasıl değişiklikler yaşadığını anlamak için önemli bilgiler sunmaktadır.

III. BULGULAR VE TARTIŞMA

Katkısız ve 3-glycidyloxypropyl trimethoxysilane (GPS) bileşiği ile modifiye edilen %0.5, %1 ve %2 oranlarında bor karbür nanopartikülleri epoksi numunelerin hidroklorik asit ortamına maruz bırakılması sonucu, hassas terazi yardımıyla kütle değişimleri ölçülmüş olup, sonuçlar zamana bağlı grafiksel olarak Şekil 4'te verilmiştir. Epoksi numunelerinin su emme miktarı Denklem 1 kullanılarak belirlenmiştir.

$$M_t = \frac{m_t - m_i}{m_i} \times 100 \qquad (1)$$



Şekil 4. Hidroklorik asit ortamına maruz numunelerin kütle değişimi-zaman grafikleri

Katkısız ve 3-glycidyloxypropyl trimethoxysilane (GPS) bileşiği ile modifiye edilen ağırlıkça %0.5, %1 ve %2 bor karbür nanopartikülleri katkılı epoksi numunelerin kütle değişim grafikleri incelendiğinde, tüm numunelerde hidroklorik asit ortamında sıvı emilimi gerçekleştirdiği ancak emilen sıvı miktarının üretilen epoksi numunelerin türüne yani partikül takviye oranına bağlı olarak değişiklik sergilediği görülmektedir. Epoksi numuneleri, hidroklorik asit çözeltisine maruz bırakıldıklarında, maruziyetin başlangıcında hızlı ve yoğun bir sıvı emilimi göstermiştir. Zaman ilerledikçe, numuneler denge durumuna yaklaştıkça sıvı emilimi yavaşlamıştır.

30 gün sonunda katkısız, %0.5, %1 ve %2 oranlarında bor karbür katkılı epoksi numunelerin kütle değişimleri sırasıyla %17,35, %13,98, %12,85 ve %12,68 oranlarında elde edilmiştir. Bor karbür nanopartiküllerinin hidrofobik doğası, kimyasallara karşı inert davranması ve sıvı emilimini engelleyici

özellikleri sayesinde bor karbür katkılı numunelerin hidroklorik asit ortamında sıvı emilimi katkısız numune ile kıyaslandığında daha az oranda elde edilmiştir. Korkmaz ve Gültekin [7], tarafından yapılan bir çalışmada, katkısız, bor nitrür ve bor karbür katkılı epoksi numuneler saf su ortamına maruz bırakmışlardır. Çalışma sonucunda, doygunluk durumunda katkısız, bor nitrür ve bor karbür katkılı kompozitlerin kütle değişimleri sırasıyla %2,98, %2,26 ve %2,48 oranlarında elde edildiği ifade edilmiştir.

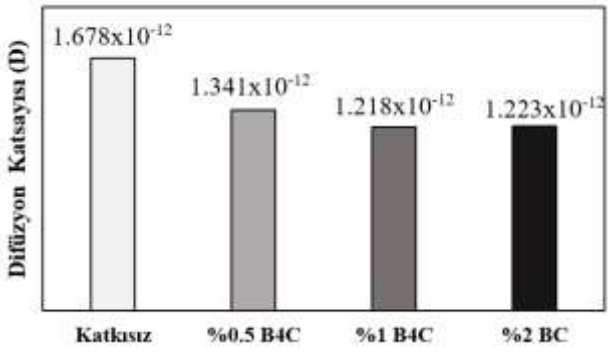
Epoksi matris içindeki boşluklar, yani serbest hacimler, sıvı emilimine olanak sağlamaktadırlar. Bor karbür nanopartikülleri ile takviye edilen epoksi numuneler içindeki bu boşluklar azalmakta ve bunun sonucunda ise sıvı emilimi daha düşük oranda gerçekleşmetedir. Bor karbür nanopartikülleri 3-glycidyloxypropyl trimethoxysilane bileşiği ile fonksiyonelleştirildiğinde, difüzyon yolları üzerinde bir bariyer görevi görürler ve partiküller sıvı geçirmez bir film gibi davranırlar. Bu nedenle, katkılı numunelerde sıvı emiliminin daha düşük olduğu söylenebilir. Epoksi numunelerin yüksek orandaki sıvı emilimindeki önemli faktörlerden biri, numunenin bulunduğu ortamın sıcaklığıdır. Ortamın sıcaklığı, sıvı moleküllerinin hareketliliğini arttırırken aynı zamanda epoksi matris tarafından emilen sıvı miktarını da artırmaktadır.

Epoksi içerisine eklenen bor karbür partikül oranının artmasıyla birlikte, sıvı emilim oranlarının azaldığı elde edilen sonuçlardan görülmektedir. Epoksi matris takviye malzemesi olarak eklenen bor karbür nanopartikülleri oranı arttıkça, matris içerisindeki boşlukları daha fazla doldurduğu, sıvı emilim yollarında daha fazla bariyer görevi gördüğü ve bu durum sonucunda da sıvı emiliminin azaldığı ifade edilebilir.

Epoksi numunelerde sıvı emilimi, difüzyon süreciyle gerçekleşmektedir. Difüzyon katsayısı (D), difüzyon mesafesiyle ilişkilidir ve bu mesafe, matris içindeki takviye malzemelerinin varlığı nedeniyle uzamaktadır. Sonuç olarak, sıvı difüzyonu epoksi malzeme içinde yavaşlar ve daha düşük bir difüzyon katsayısı elde edilir. Katkısız ve bor karbür katkılı numunelerin difüzyon katsayıları Denklem 2'ye göre hesaplanmıştır.

$$D = \pi \left[\frac{h}{4 \times (\%M_{\infty})}\right]^2 \times \left[\frac{(\%M_2 - \%M_1)}{\sqrt{t_2} - \sqrt{t_1}}\right]^2 \quad (2)$$

Denklemde; D difüzyon katsayısı, h numune kalınlığı, M_∞ doygunluk anındaki sıvı emilim yüzdesi, $\%M_2$-$\%M_1$ yaşlandırma periyodunun ilk zamanında (t_2-t_1) kütle değişimin grafiğinin eğimini ifade etmektedir. Hidroklorik asit ortamına maruz bırakılan katkısız ve %0,5, %1 ve %2 oranlarında bor karbür katkılı epoksi numunelerin difüzyon katsayıları Denklem 2 kullanılarak hesaplanmış ve Şekil 5'te verilmiştir.



Şekil 5. Epoksi numunelerin difüzyon katsayıları

Epoksi numunelerin difüzyon katsayıları incelendiğinde, katkısız epoksi için $1{,}678 \times 10^{-12}$ m^2/s olarak hesaplanırken, ağırlıkça %0,5, %1 ve %2 bor karbür katkılı epoksi numunelerde ise difüzyon katsayıları sırasıyla $1{,}341 \times 10^{-12}$ m^2/s, $1{,}218 \times 10^{-12}$ m^2/s ve $1{,}223 \times 10^{-12}$ m^2/s bulunmuştur. Epoksi matrisin difüzyon yolları üzerindeki fonskiyonelleştirilmiş bor karbür nanopartikülleri, sıvı moleküllerinin matris içine daha fazla difüzyonunu engelleyerek difüzyon mesafesini uzatmıştır. Bu durum, bor karbür katkılı epoksi numunelerin, katkısız numunelere kıyasla daha düşük difüzyon katsayılarına sahip olmasını sağlamıştır.

IV. SONUÇLAR

Katkısız ve bor karbür nanopartikülleri katkılı epoksi numuneler HCl asit ortamına maruz bırakılarak numunelerin sıvı emilim davranışları incelenmiş ve çalışmadan aşağıdaki sonuçlar elde edilmiştir:

1) Tüm numunelerde hidroklorik asit ortamında sıvı emilimi gerçekleştirdiği ancak emilen sıvı miktarının üretilen epoksi numunelerin türüne yani partikül takviye oranına bağlı olarak değişiklik sergilediği belirlenmiştir.
2) Bor karbür nanopartiküllerinin hidrofobik doğası ve kimyasallara karşı inert davranması gibi özellikleri sayesinde hidroklorik asit ortamında sıvı emilimi katkısız numune ile kıyaslandığında daha düşük oranda elde edilmiştir.
3) Epoksi içerisine eklenen bor karbür partikül oranının artmasıyla birlikte, sıvı emilim oranlarının azaldığı belirlenmiştir.
4) Difüzyon yolları üzerindeki bor karbür nanopartikülleri, sıvı moleküllerinin matris içine daha fazla difüzyonunu engelleyerek katkısız numunelere kıyasla daha düşük difüzyon katsayılarına sahip olmasını sağlamıştır.

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Influence of Various FRP Reinforcement Types and Concrete Strength on Structural behavior of Flexural Members

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Abstract – In this study, the flexural behavior of hybrid beams incorporating various fiber-reinforced polymer (FRP) bars and concretes made with different fibers was investigated. The hybrid beams were constructed by embedding polypropylene, steel, and glass fiber concretes into glass-fiber reinforced polymer (GFRP) box profiles. Flexural tests were conducted using carbon, aramid, glass, basalt, and steel bars in the tensile zone for each beam type. Load-deflection graphs were generated, and the flexural strengths of the hybrid beams were calculated and compared. The performance of the different FRP bars and fiber types was analyzed and interpreted. The results were evaluated in terms of the impact of both bar type and fiber type on the behavior of the hybrid beams. It was determined that carbon fiber reinforced polymer (CFRP) bars provided the highest contribution to hybrid beam behavior, enhancing flexural strength by 70%, while steel fiber concrete offered the greatest improvement among fiber concrete types, increasing flexural strength by 56%.

Keywords – Beams; fiber reinforced polymer (FRP); flexural strength; fibers

1. INTRODUCTION

Despite some limitations, the development and design of numerous building materials have addressed concerns about poor quality. Concrete and steel are fundamental components in construction, but concrete's low tensile strength and steel's corrosive nature and high unit weight present significant challenges for environmental sustainability. To overcome these issues, the design of sustainable building materials has garnered significant attention from scholars. For example, fiber-reinforced polymer (FRP) composites have become increasingly popular due to their light weight, resistance to corrosion, and high tensile strength. Additionally, the hybrid application of FRP composites with conventional construction materials has been tested and found to be effective in reinforcing and strengthening various structural elements [1-6]. Primarily, these composites have been applied to overcome the lack of benefits of conventional products such as corrosion of steel bars [5, 7-12]. Furthermore, a wide range of literature has been devoted to fiber-reinforced concrete material. For instance, different works may be consulted to assess the suitability of fibers with varying proportions and their intended characteristics in concrete [13, 14].

To replace the reference specimens containing steel reinforcing bars in concrete, this study analyzes hybrid beam specimens that incorporate four distinct types of FRP bars: basalt fibers, glass, aramid, and carbon. Additionally, three different fiber types—steel, glass, and polypropylene—were integrated into the concrete during the fabrication of multivariate experimental classes. These fibers were added to develop the profiles of GFRP test specimens. The reinforcing bars with fiber-reinforced concrete specimens were then evaluated

through flexural testing, producing load-displacement plots of the beam specimens. Based on these findings, flexural strength plots were developed and analyzed.

2. MATERIALS AND METHOD

2.1. MATERIALS

The geometric details of the 500 mm long GFRP box profiles, while the cross-sectional dimensions were 75×75×4 mm. Furthermore, the hybrid beam specimens contained a 10 mm diameter of FRP ribbed reinforcing bars in the tensile region. Table 1 enlists the test features of FRP bars, steel, and GFRP profiles. Concrete with 37 MPa of compression strength was employed in the GFRP box profile. Furthermore, to examine the impact of varying fiber types on the flexure strength of fiber-reinforced concrete specimens 1% of glass, steel, and polypropylene fibers were incorporated. Table 2 provides the associated features of the fibers. Figure 1 shows the stress-strain curves of FRP bars.

Table 1. Characteristics of FRP materials

.

	GFRP profile	Steel Bar	AFRP Bar	BFRP Bar	CFRP Bar	GFRP Bar
Specific gravity	1.78	7.68	1.42	1.55	1.55	1.87
Tensile Strength (MPa)	610	555	1320	1125	1340	950
Longitudinal fiber (%)	41	–	74	74	74	74
Young Modulus (GPa)	31	200	60	55	125	48

Table 2. Fiber properties

	Steel fiber	Polypropylene fiber	Glass fiber
Specific gravity	7.78	0.89	2.45
Tensile Strength (MPa)	1110	655	1710
Fiber diameter and length (mm)	1–28	1–28	0.1–28

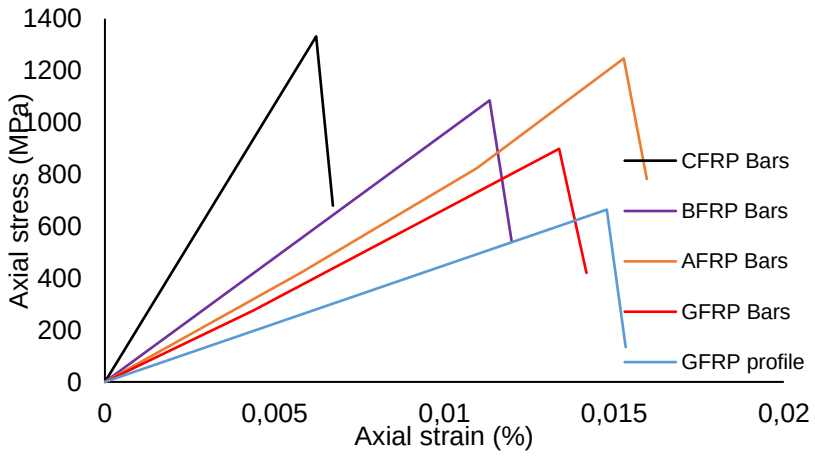

Figure 1. FRP bars and GFRP box profile tensile charts

2.2. Fabrication and Testing of Specimens

To test the specimens, 5 distinct classes of reinforcing bars were included for GFRP box profiling. These types were chosen as steel bars, GFRP and basalt fiber reinforced polymer (BFRP) bars, aramid fiber reinforced polymer (AFRP) bars, and carbon reinforced polymer (CFRP) bars. In addition, the experimental

design involved the flexural testing of beam specimens fabricated by utilizing three distinct classes of fibers glass fibers, polypropylene fibers, and steel fibers. In addition, the flexural response and fracture toughness of beam specimens were noted by observing the loading–deflection plots. The experimental design involved fabricating two hybrid beams from each beam class, using the mean values of the results to create the final tables and plots. Hybrid beam specimens made with plain concrete were labeled with the prefix 'RH,' serving as the control model. Specimens with steel fiber concrete were labeled 'SH,' and those with glass fibers were labeled 'GH.' The bars used to reinforce the tensile region of the flexural components were designated as steel, GFRP, AFRP, CFRP, and BFRP. For example, beam specimens without bars were referred to as 'WH,' while specimens without GFRP bars and fiber profiles were termed 'Plain Concrete.' Beam specimens with polypropylene fibers, glass fibers, and steel fibers were labeled 'PFRC,' 'GFRC,' and 'SFRC,' respectively.

Hybrid specimens reinforced with steel bars in the tensile regions and lean concrete were labeled as RH-steel bars specimens. Hybrid specimens with GFRP bars in the tensile regions and glass fiber concrete were termed GH-GFRP specimens. Concrete specimens with polypropylene fibers but no bars were referred to as 'PH-WR' specimens. During testing, all bars (GFRP, Steel, BFRP, AFRP, and CFRP) were placed within the GFRP profile along with fiber and non-fiber concrete in the tensile region. The span width of 400 mm was maintained during the tests. A computer-connected flexural testing machine with a 50 kN capacity was used to test the 500 mm long beam specimens at a loading speed of 2 mm/min. Displacements were recorded at the mid-region of the 400 mm effective span. Figure 2 illustrates the flexural testing of the specimens.

Figure 2. Four-point beam tests

3. Discussion of Results

3.1.1. Impact of Reinforcement Material

After testing the specimens for flexure, the load-deflection plots were compiled and compared. Figure 3a provides insights into the comparative statistics of the flexure of hybrid specimens without fiber modification. The plots (Figure 3a) of beam specimens with different bars revealed that the flexural loading retained the lowest value of only 4.5 kN, with an abrupt sign of fracture. However, the plain concrete sourced RH specimens presented a linear pattern, attaining the largest flexural loading of up to 20.5 kN. Similarly, RH-BFRP specimens reinforced with basalt fibers exhibited comparatively reduced stiffness, achieving a loading of 22.5 kN. RH-GFRP sourced specimens fabricated with glass fiber bars, as well as RH-AFRP specimens with aramid fiber bars, presented a linear response with flexural loadings of 23.5 kN and 24.5 kN, respectively. Compared to other beams, RH-SFRP specimens achieved the greatest flexural loading, reaching 26.2 kN. However, these specimens showed reduced stiffness beyond 15.5 kN of loading. In contrast, RH-CFRP specimens reached a flexural loading of 26 kN. Except for plain concrete beams, most hybrid specimens sustained loading after breakage without any minor signs of rupture. Figure 3b

illustrates the behavior of polypropylene-sourced specimens in GFRP profiles. In contrast to PFRC specimens with reduced flexural loadings, the hybrid specimens with plain concrete achieved a flexural loading of 18.8 kN. As the flexural loading increased, the stiffness of PH-GFRP beams notably decreased, reaching a maximum load of 24.5 kN. Results revealed that PH-CFRP and PH-AFRP specimens achieved flexural loadings of 22.8 kN and 26 kN, respectively, with CFRP-based specimens demonstrating comparatively greater stiffness in flexure. Although a few signs of fracture were noted for PH-BFRP specimens, the CFRP-strengthened beams exhibited a response similar to that observed for PH-BFRP specimens. Furthermore, PH-BFRP beams sustained the greatest flexural loading of 23.6 kN, displaying a comparatively higher value of toughness. Figure 3c elaborates on the flexural performance of glass fibers sourced from hybrid specimens.

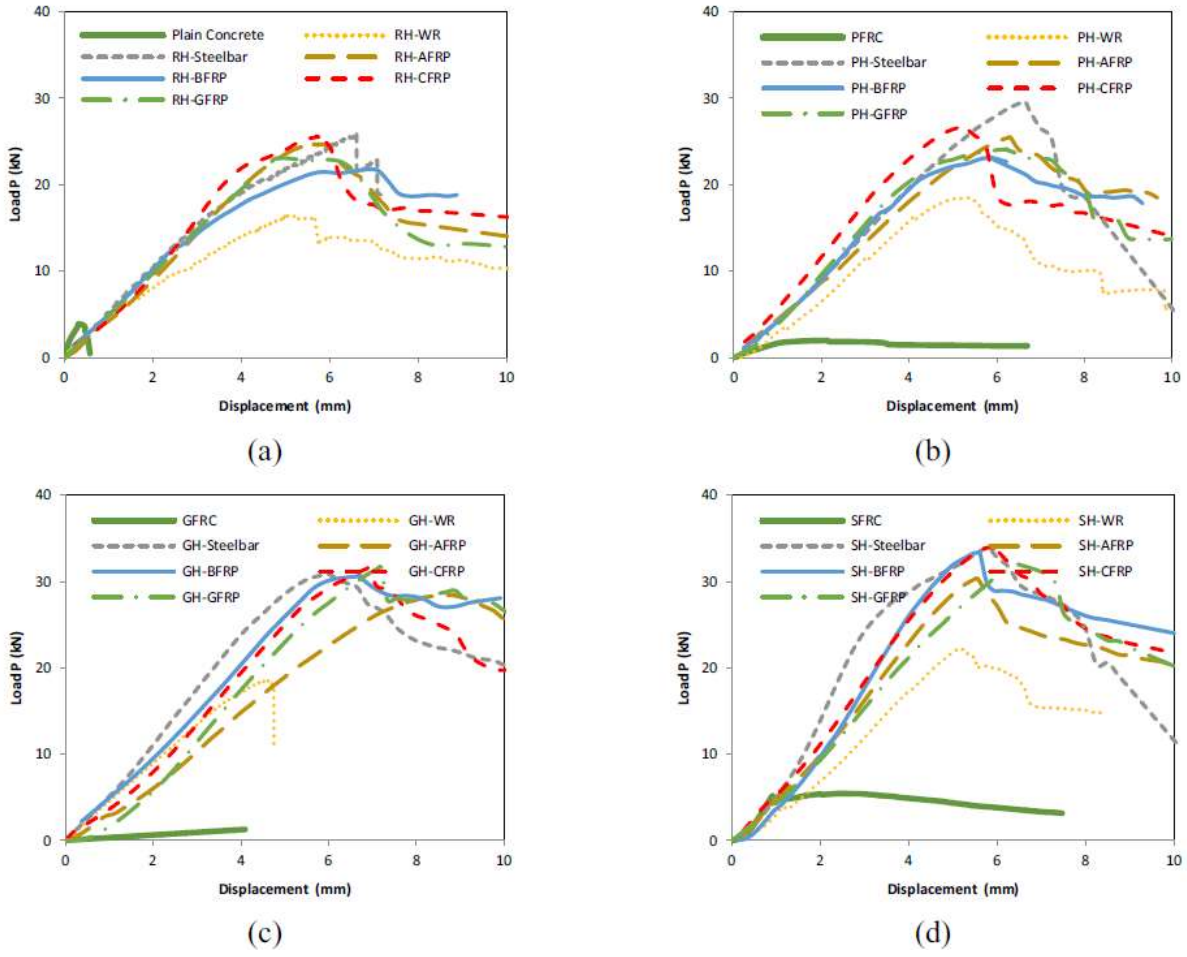

Figure 3. Loading-displacement plots of reinforced hybrid beam specimens a) non-fiber b) polypropylene fibers c) glass fibers d) steel fibers.

Compared to the GFRC specimens, the GH-WR beams exhibited a linear response, reaching the highest flexural load of 19 kN. While the peak sustained flexural loads in most of the hybrid specimens were close to one another, the highest loads were 32.1 kN, 31.4 kN, 28.9 kN, 32 kN, and 31.1 kN for the respective GH-CFRP, GH-Steel bars, GH-AFRP, GH-GFRP, and GH-BFRP specimens. Notably, the GH-Steel bars specimens achieved the greatest stiffness, whereas the carbon and glass sourced specimens demonstrated nearly identical flexural strength. Figure 3d illustrates the response of steel fiber-based hybrid concrete specimens. Although the SRFC specimens developed lower flexural strength, the test beams exhibited a ductile response. In contrast, the SH-sourced steel fiber-based GFRP profile concrete specimens achieved the highest load, with a corresponding value of 22.7 kN. Even though the beams in this class developed

flexural loads similar to those observed for SRFC specimens, these beams were free from abrupt cracking. Comparing the flexural response of different beam specimens, test findings revealed that the SH-GFRP and SH-AFRP followed a linear pattern up to the highest flexural load, which was 32.5 kN and 30.8 kN, respectively. According to the test findings, the flexural load for the SH-Steel bars, SH-BFRP, and SH-CFRP beam specimens was nearly 34.5 kN. Nonetheless, the SH-Steel bars beams achieved the highest stiffness. Both the SH-BFRP and SH-GFRP beam specimens exhibited a linear pattern under applied loading conditions. When assessing the impact of bar type on flexural strength, results showed that the steel-based beam specimens developed the highest flexural strength. Additionally, when comparing the bar-free hybrid beams, it was found that steel-sourced beams achieved a 57.5% increase in flexural strength. Meanwhile, AFRP, BFRP, CFRP, and GFRP strengthened specimens showed increases of 50.5%, 33.5%, 56.5%, and 40.5%, respectively. Compared to FRP-strengthened beams, this rise in strength for CFRP, BFRP, AFRP, and GFRP was greater by 1.5%, 18.5%, 5.5%, and 12.5%, respectively.

Among the other hybrid beam specimens, the beams with CFRP and steel achieved the highest flexural strength, with an increase in flexural strength of nearly 54.5%. However, compared to steel fibers reference beams, the specimens with BFRP, AFRP, and GFRP achieved gains of 34%, 37.5%, and 44.5%, respectively. AFRP, BFRP, and GFRP strengthened specimens with CFRP and steel presented the highest flexural strength, with corresponding increases in flexural strength of 12.5%, 2.5%, and 6.5%. When compared to hybrid beam specimens without polypropylene fibers, the corresponding flexural strength for steel, AFRP, BFRP, CFRP, and GFRP sourced specimens improved by 35.5%, 40.5%, 27.5%, 47.5%, and 32.5%, respectively. Nevertheless, the CFRP-sourced specimens with polypropylene fibers achieved the highest strength. This measured strength was 5.5% greater than that observed for AFRP beam specimens. Likewise, the observed strength was 8.5%, 12.5%, and 16.5% higher for corresponding modifications in specimens with steel, GFRP, and BFRP materials. Although specimens with glass fibers developed nearly similar flexural strength, the GFRP and CFRP reinforced specimens achieved the greatest strength. Yet, compared to the glass fiber sourced specimens, the beams in this class achieved a higher rate of strength increase. Compared to hybrid specimens with no glass fibers, steel-based beam specimens showed a 67.5% increase in strength. Similarly, compared to AFRP, BFRP, CFRP, and GFRP sourced specimens, observed strength improved by 54.5%, 63.5%, 70.5%, and nearly 70.5%, respectively. When compared to the strength of GFRP and CFRP, the specimens with steel, AFRP, and BFRP developed 2.5%, 10.5%, and 4.5% greater flexural strength, respectively.

3.1.2. Impact of Concrete Type

Figure 4a illustrates the impact of fiber reinforcement on concrete specimens of the same class of strengthened beams. The analysis revealed that both non-fibrous and polypropylene fiber-reinforced specimens sustained almost 25.5 kN of flexural loading. However, the glass fiber-reinforced specimens sustained the highest loading of up to 31.4 kN. The highest loading was observed in the steel fiber-reinforced beams, which sustained a load of 34.5 kN. Additionally, as the strength of the steel fiber and glass fiber-reinforced beams increased, the corresponding toughness of these beams also significantly improved. Conversely, polypropylene fibers had a negligible impact on the flexural response. Figure 4b illustrates the effect of fibers on AFRP-based hybrid concrete specimens, showing that the non-fibrous control beams, designated as RH-AFRP, sustained 24.85 kN of flexural loading. Similarly, the PH-AFRP specimens sustained a flexural loading of 25.75 kN. This increase in flexural loading was accompanied by a corresponding increase in toughness. The GH-AFRP and SH-AFRP specimens sustained flexural loadings of 28.85 kN and 30.90 kN, respectively. The SH-AFRP beams exhibited a notable increase in toughness compared to the control and polypropylene fiber-reinforced beams. The steel and glass fiber-reinforced beams demonstrated increased stiffness and flexural loading [15].Figure 4c shows the impact of fibers on BFRP-reinforced beam specimens. The reference RH-BFRP specimens without fibers sustained 22.05 kN of flexural loading. Similarly, the PH-BFRP specimens sustained 23.35 kN. This increase in flexural loading was associated with a corresponding increase in toughness. The GH-BFRP and SH-BFRP specimens carried flexural loadings of 31.10 kN and 33.90 kN, respectively. The SH-BFRP beams showed

a significant increase in flexural loading. Both the steel and glass fiber-reinforced beams exhibited increased stiffness and strength in flexure. Figure 4d presents the impact of fibers on CFRP-reinforced hybrid beam specimens. The RH-CFRP control beams without fibers sustained nearly 25.85 kN of flexural loading. The polypropylene fiber-reinforced hybrid beams (PH-CFRP) sustained approximately 26.95 kN. The SH-CFRP and GH-CFRP beams carried loadings of 34.5 kN and 32.00 kN, respectively. The steel fiber-reinforced beams sustained the greatest loading, followed by the glass fiber-reinforced beams. In contrast, the polypropylene fiber-reinforced specimens showed loading values similar to the non-fiber beam specimens.

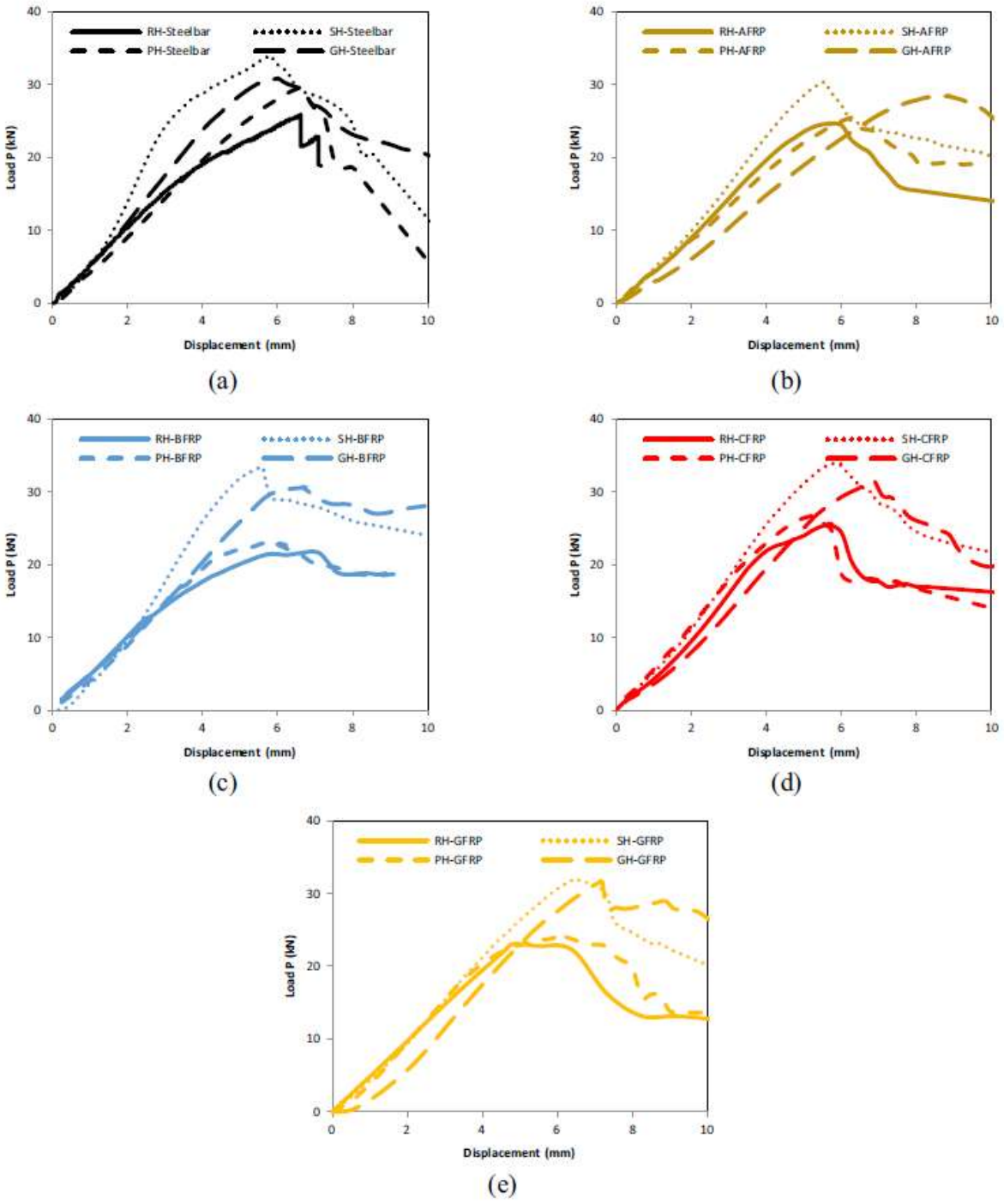

Figure 4. Load-displacement graphs of reinforced hybrid beams (a) steel bar b) AFRP bar c) BFRP bar d) CFRP bar e) GFRP bar

A plot dedicated to assessing the response of GFRP-sourced beam specimens is shown in Figure 4e. This class, comprising all the GFRP hybrid beam specimens, achieved the corresponding flexure loading of 23.5 kN for RH-GFRP and 24.5 kN for PH-GFRP beams. Similarly, SH-GFRP and GH-GFRP specimens sustained loadings of 32.5 kN and 32.1 kN, respectively. Hence, the beams with steel fibers, glass fibers, and polypropylene fibers demonstrated a notable capacity to carry the greatest flexure loading. When assessing the impact of fibers, the analysis revealed that the specimens with steel fibers achieved the greatest flexure strength. Moreover, these specimens contained GFRP box profiles without bars. In contrast to hybrid beams without fibers, the steel fiber specimens showed a 35.5% increase in flexure strength. Likewise, the specimens with glass fibers and polypropylene fibers exhibited strength increases of 13.5% and 11.5%, respectively. Comparing the fiber-based beams, the results indicated that steel fiber concrete beams achieved 22.5% greater strength than polypropylene fiber beams and 20.5% greater strength than glass fiber specimens. Compared to non-fiber steel beams, the steel-reinforced hybrid beams with steel fibers and glass fibers showed increases in flexure strength of 32.5% and 19.5%, respectively. However, the beam specimens with steel bars and polypropylene fibers did not show any increase in flexure strength. Results revealed that steel fiber beams achieved 10.5% greater strength than glass fiber steel hybrid beams and 37.5% greater strength than polypropylene fiber steel-reinforced beam specimens. When comparing AFRP-reinforced hybrid beams without fibers, the AFRP beams with steel fibers achieved a rise in flexure strength of nearly 23.5%. Similarly, the AFRP specimens with polypropylene fibers and glass fibers exhibited strength increases of 3.5% and 15.5%, respectively. Moreover, the flexure strength of AFRP-reinforced beam specimens with steel fibers and polypropylene fibers was 19.5% and 7.5% greater than those with glass fibers. Conversely, AFRP beams with glass fibers showed 12.5% greater flexural strength than those with polypropylene fibers.

Compared to BFRP beam specimens without fibers, the specimens with steel fibers, polypropylene fibers, and glass fibers showed increases in flexure strength of 56.5%, 6.5%, and 10.5%, respectively. Similarly, compared to polypropylene and glass fiber BFRP beams, the BFRP specimens with steel fibers developed 45.5% and 10.5% greater flexural strength, respectively. Additionally, the BFRP specimens with glass fibers achieved 31.5% greater flexural strength compared to those with polypropylene fibers. Compared to the reference CFRP bars hybrid beams without fibers, the specimens with steel fibers and CFRP bars showed a 33.5% increase in flexure strength. This rise was 5.5% and 23.5% for the polypropylene fibers and glass fibers sourced CFRP hybrid specimens, respectively. Compared to polypropylene fiber-based CFRP hybrid beam specimens, steel fibers in CFRP-strengthened hybrid beams achieved 27.5% greater flexure strength. Furthermore, the CFRP specimens with CFRP bars and glass fibers developed 18.5% greater flexural strength compared to the GFRP specimens with polypropylene fibers. Compared to the reference GFRP bars hybrid beams without fibers, the specimens with steel fibers and GFRP bars showed a 39.5% increase in flexure strength. This rise was 5.5% for polypropylene fibers and GFRP bar hybrid specimens. Conversely, glass fibers and GFRP bars-based beams achieved a 37.5% increase in flexure strength. Additionally, the GFRP specimens with steel fibers achieved 33.5% greater flexural strength compared to those with polypropylene fibers, and 1.5% greater flexural strength compared to those with glass fibers. Compared to hybrid beams with GFRP bars and polypropylene fibers, GFRP-strengthened beams with glass fibers achieved 31.5% greater flexure strength.

4. Conclusions

The study examined the impact of bar types and fibers on these variables which concluded the following key findings:

- Compared to WR bars, steel bars strengthened RH beams, and SH beams showed increases of 157% and 154% in flexural strength, respectively. Similarly, CFRP strengthened SH beams and PH beams exhibited respective gains of 147% and 170% in flexural strength. Among these, GFRP hybrid specimens with GH class achieved the highest strength.
- Comparing fibers of the RH class, steel-bar strengthened SH beams showed a 132% increase in flexural strength. Additionally, AFRP, BFRP, CFRP, and GFRP bars strengthened SH beams,

resulting in improvements of 123%, 156%, 133%, and 139%, respectively. Among these, GFRP hybrid specimens with SH class achieved the highest strength.

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Impact of Concrete Strength and FRP Reinforcement Type on Fracture Toughness and Stiffness of Flexural Members

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Abstract – In this study, the flexural behavior of hybrid beams incorporating various fiber-reinforced polymer (FRP) bars and concretes made with different fibers was investigated. The hybrid beams were constructed by embedding polypropylene, steel, and glass fiber concretes into glass-fiber reinforced polymer (GFRP) box profiles. Flexural tests were conducted using carbon, aramid, glass, basalt, and steel bars in the tensile zone for each beam type. The fracture toughness and stiffness of the hybrid beams were calculated and compared. The performance of the different FRP bars and fiber types was analyzed and interpreted. The results were evaluated in terms of the impact of both bar type and fiber type on the behavior of the hybrid beams. BFRP and CFRP strengthened beams exhibited respective gains of 188% and 127% in stiffness.

Keywords – Beams; fiber reinforced polymer (FRP); fibers; fracture toughness; stiffness

I. INTRODUCTION

Despite some limitations, the development and design of numerous building materials have addressed concerns about poor quality. Concrete and steel are fundamental components in construction, but concrete's low tensile strength and steel's corrosive nature and high unit weight present significant challenges for environmental sustainability. To overcome these issues, the design of sustainable building materials has garnered significant attention from scholars. For example, fiber-reinforced polymer (FRP) composites have become increasingly popular due to their light weight, resistance to corrosion, and high tensile strength. Additionally, the hybrid application of FRP composites with conventional construction materials has been tested and found to be effective in reinforcing and strengthening various structural elements [1-6].

After proving their benefits in aircraft applications, FRP composites have successfully paved a notable course for the construction industry. Besides their utilization in fiber form, FRP composites are also used for repairing building components in the form of fabrics. A few structural components including profile steel also make use of the FRP profiles to sustain the loading. To substitute the steel reinforcing bars in concrete, a new generation of FRP reinforcing bars has been specifically designed with the inclusion of basalt fibers, glass, and carbon. Also, different studies can be found investing the usage of bars of concrete [7], steel [8] wood [9] for structural components, which are generally considered as the most fundamental constituents of laminated or fiber forms of FRP. Nonetheless, one may point out a variety of hybrid aspects with the combination of building constituents with those of the FRP composites. In most of these aspects, different studies have primarily aimed at beams [10], hybrid columns [11, 12] and pile components [13]

developed by inclusion of the GFRP profiles within the fresh state concrete material. After the successful implementation of FRP composites in a variety of construction applications, a rise in the market demand has tuned the fabrication of FRP fabrics to the bar shape [14]. Also, numerous applications of these bars have been successfully tested in different reinforced concrete structures under submerged environments [15]. Likewise, different articles are available aiming to assess the impact of FRP materials on shear strength, tension response, and cracking pattern [16].

Furthermore, a wide range of literature has been devoted to fiber-reinforced concrete material. For instance, different works may be consulted to assess the suitability of fibers with varying proportions and their intended characteristics in concrete [17, 18]. In contrast to the aforementioned studies, the current work aims to combine a few topics as reported previously. For example, a few investigations can be noted to assess the suitability of numerous fiber types on the structural characteristics of hybrid beams. Yet, none of the available studies aims to assess the impact of these fiber types on hybrid beams fabricated by employing various types of FRP reinforcing bars. Consequently, this study intends to assess the most suited FRP re-bar and fiber type to enhance the structural response of beam specimens. The external confinement of concrete using FRP materials significantly enhances the structural properties of concrete [19-27].

To replace the reference specimens containing steel reinforcing bars in concrete, this study analyzes hybrid beam specimens that incorporate four distinct types of FRP bars: basalt fibers, glass, aramid, and carbon. Additionally, three different fiber types—steel, glass, and polypropylene—were integrated into the concrete during the fabrication of multivariate experimental classes. These fibers were added to develop the profiles of GFRP test specimens. The reinforcing bars with fiber-reinforced concrete specimens were then evaluated through flexural testing, producing load-displacement plots of the beam specimens. Based on these findings, toughness and stiffness plots were developed and analyzed.

II. MATERIALS AND METHOD

A. Materials

The geometric details of the 500 mm long GFRP box profiles, while the cross-sectional dimensions were 75×75×4 mm. Furthermore, the hybrid beam specimens contained a 10 mm diameter of FRP ribbed reinforcing bars in the tensile region. Table 1 enlists the test features of FRP bars, steel, and GFRP profiles. Concrete with 37 MPa of compression strength was employed in the GFRP box profile. Furthermore, to examine the impact of varying fiber types on the flexure strength of fiber-reinforced concrete specimens 1% of glass, steel, and polypropylene fibers were incorporated. Table 2 provides the associated features of the fibers. Figure 1 shows the stress-strain curves of FRP bars.

Table 1. Characteristics of FRP materials.

	GFRP profile	Steel Bar	AFRP Bar	BFRP Bar	CFRP Bar	GFRP Bar
Specific gravity	1.78	7.68	1.42	1.55	1.55	1.87
Tensile Strength (MPa)	610	555	1320	1125	1340	950
Longitudinal rate (%)	41	–	74	74	74	74
Young Modulus (GPa)	31	200	60	55	125	48

Table 2. Fiber properties

	Steel fiber	Polypropylene fiber	Glass fiber
Specific gravity	7.78	0.89	2.45
Tensile Strength (MPa)	1110	655	1710
Fiber diameter and length (mm)	1–28	1–28	0.1–28

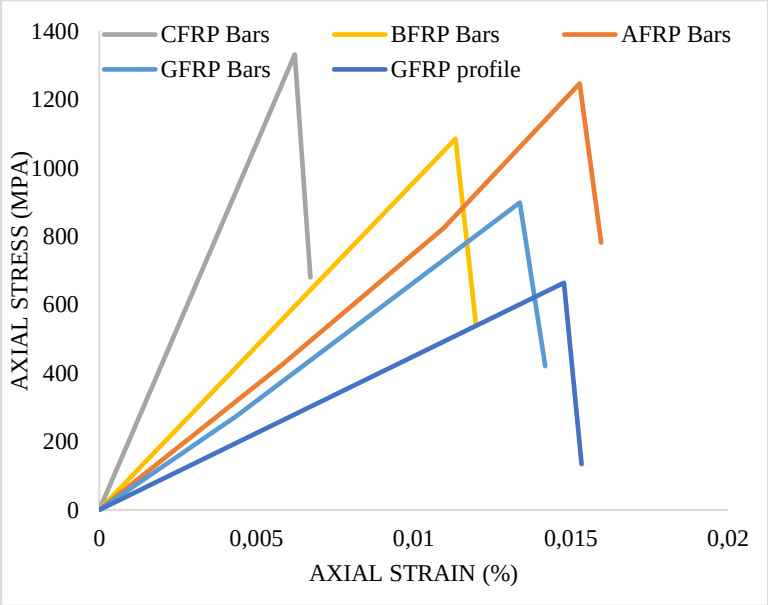


Figure 1. FRP bars and GFRP box profile tensile charts

B. Fabrication and Testing of Specimens

To test the specimens, 5 distinct classes of reinforcing bars were included for GFRP box profiling. These types were chosen as steel bars, GFRP and basalt fiber reinforced polymer (BFRP) bars, aramid fiber reinforced polymer (AFRP) bars, and carbon reinforced polymer (CFRP) bars. In addition, the experimental design involved the flexural testing of beam specimens fabricated by utilizing three distinct classes of fibers glass fibers, polypropylene fibers, and steel fibers. In addition, the flexural response and fracture toughness of beam specimens were noted by observing the fracture toughness and associated stiffness values. The experimental design involved fabricating two hybrid beams from each beam class, using the mean values of the results to create the final tables and plots. Hybrid beam specimens made with plain concrete were labeled with the prefix 'RH,' serving as the control model. Specimens with steel fiber concrete were labeled 'SH,' and those with glass fibers were labeled 'GH.' The bars used to reinforce the tensile region of the flexural components were designated as steel, GFRP, AFRP, CFRP, and BFRP. For example, beam specimens without bars were referred to as 'WH,' while specimens without GFRP bars and fiber profiles were termed 'Plain Concrete.' Beam specimens with polypropylene fibers, glass fibers, and steel fibers were labeled 'PFRC,' 'GFRC,' and 'SFRC,' respectively.

Hybrid specimens reinforced with steel bars in the tensile regions and lean concrete were labeled as RH-steel bars specimens. Hybrid specimens with GFRP bars in the tensile regions and glass fiber concrete were termed GH-GFRP specimens. Concrete specimens with polypropylene fibers but no bars were referred to as 'PH-WR' specimens. During testing, all bars (GFRP, Steel, BFRP, AFRP, and CFRP) were placed within the GFRP profile along with fiber and non-fiber concrete in the tensile region. The span width of 400 mm was maintained during the tests. A computer-connected flexural testing machine with a 50 kN capacity was

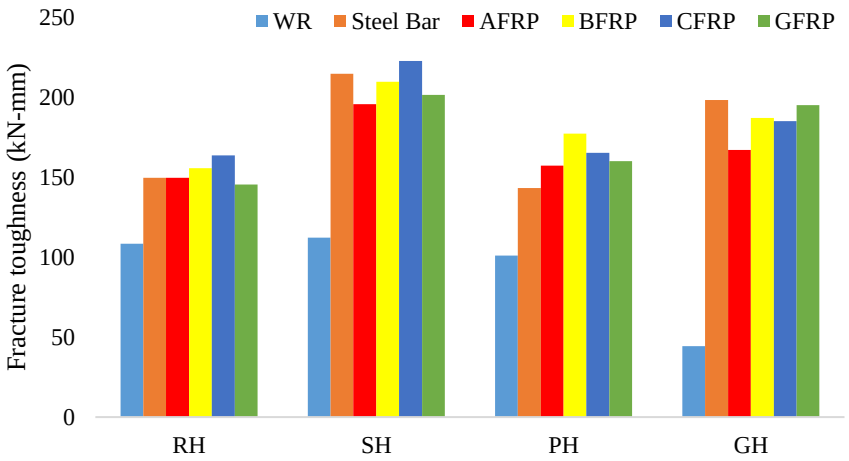
used to test the 500 mm long beam specimens at a loading speed of 2 mm/min. Displacements were recorded at the mid-region of the 400 mm effective span. Figure 2 illustrates the flexural testing of the specimens.

Figure 2. Four-point beam tests.

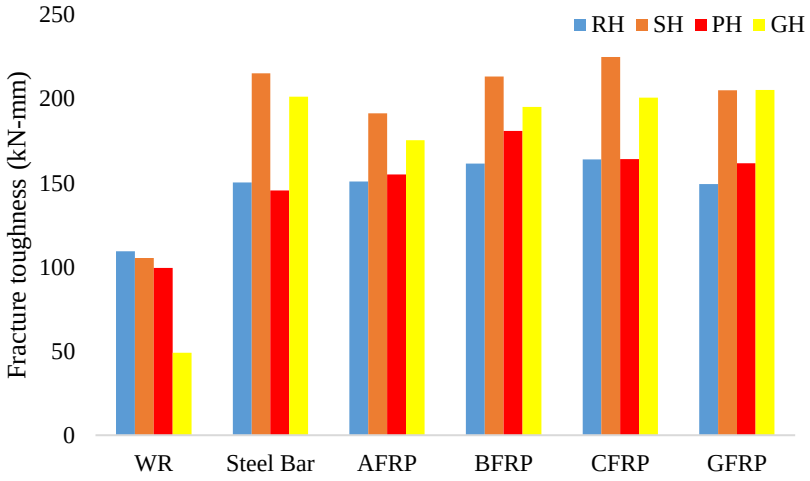
III. DISCUSSION OF RESULTS

A. Fracture Toughness

Following the flexure testing, the hybrid beams were analyzed for their respective fracture toughness, and the associated impact from different bar types was assessed, as presented in Figure 3a. Similarly, Figure 3b illustrates the relationship between the fiber types and toughness outcomes. Compared to hybrid beam specimens without fibers, CFRP-strengthened beams exhibited the highest toughness. Specifically, beams strengthened with BFRP, CFRP, AFRP, and GFRP showed a corresponding increase in toughness by 45.5%, 48.5%, 40.5%, and 34.5%, respectively, over hybrid specimens without any strengthening. When comparing the toughness outcomes of hybrid beam specimens with steel fibers, the beams strengthened with CFRP achieved the highest fracture toughness, with CFRP-strengthened beams demonstrating twice the toughness of hybrid specimens with steel fibers but without strengthening. Additionally, specimens with steel, BFRP, GFRP, and AFRP showed corresponding increases in toughness of 98.5%, 92.5%, 84.5%, and 77.5%, respectively. The toughness of CFRP-strengthened beam specimens containing AFRP, steel, GFRP, and BFRP was found to be 15.5%, 3.5%, 11.5%, and 6.5% higher, respectively. Compared to unreinforced beam specimens, the toughness of hybrid specimens containing BFRP, CFRP, GFRP, AFRP, and steel increased by 75.5%, 62.5%, 59.5%, 56.5%, and 44.5%, respectively. In the analysis of the toughness of hybrid specimens with glass fibers, beams with steel, GFRP, CFRP, BFRP, and AFRP demonstrated 75.5%, 62.5%, 59.5%, 56.5%, and 44.5% greater toughness than those of specimens without any strengthening.



(a)



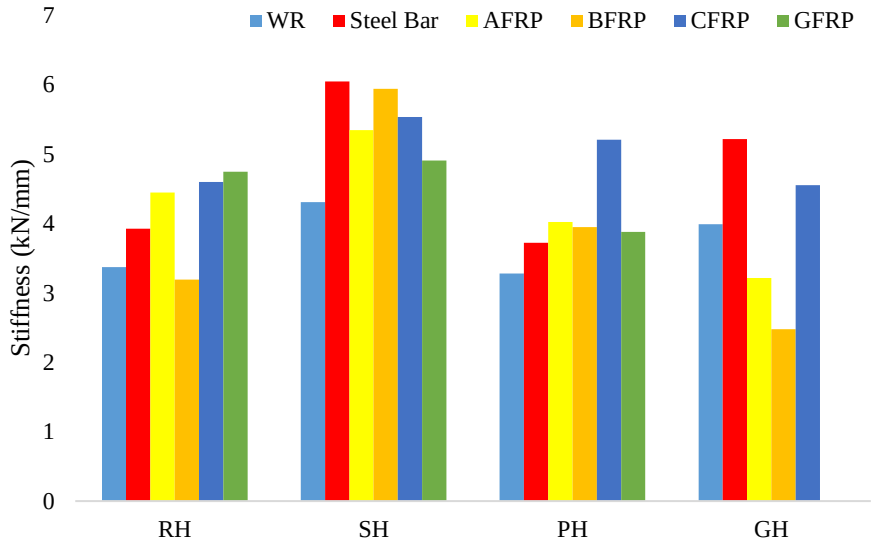
(b)

Figure 3. Comparison of fracture toughness of hybrid beam specimens a) by bar types and b) by fiber types.

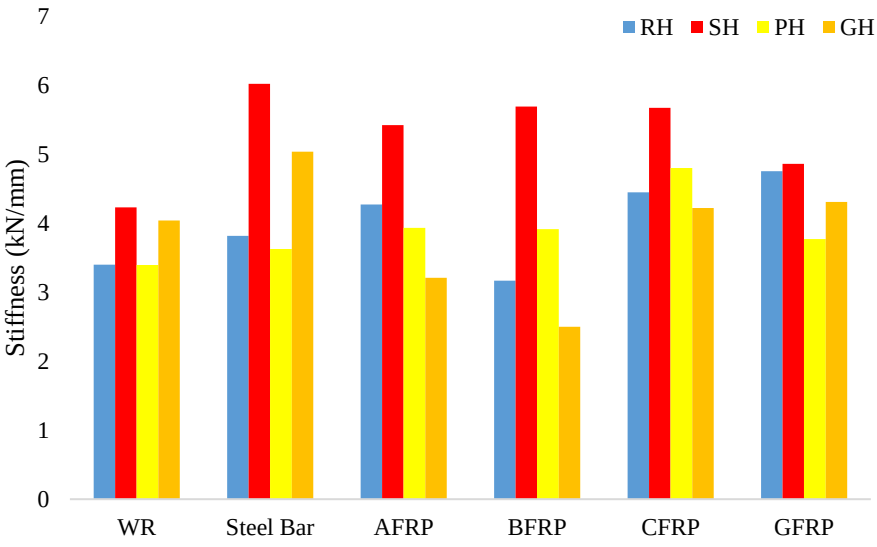
In comparison to specimens lacking fibers, the hybrid beam specimens reinforced with both steel and glass fibers demonstrated a 37.5% and 30.5% increase in toughness, respectively. However, the hybrid specimens incorporating polypropylene fibers exhibited a 5.5% decrease in toughness. Similarly, when compared to AFRP-reinforced specimens, beams containing polypropylene fibers showed nearly identical toughness. Nevertheless, beams reinforced with glass fibers and steel fibers exhibited toughness increases of 14.5% and 25.5%, respectively. Compared to specimens lacking fibers, beams reinforced with steel fibers, polypropylene fibers, and glass fibers demonstrated toughness increases of 31.5%, 12.5%, and 21.5%, respectively. In contrast, beams with CFRP exhibited toughness enhancements of 19.5%, 37.5%, and 2.5% for those incorporating glass fibers, steel fibers, and polypropylene fibers, respectively, in comparison to fiberless beams. Lastly, GFRP-strengthened beams showed toughness enhancements of 35.5%, 36.5%, and 10.5% for specimens incorporating glass fibers, steel fibers, and polypropylene fibers, respectively, compared to non-fiber specimens.

B. Stiffness

Figure 4a illustrates the influence of different types of bars on the stiffness of the specimens, while Figure 4b shows the impact of various fiber types. Upon evaluating the stiffness of the tested specimens, it was found that beams reinforced with steel bars exhibited the highest stiffness. Compared to the unreinforced specimens, the use of BFRP, steel bars, CFRP, AFRP, and GFRP resulted in stiffness improvements of 88.5%, 50.5%, 27.5%, 25.5%, and 3.5%, respectively. When comparing the stiffness of hybrid specimens reinforced with steel fibers, the stiffness values for BFRP, steel bars, CFRP, AFRP, and GFRP strengthened beams increased by 37.5%, 35.5%, 32.5%, 26.5%, and 14.5%, respectively. For hybrid specimens reinforced with polypropylene fibers, the corresponding stiffness values for CFR, AFRP, BFRP, GFRP, and steel were 54.5%, 22.5%, 19.5%, 17.5%, and 12.5% higher than those of the unreinforced specimens. Comparing the stiffness of hybrid samples reinforced with glass fibers, beams reinforced with steel showed a 29.5% increase in stiffness compared to unreinforced samples. Similarly, beams reinforced with CFRP exhibited a 15.5% increase in stiffness. However, compared to unreinforced specimens, those reinforced with GFRP, AFRP, and BFRP showed a decrease in stiffness by 11.5%, 19.5%, and 37.5%, respectively.



(a)



(b)

Figure 4. Comparison of stiffness of hybrid beams (a) by type of bar and (b) by type of fiber concrete.

During the evaluation of steel-bar strengthened hybrid specimens, it was found that specimens with steel fibers showed a 50.5% increase in stiffness compared to those without fibers. Similarly, hybrid specimens with glass fibers exhibited a 31.5% increase in stiffness, while those with polypropylene fibers experienced a 4.5% decrease in stiffness. In the case of beams strengthened with AFRP, those with steel fibers showed a 25.5% increase in stiffness, whereas beams with glass fibers and polypropylene fibers showed decreases in stiffness of 7.5% and 26.5%, respectively. For BFRP-strengthened beams, specimens with steel fibers showed an 88.5% increase in stiffness, while those with glass fibers and polypropylene fibers showed decreases of 20.5% and 23.5%, respectively. Regarding CFRP-strengthened beam specimens, those with steel fibers, polypropylene fibers, and glass fibers showed increases in stiffness of 27.5%, 13.5%, and 2.5%, respectively, compared to beams without fibers. In GFRP-strengthened beams, specimens with steel fibers showed a 3.5% increase in stiffness compared to those without fibers. However, the addition of polypropylene fibers and glass fibers led to decreases in stiffness of 7.5% and 19.5%, respectively, compared to beams without fibers.

IV. CONCLUSIONS

Following are the key fiondings:

- Compared to WR bars, CFRP strengthened RH and SH beams exhibited increases of 157% and 200% in toughness, respectively. Additionally, both BFRP and steel-bar strengthened PH and GH beams showed respective gains of 175% in toughness. Among these, steel-bar hybrid specimens with GH class achieved the maximum toughness. Comparing with fibers of the RH class, steel-bar strengthened SH beams and AFRP strengthened SH beams showed increases of 137% and 125% in toughness, respectively. Moreover, BFRP and CFRP strengthened SH beams exhibited respective gains of 131% and 137% in toughness. Among these, GFRP hybrid specimens with SH class achieved the highest toughness.
- Compared to WR bars, GFRP-strengthened RH beams and BFRP-strengthened SH beams exhibited increases of 147% and 137% in stiffness, respectively. Additionally, both CFRP and steel-bar strengthened PH and GH beams showed respective improvements of 154% and 129% in stiffness. Among these, steel-bar hybrid specimens with GH class achieved the maximum stiffness. Comparing with fibers of the RH class, steel-bar and AFRP-strengthened SH beams showed increases of 150% and 125% in stiffness, respectively. Moreover, BFRP and CFRP strengthened SH beams exhibited respective gains of 188% and 127% in stiffness. Among these, GFRP hybrid specimens with SH class achieved the highest stiffness.

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Do Economic Growth, Green Growth, and Net Migration Improve Environmental Quality in Countries with the Highest Net Migration?

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Abstract – Following industrialization, the intensive use of fossil-based energy resources, which is the dominant factor of global climate change, has increased the amount of greenhouse gas emissions (GGE) in the atmosphere. In many international regulations, especially the Paris Agreement, measures to reduce GGE in the fight against risks and threats arising from climate change are frequently emphasized. This study investigates the impact of economic growth (EG), green growth (GG), and net migration (NM) on CO2 emissions (CE) in nine countries with the highest NM for the period 1992-2020. As is well known, the increase in the supply of renewable energy, used as an indicator of GG on a global scale, plays a significant role in sustainable environmental policies. In contemporary academic research, the issue of whether NM leads to environmental degradation (ED) remains a contentious topic. In this study, where a cointegration relationship was identified among the variables, the results of the Dynamic Seemingly Unrelated Regressions (DSUR) revealed that EG and GG reduced environmental pollution (EP), while NM contributed to ED. It was observed that in the countries with the highest NM, the number of people entering the country exceeded the number of people leaving. Therefore, policy implementations aimed at attracting skilled labor to these countries were crucial. Additionally, considering the contribution of GG to environmental sustainability (ES), increasing investments in the renewable energy sector should be among the priorities in government policies.

Keywords – Economic Growth, Green Growth, Net Migration, Environment, DSUR

I. INTRODUCTION

In the process of sustainable development (SD), climate change ranks among the most serious environmental issues, as increasing global warming and GGE worldwide have become a threat to humanity [1]. In this context, the transition to a "low-carbon future" is crucial. The "Kyoto Protocol," which came into effect in 2005 aiming to reduce CE globally, and the "European Union Emissions Trading System" (EUETS), the largest CE trading system in the world, have heightened interest in the issue of global warming [2]. This system provides incentives to countries for the mitigation and management of CE. Governments are encouraging the renewable or clean energy sector to reduce the adverse environmental impacts caused by increasing GGE [3], [4].

One of the most serious environmental issues faced by all countries around the world today is global climate change. This issue has become a focal point for researchers because it significantly threatens SD [5]. CE plays a substantial role in global warming and ED, which are the primary sources of climate change [6]. Considering the adverse impact of these emissions on environmental quality (EQ), it is crucial to identify the factors affecting CE.

The purpose of this study is to determine the role of EG, GG, and NM on EQ using panel data from nine countries with the highest net migration for the period 1992-2020. Numerous studies in the literature focus on the determinants of EQ. However, few studies specifically focus on GG and NM as determinants. This study is significant as it evaluates the role of these variables in EQ for the first time from the perspective of countries with the highest net migration. Additionally, this study can contribute to the literature by identifying the relationships between the relevant variables using second-generation panel data techniques and by proposing policy recommendations based on the analysis results.

The study is divided into four sections: (i) The introduction section, (ii) The second section includes the literature on the determinants of EQ, (iii) The third section evaluates the econometric model and analysis findings, and (iv) Finally, the conclusion and policy recommendations are presented.

II. Literature Review

The literature includes numerous studies analyzing the determinants of EQ, such as technological innovation, economic growth, foreign trade, trade openness, financial development, renewable energy, urbanization, and globalization. Recently, the variable of green growth has also started to gain attention in academic research. However, studies analyzing the impact of net migration on the environment are extremely scarce.

Grossman and Krueger (1991) found that per capita income leads to ED in their study of 42 countries [7]. Baek, Cho, and Koo (2009) examined the impact of foreign trade and economic growth on EQ. Their findings revealed that these variables improve EQ in developed countries but lead to ED in most developing countries [8]. On the other hand, Tamazian et al. (2009) investigated the impact of financial development on the environment and found that financial development is effective in reducing CE [9]. Cetin and Seker (2014) stated in their study based on the ARDL model for the Turkish economy that trade openness and economic growth deteriorate EQ in the long term [10].

Ozatac, Gokmenoglu, and Taspınar (2017) tested the EKC hypothesis for Turkey. According to the analysis results, the validity of the EKC hypothesis was confirmed for the variables of energy consumption, foreign trade, urbanization, and financial development in the long term [11]. Orman, Ceylan, and Yılmaz Sahin (2019) investigated the environmental impacts of trade openness on the Turkish economy. The results of the ARDL model showed that trade openness leads to ED [12]. Cetin, Saygın, and Demir (2020) found that the value added by the agricultural sector in Turkey improves EQ and that the EKC hypothesis is valid for the Turkish economy [13]. Koc, Sarac, and Koc (2022) concluded in their study that economic growth, trade openness, and urbanization cause ED in the Turkish economy, according to the results of the ARDL model [14].

Ullah et al. (2023) investigated the connections between financial development, globalization, technological innovation, trade openness, renewable energy consumption, and the environment in a sample of 14 countries with the highest levels of financial development. The AMG estimation findings revealed that financial development leads to ED, whereas globalization, technological innovation, trade openness, and renewable energy consumption support EQ [15]. Altay Topcu (2023), in his study on 12 countries with the highest carbon emissions, based on AMG estimation results, found that environmental taxes and renewable energy consumption enhance EQ, while economic growth deteriorates it [16].

Among the limited studies examining the impact of migration on the environment, Altunc (2017) analyzed the causality relationship between net migration and the environment in the case of Turkey. The Granger causality test results indicated a unidirectional causality from net migration to EP [17]. In another study, Alola et al. (2019) found that migration leads to ED in the economies of France, Germany, and the United Kingdom [18]. Conversely, Alola and Kırıkkaleli (2019) investigated the impact of renewable consumption, migration, and healthcare services on EQ in the USA using wavelet and gradual change causality approaches. The analysis results showed that migration significantly caused ED during the period 2008-2010. Additionally, they found a bidirectional causality between EQ and healthcare services at different frequencies and time intervals [19]. Lastly, Altay Topcu and Sumerli Sarıgul (2023)

found that net migration and renewable energy consumption improved EQ in the case of Turkey, while financial development led to ED [20].

III. Econometric Model and Analysis Results

This study investigates the impact of EG, GG, and NM on CE for the period 1992-2020, focusing on the nine countries[1] with the highest levels of net migration. The estimated logarithmic model is as follows:

$$lnCO2_{i,t} = \beta_0 + \beta_1 lnEG_{i,t} + \beta_2 lnGG_{i,t} + \beta_3 lnNM_{i,t} + \varepsilon_{i,t} \qquad (1)$$

Table 1 presents the variables and symbols used in the estimated model. The environmental pollution indicator, ln CO2, represents per capita CO2 emissions in 2015 dollars. The variable ln EG used as an indicator of economic growth, represents real GDP in 2015 dollars. The variable ln GG used as an indicator of green growth, represents the share of renewable energy in the total energy supply. Finally, the variable ln NM represents net migration, which is the difference between immigrants entering and emigrants leaving the country. The variables ln CO2, ln EG, and ln NM were obtained from the World Bank's WDI database. The variable ln GG was compiled from the OECD Green Growth Indicators database.

Table 1. Variables, and symbols of variables

Variables	**Symbols**
CO2 emissions	lnCO2
Economic growth	lnEG
Green growth	lnGG
Net migration	lnNM

In the study, it is first necessary to test for cross-sectional dependence (CSD). The results of the CD test developed by Pesaran (2004) [21] indicate the presence of CSD for all variables.

Table 2. CSD analysis results

Variables	**CD-test**	**P-value**
lnCO2	22.664	.000
lnEG	30.983	.000
lnGG	9.449	.000
lnNM	-1.655	.098

To determine the appropriate long-term estimation method for the model, it is necessary to identify whether there is slope homogeneity (SH). The SH test results, developed by Pesaran and Yamagata (2008) [22], are presented in Table 3. The results indicate that the alternative hypothesis, which suggests the presence of slope heterogeneity, is accepted. Therefore, the panel model is characterized by heterogeneous panel data.

Table 3. SH test results

$\tilde{\Delta}$	18.425 (.000)
$\tilde{\Delta}$adj	20.253 (.000)

Note: The *p*-values are given in parentheses.

[1] United States, Germany, Russia, United Kingdom, United Arab Emirates, France, Canada, Australia, Spain.

Before calculating the long-term elasticity coefficients of the variables, it is necessary to identify the cointegration relationship between the variables. The cointegration test results, developed by Westerlund (2007) [23], are presented in Table 4. In this table, the Pt and Pa test statistics confirm the presence of a cointegration relationship.

Table 4. Cointegration Analysis

Westerlund (2007)	**Z-value**	**P-value**
Gt	-.981	.163
Ga	-.390	.348
Pt	-2.175	.015
Pa	-1.365	.086

Mark et al. (2005) suggest that the DSUR technique provides efficient results in cases of CSD and slope heterogeneity among the series [24]. The DSUR analysis results are presented in Table 5. A 1% increase in ln EG reduces EP by 0.18%. Conversely, a 1% increase in ln GG improves EQ by 0.08%. Lastly, a 1% increase in ln NM leads to a 0.02% increase in ED.

Tablo 5. DSUR estimation results

Dependent variable: lnCO2		
	Coefficients	**P-value**
lnEG	-.1812	.000
lnGG	-.0859	.004
lnNM	.0203	.005
Constant	3.9225	.001
Wald $\chi 2$	50.07	
P-value	.000	
Observation	261	
Number of countries	9	

IV. Conclusion and Policy Recommendations

One of the main components of climate change is global warming. Global warming refers to the long-term heating of the Earth's climate system due to an increase in GGE in the atmosphere, resulting from production and consumption activities. Recently, one of society's greatest concerns has been the adverse effects of global warming on quality of life. In this context, the importance of environmental protection awareness and the connections between EQ and certain indicators are frequently discussed topics in the literature. Today, minimizing CE is among the most important goals for both developed and developing countries in the context of SD goals.

Although there are studies in the literature investigating the determinants of CE, studies examining the impact of GG and NM on EQ are limited. This study is the first to determine the impact of EG, GG, and NM on ES for the nine countries with the highest net migration during the period 1992-2020. By using second-generation panel data techniques, this study fills a gap in the literature by identifying these effects. The analysis findings highlight four important points: (i) It was observed that the panel data exhibit CSD and slope heterogeneity. (ii) The Westerlund (2007) ECM test results revealed a long-term relationship between the variables. (iii) The DSUR analysis results, which provide consistent results in heterogeneous panels, showed that EG and GG improve EQ, while NM leads to ED in the relevant countries. (iv) In this context, the countries included in the analysis should reconsider their migration policies and introduce new regulations related to migration legislation to align with SD goals. Additionally, promoting investments in renewable energy is crucial for ES.

This study has some limitations and recommendations for future research. Future studies could focus on NM and GG as determinants of CE, evaluating their effects on both developed and developing countries. Additionally, the impact of these variables on ES could be analyzed for different country

groups, such as BRICS Plus countries and countries listed in the Environmental Performance Index. The results of these analyses could provide significant insights for policymakers.

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Innovations and Frontiers in the Nixtamalization Process

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Abstract – Nixtamalization is a process that involves cooking corn kernels in an alkaline solution, then letting them steep in the cooking solution (nejayote) for a while, and then washing them. This process increases the nutritional value of corn and the pericarp, starch and proteins are modified. We can collect the innovations in the nixtamalization process under two headings; The first is the use of different chemicals and different technologies in nixtamalization applied to corn, and the second is the application of nixtamalization process to other grains and seeds other than corn. Factors such as the release of wastewater with high organic matter content at the end of the nixtamalization process and the increase in the mineral content of the resulting products, especially the calcium content and pH value, are the factors that limit this process. In this study, the mentioned innovations and frontiers in the nixtamalization process were investigated by scanning the current literature.

Keywords – Nixtamalization, innovations, frontiers, corn, ecological applications

I. INTRODUCTION

Nixtamalization, a very old method of processing corn, was developed by the Mayan and Aztec civilizations in Mesoamerica [1], [2]. The resulting product (nixtamal) is used in the production of various products (hominy, tortillas, corn chips, tamales, tostadas, tacos, enchiladas, atoles, etc.) or nixtamal flour, especially consumed in Latin American countries. Nikstamal can be ground in a disc mill while it is fresh, without drying, to obtain the "masa" dough used in tortilla production. It can also be used to obtain instant masa flour by drying and grinding “masa” [3], [4]. With the nixtamalization process, many positive changes occur, such as facilitating the separation of the pericarp from the corn grain, modification of starch and proteins, decreasing aflatoxin levels, increasing niacin bioavailability, increasing the amount of enzyme-resistant starch and calcium content [5], [6], [7], [8]. The traditional nixtamalization process involves cooking corn kernels in calcium hydroxide solution (0.3-2%, w/w) for a certain period of time (30-60 min), then steeping them in the cooking solution (nejayote) for a while (1-24 h) and then washing them [3], [9]. Today, innovations have been made in the traditional nixtamalization process, such as ecological nixtamalization, nixtamalization by extrusion method, and microwave-assisted nixtamalization. In addition, innovations have been made in terms of target material by applying the nixtamalization process to other grains, brans and legumes other than corn.

II. INNOVATIVE NIXTAMALIZATION METHODS

One of the first methods developed to reduce the environmental polluting effect of the traditional nixtamalization method is ecological nixtamalization (Fig. 1). In the ecological method, calcium salts (such as $CaCl_2$, $CaSO_4$, and $CaCO_3$, 0.2–2.0 g/100 g corn) are used instead of $Ca(OH)_2$. In nixtamalization carried out with the ecological method, less dry matter passes into the nejayote, thus reducing its polluting effect on the environment [10], [11].

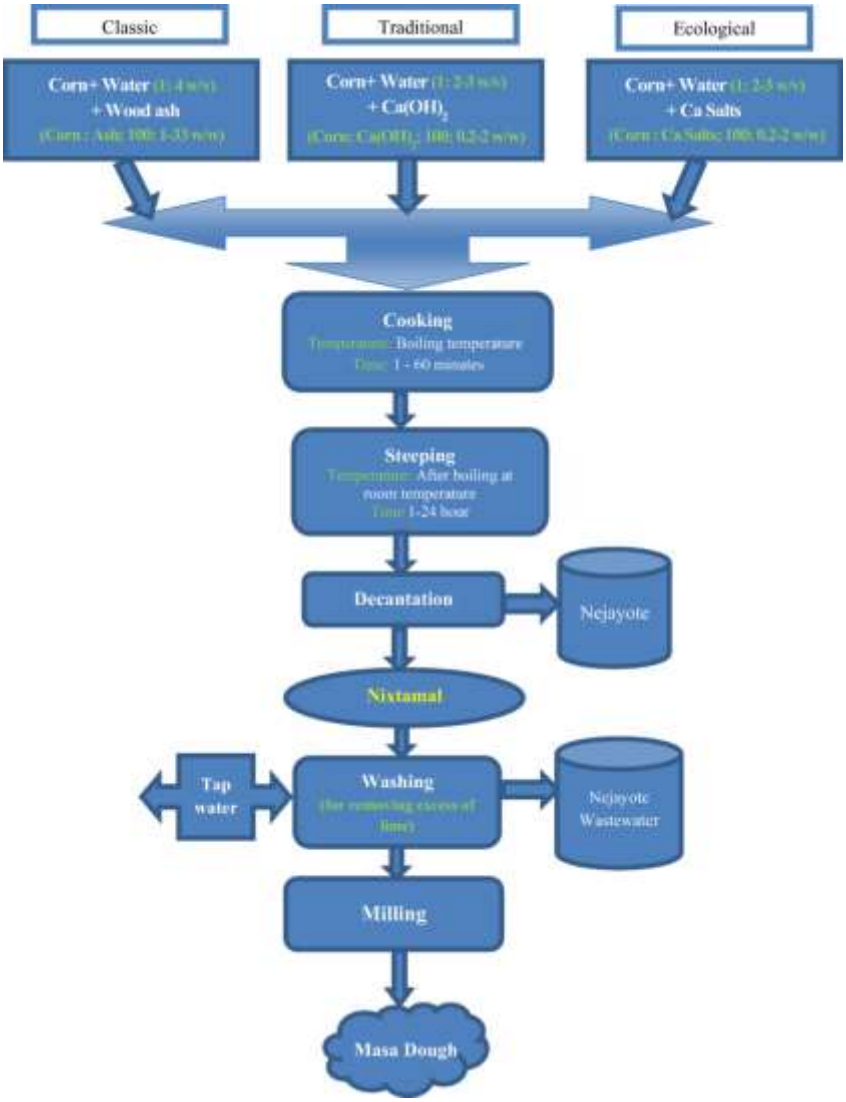

Fig. 1 Nixtamalization processes steps adapted from published data [2], [9], [10]

Another important innovation in the nixtamalization process is the use of extrusion technology. We can list the innovations in nixtamalization as follows: Extrusion for nixtamalization with a single screw, extrusion with low-shear transport system, extrusion wet milling nixtamalization, nixtamalization with ohmic heating and nixtamalization with microwave [12], [13], [14]. Solar energy can also be used as a heat source in the nixtamalization process [15]. Extrusion wet milling nixtamalization is an innovative process that combines traditional nixtamalization with wet extrusion technology to produce high-quality corn products. In this method, high humidity, low temperature, low screwing speeds are used and the corn grain is ground to 3 mm size. The method is based on mixing ground corn with water and lime (there may be other calcium salts) to form a homogeneous dough that is extruded using a screw or twin screw. Operating parameters such as humidity, cooking time, production speed and cutting are critical in this process. Following extrusion, the product is dried to reduce moisture to safe and desirable levels for storage [16]. The advantages of extrusion technology include preventing the formation of wastewater (nejayote), preserving the nutrients in the pericarp and aleurone of corn, and producing whole grain foods [17], [18].

Another innovation is the application of the nixtamalization process to different foods. These include wheat bran [19], legumes [20], soybean [21] and pearl millet [6].

III. FRONTIERS IN THE NIXTAMALIZATION PROCESS

Important factors that limit the application of the nixtamalization process include the generation of wastewater, the necessity of cooking the raw material in water in the traditional method, the increase in the pH value of the final product (especially when $Ca(OH)_2$ is used) and the loss of valuable water-soluble substances.

An important limiting factor in performing nixtamalization using extrusion technology is the dextrinization of starch. The dextrinization process causes an increase in solubility and a decrease in viscosity [17].

IV. CONCLUSION

Nixtamalization is a process that plays a very important role in the transformation of corn into products such as tortillas. The nutritional and technological properties of corn are improved by this process. Due to these advantages, the nixtamalization process has begun to be applied to other foods. However, there are factors that limit the application of this process, such as wastewater generation, increased pH value of the final product, and hydration of the raw material. Innovative nixtamalization methods are being developed to solve these limiting factors and further development is needed. These innovative methods in nixtamalization include technologies such as (1) ecological nixtamalization, (2) extrusion technology, (3) ultrasound and microwave application, (4) ohmic heating.

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Chronological Age Estimation Using Multi-Task Convolutional Neural Networks with Facial Images and Weight Sharing

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Abstract – Age estimation is important in human-computer interaction because the image is sent into the system and the system produces a result based on the methodologies used. In addition, estimating near-accurate age from face photos necessitates a significant amount of data and a lengthy training time. This paper suggests an age estimator deep learning model based on the Convolutional Neural Network (CNN), which can virtually precisely determine age from facial photos. Our method uses less training data than previous efforts while maintaining a low Mean Absolute Error (MAE) of 0.60 in years and an age-group classification percentage of 98%. We created a custom model that simultaneously executes age estimation as a regression and classification. Our results are compared to those of other age estimation methods. The assessment shows that our age estimate system performs better to previous related efforts.

Keywords –Chronological age prediction, Convolutional Neural Network (CNN), Facial images, multi-task learning, Weight sharing.

I. INTRODUCTION

Estimating a person's age from facial images has gained significant interest due to its practical applications. Existing methods often rely on handcrafted features or shallow learning models, which may not capture complex age-related patterns. In contrast, deep learning approaches, particularly CNNs, have shown promising results in various computer vision tasks. In this work, we propose a multi-task CNN model that jointly predicts chronological age and leverages weight sharing to enhance performance.

Estimating a person's age from a photograph is a difficult challenge in the field of facial investigation. Computer vision and pattern recognition have advanced rapidly, making computer-based age prediction from facial photos an intriguing topic. As a biological information carrier, a human facial image can provide a wealth of information such as identification, emotional state, ethnic origin, gender, and age [1], [2]. A person's face picture can be characterized as a combination of many facial variables such as skin color, geometric facial features, and so on. When humans communicate with one other in person, all of this information is crucial. As humans we have an incredible ability to intercept and recognize faces and facial expressions. Facial age detection can be seen as where the value might be either a range of ages (classification problem) or a specific age value (regression problem). The first step in developing an automatic age estimate model is to obtain a good training set and a dataset for testing. There are currently a plethora of publicly available datasets containing tagged samples of varied illuminations, head positions, and circumstances. In this work we used a combination of the UTK dataset and wiki arts dataset.

There are numerous real-world applications for an image-based automatic age estimation system [3]–[5]. If computers could discern the age of their users, the computing environment and kind of interaction might be tailored to the user's age. By filtering the gallery database using the predicted age, age estimation from

photos can be used for categorization e-photo albums as well as finding presumptive suspects more effectively and reliably [2]. Teenagers can be prevented from visiting certain websites by using an automatic age estimation method. Improper web pages are visited, and ill-suited products are purchased from vending machines.

The measurement of aging-related traits on faces enables humans to predict the age groups of others just by glancing at their face; nevertheless, facial-based age prediction is less precise in general.

when compared to estimating age groups and gender. As a result, researchers have recently developed a multitude of ways for feature extraction and application of these facial traits in the development of Automated Facial Age Estimation systems. [19],[20],[21].

The relationship between facial appearance and aging is not exactly linear, making it difficult and varying between individuals [4]. This results in automatic face age estimation, with the major

In this research, we offer a method for training a custom CNN model to accurately predict ages from identifiable faces.

II. Materials and Method

A.Convolutional Neural Network

A convolutional neural network (CNN) is a type of deep learning algorithm. It belongs to the feed forward artificial neural networks that are utilized for diverse purposes and data types. A CNN is a network design primarily for use in image recognition and pixel data processing applications. CNNs are the ideal network architecture for identifying and detecting images. This makes them ideal for computer vision (CV) tasks and applications requiring object recognition.[6][18]

[4] discovered that, of all the factors impacting aging and automated age detection systems, race is the most significant barrier to human aging patterns, such as Asians or Africans racial group have unique aging traits that cannot be learned from other races.

[5] Regardless, it is an appealing topic because of its roots in many real-life applications, such as medical, customer management systems, access control and observation systems, digital and criminal investigation, age detection and determination systems in sports, human computer interaction, job employment exercises, biological age and actual age comarketing filtering, and many others.

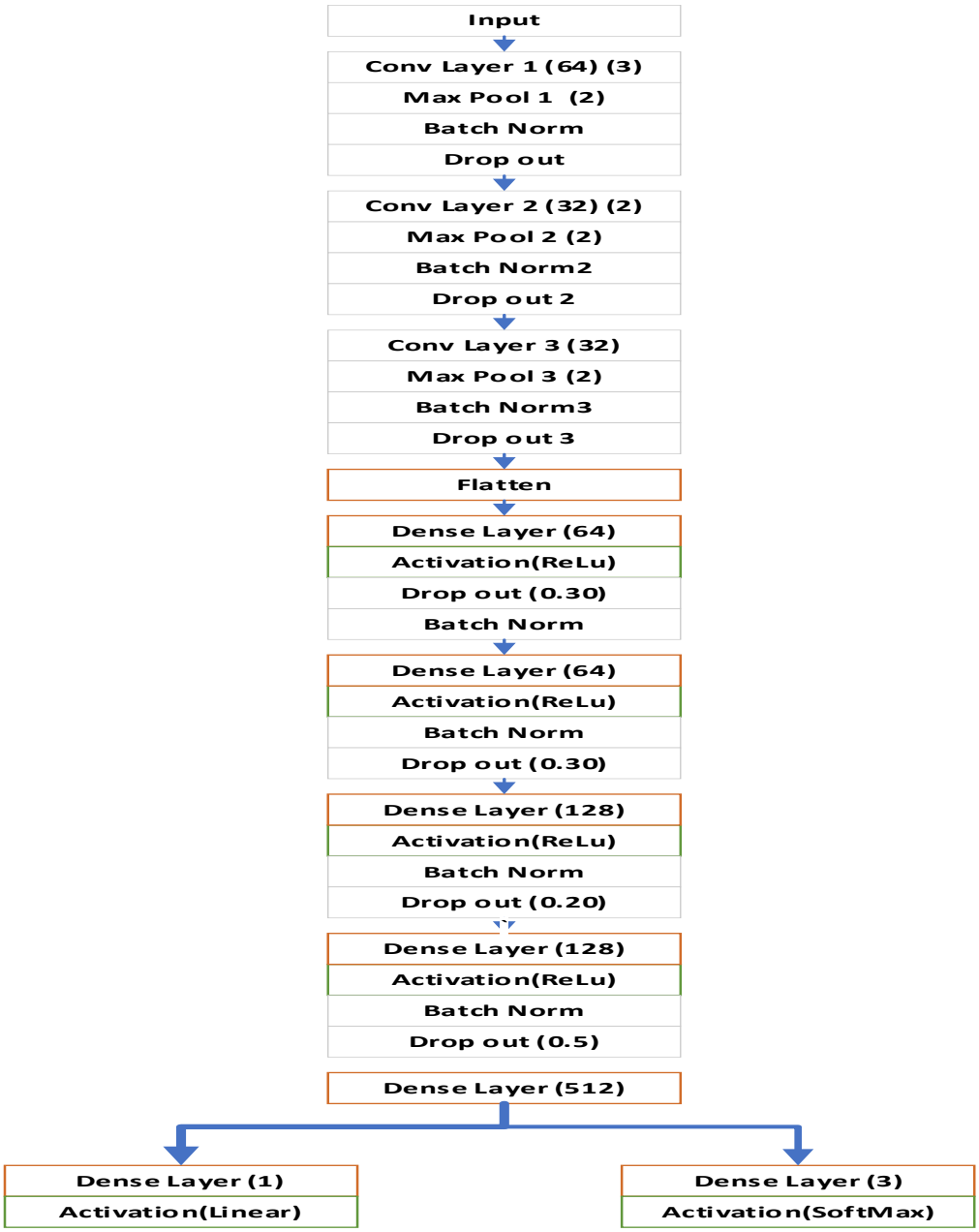


Figure 1 Block diagram of the age prediction model

B. Related Works

Because of its wide applications in tackling real-world problems, facial age detection has sparked a lot of research interest. The initial phase of facial age detection employed handmade traditional machine learning based methods which involved manually extracting aging patterns (feature extraction) from facial photos using a set of rules and algorithms.

These characteristics have been classified as local, global, or hybrid [3], [7]. Anthropometric-based models [8], Active Appearance Model (AAM) [9]and Bio-Inspired Features (BIF) [10] were also widely utilized to learn texture and form features from training facial photos.

In recent years, deep learning approaches based on CNNs have been used to build high-level semantic features in order to increase the accuracy and efficiency of automated facial age prediction systems. The multi-level CNNs perform a series of modifications on the facial image to determine the age of the person.

The authors proposed the COnsistent RAnk Logits (CORAL) framework in [11], which offers strong theoretic assurances for rank-monotonicity and reliable ratings. Furthermore, the proposed method is

architecture-agnostic and may be utilized to supplement any cutting-edge deep neural network classifier for ordinal regression applications. When compared to the reference ordinal regression network, the empirical evaluation of the proposed rank-consistent technique for age prediction on a variety of face-image datasets demonstrates a considerable reduction in prediction error. They obtained with a mean absolute error of 2.64.

The authors of this research [5] present a Convolutional Neural Network (CNN)-based age estimator that can predict age from facial images. Their method uses less training data than previous methods while maintaining a low Mean Absolute Error (MAE). ResNet 50 is a 50-layer Residual Network that conducts age estimation as a regression problem. The investigational results are compared to those of other age estimation methods. The comparison shows that their age estimation technique outperforms other relevant studies even after training with a smaller data set. Their MAE was 4.49.

In [16] The research paper presents a methodology for estimating human age from facial images using a convolutional neural network (CNN) with an attention module. The study focuses on developing a lightweight model with a low number of parameters and tests different attention modules for optimal performance. By utilizing transfer learning models and attention mechanisms, the proposed model shows improved performance in age estimation compared to conventional CNN models, aiming to enhance public security through advanced age estimation technology. The proposed model achieved a Mean Absolute Error (MAE) of 2.54 on the FG-NET dataset, outperforming existing methodologies. Additionally, the model achieved an MAE of 3.5 on the combined dataset, surpassing other methods. The proposed model achieved a Mean Absolute Error (MAE) of 3.5 on the UTK Face dataset.

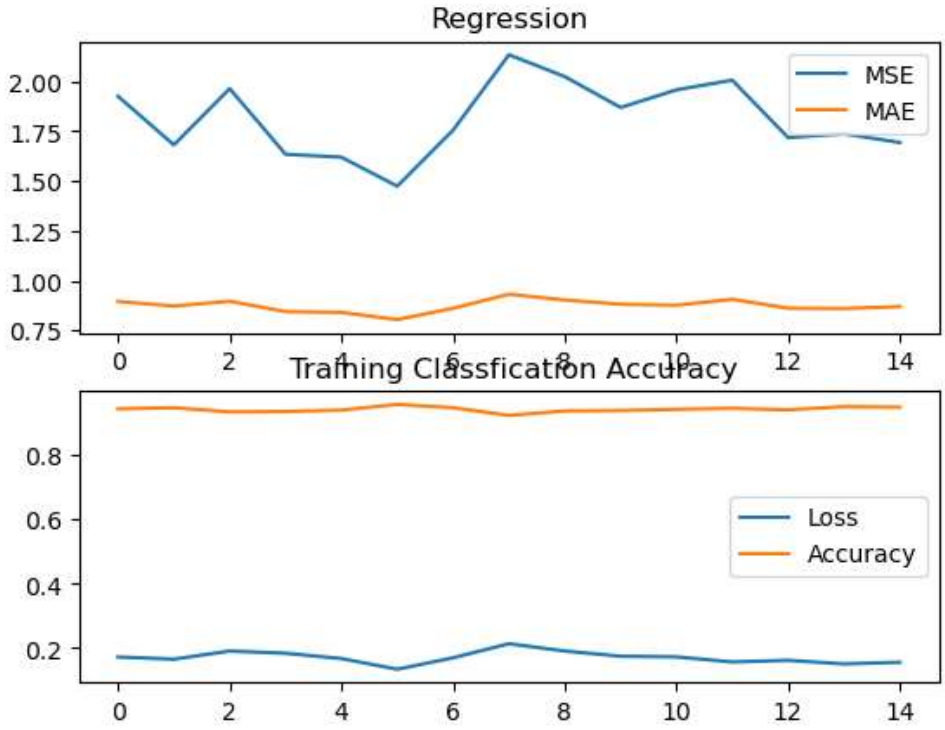
In [17] The paper discusses the application of Deep Convolutional Neural Networks (DCNN) and various image processing techniques for accurate age estimation from facial images. It introduces metrics like MAE, RMSE, Precision, Recall, and F1-Score for evaluating model performance and presents results from using different DCNN architectures like GoogLeNet, DenseNet, and ResNet. Additionally, the study highlights the use of Gabor filters, PCA, and the Cuckoo Search Algorithm for feature extraction, edge detection, and optimization in age prediction models. The proposed work achieved an F1-score of 83.19%, precision of 85.13%, and recall of 78.12% in estimating age accurately using the UTK face dataset. The proposed model outperformed existing algorithms in predicting age groups, particularly in the ranges of 0-15 and above 51. The optimized DCNN-CS (Deep Convolutional Neural Network with Cuckoo Search algorithm) model demonstrated superior performance compared to traditional approaches, with an accuracy rate of 91.45%. The confusion matrix of the UTK face dataset showed the effectiveness of the proposed DCNN-CS model in age estimation. The DCNN-CS model achieved an MAE of 8.55 in estimating age accurately from human facial images, outperforming other models such as CNN, DCNN, and SVR

III. METHODOLOGY

We performed per-processing on facial images in our study's dataset photos, added our dataset to improve the amount of train data, and then trained our CNN model to estimate the ages of facial images. The block diagram of our age estimate is shown in Figure 1.

A. *Dataset*

We made us of the CASIA Africa dataset which is publicly on http://english.ia.cas.cn/db/201610/t20161026_169405.html. We made use of 3420 images [15].



B. *TESTING*

We estimated the MAE of the model using the testing dataset after completing 50 epochs of 10-folds with the use of se of early stopping. We used the best weight saved during the training phase throughout testing with the help of check point in python which saves the best weights. The model predicts the ages of all test set input face photos in our X_test using the python function 'predict(x_test)' and we also were able to evaluate the classification using the classification report function in python. MAE and accuracy have been determined using the dataset's predicted and actual ages.

We used the dlib[12] library for face detection during the implementation process. We have the CNN model built using Kera's [13], which is a Python-based open source neural network library. We utilized numpy [14], the essential Python library for scientific computing, for data preprocessing.

C. *Evaluation Metrics*

Mean Average Error (MAE): MAE is the average of the absolute difference between projected and actual output, which is represented as

$$MAE = \frac{1}{n}\sum_{1}^{n}(|yi - yi!\,|)$$

where yi is the nth image's ground truth label and yi! is the predicted age based on the suggested model and n represents the total number of testing samples.

The accuracy of a classification model is calculated as the ratio of correctly predicted instances to the total number of instances in the dataset. The formula for accuracy is:

$$accuracy = \frac{total\ number\ of\ predicted}{total\ number\ of\ corrected\ predictions} \quad (2)$$

IV. RESULTS

We attained a low MAE of 0.60 in years, which shows that our model is optimal and more accurate in performance than other research works.

```
The MSE 0.7171331680126799
The MAE 0.602860272799567
this is the rmse 0.8468371555456692
Test R^2 Score: 0.97247
```

Figure 4 shows the results for the regression

We also obtained an accuracy of 98%, below in figure 5 shows the confusion matrix, from the confusion matrix we see 88 instances were classified correctly as age 13-17 while 2 were incorrectly classified as (18-25) and none were classified as (26-30), the second class 155 instances were classified correctly as (18-25) while 1 was misclassified as (13-17) and 3 were misclassified as (26-30) and the third class (26-30) we see 94 instances were classified correctly, while there was no misclassifications.

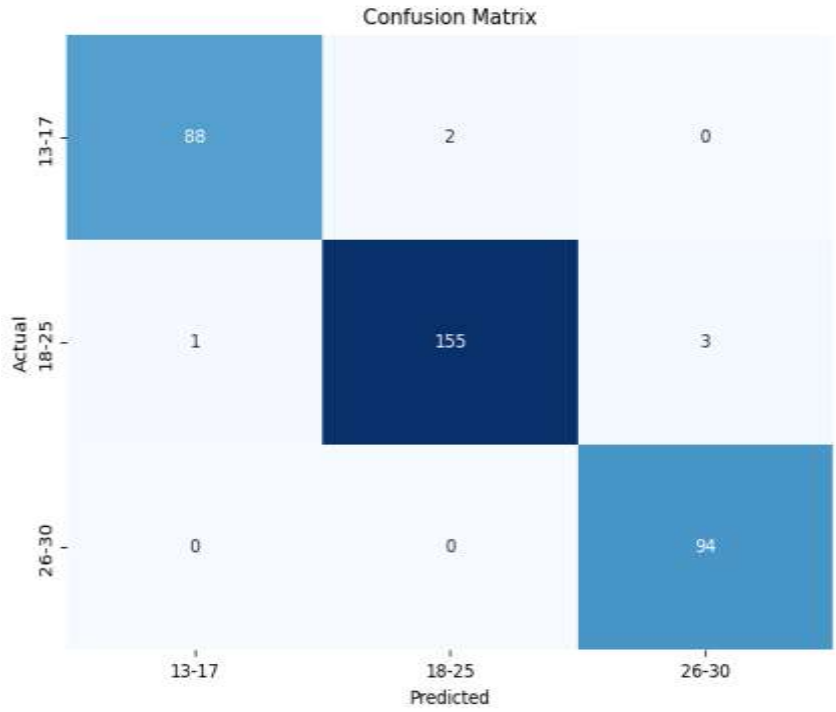


Figure 5 shows the results for the regression.

A. *Comparison with other related works*

Table 1 presents comparison details of MAE of various relevant works to give a convenient manner of comparing the performance of existing works.

Table 1 comparison of automatic age estimation methods

Work	Dataset	MAE
[4]	APPA-Real and UTK -Faces	4.49
[3]	MORPH II,FG-NET and CACD	2.54
[7]	DPR images	3.13
[11]	FG-Net	2.64
[16]	FG-NET,UTK	2.57,3.5
[17]	UTK-FACE	91.5% and 8.55 MAE
Our Model	CASIA Africa Face	**0.60 and 98%**

V. DISCUSSION

The results of the study demonstrate the significant potential of Convolutional Neural Networks (CNNs) in enhancing chronological age prediction and accuracy. The high accuracies achieved by our model indicate the effectiveness of this approach in classifying and prediction of chronological age using facial images. This has important implications for improving age verification systems and other systems such as customer satisfaction and suggestion application by enabling more accurate and efficient detection of age from facial images. Additionally, the study highlights the promise of deep learning CNNs in automating the predication process, which could lead to advancements in the field of medical imaging and age verification systems and ultimately benefit customers and users of web services through age prediction targeted services.

VI. CONCLUSION

In this study, we created an age estimator based on our custom model utilizing CNNs, batch normalization and dropouts. The primary purpose of our effort was to minimize MAE and also have increased accuracy which has been achieved. We employed Adam optimizer to reduce loss and MAE. We obtained 0.60 MAE an accuracy of 98% using a combined weight sharing model. The main contribution of this study can be determined since, although having a smaller dataset than earlier research, the MAE of our work is lower and accuracy is higher. In the future, we hope to determine race combinedly from facial photos and utilize them to improve our age prediction and classification

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Investigation of Charging Demand Times and Economic Parameters of Grid- Connected Distributed Power System Integrated Electric Charging Stations

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Abstract – It is a visible fact that with the widespread use of Electric Vehicles (EV) in recent years, the energy need is increasing day by day. As the number of vehicles increases, charging stations that traditionally provide energy are insufficient for charging demand times, and since there is no production at the stations, only consumption is made. For this reason, it should also be considered economically. Considering that energy storage system supported hybrid Renewable Energy Source (RES) charging stations can produce and store energy, it will be beneficial in terms of both economical and charging demand times. When EV are examined in terms of charging demand times, it is seen that they draw extra load by connecting to the grid, especially during periods of intense use. This helps reduce the amount of energy provided from the grid with one or more alternative energy production sources integrated into the grid. This situation, which will benefit us financially, can also allow energy to be stored with a storage unit included in the system. At the same time, economic factors such as investment cost, energy cost, capital recycling rate are important for these investments and network optimization. Distributed Power Systems (DPS), which we encounter frequently as an alternative to conventional energy production, can provide additional and supporting production by connecting to the grid at many points. In this way, it is envisaged that electric vehicles will be able to carry a part of the charging demand and reduce the cost of electricity consumption. It is thought that this system, which can be very beneficial for the environment, will reduce carbon emissions in the long term. In this study, the charging demand times of DPS vehicle charging stations connected to the grid, which are thought to be an alternative and supportive of conventional energy production, will be examined and economic parameters such as investment return rate, energy cost, capital return rate will be examined.

Keywords – Alternative energy, DPS, EVCS, Charging demand times, Energy storage system.

I. INTRODUCTION

With electric vehicle production on the rise in recent years, the need for charging power for vehicles is increasing. It can be predicted that conventional energy production will be insufficient in this case. It is also a fact that conventional production produces more energy and has a negative impact on more carbon emissions, greenhouse gas effects, emissions, etc. In order to prevent this problem, it is stated that more RES should be used and focused on these systems according to the climate action plans of countries [1]. With the Paris Agreement signed in 2016, Türkiye decided that it aims to achieve net zero emissions and that action plans will be created on industry, transportation, buildings, agriculture, natural assets and the use of waste [2]. In particular, fossil fuels constitute the majority of carbon emissions. We can say that these fuels, which we frequently use in our vehicles, not only create natural pollution but also are non-renewable,

energy prices are increasing day by day. For these reasons, the search for alternative energy sources has increased in the energy sector [3]. Electric vehicles (EV) have come to the fore to reduce carbon emissions by abandoning vehicles that use fossil fuels and to make RES more widespread [4, 5]. With the increase in the number of electric vehicles, it is important to meet the electricity production demand from RES in terms of zero emissions and carbon emissions. In this regard, the construction of charging stations with RESs is an inevitable phenomenon waiting for us. However, today, the rate of many countries, especially developing countries, to engage in such investments is not sufficient. The growth rate of RES is slowing down due to situations such as technological proficiency, especially installation costs [6]. When we examine Turkey, it is seen that the electrical energy consumption of the transportation sector reaches 1,790 GWh by 2022 [7]. There is an easy way to calculate charging times for EVs. Roughly, it is the EV battery capacity divided by the charging power. For example, it will take approximately 8 hours to fully charge an EV with a 60 kWh battery at a 7kW charging station [8]. A vehicle with a 90 kWh battery needs 22% kW = 195 minutes to charge it to 80% (90kWh*80%). At the same time, EV charging stations also have some negative effects on the grid. It increases the power demanded from the local distribution network and is exemplified by power loss, harmonic distortions, frequency imbalances and overload [9-11]. In particular, the harmonics that occur when converting alternating current to direct current negatively affect power stability and quality. For this reason, IEEE-519, a power quality standard, must be complied with during charging [12]. Stations are classified according to Total Harmonic Distortion (THD) according to the standard. If THD is less than or equal to 15%, it is classified as level 1, if it is less than or equal to 12%, it is classified as level 2, and if it is less than 8%, it is classified as level 3 and level 4 [13]. Some power distribution systems calculated according to these mentioned negativities can prevent all the negativities. For example, a converter equipped with active/passive harmonic filters can eliminate the harmonic problem caused by EV charging stations in the network. Depending on the DPS network; It has been defined that it is widely used today as solar energy systems, wind energy systems, hydroelectric energy systems, combined heat and power systems and fuel cells [14]. A grid-integrated DPS is expected to meet the energy demand for electric vehicles and the charging times at stations. Solar energy systems (Photovoltaic systems - PV), commonly thought of as renewable energy sources, are also suitable for electric vehicle charging stations. Solar Botanic Trees has developed solar panels arranged on a dome-shaped surface resembling a tree canopy, with a battery system integrated into the structure's trunk for energy storage [15, 16]. This design aims to meet charging demand durations independently of the grid using DPS. Another charging station installed at a workplace in the Netherlands can achieve a power capacity of 10 kW with solar energy. The V-tent system, which can provide a single-vehicle charging solution, is applicable in parking areas. This hybrid design utilizes the grid and PV systems to meet charging demand when energy demand is low [17]. In another project, the American company Change Wind Power developed a charging station capable of simultaneously providing energy for up to six electric vehicles using efficient wind and solar energy [18]. Thus, multiple DPS systems aim to meet the necessary charging durations. The studies have examined PV-supported and wind energy-supported charging stations and presented their findings. This study will investigate the process and outcomes of hybrid DPS-supported charging stations. Unlike other studies, a storage system will be added to the system, integrating wind and solar energy. Optimization will be performed to maximize DPS performance according to grid conditions. Additionally, the economic parameters of the system will be examined and evaluated based on current market conditions

II. MATERIALS AND METHOD

The system will be created by determining the energy capacity on a specified region. The difference between production and consumption of the created system and their effects on each other will be examined.

A. Determination of Region

Marmara University Mehmet Genç Complex (40°54.2'N, 29°8.7'E) was chosen for the installation of the system. The wind and solar energy potential in this region can be understood from the Fig.s below. Using Windatlas, the wind potential of the region was examined. Wind direction distribution is around 12 degrees as seen in Fig. 1. When the monthly wind speed is examined in Fig. 2, it is determined that the region has an average speed of 6.14 m/s and is suitable for continuous production.

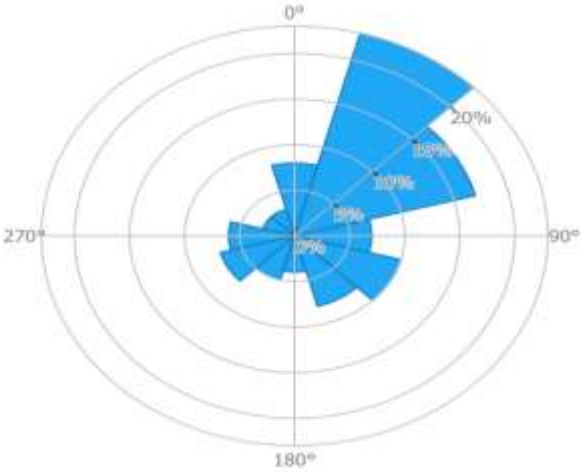

Fig. 1 Wind Direction Distribution

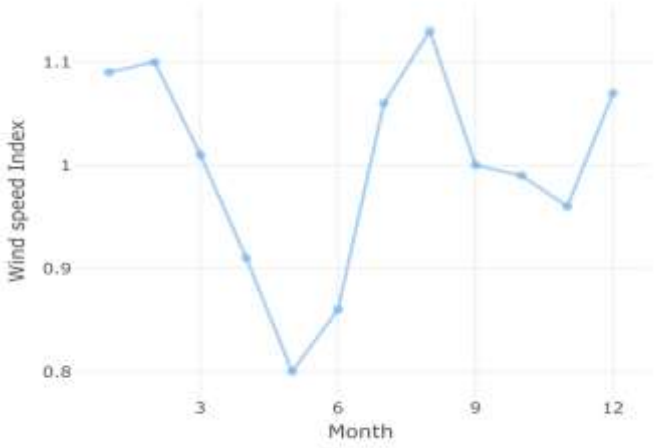

Fig. 2 Monthly Wind Speed

When the region is examined in terms of solar energy with Windatlas, as seen in Fig. 3, it is aimed that the solar panels integrated into the system operate with maximum performance with an average monthly production value of 155 kWh/m^2 and a low temperature value. As seen in Fig. 4, the monthly average temperature of Istanbul is around 20 degrees.

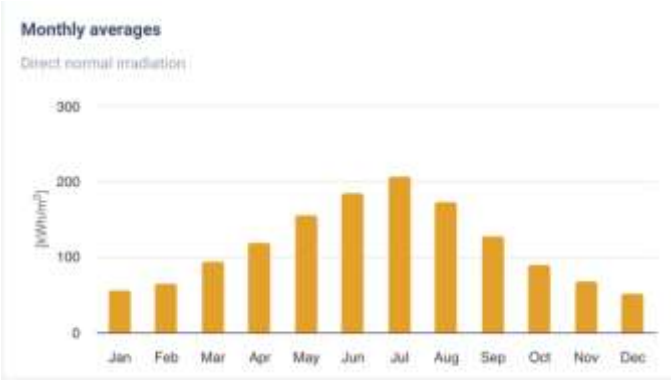

Fig. 3 Monthly Normal Irradiation Graph

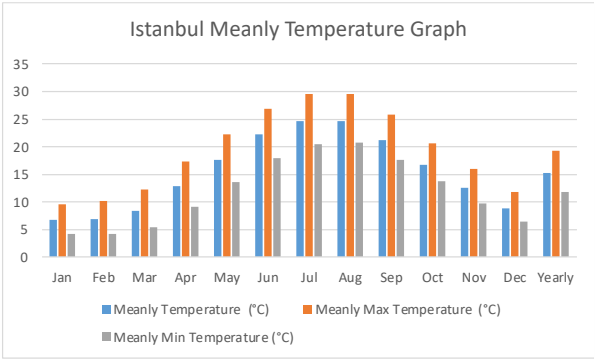

Fig. 4 Istanbul Meanly Temperature Graph

B. Distributed Power System (DPS)

DPS enable the generation of electricity on a small scale near the point of consumption. DPSs encompass decentralized single or hybrid power systems utilizing energy sources such as solar, wind, hydrogen, geothermal, and others. DPS offers a sustainable, efficient, and reliable approach to energy production. Unlike traditional centralized power systems, distributed power systems operate on an energy infrastructure model where electricity generation and distribution are carried out through local, small-scale production

facilities. These systems typically employ renewable energy sources, such as solar panels, wind turbines, hydroelectric plants, and biomass energy systems. Utilizing these renewable resources reduces environmental impacts, enhances energy supply security, and decreases dependency on the central grid [19].

C. Homer Pro Software

HOMER Pro is a software used for the design, optimization, and economic analysis of energy systems. It is specifically developed for hybrid energy systems and evaluates the integration of various energy sources, including solar, wind, hydroelectric, diesel generators, and batteries. This program optimizes the performance and best design of energy systems and conducts economic analyses. Its primary applications include research, project planning, policy development, and education. The software uses three simple equations for optimization. Equation 1 is used to calculate the net present cost of today.

$$NPC = C_0 + \sum_{t=1}^{n} \frac{C_t}{(1+r)^t} \quad (1)$$

NPC: Net Present Cost, Ct: Total cost in year t (including capital costs, operation and maintenance costs, fuel costs, replacement costs, etc.), N: Lifetime of the system (in years), C_0: initial investment cost r: Discount rate, t: Time period (year). Equation 2 is used for annual revenue and expenditure calculations.

$$CRF = \frac{r(1+r)^n}{(1+r)^n - 1} \quad (2)$$

CRF: Capital Recovery Factor, r: Discount Rate or Interest Rate, n: Repayment Period.

D. Details of Simulation

The system architecture of an integrated charging station with DPS has been developed. The system architecture is designed to include grid, electric vehicle as load, wind energy, solar energy, and storage with a Lithium-ion battery. In this system, it is assumed that the electric vehicle will consume 25 kWh of energy daily. For the components of the charging station, a 15 kW PV panel, a 10 kW wind turbine, a 1 kWh storage, and a 5 kW converter have been selected. The system utilizes 25 CV Energy 600Wp 120PM solar panels with a power capacity of 0.6 kW each. An Arysiedder 5 kW vertical wind turbine is used in the system. The storage function is fulfilled by a 12V100Ah DS-LiFePO4 model battery with a capacity of 1 kWh, composed of lithium iron phosphate chemical components. The converter duty is undertaken by the Leonics S-219Cp 5 kW converter.

Table 1. System Components Table

Components	***Name***	***Size***	***Unit***
PV	CV Enerji 600Wp 120PM flat plate PV	15.0	kW
Energy Storage	DS-LiFePO4 1 kWh Li-Ion	1	Group
Wind Turbine	Arysiedder 10 kW	2	ea.
System Converter	Leonics S-219Cp 5 kW	14.4	kW

The simulations of the system formed by the components given in Table 1 were tested, and the most optimal scenario was selected and reported. It is expected that the 15 kW capacity standard PV panel will support this system with solar energy. This panel, which has an average output of 2.21 kW and can provide a daily output of 53 kWh/day, operates with a capacity factor of 14.70. The initial investment costs of the components used in the system were researched based on market averages. For the standard wind turbine, ₺7,735 was considered; for the 1 kWh capacity standard lithium-ion battery, ₺15,471; for the 15 kW

capacity standard PV panel, ₺4,641; and for the 5 kW capacity Leonics S-219Cp converter, ₺15,619 was assumed. The initial investment cost of the system was determined to be a total of ₺43,467.

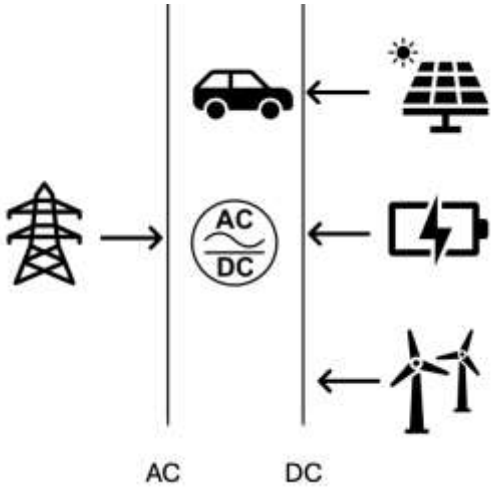

Fig. 5 PV and Wind Energy Supported System Design

Due to the selected area being a university, vehicle intensity has been observed between 9:00 AM to 11:30 AM and 1:30 PM to 5:00 PM. Therefore, charging demand is highest during these time intervals, resulting in a total peak period of 6 hours. Based on these data, feasibility studies can be conducted to determine the installation and operating costs of charging stations for Electric Vehicles (EVs) according to their charging demand times. According to the cost report prepared by the Ministry of Industry and Technology for the installation of charging stations for EVs, considering the current exchange rate, the cost of an AC charging device is ₺194,520, and the cost of a DC charging device is ₺583,560. It is projected that a standard EV with a 52 kWh battery capacity can be fully charged in 3 hours with an AC charging station and in 70 minutes with a DC charging station. With these data, daily charging demand times can be evaluated, and feasibility studies can be conducted. By implementing the charging station with hybrid DGS support as designed in this study, energy storage can be achieved during non-peak hours, and support can be provided to the grid when necessary. Thus, both energy storage and grid support can be realized outside of peak vehicle hours [20, 21].

As depicted in Fig. 6, the net capacity of the PV panel used in the system is determined to be 15 kW. The average output power is 2.21 kW, and the capacity factor is 14.70%. The total annual production of the integrated PV panel in the system, as simulated, is 19.34 kWh/1000.

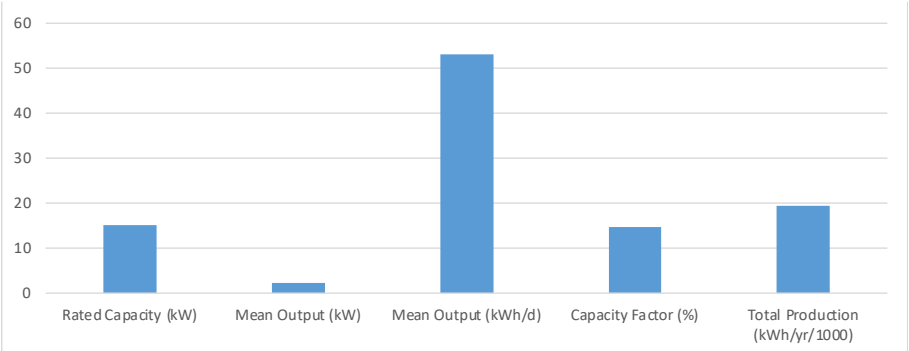

Fig. 6 PV Panel Electrical Specifications Table

The wind turbine installed in this system is expected to support the system by generating electricity with wind energy, similar to what the PV panel does. As seen in Fig. 7, the selected wind turbine can provide an average output of 3.87 kW. Its total capacity can be observed as 20 kW. It can generate an annual energy of 33.87 kWh/Yr/1000.

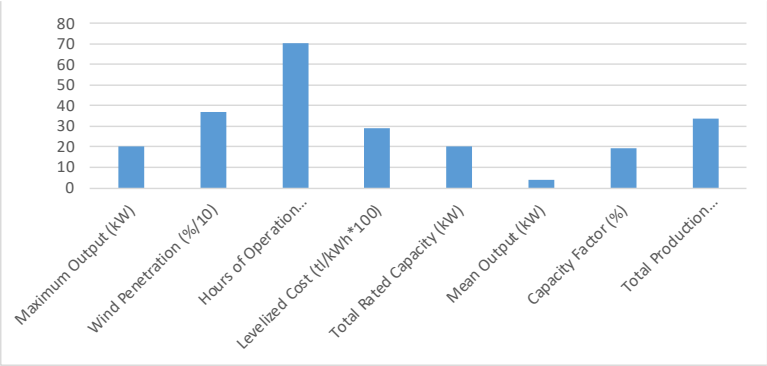

Fig. 7 10 kW Standard Wind Turbine Electrical Specifications Table

The electrical characteristics of the battery bank in the system design, required for storing the energy produced by the two systems, are indicated in Fig. 8. These batteries, with a nominal capacity of 5 kWh, are expected to store energy and provide support to the grid as needed, in addition to their charging demand periods.

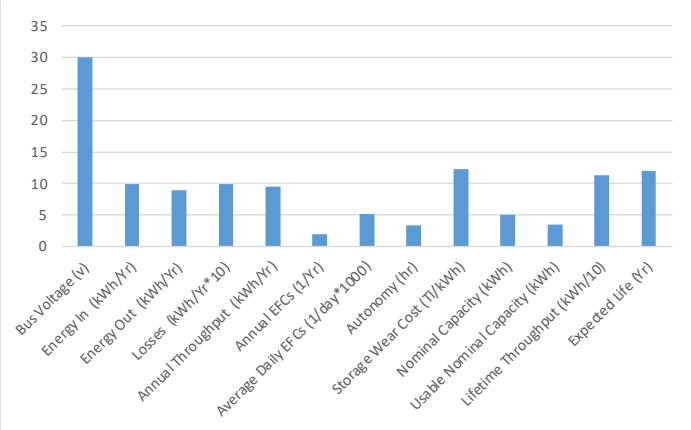

Fig. 8 Lithium Ion Battery Pack Electrical Specifications Table

E. Evaluation of Charge Demand Optimization in DPS

Considering the data mentioned in the study, the charging demand periods for vehicles increase between 10:00 and 15:00 on weekdays and between 12:00 and 14:00 on weekends. Energy generated during hours outside these periods can be stored in the lithium-ion battery in the system. This stored energy can be provided to vehicles or the grid as support when needed. By optimizing the system in this way, a lithium-ion-supported hybrid DPS charging station will be installed, operating at maximum efficiency.

F. Evaluation of Simulation

As shown in Fig. 9, the impact of the components used in the compound electric charging station system supported by DPS on the grid is presented based on their electrical parameters. In this table, you can see the purchased energy, the energy generated by the system, and the energy sold. Upon examining the difference, a significant advantage is observed in the grid's usage, positively affecting energy costs. The

internal rate of return can be seen as 21.3% based on the data in the tables. Considering the charging demand periods, especially during peak usage in the evening hours, the system supports the grid by reducing grid load. Although this may increase the charging demand period, it can be considered an advantage rather than a disadvantage due to its contribution to the grid. Furthermore, utilizing the storage unit in a hybrid manner with RES during vehicle charging reduces energy costs, leading to more efficient and optimal results. Thus, while supporting the grid during non-essential charging demand periods such as nighttime, the hybrid system reduces energy costs during critical daytime demand periods, resulting in a more optimal outcome.

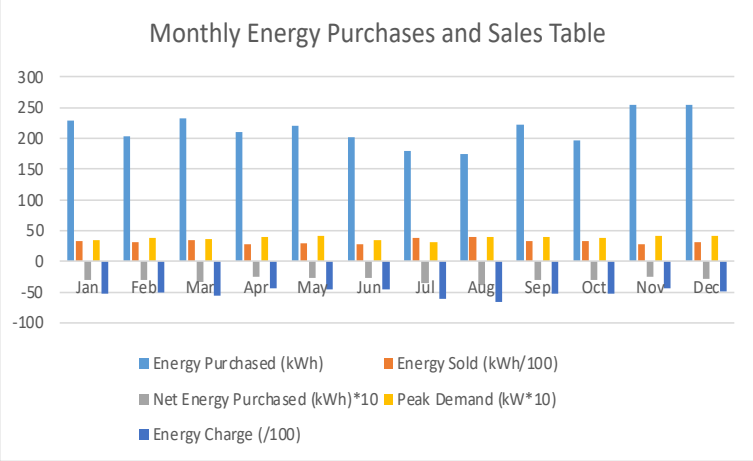

Fig. 9 Monthly Energy Purchase/Sale Table and Graph

As seen in Fig. 10, when the differences between the installed system and the base system are examined with economic parameters, it is observed that the system's electricity generation costs are much lower than those of the base system, which is a significant factor. Furthermore, when examined in terms of carbon emissions, the system integrated with renewable energy and distributed power systems pollutes nature less and is more environmentally friendly.

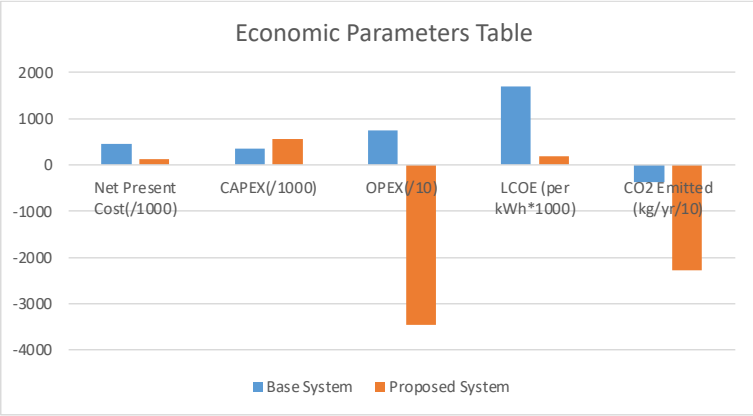

Fig. 10. Economic Parameters Table

III. Results and Discussion

In this study, the net present cost of the system is determined to be ৳115,765, with a capital expense (CAPEX) of ৳561,921, operating expense (OPEX) of ৳-3451.2, levelized energy cost of ৳187, and carbon emissions of -2284.4 (kg/yr/10). As seen in Fig. 10, when compared to the base system, the benefits of this system can be observed. It has been found to be highly beneficial both financially and environmentally. Unlike similar studies where DG-integrated charging stations generally consist of a single RES generation system, this study evaluates a hybrid DG-integrated charging station. Additionally, optimization has been

performed considering the lithium-ion battery in the system for energy storage and grid support outside of charging demand period.

IV. CONCLUSION

As a result of the study, the hybrid DG-integrated electric vehicle charging station has various contributions both environmentally and economically. Utilizing RES-based generation systems for electricity production, instead of conventional methods, can significantly reduce carbon emissions. Opting for entirely renewable emission-free energy production, as opposed to electricity obtained from carbon-based fossil fuels, would be much more preferable from an environmental perspective. Given the increasing demand for charging periods for EVs today, it has been observed that RES-supported hybrid systems have a positive impact on charging demand periods compared to production obtained through conventional means. It has been observed that electricity generated during hours outside of charging demand energy can be stored. This stored energy can be held for later use or can provide support to the grid in times of need. This will not only reduce carbon emissions but also contribute to shortening charging demand periods. Taking these factors into consideration, it has been shown that efficient energy utilization is possible. In conclusion, based on the outputs obtained from this study, it can be understood that the lithium-ion battery-supported hybrid DG-integrated charging station yields positive results in both environmental and economic aspects. Not only this study but also other different DG-integrated systems can contribute to increasing the efficient use of energy.

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A PET based and phthalimide-appended fluorescence probe for monitoring of nitric oxide: DFT study of response mechanism

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Abstract – The molecules that are chemically reactive and naturally produced within biological systems are Reactive oxygen species (ROS). Depending on the levels of ROS production, it can have beneficial or harmful consequences. Normal of ROS mediate cellular activities (cell growth and immunity). However, the excessive of ROS can cause DNA damage and cell death. ROS, as the name suggests, derive and reveal even higher redox and reaction activity than molecular oxygen. ROS consists of free radicals such as superoxide, nitric oxide, peroxyl, and alkoxyl, and non-radical structures such as hydrogen peroxide and hypochlorous acid. Endogenous ROS production occurs in three main regions: mitochondria, endoplasmic reticulum (ER), and NADPH oxidase (NOX). The detection methods of ROS are chemiluminescence, electron spin resonance (ESR), and Fluorescence Spectroscopy. Nitric oxide (NO•), produced from L-arginine by the action of NO• synthases (NOS), is one of three vital signal gasotransmitters. Nitric oxide is a biological signaling molecule. NO• is an indispensable messenger molecule in the cardiac disorders, immune system disorder and neurodegeneration. It makes white blood cells kill tumor cells and bacteria, and much like neurotransmitter, it can dilate blood vessels. Disclosing the distribution of NO and its relationship with bodily agents will be critical for the treatment for the disorders mentioned above. Therefore, it is very important to develop probes that can determine nitric oxide (NO) by fluorescence spectroscopy. In this study, the response of photoinduced electron transfer (PET) based and phthalimide added fluorescence probe to NO was examined according to DFT results.

Keywords – Fluorescence, probe, nitric oxide, NO, DFT, phthalimide

I. INTRODUCTION

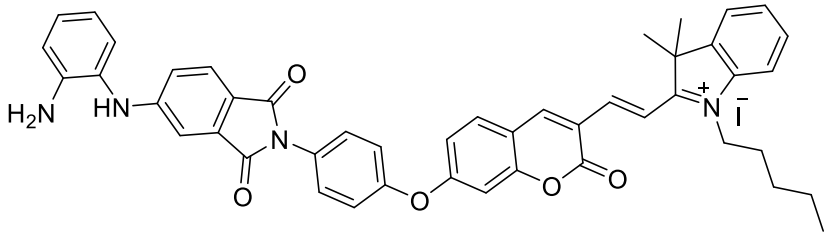
Reactive oxygen species (ROS), as the name suggests, are molecules that chemically have higher redox reaction activity than molecular oxygen and are naturally produced in biological systems. ROS are free radicals such as hydroperoxyl radical ($HO_2^{\bullet}$), superoxide radical ($O_2^{\bullet}$), nitric oxide radical ($NO^{\bullet}$), peroxyl radical ($ROO^{\bullet}$), hydroxyl radical ($HO^{\bullet}$) and alkoxyl radical ($RO^{\bullet}$). and consists of non-radical structures such as hydrogen peroxide (H_2O_2), singlet Oxygen ($^1O_2$) and hypochlorous acid (HOCl) [1]–[3]. Depending on ROS production levels, while at normal levels it is beneficial by mediating cellular activities such as cell growth and immunity, the presence of excessive ROS can have harmful consequences such as lipid peroxidation, DNA damage and even cell death [1]. Mitochondria, endoplasmic reticulum (ER) and O_2^- producing NADPH oxidase (NOX) are the three main sites of endogenous ROS production [4]. Chemiluminescence, electron paramagnetic resonance (EPR)/ electron spin resonance (ESR) spectroscopy and fluorescence spectroscopy are some detection methods for ROS [5]. Nitric oxide is obtained from L-arginine through the activity of NO• synthases (NOS) and is known

as one of the three vital signal gasotransmitters [6], [7]. NO• is a biological signaling molecule (key biochemical messenger) that plays important roles in blood pressure regulation and immune systems. Therefore, NO• is the main messenger structure in immune system problems, heart diseases and neurodegeneration. It also strengthens white blood cells to kill bacteria and tumor cells and has the ability to dilate blood vessels like a neurotransmitter [8]. Elucidating the dispersion of NO• and its relation with bodily agents will be crucial for the treatment of the above-mentioned disorders [9]. Various methods based on organic reaction with fluorescent probes have been reported for NO•. These are the o-phenylenediamine (OPD) reaction (formation of the triazole ring from o-diamino aromatics), metal-ligand complexes, N-nitrosation reaction of secondary amines on aromatics, formation of diazocyclic compounds from o-amino-3'-dimethylaminophenylaromatics, Se-NO Hantzsch of dihydropyridines. bond formation, deamination reaction and aromatization, conversion of thiosemicarbazide to 1,3,4-oxadiazole heterocycle, formation of Acylhydrazide 1,2,3,4-Oxatriazole and others [5], [10]–[16]. A series of fluorescent NO probes have been published by coupling a NO-recognizing moiety to organic fluorophores such as rhodamine, naphthalimide, coumarin, BODIPY and other derivatives [17]–[21]. NO response mechanisms have been declared as PET, FRET, ICT, ESIPT and others [6], [17], [22], [23]. Therefore, it is very important to develop probes that can detect NO• by fluorescence spectroscopy.

In the presented study, the response of photoinduced electron transfer (PET)-based and phthalimide-appended fluorescence probe to NO was examined according to DFT results.

II. Materials and Method

All theoretical computations were achieved using the DFT/B3LYP technique and the 6–31G(d,p) basis set with the Gaussian 09W program. Molecular energies were obtained using TD-DFT calculations [24]–[27]. In this study, a probe containing *o*-phenylene diamine-based coumarin, whose structure is shown in Fig. 1, was designed. In this designed structure, the fluorophore part consists of coumarin and indoline salt. The o-phenylene diamine group with phthalimide connected to this structure with an ether bond was considered as the part that can determine NO• (Fig. 1).



Probe A

Fig. 1. The designed probe

A. The photo-induced electron transfer (PET) approach for NO determination using fluorescent probes

The one of the most current and well-known approaches in the design of chemosensing probes is the photo-induced electron transfer (PET) system. Typical main components in PET comprise of aromatic fluorophores, aliphatic amines and methylene chain ligands. A PET-based fluorescent sensor is generally consists of in three parts: a fluorophore (electron acceptor), a receptor (electron donor or quencher), and a bond connecting the two. The system consists of a fluorophore bound to an electron-rich receptor structure (usually amino nitrogen). The fluorophore is the photonic processing region of excitation and emission, producing the fluorescence signal output. The receptor is responsible for complex formation and decomplexation with the target. A spacer bond keeps the fluorophore and receptor close together so that they are in separate conjugated systems.

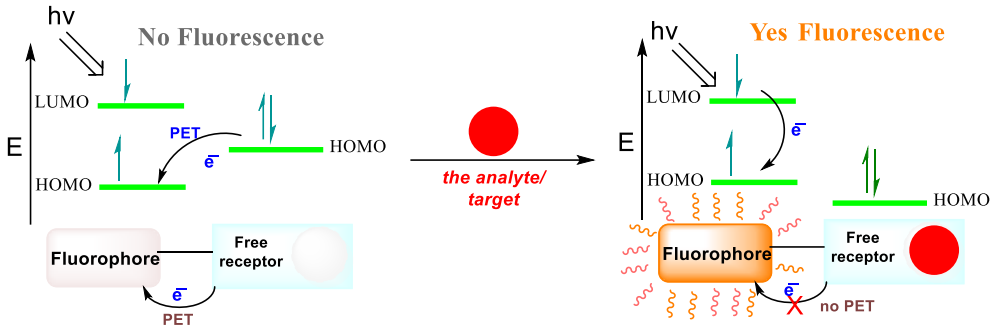
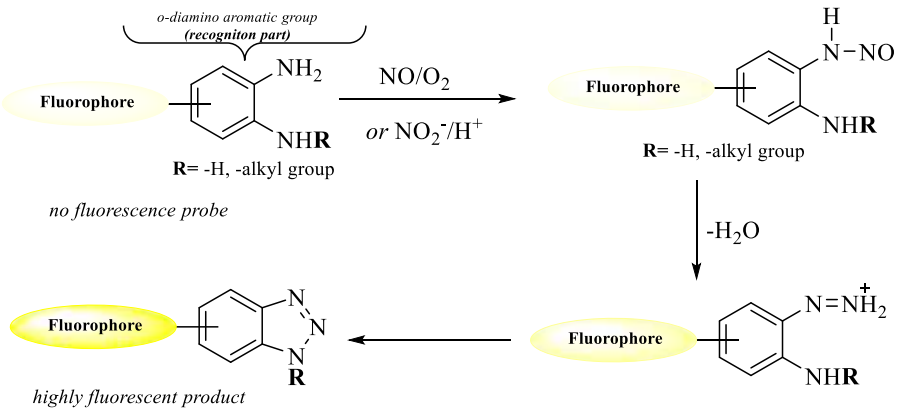


Fig. 2. PET mechanism

In the existence of light of the convenient wavelength (excitation of the fluorophore), intramolecular electrons from the HOMO (electron donor) of the receptor are transferred to the lower HOMO (electron acceptor) of the fluorophore. Thus, fluorescence in this system results in quenching. When an analyte/target binds to the identification fraction, the energy of the HOMO of the receptor decreases so that photo-induced electron moving from the HOMO of the donor to the fluorophore cannot occur, i.e. as a result the PET process is interrupted and the fluorescence intensity increases (a bright fluorescence emission is produced). In other words, the existence of the target is determined [23] (Fig. 2).

B. The o-phenylenediamine (OPD) reaction approach with NO

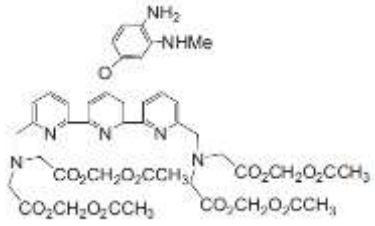
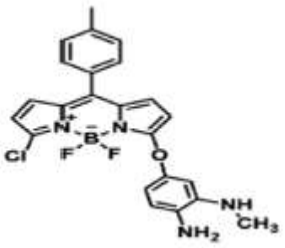
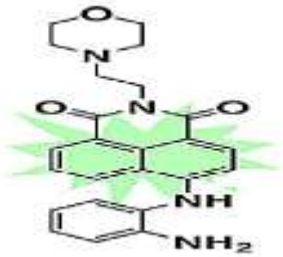
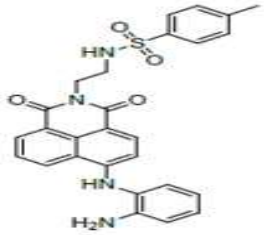
With this approach, the monitoring of NO radical is achieved as a result of triazole formation in the presence of NO/O_2 on the fluorophore or the aromatic diamino compound group attached to it. The relatively non-fluorescent diamino group reacts rapidly with the NO-derived N-nitrosating agent (N_2O_3) produced from the interaction of NO with oxygen or the acid catalyzed occurrence of nitrous acid from nitrite, yielding an exceedingly luminescent product with the skeleton of the triazole ring [5] (Scheme 1).



Scheme 1. The *o*-phenylenediamine (OPD) reaction with NO/O_2

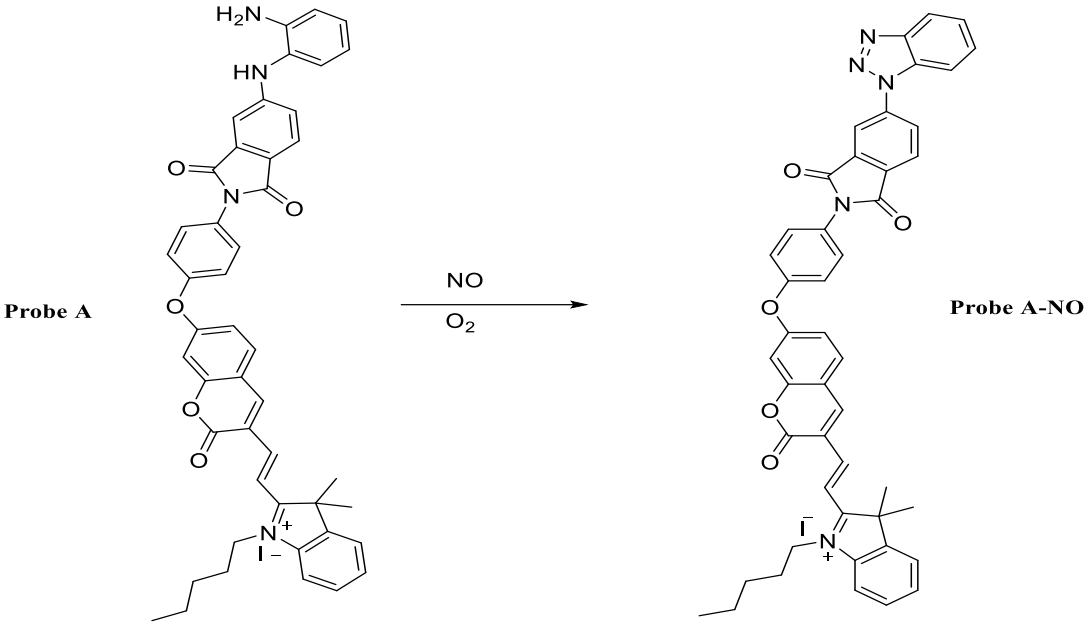
The application of fluorescent probes evolved depended on the OPD approach in NO detection has fascinated serious relevance in last years (Table 1).

Table 1. Examples of fluorescent probes based on the OPD approach

Probes	Reference	Probes	Reference
	[28]		[29]
	[12]		[30]
	[31]		[19]

III. RESULTS

The interaction mechanism of the probe designed in the study with NO/O_2 is seen in Scheme 2. The theoretical calculation results of the formation in this scheme are included in this study.



Scheme 2. The interaction mechanism of the probe designed in the study with NO/O_2

From the molecular orbitals obtained for Probe A, the HOMO-1 value was calculated as –7.26 eV, the LUMO value was calculated as –5.68 eV, and the GAP (energy gap between HOMO-1→LUMO) value

was calculated as 1.58 eV. The oscillator power (f) for this transition was found to be 0.70544. From the molecular orbitals obtained for probe A-NO, the HOMO value was calculated as –7.18 eV, the LUMO value was –5.75 eV, and the GAP (energy gap between HOMO–LUMO) value was calculated as 1.43 eV (Fig. 3). The oscillator power for this transition was found to be 0.70478, and the f values obtained are the highest among the possible transitions [28], [32], [33].

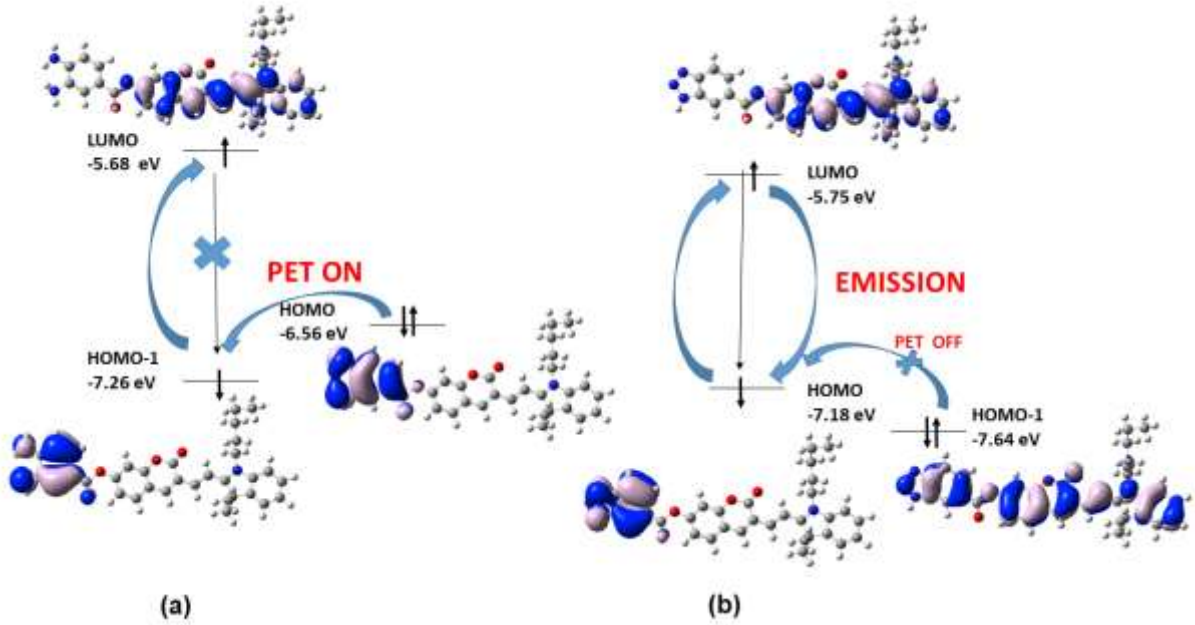


Fig. 3. Electronic transitions of Prob A (a) and Probe A–NO (b) molecules

IV. DISCUSSION

In the OPD approach, the PET mechanism is blocked by the formation of benzotriazole compounds and the formation of benzotriazole derivatives after the interaction of fluorophores obtained by binding the electron-rich o-diaminophenyl group to different molecules with NO. As could be depicted from Fig. 3, it is understood that the OPD approach supports the PET mechanism in accordance with the formation of benzotriazole compounds [28], [32], [33].

V. CONCLUSION

Thus, within the framework of the study, the results of DFT calculations of the nitric oxide-interacted structure of Probe A (Probe A-NO) were investigated. It was that the data obtained was consistent with the OPD approach and PET process.

ACKNOWLEDGMENT

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Theoretical studies of a 1,8-naphthalimide-derived fluorescent sensor for recognition nitric oxide

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Abstract – Reactive oxygen species (ROS) are chemically reactive molecules naturally produced within biological systems. Depending on ROS levels, they can have either beneficial or harmful consequences. Normal ROS mediate cellular activities such as cell growth and immunity. However, excessive ROS can cause DNA damage and cell death. ROS, as the name suggests, exhibit even higher redox and reaction activity than molecular oxygen. They consist of free radicals like superoxide, nitric oxide, peroxyl, and alkoxyl, as well as non-radical structures like hydrogen peroxide and hypochlorous acid. Endogenous ROS production occurs primarily in three regions: mitochondria, endoplasmic reticulum (ER), and NADPH oxidase (NOX). Detection methods for ROS include chemiluminescence, electron spin resonance (ESR), and fluorescence spectroscopy. Nitric oxide (NO$^{\bullet}$), synthesised from L-arginine by NO$^{\bullet}$ synthases (NOS), serves as a vital signalling gasotransmitters. It plays essential roles in cardiac disorders, immune system function, and neurodegeneration. NO$^{\bullet}$ acts as a messenger molecule, enabling white blood cells to kill tumor cells and bacteria. Additionally, it functions similarly to a neurotransmitter, dilating blood vessels. Understanding NO distribution and its relationship with bodily agents is critical for treating the mentioned disorders. Consequently, developing fluorescence probes capable of detecting nitric oxide (NO) is of utmost importance. In this work, we investigated the respond of a fluorescence probe based on photoinduced PET with derived 1,8-naphthalimide, to NO using density functional theory (DFT) outcomes.

Keywords – Fluorescent, sensor, nitric oxide, NO, density functional theory, 1-8-naphthalimide

I. INTRODUCTION

Naturally occurring molecules in biological systems that exhibit enhanced redox reaction activity compared to molecular oxygen are Reactive oxygen species (ROS). These species include free radicals like hydroperoxyl ($HO_2^{\bullet}$), superoxide ($O_2^{\bullet}$), nitric oxide ($NO^{\bullet}$), peroxyl ($ROO^{\bullet}$), hydroxyl ($HO^{\bullet}$), and alkoxyl ($RO^{\bullet}$), alongside non-radical entities like hydrogen peroxide (H_2O_2), singlet oxygen ($^1O_2$), and hypochlorous acid (HOCl) [1]–[3]. At moderate concentrations, ROS facilitate cellular processes such as growth and immunity; however, excessive ROS levels can induce detrimental effects like lipid peroxidation, DNA damage, and cellular demise [2]. Endogenous ROS generation predominantly occurs within mitochondria, endoplasmic reticulum (ER), and via O_2^{-} producing NADPH oxidase (NOX) activity [4]. Detection methodologies for ROS include chemiluminescence, electron paramagnetic resonance (EPR)/Electron spin resonance (ESR) spectroscopy, and fluorescence spectroscopy [5].

Nitric oxide radical, synthesized from L-arginine by NO$^{\bullet}$ synthases (NOS), serves as a critical signaling gasotransmitter, regulating blood pressure and immune responses [6]. NO$^{\bullet}$ functions as a pivotal biochemical messenger implicated in immune disorders, cardiovascular diseases, and neurodegeneration.

Moreover, it enhances the bactericidal activity of white blood cells, induces vasodilation akin to neurotransmitters [7]. Understanding the distribution of nitric oxide and its interactions within the body holds significance for treating aforementioned pathologies [8]. Various organic reaction-based methods utilizing fluorescent probes have been proposed for NO• detection, including the o-phenylenediamine (OPD) reaction, metal-ligand complexes, and N-nitrosation reactions [5], [9]–[15]. Furthermore, fluorescent NO probes employing organic fluorophores like rhodamine, naphthalimide, and coumarin have been developed, coupled with NO-recognizing moieties [16]–[20]. Mechanistic insights into NO response encompass photoinduced electron transfer (PET), Förster resonance energy transfer (FRET), and intramolecular charge transfer (ICT) mechanisms [6], [19], [21], [22]. Hence, the advancement of fluorescence spectroscopy-enabled probes for NO• detection holds paramount importance.

In the present work, we inquired out the response of a photoinduced electron transfer (PET)-based fluorescence probe appended with derived 1,8-naphthalimide to NO, leveraging Density Functional Theory (DFT) analyses.

II. Materials and Method

Theoretical computations were achieved using the DFT/B3LYP technique and the 6–31G(d,p) basis set with the Gaussian 09W program. Molecular energies were obtained using TD-DFT calculations [23]–[26]. In this study, a probe containing *o*-phenylene diamine-based coumarin, whose structure is shown in Figure 1, was designed. In this designed structure, the fluorophore part consists of coumarin and indoline salt. The o-phenylene diamine group with 1,8-naphthalimide linked to this structure with an ether bond was cogitated as the part that can monitor NO• (Fig. 1).

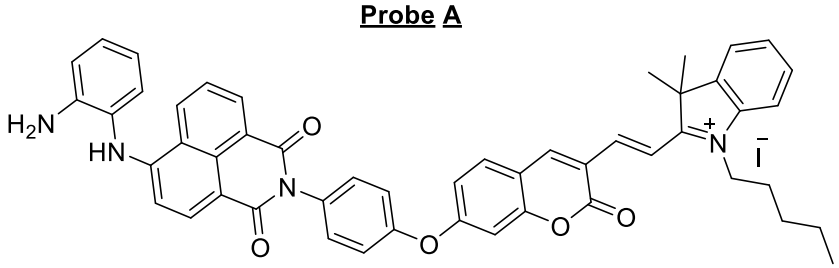


Fig. 1. The arranged probe

A. The photo-induced electron transfer (PET) mechanism for NO determination using fluorescent probes

The photo-induced electron transfer (PET) mechanism has become one of the most current and well-known approaches in the design of chemosensing probes. Typical main elements in PET systems consist of aromatic fluorophores, aliphatic amines and methylene chain ligands. A PET-based fluorescent probe is usually structured in three parts: a fluorophore (electron acceptor), a receptor (electron donor or quencher), and a bond connecting the two. The system consists of a fluorophore bound to an electron-rich receptor structure (usually amino nitrogen). The fluorophore is the photonic processing region of excitation and emission, producing the fluorescence signal output. The receptor is responsible for complex formation and decomplexation with the target. A spacer bond keeps the fluorophore and receptor close together so that they are in separate conjugated systems.

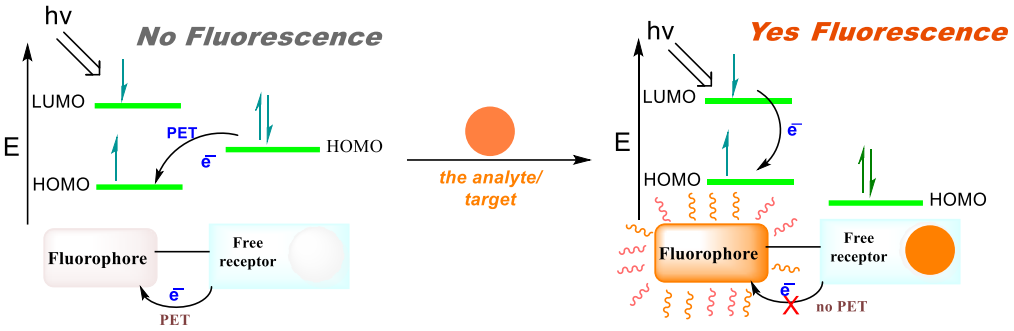
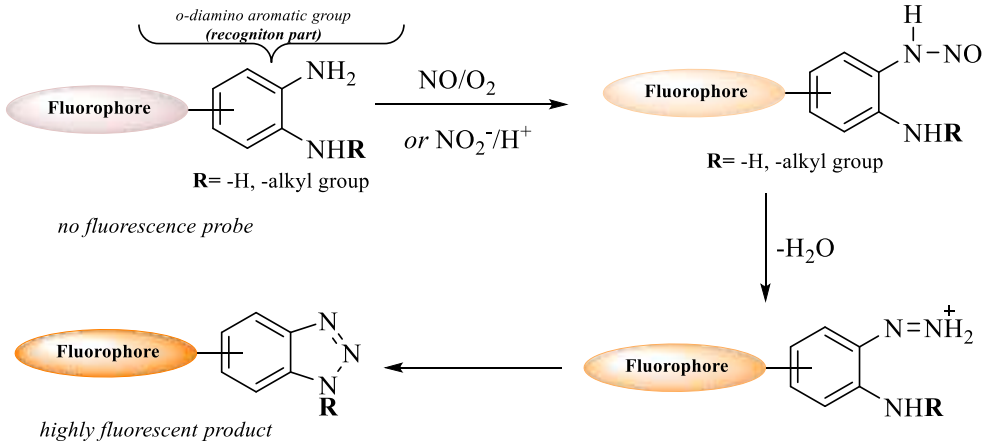


Fig. 2. PET mechanism

In the presence of light of the appropriate wavelength (excitation of the fluorophore), intramolecular electrons from the HOMO (electron donor) of the receptor are transferred to the lower HOMO (electron acceptor) of the fluorophore. Thus, fluorescence in this system results in quenching. When an analyte/target binds to the recognition moiety, the energy of the HOMO of the receptor decreases so that photo-induced electron moving from the HOMO of the donor to the fluorophore cannot occur, i.e. as a result the PET process is interrupted and the fluorescence intensity increases (a bright fluorescence emission is produced). In other words, the existence of the target is determined [27] (Fig. 2).

B. The o-phenylenediamine (OPD) reaction approach with NO

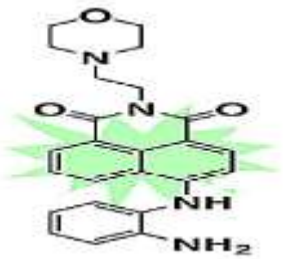
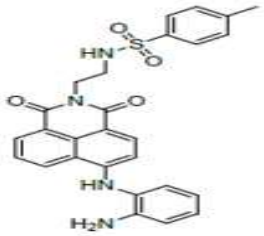
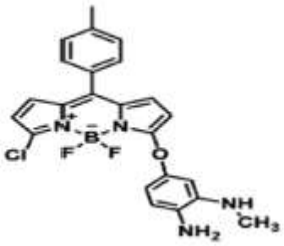
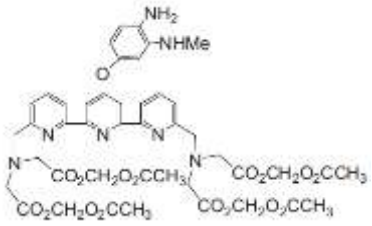
With this method, the detection of NO radical is achieved as a result of triazole formation in the presence of NO/O_2 on the fluorophore or the aromatic diamino compound group attached to it. The relatively non-fluorescent diamino group reacts rapidly with the NO-derived N-nitrosating agent (N_2O_3) produced from the interaction of NO with oxygen or the acid catalyzed occurrence of nitrous acid from nitrite, yielding an exceedingly luminescent product with the skeleton of the triazole ring [5] (Scheme 1).



Scheme 1. The *o*-phenylenediamine (OPD) reaction with NO/O_2

The application of fluorescent probes developed based on the OPD approach in NO detection has fascinated serious relevance in recent years (Table 1).

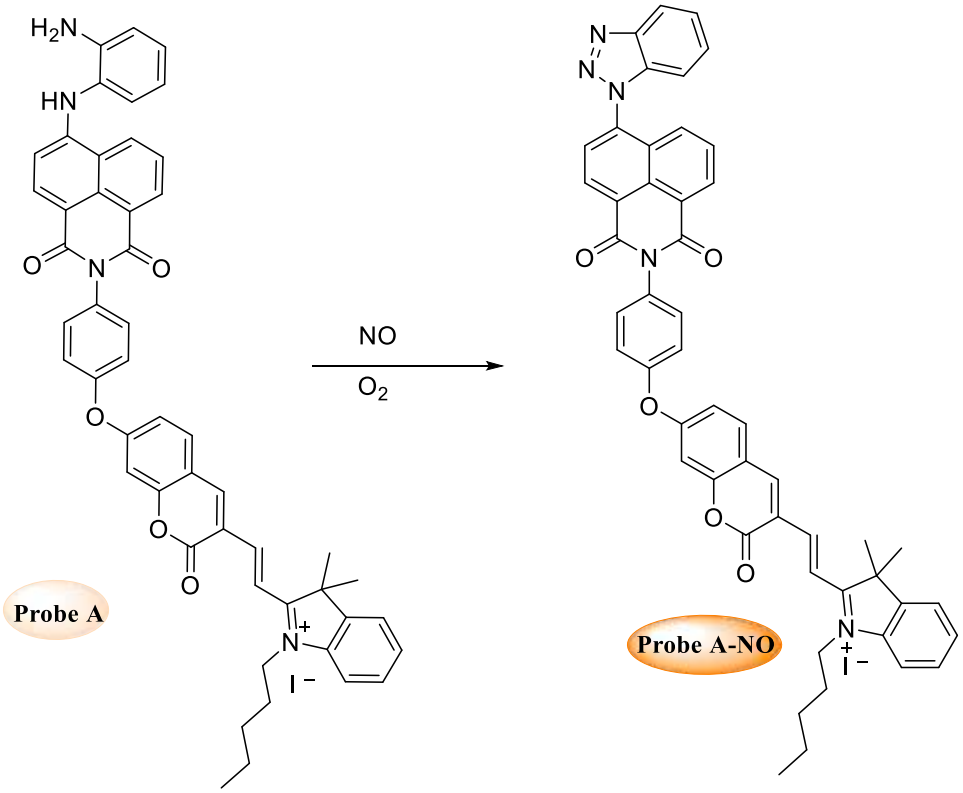
Table 1. Examples of fluorescent probes based on the OPD approach

Probes	Reference	Probes	Reference
	[28]		[29]
	[11]		[30]
	[31]		[20]

III. RESULTS

The interaction mechanism of the probe designed in the study with NO/O_2 is seen in Scheme 2. The theoretical calculation results of the formation in this Scheme are included in this study.

From the molecular orbitals obtained for Probe A, the HOMO-1 value was calculated as –7.18 eV, the LUMO value was calculated as –5.66 eV, and the GAP (energy gap between HOMO-1→LUMO) value was calculated as 1.52 eV. The oscillator power (f) for this transition was found to be 0.70625. From the molecular orbitals obtained for probe A-NO, the HOMO value was calculated as –7.30 eV, the LUMO value was –5.72 eV, and the GAP (energy gap between HOMO–LUMO) value was calculated as 1.58 eV (Fig. 3). The oscillator power for this transition was found to be 0.70640 and the f values obtained are the highest among the possible transitions [30], [32], [33].



Scheme 2. The interaction mechanism of the probe designed in the study with NO/O_2

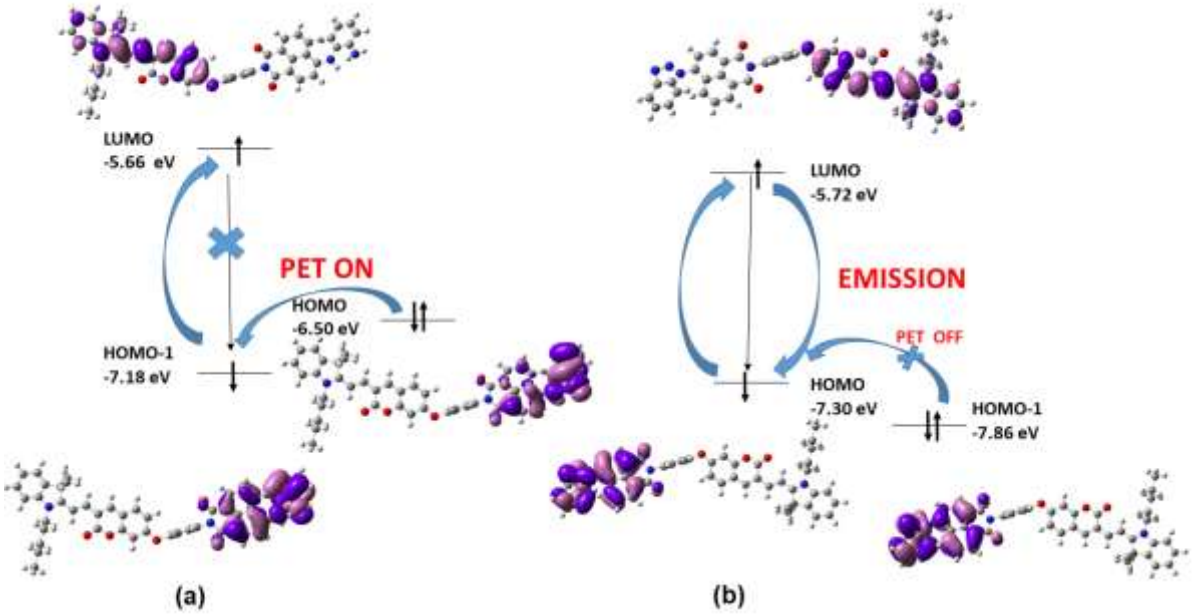


Fig. 3. Electronic transitions of Prob A (a) and Probe A–NO (b) molecules

IV. DISCUSSION

In the o-phenylenediamine pathway, the PET mechanism is inhibited due to the formation of benzotriazole compounds and their derivatives, which result from the interaction between fluorophores, created by binding the electron-rich o-diaminophenyl group to various molecules, and NO. Fig. 3 illustrates that the OPD approach aligns with the PET mechanism, evidenced by the formation of benzotriazole compounds [30], [32], [33].

V. CONCLUSION

Thus, in the present work, the results of DFT calculations for the nitric oxide-interacted structure of Probe A (Probe A-NO) were examined. The findings proved that the data aligned with the OPD approach and the PET phenomenon.

ACKNOWLEDGMENT

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Theoretical Analysis of nitric oxide sensing of a new designed coumarin-hemicyanine conjugate through 1,3,4-oxadiazole heterocycle formation by DFT method

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Abstract – Molecules that are chemically reactive and naturally produced in biological systems are Reactive oxygen species (ROS). While the production of ROS at normal levels mediates cellular activities such as cell growth and immunity, excess can cause lipid peroxidation, DNA damage, and even cell death. ROS are free radicals such as superoxide ($O_2^{\bullet-}$), hydroperoxyl ($HO_2^{\bullet}$), nitric oxide ($NO^{\bullet}$), hydroxyl ($HO^{\bullet}$), peroxyl ($ROO^{\bullet}$), alkoxyl ($RO^{\bullet}$), and non-radicals such as hydrogen peroxide (H_2O_2), singlet oxygen ($^1O_2$) and hypochlorous acid (HOCl). Endogenous ROS production occurs from L-arginine under the action of $NO^{\bullet}$ synthases (NOS) and in three main regions: mitochondria, endoplasmic reticulum (ER), and O_2^- producing NADPH oxidase (NOX). Detection methods of ROS are Chemiluminescence, Electron spin resonance (ESR) or electron paramagnetic resonance (EPR) spectroscopy and Fluorescence Spectroscopy. $NO^{\bullet}$, one of the three vital signaling gasotransmitters, is an important biochemical messenger (a biological signaling molecule) that plays an important role in the regulation of blood pressure, neurodegeneration, and immune systems. It enables white blood cells to kill tumor cells and bacteria, and like a neurotransmitter, it can dilate blood vessels. Diagnosis of the distribution of NO and its relationship with agents in the body will be critical to the treatment of the above-mentioned disorders. Therefore, it is very important to develop probes that can detect nitric oxide (NO) by fluorescence spectroscopy. In this study, the response of photoinduced electron transfer (PET)-based and fluorescence probe-bound coumarin-hemicyanine to NO was examined according to DFT results.

Keywords – Fluorescence, nitric oxide, NO, DFT, coumarin-hemicyanine

I. INTRODUCTION

Reactive oxygen species (ROS) is a common term encompassing oxygen-derived radicals (such as nitric oxide, hydroxyl radical, and superoxide) and non-radical oxygen species (including singlet oxygen, hydrogen peroxide, peroxynitrite, and hypochlorite). ROS can exert both beneficial and detrimental effects on the body. An imbalance in free radical production can lead to oxidative stress, contributing to aging and age-related ailments like cardiovascular diseases, cancer, and neurodegenerative disorders [1]. Mitochondria serve as the primary site for ROS and Reactive nitrogen species (RNS) generation. Nitric oxide radical ($NO^{\bullet}$), among these reactive species, rapidly interacts with other radicals or metalloproteins within organisms. As a colorless, heteronuclear diatomic, paramagnetic, and highly reactive gas molecule, NO plays crucial roles in diverse physiological and pathological processes. In mammals, $NO^{\bullet}$ serves as a signaling molecule in many pathways, aiding in inter-tissue communication and homeostasis. However, excessive $NO^{\bullet}$ production is associated with cancer and neurodegenerative diseases [2], [3]. Hence, the

development of sensitive and selective methods to detect NO• production and distribution within living cells holds critic importance [4]. Among these methods, fluorescent probe techniques, particularly utilizing fluorescence microscopy, stand out due to their high sensitivity, selectivity, and experimental feasibility [5]. When exploring methods for detecting Nitric Oxide (NO•), it becomes evident that various fluorimetric techniques are utilized, each proceeding through distinct mechanisms. Numerous approaches relying on organic reactions with fluorescent probes have been documented for NO• detection. These encompass the o-phenylenediamine (OPD) reaction, which entails the formation of a triazole ring from o-diamino aromatics, as well as metal-ligand complexes, N-nitrosation reaction involving secondary amines on aromatics, and the generation of diazocyclic compounds from o-amino-3'-dimethylaminophenylaromatics, Se-NO Hantzsch bond formation of dihydropyridines, deamination reaction coupled with aromatization, conversion of thiosemicarbazide into 1,3,4-oxadiazole heterocycle, and formation of 1,2,3,4-Oxatriazole from acylhydrazide have been reported [6]–[15].

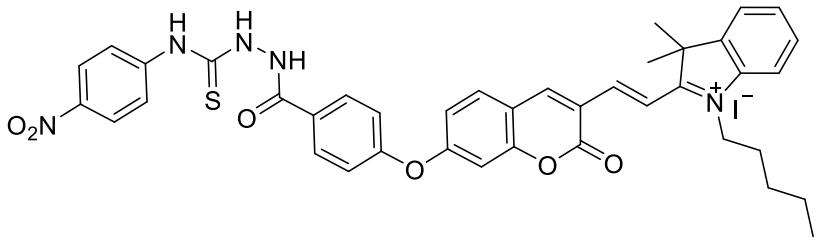
Fluorescent probes for NO• typically comprise a capture site and an organic fluorophore, designed to effectively quench fluorescence via the photoinduced electron transfer (PET) phenomenon and react with NO• to activate fluorescence [16].

Generally, fluorescent probes for Nitric Oxide (NO•) are synthesized through the incorporation of an electron-rich amino group with diverse fluorophores. This combination serves a dual purpose: it can efficiently dampen the fluorescence of fluorophores via the photo-induced electron transfer (PET) mechanism and can also undergo reaction with NO• in aerobic conditions (NO/O_2), leading to the activation of fluorophores' emission and the formation of corresponding cyclization derivatives [5]. Developing methods and tools for real-time detection of nitric oxide is crucial for gaining deeper insights into its origins, activities, and both physiological and pathological functions.

Hence, it is imperative to devise probes capable of detecting NO• through fluorescence spectroscopy. This study investigates the reactivity of a photoinduced electron transfer (PET)-based fluorescence probe incorporating coumarin-hemicyanine towards NO•, achieved via the conversion of thiosemicarbazide to 1,3,4-oxadiazole heterocycle, as assessed through Density Functional Theory (DFT) findings.

II. Materials and Method

All theoretical computations were achieved using the DFT/B3LYP technique and the 6–31G(d,p) basis set with the Gaussian 09W program. Molecular energies were obtained using TD-DFT calculations [17]–[20]. In this study, a probe containing The thiosemicarbazide-based coumarin, whose structure is shown in Fig. 1, was designed. In this designed structure, the fluorophore part consists of coumarin and indoline salt. The thiosemicarbazide group from 4-nitrophenyl isothiocyanate connected to this structure with an ether bond was considered as the piece that could determine NO• (Fig. 1).



Prob-A

Fig. 1. The designed probe

A. The photoinduced electron transfer (PET) approach for NO determination using fluorescent probes

The one of the most current and well-known approaches in the design of chemosensing probes is the photoinduced electron transfer (PET) system. Typical main components in PET comprise of aromatic fluorophores, aliphatic amines and methylene chain ligands. A PET-based fluorescent sensor is generally consists of in three parts: a fluorophore (electron acceptor), a receptor (electron donor or quencher), and a

bond connecting the two. The system consists of a fluorophore bound to an electron-rich receptor structure (usually amino nitrogen). The fluorophore is the photonic processing region of excitation and emission, producing the fluorescence signal output. The receptor is responsible for complex formation and decomplexation with the target. A spacer bond keeps the fluorophore and receptor close together so that they are in separate conjugated systems.

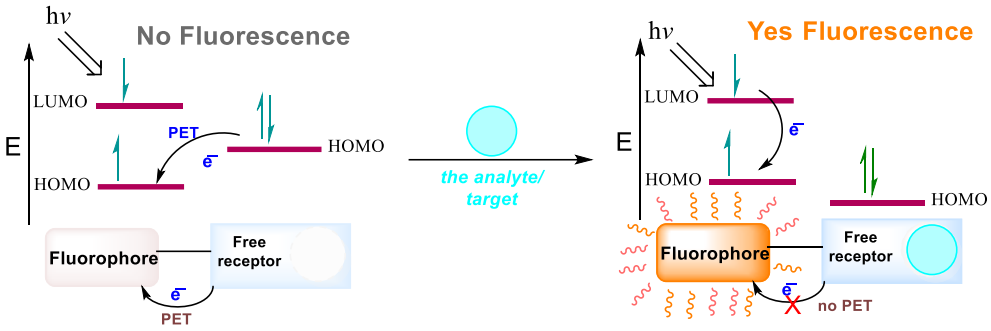
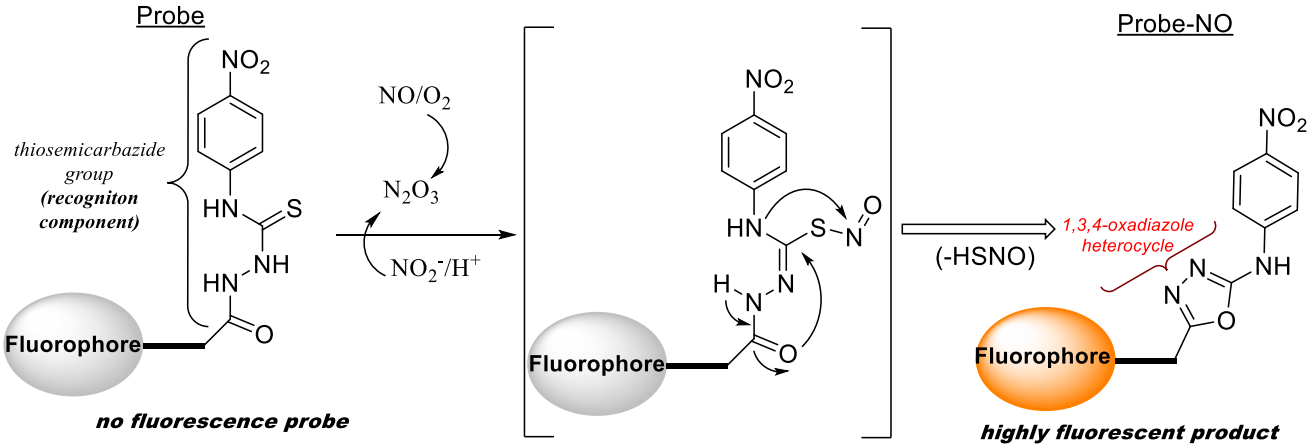


Fig. 2. PET mechanism

In the existence of light of the convenient wavelength (excitation of the fluorophore), intramolecular electrons from the HOMO (electron donor) of the receptor are transferred to the lower HOMO (electron acceptor) of the fluorophore. Thus, fluorescence in this system results in quenching. When an analyte/target binds to the identification fraction, the energy of the HOMO of the receptor decreases so that photo-induced electron moving from the HOMO of the donor to the fluorophore cannot occur, i.e. as a result the PET process is interrupted and the fluorescence intensity increases (a bright fluorescence emission is produced). In other words, the existence of the target is determined [21] (Fig. 2).

B. 1,3,4-oxadiazole heterocycle formation mechanism from thiosemicarbazide for NO

With the presented approach, the NO recognition mechanism is realized by using a fluorophore as the signaling unit and the thiosemicarbazide moiety as the recognition unit.



Scheme 1. The conversion of thiosemicarbazide to 1,3,4-oxadiazole heterocycle

Due to the weak fluorescence emission of the recognition unit-bound probe, the fluorescence intensity of the probe can be quickly restored due to the conversion of thiosemicarbazide to 1,3,4-oxadiazole heterocycle in the presence of NO. Thus, it leads to restriction of free rotation of N–N single bond. Specifically, the NO• radical reacts with the probe to form rearranged Probe-NO [10] (Scheme 1).

The application of fluorescent probes improved depended on 1,3,4-oxadiazole heterocycle formation approach in NO detection has enchanted serious relevance in last years (Fig. 4) [10], [15].

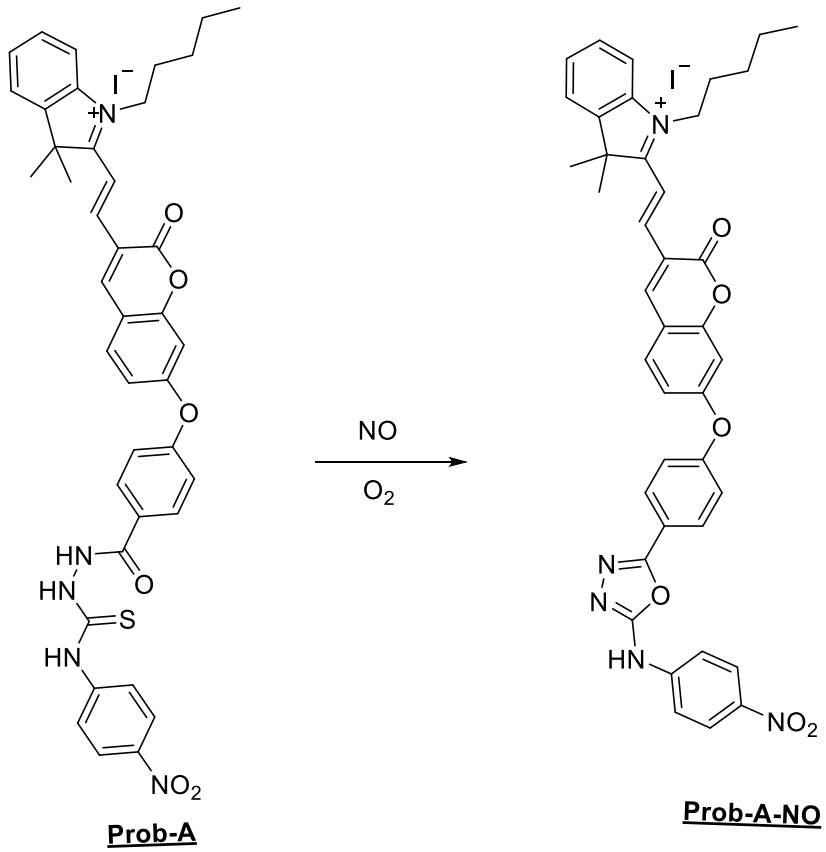
[10] [15]

Fig. 3. Examples of fluorescent probes based on the 1,3,4-oxadiazole heterocycle formation

III. RESULTS

The interaction mechanism of the model probe in the present work with NO/O_2 is seen in Scheme 2. The theoretical calculation results of the formation in this scheme are included in the present work.

From the molecular orbitals obtained for Probe A, the HOMO-1 value was calculated as –8.13 eV, the LUMO value was calculated as –5.86 eV, and the GAP (energy gap between HOMO-1→LUMO) value was calculated as 2.27 eV. The oscillator power (f) for this transition was found to be 0.70573. From the molecular orbitals obtained for probe A-NO, the HOMO value was calculated as –7.46 eV, the LUMO value was –5.89 eV, and the GAP (energy gap between HOMO–LUMO) value was calculated as 1.57 eV (Fig. 4). The oscillator power for this transition was obtained to be 0.70613, and the f values found are the highest among the possible transitions [16].



Scheme 2. The sensing approach of the model probe in the work with NO/O_2

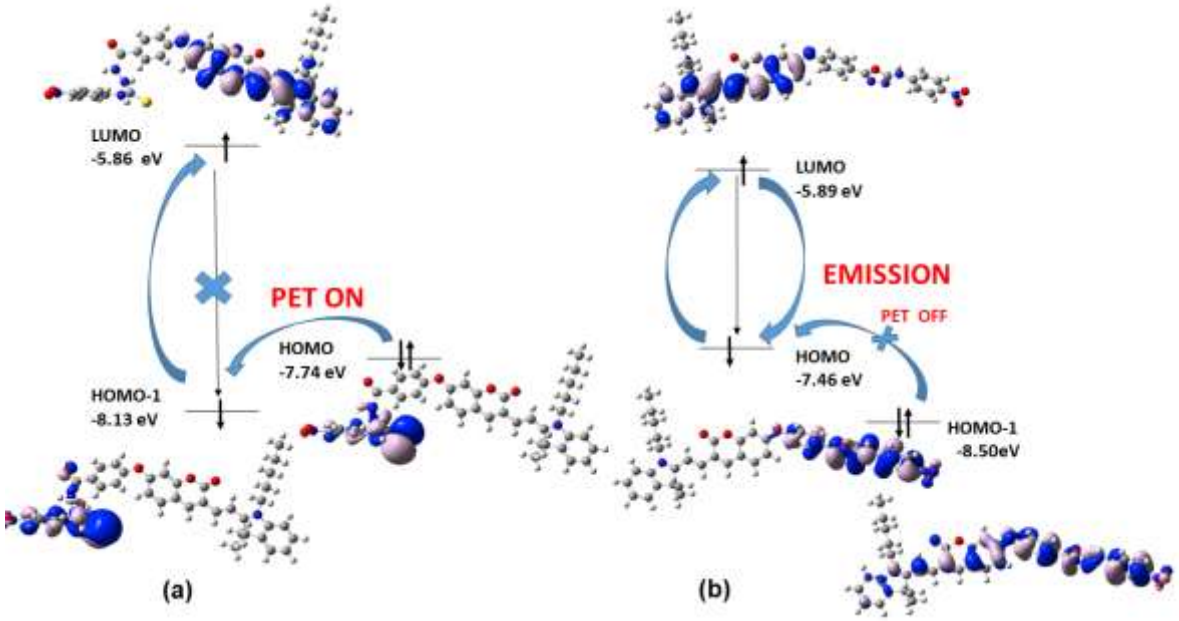


Fig. 4. Electronic transitions of Prob A (a) and Probe A–NO (b) molecules

IV. DISCUSSION

The thiosemicarbazide moiety adjoining to the carbonyl moiety of the fluorophore undergoes a reaction with NO, yielding the 1,3,4-oxadiazole ring while simultaneously releasing thionitrosic acid [10], [15]. As shown in Fig. 4, the transitions observed between the ligand and the complex align with the literature's description of the PET mechanism associated with [16].

V. CONCLUSION

To sum up, in the context of the research, the study delved into the outcomes derived from DFT computations concerning the nitric oxide-interacted configuration of Probe A (Probe A-NO). The findings indicated a harmonization with the 1,3,4-oxadiazole heterocycle formation methodology and PET mechanism.

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Evaluation of theoretical calculation of a novel coumarin-indolinium-iodide based fluorescent probe for detection nitric oxide

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Abstract – Molecules that are chemically reactive and naturally produced in biological systems are known as Reactive Oxygen Species (ROS). While ROS play a critical role in cellular activities such as cell growth and immunity at normal levels, excessive ROS can lead to lipid peroxidation, DNA damage, and cell death. ROS have an even higher redox and reaction activity than molecular oxygen. They include free radicals like superoxide ($O_2^{\bullet-}$), hydroperoxyl ($HO_2^{\bullet}$), nitric oxide ($NO^{\bullet}$), hydroxyl ($HO^{\bullet}$), peroxyl ($ROO^{\bullet}$), alkoxyl ($RO^{\bullet}$), as well as non-radicals such as hydrogen peroxide (H_2O_2), singlet oxygen ($^1O_2$), and hypochlorous acid (HOCl). Endogenous ROS production occurs from L-arginine through the action of NO• synthases (NOS) in three main regions: mitochondria, endoplasmic reticulum (ER), and O_2^--producing NADPH oxidase (NOX). Detection methods for ROS include Chemiluminescence, Electron Paramagnetic Resonance (EPR) spectroscopy, and Fluorescence Spectroscopy. Nitric oxide ($NO^{\bullet}$), one of the three essential signaling gasotransmitters, serves as an important biochemical messenger in regulation blood pressure, neurodegeneration, and immune responses. It helps white blood cells in killing tumor cells and bacteria and acts as a vasodilator. Accurate diagnosis of nitric oxide distribution and its interactions within the body is critical for treating the mentioned disorders. Therefore, the development of probes capable of detecting nitric oxide (NO) using fluorescence spectroscopy is essential. In this study, we investigated the response of a PET (photoinduced electron transfer)-based and fluorescence probe-bound coumarin-indolinium salt to NO depend on Density Functional Theory (DFT) data.

Keywords – Fluorescent, nitric oxide, NO, coumarin-indolinium, *density functional theory*

I. INTRODUCTION

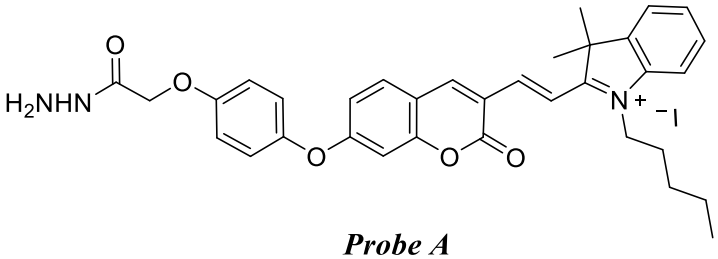
Reactive oxygen species (ROS) is a term used to describe oxygen-containing radicals (such as superoxide, hydroxyl radical, and nitric oxide) and non-radical oxygenated structures (including singlet oxygen, hydrogen peroxide, peroxynitrite, and hypochlorite). ROS can exert both beneficial and detrimental effects on the body. An imbalance in the production of free radicals can result in oxidative stress, contributing to aging and the onset of age-related diseases such as cardiovascular diseases, cancer, and neurodegenerative disorders [1]. Mitochondria are the main sites of ROS and reactive nitrogen species (RNS) production. Among these reactive species, the nitric oxide radical ($NO^{\bullet}$) interacts rapidly with other radicals or metalloproteins in organisms. $NO^{\bullet}$, a colorless, heteronuclear diatomic, paramagnetic, and highly reactive gas, is crucial in various physiological and pathological processes. In mammals, $NO^{\bullet}$ facilitates intertissue communication and homeostasis by acting as a signaling molecule in several pathways. However, overproduction of $NO^{\bullet}$ is linked to cancer and neurodegenerative diseases [2], [3]. From this reason, it is essential to develop sensitive and selective methods to detect $NO^{\bullet}$ production and distribution in living cells [4]. Detection methods for NO include chemiluminescence, electron paramagnetic resonance

(EPR)/electron spin resonance (ESR) spectroscopy [5], and fluorescence spectroscopy, with fluorescent probe techniques, particularly fluorescence microscopy, being notable for their high sensitivity, selectivity, and experimental applicability [6]. When examining methods for NO• detection, various fluorimetric techniques emerge, each with distinct mechanisms. Numerous approaches utilizing organic reactions with fluorescent probes have been documented for NO• detection. These approaches include the o-phenylenediamine (OPD) reaction, which involves forming a triazole ring from o-diamino aromatics, as well as metal-ligand complexes, the N-nitrosation reaction involving secondary amines in aromatics, and the formation of diazocyclic compounds from o-amino-3'-dimethylaminophenylaromatics, Se-NO Hantzsch bond formation of dihydropyridines, deamination reaction coupled to aromatization, the conversion of thiosemicarbazide to 1,3,4-oxadiazole heterocycle, and formation of 1,2,3,4-oxatriazole from acylhydrazide [5], [7]–[15]. Fluorescent probes for NO• typically comprise a capture site and an organic fluorophore; they are designed to effectively quench fluorescence via the photo-induced electron transfer (PET) mechanism and react with NO• to activate fluorescence [16]. Generally, these probes are synthesized by coupling an electron-rich amino group with various fluorophores, serving to quench fluorescence through the PET mechanism and react with NO• in aerobic conditions (NO/O_2), leading to the activation of fluorophore emission and the formation of the corresponding cyclization derivatives [6]. Developing methods and tools for real-time NO• detection is crucial for gaining deeper insights into its origins, activities, and both physiological and pathological functions. Consequently, designing probes capable of detecting NO• via fluorescence spectroscopy is imperative.

This study focused on examining the fluorescence emission reactivity of the coumarin-hemicyanine-containing probe A with NO based on light-induced electron transfer (PET) and DFT (Density Functional Theory) findings via the formation of 1,2,3,4-oxatriazole heterocycle from acylhydrazide.

II. Materials and Method

All theoretical computations were achieved using the DFT/B3LYP technique and the 6–31G(d,p) basis set with the Gaussian 09W program. Molecular energies were obtained using TD-DFT calculations [17]–[20]. In this study, a probe containing the acylhydrazide-based coumarin, whose structure is shown in Fig. 1, was designed. In this designed structure, the fluorophore part consists of coumarin and indoline salt. The acylhydrazide group structured on the probe A with an ether bond was regarded as the entity that could recognize NO• (Fig. 1).



Probe A

Fig. 1. The designed probe

A. The photoinduced electron transfer (PET) approach for NO determination using fluorescent probes

The one of the most current and well-known approaches in the design of chemosensing probes is the photo-induced electron transfer (PET) system. Typical main components in PET comprise of aromatic fluorophores, aliphatic amines and methylene chain ligands. A PET-based fluorescent sensor is generally consists of in three parts: a fluorophore (electron acceptor), a receptor (electron donor or quencher), and a bond connecting the two. The system consists of a fluorophore bound to an electron-rich receptor structure (usually amino nitrogen). The fluorophore is the photonic processing region of excitation and emission, producing the fluorescence signal output. The receptor is responsible for complex formation and decomplexation with the target. A spacer bond keeps the fluorophore and receptor close together so that they are in separate conjugated systems.

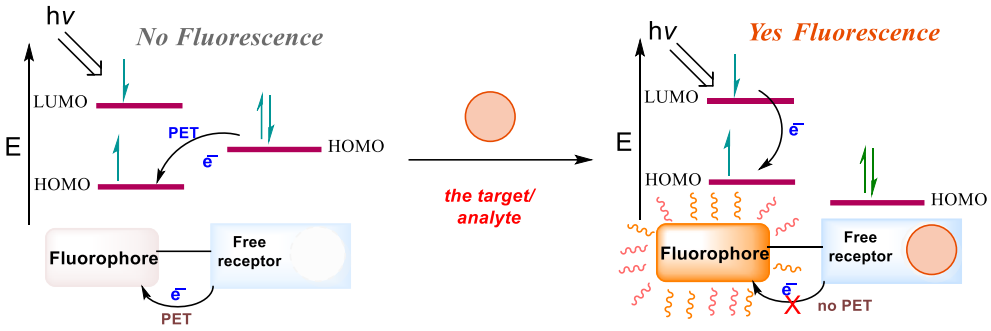
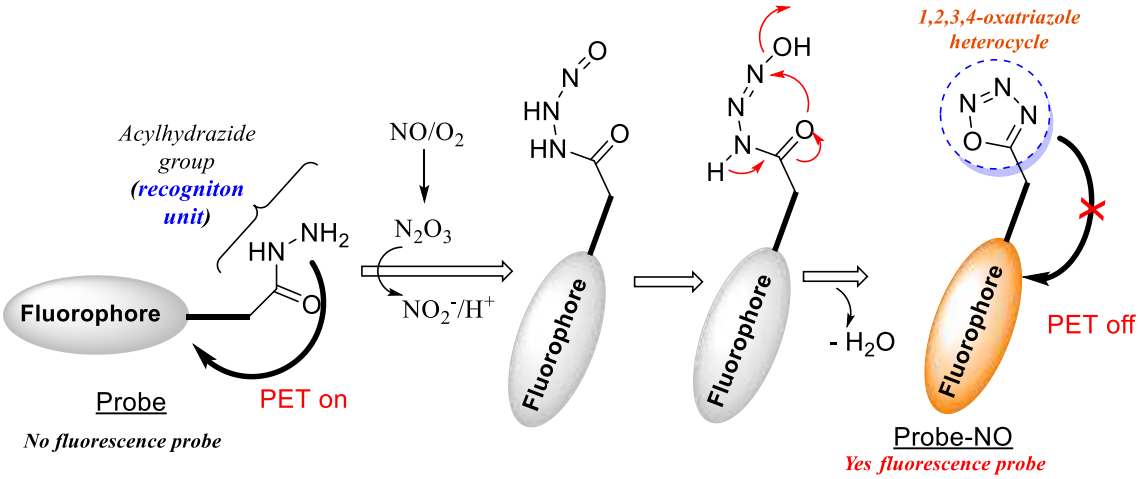


Fig. 2. PET mechanism

In the existence of light of the convenient wavelength (excitation of the fluorophore), intramolecular electrons from the HOMO (electron donor) of the receptor are transferred to the lower HOMO (electron acceptor) of the fluorophore. Thus, fluorescence in this system results in quenching. When an analyte/target binds to the identification fraction, the energy of the HOMO of the receptor decreases so that photo-induced electron moving from the HOMO of the donor to the fluorophore cannot occur, i.e. as a result the PET process is interrupted and the fluorescence intensity increases (a bright fluorescence emission is produced). In other words, the existence of the target is determined [21] (Fig. 2).

B. 1,2,3,4-Oxatriazole heterocycle formation mechanism from Acylhydrazide for NO

The relevant mechanism is summarized in scheme 1. Here, N_2O_3 is first formed under NO/O_2 conditions, which nitrosylates the $–NH_2$ of the probe to produce –NH–NO, resulting in 1,2,3,4-oxatriazole (probe-NO) as a stable product. From an electronic perspective, the main mechanism for NO detection by OPD-based probes is based on the PET blocking (PET off) process. The PET on mechanism resulting from electron repulsion from the hydrazide moiety to the fluorophore containing coumarin-hemicyanine makes the probe weakly fluorescent. However, upon reaction with NO, the formation of the electron-deficient 1,2,3,4-oxatriazole moiety, which restricts or interrupts the PET process, results in a notable fluorescence increase. [8], [13] (Scheme 1).



Scheme 1. The conversion of acylhydrazide to 1,2,3,4-oxatriazole heterocycle

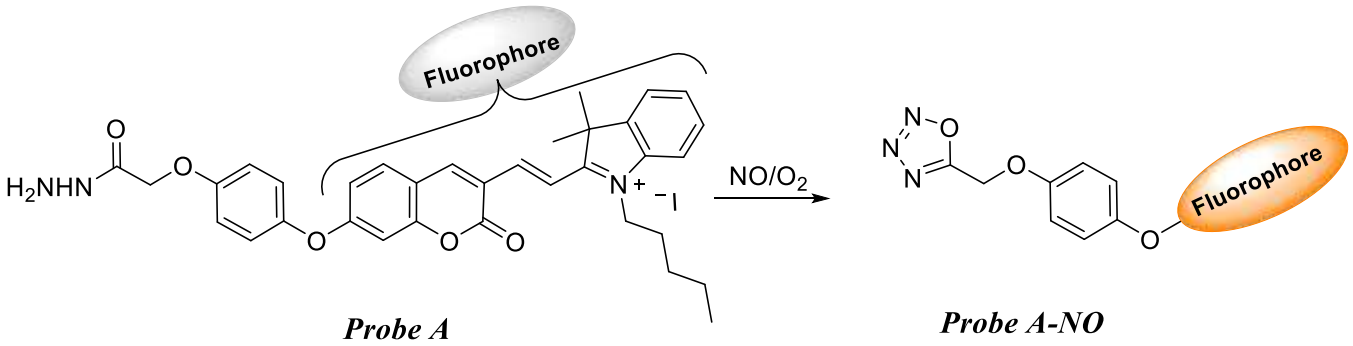
The fluorescent probes developed based on the 1,2,3,4-oxatriazole heterocycle formation approach in NO detection have gained attention in last years (Fig. 3) [8], [13].

[8] [13]

Fig. 3. Examples of fluorescent probes based on the 1,2,3,4-oxatriazole heterocycle formation

III. RESULTS

The interaction mechanism of the probe designed in the study with NO/O_2 is seen in Scheme 2. The theoretical calculation results of the formation in this scheme are included in the present work.



Scheme 2. The sensing approach of the probe designed in the study with NO/O_2

From the molecular orbitals obtained for Probe A, the HOMO-1 value was calculated as –7.74 eV, the LUMO value was calculated as –5.92 eV, and the GAP (energy gap between HOMO-1→LUMO) value was calculated as 1.84 eV. The oscillator power (f) for this transition was found to be 0.70681. From the molecular orbitals obtained for probe A-NO, the HOMO value was calculated as –7.22 eV, the LUMO value was –5.91 eV, and the GAP (energy gap between HOMO–LUMO) value was calculated as 1.31 eV (Fig. 4). The oscillator power for this transition was found to be 0.70610 and the f values obtained are the highest among the possible transitions [13].

IV. DISCUSSION

The fluorophore containing an electron-rich hydrazide group causes the formation of the electron-deficient 1,2,3,4-oxatriazole ring as a result of NO interaction. As shown in Fig. 4, it is understood that the transitions between the ligand and the complex support the PET mechanism in accordance with the literature [8], [13].

V. CONCLUSION

Shortly, this study investigated the outcomes derived from DFT calculations concerning the nitric oxide-bound structure of Probe A (Probe A-NO). The findings were consistent with both the 1,2,3,4-oxatriazole heterocycle formation method and the PET mechanism.

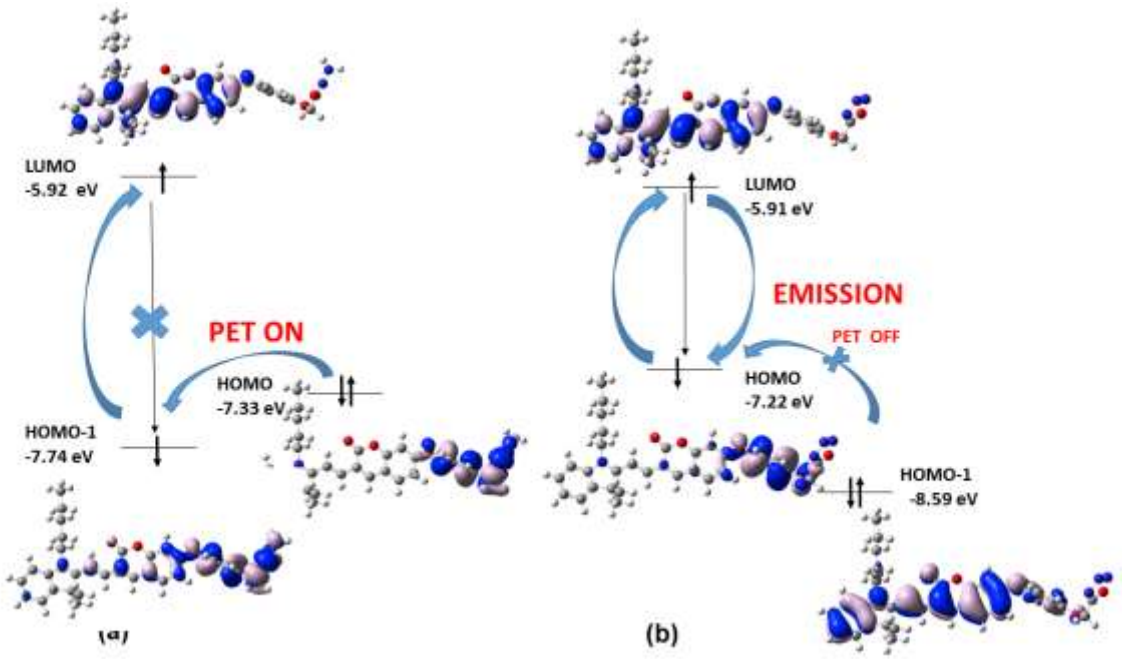


Fig. 4. Electronic transitions of Prob A (a) and Probe A–NO (b) molecules

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Betanin'in Potansiyel Anti-inflamatuvar Özelliğinin Moleküler Kenetlenme ve Moleküler Dinamik Simülasyonla İncelenmesi

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Özet – İnflamasyon, doku hasarı, enfeksiyon veya diğer uyaranlara karşı bağışıklık sisteminin normal bir tepkisidir. Ancak kronik inflamasyon, artrit, kalp hastalığı ve kanser gibi birçok hastalığın gelişmesine katkıda bulunabilir. Bu nedenle, yeni ve etkili anti-inflamatuvar ilaçların geliştirilmesi önemli bir araştırma alanıdır. Bu çalışmada, pancarda bulunan doğal bir bileşik olan betanin'in anti-inflamatuvar potansiyeli *in siliko* olarak incelenmiştir. Moleküler kenetlenme çalışmalarında insan salgı fosfolipaz A2 proteini (HSPLA2, PDB ID: 1DB4) kullanılmıştır. Moleküler kenetlenme çalışmaları sonucunda betanin ve 1DB4'den oluşan kompleksin bağlanma enerjisi -8,2 kkal/mol olarak elde edilmiştir. Betanin ve 1DB4'ün en iyi pozunda ligand ve protein arasında meydana gelen hidrojen bağları ve hidrofobik etkileşimler de belirlenmiştir. Betanin-1DB4 kompleksinin fizyolojik koşullardaki kararlılığı 1 atm basınç, 298 K sıcaklık ve pH= 7,4'de gerçekleştirilen moleküler dinamik simülasyonla incelenmiştir. 100 ns süreyle gerçekleştirilen moleküler dinamik simülasyon çalışmasından sistemin toplam potansiyel enerjisi, hidrojen bağı sayısı, Rg, SASA, RMSD ve RMSF parametreleri elde edilmiştir. Moleküler dinamik simülasyon çalışması betanin-1DB4 kompleksinin fizyolojik koşullarda kararlı olabileceğini göstermiştir. Betanin molekülünün yeni anti-inflamatuvar ilaç keşfi çalışmalarında kullanılabilme potansiyeline sahip olduğu sonucuna ulaşılmıştır.

Anahtar Kelimeler – Betanin, anti-inflamatuvar, moleküler kenetlenme, moleküler dinamik simülasyon, protein

I. GİRİŞ

İnflamasyon, vücudun zararlı uyaranlara karşı verdiği biyolojik yanıt olup, akut ve kronik birçok hastalığın patogenezinde merkezi bir rol oynamaktadır. Özellikle kronik inflamasyon, kardiyovasküler hastalıklar, kanser, diyabet ve nörodejeneratif hastalıklar gibi ciddi sağlık sorunlarına yol açabilmektedir. Bu nedenle, inflamasyonun düzenlenmesi ve tedavisi için etkili ve güvenli ajanların geliştirilmesi büyük önem taşımaktadır. Son yıllarda doğal bileşiklerin anti-inflamatuvar potansiyelleri üzerine yoğun araştırmalar yapılmaktadır. Bu bağlamda, pancarın (Beta vulgaris) kırmızı rengini veren betanin pigmenti, dikkat çeken doğal bileşiklerden birisidir. Moleküler düzeyde, betanin'in anti-inflamatuvar mekanizmalarının detaylı olarak anlaşılması, bu bileşiğin terapötik potansiyelinin değerlendirilmesi açısından kritik öneme sahiptir [1], [2].

Bu çalışmada, betanin bileşiğinin inflamasyonla ilişkili anahtar bir enzim üzerindeki inhibitör etkisi moleküler kenetlenme tekniği ile incelenmiştir. En iyi bağlanma pozu belirlendikten sonra, bu pozu oluşturan ligand-protein kompleksinin fizyolojik koşullardaki kararlılığı moleküler dinamik simülasyon kullanılarak değerlendirilmiştir.

II. MATERYAL VE YÖNTEM

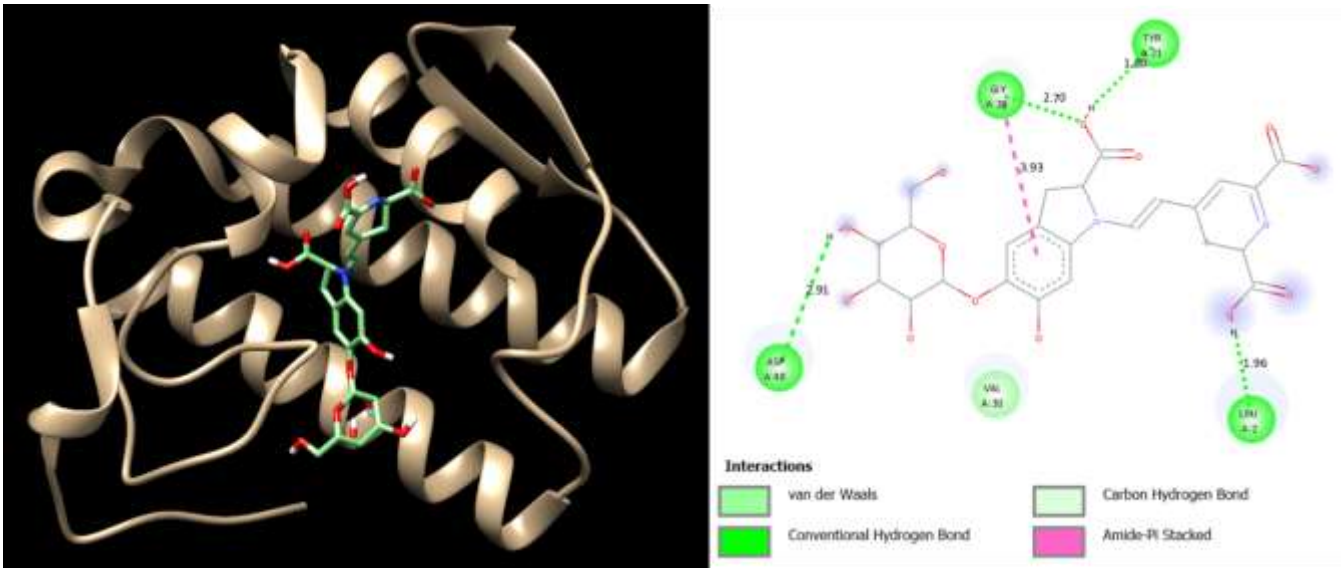
A. *Moleküler Kenetlenme Çalışması*

Betanin'in moleküler kenetlenme çalışmasını gerçekleştirmek için AutodockVina 1.1.2 programı kullanılmıştır [3]. Bileşiğin optimize geometrisi Avogadro 1.2.0n programı kullanılarak moleküler mekanik yöntemle optimize edilmiştir [4]. İnsan salgı fosfolipaz A2 proteininin (HSPLA2, PDB ID: 1DB4) kristal yapısı Protein Data Bank'tan alınmıştır (https://www.rcsb.org/). Moleküler kenetlenme çalışmalarına başlamadan önce, proteinin yapısından standart olmayan kısımlar uzaklaştırılmış daha sonra protein yapısına polar hidrojenler ve Kollman yükleri eklenmiştir. Proteinin aktif bölgesi DeepSite web sunucusu kullanılarak belirlenmiştir [5]. Moleküler kenetlenme çalışmalarındaki görüntüler, UCSF Chimera 1.17.2 ve BIOVIA Discovery Studio Visualizer v21.1.0.20298 programları kullanılarak alınmıştır [6], [7].

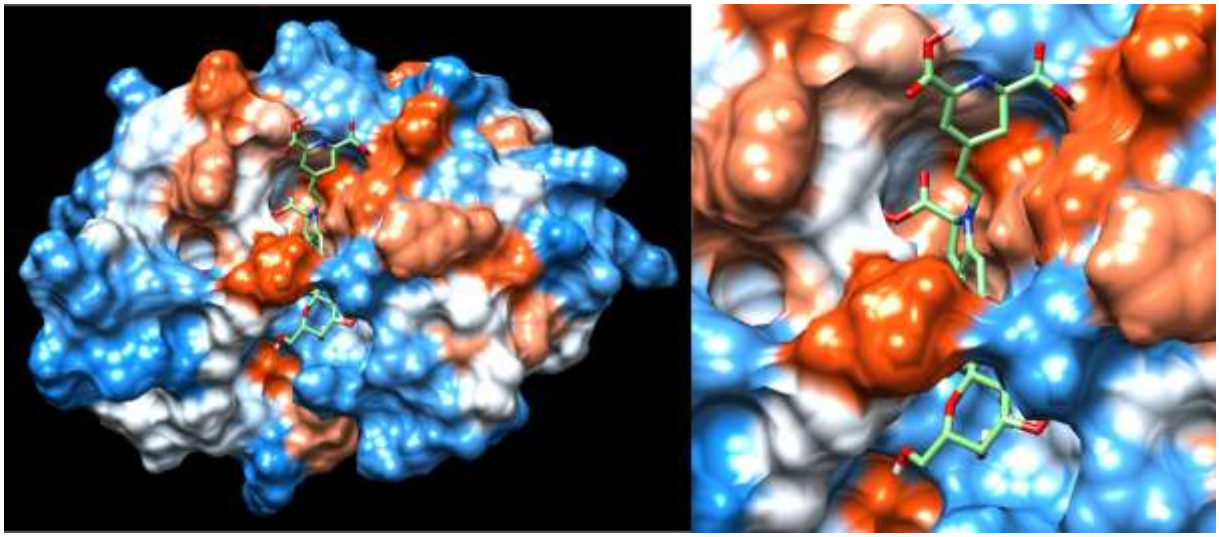
B. *Moleküler Dinamik Simülasyon*

Betanin-1DB4 kompleksinin moleküler dinamik simülasyonu YASARA programı kullanılarak gerçekleştirilmiştir [8]. Kompleksin kararlılığını artırmak için hidrojen bağı ağı optimize edilmiş ve protein kalıntılarının pH değeri 7,4'e ayarlanmıştır [9], [10]. Hücreyi nötralize etmek için % 0,9'luk fizyolojik bir konsantrasyonda Na^+ veya Cl^- iyonları eklenmiştir. Moleküler dinamik simülasyon, protein için AMBER14 kuvvet alanı, ligand için GAFF2 ve AM1BCC ve su için ise TIP3P kullanılarak 100 ns süresine gerçekleştirilmiştir [11]-[13]. Hareket denklemleri, 298 K sıcaklıkta ve 1 atm basınçta (NPT topluluğu) bağlı etkileşimler için 2,5 fs ve bağlı olmayan etkileşimler için 5,0 fs çoklu zaman adımıyla uygulanmıştır [14].

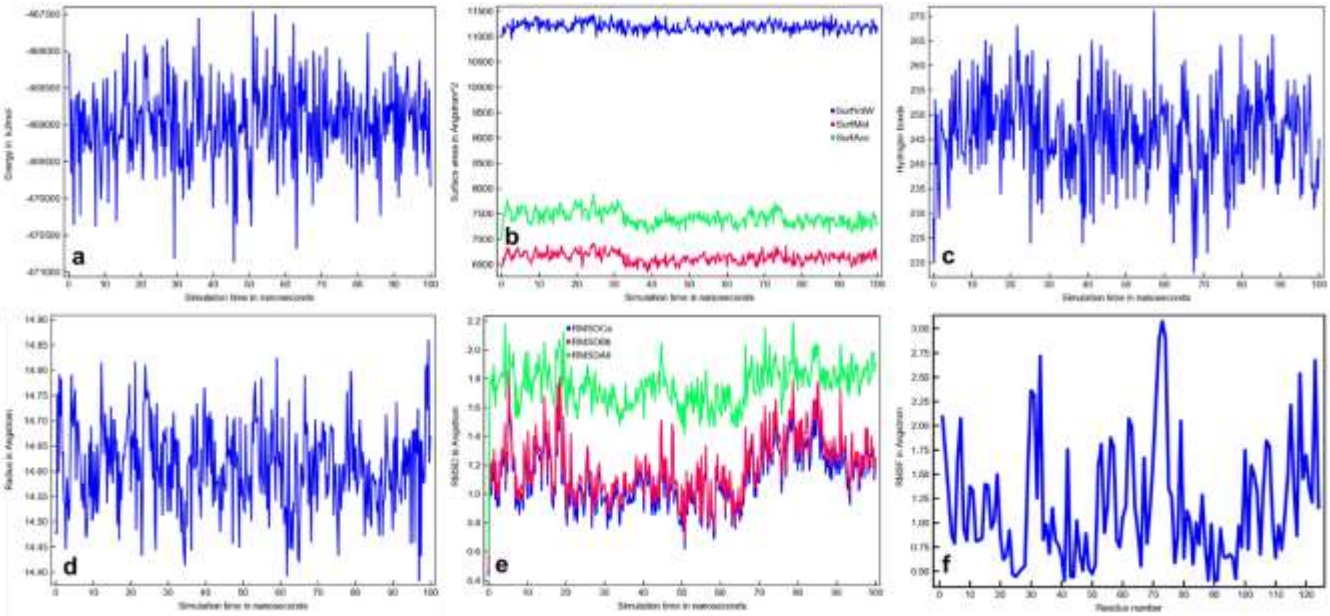
III. BULGULAR



Şekil 1. Betanin-1DB4 kompleksinin en iyi bağlanma pozunun 3D (solda) ve 2D (sağda) görüntüsü



Şekil 2. Betanin'in, 1DB4 ID'li proteinin hidrofobik yüzeyine yerleşme görüntüleri



Şekil 3. Betanin-1DB4 kompleksinin en iyi bağlanma pozunun MD simülasyon grafikleri a) Toplam Potansiyel Enerji, b) SASA, c) Hidrojen Bağ Sayısı, d) Rg, e) RMSD, e) RMSF

IV. TARTIŞMA

Betanin bileşiğinin anti-inflamatuvar özellik gösterme potansiyeli *in siliko* olarak incelenmiştir. Betanin'in anti-inflamatuvar potansiyelini inceleyebilmek amacıyla insan salgı fosfolipaz A2 proteini (HSPLA2, PDB ID: 1DB4) kullanılmıştır. Moleküler kenetlenme çalışmalarında, seçilen proteinin bağlanma bölgelerinin *xyz* koordinatları x= 60,44, y= 30,80 ve z= 47,21 olarak çalışılmıştır. Betanin'in HSPLA2 proteini ile gerçekleştirilen moleküler kenetlenme simülasyonu sonucu elde edilen ligand-protein kompleksinin bağlanma enerjisi -8,2 kkal/mol olarak bulunmuştur. Bu bağlanma enerjisi değeri, betanin ve 1DB4'den oluşan kompleksin istemli bir şekilde meydana geldiğini ortaya koymuştur. Betanin-1DB4 kompleksinin en iyi pozunun 3D ve 2D görüntüleri Şekil 1'de, betanin'in 1DB4'ün hidrofobik yüzeyine yerleşme görüntüsü ise Şekil 2'de verilmiştir. Betanin-1DB4 kompleksinin en iyi bağlanma pozu incelendiğinde betanin ve 1DB4 arasında hidrojen bağlarının ve hidrofobik etkileşimlerin bulunduğu belirlenmiştir. Betanin molekülü 1DB4 ID'li protein ile 4 adet hidrojen bağı yapmış olup, proteinde bu bağları gerçekleştiren aminoasit kalıntıları LEU2 (1,96 Å), TYR21 (1,80 Å), GLY29 (2,70

Å) ve ASP48 (2,91 Å)'dir. Betanin ve 1DB4 arasında meydana gelen kuvvetli etkileşimde bu 4 hidrojen bağının etkili olduğu düşünülmektedir.

Ligand-protein kompleksinin moleküler dinamik (MD) simülasyonunun amacı, komplekslerin dinamik davranışlarını, etkileşimlerini ve yapısal değişikliklerini zaman içinde atomik düzeyde anlamaktır. MD simülasyonları, çeşitli biyokimyasal ve biyofiziksel süreçlerin ayrıntılı analizini yapma imkanı sunmaktadır.

Betanin-1DB4 kompleksinin en iyi pozunun zaman içindeki kararlılığını değerlendirmek ve hangi koşullarda daha kararlı olduğunu belirlemek amacıyla fizyolojik koşullarda 100 ns'lik MD simülasyon gerçekleştirilmiş ve elde edilen grafikler Şekil 3'de verilmiştir. Şekil 3a'dan görüldüğü üzere MD simülasyonun başında ve sonunda sistemin toplam potansiyel enerjisi yaklaşık olarak -469,000 kj/mol olarak bulunmuştur. Sistemin ortalama toplam potansiyel enerjisinin 100 ns boyunca değişmemesi, sistemin kararlılığını koruduğunun önemli bir göstergesidir. Ligand-protein komplekslerinin MD simülasyonlarında çözücüye erişilebilir yüzey alanı (SASA), önemli bir metriktir. SASA, protein veya ligandın konformasyonel değişikliklerini izlemekte kullanılır. Protein veya ligandın yüzey alanında meydana gelen değişiklikler, kompleksin kararlılığına ve konformasyonel durumuna dair bilgi vermektedir. Betanin-1DB4 kompleksinin SASA grafiğinden (Şekil 3b) görüldüğü üzere kompleksin MD simülasyonun başındaki SASA değeri 7500 $Å^2$'dir. MD simülasyonunun tamamlandığı 100. ns'de SASA değerinin pek değişmemesi, Betanin-1DB4 kompleksinin çok fazla konformasyonel değişikliğe uğramadığını ortaya koymuştur. Betanin-1DB4 ve çözücü arasında ortalama 250 hidrojen bağının oluştuğu gözlenmiştir (Şekil 3c).

Dönme yarıçapı (Rg), bir molekülün kütle merkezine göre dağılımının ortalama karesel uzaklığının bir ölçüsüdür. MD simülasyonlarında ise Rg, protein ve ligandın ne kadar yakın bir şekilde paketlenmiş olduğunu ve kompleksin ne kadar kompakt olduğunu belirlemek için kullanılabilmektedir. Daha düşük bir Rg değeri, protein ve ligandın daha kompakt bir şekilde paketlenmiş olduğunu ve kompleksin daha kararlı olma olasılığını göstermektedir. Betanin-1DB4 kompleksinin Rg değeri simülasyon başında ortalama 14,65 Å, simülasyon sonunda ise bir miktar düşüşle ortalama 14,60 Å olduğu belirlenmiştir (Şekil 3d). Betanin-1DB4 kompleksinin Rg değerini koruması hatta bir miktar düşüş sergilemesi, kompleksin kompaktlığını önemli ölçüde koruduğunu göstermiştir. Ligand-protein komplekslerinin simülasyonlarında kök ortalama kare sapması (RMSD) yapısal değişiklikleri ve kararlılığı değerlendirmede önemli bir kriterdir. Düşük RMSD değerleri, yapının simülasyon boyunca kararlı kaldığını gösterirken, yüksek RMSD değerleri önemli yapısal değişiklikleri işaret emektedir. MD simülasyonlarda ligand-protein kompleksinin RMSD değerlerinin 3 Å'ün altında kalması, kompleksin kararlılığının ortaya konabilmesi açısından yeterli görülmektedir. Şekil 3e'den görüldüğü üzere betanin-1DB4 kompleksinin RMSD değerlerinin 100 ns boyunca 3 Å'den küçük olması, kompleksin kararlılığının önemli bir göstergesidir. Kök ortalama kare sapması (RMSF), protein ve ligandın belirli bölgelerindeki atomların veya kalıntıların ne kadar hareketli olduğunu göstermektedir. Yüksek RMSF değerleri, o bölgedeki atomların veya kalıntıların daha esnek olduğunu, düşük RMSF değerleri ise daha katı ve sabit olduklarını ifade etmektedir. MD simülasyon sürecinde 1DB4 ID'li proteinin en çok 70 ile 80 arasındaki kalıntılarının hareketli olduğu gözlenmiştir. En fazla dalgalanma ise GLY72 (2,90 Å), SER73 (3,08 Å) ve ARG74 (2,90 Å) amino asitlerinde meydana gelmiştir.

V. SONUÇLAR

Bu çalışmada, betanin bileşiğinin anti-inflamatuvar özelliğini *in siliko* olarak araştırmak amacıyla yapılan moleküler kenetlenme ve dinamik simülasyonlar, betanin'in insan salgı fosfolipaz A2 (HSPLA2, PDB ID: 1DB4) ile güçlü bir etkileşim sergilediğini göstermiştir. Moleküler kenetlenme analizleri, betanin-1DB4 kompleksinin bağlanma enerjisinin -8,2 kkal/mol olduğunu ortaya koyarak, bu etkileşimin termodinamik olarak istemli olduğunu doğrulamıştır. Betanin'in 1DB4 proteinine bağlanması sırasında 4

hidrojen bağı ve çeşitli hidrofobik etkileşimlerin etkili olduğu belirlenmiştir. MD simülasyonu, betanin-1DB4 kompleksinin 100 ns boyunca kararlı bir yapıda kaldığını ve toplam potansiyel enerji, SASA, Rg ve RMSD analizleri ile doğrulanmıştır. Ayrıca, betanin-1DB4 kompleksinin düşük RMSD ve Rg değerlerini koruyarak kompakt ve kararlı bir yapı sergilediği gözlenmiştir. Bu bulgular, betanin'in HSPLA2 proteini ile güçlü ve kararlı etkileşimler kurarak potansiyel anti-inflamatuvar özellik gösterebileceğini desteklemektedir. Ayrıca bu sonuçlar, betanin'in anti-inflamatuvar ajan olarak potansiyelini doğrulamak üzere ileri *in vitro* ve *in vivo* çalışmalara zemin hazırlamaktadır.

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Yeni Bir Antineoplastik Ajan Olan Tovorafenib'in Bazı Kuantum Mekaniksel Hesaplamaları

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Özet – Tovorafenib, kanser tedavisinde kullanılan yeni nesil bir antineoplastik ajandır ve özellikle kinaz inhibitörü olarak işlev görmektedir. Kinaz inhibitörleri, hücre içi sinyal iletim yollarını düzenleyen kinaz enzimlerini hedef alarak kanser hücrelerinin büyümesini ve çoğalmasını engeller. Tovorafenib'in hedef aldığı spesifik kinazlar ve mekanizmalar, bu molekülü belirli kanser türlerine karşı etkili kılmaktadır. Bu spesifik hedefleme, yan etkilerin azaltılmasına ve tedavi etkinliğinin artırılmasına yardımcı olabilmektedir. Tovorafenib'in etkinliği, belirli kanser türlerine karşı yapılan klinik çalışmalarla desteklenmiştir ve bu bileşiğin gelecekteki kanser tedavilerinde önemli bir rol oynayabileceği düşünülmektedir. Bu çalışmada, tovorafenib bileşiğinin kuantum mekanik hesaplamaları gerçekleştirilmiştir Bileşiğin optimize edilmiş geometrisi, moleküler elektrostatik potansiyel (MEP) diyagramı, HOMO/LUMO'ları, toplam durum yoğunlukları (TDOS) ve kovalent olmayan etkileşimleri (NCI) incelenmiştir. Tovorafenib'in optimize edilmiş geometrisi DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış ve moleküler yapıdaki önemli bağ uzunluğu, bağ açısı ve dihedral açısı gibi geometrik parametreleri belirlenmiştir. Ardından, HOMO/LUMO'ları hesaplanmış ve HOMO-LUMO enerji farkından, tovorafenib'in elektronik kararlılığı ve reaktivitesi hakkında değerlendirmeler yapılmıştır. Tovorafenib'in, kovalent olmayan etkileşimleri de incelenmiş ve bu etkileşimlerin molekülün kararlılığına olan etkisi değerlendirilmiştir.

Anahtar Kelimeler – Antineoplastik, yoğunluk fonksiyonel teorisi, optimizasyon, HOMO, LUMO

I. GİRİŞ

Tovorafenib, son yıllarda kanser tedavisinde umut verici bir ajan olarak öne çıkmıştır. Tovorafenib, BRAF V600E mutasyonu taşıyan BRAF-pozitif melanom ve anaplastik PLGG gibi çeşitli kanser türlerinin tedavisinde kullanılan bir ilaçtır. FDA tarafından BRAF V600E mutasyonu taşıyan BRAF-pozitif melanom tedavisinde onay almış ve klinik kullanıma girmiştir. Tovorafenib, RAF proteininin bir kinaz inhibitörü olarak işlev görerek MAPK sinyal yolunu bloke eder ve bu da kanser hücrelerinin büyümesini ve çoğalmasını engeller [1], [2].

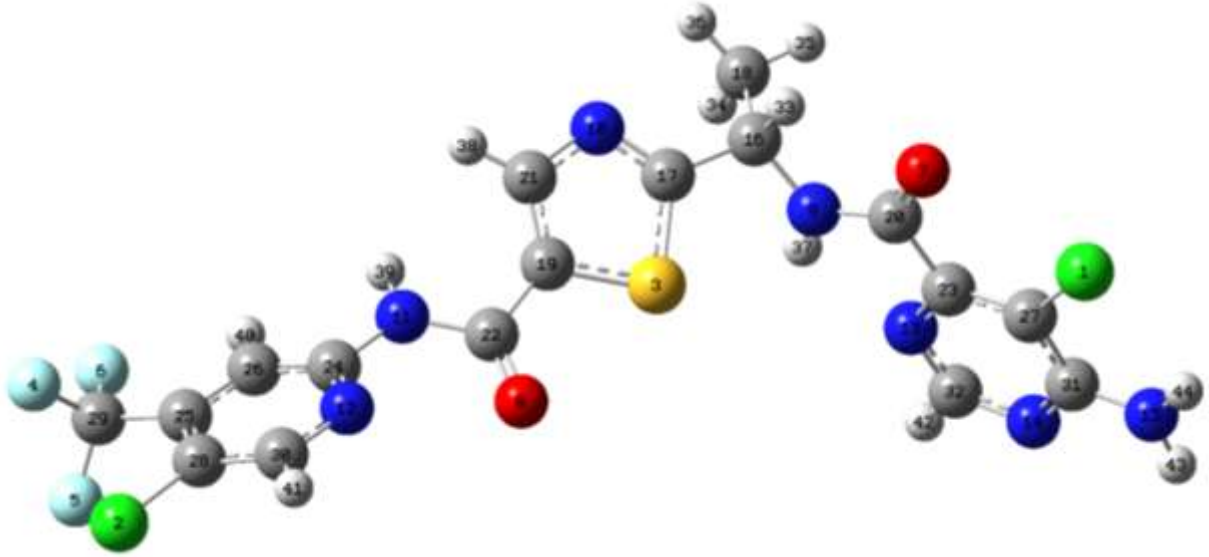
Moleküllerin etki mekanizmalarını anlamak ve onları daha iyi analiz etmek için, kuantum mekanik hesaplamalar önemli bir rol oynamaktadır. Kuantum mekaniksel hesaplamalar, moleküllerin elektronik yapısını ve kimyasal reaksiyonlarda nasıl etkileşime girdiklerini anlamak için kullanılabilmektedir. Bu çalışmada tovorafenib'in bazı kuantum mekaniksel hesaplamaları gerçekleştirilmiştir.

II. MATERYAL VE YÖNTEM

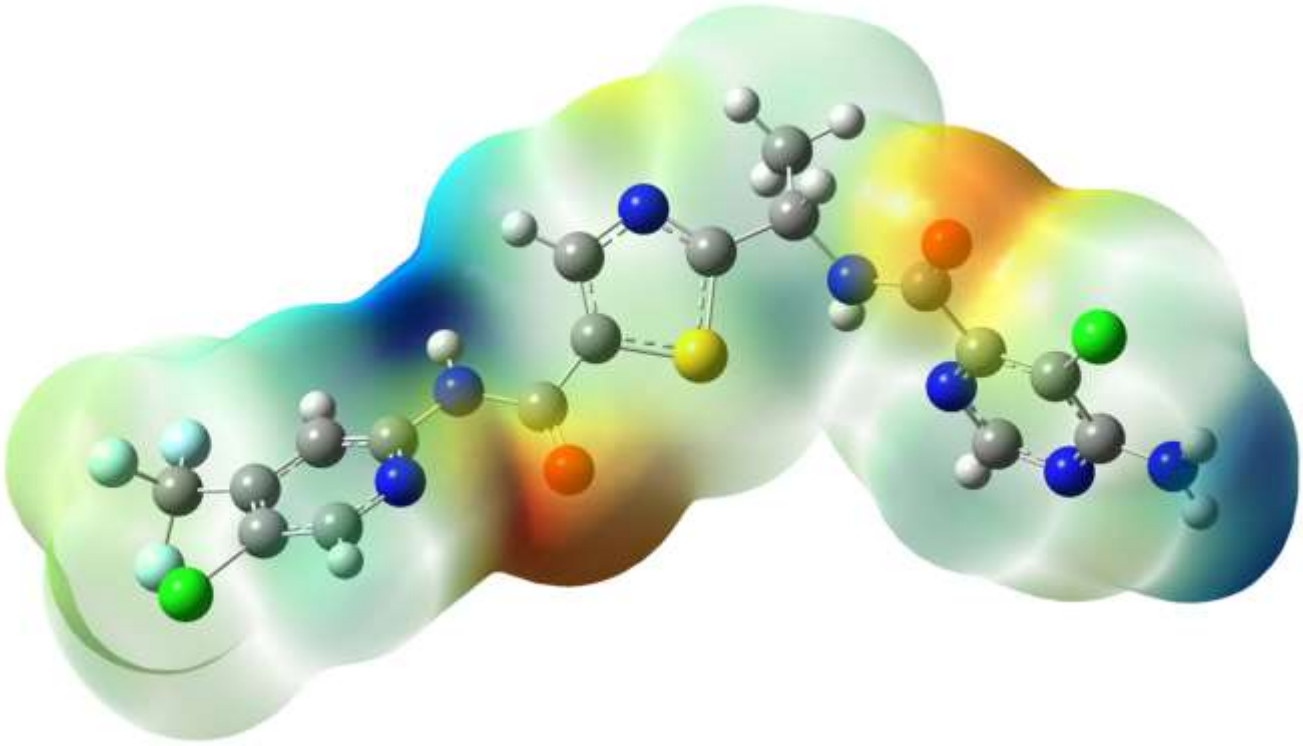
Tovorafenib'in kuantum mekaniksel hesaplamaları Gaussian 09 paket programı kullanılarak gerçekleştirilmiştir [3]. Tüm görüntüler GaussView 5.0.9 programı kullanılarak alınmıştır [4]. Bileşiğin temel hal moleküler yapısı DFT yöntemi ve 6-311G(d,p) temel seti ile B3LYP fonksiyoneli kullanılarak optimize edilmiştir [5], [6]. Tovorafenib'in MEP ve HOMO/LUMO hesaplamaları da aynı seviyede

yapılmıştır. Bileşiğin molekül içi etkileşim (NCI) ve indirgenmiş yoğunluk gradyanı çalışmaları Multiwfn 3.8 yazılımı ile gerçekleştirilmiş ve sonuçlar VMD 1.9.4a53 programı ile görselleştirilmiştir [7], [8].

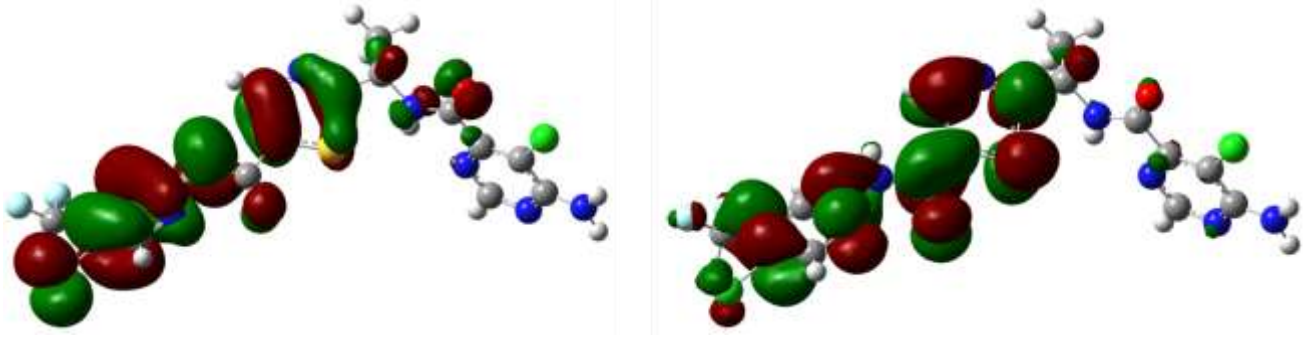
III. BULGULAR



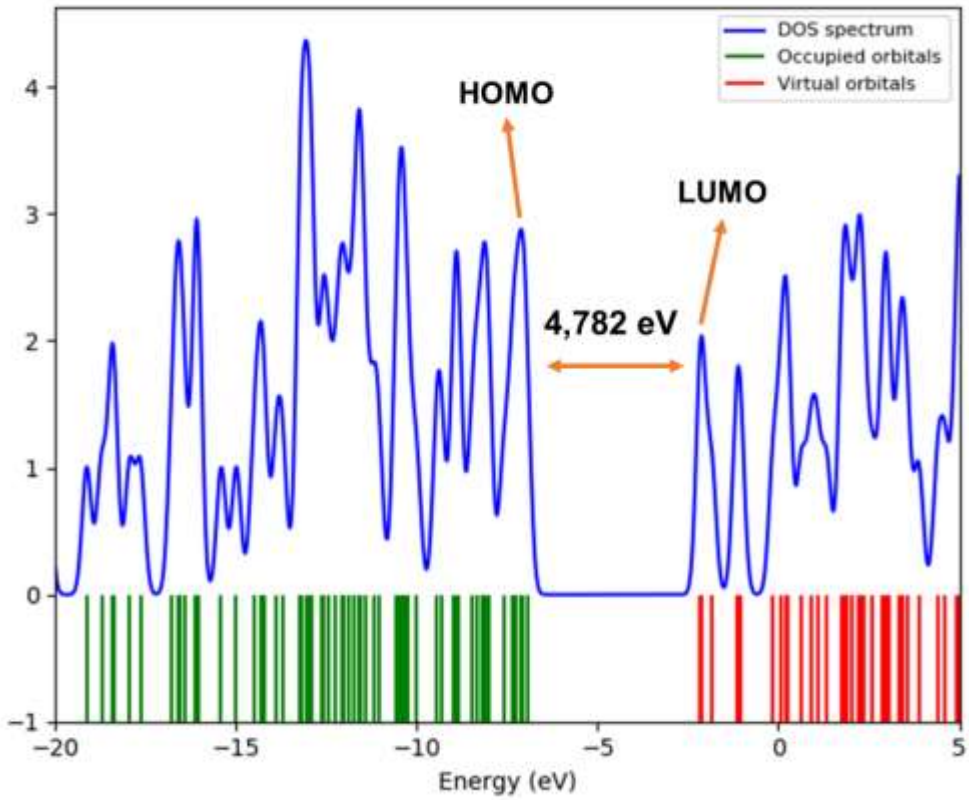
Şekil 1. Tovorafenib'in optimize moleküler geometrisi



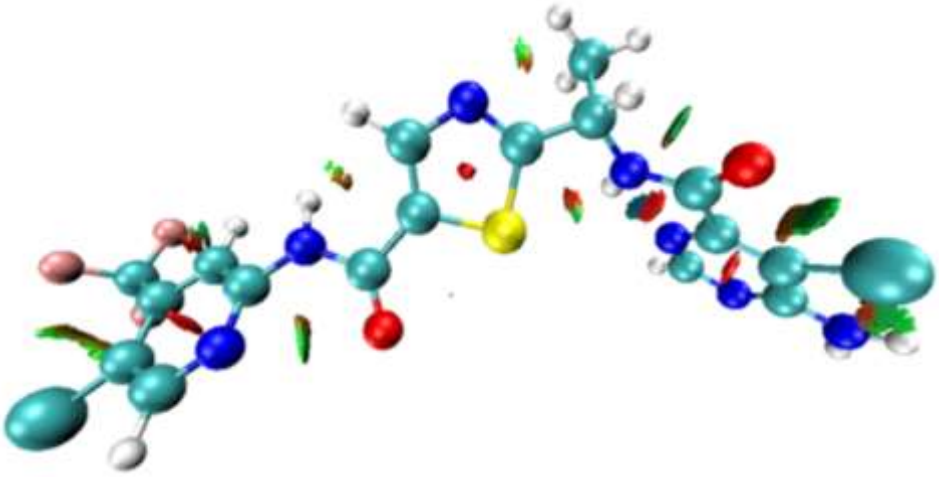
Şekil 2. Tovorafenib'in MEP diyagramı



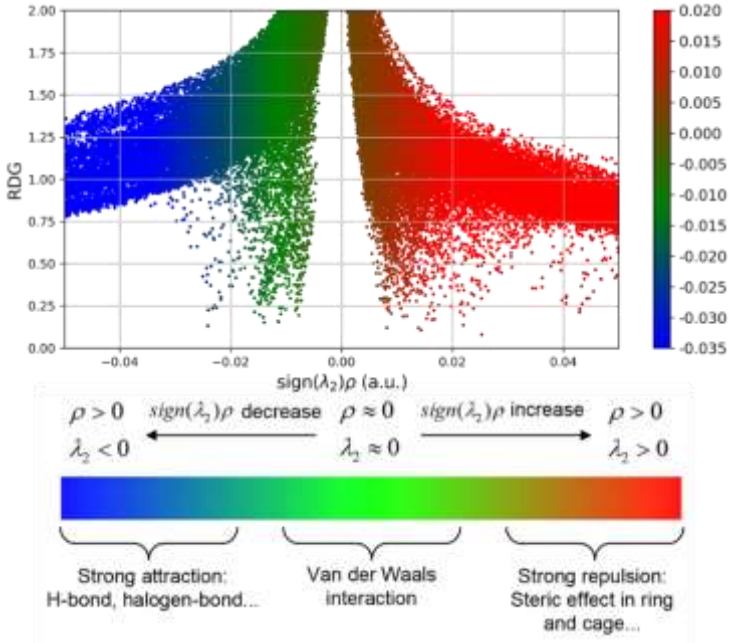
Şekil 3. Tovorafenib'in hesaplanmış HOMO (solda) ve LUMO (sağda) orbitalleri



Şekil 4. Tovorafenib'in TDOS grafiği



Şekil 5. Tovorafenib molekülündeki kovalent olmayan etkileşimler



Şekil 6. Tovorafenib'in RDG grafiği

IV. TARTIŞMA

Tovorafenib'in optimize moleküler geometrisi DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış ve Şekil 1'de gösterilmiştir. Moleküldeki piridin ve bu halkaya bağlı -CF_3 grubunun karbon arasındaki C25-C28 bağ uzunluğu 1,514 Å, piridin ve amin grubu arasındaki C24-N11 bağ uzunluğu 1,401 Å, tiyazol halkası ile karbonil karbonu arasındaki C22-C19 bağ uzunluğu ise1,481 Å olarak hesaplanmıştır. Gerçekleştirilen hesaplamalar yapıdaki amit ve piridin yapılarında bulunan N9-C20 ve C30-N12 bağ uzunluklarının sırasıyla 1,365 Å ve 1,329 Å olduğunu göstermiştir. Moleküldeki N11-C22-O8, C17-C16-C18 ve O7-C20-C23 bağ açıları sırasıyla 124,2^o, 111,5^o ve 123,5^o olarak hesaplanmıştır. Bir yapıdaki dört atoma ait dihedral açının 0^o veya 180^o'ye eşit veya yakın olması, bu atomların aynı düzlemde bulunduğunu gösterir. Tovorafenib molekülündeki piridin-amit birimleri arasındaki N12-C24-N11-C22, karbonil-tiyazol birimleri arasındaki O8-C22-C19-S3 ve tiyazol ile bu halkaya bağlı metil birimi arasındaki N10-C17-C16-C18 dihedral açıları sırasıyla 33,5^o, 16,1^o ve -39,1^o olarak elde edilmiştir. Bu sonuçtan hareketle bu birimlerin aynı düzlemde bulunmadığı sonucuna ulaşılmıştır Bileşikteki pirimidin halkası ve karbonil grubu arasında yer alan O7-C20-C23-C27 dihedral açısının ise 5,9^o olarak hesaplanmış olması, bu birimlerin yaklaşık olarak aynı düzlemde bulunduğunu göstermiştir.

Moleküler elektrostatik potansiyel (MEP) diyagramı, bir molekülün etrafındaki elektrostatik potansiyeli gösteren bir görselleştirmedir. Bu diyagramlar, bir moleküldeki elektron yoğunluğunun uzayda nasıl dağıldığını ve farklı bölgelerdeki potansiyel enerjiyi temsil etmektedir. MEP yüzey diyagramlarında kırmızı bölgeler negatif elektrostatik potansiyelin, mavi bölgeler ise pozitif elektrostatik potansiyelin yüksek olduğu yerleri temsil etmektedir. MEP yüzey diyagramındaki yeşil bölgeler ise elektrostatik potansiyelin nötr veya ortalama değerlere yakın olduğu yerleri göstermektedir. Tovorafenib'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış MEP yüzey diyagramı Şekil 2'de gösterilmiştir. Bileşiğin karbonil grubundaki oksijen atomları üzerinde kırmızı bölgelerin bulunması, bu noktalarda negatif elektrostatik potansiyelin yüksek olduğunu göstermiştir. Moleküldeki -NH- ve -NH_2 protonları üzerinde ise azot atomunun yüksek elektronegatifliğinden de kaynaklanmış pozitif elektrostatik bölgeler belirlenmiştir. Molekülün geriye kalan kısımları ise ortalama bir elektrostatik potansiyele sahipti.

Tovorafenib üzerinde belirlenen bu kırmızı ve mavi bölgeler, molekülün diğer bileşiklerle vereceği reaksiyonlarda nükleofilik ve elektrofilik bölgeler olarak davranabilir.

HOMO (Highest Occupied Molecular Orbital), bir molekülün en yüksek enerjili dolu moleküler orbitalidir. LUMO (Lowest Unoccupied Molecular Orbital) ise bir moleküldeki en düşük enerjili boş moleküler orbitaldir. Tovorafenib'in DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanmış HOMO'larının, bileşiğin pirimidin ve bu halkaya bağlı amin grubu hariç molekülün tamamının üzerinde olduğu gözlenmiştir. LUMO'larının ise genel olarak pirimidin ve bu halkaya bağlı amin ve amit birimleri hariç molekülün geri kalan kısımlarının üzerinde kümelendiği belirlenmiştir (Şekil 3).

HOMO-LUMO enerji farkı, bir molekülün reaktivitesini, elektron transfer kapasitesini ve fotofiziksel davranışını doğrudan etkilemektedir. Küçük bir HOMO-LUMO enerji farkı, molekülün daha kolay uyarılabilir olmasını ve kimyasal reaksiyonlara daha yatkın hale gelmesini sağlar, bu da onu daha reaktif kılmaktadır. Büyük bir HOMO-LUMO enerji farkı ise, molekülün daha kararlı ve kimyasal olarak daha az reaktif olmasına neden olmaktadır. Tovorafenib'in HOMO-LUMO enerji farkı 4,782 eV olarak hesaplanmıştır. Nispeten yüksek olan bu değer, çalışılan bileşiğin kimyasal kararlılığının yüksek olduğu ve kimyasal reaksiyonlarda reaktivitesinin düşük olabileceğini göstermiştir. Şekil 4'de verilen TDOS grafiğindeki yaklaşık olarak -11 ve -14 eV arasındaki büyük pikler, molekülün bu bölgelerde yüksek elektron yoğunluğuna sahip olduğunu ortaya koymuştur.

Tovorafenib'in kovalent olmayan etkileşim bölgeleri, türleri ve RDG analizleri Şekil 5 ve 6'da gösterilmiştir. Moleküllerin NCI görüntülerindeki mavi, yeşil ve kırmızı bölgeler, düşük yoğunluk ve düşük indirgenmiş gradyana dayalı olarak sırasıyla çekici, Van der Waals ve itici kuvvetleri temsil etmektedir. Benzer şekilde, RDG dağılım grafiğinde de bu etkileşim türleri sırasıyla hidrojen bağı (çekici), Van der Waals etkileşimleri ve sterik (itici) kuvvetler olarak tanımlanabilir. Moleküldeki pirimidin ve bu halkaya bağlı -NH- grubu arasında iç bölgelerde sterik etki, dış bölgelerde ise hidrojen bağının bulunduğu belirlenmiştir. Tovorafenib'in tiyazol-metil, piridin-karbonil oksijen atomu gibi bazı bölgeler arasında Van der Waals etkileşimlerinin, aromatik halkaların içinde ise sterik kuvvetin bulunduğu gözlenmiştir.

V. SONUÇLAR

Bu çalışmada, Tovorafenib bileşiğinin kuantum mekanik hesaplamaları gerçekleştirilmiştir. Bileşiğin optimize edilmiş geometrisi DFT/B3LYP/6-311G(d,p) seviyesinde hesaplanarak, moleküler yapıdaki önemli geometrik parametreler ve yapıdaki elektrostatik potansiyeller belirlenmiştir. Elektronik özellikler, HOMO/LUMO'ların hesaplanmasıyla analiz edilmiş ve HOMO-LUMO enerji farkı üzerinden Tovorafenib'in elektronik kararlılığı ve reaktivitesi değerlendirilmiştir. Ayrıca, kovalent olmayan etkileşimler (NCI) incelenmiş ve bu etkileşimlerin molekülün kararlılığına olan etkisi ortaya konmuştur. Bu bulgular, Tovorafenib'in kimyasal ve fiziksel özellikleri hakkında bilgiler sunmakta dolayısıyla molekülün ileri düzey analizleri için önemli bir temel oluşturduğunu düşünmekteyiz.

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REKABET HUKUKU VE HAKSIZ REKABET HUKUKU AÇISINDAN BLOKZİNCİR TEKNOLOJİSİ

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Özet – Blokzincir teknolojisi, 2008 yılında Satoshi Nakamato isimli kişi ve/veya kişiler tarafından mail zinciri ile gönderilen eşler arası ödeme yöntemi olarak Bitcoin'i tanıtması ve akabinde Bitcoin ile pizza satın alınması ile hayatımıza girse de eşler arası ödeme sistemlerini üzerinde çalışılması 2009 yılından öncesine dayanmaktadır. Benzer şekilde smart contracts (akıllı sözleşmeler) Ethereum blokzinciri ki Bitcoin 3.0 olarak hayatımıza girse de Nick Szabo tarafından otomatik sözleşmeler Ethereum'dan önce tanıtılmıştır. Nick Szabo aynı zamanda bir hukukçudur. Bu nedenle hukuk ve teknolojinin kesişim alanı olması yeni bir durum değildir. Buradaki yenilik, çalışmamız açısından haksız rekabet ve rekabet hukuku ihlallerinin blokzincir ile farklı bir boyut kazanacağı, bununla birlikte blokzincirin olumlu özelliklerinin neler olabileceği kısaca izah edilecektir. Tabii olarak, blokzincir teknolojisi izah edilirken büyük veriden ve algoritmalardan da bahsetmek gerekmektedir. Benzer şekilde Sermaye Piyasası Hukuku açısından kripto paralar, NFT'ler ve ICO'lardan da bahsetmek gerekmektedir. Görüleceği üzere, mezkur alan hukukumuzun pek çok alanına etki edecek mahiyettedir. Ancak, çalışmamızın kapsamını sınırlandırmak adına blokzincir teknolojisini 6102 sayılı Türk Ticaret Kanunu madde 54 vd. düzenlenen haksız rekabet hukuku ve 4054 sayılı rekabetin Korunması Hakkında Kanun'da düzenlenen rekabete aykırı davranışlar açısından genel olarak değerlendirilmiştir. Örneğin, hukukumuzda haksız rekabet hali olarak düzenlenen iş şartlarına aykırılık halinin blokzincir teknolojisi kullanan teşebbüsler açısından nasıl belirleneceği önemli bir husustur. Zira, ülkemizde blokzincir teknolojisini regüle eden bir düzenleme bulunmamaktadır. Haddizatında bu regülasyonun soft law olarak mı yoksa hard law olarak mı yapılması gerektiğine dair de kanunkoyucu nezdinde bir çalışma bulunmamaktadır. Gündemi meşgul eden tek tartışma ise kripto paralardan vergi alınıp alınmamasına yönelik olup, bu husus da kadik kalmıştır.

Anahtar Kelimeler – blokzincir, rekabet hukuku, haksız rekabet, regülasyon, akıllı sözleşmeler

I. GİRİŞ

Blokzincir teknolojisi sadece kripto paralar üzerinde değil, DeFi olarak adlandırılan merkeziyetsiz finans, merkeziyetsiz uygulamalar, akıllı sözleşmeler gibi pek çok alanda karşımıza çıkmaktadır. Ancak, bu teknolojinin günlük yaşamı ve özellikle hukuk alanını etkilemesinde iki temel sorun karşımıza çıkmaktadır. Her gün yeni bir uygulama alanı ortaya çıkan blokzincirin, bu yenilikçi yapısının anlaşılması için daha fazla çalışma gerekmektedir. Buna ek olarak sistemin karmaşık yapısı da izahını güçleştirmektedir. Blokzincir teknolojisi, son yıllarda finans, sağlık, tedarik zinciri ve daha birçok sektörde büyük bir devrim yaratmıştır. Bu teknolojinin temel özellikleri arasında merkezi olmayan yapı, güvenlik, şeffaflık ve değiştirilemezlik

bulunmaktadır. Şunu da belirtmek gerekir ki, güvenlik, ölçeklenebilirlik ve merkeziyetsizlik özelliğinin aynı anda sağlanması şimdiye kadar imkansız olup, bu hususa blokzincir trilemması denilmektedir.

Blokzincir teknolojisi, verilerin bloklar halinde kaydedildiği ve bu blokların kriptografik yöntemlerle birbirine bağlandığı bir yapıya sahiptir. Bu yapı, verilerin değiştirilmesini neredeyse imkansız hale getirir ve bu nedenle güvenlik açısından büyük avantajlar sunar (Nakamoto, 2008). Ayrıca, blokzincirlerin merkezi olmayan yapısı, tek bir noktadan kontrol edilmelerini engeller ve böylece manipülasyon riskini azaltır (Swan, 2015). Haksız rekabet, piyasa aktörleri arasında adil olmayan avantajlar elde etme çabaları sonucunda ortaya çıkan ve piyasa dinamiklerini bozan uygulamaları ifade eder. Bu tür uygulamalar, fiyat manipülasyonu, bilgi asimetrisi ve tekelci davranışlar gibi çeşitli şekillerde kendini gösterebilir (Bağcı, 2017). Bununla birlikte blokzincir teknolojisi , blokzincir üzerinde yapılan tüm işlemler, şeffaf bir şekilde kaydedilir ve herkes tarafından izlenebilir. Bu, piyasa aktörlerinin haksız rekabet oluşturacak gizli anlaşmalar yapmasını zorlaştırır (Pilkington, 2016). Blokzincirin kriptografik yapısı, verilerin güvenliğini sağlar ve bu verilerin değiştirilmesini engeller. Bu, özellikle finansal işlemlerde manipülasyon riskini azaltır (Yaga et al., 2018).Blokzincirin kriptografik yapısı, verilerin güvenliğini sağlar ve bu verilerin değiştirilmesini engeller. Bu, özellikle finansal işlemlerde manipülasyon riskini azaltır (Yaga et al., 2018).

II. Rekabet Hukuku ve Haksız Rekabet Açısından Blokzincirin Kısa bir Değerlendirmesi

6102 sayılı Türk Ticaret Kanunu'nun 54 vd. maddelerinde haksız rekabet düzenlenmiştir. Burada amaç, bütün katılanların menfaatine dürüst ve bozulmamış rekabetin sağlanmasıdır. Bu hüküm, tüm haksız rekabete ilişkin kuralların üzerine yapılandırıldığı iki taşıyıcı kolon içermektedir. Birinci kolon, bütün katılanların menfaatine dürüst ve bozulmamış rekabetin sağlanması gerekliliğini ifade etmektedir. Bu kolon bir taraftan, "bütün katılanlar" kavramı ve diğer taraftan da, dürüst ve bozulmamış rekabet kurumu ile tanımlanmaktadır. Dürüst ve bozulmamış rekabet kavramları İsviçre öğretisinde savunulan bir görüş uyarınca - rekabetin niteliğini, başka bir deyişle "kalitesi"ni belirtmektedir. Eski kanun "iktisadi rekabet"ten söz ederdi. Bu kavram hukukî olmadığı gibi, anlam ve içeriği de belirsizdi; karşıt kavramı olan "iktisadî olmayan (gayrî iktisadî) rekabet" ile anlamlandırılmak yoluna gidince de kavramı yorumlamak iyice zorlaşıyordu. Ayrıca, iktisadî rekabet "rakipler arası rekabet"i akla getiriyordu. Yeni metin dürüst ve bozulmamış rekabet kavramı ile hukuken tanımlanabilir bir rekabeti vurgulamaktadır. 4054 sayılı Rekabetin Korunması Hakkında Kanun da "bozulmamış", "engellenmemiş", "kısıtlanmamış" rekabeti esas alır ve engellenmiş, bozulmuş, kısıtlanmış rekabete sonuçlar bağlar. Tüm bu kavramlar hukukîdir. İkinci kolon, dürüst davranış kuralını tek başına temsil eder. Böylece 6762 sayılı Kanunda "suiistimal"de bulunan anlam ağırlığı, Tasarıda "dürüstlük kuralı"na geçmiştir. Çünkü, İsviçre öğretisinde isabetle belirtildiği gibi, kötüye kullanma istisnaî bir hukuk kuralı olup dar bir uygulama alanına sahiptir. 6762 sayılı Kanunun 56 ncı maddesine göre bir eylemin haksız rekabet olabilmesi için dürüst davranış kurallarını ihlâl etmesi yetmez. Bu ihlâlin ayrıca iktisadi rekabetin kötüye kullanılması niteliğini taşıması da gerekir.

Dürüst davranma kuralı ise artık haksız rekabetin tanınmasında (teşhisinde) belirleyicidir. Hukuka uygun ve bozulmamış rekabet ortamında (ortamın her zaman piyasa olması şart değildir) tüm katılanlar piyasanın tüm aktörlerinin dürüst davranış kurallarına göre hareket edeceğine güvenir ve güvenmek hakkını haizdir. Dürüstlük kuralını ihlâl eden bu güvene aykırı hareket edilmiş olur. Bu da haksız rekabet oluşturur.

Haksız rekabete ilişkin hükümlerin amacı hukuka uygun ve bozulmamış rekabetin sağlanmasıdır. Kanun ne "dürüst" ne de "bozulmamış" rekabeti tanımlamıştır. "Dürüst" terimi için kaynak kanunun Almanca metninde "saf, karışık ve katışık olmayan" anlamına gelen "lauter" sözcüğü için kullanılmıştır. Fransızca

metinde ise "loyale" sözcüğü yer almaktadır. Fransızca sözcüğün sözlükte çeşitli karşılıkları vardır: Sadık, dürüst ve haksız olmayan gibi. Dürüst sözcüğü Fransızca "loyale"den çevrilmiştir. Ancak, hüküm yorumlanırken bu sözcüğe Almancadaki "saf, karışık, katışık olmayan" anlamı da verilmeli, ayrıca dürüst kelimesi, sadece doğru veya kanunlara uygun şeklinde anlaşılmamalıdır. Kastedilen saf, geniş anlamda, kurallara uygun, dürüst rekabettir. Şunu da belirtelim, hukuka uygun rekabet kat'iyen 6762 sayılı Kanunun 56 ncı maddesi anlamında kanunî rekabete, kanun kurallarına uygun olarak yapılan rekabete özgülenemez. Hukuka uygun rekabet, oyunun dürüstlük kurallarına, centilmenliğe uygun olarak oynandığı katışıksız, saf bir rekabettir. "Bozulmamış" rekabet ise güven duyulan bir anlamda "hilesiz" demektir. Kanunun 55. Maddesinde sınırlı sayıda olmamak üzere bir kısım haksız rekabet halleri düzenlenmiştir. Konunun sınırlandırılması adına iş şartlarına aykırılığa ilişkin hükmü, blokzincir teknolojisi kapsamında inceleyeceğiz. İş şartlarına uymamak; özellikle kanun veya sözleşmeyle, rakiplere de yüklenmiş olan veya bir meslek dalında veya çevrede olağan olan iş şartlarına uymayanlar dürüstlüğe aykırı davranmış olur. Bu hususta tedarik zincirine ilişkin bir örnek verilebilir. gıda sektöründe faaliyet gösteren iki büyük şirket olan A ve B bulunmaktadır. TTK Madde 55'e göre, bu şirketlerin tedarik zincirlerinde belirli sağlık ve güvenlik standartlarına uymaları gerekmektedir. Ancak, şirket B, maliyetleri düşürmek amacıyla bu standartlara uymamaktadır. Bu durum, haksız rekabet oluşturur çünkü şirket B, yasal düzenlemeleri ihlal ederek haksız bir maliyet avantajı elde etmektedir.Bu sorunu çözmek ve haksız rekabeti önlemek için şirket A, tedarik zincirinde blokzincir teknolojisini kullanmaya karar verir. Blokzincir, tüm tedarik zinciri işlemlerinin şeffaf ve değiştirilemez bir şekilde kaydedildiği bir dijital defter sağlar. Tedarik zincirinin blokzincir üzerinde çalışabilmesi için de büyük veri kümeleri toplanmaktadır. Zira, farklı sensörlerden gelen bilgiler, blokzincirde yer alan bloklara kaydedilmektedir. Böylelikle gerçek zamanlı verilerin her birinin SHA-256 teknolojisi ile şifrelenmesi ile bloklara kaydedilerek şeffaflık ve değiştirilemezlik ilkesi korunmuş olup, bu durum tüm katılanlar menfaatine dürüst ve bozulmamış rekabeti sağlayacaktır.

4054 sayılı Rekabetin Korunması Hakkındaki Kanun Türkiye'deki rekabeti koruma amacıyla yürürlüğe konmuş temel bir düzenlemedir. Bu kanun, piyasalarda adil rekabetin sağlanması ve tüketicilerin korunması için çeşitli rekabete aykırı halleri düzenlemektedir. Son yıllarda hızla gelişen blokzincir teknolojisi, rekabet hukuku açısından yeni fırsatlar ve zorluklar doğurmaktadır. Rekabeti sınırlayıcı anlaşmalar, teşebbüsler arasında yapılan ve rekabeti engelleyen, bozan veya kısıtlayan anlaşmalardır. Bu tür anlaşmalar genellikle fiyat belirleme, üretim miktarlarının sınırlandırılması, piyasaların veya müşteri gruplarının paylaşılması gibi uygulamaları içerir. Piyasa paylaşımı anlaşmaları, teşebbüslerin belirli coğrafi bölgeleri veya müşteri gruplarını paylaşarak rekabet etmeme konusunda anlaşmalarını içerir. Bu tür anlaşmalar, rekabeti sınırlandırarak piyasa dinamiklerini bozar. Blokzincir teknolojisi, teşebbüsler arasında piyasa paylaşımı anlaşmalarını izlemeyi zorlaştırabilir. Dağıtık yapısı nedeniyle, bu tür anlaşmaların tespit edilmesi daha zor hale gelebilir. Ancak, blokzincir üzerinde yapılan işlemlerin izlenebilirliği, piyasa paylaşımı anlaşmalarının ortaya çıkarılmasını da kolaylaştırabilir. Benzer şekilde, rekabet hukuku açısından kartellerin varlığı istenilmeyen bir durumdur. Kartellerin çözülmesi ise çoğunlukla aralarındaki bir veya birkaç teşebbüsün, diğerlerinin kartel anlaşmasına sadık kalacağına ilişkin güvenlerinin zedelenmesi suretiyle mümkün olmaktadır. Blokzincir ise yeni güven teorisi ile güvensiz güven ilkesini kabul etmektedir. Burada taraflara değil, sistemin temelindeki matematiğe güven esası olduğundan karteller arasındaki çözülmeyi zorlaştırdığını söylemek mümkündür.

III. BULGULAR

Blokzincir teknolojisinin yıkıcı devrim özelliği, yenilikçi ve yapısının karmaşık olması nedeniyle haksız rekabet ve rekabet hukuku ihlallerinin tespitini zorlaştırabileceği, diğer taraftan ise şeffaflık ve merkeziyetsiz özellikleri ile dürüst ve bozulmamış rekabeti sağlayacağı söylenebilir. Ancak, bu teknolojisinin kullanımına ilişkin ülkemizde bir regülasyon bulunmamaktadır. Bu regülasyonun nasıl yapılması gerektiği ise diğer devletlerde tartışma konusu yapılmıştır. Bir görüşe göre, teknolojisinin gelişimine izin verecek şekilde yumuşak düzenlemeler (soft law) yapılması gerektiğini ileri sürerken diğer bir görüş ise kazuistik yöntemler ile meselenin her açından kodifikasyona tabi tutulmasını yani sert düzenleme yapılmasını (hard law) savunmaktadır.

IV. TARTIŞMA

Biz, bu hususta yumuşak düzenlemeler yapılması suretiyle teknolojinin gelişmesine yer açılması görüşünü desteklemekteyiz. Blokzincir teknolojisi, hem rekabet ihlallerine neden olarak bunların ilgili otoriteler tarafından tespit edilmesini zorlaştırabileceği gibi işlemlerin şeffaflık, değiştirilemezdik ve merkeziyetsiz yapısı sayesinde dürüst ve bozulmamış rekabet ortamının sağlanmasına katkı sunacağı aşikardır. Bununla birlikte, tıpkı Avrupa Birliğinin yapay zekaya ilişkin temel prensipleri belirlemesinde olduğu gibi kabul edilemez riskli, yüksek riskli ve kabul edilebilir riskli gibi alanlarda sistemin kategorize edilmesi gerekmektedir.

V. SONUÇLAR

Blokzincir teknolojisinin anlaşılması ve uygulama alanlarının genişletilmesi için bilimsel çalışmalar yapılmalıdır. Biz de hukuki perspektif yönünden meseleyi kısaca değerlendirmiş olup, özünde bu teknolojisinin olumlu katkıları olacağını belirtmekteyiz.

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Change of Root Biomass in Thinned Oriental Beech Stands and Adjacent Oak and Grassland

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Abstract – Roots have an important role in forest ecosystems, as they perform physiological functions such as absorbing and transporting water and nutrients for growth and development, as well as mechanical functions such as keeping trees standing. Thinning, which is frequently applied in forest management, regulates the stand structure by reducing stand density and encourages faster growth of the remaining quality trees. Although root biomass may vary from species to species, it can be quite sensitive to environmental factors changed as a result of interventions such as thinning. In this study, root biomass changes in oriental beech (*Fagus orientalis* Lipsky) stands and the adjacent sessile oak (*Quercus petraea* Liebl.) stand and grassland, where thinning care was applied at different intensities, were investigated. In the oriental beech stand, thinning was done three times in two fields in 2010, 2016 and 2022, and on average, 0% of the chest surface was removed in the control, 18% and 25% in the other parcels. Three randomly selected trial areas were established in five different fields (3 beech, 1 oak, and 1 grassland), and root sampling was carried out in every trial area from six different points for seven months. According to the results of variance analysis, no significant difference was found in terms of root biomass in oriental beech stands thinned at different severities. The average live root biomass in forest areas was 1673.6 g m^{-2}, which was approximately 82% higher than in the grassland. While approximately 70% of the live root biomass in forest areas was fine root (0-2 mm), this value was 95% in the grassland. Dead root biomass did not vary significantly between sites. As a result, even though root biomass differs depending on vegetation type, regular thinning did not significantly impact root biomass in oriental beech stands.

Keywords – Carbon, Düzce, Fagus orientalis, fine root, Quercus petraea, root biomass, thinning

I. GİRİŞ

Toplam bitki biyokütlesinin, özellikle ağaçların, önemli bir kısmı toprak altında bulunmaktadır. Orman ekosistemlerinde biyokütle toprak üstü ve toprak altı olarak ayrılmakta ve ekosistemlerdeki madde dolaşımı ve dinamikleri anlamada büyük önem taşımaktadır [1]. Toprak altı biyokütleyi oluşturan kökler; kılcal kök (0-2 mm), ince kök (2-5mm), kaba kök (5-10mm) olarak ayrılabilir [2, 3].

Kılcal kökler topraktan su ve bitki besin elementlerinin alımında en önemli rol üslenirken [4, 5] bitki gelişimini kolaylaştırmak için değişen ortamlara uyum sağlama yeteneğine sahiptir. İnce kök aktivitesi toprağın fiziksel, kimyasal ve biyolojik özelliklerini değiştirebilir ve bunun bitki düzeyinde ve aynı zamanda ekosistem düzeyinde de etkileri olabilir [6].

Kalın kökler (2 mm'den kalın) ise besin maddesi ve su geçişi için kanallar içerir, karbon ve besin maddeleri için bir depolama alanı görevi görür ve ağaçlar için fiziksel bir dayanak noktası sağlar [7]. Ek olarak kaba köklerin döngüsü, C ve besin maddelerinin toprağa ve toprak biyotasına yavaş yavaş

iletilmesini sağlar ve uzun vadeli ekosistem üretkenliğini ve ormanlardan kaynaklanan CO_2 emisyonlarını etkiler [7].

Orman bakımı tedbirlerinden biri olan aralama orman yönetiminde ve işletilmesinde sıklıkla uygulanmaktadır. Aralama uygulamaları ağaçların ve bitki örtüsünün fiziksel yapısını doğrudan değiştirebilir ve dolaylı olarak toprak altı çevre koşullarını (örneğin toprak verimliliği ve mikro iklim) etkileyerek kök özelliklerini (özellikle kılcal kök) potansiyel olarak etkileyebilir [8]. Ancak aralamanın kök biyokütlesi üzerine etkisi olarak net bir fikir birliği yoktur. Aralamanın kılcal kök biyokütlesini artırdığı [9, 10] veya azalttığı [11-14] dair çalışmalar mevcuttur.

Doğu kayını (*Fagus orientalis* Lipsky) ve sapsız meşe (*Quercus petraea* Liebl.) Türkiye'de orman kuran ve yayılış alanı olarak ilk sırada yer alan asli yapraklı orman ağaçlarıdır. Bu çalışmanın amacı Düzce'de düzenli aralıklarla farklı şiddette aralanmış doğu kayını (*Fagus orientalis* Lipsky) meşcereleri ile bitişiğindeki sapsız meşe (*Quercus petraea* Liebl.) meşceresi ve çayırlıkta kök biyokütlesi değişimini araştırmaktır.

II. MATERYAL VE YÖNTEM

A. Araştırma Alanının Tanıtımı

Araştırma alanı Düzce Orman İşletme Müdürlüğü, Konuralp Orman İşletme Şefliğinin 72 numaralı bölmesinde (Düverdüzü mevkiinde) yer almaktadır (40° 55.7' K, 31° 5.57' D, 495 m). Saha batı bakıda ve %18 ortalama eğimde, amenajman planı verilerine göre 3. bonitette yer almaktadır. Meşcere altında diri örtü yoktur.

Araştırma alanına en yakın Düzce Meteoroloji İstasyonunun verilerine (150 m) göre 2022 yılı ortalama sıcaklık 14.3 ºC ve yıllık toplam yağış 883.4 mm'dir. Vejetasyon mevsimi Nisan-Ekim ayları arasında yaşanmakta ve saha bu sürede 426 mm yağış alabilmektedir.

Araştırma sahasında birbirine bitişik olarak yer alan Doğu kayını (*Fagus orientalis*), sapsız meşe (*Quercus petraea*) meşcereleri ve çayırlık vejetasyonunda beş adet deneme alanları (900 m^2) alındı. Bunlar aralanmamış (kontrol) doğu kayını meşceresi, Kayın_MA, Kayın_ŞA meşceresi, meşe meşceresi ve çayırlık alandır. Doğu kayını meşceresinde iki sahada 2010, 2016 ve 2022 yıllarında üç kez aralama yapılmış ve ortalama olarak göğüs yüzeyinin kontrolde %0, diğer parsellerde % 18 (Kayın_MA) ve % 25'i (Kayın_ŞA) çıkartılmıştır. Daha sonra deneme alanları içerisinde tesadüfi olarak üç adet alt örnekleme alanları (150 m^2) alınmıştır. Kök örneklemeleri alt örnekleme parsellerinde gerçekleştirilmiştir.

B. Yöntem

Her alt örnekleme alanında altı adet olmak üzere 6.4 cm çapında ve 30 cm boyunda çelik boru ve balyoz yardımıyla kök ihtiva eden toprak örnekleri alındı [14]. Daha sonra laboratuvara getirilen örnekler bir gün suda bekletilerek, toprağın gevşemesi ve köklerden kolay ayrışması sağlandı. Sonra bu örnekler bir leğene aktarılıp yıkanarak 0.2 mm'lik elekten süzüldü. Böylece topraktan arındırılan kökler 0-2 mm, 2-5 mm, ve 5-10 mm çap sınıflarına göre ayrılarak 65-70 °C sıcaklıkta 24 saat süre zarfında fırında bekletilerek kurutuldu [1]. Kurutulan kökler 0,001 gr hassasiyetteki terazide tartılıp, gerekli dönüşümler yapılarak metrekaredeki kök kütlesi belirlendi.

Verilerin istatistik değerlendirilmesinde SPSS (v.21) programı kullanılmıştır. Kök biyokütlesinin sahalar arasında farklı olup olmadığına basit varyans analizi (One-way ANOVA) ile bakıldı. Sonuçlar $p<0.05$ düzeyinde istatistiki olarak farklı kabul edildi. Analizler öncesinde tüm değişkenlere ait verilerin normal dağılım gösterip göstermediği ve ayrıca varyansların homojen olup olmadığı kontrol edildi. Normallik kontrolü "Shapio-Wilk" testi ile varyansların homojenlik kontrolü ise "Levene's testi" ile gerçekleştirildi.

III. BULGULAR

Toplam kök biyokütlesi kayın ormanlarında benzer (1932.4 g m^{-2}) ve çayırlıktan %55 daha yüksekti. Toplam canlı kök biyokütlesi de tüm orman sahalarında benzer (1673.6 g m^{-2}) ve çayırlıktan %81.9 fazla iken, canlı kök biyokütlesi Kayın_ŞA ve Kayın_MA benzer ve çayırlıktan yaklaşık %22 daha yüksekti.

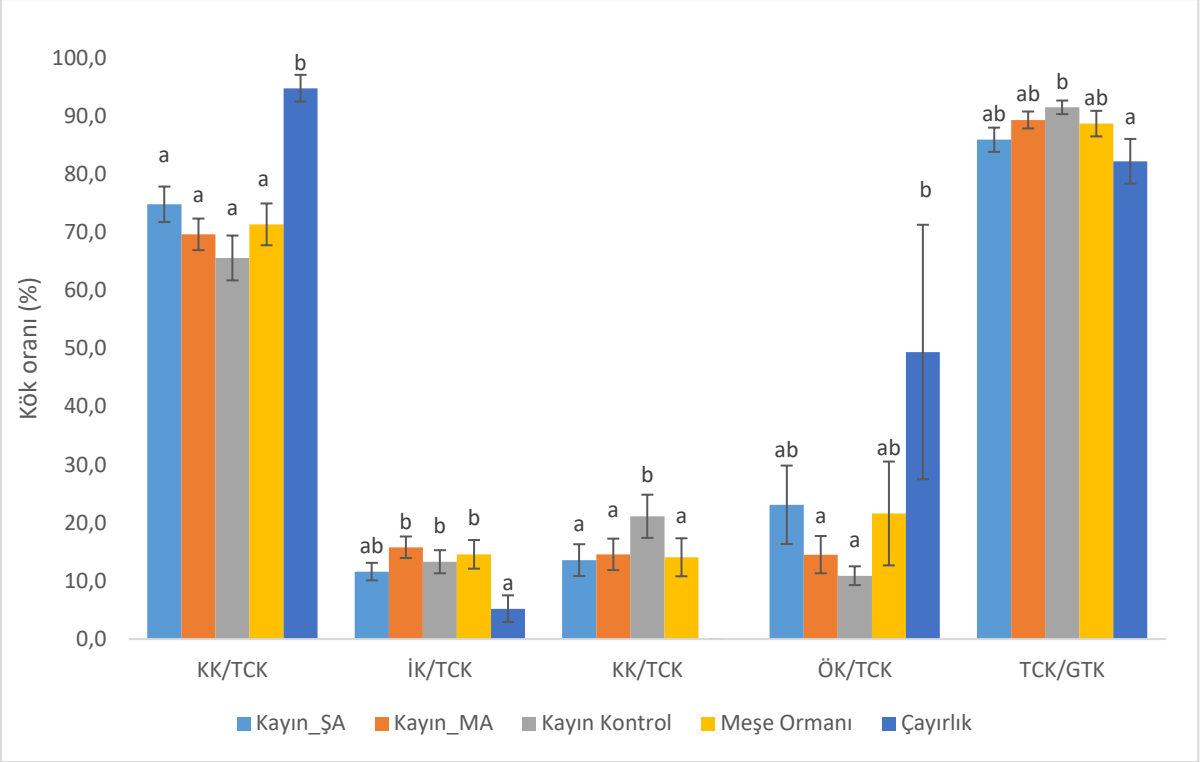
Kayın ormanlarında ortalama 1705.3 g m^{-2}, meşe ormanında 1578.4 g m^{-2}, çayırlık alanda ise 920,3 g m^{-2} canlı kök biyokütlesi bulundu. Toplam canlı kök biyokütlesinin ortalama olarak büyük kısmını (~% 65) kılcal kökler oluşturmaktadır. Bu oran Kayın ŞA, Kayın MA, Kayın kontrol, Meşe ormanı ve çayırlıkta sırasıyla %69, %64, %55, %63 ve %95 olarak belirlendi. İnce kök biyokütlesinin toplam canlı kök biyokütlesi içerisindeki oranı Kayın_ŞA, Kayın_MA, Kayın kontrol, Meşe ormanı ve çayırlıkta sırasıyla yaklaşık %13, %15, %14, %16 ve %6 civarıdır. Kalın kök sınıfına giren kök biyokütlesi çayırlıkta bulunamadı, diğer sahalarda ise yaklaşık 293 g m^{-2} idi. Ölü kök biyokütlesi ortalama 244.1 g m^{-2} olarak belirlendi (Tablo 1).

Tablo 1. Sahaların faklı kök sınıflarına göre kök biyokütleleri (g m^{-2} ± std hata)

Sahalar	Kılcal kök (0-2 mm)	İnce kök (2-5 mm)	Kalın kök (5-10 mm)	Canlı kök Toplamı	Ölü kök	Genel toplam
Kayın_ŞA	1079,6 ± 50,7 b*	195,9 ± 29,1 ab	296,2 ± 69,5 ab	1571,6 ± 96,1 b	322,4 ± 94,2 a	1893,9 ± 143,2 b
Kayın_MA	1065,6 ± 52,8 b	256,9 ± 30,8 b	347,6 ± 91,9 ab	1670 ± 116,6 b	195,4 ± 38,9 a	1865,4 ± 131,5 b
Kayın Kontrol	1035,7 ± 51,1 ab	254,0 ± 36,3 b	585 ± 161,3 b	1874,6 ± 172,6 b	163,3 ± 25,2 a	2037,9 ± 200,7 b
Meşe Ormanı	990,0 ± 48,9 ab	245,2 ± 59,6 b	343,3 ± 110,1 ab	1578,4 ± 121,2 b	213,7 ± 50,4 a	1792,1 ± 129,4 ab
Çayırlık	876,7 ± 65,9 a	58,5 ± 27,8 a	0 ± 0 a	920,4 ± 69,6 a	325,8 ± 133,1 a	1246,1 ± 139,3 a
F	*2,549*	*3,608*	*3,265*	*6,524*	*1,109*	*3,67*
P	*0,041*	*0,007*	*0,013*	*<0,001*	*0,353*	*0,007*

*Her sütunda aynı harfle gösterilen ortalamalar istatistiki olarak benzerdir (p>0.05).

Kılcal kök/Canlı kök biyokütlesi oranına (KK/TCK) bakıldığında orman alanları benzer ve çalılık alandan düşüktür (Şekil 1). İnce kök-Canlı kök biyokütlesi oranı (İK/TCK) en düşük çayırlıkta ve diğer sahalar ise benzer ve daha yüksektir. Kalın kök-Canlı kök biyokütlesi oranı (KK/TCK) kayın kontrol sahasında en yüksek, diğer sahalar ise benzer ve daha düşüktü. Ölü kök-Canlı kök biyokütlesi oranı (ÖK/TCK) kayın_MA ve kayın kontrolde aynı ve en düşük, çayırlıkta ise en yüksekti. Canlı kök biyokütlesi-Genel kök biyokütlesi oranına (TCK/GTK) bakıldığında kayın kontrol sahasının çayırlık alanından daha yüksek olduğu görülmektedir.



Şekil 1. Sahalara göre kök sınıflarının oransal dağılımın karşılaştırılması (Barlar standart hatayı göstermektedir. Kök sınıfı oranlarında sahalar arasındaki aynı harfle gösterilen sütunları istatistiki olarak benzerdir)

IV. TARTIŞMA

Araştırma alanındaki kayın ormanlarında ortalama 1705.3 g m^{-2}, meşe ormanında 1578.4 g m^{-2}, çayırlık alanda ise 920,3 g m^{-2} canlı kök biyokütlesi bulundu. Aynı türler üzerinde yapılan birçok çalışmada da benzer sonuçlar bulunmuştur. Örneğin Artvin doğu kayını ormanlarında toprak altı biyokütle güney bakılarda 1719 g m^{-2}, kuzey bakıda 1326 g m^{-2} [15], aynı ilde başka bir doğu kayını meşceresinde ise güney bakılarda 1195 g m^{-2}, kuzey bakıda 688g m^{-2} olarak [16] bulunmuştur. Özbayram and Güvendi [17] Sinop yöresi doğu kayını meşcerelerinde ise kalın kök biyokütlesi yaklaşık 1670-1719 g m^{-2} olarak bulmuşlardır. Artvin'deki bir çalışmada çayırlık alanda kök biyokütlesi 694 g m^{-2} [18], başka bir çalışmada ise çayırlık ve meşe meşceresinde kök biyokütlesi sırasıyla 979 g m^{-2} ve 2055 g m^{-2} olduğu belirtilmiştir [19].

Ormanlık alandaki canlı kök biyokütlesi çayırlık alandan %82'i daha fazlaydı. Bitkilerin toprak üstü ve toprak altı kısımlar arasında denge olması beklendiğinden bu sonuç anlaşılabilirdir. Ayrıca orman ağaçları yaş ve çapa bağlı olarak kalın (5-10mm) ve kaba kök (<10mm) biyokütlesi oluşturabilirken, çayırlıklar sadece kılcal (0.-2 mm) ve ince (2-5mm) kök oluşturmaktadır. Benzer çalışmalarda da meşe ormanlarındaki kök biyokütlesinin çayırlık alandan [19]; elma bahçesi ve kavak plantasyonu kök biyokütlesinin çayırlıktan [18, 20] daha yüksek olduğu belirtilmektedir.

Toplam canlı kök biyokütlesinin büyük kısmını (% 55-95) kılcal kökler oluşturmaktadır. Kılcal kök dinamikleri orman ekosisteminde karbon ve besin maddesi döngüsünde önemli rol oynamaktadır [21]. Sahalar arasında en fazla kılcal kök biyokütlesi Kayın_ŞA ve Kayın_MA sahalarında belirlendi ve çayırlık sahadan yaklaşık %22 daha yüksekti. Doğu kayınında aralamanın canlı kök ve kılcal kök biyokütlesine önemli etkisi olmadı. Birçok çalışmada net fikir birliği olmamakla birlikte aralamanın kılcal kök biyokütlesini artırdığı [9, 10] veya azalttığı [11-14] şeklinde sonuçlar elde edilmiştir. Doğu kayını meşcerelerinde kılcal kök biyokütlesi ortalama 1060.2 g m^{-2} dir. Bu değer doğu kayını ormanlarında yapılan önceki çalışmalardan elde edilen sonuçlarla örtüşmektedir. Örneğin; Doğal doğu kayını meşceresinde kılcal kök biyokütlesi 57.9-703,3 g m^{-2} arasında [22], diğer bir çalışmada 411-1452 g m^{-2}

arasında [15], başka bir çalışmada ortalama 905 g m^{-2} olduğu, belirtilmiştir. Ayrıca Finér, Ohashi [23] ılıman ormanlarda kılcal kök ortalama 775±474 g m^{-2} olarak hesaplamıştır.

V. SONUÇLAR

Doğu kayını aralama şiddetinin kök biyokütlesi üzerine önemli bir etkisi olmadı. Genel olarak orman alanlarında kök biyokütlesi çayırlık alandan fazlaydı. Ancak canlı kök biyokütlesindeki kılcal kök oranı çayırlık orman alanlarına nazaran daha yüksekti.

Ağaçların toprak altı kısımları karasal verimliliğe ve karbon stokuna kritik katkılar sağlamaktadır. Ancak aralama şiddetinin toprak altı verimliliği üzerindeki etkisi hakkında sınırlı ve net olmayan bilgiye sahibiz. Elde ettiğimiz sonuçlar Düzce yöresi için geçerli olup, diğer yörelerde yapılmış çalışmalarla paralellik arz etse de, farklı yörelerde elde edilen sonuçlar değişkenlik gösterebilir.

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Plazma Elektrolitik Oksidasyon (PEO) Yöntemi ile Al 7075 Alaşımı Yüzeyine Büyütülen Al_2O_3 ve Al_2O_3:TiB_2 Katkılı Oksit Kaplamaların Yapısal Özelliklerinin İncelenmesi

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Özet – Endüstriyel uygulamalarda Alüminyum (Al) ve alaşımları; sahip olduğu düşük özgül ağırlık, yüksek mukavemet ve korozyon direnci nedeni ile yapı malzemesi olarak kullanılan hafif metalik mühendislik malzemeleridir. Ancak bu malzemelerin tribolojik özellikleri ve korozyon dirençlerinin, agresif ortamlarda ve/veya aşırı yükler altında uzun süre kullanımında istenilen performansı sergileyememesi en önemli dezavantajlarıdır. Bu dezavantajları iyileştirmek, Al ve alaşımlarına istenilen özellikleri kazandırıp kullanım alanlarını geliştirmek için uygulanan yüzey iyileştirme yöntemlerinden biri de Plazma Elektrolitik Oksidasyon (PEO) yöntemidir. Bu yöntem ile Al ve alaşımlarının yüzeyine sert, yüksek aşınma ve korozyon direncine sahip oksit kaplamalar büyütülmektedir. Bunun yanında PEO yönteminde elektrolitik çözelti içerisinde ilave partiküller eklenerek yüksek tribolojik özelliklere sahip, farklı çalışma ortamlarına uygun niteliklerde katkılı oksit kaplamalar da elde edilebilmektedir. İlave nanopartiküller içerisinde ergime sıcaklığı 3000 °C üzerinde olan metal geçiş borürleri gibi ultra yüksek sıcaklık seramikleri (UHTCs)' de uygulamalarda kullanılmaya aday yeni nesil katkı maddeleridir. Bu seramikler içerisinde titanyum diborür (TiB_2) sahip olduğu yüksek ergime sıcaklığı, yüksek dayanım ve sertlik değeri ile yüksek aşınma direnci sayesinde umut vadeden UHTCs' lerindendir. TiB_2 sahip olduğu bu üstün özelliklerinden dolayı aşınmaya dayanıklı kaplamalarda, hava araçlarının burun uç kısımları ile kanat uçlarında uygulama alanı bulabilmektedir. Bu çalışmada Al 7075 alaşımı üzerine sırasıyla Al_2O_3 ve TiB_2 nanopartikül ilavesi ile Al_2O_3:TiB_2 katkılı oksit kaplamalar büyütülmüş, büyütülen bu kaplamaların yapısal analizleri XRD, SEM ve EDS ile karakterize edilmiştir. Sonuç olarak TiB_2 nanokompozit ilavesi ile büyütülen katkılı oksit kaplamaların yüzeyde homojen bir yapıda olduğu, yüzeylerinde oluşan mikro çatlaklar ile gözenek boyutlarının ise azaldığı belirlenmiştir.

Anahtar Kelimeler – Al 7075, Aşınma, Plazma Elektrolitik Oksidasyon (PEO), TiB_2, Triboloji

I. GİRİŞ

Alüminyum (Al) elementi sahip olduğu 2,70 g/cm³ yoğunluğu ile Titanyumun (Ti) yoğunluğundan 1,67 kat, Çeliğin yoğunluğundan 2,9 kat daha düşük bir değere sahiptir. Düşük yoğunluk değerinin kazandırmış olduğu hafiflik, endüstrinin birçok alanında özellikle verimliliğin ön plana çıktığı mühendislik uygulamalarında alüminyum ve alaşımlarının yapı malzemesi olarak tercih edilmesini sağlamaktadır [1], [2].

Endüstriyel uygulamalarda çelikten sonra en çok kullanılan yapı malzemesi olan Alüminyumun birden fazla alaşım sistemi bulunmaktadır. Bu alaşım sistemleri içerisinde Al 7XXX serisi alüminyum alaşımları sahip olduğu düşük yoğunluk, yüksek mukavemet ve tokluk, yüksek elastisite modülü, yüksek yorulma direnci, süneklilik, kaynak edilebilirlik ve iyi işlenebilme özelliklerinden dolayı başta savunma sanayisi, otomotiv, havacılık ve uzay endüstrisi olmak üzere denizcilik, elektronik ve telekomünikasyon ekipmanları ile genel mühendislik ve imalat uygulamalarında en çok tercih edilen mühendislik malzemeleridir [2]-[7].

7XXX alaşım serisi içerisinde ise en çok bileşiminde ana alaşım elementi olarak çinko içeren Al 7075 alaşımları kullanılmaktadır [1], [6], [7].

Al 7075 alaşımının sahip olduğu yüksek mukavemet, işlenebilirlik, süneklilik ve yüksek yorulma direncinin yanında 2xxx serisi alüminyum alaşımlarından çok daha iyi korozyon direncine ve yüksek mukavemet/ağırlık oranına sahip olması nedeniyle uçak yapılarının üst kanat kaplamalarında, üst panellerinde, kirişlerinde, yatay/dikey kuyruklarına yapı malzemesi olarak kullanılmaktadırlar [1], [2], [7], [8]. Bunun yanında Al 7075 alaşımının hava araçlarındaki uygulamalarında, düşük kırılma tokluğu sergilemesi, düşük hasar toleransı göstermesi, çalışma ortamına bağlı olarak istenilen düzeyde korozyon direnci sergileyememesi, kullanım şartlarına bağlı olarak düşük yüzey sertliği, yüksek sürtünme katsayısı ve zayıf aşınma direnci gibi istenen tribolojik özellikleri karşılayamaması uygulama alanlarını kısıtlamaktadır [2], [8]-[10].

Bu dezavantajları gidermek için yüzey iyileştirme yöntemlerine ihtiyaç duyulmaktadır [11], [12]. Bu yöntemler arasında son dönemde öne çıkan Plazma Elektrolitik Oksidasyon (PEO) yöntemi, Al ve alaşımları gibi hafif metalik malzemelerin üzerinde seramik kaplamaların büyütülmesinde kullanılan basit, ekonomik ve çevre dostu bir teknolojidir. Bu yöntem, sulu bir çözelti içinde iki elektrot arasına bir potansiyel uygulanarak elektrot yüzeyinde plazma mikro deşarjlarına yol açan voltajlarda metallerin ve alaşımlarının anodik polarizasyonu yoluyla oksidasyonuna dayanmaktadır [13]-[16]. PEO işlemi sonucu yüksek adhezyon kuvvetine, yüksek sertliğe, yüksek korozyon ve aşınmaya dirence sahip, elektrolitte bulunan kimyasal elementlerin oksitleri ve taban malzemeden gelen oksitlerin bir kombinasyonu olan seramik kaplamalar büyütülmektedir [17], [18].

PEO yöntemi ile büyütülen kaplamalar çok iyi özelliklere sahip olsa da uzun süreli uygulamalarda agresif çalışma ortamlarında kaplamalarda çözünmeler ve bozulmalar meydana gelebilmektedir. Bunun nedeni ise PEO yönteminin doğasından kaynaklı olarak malzeme yüzeyinde büyütülen kaplamaların gözenekli ve pürüzlü bir yapıda olmasıdır [16], [19]. Bu dezavantajları gidermek, taban malzemeye istenilen özellikleri kazandırmak, yüksek aşınma ve korozyon direnci elde etmek için elektrolitik çözelti içerisine nanopartiküllerin ilave edilmesi ihtiyacı doğmuştur. PEO yönteminde elektrolitik çözelti içerisine nanopartiküllerin ilave edilmesi ile büyütülen katkılı oksit kaplamaların gözenek boyutu ve gözenekliliği azalmakta, mekanik, tribolojik özellikleri gelişmekte ve korozyon direnci artmaktadır [16], [19], [20].

Mevcut literatürde Al ve alaşımları yüzeyine büyütülen PEO kaplamalarda partikül ilavesinin kaplamaların farklı özellikleri üzerindeki etkilerine yönelik birçok bilimsel çalışma olduğu görülmektedir [16], [19]-[22]. Ancak sön dönem çalışmalar ergime sıcaklığı 3000 °C üzerinde olan metal geçiş borürleri gibi ultra yüksek sıcaklık seramikleri (UHTCs) üzerine yoğunlaşmaktadır. Bu seramikler içerisinde titanyum diborür (TiB_2) sahip olduğu yüksek ergime sıcaklığı, yüksek dayanım ve sertlik değeri, yüksek aşınma direnci, düşük termal genleşme katsayısı ve yüksek korozyon direnci sayesinde umut vadeden ultra yüksek sıcaklık seramiklerindendir. TiB_2' nin sahip olduğu üstün özelliklerinden dolayı aşınmaya dayanıklı kaplamalarda, nozüllerde, hava araçlarının burun uç kısımlarında ve kanat uçlarında uygulama alanı bulmaktadır [23]-[25].

Bu çalışmada, Al 7075 alüminyum alaşımı yüzeyine PEO yöntemi uygulanarak sırasıyla Al_2O_3 ve TiB_2 ilavesi ile Al_2O_3:TiB_2 katkılı kompozit kaplamalar büyütülmüştür. Büyütülen kaplamların yapısal ve morfolojik özellikleri X-ışını Difraksiyonu (XRD), Taramalı Elektron Mikroskobu (SEM), Enerji Dağılımlı X-ışını Spektroskopisi (EDS) ile tespit edilmiştir. Sonuç olarak, TiB_2 nanopartikül ilavesi ile büyütülen Al_2O_3:TiB_2 katkılı kompozit kaplamaların yoğun ve homojen bir şekilde büyütüldüğü, TiB_2 ilavesinin kaplama yüzeyinde gözenek sayısı ile gözenek boyutlarının küçülmesine, mikro çatlakların azalmasına etki ettiği belirlenmiştir.

II. MATERYAL VE YÖNTEM

Taban malzeme olarak, Tablo 1'de kimyasal değerleri gösterilen alüminyum alaşımı olan Al 7075 alaşımı seçilmiştir. 30*30*4 mm ebatlarında kesilmiş olan taban malzemelerin yüzeyi sırasıyla 600, 800, 1000 ve 1200 tane boyutlu SiC zımparalarla temizlenip Ra≈ 0.15 ile 0.5 μm pürüzlülük değerine kadar düşürülmüştür. Taban malzemelerin yüzey pürüzlülük ölçümleri Mahr marka yüzey profilometre cihazı ile gerçekleştirilmiştir. İstenilen yüzey pürüzlülük değerine ulaşılan numuneler sırasıyla saf su ve etanol ile temizlenerek kurutulmuştur.

Tablo 1. Al 7075 taban malzemenin kimyasal bileşimi [2].

Alaşım	**Zn**	**Mg**	**Cu**	**Fe**	**Si**	**Mn**	**Cr**	**Ti**	**Diğer**		**Al**
									Her bir	**Toplam**	
% Ağırlık	5.1~6.1	2.1~2.9	1.2~2.0	≤0.50	≤0.40	≤0.30	0.18~0.28	≤0.20	≤0.05	≤0.15	Kalan

Kaplama işlemi; Faraday Elektrik tarafından üretilen PEO sisteminde AC güç kaynağı kullanılarak bipolar modda biri potasyum, fosfat, silikat ve alüminat içerikli çözelti (Deney-1) diğeri ise çözelti içerisine TiB2 nanopartikül ilave edilerek elde edilen (Deney-2) iki farkı elektrolitik sulu çözelti içerisinde gerçekleştirilmiştir. Tablo 2' de çözelti içerikleri, Tablo 3' de kaplama işlem parametreleri verilmektedir.

Tablo 2. Çözelti içerikleri

Elektrolit Çözelti					
Kod	**Na_2SiO_3 (g/l)**	**Na_2HPO_4 (g/l)**	**KOH (g/l)**	**$NaAlO_2$ (g/l)**	**TiB_2 (g/l)**
Deney-1	3	3	2	3	-
Deney-2	3	3	2	3	1,5

Tablo 3. Kaplama işlem parametreleri

Parametreler	**Voltaj (V)**	**Frekans (Hz)**	**% duty**	**İşlem süresi (dk)**
Deney Şartları	550 / -150	250	%20 / -%10	15

Kaplama işlemi sonrası Al 7075 taban malzemesi yüzeyinde büyütülen oksit kaplamaların yüzey topografyası, kalınlığı ve kesit görüntüleri Quanta FEG 250 taramalı elektron mikroskobu (SEM), faz analizleri ise oda sıcaklığında, 20º ila 90º arasında, 0,1º adımda ve 2º /dk tarama hızında Cu Kα radyasyonlu (λ=1.54060 Å) Rigaku marka XRD cihazında gerçekleştirilmiştir.

III. BULGULAR

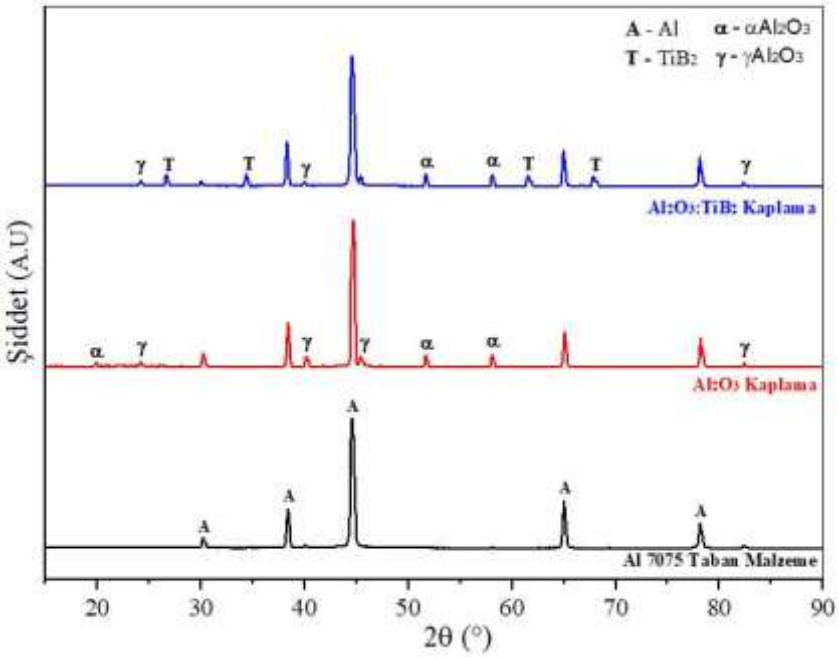
Kaplama öncesi Al 7075 taban malzemesinin ve kaplama işlemi sonrası taban malzemede büyütülen Al_2O_3 ve Al_2O_3:TiB_2 katkılı oksit kaplamaların yüzey pürüzlülük değerleri Tablo 4' de verilmiştir.

Tablo 4. PEO işlemi öncesi ve sonrası Al 7075 taban malzemenin yüzey pürüzlülük değerleri

	Al 7075 Taban Malzeme	**Al_2O_3**	**Al_2O_3:TiB_2**
Ra (µm)	0,3	1,211	1,076

Tablo 4 incelendiğinde Al 7075 taban malzeme yüzeyine Deney-1 şartlarında büyütülen Al_2O_3 kaplamaların yüzey pürüzlülüğünün en yüksek değerde olduğu görülmektedir. Bu durum PEO yönteminin doğası gerçekleşen mikro deşarjlar sonucu pürüzlü ve volkan görünümüne sahip mikro gözenekli seramik bir yüzeyin oluşmasından kaynaklanmaktadır. Deney-2 şartlarında büyütülen Al_2O_3:TiB_2 katkılı kompozit kaplamaların pürüzlülük değerinin ise Deney-1şartlarında büyütülen kaplamalara göre daha az olduğu görülmektedir. Bunun nedeni ilave edilen TiB_2 nanopartiküllerin kaplama oluşumu sırasında açığa çıkan mikro gözeneklerin içine girerek gözeneklerin çapının ve sayısının azalmasına neden olmasından kaynaklandığı düşünülmektedir.

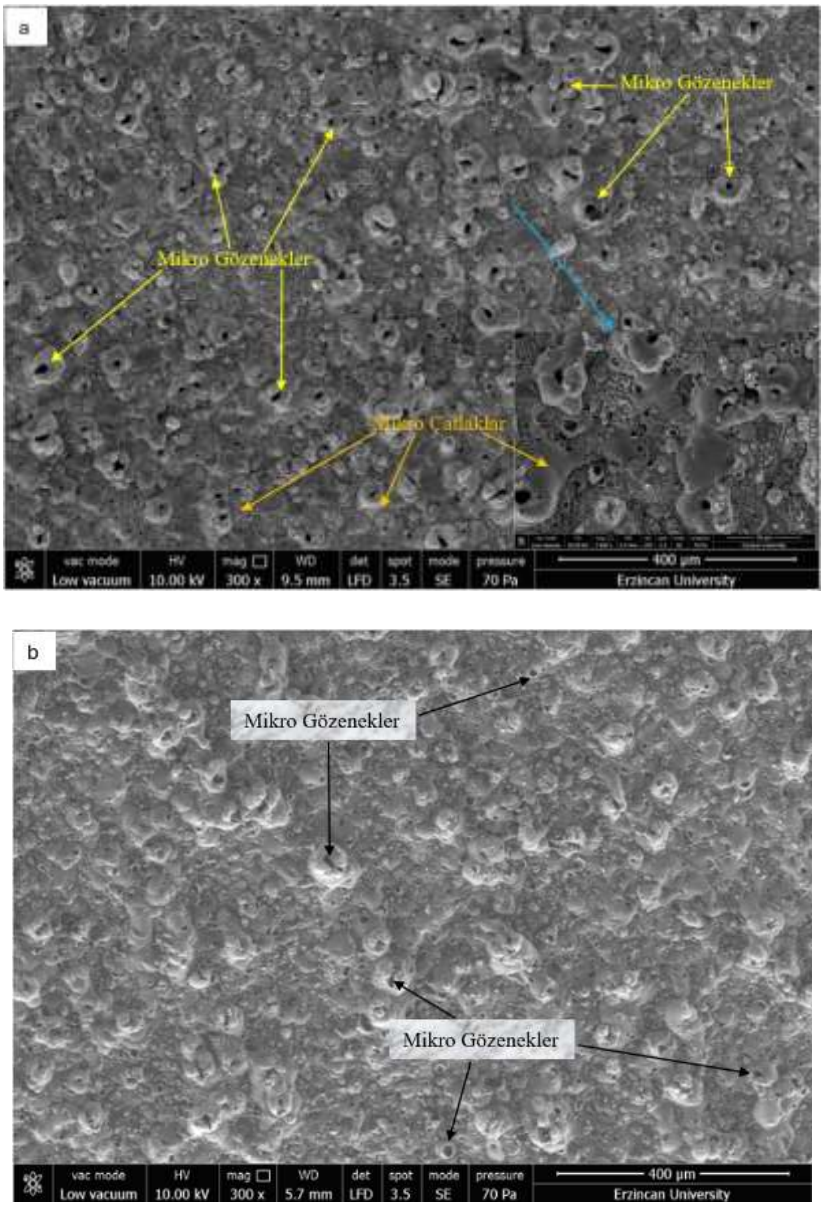
Literatür incelendiğinde PEO yöntemiyle Al alaşımlarının yüzeyinde büyütülen kaplamalarda oluşan temel fazın Al_2O_3 olduğu bilinmektedir [16], [19]. Şekil 1' de gösterilen XRD sonuçları incelendiğinde hem Deney-1 hem de Deney-2 şartlarında büyütülen kaplamaların yüzeyinde Al_2O_3 fazlarının oluştuğu görülmektedir. Deney-2 kaplamalarında TiB_2 fazları görülmüştür. Bu durum literatür ile paralellik göstermektedir [26]-[27]. Çözelti içerisine ilave edilen partiküllerin etkisiyle başlangıç voltaj değeri düşmekte ve kaplamanın büyütülmesini uzun süre almaktadır [20]. Buna bağlı olarak TiB_2 nanopartiküllerin ilave edildiği elektrolitik çözeltide büyütülen kaplamalarda TiB_2 fazları görülmektedir. XRD sonuçları, elektrolit içinde dağılmış TiB_2 nanopartiküllerin PEO kaplamalarına başarılı bir şekilde dahil edildiğini açıkça göstermektedir.



Şekil 1. Kaplanmış ve kaplanmamış örneklerin XRD grafiği

Şekil 2' de PEO yöntemi ile büyütülen kaplamaların yüzey morfolojilerine ait taramalı elektron mikroskobuyla (SEM) ile çekilen görüntüleri gösterilmektedir. SEM görüntüleri incelendiğinde PEO yönteminin doğasından kaynaklı büyütülen kaplama yüzeyinin pürüzlü ve volkan görünümüne sahip mikro gözenekler içeren bir yapıya sahip olduğu görülmektedir. Yüzeyde oluşan ve yüzeyin pürüzlü bir yapıda olmasını sağlayan bu porlar mikro deşarj kanalları olarak adlandırılmaktadır. Mikro deşarj kanallarında meydana gelen mikro ergimeler farklı boyutlarda çok sayıda dairesel yapıda, volkan görünümlü mikro gözeneklerin oluşmasına neden olmaktadır. Kaplama işlemi sırasında deşarj kanalları içerisinde meydana

bölgesel ergimelerin akabinde gerçekleşen katılaşma izinin dairesel bir şekilde ilerlemesinden dolayı kaplama yüzeyinde oluşan gözenekler dairesel bir geometriye sahiptir. Ayrıca kaplama yüzeyinde üniform ve üniform olmayan mikro gözenekler ile mikro çatlaklar net bir şekilde görülmektedir [28]-[30].

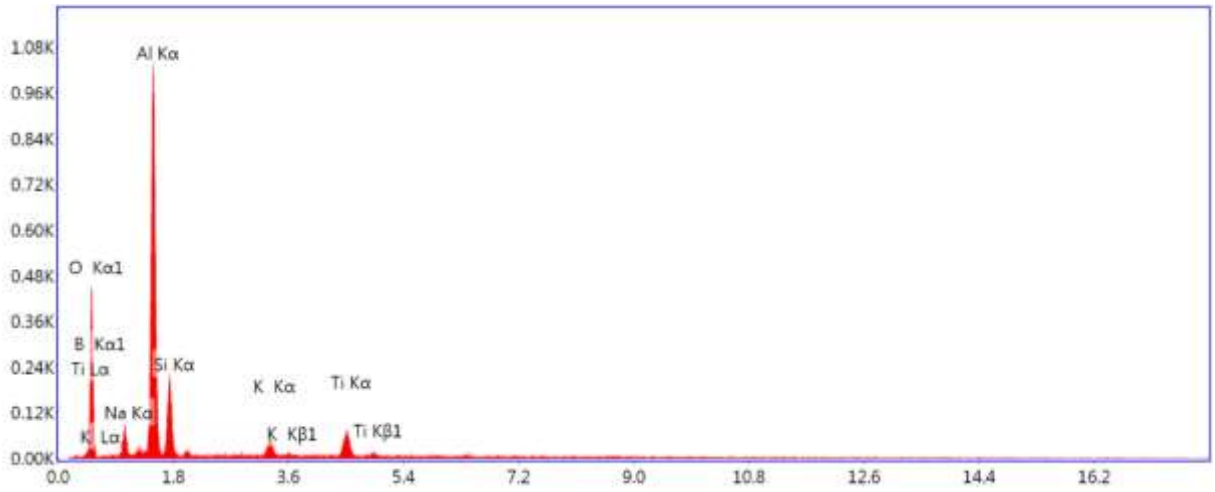


Şekil 2. PEO Kaplamalara ait SEM görüntüleri, a) Deney-1 kaplamanın SEM görüntüsü (Al_2O_3) b) Deney-2 kaplamanın SEM görüntüsü (Al_2O_3:TiB_2)

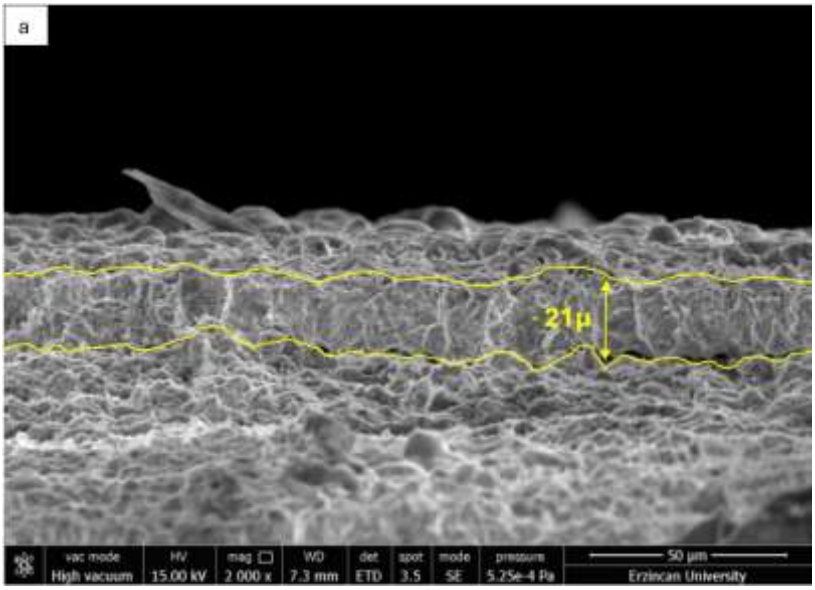
Şekil 2-a Deney-1 şartlarında büyütülen kaplamaya ait, Şekil 2-b ise Deney-2 şartlarında büyütülen katkılı oksit kaplamaya ait yüzey görüntüleridir. Şekil 2-a ile Şekil 2-b incelendiğinde Deney-2 şartlarında büyütülen kaplamanın yüzeyinin daha az pürüzlü bir yapıda olduğu, farklı boyutlardaki volkan görünümlü oluşumların ve dairesel yapıdaki mikro gözeneklerin çok daha az sayıda olduğu gözlemlenmiştir. Bunun nedeni ilave edilen TiB_2 nanopartiküllerin kaplama oluşumu sırasında açığa çıkan mikro gözeneklerin içine girerek gözeneklerin çapının ve sayısının azalmasına neden olmasından kaynaklandığı düşünülmektedir [20].

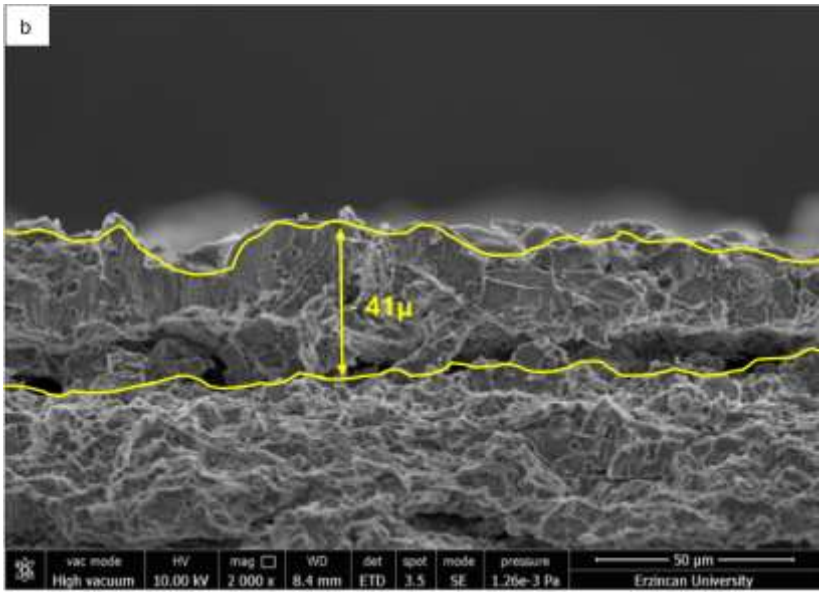
Şekil 3' te Deney-2 şartlarında büyütülen katkılı oksit kaplamaların EDS analizi verilmiştir. TiB_2 nanopartikül ilave edilen kaplamanın yüzeylerinden alınan EDS analizine göre kaplama elektrolitik çözeltisi içerisinde ilave edilen çözelti bileşiklerinden kaynaklı Si, Al, Na, K, O, ve Na elementlerine

rastlanmıştır. Bu durum elektrolitik çözelti içerisindeki elementlerin kaplamanın içine nüfus ettiğinin göstergesidir. Ayrıca kaplamanın yüzeyinden alınan EDS analizi incelendiğinde Ti ve Bor (B) elementlerine de rastlanmıştır. Bu durum elektrolitik çözelti içerisine ilave edilen TiB_2 partiküllerinin kaplama içerisine nüfuz ettiği ve yüzeyde büyütülen Al_2O_3 kaplamalara TiB_2 katkısının yapılarak Al_2O_3:TiB_2 ilaveli katkılı oksit kaplamaların büyütüldüğünü göstermektedir.



Şekil 3. Deney-2 kaplamaya ait EDS analizi





Şekil 4. PEO Kaplamalara ait kesit görüntüleri, a) Deney-1 kaplamanın kesit görüntüsü (Al_2O_3) b) Deney-2 kaplamanın kesit görüntüsü (Al_2O_3:TiB_2)

Şekil 4' te PEO yöntemi ile büyütülen Deney-1 ve Deney-2 şartlarında büyütülen kaplamaların kesit görüntüleri verilmektedir. SEM görüntüleri incelendiğinde Deney-2 şartlarında büyütülen kaplamaların kalınlıkları ile Deney-1 şartlarında büyütülen kaplamanın kalınlıkları arasında bir fark olduğu görülmektedir. Şekil 4 a'da gösterilen Deney-1 kaplamanın kalınlığı ≈21µ, Şekil 4-b' Deney-2 kaplamanın kalınlığı ise ≈41µ olarak ölçülmüştür. Bu durumun elektrolitik çözelti içerisine ilave edilen TiB_2 nanopartiküllerin kaplama başlangıç voltaj değerini düşürmesine ve aynı süre içerisinde daha kalın ve homojen bir kaplama büyütülmesine olanak sağladığı düşünülmektedir [20].

IV. SONUÇLAR

- ✓ TiB2 ilavesi ile Al 7075 alaşımı üzerine Al_2O_3:TiB_2 katkılı oksit tabakası başarıyla büyütülmüştür.
- ✓ Al_2O_3 ve Al_2O_3:TiB_2 kaplı yüzeyler karşılaştırıldığında Al_2O_3:TiB_2 katkılı yüzeylerde daha homojen, daha az gözenekliliğe ve çok daha küçük gözenek çapına sahip yüzeyler elde edilmiştir.
- ✓ Elektrolitik çözeltiye ilave edilen TiB_2'nin yüzeyden alınan EDS analiz verilerine göre kaplama yüzeyinin birçok yerinde bulunduğu belirlenmiştir.
- ✓ XRD analizine göre yüzeyde α-Al_2O_3 ve γ-Al_2O_3 fazlarının oluştuğu görülmektedir. Bunun yanında TiB_2 ilave edilen kaplamalarda yaklaşık 26º, 34º, 62º ve 67º de TiB_2 fazları görülmüştür. Bu da TiB_2 parçacıklarının PEO kaplamalarına başarılı bir şekilde dahil edildiğini açıkça göstermektedir.
- ✓ Al_2O_3 ve Al_2O_3:TiB_2 kaplı örneklerin kesit görüntüleri karşılaştırıldığında TiB_2' nin ilavesi ile büyütülen Al_2O_3:TiB_2 katkılı yüzeylerin daha kalın ve yoğun yapıda olduğu gözlemlenmiştir.

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Influence of Unbraced Slope Excavation in Cohesive Soils on Building Settlements: A Multiparametric Analysis

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Abstract – This paper investigates the influence of unbraced sloped excavations in cohesive soil on building settlement through a comprehensive multiparametric analysis. Using the Mohr-Coulomb constitutive model in GeoStudio 2024, 288 simulations were conducted to explore the impact of excavation depth, slope angle, soil strength, compressibility, and building proximity on settlement. The results indicate that increased excavation depth and steeper slopes significantly amplify building settlements, particularly for weaker and more compressible soils. Conversely, greater distances between the building and the excavation edge mitigate these effects. Findings suggest maintaining a distance of at least 2 meters for safe excavation. This study provides valuable guidelines for geotechnical engineers to design effective excavation plans, minimizing potential negative effects on nearby buildings.

Keywords – Geotechnical engineering, excavation, building settlement, cohesive soil

I. INTRODUCTION

With increasing urban density and limited space, the proximity of building foundations to excavations presents a significant engineering challenge. Deep excavations are typically conducted using various types of support structures, such as pile walls, diaphragm walls, and sheet pile walls. However, these support systems are expensive and time-consuming. Consequently, shallower excavations are often performed as unbraced sloped excavations. Ramadan and Hussein [1] investigate the effect of unbraced excavation in clayey soil on adjacent buildings. Utilizing the Finite Element Method, they conduct numerical analyses to examine the impact of various factors on the settlement of a building located in the immediate vicinity of the excavation. Their findings indicate that building settlement decreases with an increase in foundation depth. They also demonstrate that the stresses at the foundation-soil interface are higher on the side of the building closer to the excavation. Furthermore, the finite element modeling accurately represents the realistic behavior of a building near an excavation. Aswathy et al. [2] study the effect of excavation on settlement of adjacent structures. They conclude that in sandy soil, the maximum surface settlement due to excavation typically amounts to about 0.2% of the excavation depth. The settlement pattern near the excavation site is influenced by the wall deflection shape; if the wall deflects deeply inward, the maximum displacement occurs at a distance from the wall. Beyond a distance equal to twice the excavation depth from the boundary, surface settlement becomes insignificant. Saptarshi et al. [3] conducted a study on ground settlement behind a braced excavation in soft clay. They conclude that surface settlement decreases significantly with depth. Deeper soil layers experience less deformation from ground movement. This settlement is mainly caused by consolidation and undrained deformation, with creep playing a minor role. The impact of undrained deformation is strongest near the excavation wall.

In engineering practice, shallow excavations are often carried out as unbraced sloped excavations. Executing an excavation in close proximity to existing buildings can significantly impact their stability.

Deformations resulting from the excavation can lead to damage to the structural elements of neighboring buildings. To avoid the aforementioned issues, it is necessary to assess the specific conditions under which unbraced sloped excavations can be safely performed in each individual case.

This study aims to quantify how excavation depth, building proximity, slope angle, and soil strength affect the settlement of adjacent buildings. The analyses focus on excavations in cohesive soil.

II. Materials and Method

This study employed the Mohr-Coulomb constitutive model within a 2D plane strain finite element analysis framework implemented in the GeoStudio 2024 software to idealize the problem and generate realistic predictions regarding the stability and deformations of the adjacent building. Geometry of the model is presented in Figure 1.

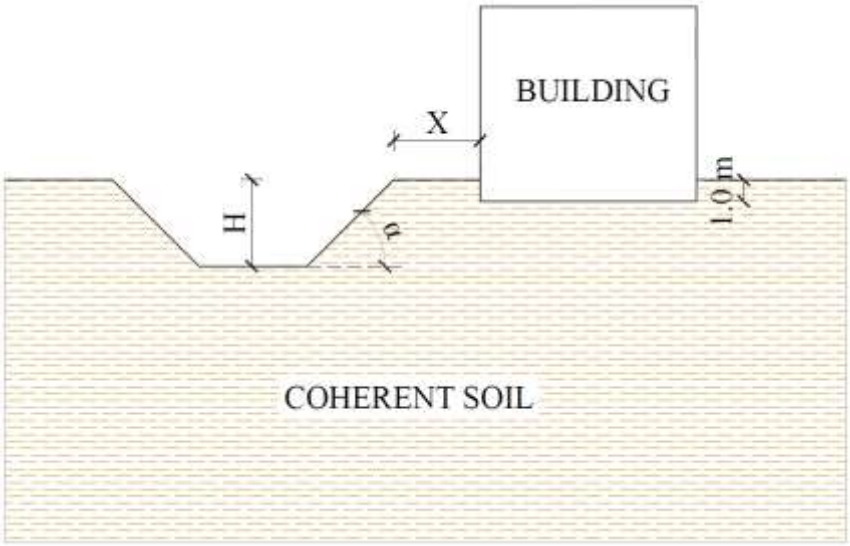

Fig. 1 Geometry of the model

Symbols used in Figure 1:

- H: excavation depth,
- X: distance between the existing building and the excavation edge
- A: excavation slope.

The analyses were conducted under the assumption of a foundation soil load of 45 kPa, corresponding to a three-story building. A total of 288 analyses were performed by varying the following parameters:

- H=2, 3, 4 and 5m
- X= 0, 1, 2, 3, 4 and 5m
- α = 1:2, 1:1, 2:1 and 3:1 (V:H)
- Soil parameters:
    - c_u=30kPa, Mv=4MPa (soft clay);
    - c_u=50kPa, Mv=6MPa (firm clay);
    - c_u=70kPa, Mv=8MPa (stiff clay) [4]

  (c_u is undrained cohesion, Mv is constrained modulus)

Other geotechnical parameters remained constant across all analyses:

- Unit weight: γ=20kN/m3,
- Poisson's ratio: υ=0.5,
- Friction angle: ϕ=0,
- Dilatancy angle: ψ=0.

All analyses assumed a groundwater level below the excavation base, eliminating its influence on the results.

III. RESULTS

Figures 2 and 3 present the analysis results for the case of c_u = 30 kPa and Mv = 4 MPa. Results for the excavation depth H = 5 m are not shown as the settlements in these cases were significantly larger (approximately 70 cm) compared to those for depths of 2, 3, and 4 m. Such displacements are presumed to lead to ground failure. The building settlements, denoted as "s_y" in Figures 2 and 3, range from 40 to 170 mm and increase with excavation depth. For depths of 2 and 3 m, X has no significant impact on building settlement, while for an excavation depth of 4 m, settlement decreases with increasing X. A trend of increasing settlement with increasing excavation slope can also be observed.

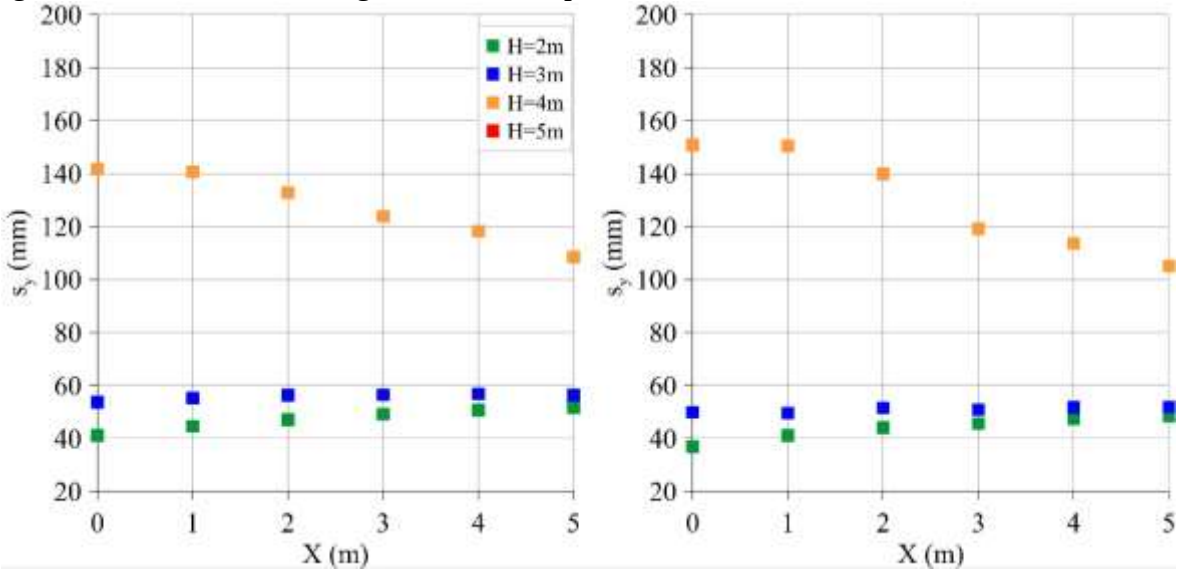

Fig. 2 Analysis results for excavation slopes of 1:2 (left) and 1:1 (right), considering a case with c_u = 30 kPa and Mv = 4 MPa.

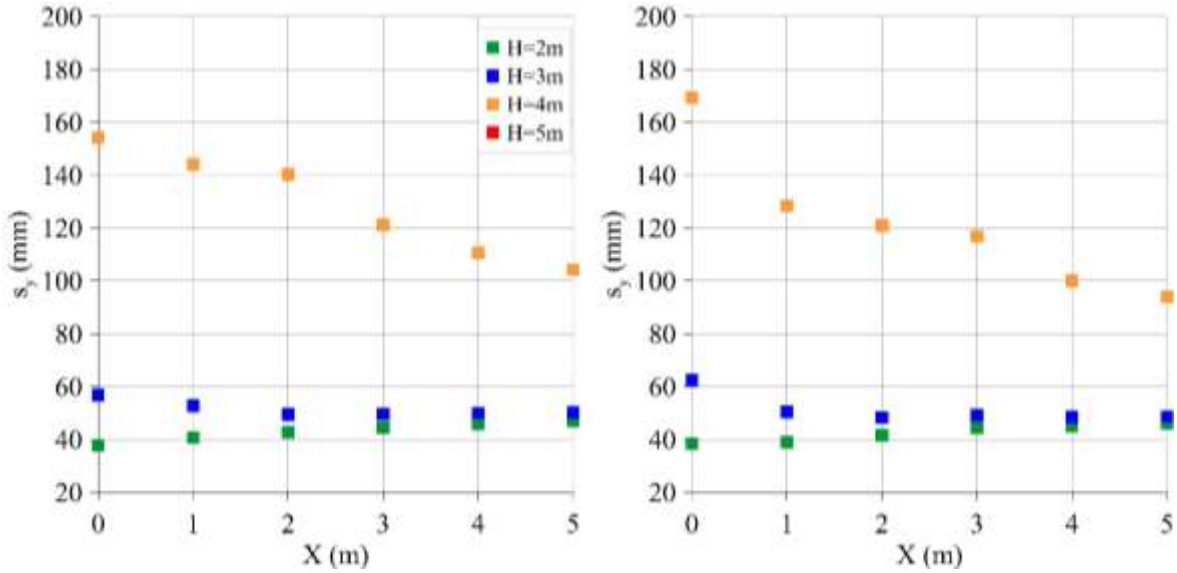

Fig. 3 Analysis results for excavation slopes of 2:1 (left) and 3:1 (right), considering a case with c_u = 30 kPa and Mv = 4 MPa.

Figures 4 and 5 present the analysis results for the case of c_u = 50 kPa and Mv = 6 MPa. As expected, due to the increased strength and compressibility parameters, settlements in this case are generally smaller than in the previous one, ranging from 25 to 100 mm. For excavation depths of 2, 3 and 4 m, X has no significant impact on settlement, while for the depth of 5 m settlement generally decreases with increasing X values. A trend of increasing settlement with increasing excavation slope is also clearly visible. This trend is

particularly evident in the cases of excavation slopes of 2:1 and 3:1 and excavation depth H=5m, which result in significantly larger settlements compared to the other considered depths.

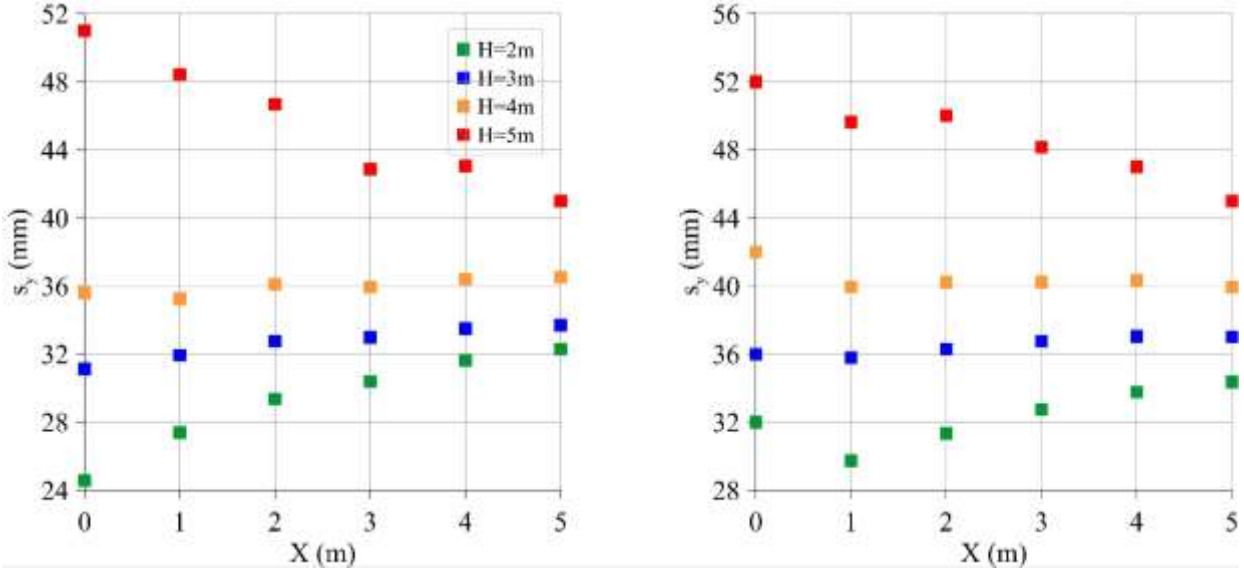

Fig. 4 Analysis results for excavation slopes of 1:2 (left) and 1:1 (right), considering a case with c_u = 50 kPa and Mv = 6 MPa.

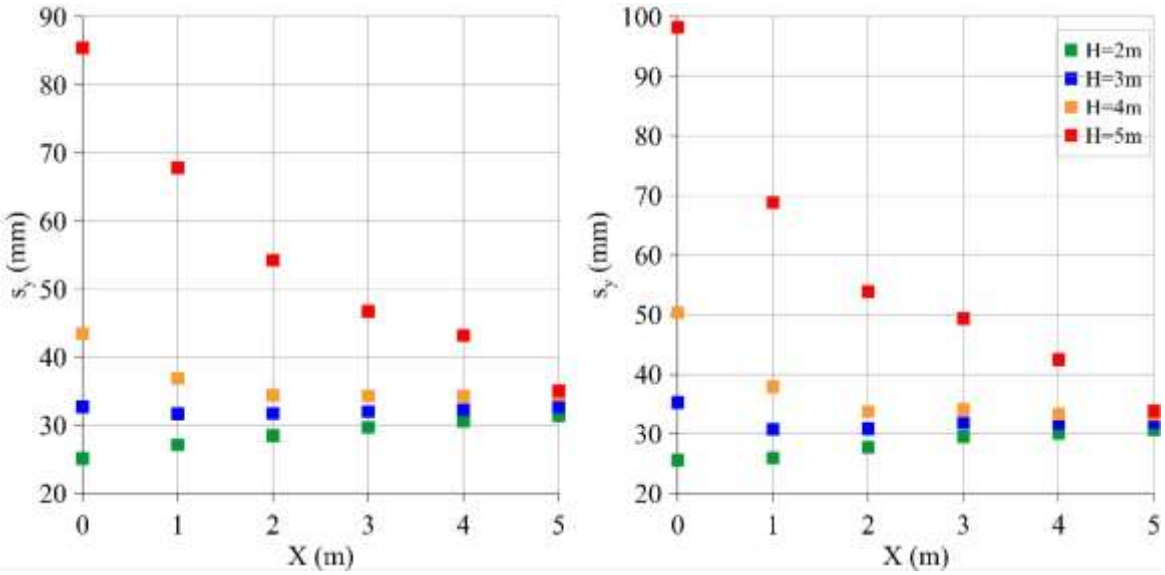

Fig. 5 Analysis results for excavation slopes of 2:1 (left) and 3:1 (right), considering a case with c_u = 50 kPa and Mv = 6 MPa.

Figures 6 and 7 present the analysis results for the case of c_u = 70 kPa and Mv = 8 MPa. Compared to the previous two cases, due to the increase in soil strength and compressibility parameters, settlements are expected to be smaller and range from 19 to 45 mm. The influence of X on settlement is significant for excavation depths of 4 and 5 meters, while it is negligible for excavation depths of 2 and 3 meters. With increasing excavation slope, settlement increases in all analysed cases. Similarly, this is also the case for the ratio of excavation depth to settlement. Due to the relatively large values of soil strength and compressibility parameters, the difference in settlement for the considered excavation depths and slopes is the smallest compared to the previous two cases.

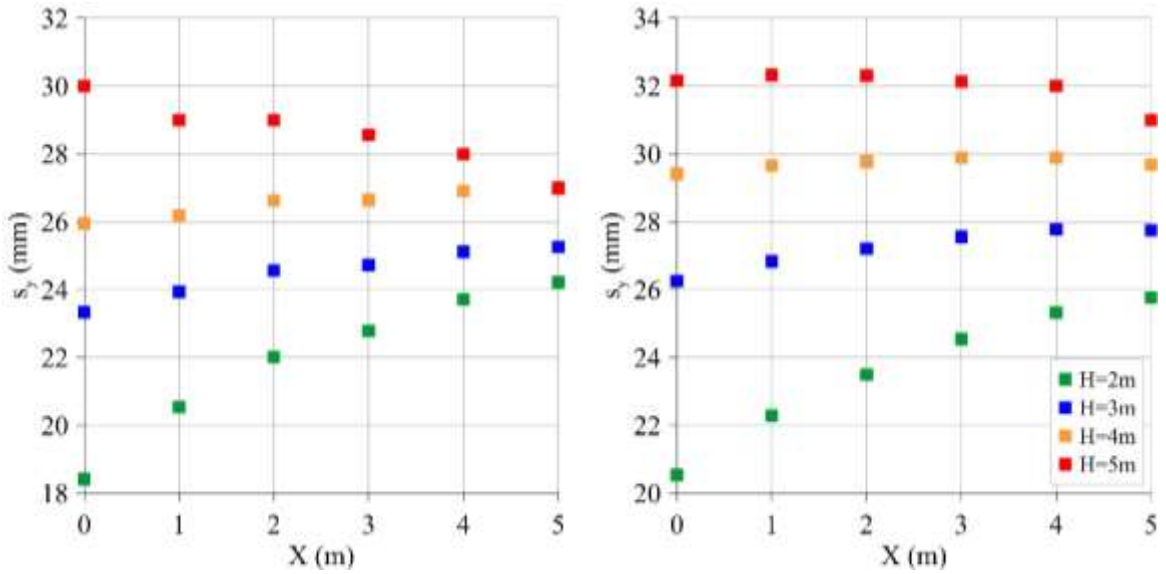

Fig. 6 Analysis results for excavation slopes of 1:2 (left) and 1:1 (right), considering a case with c_u = 70 kPa and Mv = 8 MPa.

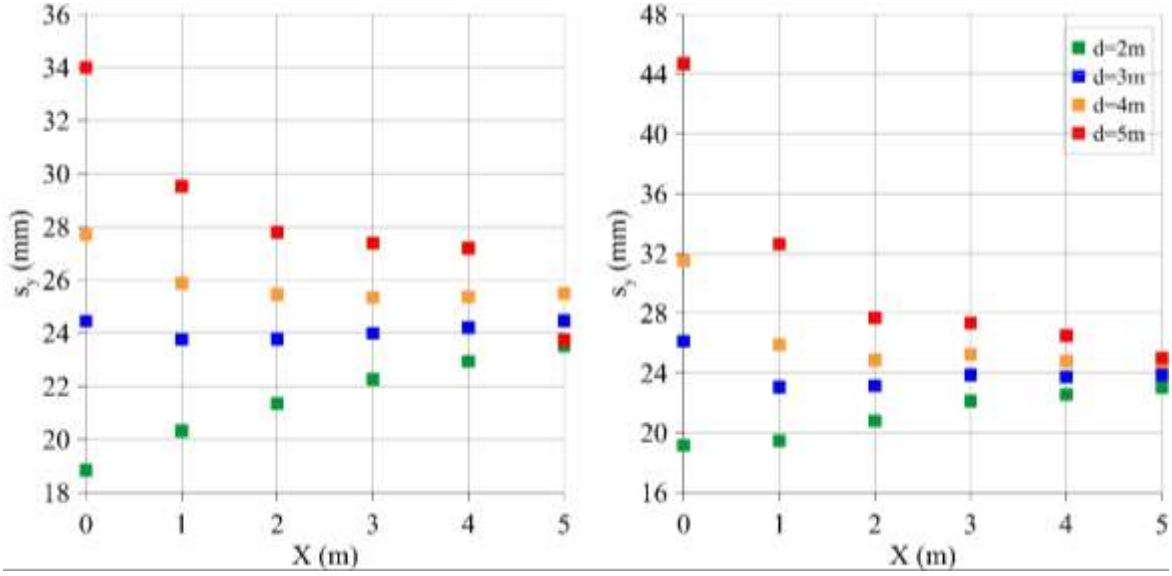

Fig. 7 Analysis results for excavation slopes of 2:1 (left) and 3:1 (right), considering a case with c_u = 70 kPa and Mv = 8 MPa.

On Figure 8, a summary of the multiparametric settlement analysis results for various combinations of soil geotechnical parameters is presented.

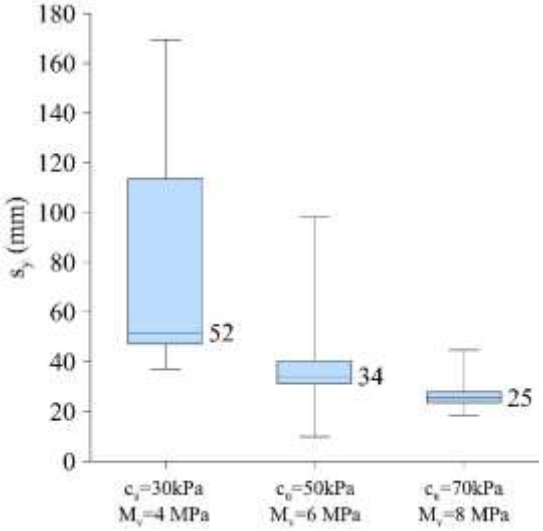

Fig. 8 Summary of multiparametric settlement analysis results for various combinations of soil geotechnical parameters.

The trend of decreasing settlement with increasing geotechnical parameters is evident from the Figure. 8. Median settlement values for c_u=30kPa, Mv=4MPa, za c_u=50kPa, Mv=6MPa, and c_u=70kPa, Mv=8MPa are 52mm, 34mm, and 25mm, respectively. The trend of decreasing range between minimum and maximum settlement values for the selected geotechnical parameter pairs with increasing soil strength and compressibility is also clearly visible.

IV. DISCUSSION

This paper presents the results of a multiparametric settlement analysis for an unbraced slope excavation near an existing building. The analysis varied the depth and inclination of the excavation, the distance of the building from the excavation edge, and the strength and compressibility parameters of the soil. The results show that for undrained cohesion of 70kPa and constrained modulus of 8MPa, the maximum settlements are relatively small and do not pose a significant risk of damage to the neighboring building due to the excavation, regardless of the slope inclination or excavation depth, as long as the distance between the building and the excavation edge exceeds 2 meters. With an undrained cohesion of 50 kPa and a constrained modulus of 6 MPa, settlements are relatively small only for excavation depths of up to 2 meters, regardless of the distance between the building and the excavation edge. For the lowest values of soil strength and compressibility parameters, regardless of slope inclination, excavation depth, and distance from the excavation edge to the building, settlements are more significant and may cause damage to the structural elements of the building.

Based on the presented results, it is generally advisable to execute slope excavation at the greatest practicable distance from existing structures. Regarding the excavation slope angle itself, for cohesive materials with poorer geotechnical properties, shallower slopes (1:1 and 1:2) are recommended. Conversely, for cohesive materials with better geotechnical properties, steeper slopes (2:1 or 3:1) could be considered.

Additional analyses of building settlement near the excavation are necessary. These analyses will involve considering the influence of soil type, groundwater level, foundation depth, and load intensity on building settlement.

V. CONCLUSION

A multiparametric analysis of unbraced sloped excavations in cohesive soils provided valuable insights into building settlements adjacent to excavation sites. The study identified excavation depth, slope angle, soil strength, and building proximity as significant factors influencing settlement:

- Excavation Depth: Greater depths consistently led to increased settlement. Depths exceeding 2 meters resulted in significant settlements, especially when the excavation is conducted within 2 meters of an existing building.
- Slope Angle: Steeper excavation slopes result in greater settlement. While shallower slopes (1:2 and 1:1) are more stable for soils with lower strength parameters, steeper slopes (2:1 and 3:1) can be considered for soils with higher strength and compressibility.
- Soil Strength and Compressibility: Soils with higher undrained cohesion and constrained modulus showed reduced settlement, emphasizing the importance of understanding soil properties in planning excavations.
- Building Proximity: The distance between the excavation edge and the building significantly influences settlement, especially for deeper excavations. To ensure safe excavation practices, maintaining a minimum distance of 2 meters between the excavation and existing buildings is recommended.

This study demonstrates that unbraced sloped excavations near existing buildings can be conducted safely with careful consideration of excavation depth, slope angle, and soil properties. These findings are particularly relevant for urban excavation projects where limited space and the preservation of existing structures are key concerns.

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International Law for Afghanistan

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Abstract – Although Afghanistan's long conflict has entered a new and maybe last phase, the country's disintegration forces are still quite strong. The United States can affect whether this chance is seized. Four decades of war could be ended well with a personally accountable and cogent set of U.S. actions; on the other hand, a hasty and reckless approach could increase the likelihood of an Afghan breakdown and an increasingly dire war, with dire consequences for the region and ever-increasing threats to U.S. interests and allies. In December, the Afghanistan Study Group was established. Congress requested that the "Afghanistan Peace Process Study Group" "examine the implications of a peace agreement or the failure to reach a consensus on U.S. policy, resources, and responsibilities in Afghanistan" Most Americans want ending the war right away. Twenty years have passed. Instead of fighting, they should mediate peace. These are crucial factors to take into account for our approach in Afghanistan. The Study Group convened at the outset of Afghanistan's peace process. As the United States and the Taliban worked out the details of a troop departure in February 2020, the Group's makeup was still unknown. The Study Group convened while Afghanistan attempted to settle the presidential contest and designate a dialogue team for April. Following the initial gathering in September, the sixth plenary took place. Afghanistan peace negotiations may result in a new tactic. The Study Group thinks it will be hard or impossible to provide these conditions by May 2021, when the treaty calls for a military withdrawal. The first step toward a negotiated, long-term peace that serves American interests is a deadline extension. This essay suggests the US get out of Afghanistan in order to promote peace. The United States has exerted considerable effort to get the parties together for discussions.

Keywords – Afghanistan, International Law, Policy, Strategy, Diplomacy, Conflict

I. INTRODUCTION

Afghanistan has benefited from international law in bridge trade, member status in international groups, peace agreements, and war. The Afghan government has entered into trade agreements and conformed to international conventions to facilitate cross-border commercial transactions and attract foreign investment. Afghanistan has a ballot in the United Nations General Assembly, where big-world policies are decided. Since Afghanistan's independence, peace keeping treaties and norms have prevented foreign occupation. Afghanistan is a war-torn country. International law justified the presence of global security forces in Afghanistan, and violators faced sanctions and trials. International law covers a wide range of topics. This book will analyze international law's most important subareas and start debating their components and applications in Afghanistan to define and introduce them. Our nonviolent offender and commercial law publications start debating legal guidelines and procedures destined to govern individual behavior in Afghanistan, putting this topic in context. Introduction to Law is a general introduction to national law(Qazi Zada, 2021b). In this series, we'll examine Afghanistan's exchanges and communications for the first time. You can start learning international trade and criminal law here. Any legal area likely has national and international elements. After trying to distinguish "international" law

from most of the "domestic" law you've researched, we can move on to the central bifurcation in global humanitarian law: public vs. private international law. This publication focuses on public international law, which governs nation-to-nation relations. Afghanistan and the U.S. enact public international law(De Lima & Rezende Veloso, 2021). Public international law is in effect when two or more nations agree to share common responsibilities, such as in a nuclear treaty. Private international law is international law's other face. Most international lawyers represent clients with cross-border concerns, assertions, or needs.

A lawyer could represent an Afghan business with customers in Pakistan, Tajikistan, and Uzbekistan. How will the client deal with foreign buyers? A lawyer implicated in a general sector shipment deals with megacorporations, producers, shops, and distributors, not Pakistani, Tajik, or Uzbek government agencies(Amini & Arifani, 2021). Private international law is complex and time-consuming when a dispute involves parties from different countries. If a company ships its product to Pakistan but the winning bidder there doesn't pay the full amount, the company may take recourse to legal action to compel payment. Can it sue under Afghan or Pakistani law, or is it restricted by an international agreement with which all three nations have consented and to which the company, as an individual actor, is obligated? Therefore, contract details and the selection of law provisions ascertain private international law(Kouvo, 2021). Domestic and international law principles will determine the specifics of each case. This book focuses on public international law because (a) it is generally bothered to research before actual private international law (though not always), and (b) public and private international law have become so broad that each deserves its volume. According to the book's main point, nation-states are the main players in international law. Comparable to private actors in domestic court actions, the nation, represented by a lawyer or group of lawyers from a government subsidiary or ministry, can file and defend against complaints(Jupp, 2022). The national and international court system, arbitral proceedings, tribunals, and intergovernmental organizations can hear claims. Able to participate, lawyers and countries must follow each international court's rules, processes, pomp, and circumstance. This topic has many similarities to domestic law. There are differences, though. Most disputing parties are independent states(De Lima & Rezende Veloso, 2021).

1.1.1. Theories in International Law

A good understanding of the conceptual approaches academics use in their research aids the study of modern international law. With the assistance of the following theories, you can organize your time regarding international law and the ways it can be applied:

- **Natural Law / Fundamental Rights:** This school of thought regards international law as a set of fundamental freedoms, just as if a nation were a human being. According to this school of thought, there is a corrected, natural condition in which states share information in a manner that safeguards fundamental liberties. The rights description includes personal autonomy, inclusivity between many nations, regard between many states, and conversation with others(Dill, 2019).
- **Positivism:** The positivist approach is a theory based on mutual agreement. According to this viewpoint, nations have unanimously agreed on a set of rules known as "international law." As a result, unless the government legislature approves, a principle is not law, and a nation is not obligated to adhere to it. There are several ways to express approval, such as signing a peace treaty or joining an international organization. Countries could also give their implicit approval by adhering to social processes and rules. Theories posit that all governments are treated equally and should be bound only by the laws they enact(Kouvo, 2021).
- **Law and Economics:** This hypothesis examines the legal framework through the lens of rational economic decision-making. The sovereign must weigh numerous potential scenarios, each with its costs and benefits. A rational state considers possible future outcomes and consequences when optimizing its resources. International law sociologists who use economic frameworks (such as behavioral finance and the detainees' dilemma) try to demonstrate why states agree to and follow international law. Environmental law (via mechanisms such as cap-and-trade legal standards on

environmental damage) and trade regulations are two obvious zones where this has received great attention(Rahim, 2018).

1.1.1.1. International Relations Theories

Conciliatory specialists in international laws and politics use a range of theoretical architectures to explain sovereign states' actions. Realists argue that there is no worldwide cop on the rhythm to keep the provinces in line. States must highlight their interests when keeping peace and broadening their power. If a state can benefit from following international law, it will comply voluntarily. Nevertheless, when doing so would help stop a state from pursuing its interests, it will refuse to comply(Hashimy et al., 2022). According to the liberal approach to international relations, states portray the combined amount of the value systems of the actual persons within the state. To comprehend when and why a head of state will be using or complying with international law, one must first comprehend the troubled relationship between domestic politics and residential regulation, which liberals regard as the most significant and influential motorists of state action. Finally, constructivists make logical sense of governmental policy through experience. Constructivist theories investigate the interaction of legislation and social rules and start practicing to provide a clear roadmap of international treaties that opposes the idea that jurisdictions are fully logical actors with well-defined goals(Qazi Zada, 2021a).

However, there is agreement on at least one central concept: international law. The realization that nations, persons, and organizations tend to comply with these pre-defined global standards and regulations, although to differing extents and with highly variable applications and legal instruments, illustrates the presence and functionality of the global legal system(Qazi Zada, 2021b).

1.2. International law and armed non-state actors in Afghanistan

1.2.1. Applicable international humanitarian law

Researchers have shown that the rules regulating non-international armed conflicts may be traced back to the war in Afghanistan. The current military conflict in Afghanistan may be traced back to at least three distinct phases of the disagreement that began in 2001. Since the battle between the Taliban government and the Northern Alliance before the American-led invasion of Afghanistan in October 2001 was primarily an internal conflict rather than a global one, it falls under the first stage. The war started its second phase as an international armed conflict on October 6, 2001, when the United States and its allies initiated military operations against the Taliban (Scholdan, 2018). It is not relevant whether the measures conducted against Al Qaeda during that disagreement might be deemed part of this international armed conflict or constituted another non-international armed war. The continuing invasion of Afghanistan by the United States and other countries represents the third phase. This conflict may qualify as an international armed conflict under Article 2 of the Four Geneva Conventions (Common Article 2). When this invasion ended, it was legally murky. Subsequent wars in Afghanistan always reached a level of violence that qualified them as a state-sponsored armed conflict (Bellal et al., 2011). Conventions, and the Protocol Additional to the Geneva Conventions of 12 August 1949, dealing with the protection of Victims of Non-International Armed Conflicts, are the two sets of treaty regulations commonly applicable to such conflicts (Additional Protocol II). Afghanistan ratified the four Geneva Conventions in 1956, and the two Additional Protocols were ratified in June and December 2009, respectively, with the second coming into effect on December 24, 2009. In this part, we examine whether Common Article 3 and Additional Protocol II are relevant to the current situation in Afghanistan. An independent but related issue is how all ANSAs involved in the dispute may fairly comply with this hodgepodge of rules (Bijlert, 2022).

1.2.2. Armed non-state actors in Afghanistan

Commentators disagree on Afghanistan's ANSA number, makeup, and connections. In the early 1990s, the Soviet withdrawal from Afghanistan sparked conflict in northern Pakistan, which gave rise to the Taliban. They quickly expanded their hegemony from southwestern Afghanistan to the entire country. After taking control in September 1996, they took 90% of Afghanistan by 1998. (when they seized Kabul). Before 2001, only three countries—Pakistan, Saudi Arabia, and the United Arab Emirates

(UAE)—officially recognized the Taliban as Afghanistan's government. They were the only ones to do so. 8 A government chosen by the people in 2002 is now being opposed by a rebellion that has been going on for some time. The United Nations Assistance Mission in Afghanistan-UNAMA refers to a broad range of groups and individuals who are fighting in Afghanistan as an "insurgency," including the Taliban, the Haqqani network, and al-Qaeda (Korishetti, 2022)." The US estimates that 25,000 troops surround Hezb-e-Islami in Afghanistan. "This number is disputed.

Source: (*The Rise of Non-State Actors in Yemen | Middle East Institute*, 2022)

The Taliban' started deploying increasingly brazen threats in urban areas' in 2009, and by 2010 they controlled wide chunks of the government's east and south as well as remote territories of the west and north. It is a commonly held belief that Mullah Omar, the local cleric who was instrumental in the formation of the Taliban and who continues to serve as its head, currently has full control over the Taliban in Afghanistan. In 2010, there were less than fifty fighters affiliated with Al Qaeda in Afghanistan (Malejacq & Sandor, 2020). At best, there is a lack of clarity about the nature of the relationship between Al Qaeda and the Taliban in Afghanistan. As a direct consequence of the fighting, an enormous amount of suffering has been inflicted on the civilian people of Afghanistan. They have been taught that armed organizations not part of a state are to blame for their situation and that these organizations are accountable for their suffering. Amnesty International has accused several Afghan rebel organizations, including the Taliban, of "demonstrating scant respect for human rights and the rules of war" by targeting and killing civilians, rescue workers, and civilian structures like schools (particularly girls' schools). These accusations have been leveled against the Taliban and other Afghan rebel organizations. (Koehnlein & Koren, 2022).

1.2.3. Implementation of applicable norms in Afghanistan by armed non-state actors

The task of guaranteeing that Afghanistan's numerous ANSAs fully implement the best answer is enormous and pressing. Indeed, UNAMA stated in its mid-year document on civilian safeguard in armed conflict in 2010 that the number of civilians killed in Afghanistan is increasing. Now, nine years into the conflict, it is more important than ever to protect Afghan civilians and ameliorate the conflict's impact on basic human rights(Stepanova, 2020).

In light of these sad facts, we recommend several specific and general proposals in the remainder of this article that we believe would help improve ANSAs' reverence for appropriate standards. These genuine, political, and presentational steps will impact many individuals, not just ANSAs. To begin, both customary and treaty law are covered by international humanitarian law, which provides a broad foundation of safeguard for civilians caught up in armed conflict. However, questions about which regulations of global humanitarian law apply in a conflict that isn't governed by an international treaty remain unanswered, both usually and about the situation and actors in Afghanistan. This undermines the effectiveness of any intended safeguards and necessitates an explanation(Thomas, 2019b). According to the findings of this research, the application of Additional Protocol II to the various parties involved in the conflict in Afghanistan is, at best, unclear. Before the Taliban is convinced to abide by the terms of

the Protocol, there must first be a public declaration of intent to do so by the Afghan government and all foreign forces serving with ISAF. It is possible that this and any other pertinent customary standards may be included in "special agreements" between the Afghan government, ISAF, and the Taliban. These agreements will be subject to inspection inside Afghanistan and outside the country (Meier, 2021). In a statement that was published on the Taliban's website in August 2010 and which seemed to be a response to the most recent report on innocent victims in armed conflict published by the United Nations, the Taliban proposed the establishment of a joint committee to study the potential for civilian casualties in Afghanistan. Members of the Organization of the Islamic Conference, those who study human rights at the United Nations, members of the North Atlantic Treaty Organization, and members of the Taliban were all included in the statement as potential participants in the proposed body. Responding positively to the Taliban's proposal, depending on how seriously one takes it, would either advance the cause of trying to promote non - combatant protections or call the Taliban's bluff(Laborie, 2017).

Second, humanistic and civilian safeguards issues should be addressed in ongoing discussions with the Taliban and other ANSAs about potential paths to peace. Amongst other things, the parties should have an extensive discussion (and, if at all feasible, a contract) concerning who qualifies as a government employee and, as a result, how the Process and other relevant laws should be applied to the dispute. If at all possible, a contract should be reached. Third, the Taliban can present themselves in a manner that demonstrates they respect international humanitarian law (Korishetti, 2022). This law governs the conduct of hostilities concerning specific means and methods of warfare, and the Taliban can demonstrate that they respect this law. The United Nations Assistance Mission in Afghanistan-UNAMA has requested that the Taliban abandon their favored strategy of using improvised explosive devices-IEDs. As stated by UNAMA, "AGEs-Anti-Government Elements predominantly targeted military targets employing... IEDs" when carrying out these operations, therefore adhering to the principle of distinction. The strategy appears to have significantly affected the government and, more particularly, international military forces (Amini & Arifani, 2021).

Suicide bombings have been widely used in the Afghan conflict, which also helps bring us all to our fourth point. Any targeting of civilians, whether on particular individuals or innocent people as a whole, is a war crime. Whether these threats are directed at specific targets or not, problems of equality, deceitfulness and indiscriminate attacks persist. Mullah Omar issued a new edition of the Taliban's "Code of Conduct" in 2009, discussing attack reasonableness and precaution (Rahmad, 2019). Expressing the group's dedication to itself through codes and standards increases ownership of the standards. It motivates respect, implying that ANSAs' guidelines for conduct may enable communication for the respect of international treaties. Innately, such a commitment must adhere to fundamental humanitarian principles. Some rules in the Taliban's self-created Code of Conduct contradict international standards. Nonetheless, it appears to be a good point of departure for talks likely to lead to a peace treaty to reduce the number of bomb attacks. UNAMA, for example, has repeatedly referred to its regulations and prompted the Taliban to adhere to them(Mena & Hilhorst, 2021).

Fifth, researchers believe it is high time for people to stop vehemently rejecting the applicability of human rights law to ANSAs and start acknowledging that the world has changed and that many different types of non-state actors may be subject to a wide range of international human rights law obligations. We think it is high time for people to stop adamantly rejecting the applicability of human rights law to ANSAs because it is high time. The need to provide citizens with constitutionally-guaranteed protections against the government was the original impetus behind developing human rights law (Ide, 2021). In 2019, assuming that Kabul has a democratically elected government and its residents do not require legal protection from non-state armed groups, the question becomes whether or not this concept can be taken seriously. As a result, the Taliban should be acknowledged as an entity subject to various legal commitments consistent with international humanitarian law, particularly in regions under the Taliban's control and administration. These responsibilities must be clarified more explicitly (Islam et al., 2022).

1.3. Non-international armed Conflicts in Afghanistan

1.3.1. Communist Rule and Soviet Occupation (1979 – 1992)

Mohammad Daoud Khan overthrew Zahir Shah in 1973. 2 Late in the 1970s, Daoud's reforms faltered. With the Soviet Union's help, national communist parties have grown in response to Daoud's rule. Nur Mohammad Taraki's 1978 communist military takeover killed Daoud and his family. Taraki and his heir apparent Hafizullah Amin repressed and violently imposed their communist policy changes on the population. Many educated Afghans, landowners, and religious leaders left the country because of the regime's violence(Hashimy et al., 2022). This viciousness prompted a protest movement among Islamic groups known as the mujahadeen in 1979. Amin, a rival Communist, deposed Taraki in October 1979. The Soviet Union invaded Afghanistan in late December 1979. As the protests increased, the Soviets sent the army to end them. Most Afghan cities remained under government and Soviet control, while mujahadeen fought a guerrilla war in the hinterlands. Whereas the conflict was intense in rural areas, Kabul was spared(De Lima & Rezende Veloso, 2021).

Soviet and government forces decided to commit genocide in their attempts to massacre or capture mujahadeen rebel fighters and drive civilians out of cities and towns. Bombing civilian areas, planting mines to interrupt pressure supply routes, and banditry in villages suspected of concealing mujahadeen were standard methods. Many "collaborators" were detained, tortured, and disappeared(Zhang et al., 2019).

Many people fled to refugee camps or cities near the Iran and Pakistan borders. Despite economic and other opportunities, refugees' lives were difficult. Pakistani women's movement rights and expression were more restricted than Afghan women's. Due to a lack of health coverage, schooling, and economic opportunities, most refugees lived in abject poverty. A survey found that two-thirds of Quetta's refugee children were underweight(Gibbs et al., 2018).

Source: (*A Communist History of Afghanistan | Research News, The Indian Express*, 2022)

In March 1992, Najibullah resigned from the interim government. This ended up causing earlier loyal militia groups to become abnormal and prompted revolts led by northern Uzbek and Tajik commanders associated with mujahadeen commander Ahmad Shah Massoud of Burhanuddin Rabbani's Islamic Society. Najibullah's government fell in April 1992(Khakimova & Khaliov, 2020).

1.3.2. Civil War (1992 – 1996)

With the fluctuating backing of key mujahadeen organizations, a power structure for the executive branch that was indecisive was agreed upon. Sibghatullah Mojadeddi, the commander in charge of the Afghan National Liberation Side, served as the representative for the first term. In contrast, Rabbani was slated to serve as the representative for the second term. The new Islamic authority established Sharia rule, which included stringent restrictions on women, even though it had little control over the nation and a small fraction of the city proper. Gulbuddin Hekmatyar's Hezbe-Islami faction, which refused to form a partnership with the new administration, fired missiles at even ostensibly government-controlled areas of Kabul. Rabbani consented to step aside in December 1992 but changed his mind. Formerly government-

aligned Mujahadeen factions revolted, and any cooperation among military leaders crumbled as open civil war erupted. The country devolved into chaos(Amini & Arifani, 2021).

It's also hard to determine how many Afghans were locked up during this time. However, an Amnesty International report published in 1995 claims that "thousands" of individuals were taken hostage and never seen or heard from again. The kidnapping of women, sexual assault on women, and the practice of forcing women into married couples increased dramatically. To further torment and murder civilian populations and as a method to "reward" combatants, it seems that militia commanders have sanctioned the rape of women and girls as a war strategy. Girls were frequently denied the right to attend school, and women were denied the right to work outside the house in mujahideen-controlled areas. Out of fear of sexual violence or "dishonor" at the fingers of the mujahadeen, many family members in conflict areas "shielded" their daughters by maintaining them out of school and into early marriage. The Taliban started hiring boys as young as twelve to fight for barbarian warrior groups(Hashimy et al., 2022).

Source: (*The Judiciary and the Rule of Law in Afghanistan*, 2022)

1.3.3. Taliban Rule (1996 – 2001)

The Taliban imposed strict rules predicated on their revolutionary interpretation of Islam and shariah law. Girls' education was restricted. Women were not allowed to work and were considered necessary to have a male prostitute and wear a full burqa. Numerous tens of thousands of war widows were still subjected to harsh laws, and many had to rely on international aid or beg. Women in Kabul have reported an 81% reduction in the prevalence of mental illness, with 42% meeting the criteria for PTSD and 21% having suicidal ideation "fairly frequently" or "so often." The violence and sexist norms were not limited to women and girls but also affected boys and men. Men wore beards and shalwar kameez. Thousands of men were victims of coercion, physical violence, and sex crimes, and many were brutalized(Floreani et al., 2021).

Basic amenities were lacking. Kabul's half-million women report diminished access to health services. The town's only hospital is barebones. As women held teaching positions, boys legally allowed to attend school had fewer opportunities(Shahed, 2018).

Source: (*"No Smoking, No Shaving": Taliban Restore Old Rules in Newly Seized Afghan Territory - World - DAWN.COM*, 2022)

Many escaped prisoners were brought back to Afghanistan, hoping for stability under the new government. Initial returnees quickly dwindled. Even though the civil war had ended, new forms of violence, tyranny, and abuse emerged, and refugees continued to flee to Pakistan, Iran, and other European nations. In September 2001, approximately 1.9 million Afghans lived in Pakistan and 1.5 million in Iran (Ishchenko, 2021).

1.4. International dimensions of internal conflict

On October 7, 2001, the United States led an international coalition in an attack against the Taliban government. After September 11, 2001, the United States and its allies invaded Afghanistan to remove that country as a haven for terrorists. Human rights violations committed by the Taliban, particularly their treatment of women, bolstered international support for the war. Since the United States took no significant military action, most of the Taliban distributed or escaped to Pakistan. The Taliban insurgency was aided by special operations combat forces and airstrikes(Wikipedia, 2021). There were few major ground battles between the US and the Taliban, especially in the north. The Taliban suffered a serious setback with the loss of Mazar-e-Sharif. By the end of November 2001, the United States and its allies had gained control of Kabul, and the Taliban had abandoned Kandahar. As of May 2003, all US combat operations were over. The United Nations and other Afghan groups met for a conference held in Bonn, Germany, in November 2001. The Bonn Agreement installed Hamid Karzai as interim leader and allowed transnational corporations to exert pressure on the Afghan government to keep the peace in Kabul. Afghanistan ranks among the world's poorest nations. Forty percent of the population may be unemployed or underemployed, and nearly half of the children live in poverty due to chronic malnutrition(Rutherford & Saleh, 2019).

1.4.1. Recommendations

A lack of war, protection of fundamental freedoms, poverty alleviation, creating of accountable and transparent government institutions, and providing essential services and goods, such as education and healthcare, were all cited as preferred by those polled. Addressing poverty and corruption, the root causes of the recent war is crucial for restoring peace. When asked to reduce tension, individuals were eager to share ideas(Samay, 2020). Interviewees suggested the following actions to address the conflict in the middle east underlying causes and protect civilians:

To the Afghan Government

- Take meaningful action to enforce the law at all levels, crack down on graft and eliminate impunity and patronage.
- Investigate specific incidents to fight for justice, affirmation, unification, and redress for wartime wrongdoings.

To the International Community

- Donate more money to relief, rebuilding, and development projects around the nation, and do it effectively.
- Ensure to give more assistance for charitable, rebuilding, and development efforts throughout the country, and do so efficiently.
- Ensure to give more assistance for charitable, rebuilding, and development efforts throughout the country, and do so efficiently.
- The Afghan legislature must be responsible and give more funds to fight criminality and corruption.
- Support local multi-stakeholder partnerships and conflict resolution initiatives led by the public spotlight, and strongly urge the Afghan government to pursue justice, affirmation, reconciliation, and reparation for mistreatment resulting from the war over the past three decades.
- Support local multi-stakeholder partnerships and conflict resolution initiatives led by the public sphere, and pray for the Afghan government to seek justice, affirmation, reconciliation, and reparation for violations resulting from the war over the past three decades.
- A geographic peace process encompassing all regional powers should be formed to end the interference problem in Afghanistan's matters and to offer serious support for the government's safety and economic development.

To Pro-Government Forces

- Increase civilian protection efforts by trying to limit the use of power.
- Sustain a sense of respect toward Afghanistan's rich cultural heritage.
- Create strong, responsive, and inclusive redress processes, and guarantee that all allegations of civilian harm are explored promptly and transparently.

To Anti-Government Elements

- Stop immediately attacking civilians and hiding out in densely populated areas; instead of resorting to violence.
- Voice your frustrations and demands through democratic channels.

(Mulholland, 2022)

1.5. Afghanistan and the International community

In December 2011, the international community pledged to "stay on course" in Afghanistan. The centre government and the security equipment are too weak to fight insurgents without global and U.S. involvement. A try to negotiate a workaround with the Taliban requires international involvement. Afghan security services and financial systems completely depend on international aid and have to spend, making its continuation essential. The international community and the U.S. have short, medium, and long-term limits in Afghanistan. This paper will assess these constraints with a focus on three areas: domestic pressures on short- and long-term techniques forward into Afghanistan; (ii) the Strategic Partnership Agreement-SPA between the United States and the Afghan government; and (iii) efforts to settle with the Taliban. The first of these three areas are domestic pressures on short- and long-term techniques forward into Afghanistan (Fluri, 2019).

1.5.1. Domestic Pressure & International Engagement

The global community has promised to keep propping up Afghanistan further than in 2014. Still, the financial downturn and Western condemnation of the war make it highly unlikely that any of these promises will be kept. Survey results published in The New York Times show that most respondents favor withdrawing American troops from Afghanistan (Visentini, 2021). The US and its coalition partners view the Afghanistan war as failing. Such polls may not sway the US decision to keep a residual force in Afghanistan after 2014, but they could affect the country's long-term aid. Public pressure at home influences how American allies perceive Afghanistan more than the conditions on the ground. Nicolas Sarkozy, up for reelection in 2013, bowed to public pressure and brought French troops home from Afghanistan 2013(Peers, 2018).

Domestic pressure may also affect global participation. Instead of funding a corrupt and inefficient government, Western governments are under pressure to boost their economies. Sir William Patey, the outgoing UK Ambassador to Afghanistan, said it would be hard for the UK to justify its yearly assistance to Afghanistan if the Afghan administration did not tackle corruption(Bazan, 2021).

What's NATO's budget? These revisions cut the Afghan security service by two-thirds. The US and its allies will only be capable of paying USD 4.1 billion annually after 2014, down from USD 11.2 billion in 2012. NATO may reduce the number of Afghan troops from 352,000 to 230,000 by 2014. This likely means fewer Afghan National Security Forces. It's ambiguous how this total amount will be divvied among coalition members, particularly since some are less willing to contribute beyond 2014(O'Leary et al., 2018).

1.5.2. Long-Term American Presence

SPA is part of the U.S. long-term strategic approach in Afghanistan. Many important subtleties are unresolved or outside the agreement's scope. The SPA says the US can't commit to Afghanistan and will continue financial help beyond 2014. The aid amount is unknown. Also, SPA negotiations won't cover how the US military will function after 2014. The United States views maintaining a residual presence in Afghanistan as necessary to prevent al Qaeda and other terrorist organizations from using the nation as a haven and to maintain a command post in the region to increase American influence in Central Asia and compete with Russia and China. The negotiation process had significant drawbacks that could weaken the American presence in Afghanistan (Samay, 2020).

The United States' long history of success is not worth the risk of visiting the country. The U.S. attempts to resume peace negotiations with the Taliban, who have suspended them, might be harmed in many ways. The Taliban want all foreign armed units to leave the country, contrary to the SPA and U.S. Now the U.S. must start figuring out how to preserve its protection interests in Afghanistan without ending the Taliban's peace hopes. Combining them seems unlikely(Swed, 2021).

Second, geographic actors — particularly Iran, are worried. The U.S. presence in Afghanistan threatens Tehran's security. This view will likely grow since the US stays in Afghanistan beyond 2014. Iran has opposed the deal, and reports indicate strained relations with Kabul. Iran could increase unstable covert actions, including limited support for the Taliban, to stymie American war efforts(Awotona, 2019).

1.5.3. Talking to the Taliban

The United States was instrumental in getting the rebels to the table and negotiating a peace agreement with them, despite Hamid Karzai's misgivings. Anti-American sentiment has risen in Afghanistan in the wake of the Kandahar slaughter, the Quran burning, and the video showing U.S. troops ejaculating on dead Afghans. Under these circumstances, Mullah Omar's Quetta Shura halted peace talks. Changed circumstances make it harder to restart peace talks and reach a deal with the Taliban. The last several events have made Afghan foreign troops and consultants more vulnerable to attack(Peerwani, 2017). Because of anti-American sentiment, Afghan National Security Force representatives have attacked their

foreign counterparts more. Whether these incidents are Taliban penetration or spontaneous, they make it harder for the US conventional forces to confront the Taliban. This would make it harder for the US to exert military pressure on the insurgents and enhance its negotiating leverage, both of which are needed to convince the Taliban to accept the US's terms. The Taliban's return to US talks seems unlikely. The present situation has likely empowered Quetta Shura hardliners who have always opposed talking to the U.S. Recent events to support their lengthy claim that the US taunts Islam and Afghans(Amini & Arifani, 2021). Mullah Omar may want to appease hardliners to prevent an internal struggle. Mullah Omar should worry about more than internal fighting. If so, he wouldn't have agreed to peace talks. His assessment of negotiating terms with the Americans demonstrates that he is reasonable in his political estimations, which would lead him to consider the country's current conditions. Afghanistan's significant political factions pay consideration to public opinion to win voters. Hamid Karzai has been firm during SPA bargaining to protect Afghan sovereignty. Gulbuddin Hekmatyar's Hizb-e-Islami also canceled peace talks. If only the Taliban restarted negotiations, their legitimacy would suffer(Floreani et al., 2021).

1.6. International Conferences

The organization Welthungerhilfe, which assists 95 percent of Afghanistan's malnourished population, has warned that the upcoming international donor conference will only worsen Afghanistan's already precarious situation with hunger. Seven out of every ten different households are constantly having financial difficulties. Extreme poverty compels families to engage in behaviors such as delaying or skipping meals, forgoing medical care, and employing children younger and younger to survive. A cataclysmic crisis is on the verge of breaking out as a direct result of the rising cost of fuel and food caused by the Ukraine conflict (Welthungerhilfe, 2022).

Afghanistan is seeing a severe decline in quality of life. By preventing the flow of foreign cash, sanctions are having a severe impact on the economy. As a result of the record price hikes, farmers will continue to fall farther behind their competition because they cannot afford to purchase new seeds or fertilizer. In particular, young people with higher levels of education are emigrating in huge numbers from the country. Our position is dire: It is another indication that the present government does not place high importance on women's rights and that they have allowed male-dominated secondary schools to reopen for female students. That does not meet our standards in any way. If a group is going to work together, women must have a voice in the decisions. We are putting the future of an entire generation in jeopardy because they cannot get enough nutrition and quality education, and the whole population is struggling with hunger and poverty. Thomas ten Boer, the country director for Welthungerhilfe in Kabul, is certain that "we cannot commit a whole generation to starvation." The people of Afghanistan cannot be held hostage by their government, and ten Boer's statement echoes this sentiment (Welthungerhilfe, 2022).

In preparation for the upcoming international conference that Germany is helping to co-organizer, Welthungerhilfe is advocating for sufficient funds to be allotted to both short-term emergency relief and long-term programs, such as those aimed at agricultural self-sufficiency or income generation. These programs include short-term emergency relief that can be provided immediately and long-term programs that can be implemented over a longer period. A portion of frozen funds should be released to international and local organizations working on programs to assist those in the greatest need. These funds include those that the World Bank holds. In addition, specific project funds should be made available to provide adaptable and long-term assistance for women's initiatives that are taking place locally (Welthungerhilfe, 2022).

1.7. International Criminal Court about the armed conflict

One of the current (legal) challenges faced by those engaged in international humanitarian law-IHL and related fields, such as international criminal law, is the typology of armed conflicts, also known as the categorization of such wars. Since the application of IHL depends on the existence or absence of war, determining whether or not an ongoing international or non-international armed conflict exists is of the utmost importance (Sassòli, 2019). More significantly, it is essential to define the difference between

these two forms of armed conflict since not all laws apply to either type. It is impossible to determine whether international humanitarian law applies to a certain situation by first determining whether or not there is an armed conflict simpliciter. There is already an armed struggle going on whenever there is a war, regardless of whether or not it is on an international scale (Bartels, 2018).

The Geneva Conventions of 1949 and its 1977 Additional Protocols differentiate between "situations of international armed conflict" (IAC) and "conflicts not having an international character" or "non-international armed conflict" (ICRC, 2014, 2021; Sattar, 2020). The regulations of IAC are applicable in "all situations of declared war or of any other armed conflict which may emerge between two or more of the High Contracting Parties," as well as "all conditions of partial or total occupation," per Article 2 of the 1949 Geneva Conventions. The above norms were established to govern armed wars (Cameron et al., 2015). Article 1 of Additional Protocol I has broadened the definition of international armed conflict since the anti-colonial uprisings of 1977. The terms "other armed conflict" and "armed conflict" are not defined nor specified in the Geneva Conventions of 1949 or the Additional Protocol I. This wasn't a fluke, as it had already been shown that "the legal notion of war had given way to a de facto definition of armed conflict" (Frhd & Iwuoha, 2017). Conflicts not of an international nature" is another vague word used in Common Article 3 (Gill, 2021). However, experts in International Humanitarian Law do not consider this a major problem (Bartels, 2018). According to one of the writers of the 1949 Geneva Conventions, a definition of "NIAC" in Common Article 3 was intentionally left out due to concerns that it would lead to an overly restrictive interpretation of the agreement (Bara et al., 2021). In light of this particular worry, the convention was formed. A rigid definition of NIAC or 'armed conflict' could exclude certain kinds of armed clashes and warfare involving states and non-state actors (Bartels, 2018).

1.8. The Organization for Security and Cooperation in Europe: Its Contribution to Conflict Prevention and Resolution

During the Cold War, opposing countries signed the Helsinki Final Act, establishing the OSCE and entrenched national sovereignty and human rights. The CSCE held follow-up meetings to monitor the act's implementation. The Paris Charter envisioned a postwar European order, and in 1995, the CSCE was legitimized and changed to the OSCE (OSCE). With the idea of "enhanced security" in mind, the OSCE was founded to promote human rights and international cooperation on economic issues. As divisions reemerged between an augmented EU, NATO, and Russia, hope that the OSCE could become a post-Cold War pillar faded(Schmitt, 2017).

1.8.1. An active role in conflict management

The Organization for Security and Cooperation in Europe-OSCE is the only truly pan-European security organization. Its mission is to steer political efforts toward resolving conflicts in countries such as the former Soviet Union and Yugoslavia. It participates in international forums such as the Geneva International Discussions on Georgia and the Minsk Group on Nagorno-Karabakh, amongst other international gatherings. The OSCE helped Bosnia, Herzegovina, and other former Yugoslavian countries create disarmament and military accountability contracts after the 1995 Dayton/Paris Peace Accords. At the 1992 CSCE summit in Helsinki, participants agreed to deploy peacekeepers to conflict zones. Several OSCE activities, such as noncombatant and armed services tracking operations, meet UN peace operation criteria, but they were never implemented (Shcherbak, 2021b). The Observer Mission to Two Border Crossings in the Donbas, the Kosovo Verification Mission (1998-1999), oversaw the end of fighting and the withdrawal of Serbian forces, and the Russia-Georgia Border Monitoring Mission are a few other examples. The Special Monitoring Mission in Ukraine is a peaceful, civilian organization with no military component. Despite OSCE involvement, several post-Soviet conflicts remain. No progress has been made in Moldova and Georgia negotiations, and the OSCE's Minsk Group has no role in Nagorno-Karabakh peacekeeping operations due to a November 2020 agreement brokered by Russia. Some observers doubt the organization can avoid or resolve conflicts (Scalettaris, 2020).

1.9. International intervention in conflicts UN, OSCE, EU, NATO, CSTO

1.9.1. United Nations (UN)

After the 2001 Bonn Conference, the UN Security Council established UNAMA to give rise to a particular political objective for Afghanistan. UNAMA "has built a fair amount of confidence with the Afghan public with its community outreach to civilized society"(Scalettaris, 2020). Still, opponents claim it lacks a legal foundation for quietude, an adequate necessity, and the mineral wealth necessary for implementing its mandate (Wikipedia, 2021). During Afghanistan's election process, UNAMA provided technical and financial support to elections" and incentivized "local conversation and peace initiatives" in 12 provinces. Afghanistan has 20 UN agencies. Most of their time is spent advising departments and developing training programs. According to UN Security Council resolutions on Afghanistan, "conversation for all those who renounce violence [and] have no connections to regional and global terrorist organizations" is essential for peace in the country (Rubin et al., 2001). Afghanistan's government, insurgents, NATO, and US forces have all been urged by UNAMA to ensure the population's safety and respect human rights regulations. The Islamic Emirate of Afghanistan viewpoints the UN as US-influenced, not nonpartisan. It disputes official UN statistics that place 75% of civilian injuries and deaths on the insurgency and claims UNAMA research results on civilian causalities are "straightforwardly generated by the US immigration office and then having written under the name of the UN" (Scalettaris, 2020).

1.9.2. EU

Before a thousand years, the EU emphasized harmonious economic relationships among its members. Transboundary free enterprise, internal security cooperation, potential exterior vulnerabilities, and the EU's potential contribution ranked low at both the executive and political levels. It was only natural that countries interested in joining the EU would receive top diplomatic priority, and the démocratique Communautaire would be the primary, if not sole, subject of discussion(Maier, 2021). Some who did not want to join were fed platitudes, aid, and activities ostensibly designed to alleviate pressure points. Previously, PCAs only covered economic issues. Individually, Mediterranean countries have a long history of trade and migration links with the EU. However, these relationships weren't finalized on a geographic and programmed basis until 1994. The EU doesn't appear to recognize the Black Sea. After recognizing in 2003–2004 that it needed a neighborhood policy, the EU is quickly catching up. The EU lacks a military identity. Since the Iraq War, however, personal views have diverged, even more, making a consensus unlikely(Çelik, 2020). It's even more important that it be regarded as a representative for security improvements in a general context by cultivating a common sense of mission and addressing the fundamental causes of feelings of inadequacy within and beyond its borders. Examples include economic and mass movement, trafficking, a lack of reliable energy sources, and inequitable international power structures. Unfortunately, the EU's initiatives in this area have been ineffective (think Cyprus) or so reduced to be unnoticed by the ordinary individual(Bafoev, 2020). The EU appointed a special spokesperson for Moldova in the spring of 2005, even though the country had been seeking help for over a decade to settle a separatist dispute with the criminalized military dictatorship in Transnistria. Moldova, Europe's poorest country, borders the EU. In October 2005, after adopting an Action Plan under the European Neighbor Policy in June, the EU joined the 'five-sided' talks on Transnistria's status. Relations with Russia took time to develop. Institutional attitudes are improving, but public attitudes remain ignorant and stereotypical. The "four common spaces" consented upon in May 2003 are cost-effective; autonomy, security, and justice; international security cooperation; and research, education, and culture(Shcherbak, 2022). They provide a structure on which meaningful operations can be bonded to hide a lack of fundamental consensus.

Kaliningrad's geopolitical situation has gotten a lot of attention since EU enlargement. Both parties knew about the EU's plan to improve border security and the subsequent €13mn spent in Kaliningrad. Neither Russia nor the EU knows about Kaliningrad's $23.3 million economic and environmental aid. Until the Orange Revolution and new EU members, its relationship with Ukraine was "embarrassing." The 1994 PCA took four years to take effect. While the EU recognized Russia's market economy transition in 1997,

Ukraine didn't come until 2000. Despite spending nearly €1 billion in Ukraine between 1998 and 2004, the EU's absence of support for Westernizing trends may have hurt public perception(Çelik, 2020).

The EU's security concerns have decided to expand further than economics to include military defense, traditionally NATO's domain. The paper need not rehash the well-documented crossover and demarcation between the EU's purely theoretical military forces and NATO's. Despite the EU's eagerness to motivate non-NATO member nations to participate in its worldwide working group, such countries may grow demands obstacles to collaborative efforts, such as processes, certifications, decision matrices, and room layouts(Ahmed, 2018).

1.9.3. NATO

NATO understood the benefits of genuine partnerships outside its borders faster than the EU, but Black Sea states came in last. Central and Eastern Europe decided to add to the first expansion wave, which was the focus. The Middle eastern Dialogue was reduced to polite exchanges despite its long history. Like the EU, many events and initiatives target potential members. PfP [Partnership for Peace] was hijacked in the mid-1990s to centralize NATO hopefuls' action plans. Russia, Switzerland, and Central Asian countries are included(Brattvoll, 2018).

Source: (*NATO - Topic: Member Countries*, 2022)

With the major ripples of augmentation behind them, NATO can focus more of its overstretched international staff on helping national delegations develop additional programs of operations that fulfill NATO's obligations as a security operations center rather than a political union. Its more comprehensive security approach should be built on NATO Confidentiality through the Science program and other confidence-building actions, such as the NATO Trust Fund's excellent disarmament work. Still, the organization has a very limited budget. Since most actions rely on member funding, it isn't easy to implement an effective NATO strategy(Wright, 2019). The Alliance's orientation is rooted in the past. Its area of influence remains largely military-focused. Many requests for military cooperation go unaccomplished due to a lack of funds and national governments prioritizing other demands on their militaries. NATO's staff and dignitaries believe the Alliance's focus on military solutions to security problems has transformed its military capability. The NATO Reaction Force is a versatile tool that can't guarantee safety(Bartosh & Letyago, 2022). Due to its relative ease of implementation, the more difficult metaphysical and strategic survey of what should be NATO's distinguishable additional benefit as a security organization has been favored over the military transformation agenda. As a security-focused institution, NATO hasn't gained the same credibility and trust it did during the Cold War(NATO, 2019).

1.9.4. CSTO

Due to a lack of support from NATO, Russia attempted to elevate the CSTO's role as a regional security activist group that could aid the Afghan government. In March 2007, the CSTO approached the government about collaborating against drug trafficking and terrorism by reinforcing the military, intelligence, and border enforcement. The CSTO wanted a UN mandate to send ground troops to a place

other than Afghanistan. CSTO was prepared to enter the auditorium under a UN mandate or at a national government's request if NATO teamwork became unworkable(Guliyev & Gawrich, 2021). How much freedom does the Afghan government have to determine its world relations, including collaboration with the CSTO and SCO, without NATO? The Shanghai Cooperation Organization-SCO, created in 1996 by China, Russia, Kyrgyzstan, Kazakhstan, and Tajikistan (with Uzbekistan joining in 2001), may have aided Afghan stability but was ignored.

Source: (*Collective Security Treaty Organisation*, 2022)

By 2005, it included economic cooperation and security (Rusakovich, 2021). The Shanghai Cooperation Organization (SCO) members took an oath of allegiance to fight terrorism in the region while abiding by the rule of cooperation for non-interference and sovereign rights in each other's internal affairs. This was done to establish a foundation for security cooperation and a business strategy lever to deal with the expansive role that the United States plays in the region. SCO members and Afghanistan founded a Contact Group in November 2005 to secure the war. The SCO requested the U.S. exit strategy in July 2005. NATO and the SCO have not made any tangible progress despite many Washington pundits arguing for the benefits of concrete cooperation, including in Afghanistan (Jureńczyk & Nicharapova, 2020).

1.9.5. OSCE

The OSCE froze quarrels in Moldova, Georgia, and Nagorny Karabakh in the early 1990s before NATO's community outreach. The group valued common understanding and cooperation over confrontation, so they talked and mediated. Despite the continued activity, the successful resolution has been stuck in these disputes for a decade. This shows that large international organizations can't resolve conflicts(Dr. Muhammad Tariq et al., 2021). All parties concerned, not just intermediaries, must be proactive in resolving a crisis. The OSCE's Commissioner on (not 'for') national minorities has a commendable track record in the Baltic states and the regions under review. Most observers misinterpreted the OSCE's actions in Georgia and Moldova as biassed. Unfortunately, the OSCE's notoriety hit last year when it closed its Georgia Border Monitoring Mission. In the late 1980s, the Conventional Forces in Europe Agreement was a cornerstone of détente(Jalal et al., 2021). However, Russia has been able to perpetuity delay instituting the adapted treaty and the 2001 Istanbul summit commitments. In terms of public awareness of the program's achievements, the final two on security have surpassed the OSCE. Despite having the most militarily advanced European countries as members, the OSCE focuses more on quasi-equipment. It lists 18 critical areas of operation on its website. They all volunteer a lot. Why do some believe the OSCE is a friendly chat, an ineffectual worldwide screen of national election systems, or that a sovereign country or lobbyist could easily take over its activities(Wani, 2021)?

Its 55-state membership makes it awkward for anything but superficial political cooperation. Despite the efforts of its commission, program directors, and "permanent" employees, the institution has faced a series of problems(Dr. Muhammad Tariq et al., 2021).

1.10. U.S Relations with Afghanistan- United States Department of State

1.10.1. U.S. National Interests and Afghanistan

The chief U.S. interests in Afghanistan today are the following:

- Stop al-Qaeda and other groups from attacking the US or its allies. The Study Group has concluded, based on expert advice and their investigations, that the military engagement of the Allied Powers in Afghanistan has significantly reduced the danger of a serious attack by the U.S. or its allied countries from extremist groups predicated in Afghanistan. These include al-Qaeda and ISIL (ISKP)(Chapman, 2018).
- Avoid the spread of nuclear weapons and technology to terrorists and other extremists. Several Afghan factions, particularly those that inflame tensions between India and Pakistan, are a serious destabilizing force in the region. The possibility of a terrorist organization acquiring nuclear weapons remains a serious concern. It's difficult to foresee the possibility of this happening, but the consequences would be devastating if it did. Threats of nuclear terrorism against the United States were not entirely discounted (Herd, 2021).
- Maintain peace. The US is invested in regional peace. Nuclear war is the biggest concern in the region. Afghanistan's six neighbors include three nuclear powers (China, Pakistan, and Iran). Russia and India are also nuclear powers. Afghanistan's instability threatens regional security(Lawrence et al., 2021).
- Help Afghanistan manage radicalization, drug smuggling, massive immigration, and other potential vulnerabilities. Afghanistan's instability makes it a safe place for terrorists financially backed by international terrorism, especially drug trafficking. More conflicts could break out. It could cause a new refugee crisis, destabilizing Afghanistan's neighbors, exacerbating Europe's migrant crisis, and harming the U.S.'s global reputation(Owais, 2019).
- Protect the progress made in the last 20 years, especially women's and marginalized groups' rights. Afghanistan's lengthy stability depends on the president's capacity to listen to and protect the rights of all community members, including women. Rules of law, a prosperous, fairly distributed financial system and political freedom are essential for a functional society(Ejaz, 2018).
- Keep America relevant. U.S. national interests include U.S. foreign policy legitimacy and alliance stability. Success in Afghanistan will determine our allies' future support. The Afghanistan mission's outcome will affect the U.S.'s leadership and influence. For national security, it's important never to let enemies think the U.S. is vulnerable or irresolute and to keep allies' trust. These aren't rationalizations for an indeterminate military presence in Afghanistan, and they shape our exit(Zahid et al., 2018).

1.11. U.S policy in Afghanistan and their strategies for political Settlement in Afghanistan

Taliban rule in Afghanistan could affect American policy goals. Since then, the US has abandoned plans to partner with Afghan diplomats to combat "over-the-horizon" terrorist threats, providing chances and difficulties for numerous terrorist groups in Afghanistan. Since 2001, U.S. policy in Afghanistan has prioritized human rights, especially for women. The Taliban's emergence to the country's presidency has set this back. The relocation of the remaining U.S. citizens and Afghans who started working for the U.S. government is still underway as of August 2022(Rahman, 2019).

1.11.1. Economic Collapse, Humanitarian Crisis, and U.S. Policy

Afghanistan is one of the lowest-income and most-aided countries, and the Taliban's return has only made things worse. It would appear that several policy actions taken by the United States, including the suspension of international development aid, sanctions imposed by both the United States and the Taliban, and a retain placed by the United States on the assets of Afghanistan's central bank, are

connected to the humanitarian catastrophe. Over half of the erstwhile Afghan government's $6 billion annual budget and 80% of public spending were funded by the US and other foreign donors. The country's economy went into "free fall" after the Taliban took power in August 2021 and cut off most of the country's humanitarian aid, causing a quarter of the population to leave in the last four months of that year (Shaffan et al., 2020). Transfer payments and other humanitarian assistance have helped "stabilize" Afghanistan's economy, but the outlook is "dark." The breakdown of the Afghan economy has aggravated a humanitarian catastrophe that had already been extreme before August 2021 due to war, drought, and COVID-19. In August 2022, 92% of Afghans were hungry, up from 80% before the Taliban took power (Lansford, 2017). WFP reported in June that the Ukraine war was affecting its Afghanistan operations, leading to higher commodity prices and supply chain delays. With emergency aid from international donors, the U.N. Special Representative for Afghanistan announced in March 2022 that "we may have avoided famine and widespread starvation." 71 In August 2022, UNICEF predicted that 1.1 million Afghan children would need treatment for severe acute malnutrition(Page & Williams, 2022).

Since the Taliban's merger, the US has given Afghanistan $900 million in aid. This aid is essential for avoiding further human misery, but it differs from the $5 billion annual U.S. security, progress, and stabilization aid provided in FY2019 and FY2021. These funds provided humanitarian aid, paid Afghan soldiers and civil servants, supported key government programs, and managed to make up a significant portion of Afghanistan's economy. The Biden administration has suggested allocating $345 million to Afghanistan for health, coaching, and other assistance in FY2023. However, the lack of a U.S. diplomatic presence in Afghanistan may make execution and oversight more difficult(Rubin, 2020).

Sanctions and the U.S. hold on Afghanistan's central bank deposits have the most significance to the institutional and humanitarian situation beyond aid. In January 2022, the neck of the Norwegian Refugee Council said punitive measures had "slowed" their operations, but how this affects charitable conditions in Afghanistan is unclear. Since 1999, the Taliban have faced various sanctions. Since the Taliban's power grab, the U.S. Treasury has authorized several broad sense permission announcing that U.S. sanctions do not specifically prohibit advising Afghanistan and authorizing humanitarian and advertising transactions(Shahrani, 2020).

1.12. Peace-building approaches in Afghanistan

1.12.1. Methods of Peacemaking: To Negotiate or Not? And Who Should Negotiate with Whom?

National reconciliation has not yet occurred in Afghanistan six years after the Taliban were dethroned. In contrast, peace agreements between Tajikistan's warring factions didn't start being signed until a full year after the country's civil war ended. They laid the groundwork for peace and reconciliation, as well as hope and the authority of those in positions of power. Because it was widely believed that the Taliban were dead at the time, the 2001 Bonn Equitable distributions did not include a reconciliation process. The Taliban were not at the Bonn gathering, and the Mujaheddin of the Rebel Movement were given more power. This prevented peaceful co-existence and peace-building from being established. The Bonn Agreement excluded the Taliban from negotiations(Farizan & Heryadi, 2021). Their marginalization hindered rapprochement and significantly contributed to the myth that the war was won or settled. By 2008, it was no longer illegal to have discussions with the Taliban; even though entire engagement with Taliban leaders on the Centralized List could violate Resolution 1267, it was never illegal to hold discussions with the Taliban. Secret conversations were made between different parties with conflicting goals. Who should have been the one to commence discussions with the Taliban, and for what reason was not clear? In this fog of war, neither the U.S. nor its allies could admit they had committed a mistake by excluding the Taliban in the Bonn coalition government agreements or by declaring military victory too soon. Nor could the Karzai government should implement a national reconciliation project(Bachmann & Schouten, 2018).

1.12.2. Methods of Peace building: Coordination Between International Actors

Afghanistan's model indicates a new kind of involvement (Iraq is another example) in which various parties are active within the same area at once, often without defined limits or a good understanding of their requirement. Conflict operations between the Coalition and the Taliban, supported by NATO's ISAF, have continued unabated since the 2001 Bonn Agreement, despite the presence of humanitarian, military, and advancement actors in the same scene (Anam, 2018). In May 2006, when foreign troops caused a potentially deadly road accident in Kabul, violent mobs descended on UN agencies, government-to-government office complexes, and intergovernmental Organizations like CARE. Disappointed Kabulis saw no distinction between the military, diplomatic missions, and caring aid and development workers. Campaign promises of reconstruction and massive aid had not improved their day-to-day lives. Regional Reconstruction Teams in Afghanistan deliver aid and rebuild local infrastructure(Terpstra, 2020). Humanitarian groups say PRTs have eroded differences between military and civilians, trying to make aid workers easier targets for insurgents. Despite the conflict, economic actors like International Financial Institutions have begun rebuilding and planning the economy, such as developing an I-PRSP. To ensure that everyone was working in unison, the United Kingdom was given charge of the drug program and structural adjustment, Italy of the rule of law, and so on. The government and the process of regularization are linked. It's a typical trap to ignore both positive and negative interdependencies. Uncoordinated sectoral efforts don't develop interconnections between sector-based intervention strategies(Kester, 2021).

1.12.3. Methods of Peace building: Peace Through a National State and its Institutions

Since Afghanistan lacked a centralized government and unified nation for two decades before the 2001 intervention, achieving equilibrium and peace was more difficult than in Tajikistan. Only if the Taliban government is credited for "trying to secure" the regions it has inhabited can it be considered a Weberian powerful state. The U.S. and its allies originally concentrated on defeating the Taliban, but Afghanistan also needed a strong government. Post-conflict reconstruction included state-building, as in previous cases(Lahmann, 2021). Afghanistan needed its government. However, its type and duties were up for debate. Some argue Afghanistan's multiracial citizenry would be served better by a federal system of government, while others say the country needs a strong, democratic central government immediately. The validity of public authority and the nation's monopoly on physical harm needed to be rebuilt. With the signing of the Bonn Agreement on December 5, 2001, liberal democratic reform of the government officially got underway. The political transition to constitutional democracy was laid out in this agreement (Kamminga, 2019). Rather than being firmly rooted in an understanding of childhood trauma and unquestionable traumatization, it appears that the rapid configuration of the official tenants of a democratic republic in the countryside (founding document, statesmanlike and representative democracy electoral campaigns, creation of completely separate executive, parliamentary, and judicial bodies) was more closely connected to the need of the civilized world to illustrate achievement in Afghanistan. Efforts to introduce Modern democracy and government to Afghanistan wasted money and had little influence on the country's political culture(Farizan & Heryadi, 2021).

1.12.4. Peace through Cash?

In Afghanistan, a conflict that received a significant amount of media attention and was portrayed against the backdrop of a global war against terrorism, the succession was completely backward: an upsurge of assistance at the beginning of the battle due to manifesto commitments that may have contributed to the difficulties of assimilating national peace. It is not possible to do the subject of support for Afghanistan justice in this article due to the complexity of the topic. According to Oxfam, $15 billion in aid has been provided to Afghanistan since 2001. In January 2008, the House of Representatives in the United States of America approved $6.4 billion in economic and social aid for Afghanistan (Bachmann & Schouten, 2018). The report argued that Afghanistan had received too much inefficient aid. As in Iraq, an excessive amount of funding went to profitability, non-Afghan energy use, ex-pat salaries, and living expenses.

40% of Afghanistan's aid left the country. Oxfam says humanitarian assistance is unsustainable because it's too "upper, prescriptive, and supply-driven." Due to the obvious widespread coverage in the media of the massive amount of money that comes into continuing catastrophic events or post-crisis circumstances like Afghanistan, there is a strong temptation to envisage quick-fix solutions. One example of this is Afghanistan. When finances are not handled effectively, even the best of scenarios may result in fraud and waste, and the worst of situations can lead to fraud and waste (Mahfudin & Sundrijo, 2021).

Inadequate aid prevents states from consolidating peace, ensuring human security, and delivering public goods. Overhelping states in transition after a disagreement can keep increasing their accountability to international banks and foreign taxpayers. Unmet needs could result in frustration and loss of confidence in a rogue government(Lahmann, 2021).

1.13. Peacemaking agreements on the Settlement of the Afghanistan situation

In July 2018, the Current administration began preliminary negotiations with the Taliban about withdrawing American conventional forces. It was correct that the United States' approach in Afghanistan since 2011 has focused on attempting to broker a peace agreement between the Taliban and the Afghan government. A break from previous American tactics was represented by the fact that the Afghan government was not present throughout the talks. In 2013, discussions between the United States of America and the Taliban took place in Doha, Qatar, which serves as the Taliban's de facto political headquarters (Cordell, 2019). In May 2014, President Obama used this office to trade five Taliban detainees for Bowe Bergdahl. The Obama administration wanted to open the door for broader conversations about a peaceful Afghanistan resolution. The United States refused to talk with the Taliban because there was no representation from the Afghan government at the meeting. At the beginning of 2018, major talking points included the reduction of United States military forces and acts of international terrorism. Since September 2018, Ambassador Zalmay Khalilzad has served as the leader of the negotiation team for the United States (Lemay-Hébert, 2020). According to Khalilzad, an agreement between the United States and the Taliban regarding disengagement and assurances regarding counterterrorism would be tied to a ceasefire, as well as agreements between the Taliban and the Afghan government regarding an election arrangement. Khalilzad convinced his Afghan contemporaries that "nothing was agreed until everyone agreed" Kabul felt its fate was being spoken about without it(Padmi, 2017).

The Doha accord required Afghan negotiations to begin within ten days. The Afghan government elected a bargaining team to conform to this necessity, which frustrated President Ashraf Ghani because it considered it necessary for the government to preserve commitments it had not managed to negotiate. Many Afghans told the Study Group that the US-Taliban talks gave the insurgency more credibility(Farizan & Heryadi, 2021).

Despite the agreement, two major obstacles prevented negotiations from starting early March. Two reasons prevented Kabul from naming a negotiating team. First, President Ghani and September 2019 runner-up Dr. Abdullah Abdullah are in dispute. Second, a "confidence-building" provision called for the Taliban to release 1,000 Afghan soldiers in interaction with 5,000 Taliban former prisoners in Kabul(Cordell, 2019). First, the US threatened to withhold funding unless the election disagreement was cleared up and a trying-to-negotiate team was given the name. The Taliban insisted on choosing which detainees to release, including a few responsible for heinous crimes or attacks. The US threatened to withdraw financial aid to get the Afghan government to agree to submit the final launch dates and send its foreign ministry to talks sponsored by Qatar in September(Kamminga, 2019).

Summer began a rise in violence. The Taliban kept their commitment not to strike international forces or Afghan urban areas but attacked Afghan checkpoints. Multiple times, the US has used air power to protect Afghan ground forces. Initially, there were many airstrikes but few deaths. In August and September, fighting escalated, and death tolls soared(Sahar & Kaunert, 2021). The Taliban began bombarding Helmand, Kandahar, and Uruzgan Provinces—areas where they have significant cultural

influence—in November, briefly holding some districts and invading Kandahar and Lashkar Gah's suburbs as the U.S. prepared to withdraw troops by the end of the year. U.S. airpower and ASSF operations repelled the Taliban. Afghan government sources told the Study Group that the ANDSF's weaknesses, such as the involvement of many "ghost soldiers" (individuals who are mistakenly enlisted in the military and get a wage while not working for the government), were evident in the fight (Podiotis, 2021).

U.S. diplomats pressed the Taliban to reduce terrorism as a basis for negotiations, and they were successful. They were uphill. The Taliban use violence to negotiate. According to Study Survey research with Afghan officials, Taliban leaders sold the ceasefire agreement to their generals as a way to win after May 2021, when U.S. troops leave. Each side held the other responsible for the fighting. Never-ending growth was the result(M. F. Johnson, 2022). After meeting face-to-face and in small contact groups, the parties stopped communicating directly and depended on their Qatari hosts to deliver information. The attempt to negotiate a team to represent the Afghan government comprised members from various Afghan opposition groups that endorsed the current constitution, so anxieties that the Taliban may use contrary domestic viewpoints to subvert team unity were unfounded(M. F. Johnson, 2022).

In December, we got back to work. The High Council for National Reconciliation held its first Leadership Committee meeting on December 5 after early resistance in Kabul faded, and discussions resumed in Doha (Dodge, 2021). Midway through December, the two teams announced a deal on the code of civil procedure, demonstrated their various priority issue lists, and agreed to extend the deadline until January 5, 2021. During the interregnum, five Kabul civil society members were assassinated. The Taliban tried to claim innocence. U.S. forces in Afghanistan demanded on January 4 that the Taliban stop unallocated extrajudicial assassinations of journos, civil society activists, and political figures(Unsworth, 2019).

1.14. World Economic Forum for peace and challenges in Afghanistan

The World Bank says no fragile or disunity strife country has met a single MDG, despite 1.5 billion people living there. In addition, "high unemployment is continuously cited as a real motive for actually joining both rebel movements and urban gangs," and "85 percent of the last century's civil wars occurred in nations that had already experienced a devastating war in the last thirty years." Both of these points are important to keep in mind. Military and planning processes must be integrated for an international intervention to break the cycle and bring about real change successfully. The worries are increasing in intensity (Suhrke et al., 2002).

Source: (*Our Mission | World Economic Forum*, 2022)

1.14.1. Security on the Cheap

Instability and turmoil in Afghanistan can be traced to international security mismanagement. Twenty years of Red Army or armed conflicts ruined the country. During this time, only Kabul was under government control. The fragmented nation needed "imported security." The world lacked this. Foreign

actors' attempts to tighten safety in Afghanistan were heavily criticized for three strategic errors: leaving a small presence, diverting money, and failing to understand the geographic context(Dodge, 2021).

1.14.2. Light Footprint

A few hundred American soldiers were enough to topple the Taliban and complete the victory in Afghanistan in 2001, but not to keep the peace. During the country's transition years, international forces were scarce. In April 2003, there were fewer than 10,000 American and 5,000 international troops. 4 Between January 2009 and January 2010, American troops more than trebled, from 60,000 to 160,000(Mahfudin & Sundrijo, 2021). By mid-2010, the number had increased to nearly 100,000 thanks to Obama's 2009 "surge." While the Afghan insurgency peaked in 2010, global troop numbers rose from 2004 to 2010, reaching over 40,000. This military involvement was laughable compared to smaller, less crowded Iraq. Comparatively, it was a small international force. In 2007, serious work on Afghan national forces began(Mahfudin & Sundrijo, 2021).

Americans wanted a quick, cheap operation in Afghanistan, but they've been there for years. When efforts to enhance law and order were abandoned, Afghans lost trust in the new administration and its international partners. Cheap safety attempts failed(Karlsrud, 2019).

1.14.3. Diversion of Resources

Afghanistan, where many 9/11 schemes were hatched, was never meant to serve as the first line in the war on terrorism. The tempo of the victory in Kabul inspired Bush administration officials to invade Iraq quickly. Before March 2003, Afghanistan's armed services, economic, logistical, and intellectual resources were transferred to Iraq. Afghanistan's importance declined. As Iraq worsened in 2004–2005, the United States had little wiggle room in Afghanistan. In 2008, when Iraq stabilized, the world's attention returned to Afghanistan. Unrecoverable losses in 2002 and 2008 were due to insufficient business strategy troops and funding(Bachmann & Schouten, 2018).

The diverted funds affected Afghanistan, the region, and the world. Destabilization in Iraq and increased terrorist attacks boosted al-capabilities Qaeda's in Pakistan and Afghanistan. Local militants quickly adopted suicide bombings and IEDs as weapons. The Iraq invasion politicized young people in South Asia, several of whom later joined the Afghan insurgency(Collins & Thiessen, 2020).

Iraq's intervention killed international credibility and public support for the Afghan mission. There was a sharp decline in support for the Afghan mission among NATO countries when the "war of need" there blended with the "war of choice" in Iraq. Most democratic societies opposed or didn't understand their countries' just Afghanistan engagement (Anam, 2018).

1.14.4. Regional Confusion

After being defeated in 2001, the Taliban and Al Qaeda in Afghanistan could flee to Pakistan. They reorganized, restocked, and resumed fighting in Afghanistan that year. NATO forces couldn't stop the insurrection in Afghanistan because its function constructions, training and recruitment centers, and financial support and weapons were outside the country. Without this solution, Afghanistan's peace was doomed (Ozdemir, 2019).

Free reign was granted to Pakistan, a major non-NATO ally in the war on terror, to combat violent extremists in FATA and Baluchistan more. Pakistani forces made concessions to the main insurgent groups (Taliban Quetta Shura, Haqqani Network, and the Hekmatyar group) to avoid an Indian siege. These concessions were made in exchange for a promise that the insurgent groups would install a pro-Pakistani regime in Kabul after the withdrawal of Western forces. Initially focusing on counterterrorism, it sent Pakistan a confusing impression about its commitment to a safe and peaceful Afghanistan (Fabra-Mata & Jalal, 2018). Pakistan was pressured in 2009 to come down hard on extremists in FATA, but it was selective. The Western world neglected to give Pakistan the credit it deserved for its role in the battle.

It took much too long to realize that the objectives of NATO and Pakistan's government in Afghanistan were fundamentally at odds with one another. Because the West depends on Pakistani assistance to supply NATO soldiers in Afghanistan, it disregards Pakistan's inconsistent policy positions. Nevertheless, it does not address the fundamental issues that led to the Middle East's violence. Afghanistan has a strategic location at the junction of South Asia, Central Asia, and Western Asia; nevertheless, the nation has been unable to capitalize on this strategic position due to rivalry with other countries in the area (Partis-Jennings, 2017).

1.14.5. From the Marshall Plan to a Rescue Plan

Immediately after the fall of the Taliban in November 2001, the international world took note of Afghanistan's development requirements. Nearly $90 billion has been offered by the international community to aid with Afghanistan's rebuilding since the first donor's convention in Bonn in December 2001. The prospects for state-building in Afghanistan were bright when President George W. Bush proposed adopting the Marshall Plan in that country in April 2002 (Terpstra, 2020).

Despite international achievements in Afghanistan, development aid is inadequate and ineffective (in education, health care, and press freedom, among others). Lack of coordination among donors, parallel implementation of assistance programs, and extensive subcontracting contribute to wasted funds and limited project impact. As a result of violating the Paris Declaration and weakening the central government's resources and capabilities, just 20% of foreign assistance to Afghanistan in 2010 was distributed via official channels (Gordon, 2018).

Afghanistan's economic reforms and job creation were neglected. Both are vital to a nation's health and stability. Over 90% of Afghanistan's funding comes from outside sources. One million young Afghans will join the labor in the next several years, fueling the country's already volatile social and political tensions (Ozdemir, 2019).

1.14.6. Linking peace and development

Constructing a peaceful and prosperous society goes hand in hand, so peace brokers must allocate their resources fairly. Until nationwide security services are competent, states must "import security" from other nations to establish central government jurisdiction, maintain the rule of law, and create economic expansion conditions. Regional and global troops are sent out to express the opinion countries should aim for a harmonious mission and be combat-capable(Gomes, 2018).

1.14.7. The long-haul

Fixing states isn't easy. Building a nation, keeping the peace, and constructing its economy are difficult and time-consuming. They require money, well-coordinated efforts, and time. It took the Western world three centuries and a great deal of tragedy to establish secure democracies. Poor and unstable Afghanistan cannot achieve the same results in the same amount of time. Production is more precise, and those involved should often start preparing for an even longer time frame, but a century is a basic standard if all possible options are taken. Any outside actor who isn't willing to commit to long-term reconstruction should stay out. It wouldn't cause problems for itself or the country it was helping(“The Liberal Trap: Peacemaking and Peacebuilding in Afghanistan after 9/11,” 2020).

1.14.8. Regional approach

"Individual country" is false. Landlocked nations are vulnerable to their neighbors' fortunes (or misfortunes). Strong interregional connectivity and trade could boost struggling economies. Lack of trust and geographic hostility can halt progress and destabilize any nation. The United States made a mistake in Afghanistan because it failed to consider Pakistan's critical interests and the potentially catastrophic impact of the rivalry between Pakistan and India.

As most successful insurgencies in history have needed assistance from outsiders, the international community failed to push Pakistan to eliminate sanctuaries for Afghan rebels. Any future interventions must consider a conflict's regional context. When the regional impasse is unbreakable, it may be preferable to stay out(Mehran, 2018).

1.15. European union peace settlement

As U.S. diplomatic and military impacts in Afghanistan wind down and the new report on the Afghan peace process confront turbulence and dangers, European policymakers face difficult questions. What will happen to European investment and aid if peace talks end the war? In a new government order, what role could the Taliban play? How will European security assistance change after the US troop withdrawal from Afghanistan? (the possibility of a complete withdrawal until May 2021). Uncertain what other structures or collaborations the EU may pursue. Many European governments would like Afghan refugees to return as soon as possible, despite high violence levels (Podiotis, 2021). EU participation in Afghanistan planning depends on IRA-Taliban peace talks. The European Union's standpoint on peace talks may affect future policy. Many Afghans and Europeans have questioned Europe to "respond to the call" and help meet the needs and challenges that will remain after U.S. and NATO troop withdrawals. Still, many European governments are unsure of those policies' correct form and scope. European leaders say they can't keep a military appearance or provide direct assistance without U.S. protection. European campaign contribution government agencies and NATO alliance states are awaiting additional details on the future direction of the Afghan conflict, its potential for strengthening as well as a tried to negotiate remedy, and the make-up of a potential Afghan government before trying to pin out their long-term engagement and support(Dodge, 2021).

1.16. UN investment and documents for Afghanistan for sustainable development of Afghanistan

UNAMA works with the Afghan government to create and implement laws, policies, and initiatives that abide by worldwide standards and guidelines. Including cooperation negotiations to aid the ANPDF. UN normative support for the Afghan government will focus on areas such as education, food security, nutrition, livelihood opportunities, wellness, return, reintegration, advocacy for the rule of law, and protection of civil rights. The UN's socially constructed assistance for the Afghan government doesn't require a large capital cost. Still, it significantly impacts the country's standing in the international society by attempting to bring Afghanistan's legal and policy constructions into the team of states that subscribe to widely recognized human rights (Mannell et al., 2021).

There are the following goals to be achieved:

- End poverty in all its forms everywhere
- Zero Hunger
- Good Health and Well-being
- Quality Education
- Gender Equality
- Clean Water and Sanitation
- Affordable and Clean Energy
- Decent work and Economic growth
- Industry, Innovation, and Infrastructure

1.17. International Committee of the Red Cross- Protracted Conflict and Humanitarian action

In light of this, the World Humanitarian Summit-WHS and its groundbreaking talks are much appreciated by the International Federation of Red Cross and Red Crescent Societies. Members of the world's largest humanitarian network—the National Societies, the International Committee of the Red Cross, and the International Federation—have contributed thoughtfully to deliberations at the World Humanitarian

Summit. Our one-of-a-kind organization shared its knowledge of emergency management and conflict prevention via these discussions (Utsumi, 2022).

Protect the Dignity of Every Human Being and Improve Humanitarian Access to Those in Need

- Humanitarian aid should preserve and enhance people's worth and dignity and protect those at risk. Contributing is essential to human worth. The most suffering people should be engaged in international humanitarian to ease their pain and prevent further harm. Taking a significant involvement in one's recovery and survival can foster self-respect. The World Humanitarian Summit should give affected people agency over humanitarian efforts(Sevastik, 2020).
- Humanitarian workers need access. Our volunteers and staff can access hidden areas during an emergency, and our history shows that working with the needy community produces the most effective relief efforts. Humanitarian companies can effectively help those in need once they work more closely with government leaders. More than anything, proximity builds trust. Knowing people personally helps you meet their needs(Yasa, 2021).

1.18. NATO-led International Security Assistance Force

1.18.1. A Brief History of ISAF

ISAF deployed to Afghanistan after MTA ended on January 4, 2002. By mid-January, we were operational. ISAF reached its maximum operational level on February 18, 2002. Germany assumed control of the Kabul Multinational Brigade on March 19, while the UK remained ISAF's lead nation. Simultaneously, Turkey replaced the UK as ISAF's lead nation. ISAF reports indicate that Kabul's security has improved. ISAF brought a feeling of security and confidence to most Kabul residents. NA forces left Kabul and moved to MTA-specified barracks(Shortland et al., 2019).

Source: (*Our Mission | World Economic Forum*, 2022)

The US-led ISAF until April 16, 2003, when NATO took over. NATO provided 95% of the force, logistics, and strategic planning. Germany and the Netherlands handed ISAF to NATO on August 11, 2003. The Alliance's first objective was outside of Europe and North America. Canada is currently the Multinational Brigade's lead nation (KMNB). Despite NATO's command, many non-NATO and PfP nations will remain in ISAF. ISAF flies the very same stars and stripes and follows UN orders. NATO's leadership of ISAF has eliminated the requirement to select a new lead great nation every six months. The permanent ISAF headquarters has increased stability and continuity and allowed small nations to assume a greater role in a multinational organization (Aytzhanova & Aytzhanov, 2020).

1.18.2. Role of ISAF concerning Other Military and Political Efforts in Afghanistan

ISAF is a separate entity in Afghanistan from OEF. Different from ISAF, OEF is. Defeating the Taliban and Al Qaeda is the primary goal of Operation Enduring Freedom-OEF, primarily a military operation. The end goal of both initiatives is to establish a legitimate government in Afghanistan via democratic means. ISAF and OEF must cooperate to succeed. CENTCOM operations will take priority, and

CENTCOM will have operations and maintenance jurisdiction over ISAF to protect against duplication among ISAF and OEF forces(Wright, 2019). OEF forces are ready to act quickly to reanimate ISAF elements if they get into difficulties, and they've supplied logistical, communication, and accurate documentation to ISAF. ISAF is an UN-authorized but UN-uncontrolled mission. The UNSC authorized this "coalition of the willing. It operates independently of UNAMA. Resolution 1386 authorized ISAF to work closely with the UN Special Representative for Afghanistan (UNAMA). On January 13, 2002, a "Joint Coordination Body" was established to facilitate collaboration and communication between the IA, ISAF, and the UN on all protection issues. COMISAF, the Secretary General's Special Representative, and the Afghan Defense and Interior Ministers make up the JCB (Shortland et al., 2019).

1.18.3. Mission

NATO-mission, ISAF, as part of the International Community's expanded effort and under UN Security Council demand, is to support the Afghan government in imposing its authority throughout the country. Per the court's decision and the Security Council's mandate, ISAF helps Afghanistan maintain security and train the Afghan National Security Forces. ISAF will transition from a fight to a recurring role as ANSF assumes security duties. Until 2014, ISAF will train, advise, and assist the ANSF. ISAF will continue supplying military aid until 2014. These actions are part of a larger international effort to eliminate Afghanistan as a terrorist refuge(Wright, 2019).

1.19. Emergency International assistance for peace to strengthen security and stability in Afghanistan

1.19.1. The Afghan National Defense and Security Forces

States are defined by their ability to control force. No matter how much the US invests in Afghanistan's security, the Afghan government can't do it alone. Afghanistan's security forces rely more on foreign aid than the civilian government. The ANDSF must stay unchanged to maintain the state's going smoothly, and U.S. support is crucial. The Afghan National Defense and Security Forces-ANDSF still rely heavily on U.S. support, which accounts for 80% of all public security spending in Afghanistan and 85% of all economic aid for security. This is even though the United States officially handed over security to the Afghan government in 2013 and ended most combat operations in 2014. 16 The US pays most of the Afghan National Army's salaries (ANA)(Zahid et al., 2018). The US also provides logistics-related aid, purchasing guidelines, and policy to the Ministry of Defense. From 2002 to 2014, the US trained, equipped, and funded Afghanistan's national army, auxiliary forces, and militias. In 2006, the US began training the Afghan National Police. (ANP). Other nations, which include Germany and the EU, have funded police wages and self-defense equipment through the UN's Law and Order Trust Fund. Despite security threats, the US began planning its comment "advise, subway, and assist" role for 2014. With the US and its allies drawing back, the ANDSF's weaknesses were exposed(Muhammad Fahim Khan, Sajid Ali, Hashmat Ullah Khan, 2021).

1.19.2. Civil Society, Rights, and Social Gains

Since 2001, formal and informal institutions serving local communities and reflecting their priorities have driven Afghanistan's societal and political progress. In the decades after the 2001 International conventions established the foundation for the existing legislative provision, many civil society organizations sprouted to support human rights and reproductive suffrage, root out corruption, and retain the government sector accountable. Afghanistan's development is rooted in civil society, grassroots reform, local government, and self-help (Friesendorf, 2019). Since the late 19th century, the modern Afghan state has had to start competing for the support of non-governmental actors with tribal, religious, social, and granular influences.

Western assistance programs rarely include these actors and organizations, despite their impact. There are professional guilds, youth organizations, writerly communities, and other civic groups in rural areas. Afghanistan's political leaders understand the importance of factoring in societal expectations, which will affect long-term stability(Ambreen Sikander, Dr. Rubab Hasan, 2020). Afghans, particularly young people, use social media frequently thanks to mobile phones and the 3G internet. Young Afghans get news from blogs, Facebook, WhatsApp, and Twitter. These shifts have had far-reaching effects on contemporary Afghanistan, helping to close the regional wealth gap and bringing the lives of many Afghans online for the first time (62% of the population) who have disproportionately benefited from Western involvement. Many of them have benefited from the expansive educational sector due to urbanization. Afghanistan had 30,000 college students in 2003 but 386,778 in 2018. (including 100,468 female students). Constructing the American University of Afghanistan, the nation's highest university, is a U.S. accomplishment(Verma, 2022a).

1.19.3. Politics and the State

While the international society's primary objective was to facilitate a constitutional system between the Afghan government and citizens, it has become the Afghan state's lifeline. Since 2004, Afghanistan's global community and the U.S. have become major, if unproductive, local political players. Not to downplay the Afghan people and the global community's successful efforts to establish democratic institutions and democratic accountability(Berdal, 2019). The 2004 constitution established a constitutional framework and political legitimacy. Citizenship obligations and rights were outlined, along with government institutions. It sought to link Afghans' active participation, representation in government, credibility, and political stability. Many ethnic minorities had been exempted from national politics, but now they have a voice(Lubna Sunawar, 2021). Women also have equal rights. The country reintegrated after years of civil strife and Taliban rule. Without the constitution, the country's elites may have decided to stay on the battlefield. Despite having one of the world's most centralized constitutions, the government struggles to maintain order. This 19th-century system of organizations was designed for a small state. A larger effect on provincial and local administration may increase political dislocation, but it could also lead to more true representation, democratic control, and an accurate reflection of power patterns(Verma, 2021). The Constitution of 2004 has not been the dynamic, emerging document needed to address the groundbreaking and volatile changes of the past 17 years. Its unmovable system ensures elites remain deeply divided, political crises recur, and violence remains a realistic prospect in the republic, especially before elections(Mohmand, 2021).

1.20. International immigration effects on political instability

Since 1978, Afghanistan has been an example of a country that has seen substantial demographic transitions due to the deterioration of political order brought on by armed war and economic loss. These changes have affected the country's population. Because of the continuous conflict, about one-third of the population of Afghanistan has either been forced to relocate inside the nation or has fled to neighboring countries for safety, such as Pakistan and Iran. By 1990, over 6 million Afghans had left their nation, searching for refuge in the countries bordering Afghanistan (UNHCR, 2017). On the other hand, this trend was interrupted when a new political system was set up after the Taliban government was toppled in late 2001. There were three periods in which it influenced migration and internal displacement: the phase of renewing optimism, the phase of the rise of insurgency, and the phase of the triple transitions. The influx of development and military assistance, as well as the creation of an international agreement to stabilize Afghanistan, all had positive effects on the reintegration of displaced persons into their communities within Afghanistan, as well as on the return of Afghan refugees to their home countries. These effects also positively impacted the number of Afghans who were able to return to their homeland. However, after 2005, there was a significant decrease in the number of refugees who could return to their homes due to the emergence of the Taliban and the deteriorating security situation. Later, after the presidential election in 2014 was poorly administered, foreign financing substantially declined, the bulk of U.S. and NATO forces left Afghanistan, and refugees started returning to their homes in Afghanistan.

In 2014, the triple transition occurred (Nemutullah, 2016). Most Afghans, particularly young people, sought shelter in Europe this time. It is abundantly obvious, in light of the political shifts that have taken place in Afghanistan since 2001, that issues relating to safety, the economy, and politics all play a part in the manner in which and the location in which people choose to migrate (Sopko, 2021).

1.21. Conclusion

Afghanistan's war cannot be defeated militarily. As a result, conversations resulting in a political agreement must begin as soon as possible.

Despite widespread criticism, the National Consultative Peace Jirga-NCPJ was a move in the right direction. It was comprehensive and diverse enough for us to proceed with this discussion. Notwithstanding the shoddiness of the June 2011 timetable for coalition forces to leave, it emphasizes the significance of a focused search for a negotiated settlement.

The Taliban leaders on the UN Security Council Resolution 1267 list should be ruthlessly sought for expulsion. Aside from delisting, offering a safe, neutral site for discussions distant from the center of conflicts would be a fantastic idea.

Any negotiated solution, rehabilitation, or regional attempts for regional security will significantly rely on Afghanistan-globe relations. It is vital to address the fundamental lack of trust between the two countries.

It was unanimously recognized that ongoing dialogue under the "Abu Dhabi Process" was critical to building trust between Afghanistan and the world and devising strategies for resolving peacefully and reconciling with the Taliban.

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ZrO_2 Takviyeli Alüminyum Matrisli Kompozitlerin Üretimi ve Özelliklerinin Araştırılması

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Özet **–** Bu çalışmada, Al-ZrO_2 kompozitleri takviye oranları farklı olacak şekilde (%1, 2, 3, 4, 5) toz metalürjisi üretim yöntemi ve sıcak pres yöntemleriyle üretilmiştir. Genel prosesleri tozların karıştırılması, şekillendirilmesi, sinterlenmesi ve sıcak preslenmesidir. Bu işlem adımları sonrasında, kompozitlerin mikroyapısı, faz yapısı, yoğunluğu ve Vickers sertliği üzerine analizler yapılmıştır. Analizlerin neticesinde, en yoğun mikroyapı, maksimum yoğunluk değeri (2,71 g/cm^3) ve Vickers sertlik değeri (159 HV) Al6061-%4ZrO_2 kompozit yapıda tespit edilmiştir. ZrO_2 katkısının malzemenin sertliğini ve yoğunluğunu artırdığı sonucuna ulaşılmıştır.

Anahtar Kelimeler – Al6061 alaşımı, Kompozit, Zirkonya, Sertlik, Yoğunluk

I. GİRİŞ

Gelişen teknoloji, malzemelerden beklenen özelliklerin artması, geleneksel malzemelerin birçok sektörde yetersiz kalmasına yol açmıştır. Bu durum, geleneksel malzemelerin yerine daha üstün özelliklere sahip kompozit malzemelerin kullanılmasını sağlamıştır. En az iki farklı malzemenin üstün özelliklerini birleştiren kompozit malzemeler, gün geçtikçe daha da önem kazanmaktadır [1].

Kompozit malzemeler, kullanılan matris malzemesine göre seramik, polimer ve metal matrisli kompozitler olarak üç ana kategoriye ayrılmaktadır. Seramik matrisli kompozitlerde, seramik esaslı malzemeler genellikle matris malzemesi olarak tercih edilir. Bu tür kompozitler, yüksek aşınma dayanımı, korozyon direnci ve termal dayanım gibi avantajlara sahiptir. Polimer matrisli kompozitlerde ise matris malzemesi olarak genellikle polimer esaslı malzemeler kullanılır. Bu malzemeler, hafiflik, kolay üretim ve şekillendirme süreçleri gibi özellikleri nedeniyle sıkça tercih edilmektedir. Metal matrisli kompozit malzemelerde ise matris malzemesi olarak titanyum (Ti), magnezyum (Mg), bakır (Cu), alüminyum (Al), nikel (Ni), çinko (Zn), demir (Fe), silisyum (Si), kalay (Sn) ve kurşun (Pb) gibi metaller ve bu metallerin alaşımları kullanılmaktadır. Metal matrisli kompozitlerde malzemelerin özelliklerini artırmak için en çok tercih edilen takviye elemanları arasında silisyum karbür (SiC), silisyum dioksit (SiO_2), silisyum nitrür (Si_3N_4), bor karbür (B_4C), bor nitrür (BN), titanyum karbür (TiC), zirkonya (ZrO_2) ve alümina (Al_2O_3) bulunmaktadır [2, 3].

Alüminyum ve alaşımları, metal matrisli kompozitler için yaygın olarak tercih edilen matris fazı malzemeleridir. Bu malzemeler, hafiflik, yüksek korozyon dayanımı, kolay şekillendirilebilme ve yüksek özgül dayanım gibi özellikleri nedeniyle araştırmacıların ilgisini çekmektedir [4].

Bu çalışmanın takviye malzemesi olan zirkonya (ZrO_2), yüksek ergime sıcaklığı, düşük termal genleşme katsayısı, yüksek korozyon ve aşınma dayanımı gibi üstün özelliklere sahip bir ileri teknoloji seramiğidir. Zirkonyanın kristal yapısı, monoklinik, tetragonal ve kübik olmak üzere üç farklı kristal yapıya sahiptir. Ayrıca yüksek basınç ve sıcaklıkta ortorombik kristal yapısını alabilir. Zirkonyanın farklı kristal yapıları, özellikle tetragonal-monoklinik faz dönüşümü sırasında yapıda %3-5 oranında hacim değişikliğine neden olabilir. Bu dönüşüm sonucu oluşan gerilmelerin kontrol edilmemesi durumunda

yapıda hasara neden olabilir. Bu durumu düzeltmek ve zirkonyanın kullanım alanlarını genişletmek amacıyla kalsiyum, alüminyum, magnezyum, seryum veya yttrium gibi metal oksitler kullanılır [5, 6].

Literatür çalışmaları araştırıldığında, ZrO_2 takviyeli alüminyum esaslı kompozit malzemeler üzerine çeşitli mekanik özellik inceleme çalışmaları bulunmaktadır. Martinez ve ark. (2015), ağırlıkça %2 ve %5 ZrO_2 takviyesi içeren Al7075 matrisli kompozitlerde üç farklı değirmenin homojen dağılıma olan etkisini incelemişlerdir. Yatay atritör değirmeninde istenilen seviyede dağılım sağlanamazken, gezegensel bilyalı değirmende daha iyi bir dağılım elde edilmiştir. Ancak en iyi dağılım karıştırmalı bilyalı değirmende elde edilmiştir. Çalışma sonucunda değirmen tipi ve öğütme koşullarının numunelerdeki homojen dağılıma önemli oranda etki ettiği vurgulanmıştır [7]. Madhusudhan ve ark. (2017) çalışmalarında, Al7068 alüminyum matrisine ağırlıkça %2, 4, 6, 8 oranlarında ZrO_2 takviyesi yaparak karıştırmalı döküm yöntemiyle numuneler üretmişlerdir. Mikroyapı analizleri, ZrO_2 parçacıklarının yapıda homojen dağıldığını ve iyi bir arayüzey bağı kurduğunu belirtmiştir. Mekanik testler, en yüksek çekme dayanımı (163 MPa) ve sertlik (147,2 HV) değerlerine ağırlıkça %8 ZrO_2 takviyesinde ulaşıldığını göstermiştir [8]. Veeresh Kumar ve ark. (2019) çalışmalarında, ağırlıkça farklı oranlarda nano zirkonyum dioksit katkılı Al6061 esaslı kompozitin fiziksel, mekanik ve tribolojik özelliklerini incelemişlerdir. Test sonuçları, ZrO_2 katkı oranının artmasıyla kompozitin sertliğinde %39,9 ve çekme dayanımında %47,13 oranında bir artış olduğunu göstermiştir [9] Boppana ve ark. (2020) tarafından yürütülen çalışmada, karıştırmalı döküm yöntemiyle üretilen alüminyum esaslı kompozitlerin mekanik özelliklerini incelemişlerdir. Nano grafen (%1 ağırlıkça) ve ZrO_2 (%0.5 ve %0.75 ağırlıkça) takviyeli kompozitler üzerinde gerçekleştirilen testler, takviye oranının artmasıyla çekme dayanımında bir artış olduğunu ortaya koymuştur. Alüminyumun çekme dayanımı 180 MPa iken, %0,75 ZrO_2 ve %0,75 grafen takviyeli kompozitin çekme dayanımının 250 MPa'a yükseldiği belirlenmiştir [10].

Bu çalışmada, toz metalurjisi ve sıcak presleme yöntemleri ile üretilen ZrO_2 takviyeli Al6061 matrisli kompozit numunelerinin mikroyapısına, yoğunluğuna ve Vickers sertliğine bakılarak, zirkonya oranının (ağırlıkça %1, 2, 3, 4, 5) etkileri araştırılmıştır.

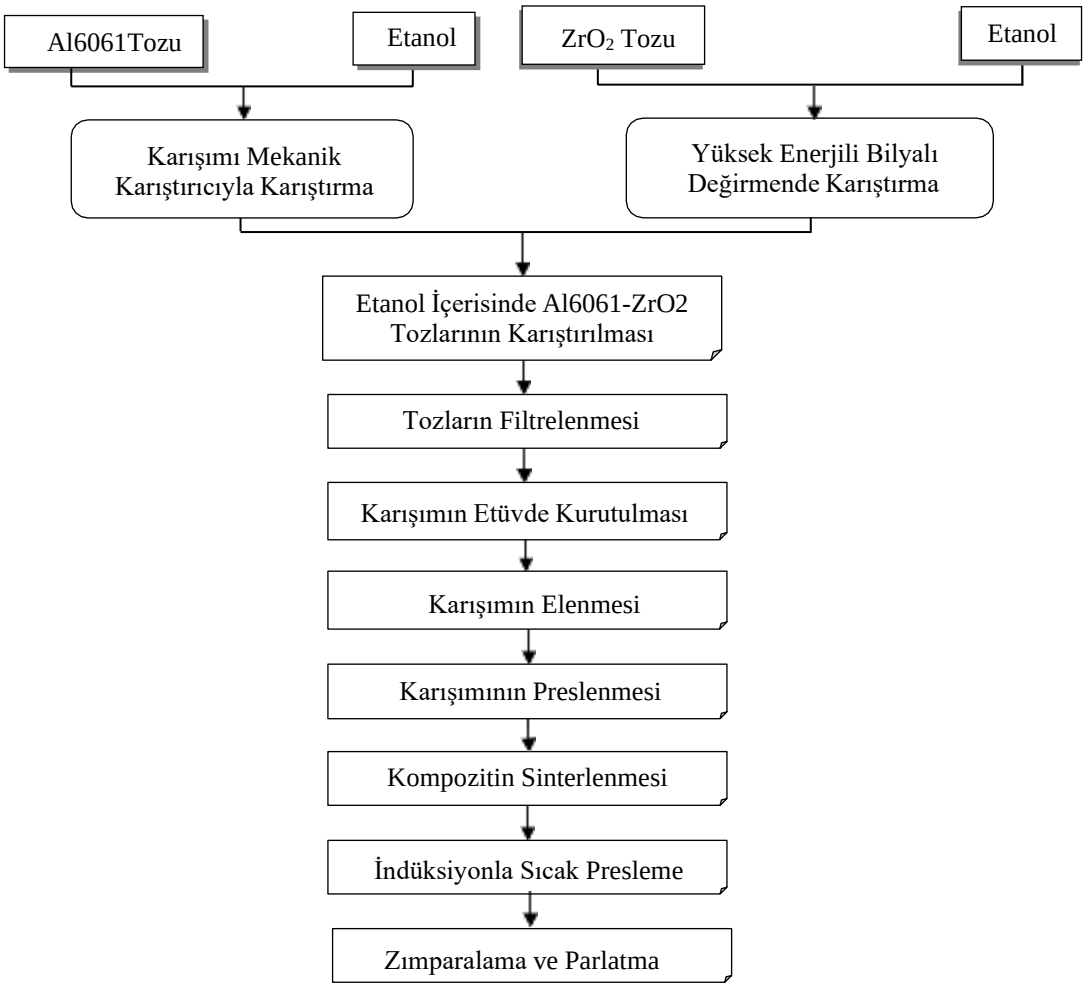
II. MATERYAL VE YÖNTEM

A. Materyal

Bu çalışmada, Al-ZrO_2 kompozitleri takviye oranları farklı olacak şekilde (%1, 2, 3, 4, 5) toz metalürjisi üretim yöntemi ve sıcak pres yöntemleriyle üretilmiştir. Kompozit malzeme üretiminde matris elemanı olarak en yaygın kullanılan 6xxx serisinden Al6061 tozu, takviye elemanı olaraksa ZrO_2 tozu kullanılmıştır. Bu çalışmada kullanılan Al6061 alaşımı, Nanografi (TR) isimli firma tarafından edinilmiştir. Al6061 alaşımı 325 mesh (~44 μm) boyutuna sahipken, 70 nm boyutundaki zirkonya (ZrO_2) ise; yüksek erime sıcaklığı, yüksek aşınma direnci, yüksek korozyon direnci ve düşük termal genleşme katsayısı gibi özellikleriyle tanınan bir ileri teknoloji seramiğidir.

B. Yöntem

Bu çalışmada, toz metalürjisi yöntemi kullanılarak Al6061-ZrO_2 hibrit kompozitin üretimi gerçekleştirilmiştir. Numunelerin üretim süreci; karıştırma, filtreleme, kurutma, eleme, şekillendirme, sinterleme ve indüksiyonla sıcak preslemeden oluşmaktadır. Şekil 1'de üretim süreci şematik olarak verilmiştir.

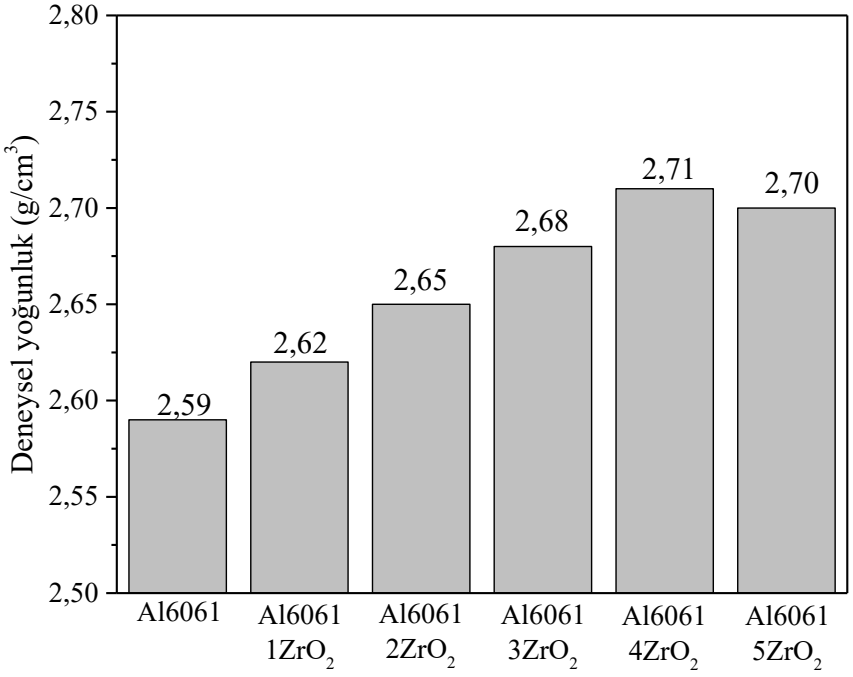


Şekil 1. Al6061-ZrO_2 kompozitlerin üretim aşamaları

III. BULGULAR VE TARTIŞMA

A. Numunelerin Yoğunluk Ölçümü

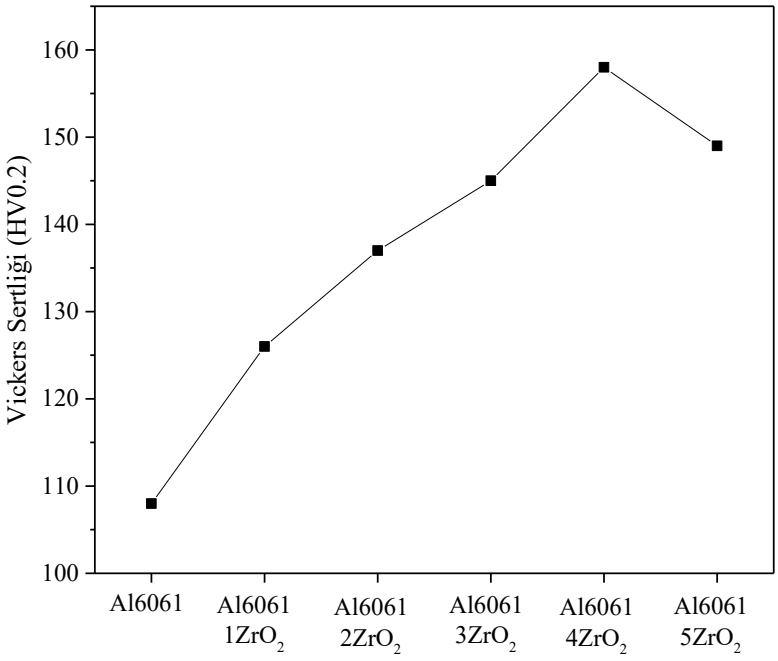
Al6061-ZrO_2 kompozitleri ve Al6061 alaşımı için yoğunluk değerleri Şekil 2'de verilmiştir. Verilen değerlere bakıldığında; maksimum yoğunluğun (2,71 g/cm^3) Al6061-%4ZrO_2'de elde edildiği belirlenmiştir. Bu durum, zirkonyanın yüksek teorik yoğunluğundan (5,68 g/cm^3) kaynaklanmaktadır. %4 ZrO_2 katkı oranından sonra ise ZrO_2 partiküllerin topaklanması sebebiyle yoğunluk değerinin düştüğü belirlenmiştir.



Şekil 2. Al6061 alaşımı ile Al6061-ZrO_2 kompozitlerinin deneysel yoğunluk değerleri

B. Numunelerin Sertlik Ölçümü

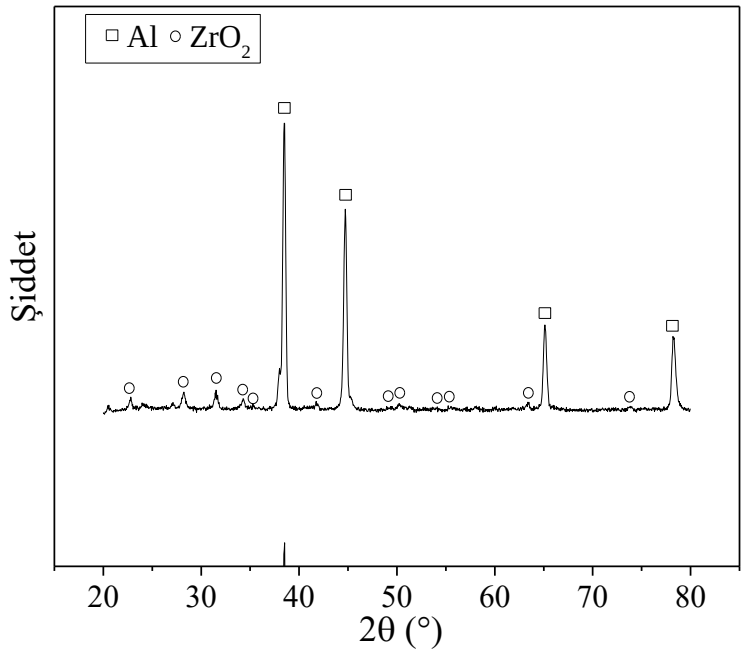
Şekil 3'te verilen Al6061-ZrO_2 kompozitleri ile Al6061 alaşımına ait elde edilen sertlik değerlerine göre en yüksek sertlik değeri (159 HV) Al6061-%4ZrO_2 kompozit yapıda tespit edilmiştir. Al6061-%4ZrO_2 kompozitinin sertliği ile Al6061 alaşımının sertlik değeri kıyaslandığında sertliğin %48 oranında arttığı belirlenmiştir. ZrO_2'nin alüminyuma karıştırılmasıyla dislokasyonların hareketini engellediğinden sertlik değerinde artışa sebep olduğu düşünülmektedir.



Şekil 3. Al6061 alaşımı ile Al6061-ZrO_2 kompozitlerine ait sertlik değerleri

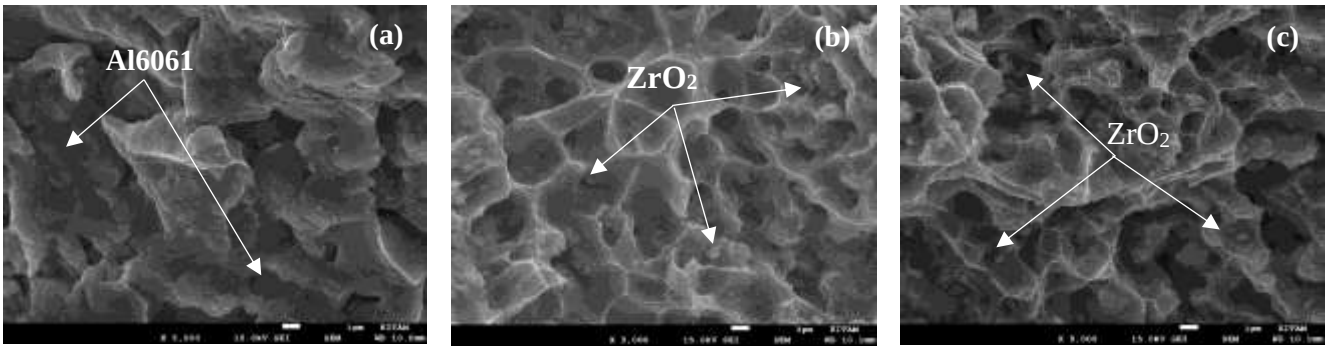
C. Numunelerin Faz Analizleri ve SEM Ölçümleri

Alüminyum esaslı ZrO_2 katkılı kompozitler için faz yapısı ve SEM incelemeleri değerlendirilmiş olup toz metalurjisi ile elde edilen Al6061-%4ZrO_2 kompozitin X-ışını kırınımı faz analizi sonuçlarına Şekil 4'de yer verilmiştir. İlgili analizlerde yapıda alüminyum ile zirkonyaya ait fazların varlığı tespit edilmesine karşın bu fazlar haricinde ikincil faz oluşumuna sebebiyet verecek bir kırınıma da rastlanılmamıştır.



Şekil 4. Al6061-%4ZrO_2 kompozitine ait XRD faz analiz verileri

Al6061 alaşımı ve ağırlıkça %4 ve %5 ZrO_2 katkılı kompozitlere ait 2500 büyütmeli kırık yüzey SEM görüntülerine Şekil 5'de yer verilmiştir. %4ZrO_2 takviyesi için inceleme yapıldığında homojene yakın bir şekilde partiküllerin dağıldığı gözlemlenmiştir. ZrO_2'nin alüminyuma karıştırılması dislokasyon hareketlerini engellediğinden sertlik değerinde artışa sebep olduğu düşünülmektedir. Bu durum, alüminyum alaşımına göre ZrO_2'nin sert seramik yapısından kaynaklanmaktadır. %5ZrO_2 katkısında ise zirkonyanın kümeleşmesi nedeniyle özelliklerin kötüleştiği öngörülmektedir.



Şekil 5. (a) Al6061, (b) ağırlıkça %4 ve (c) ağırlıkça %5 ZrO_2 takviyeli Al matrisli kompozitlerine ait kırık yüzey SEM görüntüleri

IV. SONUÇLAR

Yürütülen ilgili çalışma sonucunda, toz metalürjisi ile sıcak presleme yöntemleriyle ağırlıkça %1, 2, 3, 4 ve 5 zirkonya takviyeli kompozitler üretilmiş, zirkonya katkı oranının elde edilen kompozitin mikroyapısına, yoğunluğuna ve Vickers sertliğine etkileri üzerine araştırma yapılmış ve elde edilen sonuçlar aşağıda özetlenmiştir:

- En yüksek sertlik (159 HV) ve deneysel yoğunluk (2,71 g/cm^3) Al6061 matrisli %4ZrO_2 takviyeli kompozitte tespit edilmiştir. Al6061 alaşımına kıyasla sertliğin %48 ve yoğunluğun %4,6 oranında arttığı görülmüştür. Bu durum, alüminyum alaşımına göre ZrO_2'nin sert seramik yapısından kaynaklanmaktadır.
- XRD incelemelerine bakıldığında; kompozit yapıda oluşan fazlarda ZrO_2 ve alüminyum fazları görülmüştür. Bu iki faz haricinde diğer bir ikincil faz oluşumuna rastlanılmamıştır.
- SEM analizlerinde; Al-ZrO_2 kompozitin yapısı incelendiğinde; ZrO_2 taneciklerinin homojene yakın halde dağıldığı saptanmış ve homojen dağılıma bağlı olarak kompozitin dislokasyon yoğunluğunu dolayısı ile sertliğini olumlu yönde etkilediği de öngörülmektedir.

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Visualization of 3-dimensional Cubic B-spline Surface Approximation Model by using Interval Type-2 Neutrosophic Set Theory

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Abstract **–**The interval type-2 neutrosophic set (IT2NS) is a generalization of the type-1 neutrosophic set, interval type-2 fuzzy set, and intuitionistic fuzzy set. Using the approximation approach, this paper will demonstrate how to visualize the interval type-2 neutrosophic B-spline surface (IT2NB-sS) model for a cubic example. Nevertheless, the model is difficult to visualize due to neutrosophic features have membership functions for truth, indeterminacy, and falsehood. In addition, it is challenging since IT2NS properties have an upper and lower bound due to the existence of the triangular footprint. This work will first introduce an interval type-2 neutrosophic control net relation (IT2NCNR) to construct the model using the IT2NS theory. The IT2NCNR and the B-spline basis function will be combined to represent the IT2NB-sS models. The IT2NB-sSs are then displayed by approximating the truth, indeterminacy, and falsity memberships of the IT2NCNR for both the upper and lower bounds. The study will conclude by reviewing the algorithm utilized to generate the cubic IT2NB-sS approximate models.

Keywords – Interval Type-2 Neutrosophic Set, Control Net, B-spline Surface, Approximation Model, and Upper and Lower Bound.

I. INTRODUCTION

Zadeh [1] proposed fuzzy set (FS) theory as a generalization of the traditional concept of a set and a proposition to account for fuzziness (degree of truth) as conveyed in natural or human language [2-3]. Although type-1 FS (T1FS) is widely utilized and associated with uncertainty, past research has shown that T1FS only partially reflects uncertainty and may be unable to handle or mitigate the impacts of uncertainties seen in some real-world applications [4]. To deal with this issue, Zadeh [5] proposed expanding his previous T1FS theory to incorporate the type-2 fuzzy set (T2FS) theory, which can handle uncertainties that T1 finds difficult to manage due to T2FS's fuzzy membership grades. A few studies have shown that the outcome of a T2FS can be preferable to a T1FS [4], [6-10]. Due to the computational overhead of employing a generic T2FS, most people now only use interval T2FSs. The computations for interval T2FSs are quite manageable and practical [4].

Atanassov [11] proposed intuitionistic fuzzy sets (IFSs) that account for membership and non-membership grades. To represent the indeterminacy membership grade, Smarandache [12] extended IFSs to neutrosophic sets (NSs) with truth, indeterminacy, and falsity membership functions. Wang et al. [13] proposed the concept of a single-valued neutrosophic set (SVNS) as a solution for ambiguous, indeterminate, and incoherent data. Wang et al. [14] developed interval type-2 neutrosophic sets (IT2NSs) to more accurately assess improbability and ambiguity [15]. Touqeer et al. [16] proposed interval-type-2 trapezoidal neutrosophic numbers using operations. Rosli and Zulkifly [17] introduced an interval

neutrosophic cubic Bézier curve approximation model for complicated data. According to the studies, an interval neutrosophic set is defined and used in the same manner in this study.

The data set is an important component for presenting the surfaces. If there is any ambiguity in a data collection, it must be resolved before being used to create surface models. Using an IT2NS to create geometric models is an effective technique to address the issue of making data obvious when there is uncertainty. Research has been conducted to ensure that curves and surfaces in geometric modeling with uncertainty data are easily usable [18-21]. Various academic works have been done on fuzzy geometry modeling [22-27]. However, a few studies proposed and introduced neutrosophic geometric modeling [17], [28-34]. This paper will be introduced a 3-dimensional cubic B-spline surface approximation model by using interval type-2 neutrosophic set theory.

The main objective of this research is to visualize a 3-dimensional cubic interval type-2 neutrosophic B-spline surface (CIT2B-sS) approximation model. Before constructing the CIT2NB-sS, the interval type-2 neutrosophic set (IT2NS) theory and its basic properties must be used to define the interval type-2 neutrosophic control net relation (IT2NCNR). The B-spline basis function is used with these control nets to create models of CIT2NB-sSs, which are then visualized using an approximation method. The paper will be organized as follows: Section 1 provided some background information regarding the study. Section 2 explains the fundamental concepts of IT2NS, interval type-2 data points (IT2DPs), and IT2NCNR. Section 3 describes how to use IT2NCNR to approximate the CIT2NB-sS. Section 4 includes a numerical example and a visualization of CIT2NB-sS. The surface properties are also shown, along with the method by which they were created. Finally, part 5 will bring this study to a conclusion.

II. MATERIALS AND METHOD

This section aims to describe the IT2NDPs and IT2NCPs that refer to a dataset, with the IT2NDPs acting as IT2NCPs to visualize the CIT2NB-sSs. Before considering IT2NDPs, it is required to define IT2NS, interval type-2 neutrosophic relation (IT2NR), and interval type-2 neutrosophic point (IT2NP). Wang et al. (2005) introduced the core concept of IT2NS. Later, Tas and Topal (2017, 2018) influenced the definition of IT2NCPs for neutrosophic points. Furthermore, the notion of IT2NDPs is based on a study by Zakaria et al. [35-37] on type-2 fuzzy data points in geometric modeling, as well as interval type-2 trapezoidal neutrosophic numbers [16].

Definition 1 [14]

Let X be the universal set that elements in X denoted as x. An interval type-2 neutrosophic set (IT2NS) A is expressed by the truth membership function T_A, indeterminacy membership function I_A, and false membership function F_A. where $x \in X, T_A(x), I_A(x), F_A(x) \subseteq [0,1]$.

- When X is continuous, an IT2NS A can be expressed as

$$A = \int_X \langle T(x), I(x), F(x) \rangle / x, x \in X \tag{1}$$

- When X is discrete, an IT2NS A can be expressed as

$$A = \sum_{i=1}^{n} \langle T(x_i), I(x_i), F(x_i) \rangle / x_i, x_i \in X \tag{2}$$

Definition 2 [14]

Suppose X and Y be a non-empty crisp set. $R(X,Y)$ denoted as interval type-2 neutrosophic relation (IT2NR) in a subset of product space $X \times Y$ and containing the truth membership function $T_R(x,y)$, indeterminacy membership function $I_R(x,y)$ and false membership function $F_R(x,y)$ where $x \in X$ and $y \in Y$, and $T_R(x,y), I_R(x,y), F_R(x,y) \subseteq [0,1]$.

Definition 3 [17]

Suppose A in the space of $x \in X$ is an interval type-2 neutrosophic point (IT2NP) and $x = \{x_i\}$ is a set of IT2NPs where there exists $T_A(x) = [\sup(T_A), \inf(T_A)] : X \to [0,1]$ defining as the supremum and infimum of truth membership, $I_A(x) = [\sup(I_A), \inf(I_A)] : X \to [0,1]$ defining as the supremum and infimum of indeterminacy membership and $F_A(x) = [\sup(F_A), \inf(F_A)] : X \to [0,1]$ defining as the supremum and infimum of false membership where

$$T_A(x) = \begin{cases} 0 & \text{if } x_i \notin X \\ a \in (0,1) & \text{if } x_i \hat{\in} X \\ 1 & \text{if } x_i \in X \end{cases} \tag{3}$$

$$I_A(x) = \begin{cases} 0 & \text{if } x_i \notin X \\ b \in (0,1) & \text{if } x_i \hat{\in} X \\ 1 & \text{if } x_i \in X \end{cases} \tag{4}$$

$$F_A(x) = \begin{cases} 0 & \text{if } x_i \notin X \\ c \in (0,1) & \text{if } x_i \hat{\in} X \\ 1 & \text{if } x_i \in X \end{cases} \tag{5}$$

Definition 4 [17]

Let $A = \{x | x \text{ interval type-2 neutrosophic point}\}$ and $D = \{D_i | D_i \text{ data point}\}$ is a set of interval type-2 neutrosophic data points with $D_i \in D \subset X$, where X is a universal set and $T_A(D_i) = [\sup(T_A), \inf(T_A)] : D \to [0,1]$ for truth membership function which defined as $T_A(D_i) = 1$, $I_A(D_i) = [\sup(I_A), \inf(I_A)] : D \to [0,1]$ for indeterminacy membership function defined as $I_A(D_i) = 1$, $F_A(D_i) = [\sup(F_A), \inf(F_A)] : D \to [0,1]$ for falsity membership function defined as $F_A(D_i) = 1$ and formulated by $D = \{(D_i, T_A(D_i), I_A(D_i) F_A(D_i) | D_i \in \square)\}$. Thus,

$$T_A(D_i) = \begin{cases} 0 & \text{if } D_i \notin X \\ a \in (0,1) & \text{if } D_i \hat{\in} X \\ 1 & \text{if } D_i \in X \end{cases} \tag{6}$$

$$I_A(D_i) = \begin{cases} 0 & \text{if } D_i \notin X \\ b \in (0,1) & \text{if } D_i \hat{\in} X \\ 1 & \text{if } D_i \in X \end{cases} \tag{7}$$

$$F_A(D_i) = \begin{cases} 0 & \text{if } D_i \notin X \\ c \in (0,1) & \text{if } D_i \hat{\in} X \\ 1 & \text{if } D_i \in X \end{cases} \tag{8}$$

For all i and the three memberships, $D_i = \langle D_i^L, D_i, D_i^R \rangle$ with $D_i^L = \langle D_i^{LL}, D_i^L, D_i^{LR} \rangle$ where D_i^{LL}, D_i^L and D_i^{LR} are left-left, left, and left-right of IT2NDP and $D_i^R = \langle D_i^{RL}, D_i^R, D_i^{RR} \rangle$ where D_i^{RL}, D_i^R, and D_i^{RR} are right-left, right, and right-right of IT2NDP respectively. **Figure 1** illustrates this with the green triangle representing truth, the blue triangle representing indeterminacy, and the red triangle representing falsehood memberships. The dashed triangle for each membership at the values $[D^L, D, D^R]$ represented the type-1 neutrosophic set for each membership. The upper and lower boundaries for each membership are given by values $[D^{LL}, D, D^{RR}]$ and $[D^{LR}, D, D^{RL}]$, respectively.

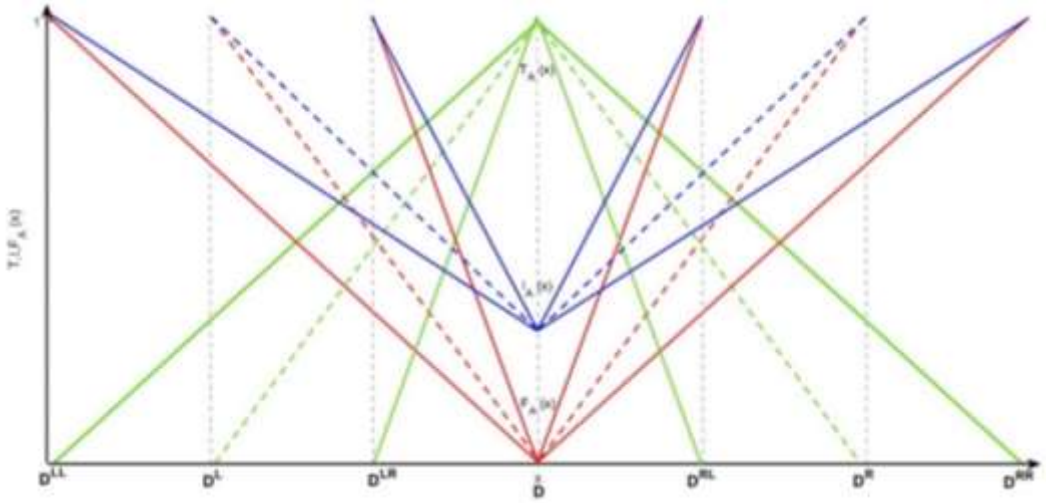

Figure 1. Interval type-2 Neutrosophic Data Points for Truth, indeterminacy, and Membership degrees

A. Interval Type-2 Neutrosophic Control Net Relation (IT2NCPR)

A spline surface's geometry can only be described by the collection of control points used to construct it. This is called "control net". The control net is a significant tool for developing, controlling, and manufacturing smooth surfaces. This section defines the interval type-2 neutrosophic control point relation (IT2NCPR) by first employing the notion of an interval type-2 neutrosophic set from the research published by Wahab et al [24-25].

Definition 5 [17] Let $\hat{R}$ be an IT2NPR, then IT2NCPR is defined as a set of point $n+1$ that indicates the positions and coordinates of a location is used to describe the curve and is denoted by

$$\begin{aligned} \hat{P}_i^T &= \left\{ \hat{p}_0^T, \hat{p}_1^T, ..., \hat{p}_n^T \right\} \\ \hat{P}_i^I &= \left\{ \hat{p}_0^I, \hat{p}_1^I, ..., \hat{p}_n^I \right\} \\ \hat{P}_i^F &= \left\{ \hat{p}_0^F, \hat{p}_1^F, ..., \hat{p}_n^F \right\} \end{aligned} \tag{9}$$

where $\hat{P}_i^T$, $\hat{P}_i^I$ and $\hat{P}_i^F$ are interval type-2 neutrosophic control points for membership truth, indeterminacy and i is one less than n. Thus, the IT2NCNR can be defined as follows.

Definition 6. Let $\hat{P}$ be an IT2NCPR, and then define an IT2NCNR as points n and m for $\hat{P}$ in their direction, and it can be denoted by $\hat{P}_{i,j}$ that represents the locations of points used to describe the surface and may be written as

$$\hat{P}_{i,j}^{T,I,F} = \begin{bmatrix} \hat{P}_{0,0} & \hat{P}_{0,1} & \cdots & \hat{P}_{0,m} \\ \hat{P}_{1,0} & \hat{P}_{1,1} & \cdots & \hat{P}_{1,m} \\ \vdots & \vdots & \ddots & \vdots \\ \hat{P}_{n,0} & \hat{P}_{n,1} & \cdots & \hat{P}_{n,m} \end{bmatrix} \tag{10}$$

Since this paper will model cubic case. Therefore, the IT2NCNR for CIT2NB-sS model is as follows:

$$\hat{P}_{3,3}^{T,I,F} = \begin{bmatrix} \hat{P}_{0,0} & \hat{P}_{0,1} & \hat{P}_{0,2} & \hat{P}_{0,3} \\ \hat{P}_{1,0} & \hat{P}_{1,1} & \hat{P}_{1,2} & \hat{P}_{1,3} \\ \hat{P}_{2,0} & \hat{P}_{2,1} & \hat{P}_{2,2} & \hat{P}_{2,3} \\ \hat{P}_{3,0} & \hat{P}_{3,1} & \hat{P}_{3,2} & \hat{P}_{3,3} \end{bmatrix} \tag{11}$$

III. APPROXIMATION OF 3-DIMENSIONAL CUBIC INTERVAL TYPE-2 NEUTROSOPHIC B-SPLINE SURFACE MODEL

Surface is a vector value function with two parameters that specify how the plane is projected into the Euclidean three-dimensional frame [21]. This sort of mapping is referred to as surface mapping. The IT2NCNR and Definition 1 are utilized to create the CIT2NB-sS, which is then used to integrate the B-spline blending function into a geometric model. The CIT2NB-sS approximation technique can be mathematically described as follows:

Definition 7

Let $\hat{P}_{3,3}^{T,I,F} = \begin{bmatrix} \hat{P}_{0,0} & \hat{P}_{0,1} & \hat{P}_{0,2} & \hat{P}_{0,3} \\ \hat{P}_{1,0} & \hat{P}_{1,1} & \hat{P}_{1,2} & \hat{P}_{1,3} \\ \hat{P}_{2,0} & \hat{P}_{2,1} & \hat{P}_{2,2} & \hat{P}_{2,3} \\ \hat{P}_{3,0} & \hat{P}_{3,1} & \hat{P}_{3,2} & \hat{P}_{3,3} \end{bmatrix}$

where $i = 0,1,...,n$ and $j = 0,1,...,m$ is IT2NCNR. The CIT2NB-sS model is given by:

$$\begin{aligned} BsS^{T}(u,w) &= \sum_{i=0}^{n}\sum_{j=0}^{m} \hat{P}_{i,j}{}^{T} N_i^k(u) M_j^l(w) \\ BsS^{I}(u,w) &= \sum_{i=0}^{n}\sum_{j=0}^{m} \hat{P}_{i,j}{}^{I} N_i^k(u) M_j^l(w) \\ BsS^{F}(u,w) &= \sum_{i=0}^{n}\sum_{j=0}^{m} \hat{P}_{i,j}{}^{F} N_i^k(u) M_j^l(w) \end{aligned} \tag{12}$$

where $N_i^k(u)$ and $M_j^l(w)$ are the B-spline functions in the u and w parametric directions.

$$\begin{aligned} N_i^1(u) &= \begin{cases} 1 & if \quad u_i \le u < u_{i+1} \\ 0 & otherwise \end{cases} \\ N_i^k(u) &= \frac{(u-u_i)}{u_{i+k-1}-u_i} N_i^{k-1}(u) + \frac{(u_{i+k}-u)}{u_{i+k}-u_{i+1}} N_{i+1}^{k-1}(u) \\ M_j^1(w) &= \begin{cases} 1 & if \quad w_j \le w < w_{j+1} \\ 0 & otherwise \end{cases} \\ M_j^l(w) &= \frac{(w-w_j)}{w_{j+l-1}-w_i} M_i^{l-1}(w) + \frac{(w_{j+l}-w)}{w_{j+l}-w_{j+1}} M_{j+1}^{l-1}(w) \end{aligned} \tag{13}$$

A. *Properties of 3-Dimensional Cubic Interval Type-2 Neutrosophic B-Spline Surface (CIT2NB-sS) Model*

From the properties of the B-spline basis function [21], the properties of 3-dimensional CIT2NB-sS are listed as follows:

- In each parametric, the degree of CIT2NB-sS is one less than the number of IT2NCNR vertices in that direction.
- The IT2NCNR shape is generally followed by the CIT2NB-sS.
- The IT2NCNR corner point and the resulting CIT2NB-sS coincide.
- The IT2NCNR 's shape is generally followed by the CIT2NB-sS.
- The CIT2NB-sS is contained within IT2NCNR's convex hull.
- The CIT2NB-sS has a continuity in each parametric direction that is two less than the number of IT2NCNR vertices in that direction.
- An affine transformation does not change the CIT2NB-sS.

- The CIT2NB-sS lacks the variation-diminishing property. For bivariant CIT2NB-sS, the variation-diminishing property is both undefined and unknown.

IV. VISUALIZATION OF 3-DIMENSIONAL CUBIC INTERVAL TYPE-2 NEUTROSOPHIC B-SPLINE SURFACE MODEL

This section illustrates the CIT2NB-sS approximation model for the truth, indeterminacy, and falsity membership functions. The matrixes below are the datasets representing IT2NCNR. Based on Definition 4 and Figure 1, $\hat{P}_{3,3}$, $\hat{P}^{L}_{3,3}$, $\hat{P}^{LR}_{3,3}$, $\hat{P}^{LL}_{3,3}$, $\hat{P}^{R}_{3,3}$, $\hat{P}^{RL}_{3,3}$ and $\hat{P}^{RR}_{3,3}$ denoted as mean, left, left-right, left-left, right, and right-right of IT2NCNR for B-spline surfaces 4×4 IT2NCNR respectively and the degree of polynomial $n=3$ for the cubic case.

$$\hat{P}_{3,3}=\begin{bmatrix} \langle(-17,17);0.4,0.7,0.2\rangle & \langle(-17,7);0.9,0.3,0.1\rangle & \langle(-17,-7);0.4,0.4,0.5\rangle & \langle(-17,-17);0.6,0.5,0.2\rangle \\ \langle(-7,17);0.6,0.4,0.3\rangle & \langle(-7,7);0.8,0.2,0.3\rangle & \langle(-7,-7);0.5,0.5,0.3\rangle & \langle(-7,-17);0.7,0.4,0.2\rangle \\ \langle(7,17);0.6,0.2,0.5\rangle & \langle(7,7);0.8,0.4,0.1\rangle & \langle(7,-7);0.5,0.7,0.1\rangle & \langle(7,-17);0.5,0.3,0.5\rangle \\ \langle(17,17);0.7,0.3,0.3\rangle & \langle(17,7);0.4,0.6,0.3\rangle & \langle(17,-7);0.4,0.6,0.3\rangle & \langle(17,-17);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{L}_{3,3}=\begin{bmatrix} \langle(-19,15);0.4,0.7,0.2\rangle & \langle(-19,5);0.9,0.3,0.1\rangle & \langle(-19,-9);0.4,0.4,0.5\rangle & \langle(-19,-19);0.6,0.5,0.2\rangle \\ \langle(-9,15);0.6,0.4,0.3\rangle & \langle(-9,5);0.8,0.2,0.3\rangle & \langle(-9,-9);0.5,0.5,0.3\rangle & \langle(-9,-19);0.7,0.4,0.2\rangle \\ \langle(5,15);0.6,0.2,0.5\rangle & \langle(5,5);0.8,0.4,0.1\rangle & \langle(5,-9);0.5,0.7,0.1\rangle & \langle(5,-19);0.5,0.3,0.5\rangle \\ \langle(15,15);0.7,0.3,0.3\rangle & \langle(15,5);0.4,0.6,0.3\rangle & \langle(15,-9);0.4,0.6,0.3\rangle & \langle(15,-19);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{LR}_{3,3}=\begin{bmatrix} \langle(-21,13);0.4,0.7,0.2\rangle & \langle(-21,3);0.9,0.3,0.1\rangle & \langle(-21,-11);0.4,0.4,0.5\rangle & \langle(-21,-21);0.6,0.5,0.2\rangle \\ \langle(-11,13);0.6,0.4,0.3\rangle & \langle(-11,3);0.8,0.2,0.3\rangle & \langle(-11,-11);0.5,0.5,0.3\rangle & \langle(-11,-21);0.7,0.4,0.2\rangle \\ \langle(3,13);0.6,0.2,0.5\rangle & \langle(3,3);0.8,0.4,0.1\rangle & \langle(3,-11);0.5,0.7,0.1\rangle & \langle(3,-21);0.5,0.3,0.5\rangle \\ \langle(13,13);0.7,0.3,0.3\rangle & \langle(13,3);0.4,0.6,0.3\rangle & \langle(13,-11);0.4,0.6,0.3\rangle & \langle(13,-21);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{LL}_{3,3}=\begin{bmatrix} \langle(-23,11);0.4,0.7,0.2\rangle & \langle(-23,1);0.9,0.3,0.1\rangle & \langle(-23,-13);0.4,0.4,0.5\rangle & \langle(-23,-23);0.6,0.5,0.2\rangle \\ \langle(-13,11);0.6,0.4,0.3\rangle & \langle(-13,1);0.8,0.2,0.3\rangle & \langle(-13,-13);0.5,0.5,0.3\rangle & \langle(-13,-23);0.7,0.4,0.2\rangle \\ \langle(1,11);0.6,0.2,0.5\rangle & \langle(1,1);0.8,0.4,0.1\rangle & \langle(1,-13);0.5,0.7,0.1\rangle & \langle(1,-23);0.5,0.3,0.5\rangle \\ \langle(11,11);0.7,0.3,0.3\rangle & \langle(11,1);0.4,0.6,0.3\rangle & \langle(11,-13);0.4,0.6,0.3\rangle & \langle(11,-23);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{R}_{3,3}=\begin{bmatrix} \langle(-15,19);0.4,0.7,0.2\rangle & \langle(-15,9);0.9,0.3,0.1\rangle & \langle(-15,-5);0.4,0.4,0.5\rangle & \langle(-15,-15);0.6,0.5,0.2\rangle \\ \langle(-5,19);0.6,0.4,0.3\rangle & \langle(-5,9);0.8,0.2,0.3\rangle & \langle(-5,-5);0.5,0.5,0.3\rangle & \langle(-5,-15);0.7,0.4,0.2\rangle \\ \langle(9,19);0.6,0.2,0.5\rangle & \langle(9,9);0.8,0.4,0.1\rangle & \langle(9,-5);0.5,0.7,0.1\rangle & \langle(9,-15);0.5,0.3,0.5\rangle \\ \langle(19,19);0.7,0.3,0.3\rangle & \langle(19,9);0.4,0.6,0.3\rangle & \langle(19,-5);0.4,0.6,0.3\rangle & \langle(19,-15);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{RL}_{3,3}=\begin{bmatrix} \langle(-13,21);0.4,0.7,0.2\rangle & \langle(-13,11);0.9,0.3,0.1\rangle & \langle(-13,-3);0.4,0.4,0.5\rangle & \langle(-13,-13);0.6,0.5,0.2\rangle \\ \langle(-3,21);0.6,0.4,0.3\rangle & \langle(-3,11);0.8,0.2,0.3\rangle & \langle(-3,-3);0.5,0.5,0.3\rangle & \langle(-3,-13);0.7,0.4,0.2\rangle \\ \langle(11,21);0.6,0.2,0.5\rangle & \langle(11,11);0.8,0.4,0.1\rangle & \langle(11,-3);0.5,0.7,0.1\rangle & \langle(11,-13);0.5,0.3,0.5\rangle \\ \langle(21,21);0.7,0.3,0.3\rangle & \langle(21,11);0.4,0.6,0.3\rangle & \langle(21,-3);0.4,0.6,0.3\rangle & \langle(21,-13);0.7,0.4,0.2\rangle \end{bmatrix}$$

$$\hat{P}^{RR}_{3,3}=\begin{bmatrix} \langle(-11,23);0.4,0.7,0.2\rangle & \langle(-11,13);0.9,0.3,0.1\rangle & \langle(-11,-1);0.4,0.4,0.5\rangle & \langle(-11,-11);0.6,0.5,0.2\rangle \\ \langle(-1,23);0.6,0.4,0.3\rangle & \langle(-1,13);0.8,0.2,0.3\rangle & \langle(-1,-1);0.5,0.5,0.3\rangle & \langle(-1,-11);0.7,0.4,0.2\rangle \\ \langle(13,23);0.6,0.2,0.5\rangle & \langle(13,13);0.8,0.4,0.1\rangle & \langle(13,-1);0.5,0.7,0.1\rangle & \langle(13,-11);0.5,0.3,0.5\rangle \\ \langle(23,23);0.7,0.3,0.3\rangle & \langle(23,13);0.4,0.6,0.3\rangle & \langle(23,-1);0.4,0.6,0.3\rangle & \langle(23,-11);0.7,0.4,0.2\rangle \end{bmatrix}$$

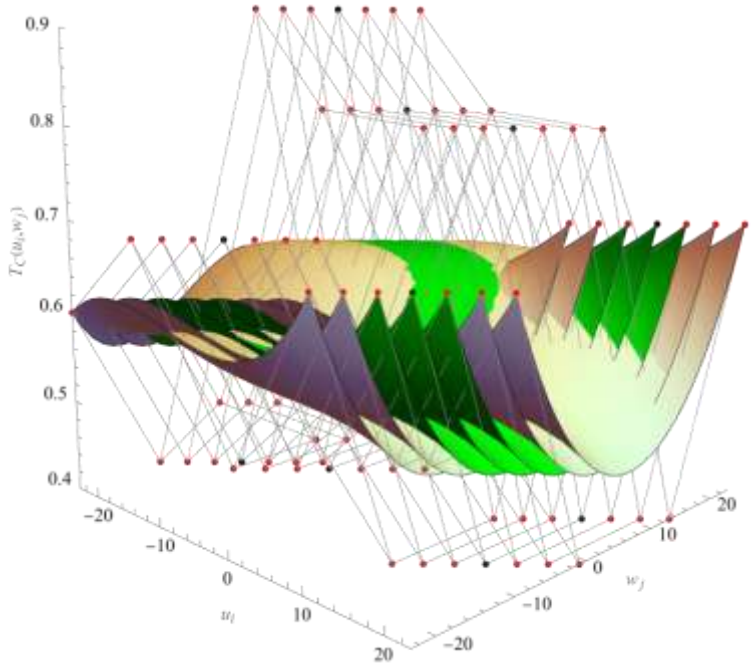

Figure 2. 3-dimensional cubic interval type-2 neutrosophic B-spline surface approximation for truth membership

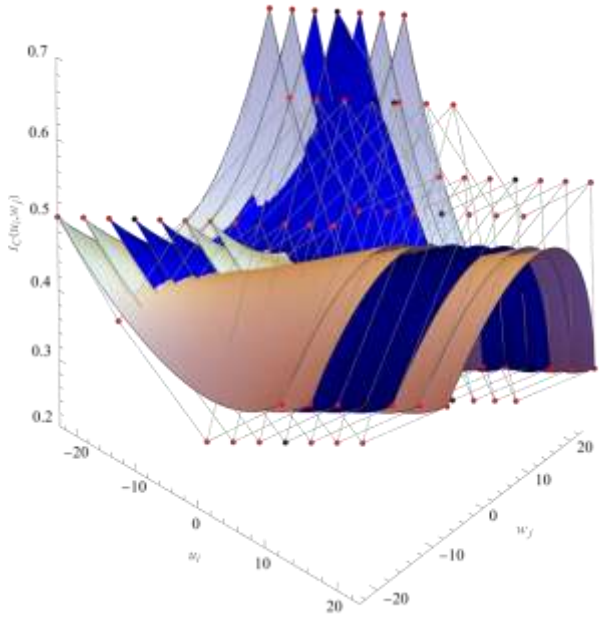

Figure 3. 3-dimensional cubic interval type-2 neutrosophic B-spline surface approximation for indeterminacy membership

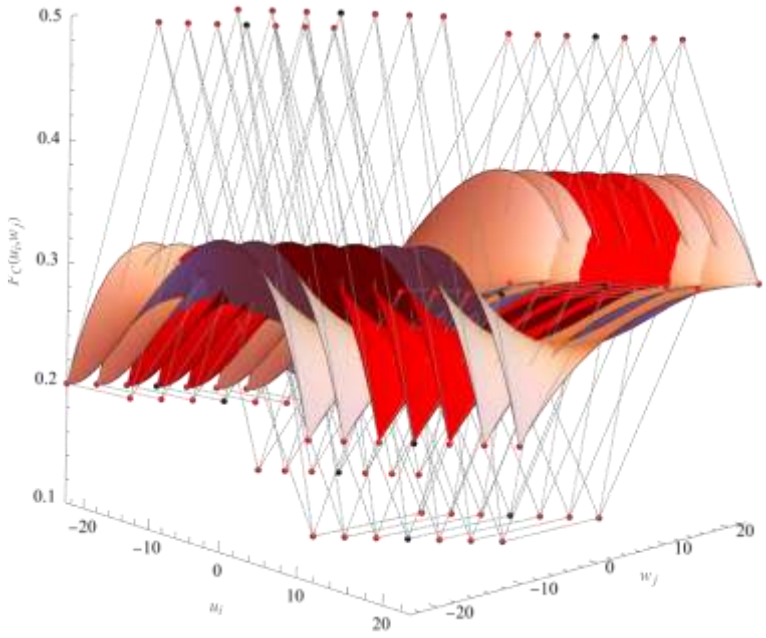

Figure 4. 3-dimensional cubic interval type-2 neutrosophic B-spline surface approximation for falsity membership

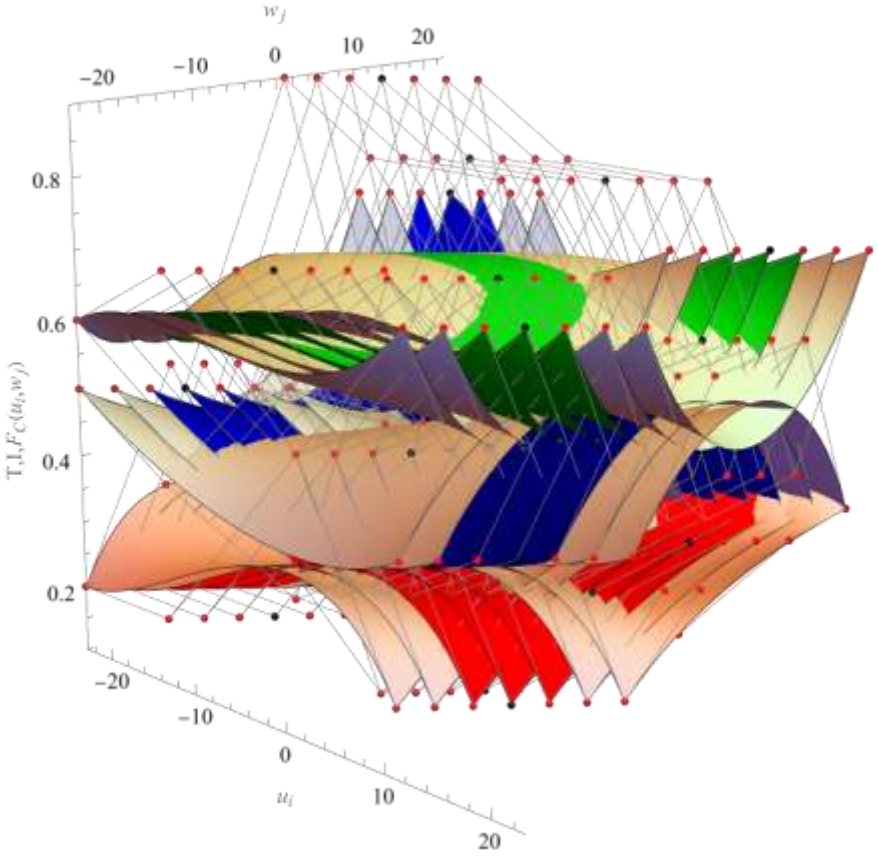

Figure 5. 3-dimensional cubic interval type-2 neutrosophic B-spline surface approximation for all memberships

Figure 2-4 depicts the CIT2NB-sSs, which comprises truth, indeterminacy, and falsity membership for each of their left and right footprints. Truth membership is represented by the green curves, indeterminacy by the blue curves, and falsehood by the red curves. **Figure 5** displays the CIT2NB-sSs with their respective IT2NCNs and memberships. **Figure 6** shows how an algorithm for creating the CIT2NB-sSs works.

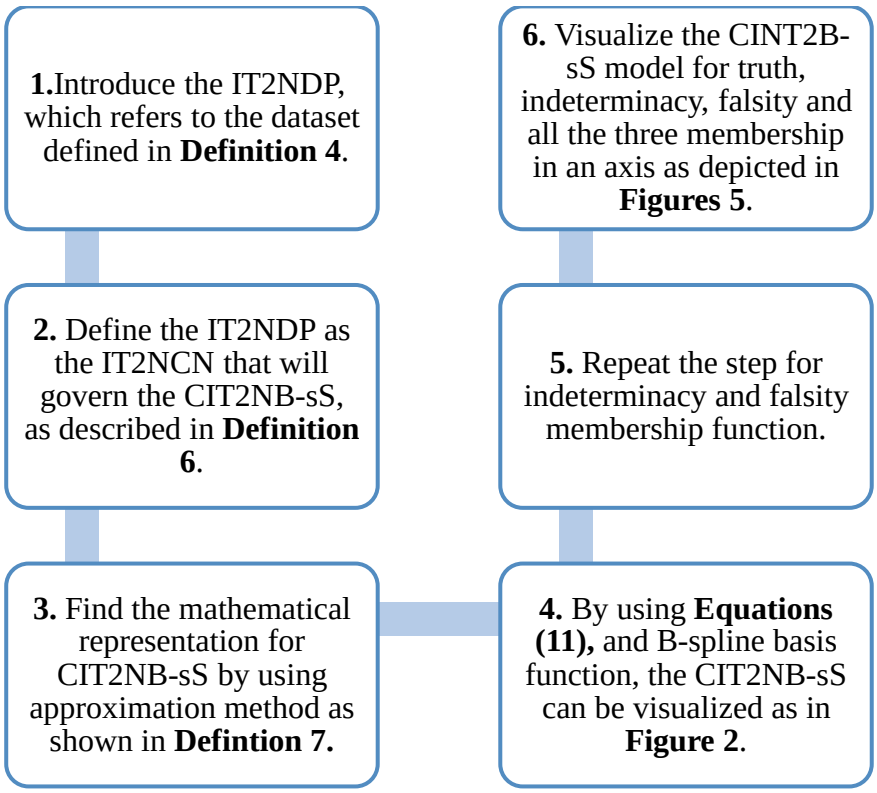

Figure 6. An algorithm to create the CIT2NB-sSs interpolation models.

V. CONCLUSION

This study proposed IT2NS principles to generate the IT2NCN, which governs CIT2NB-sS behaviors. The model shows how to display an uncertain dataset using IT2NS theory. This method can potentially significantly contribute to highly uncertain disciplines, such as bathymetry data. Predictive models are used in various medical applications, including cancer-level prediction, picture blur detection, and disaster warning systems. This study can be broadened to include more complicated situations, particularly the type-2 neutrophilic set. In addition, several geometric models, such as non-uniform rational B-spline (NURBS), could be applied in future research to improve the study's visualization capabilities. Furthermore, this study has the potential for expansion through interpolation approaches.

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Impact of gender inequality on sustainable development of economies in CAC "Central Asia & Caucasus" region

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Abstract – In the economic zone gender haven't been any universal subject matter till long period. CAC countries proceed through the economic, political, and social transformation after the decline of Soviet Union. (Raccioppi, O'Sullivan 2009). The worldwide researching of transition economies of CAC about two decades ago, got that the gender inequality's impact on the sustainable development of the transition economies. This thesis research conducted to clarify in what ways gender inequality harmed the sustainable development of these countries. Or what sustainable development with gender equality could mean for Central Asian and for the Caucasian country?

Global surveys and researchers did variety of research that corroborate the gender inequality as a substantial drawback for unsustainable economic growth. "We recognize that gender equality and women's empowerment are essential for sustainable development and our common future." (General Assembly resolution, annex, paras. 2012). To discover the replications, the existing literatures, scheme of conceptual framework, hypothesizes, introduction to variables, data collection, methodology of measurement, analyze of all the data and reports although remarkable findings related to our topic companying us.

This research paper immensely demonstrated the connection and correlation across the gender inequality and sustainable development of transition economies in CAC region. As hypothesized those gender inequality ways which can harm the sustainable developments of transition economies in CAC region, we discover that they were supporting instead of harming, and further discovered interchangeably. Then, we compared of Azerbaijan and Kazakhstan economies regarding the effect of gender inequality our findings suggest that "if Azerbaijan close the gender inequality gap, their economy will heighten till 20% comparing to status-quo".

Keywords – Gender Inequality, Sustainable Development, Economy, Global, Central Asia.

I. INTRODUCTION

Gender has never been a global issue in economic terms until the 1990s. Since the collapse of Soviet Union Central Asian and Caucasian countries went through economic, political, and social transformation. (Raccioppi, O'Sullivan 2009). After studying and researching 90s transition economies of Central Asia and the Caucasus about two decades ago, it became clear that gender inequality has a great impact on the sustainable development of the transition economies. The research paper is conducted to clarify in what ways gender inequality harmed the sustainable development of these countries. Or what sustainable development with gender equality could mean for Central Asian and for the Caucasian country?

International organizations and World surveys have done lots of research which proves that gender inequality is one of the main reasons for unsustainable economic growth. "We recognize that gender equality and women's empowerment are important for sustainable development and our common future." (General Assembly resolution, annex, paras. 2012)

Distinctions between men and women have played an important role in the history of the development of the global political economy namely, trade, production, finance, and labor. Women enter the economy in a diverse variety of roles, for example as workers, consumers, and entrepreneurs. Moreover, Women are active economic agents in all the major sectors of economic activity – agriculture, industry, and services.

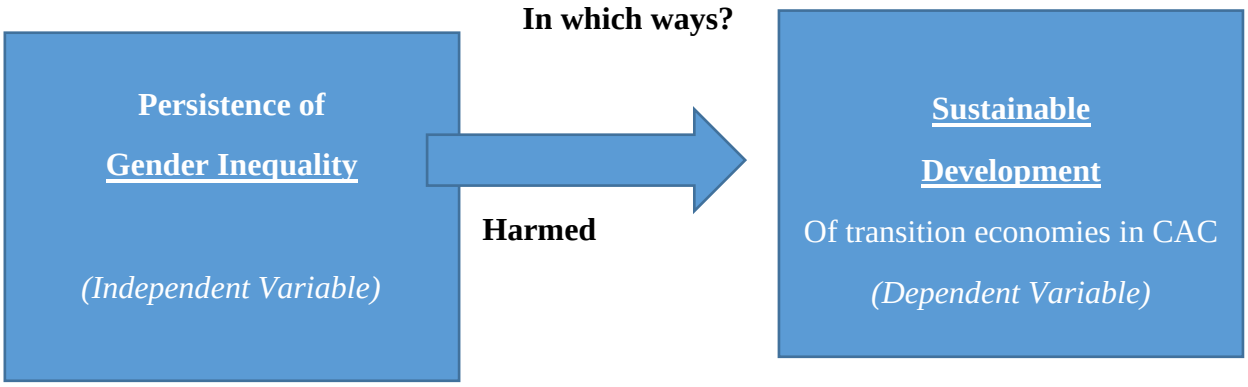
Women have been active participants in economic activity in all human societies. However, women have not always been engaged in productive activity that is remunerated in monetary terms. Thus, while women's contribution to economic growth and development has been invaluable, it has not always been acknowledged and granted recognition by official agencies. The increasing participation by women in the paid work- force has increased the visibility of women's contribution to economic growth. As the Economist (2006) stated: 'Arguably, women are the most powerful engine of global growth.' The post-1945 period has witnessed an increasing integration of women into the workforce.

Feminist theories of IR use gender as a socially constructed category of analysis when they analyze foreign policy, international political economy, and international security. Feminists believe that the struggle for greater gender equality is one of the central issues in the development of a global political economy. (Theories of IR: feminism, 2009)

In below, at section 2 we are going formulate the research question, following that, we are going to look at existing literatures related to our topic in section 3. By getting a big picture from the literatures we are then going to draw a conceptual framework and raise some hypothesizes in section 4. On the other hand, section 5 will describe the Introduction to the variables; data collection including sources of secondary data; the Methodology of measurement and the analysis. In section 6 we will analyze the data and report the results of all univariates, bivariate and multivariate analysis; moreover, we will discuss broadly about each significant finding. Finally, section 7 will be conclusion of our research study.

1.2. RESEARCH QUESTION

In what way(s) has the persistence of gender inequality in CAC region harmed the sustainable development of transition economies in CAC?



1. 3. LITERATURE REVIEW

Sustainable development and gender equality can reinforce each other in powerful ways (Johnsson-Latham, 2007; Agarwal, 2002; Cela, Dankelman and Stern, 2013; Buckingham-Hatfield). Countries with low development categories are facing with the widest gender inequality. (HDI 2018). From this literature, we can hypothesize that GII (Gender Inequality Index) can be one of the ways which can harm sustainable development of transition counties in CAC. (Please refer to the report Appendix.3)

Up to 0.9% points of differences in annual GDP/Capita growth rates between South Asian, East Asian, Middle Eastern and the Sub Sahara African, can be due to the differences in gender gaps in education between these regions. (Klasen 2002). From this literature, we can hypothesize that inequality in education can also be one of the ways which can harm sustainable transformation of transition counties in CAC.

Lack of access to education and health services, and lack of productive opportunities by women as well as ignoring the women's economic empowerment will increase gender inequality and a great loss of human potential. (IDS 2014). From this quote, we can hypothesize that inequality in health and economic empowerment can also be one of the ways which can harm sustainable transformation of transition economies in CAC. (Kochhar, Jain-Chandra, and Newiak 2017).

Women at working-age are about 5 billion people which makes almost half of the world's labor force but only about 50 percent of them are participate in the labor force, comparing to 80% of men. This effectively sidelines more than half of the world's talent, experience, and knowledge, leaving our societies operating at under 50 % capacity. The losses to an economy from economic; Removing the barriers from the female labor force participation will produce a significant gain in economic and welfare of the society. (Norris and Kochhar 2019). From these 2 finding, we can hypothesize that inequality in labor force participation can be one of the possible ways which harm the sustainable transformation of transition economies in CAC.

Studies shows that women are more risk averse, having greater fear of failure, and less competitive. Women's greater fear has benefits; gender-balanced corporate boards improve firm performances, especially in the knowledge intensive services and high-tech manufacturers. Gender diversity of gender on the boards of banking supervision agencies are also associated with a greater financial stability (Sahay & Čihák 2018).

Women shouldn't be discriminated in hiring as they are very profitable to an economy, from here we can hypothesize that inequality in hiring or discriminating against women in hiring can also be one of the possible ways which can harm the sustainable transformation of transition economies in CAC.

We have growing evidence of correlation between gender equality; and economic, environmental, and social sustainability. For Instance, when female participation in public administration is higher, then the public resources will be more likely to be allocated for investments in human development necessities, such as health, nutrition, and access to employment. (Chattopadhyay and Duflo 2004, UN Women 2014). From these 2 concepts, we can hypothesize that inequality in state higher decision-making organs such as cabinet of ministers/Parliament can also be one of the possible ways which can harm the sustainable development of transition economies in CAC.

Increasing of female wages relative to male wages in the countries in CEE region associated with a successful market reform as well as it caused to decline the slow reforms in Russia and Ukraine. (Trapido 2007). From this finding, we can hypothesize that less inequality gap in pay or income can also be one of the possible ways which can prevent harming of the sustainable development of transition economies in CAC trough declining the slow process of market reform.

In the societies where women have less freedom to participate in social life the corruption level will be higher.

Therefore, democratic representation of the women in the political and economic positions can lower the chances of corruption. (Ziegler 2011) and the less be the corruption the higher the will economic performance. From this research finding we can hypothesize that inequality in freedom can also be one of the possible ways which can harm the sustainable development of transition economies in CAC. This study suggests that almost 10% of potential female births in each Caucasus country did not occur because of sex-selective abortion: (Michael; King Guo; McKee; Richardson; and Stuckler 2013). Please refer to the Graph 5 in Appendix.

From the findings of this paper, we can hypothesize that inequality in "sex ratio preference" can also be one of the possible ways which can harming the sustainable development of transition economies in CAC.

Many women and girls in China South & Asia suffer from much higher mortality rates comparing to the men what Amartya Sen calls "missing women" (Klasen and Wink 2002, Sen 1989, Economic Review

2002). From these finding, we can hypothesize that inequality in "mortality" can also be one of the possible ways which can harming the sustainable development of transition economies in CAC.

Integration of global market and structural adjustment can worsen women's vulnerability even if they are well armed with human capital and other required resources to compete with the men in labor market. (Fodor and Horn 2015). Women in Central Asia continue to have a better status than women in many middle eastern societies and the developing countries. Their literacy rate is 98 percent.

Despite rising unemployment, Central Asian women continue to be involved in economic activity (Anuradha 1996), using this fact, we are going to hypothesis that lower inequality in literacy rate in CAC prevented the sustainable development of the economy from the harm. And will test it.

Because of agricultural reform caused many women to move out from the rural labor market economy to domestic economy (housewife). (Liu 2011). From this finding, we can hypothesize that inequality gap increased by development of economy and market, and this can also be one of the possible ways which can harming the sustainable development of transition economies in CAC by losing potential labor force.

General: The transformation of the workforce from a primarily agricultural one to an industrial one and the changes in the gender division of labor were crucial features of economic, social, and political change. Countries industrialized in a manner that had distinct gender patterns.

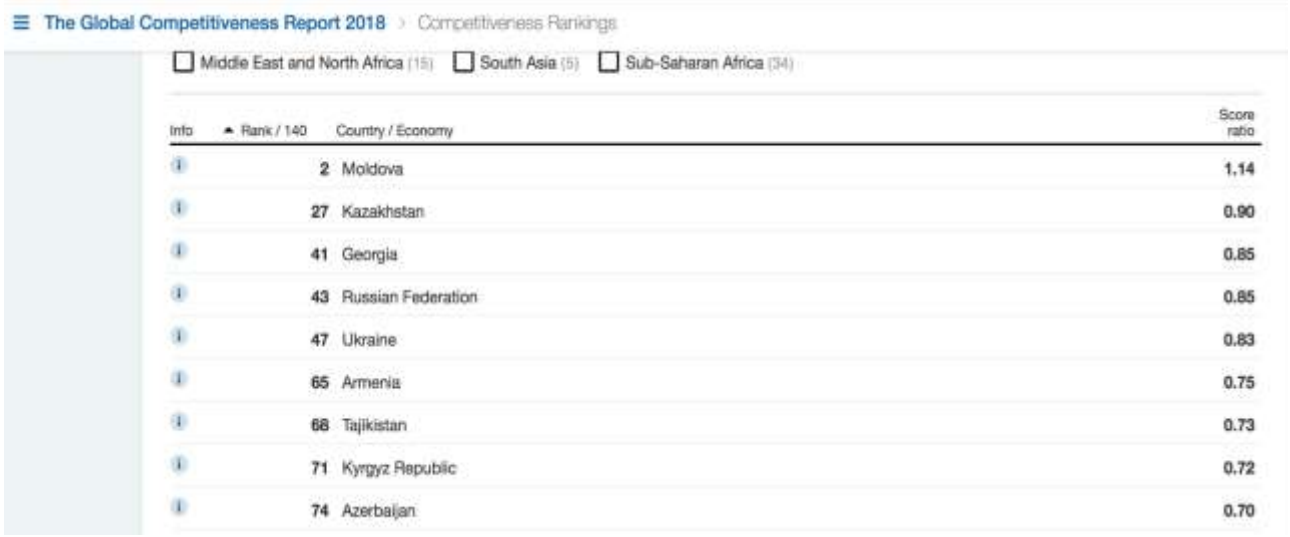
Global: The gendered nature of the post-1945 global political economy has become clearer with increasing research into the subject. Economies of all states relied on women to provide free labor to care for family members so that men could participate in the paid work- force. In addition, economic restructuring in response to financial crisis demands that women provide even more services as states cut back on social provision. At the same time, the increasing globalization of the economy is bringing more women into the global workforce in particular roles – as domestics or nannies, entertainment or sex workers, or workers in labor-intensive factories in the developing world. While some women pursue desirable career opportunities in global economy, most struggle to make ends meet. (O'Brien, McWilliams, 2016).[1]

The interesting thing about the gendered division of labor is that it is not preordained or 'natural' but changes over time depending on social and economic circumstances. For example, in Canada and the US before the Second World War, women were largely confined to domestic tasks. However, with the shortage of male workers during the war, many women were called upon to work in factories where they were more than capable of doing 'male' work. Once the war ended, women were encouraged to return to the domestic role so that men could resume their 'natural' employment patterns.

Europe: Gender relations were central to the interaction between Europeans and non- European societies. In cases where the two communities were of equal strength, European men often relied on women from other cultures for assistance.[1]In Many Western societies aspire to a division of labor based on merit and operating in response to impartial market forces, but ethnic, racial, class and gender divisions continue. However, from the survey of the leading international firms concerns the global gendered division of labor. Of the top 500 companies a mere 17 companies have appointed a woman chief executive officer (CEO).[1]

Region (Central Asia and Caucasus): below is some statistical evidence about the women participation ratio in workforce and relative salary ratio in the central Asia and Caucasus region from reliable sources:

Table.1 Work Quality of Women in the region:



The Global Competitiveness Report 2018 › Competitiveness Rankings

Middle East and North Africa (15) | South Asia (5) | Sub-Saharan Africa (34)

Info	Rank / 140	Country / Economy	Score ratio
	2	Moldova	1.14
	27	Kazakhstan	0.90
	41	Georgia	0.85
	43	Russian Federation	0.85
	47	Ukraine	0.83
	65	Armenia	0.75
	68	Tajikistan	0.73
	71	Kyrgyz Republic	0.72
	74	Azerbaijan	0.70

Source: Global competitiveness report 2018.

Table.2 Women participation in workforce as a percentage of men.

1	Economy	Equal remuneration for work of equal value?	Gender nondiscrimination in hiring?
2	Afghanistan	No	No
8	Armenia	No	No
11	Azerbaijan	No	Yes
59	Georgia	No	No
84	Kazakhstan	No	Yes
160	Tajikistan	Yes	Yes
173	Kyrgyz Republic	No	No
197	Uzbekistan	No	No

Source: Global competitiveness report 2018.

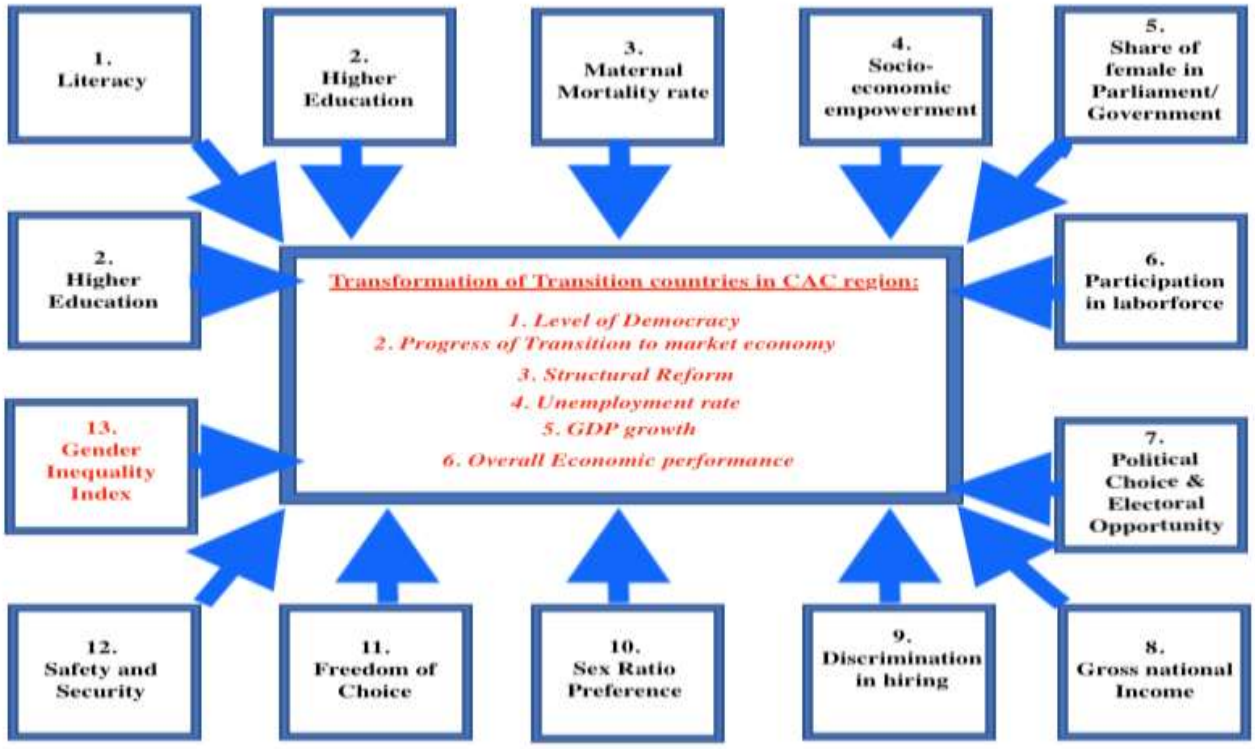
From tables 1 and 2 we can understand that the CAC region are weak performers in the aspect of developing the gender equality. Therefore, it comes to our mind that maybe this gender inequality in this region will be one of the main obstacles toward successful and sustainability of the economic transformation, societal development and political advancement comparing to the a the most developed regions and countries in the globe. Critical theorists more specially the Feminist approaches stressing the role of gender, in global political economy. From the above literatures, we can find that there is a strongly negative correlation between the "'gender inequality' and the 'societal, economic and political" development and sustainability. As by now we know that the "gender inequality" harms the "progress of development and sustainability", therefore; the next question can be that "In which way or ways it can harm?".

1.5. CONCEPTUAL FRAMEWORK

After literature review sections and considering the hypotheses which we raised earlier in preceding section, I am going to draw a conceptual framework as shown below in Figure. I choose 13 gender inequality variables as an independent variable for my research and to the best of my knowledge, gender Inequality in some of these 13 independent variables and/or in combination of these 13 Independent variables can be

they ways that can harm the "Sustainable development of the transition economies in CAC region" which is our dependent variables.

On the other Hand, for measuring my D.V (Sustainable development of the economy) I am going to use summation of the average annual GDP growth rate record, Electoral democracy rate, records of unemployment rate, progress of privatization, price and market liberalization, competition, trade and forex, structural reform, FDI, IMF standing which and overall economic performance. That is why I sub divided my Dependent variable.



1.6. METHODOLOGY

We began our paper with introduction to the historical evidence on gender relation and role in the society, following that we will look at the gender role at modern era and then we will compare the regimes, societies, and economies in different regions of the world with focusing on gender equality in order to find the relationship between gender role and the development. Our paper will start from the global, region to republic of Azerbaijan.

1. Research question: In what way(s) has the persistence of gender inequality harmed the sustainable development of the transition economies in CAC region?

2. Research Hypothesis: I have raised the following hypotheses to be tested regarding the research question, which are**:**

H1: Gender inequality harmed the sustainable development of transition economies in the region due to their low percentage of participation in the higher position of the government.

H2: due to demotivation of the women by discrimination, sexual harassment, and ignorance of their abilities in the society.

H3: due to demotivation of the women by paying a lower salary comparing the men in the similar position

and work.

H4: due to their lower literacy percentages of women that of men.

H5: Culture, History, believes, Norms and behavior of states may also intervene and can impact the relations between our Dependent and independent variables.

3. Research gap: After reviewing almost all the related literatures, I couldn't find any answer the above-mentioned question, and I find this as a problem. To fill this gap of knowledge It requires to conduct new research.

4. Purpose of research: The main purpose behind this research is to define and understand if the gender inequality is one of the obstacles to sustainable development of transition economies of the region and specially Azerbaijan.

Why this research is important? By performing this research, we will be able to know the role of the women in the shaping a state in both domestic and international level. The results of our findings from this research paper will enable us to find the "ways in which the persistence of gender inequality in Central Asia and Caucasus harmed the sustainable development of the transition economies in CAC region and Azerbaijan in Particular" which then considering those ways we can draw some immediate alternative policies and come up with the solutions to the problem as well as we will prepare policy implication. By presenting the new research finding and new policy suggestions, the Republic can review, plan, and implement the recommended policies to grow its global political economy spheres and to transform the republic of Azerbaijan from a developing country to a developed country.

5. Research Type: This research is a cross-sectional type as it will focus only on the years after Independence of the Republics (between 1991 to 2019).

6. Level of Analysis: 8 countries in CAC region,

7. Research Method: Quantitative-comparative statistics

8. Data collection: see item column 4 of table below. Our paper will mainly rely on secondary data such as available data in world bank websites, State Statistical Committee of Azerbaijan, Asian development Bank reports, Freedom house democracy Index, European Bank for regional development (EBRD), World Economic Forum Indicators, related Articles, academic journals, government published, Books, Surveys and interviews with feminists and international political economic experts.

9. Sources of data: please refer to column 4 of below table

10.References of data: please refer to column 3 of below table

11. Intro. To variables: please see column 1 of below table

12. Methodology of measurement of variables: please see column 2 of below table:

13. Methodology of grading and scoring: please see the next table titled (**Grading criteria)** (Appendix 1)

14. Analysis: Descriptive, univariate, bivariate, Multivariate, table, & graph analysis (In Excel). For analysis of the quantitative part of research will use the latest version of STATA software.

em#	1. Introduction to the variables	2. Methodology of measurement	3. References	4. Data collection
0	Independent Variable (Gender Inequality) in:	For more info please read or click on the link:	(Page# and Table#)	Source link
1	Literacy ratio (Female/Male)	Column 2/ Column 3	HDI 2018- Table#9 - Page: 54 to 57	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
2	Education ratio (mean years of study: F/M)	Column 9/ Column 10	HDI 2018- Table#4 - Page: 34 to 37	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
3	Maternal Mortality ratio (death/100k births)	Column 3	HDI 2018- Table#5 - Page: 38 to 41	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
4	* Socio Economic Empowerment in % (*)	Column 10	HDI 2018- Dash B#3 -Page: 93 to 97	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
5	Women share of seat in parliament (%)	Column 5	HDI 2018- Table#5 - Page:38 to 41	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
6	Participation in labor force ratio (F/M)	Male participation/ female participation	G.C.R (2018)- Eurasia and central Asia regions	http://reports.weforum.org/global-competitiveness-report-2018/competitiveness-rankings/#series=FMLWGEDWRKRT
7	Political choice & electoral opportunity (**)	B4 (For each country)	F.H (2018)	https://freedomhouse.org/report/freedom-world/freedom-world-2018
8	Gross national income ratio /capita (F/M)	Column 11 / Column 12	HDI 2018- Table#4 - Page: 34 to 37	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
9	Gender nondiscrimination in hiring?	Column 2	W.B.C.I (2018)- Doing business➔ labor market regulation➔Job quality	http://www.doingbusiness.org/en/data/exploretopics/labor-market-regulation
10	Sex ratio preference (from 2005 to 2009)	Reported graph results of 2009 data	Michael (2013), Figure1-Page 98	https://www.jstor.org/stable/41959961
11	Freedom of choice, ratio (F/M)	Column 6 / Column 7	HDI 2018- Table#14 -Page: 74 to 77	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
12	Feeling save, ratio (F/M)	Column 4 / Column 5	HDI 2018- Table#14 -Page: 74 to 77	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf

13	Gender Inequality Index	Column 1	HDI 2018- Table#5 - Page:38 to 41	http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf
14	Total score of I. V	Summation of the scores from item#1 to #14	All	N/A
15	I. Introduction to the variables	II. Methodology of measurement:	III. Reference (Page# and Table#)	IV. Data used:
16	Dependent Variables (Transformation)	For more info please read or click on the link:	(Page# and Table#)	Source link
17	Electoral democracy (1=lease free, 7 more free)	https://freedomhouse.org/report/freedom-world/2018/azerbaijan "search for each country"	Main page after then selection name of the country	https://freedomhouse.org/report/freedom-world/freedom-world-2018
18	Real GDP Growth Rate (10 yrs. average)	report the GDP growth rate for individual country	W.E.F.C.I. (2018)- Search for individual country and report the GDP growth rate in the main page	http://reports.weforum.org/global-competitiveness-report-2018/country-economy-profiles/#economy=AZE
19	Economic Performance (ranked out of 140)	http://reports.weforum.org/global-competitiveness-report-2018/chapter-3-benchmarking-competitiveness-in-the-fourth-industrial-revolution-introducing-the-global-competitiveness-index-4-0/	W.E.F.C.I. (2018)- search for individual country's ranking	http://www3.weforum.org/docs/GCR2018/01Frontmatter/4.%20Rankings.pdf
20	Unemployment rate (not good< 5%< good)	Report the unemployment rate for individual country	W.E.F.C.I. (2018) search for individual country	http://reports.weforum.org/global-competitiveness-report-2018/country-economy-profiles/#economy=AZE
21	Large scale privatization (Min=0, Max=4+)	https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country

22	Small scale privatization (Min=0, Max=4+)	<https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country
23	Governance and enterprise restructuring	<https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country
24	Price liberalization (Min=0, Max=4+)	https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country
25	Trade & Forex system (Min=0, Max=4+)	https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country
26	Competition Policy (Min=0, Max=4+)	https://www.ebrd.com/cs/Satellite?c=Content&cid=1395237866249&d=&pagename=EBRD%2FContent%2FContentLayout	E.B.R.D.T.I (2014)	Transition indicators by country
27	Structural reform (Min=3, Max=8)	https://2018.tr-ebrd.com/reform/	E.B.R.D.T.I (2014)	structural-reform.pdf?blobnocache=true
28	Total score for D. V	sum of item No. 17 to No. 27		

NOTE:

DEFINITIONS

Gender Inequality Index: A compound scale reflects the inequality in successes or achievement among [male/female] in few significances, like reproductive health, labour market, empowerment.

Maternal mortality ratio: Number of deaths of [pregnancy-related] per 100,000 live births.

Share of seats in parliament: section of seats held by females at national parliament declare as percentage of total seats. For the bicameral legislative procedure, share of seats measuring based on both houses.

Education Ratio: Percentage of the citizens of ages 25 and older which attain a secondary level of education.

Adult literacy rate: Percentage of the ages 15 or older that can understand [read/write] a simple statement on daily life.

Youth literacy rate: Percentage of the ages 15–24 that can understand [read/write] a simple statement on daily life.

Labor force participation rate: number of working-age citizenries [ages 15 or older] which employ in labor market, both by working or looking for work.

gross national income per capita: [female/male] economically shares. Isolated from the ratio of their wages.

Feeling safe: Percentage of respondents [yes] to the question of Gallup World Poll, [Do you feel safe to walking alone at night in the area where you are living or city?]

freedom of choice: Percentage of respondents [satisfied] to the question of Gallup World Poll, [In this country, are you satisfied/dissatisfied with the freedom to choose what you did/do with your life?]

Large-scale privatization: private ownership, schemes ready for implementation, enterprise assets, farm assets, advanced industrial economies.

Small-scale privatization: little progress, significant share privatized, privatizations of small companies within the tradable ownership rights, impressive tradability of land, performance of progressive industrial economies, neither state ownership of the small enterprises.

Price liberalization: Many prices controlled formally by government. Lifting of price administration, state procurement of non-market prices for the large product categories, complete price liberalization with non-price control outside of housing, natural monopolies, or transport.

Governance and enterprise restructuring: soft budget constraints, moderately credit, or subsidy policy, but weak implementations of bankruptcy legislation, strengthen competition and corporate governance. Substantial improvement and significant investments in the enterprise level, performance of advanced industrial economies, effective corporate controlling has exercised by markets, domestic financial institutions, which foster market-driven restructuring.

Trade and foreign exchange system: Widespread controlling of import/export, and limited legitimate or legal access to foreign exchange, liberalization of import and export controls, current account convertibility, removal of any administrative restrictions; significant export tariffs, direct involvements, and engagements in exports/imports through state-owned trading companies and ministries, no non-uniformity of the customs duties, removal of tariff barriers; WTO membership.

Competition policy: Competition policy legislation set many entry restrictions, enforcement acts, to diminish abuse of market power, to enhance a competitive environment.

Structural reform: Competitive, inclusive, well governed, normalization, resilient, integrated.

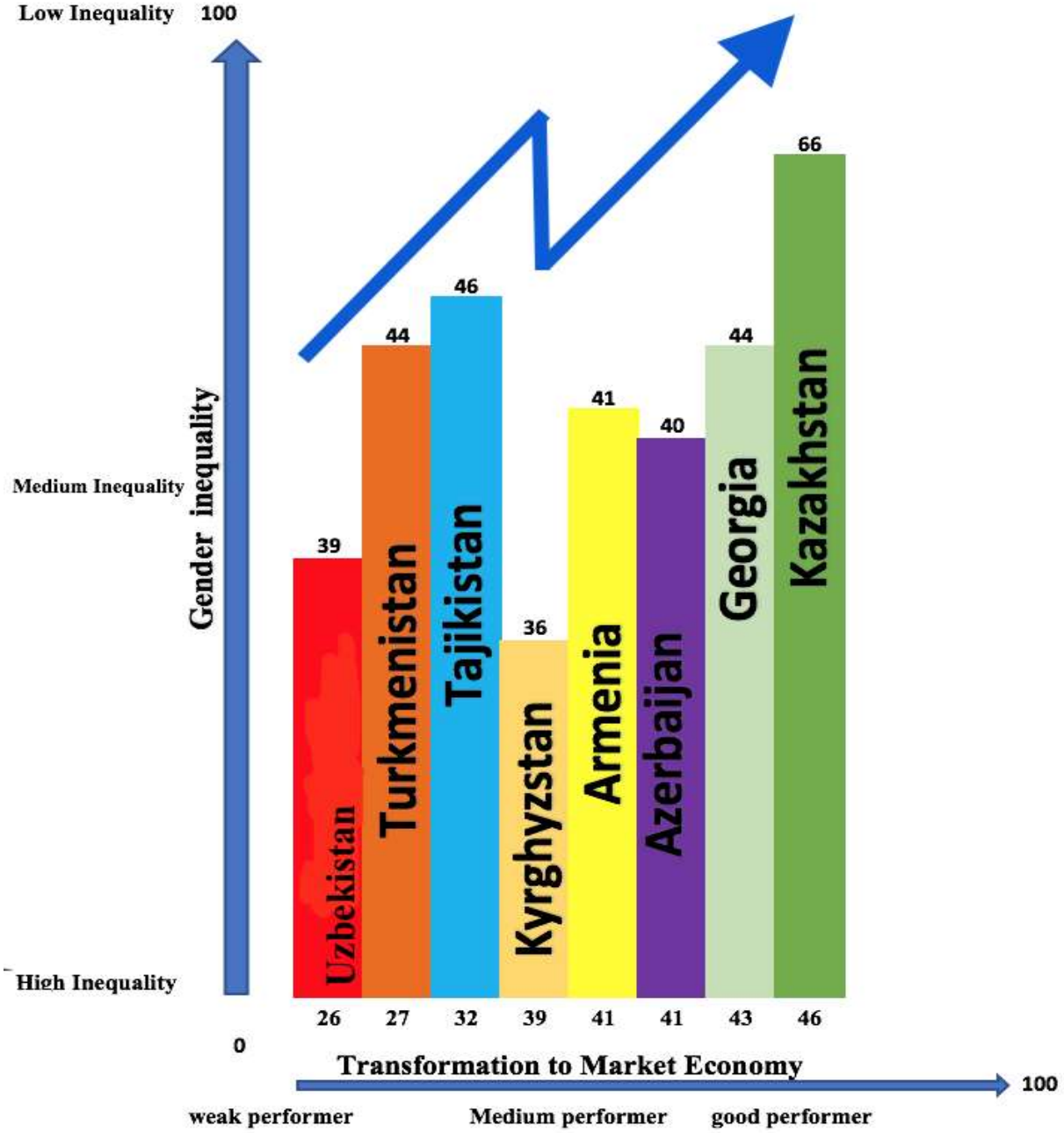
Electoral process: Political Rights, Civil Liberties, political participation, rule of law, functioning government, freedom of express, individual rights, organizational rights, personal rights.

Economic Performance, market competition, labor market, trade openness, financial system, property rights, checks and balances, social capital, public sector performance, security, transport infrastructure, corporate governance, macroeconomic stability, utility infrastructure.

Sex Ratios: Mystery of Missing Female Children in Caucasus, Birth order, first-born or second-born. Childbirth, Demography, Family planning, Sex preselection, Reproductive health, Within the framework of (WHO) definition of health as a complete physical, mental, or social well-being, not absence of disease or inability, infirmity, sex ratios skewed by the age of mother at birth, sex-selective abortion, Low fertility. (HDI. 2018)

2.1. ANALYSIS (Appendix.1, Descriptive statistics)

Graph. 1: Bivariate analysis -Gender Inequality Vs Sustainable transformation in CAC)



Discussion.1 (CAC region):

According to the Appendix1,2. graph 1, the results shows that there is a negative correlation between the "gender inequality" and "Sustainable development progress" in the transition countries of CAC region. The Lower the gender inequality gap the higher will be the sustainable development progress of that economy and vise-versa. Which also means that' the higher gender "equality" score associated with a higher sustainable development score. And lower gender equality gap also associated with weaker sustainable development progress, For example:

1. Kazakhstan: According to the Appendix1,2. graph 1. & (HDI. 2018)

Kazakhstan with highest gender equality score "66" (lowest gender inequality) in the region, hold a highest score (46) in sustainable development progress as well. Which means that Kazakhstan was good a performer in closing the gender inequality gap which leads to become a good performer in sustainable development of the economies in the region as well.

Despite being a leading performer in the region, Kazakhstan sustainable development of the economy was harmed by persistence of gender inequality in the following way:

"Share of female graduates in science, mathematics, engineering, manufacturing and construction"**.** If Kazakhstan manage to close this gender gap, could become more successful in her sustainable development of the economy comparing to its status quo.

2. Georgia: According to the Appendix1,2. graph 1. & (HDI. 2018) Georgia scored 44 in gender inequality which is the 3rd highest (gender equality) in the region and scored 43 in Transformation which is the 2nd highest in the region after (Kazakhstan). Which means that Georgian good progress of transformation to the market economy in the region is also can be described by her lower gender inequality in the region.

Based on the (Table1) of analysis, the Georgian sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. "women share of parliament/government ministers, 2. Annual average income, 3. discrimination in hiring, and 4. sex ratio preference". If Georgia managed to close this gender gap it could have a more successful and sustainable economic development comparing to its status quo.

3. Azerbaijan: According to the Appendix1,2. graph 1. & (HDI. 2018) Azerbaijan scored 40 in "gender inequality" which is the medium position (4th) in the region and scored 41 in "sustainable development of economy" which is the 3rd highest in the region after Kazakhstan and Georgia. Which means that Azerbaijan's medium progress of sustainable development of the economy in the region can be described by her medium gender inequality gap in the region.

Based on the (Table1) of analysis, the Azerbaijani sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways:1. "women share of parliament/government ministers, 2. Participation in labor force, 3. Political choice and electoral opportunity, 4. Gross annual income ratio, 5. sex ratio preference and 5. Feeling Unsafe". If Azerbaijan manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

4. Armenia: According to the Appendix1,2. graph 1. & (HDI. 2018) Armenia scored 41 in "gender inequality" which is the medium position (4th) in the region and scored 41 in "sustainable development of economy" which is almost as same as Azerbaijan performance in the region. Which means that Armenia's medium progress of sustainable development of the economy in the region can be described by her medium gender inequality gap in the region.

Based on the (Table1) of analysis, the Armenian sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. "women share of parliament/government ministers, 2. Participation in labor force, 3. Share of female graduates in science, mathematics, engineering, manufacturing and construction, 4. sex ratio preference and 5. Gender discrimination in hiring". If Armenia manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

5. Kyrgyzstan: According to the Appendix1,2. graph 1. & (HDI. 2018) Kyrgyzstan scored 36 in "gender inequality" which is the lowest gender (Equality) rate in the region and scored 39 in "sustainable development of economy" which is lower medium in the region after Kazakhstan, Georgia, Azerbaijan and

Armenia. Which means that Kyrgyzstan's less medium performance on progress of sustainable development of the economy in the region can be described by her higher gender inequality rate in the region.

Based on the (Table1) of analysis, the Kyrgyz sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. "women share of parliament/government ministers, 2. Participation in labor force, 3. Gross annual income ratio, and 5. Gender discrimination in hiring". If Kyrgyzstan manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

6. Tajikistan: According to the Appendix1,2. graph 1. & (HDI. 2018) Tajikistan scored 46 in "gender inequality" which is the 2nd highest gender (Equality) rate in the region and scored 32 in "sustainable development of economy" which is the 3rd lowest in the region after Uzbekistan and Turkmenistan.

Based on the (Table1) of analysis, the Tajikistan sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. Participation in labor force, 2. Political choice and electoral opportunity, and 3. Share of female graduates in science, mathematics, engineering, manufacturing, and construction". If Tajikistan manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

7. Turkmenistan: According to the Appendix1,2. graph 1. & (HDI. 2018) Turkmenistan scored 44 in "gender inequality" which is in the medium range in the region and scored 27 in "sustainable development of economy" which is the 2nd lowest in the region after Uzbekistan.

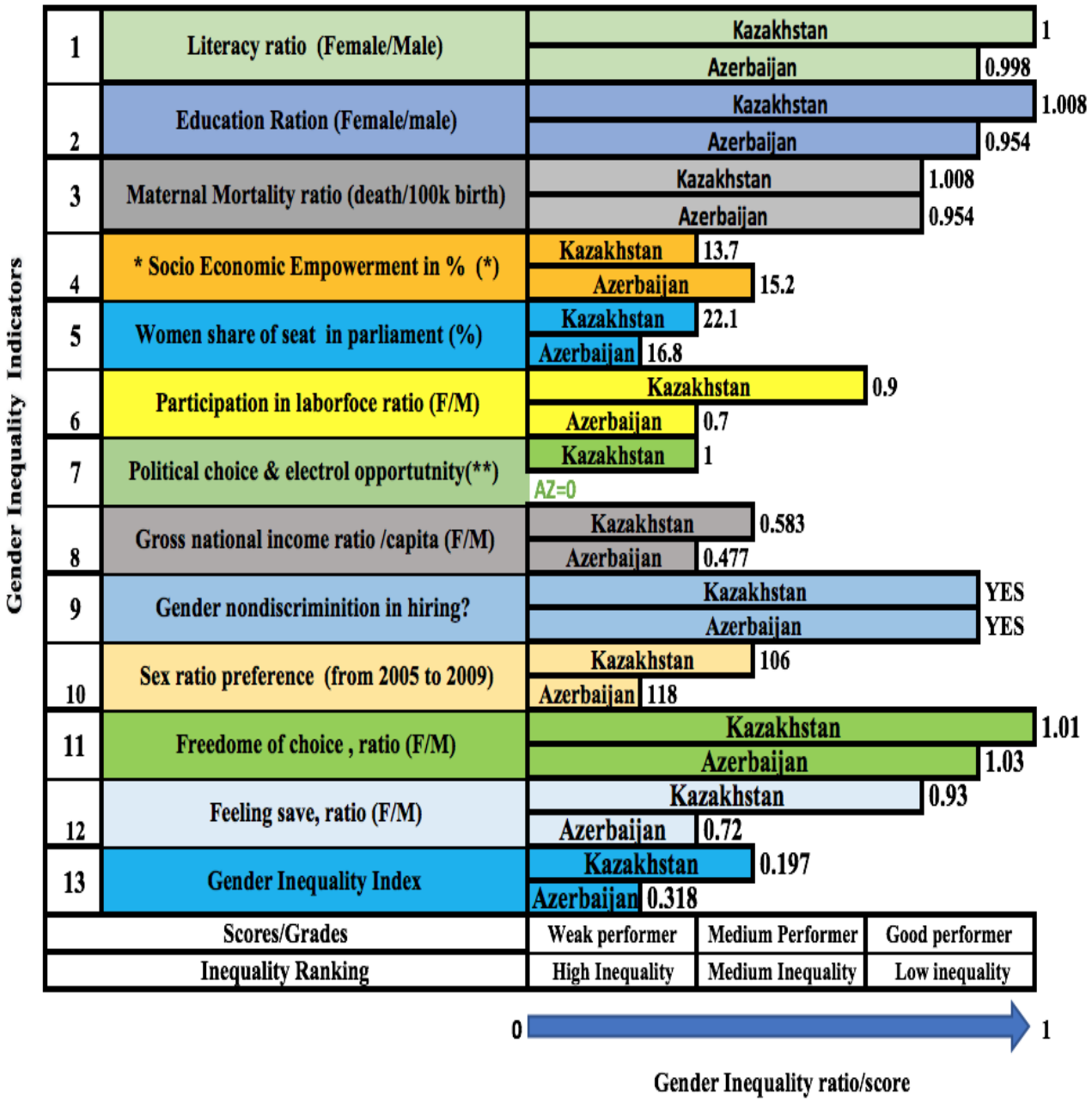
Based on the (Table1) of analysis, the Turkmenistan sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. Participation in labor force, 2. Political choice and electoral opportunity, 3. Share of female graduates in science, mathematics, engineering, manufacturing, and construction, and 4. Gender discrimination in hiring". If Turkmenistan manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

8. Uzbekistan: According to the Appendix1,2. graph 1. & (HDI. 2018) Uzbekistan scored 39 in "gender inequality" which is the 2nd highest gender inequality or the 2nd lowest in gender (Equality) rate in the region and scored 26 in "sustainable development of economy" which is the lowest in the region. Which means that Uzbekistan's weaker performance on progress of sustainable development of the economy in the region can be described by her higher gender inequality rate in the region.

Based on the (Table1) of analysis, the Uzbekistan sustainable development of the economy was mainly harmed by persistence of gender inequality in the following ways :1. Participation in labor force, 2. Political choice and electoral opportunity, and 3. Share of female graduates in science, mathematics, engineering, manufacturing, and construction, 4. Gender discrimination in hiring, and 5 women share of parliament/government ministers.". If Uzbekistan manage to close this gender inequality gaps in the mentioned areas, it could have a more successful and sustainable economic development comparing to its status quo.

Discussion 2: Country specific (**Azerbaijan Vs Kazakhstan):** referring to Graph 2 below, if we compare these 2 countries in the region, we see that there is we can find that Azerbaijan was less performed well comparing to Kazakhstan in lowering the gender inequality gap in literacy; education; maternal mortality; women share seat in parliament; participation in labor force; political choice and electoral opportunity; gross national income per capita, sex ratio preference, freedom of choice , feeling save and overall gender inequality ratio. Azerbaijan was only ahead of Kazakhstan in "socio economic empowerment indicators" by having 1.5 percentage point more than Kazakhstan. In General, Kazakhstan scored with 66 points and Azerbaijan scored 40 points in total of Gender Inequality competition, which means that –

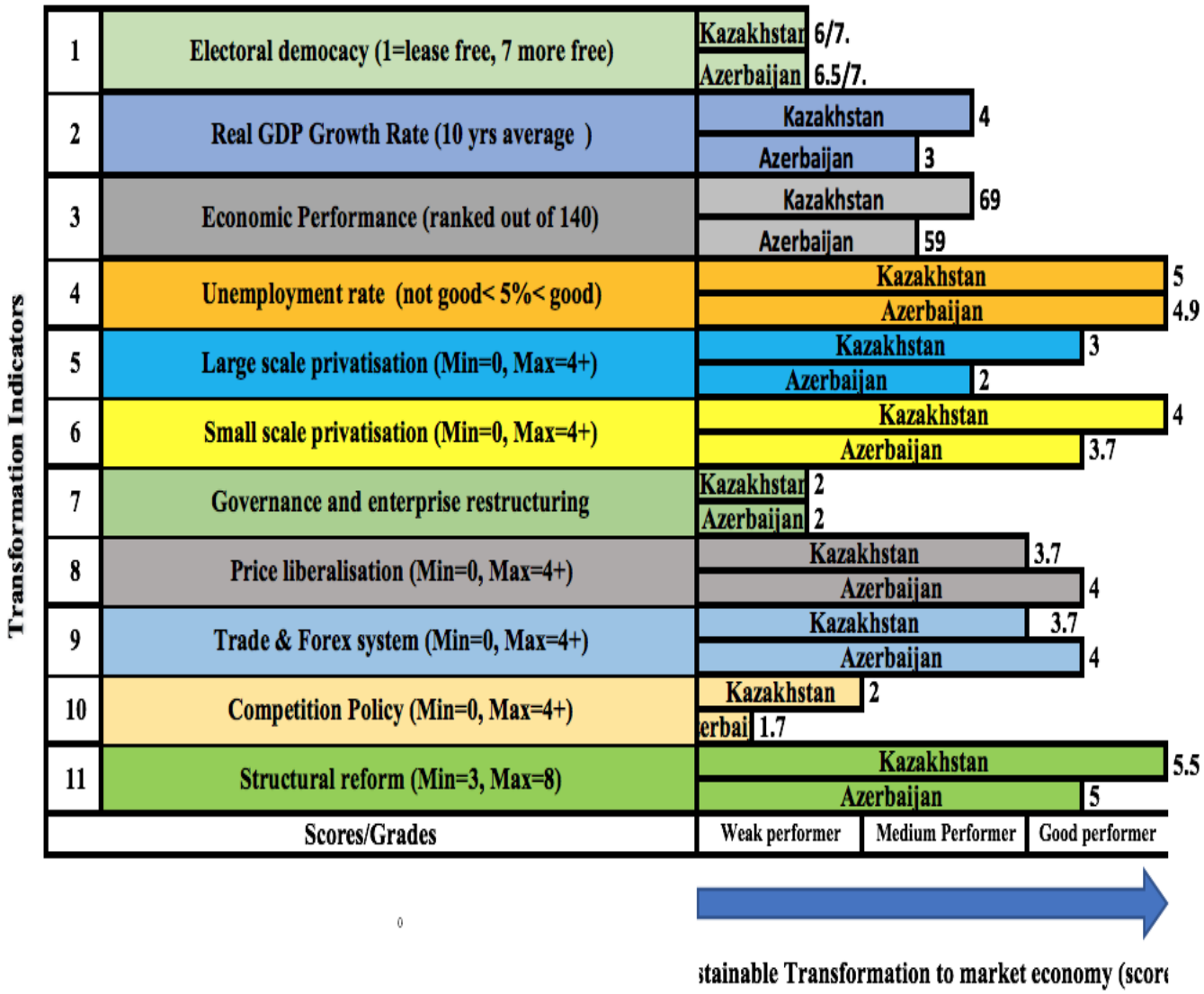
2.2. Graph 2. Univariate Analysis- Gender Inequality (Azerbaijan Vs Kazakhstan)



Kazakhstan performed 40% better than Azerbaijan in lowering/closing the gender inequality gap. This success of Kazakhstan in lowering the gender inequality gap is also correlated with another success in sustainable development of its economy. Referring to Graph.1, Kazakhstan scored 46 and Azerbaijan 41 in sustainable development of the economy, which means that Kazakhstan is performing 11% point better than Azerbaijan.

If we look at Graph 3 below, even though Kazakhstan's overall performance is higher than Azerbaijan, but still Azerbaijan was performing better in price liberalization; and trade and forex system comparing to Kazakhstan.

2.3. Graph 3. Univariate Analysis- Sustainable Transformation (Azerbaijan Vs Kazakhstan)



- Differences in "Gender Inequality"
  Score = Kazakhstan – Azerbaijan = 66 - 40 = **26**
- Difference in "Sustainable Economic Development"
  score= Kazakhstan – Azerbaijan = 46 – 41 = **5**
- Differences in Sustainable Economic Development / Differences in Gender Inequality: 5/ 26 = **0.2**

As a result, we can sum-up that; Increasing one unit in overall "gender Inequality" in Azerbaijan will be associated with an overall decrease of 0.2 unit in sustainability of economic development of Azerbaijan comparing to Kazakhstan, keeping all other variables constant.

- 0.2 x 100 = 20%

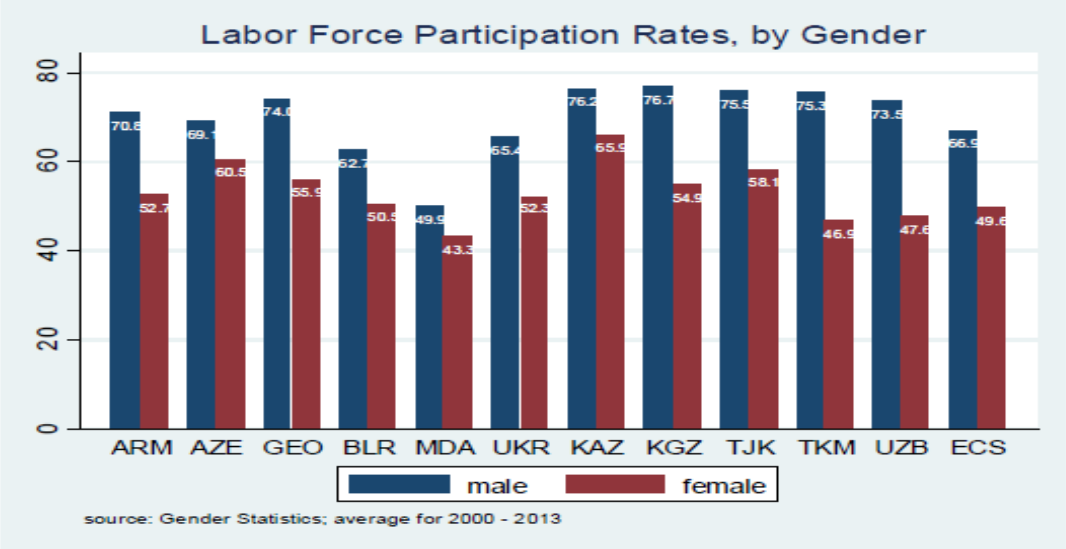
If we interpret the result in percentage %, we can say that "If Azerbaijan close the gender inequality gap, the economy will expand up to 20%.

3.1. AZERBAIJANI CASE

The government of Azerbaijan considers gender inequality as a major problem for sustainable economic development. Gender inequality threatens the sustainable development of the country.

Figure 1 indicates the labor force participation rates of post-Soviet countries. Azerbaijan is the second country after Moldova with the least gender difference in labor force participation. From the numerical point of view, this might be considered as good progress for gender equality issue. However, an increase in the number of employed women cannot hinder the discrimination and unequal behavior towards women. "To determine gender inequalities some factors as legislative frameworks protecting the economic rights of various gender groups, institutional mechanisms, gender segregation (over/under-representation of men and women in different sectors of the economy and different levels of career hierarchies), gender pay gap, access to an opportunity to freely use economic resources, for example, land, real estate should be taken into account ". (UNFPA/UNDP 2015). **Figure 1.**

Labor Force Participation Rates, 2000–2013



3.2. LEGAL FACTORS

According to Azerbaijani legislation, men and women have equal rights to work, equal payment for the same job, equal rights to have a property or to be landowner, and equal rights to have entrepreneurial activity. The constitution of Azerbaijan Republic forbids any kind of gender-based discriminative act. However, there are some loopholes in the law on Gender Equality. The law of the country based on a neo-patriarchal model and set the rules with traditional gender-based responsibilities. For instance: the labor legislation prohibits to work pregnant women, mothers with underage children, breastfeeding women, and single fathers raising children aged below three. This kind of legal approaches makes women undesired as a labor force for employers and in this case, men become officially more qualified labor force with all kinds of opportunities. Another gender-based legal issue is paternity leave, it is 14 days long and unpaid. Unpaid two weeks can never seem attractive to fathers and usually not used by them either.

3.3. DECISION MAKING AND GENDER PAY GAP

Men in Azerbaijani society is considered as a breadwinner and a main financial supporter of their household. "Income distribution, access to resources and having the opportunities to use them depends on the balance of gender relationships in the family." (UNFPA/UNDP 2015). The income of the women also regulated according to family rules and bans. In Azerbaijan, women are not considered decision makers in the family relations usually men say the last word. This situation affects the status of women without regarding if they are employed or unemployed. The main role of the women is considered mother, housewife briefly to say a person who is mainly responsible with all houses works.

A dependent and weak status of women is not limited to family relations. Women in Azerbaijan are not actively taking a part in the decision-making process neither within society nor in the state level. Figure 2 indicates the number of women in managerial positions in 2016 and 2017 years. As seen from the numbers of 2016 -2017 report only a few women work in the managerial positions in Azerbaijan. The only woman minister of Azerbaijan is Minister of Culture and Tourism of Nakhchivan Autonomous Republic. Generally, women are not active in the economic and political life of the country.

Figure 2:

4.23. Rəhbər vəzifədə çalışan qadınların sayı, nəfərlə
Number of women in managerial positions, person

	2016	2017	
Vitse-prezident	-	1	*Vise-president*
Qadın nazir[1)]	1	1	*Women Minister[1)]*
Qadın nazir müavini	3	3	*Women Deputy Minister*
Qadın Dövlət Komitəsi sədri[2)]	2	2	*Women Chair of State Committee[2)]*
Qadın Dövlət Komitəsi sədrinin müavini	2	3	*Women Deputy of Chair of State Committee*
Qadın Yerli icra hakimiyyəti başçısı[3)]	1	1	*Women Head of local Executive Authority[3)]*
Yerli icra hakimiyyəti başçısının qadın müavini	79	77	*Women Deputy head of local Executive Authority*
Ombudsman[4)]	2	2	*Ombudsman[4)]*

In most countries in the world, including Central Asian and Caucasian states, the wage gap exists. As the main reason for that is shown maternity leave. For example, a man and a woman when they start a job in the same company in the same position, they get the same wage. When a woman takes maternity leave, but the man continues his job. After maternity leave, a woman continues her career, but she does not get the same wage as her male counterpart. Long maternity leaves mean women end up with less experience and weak portfolios compare to men. With these regards, women will never be able to reach her male counterpart in the career and be as successful as him. It means that this will always result in the gender pay gap. Since women are more likely to get less employed and get less paid for doing the same job discourages women from participating actively as a workforce.

In Azerbaijan, the gender pay gap is mainly related to gender-based stereotypes. Girls in Azerbaijan are usually directed to build their career in three main sectors: Education, health care, and social sphere. According to Azerbaijani mentality, women need a job which will also leave time for family care. Teachers in secondary education system mainly are women and these jobs are low paid.

This leads to unequal distribution of labor force and pays gap. Men in Azerbaijan are usually in managerial positions and are decision makers almost in all levels from local municipalities and to ministries. (State Statistical Committee, S. S.2018)

3.4. GENDER EQUALITY AND WOMEN'S EMPOWERMMENT

The fundamental role of a woman and the need of the [equal/full] participation or leadership in any sphere of sustainable development, to accelerate the implementation of commitments in the convention on the elimination of any types of discrimination against women, as well as the UN Millennium Declaration.

Although the progress on gender equality, the potential of females to engage in, contribute/benefit from sustainable development as participants, owing to, economic, social, and political inequalities. United Nations reinforce measures to boost gender equality in all areas of societies, consisting of removal of barriers to their equal participations in management and decision-making, and accentuate on the setting distinguish targets, as appropriate, with the aim of achieving gender parity, raising the number of females in leadership statuses or positions.

The potential of women manifested as drivers of sustainable development by United Nations, encompasses removal of formal barriers and repeal of discriminatory laws, insisting equal access to legal or justice support, reform of institutions to certify and convince competences, capacities and inclusions for gender mainstreaming although adoption of innovative or peculiar approaches to administer harmful practices which operate as obstacle to gender equality, entrusting to beget authorizing environment for enhancing the occasions of females, especially in local communities and rural domains among ethnic minorities, United Nations develop virtually the collection, analysis, erosion, sex-disaggregated data in policy, use of gender-sensitive indexes or indicators and monitor of frameworks, in a settlement of national circumstances, to deliver the covenant of sustainable development actively. Promoting the equal accessibilities of women to education, reproductive health, health-care services and any other basic services, or accessibilities to safe, affordable, and acceptable methods of family planning universally. Resolving to undertake or respond administrative reforms and legislative to extend admitting men/women equal rights toward economic resources, ownership, credit, natural resources, control over land, new technology and property. Deposing the equal opportunities in economic, political decision-making and different resource allocation also the dispelling impediments which deter women from taking part in economy. United Nations reaffirming commitment to the implementation of the [Program of Action of International Conference on Population].

- United Nations distinguishing that gender equality and the women's effective participations are essential to advantageous actions of all spheres of sustainable development. The Empowerment of Women (UN-Women), United Nations Entity for Gender Equality, in cultivating women's empowerment and gender equality, with the linkages of promotion of sustainable development. By reliance the work of UN-Women in coordinating and leading, enhancing the accountabilities of UN system. Moreover, international organizations, international financial institutions, private sector, regional banks, to integrate entirely considerations on gender equality, to ensure the women's participation in decision- making and to play a supportive role in accordance with the national legislations in implementation, program planning and budgeting. (United Nations, General Assembly, A/RES/66/288*, 2012).

RECOMMENDATIONS

- key government agencies direct and execute a comprehensive monitoring for implementation of the laws and policies on gender equality, composing of Equal Rights Law.
- Boost female's meaningful participations in the government discussions, schemes, decision-making, projects also implementation of the infrastructure projects.
- Boost the beneficial strategies and methods, in which [male/female] could get equally benefit, which lead to the further outcomes for the whole society.

- Boost positive image of females in the "nontraditional" zones such as education, business, politics, culture, medicine, and arts, which the media should propagate and spread success stories concerning women in the various segments to counter gender inequality or stereotypes.
- Boost executing agencies by supporting, funding, awarding, encouraging for dissemination of female's success stories.
- Boost and facilitate the entry/reentry possibilities into workforces for females within children, consisting of affordable childcare, re-training facilities, flexibility of work schedules. Measures encouraging [male/female] to manipulate equalization of gender norms even responsibilities in family gathering and employment practices which breed and develop a balance in both professional and private life.
- Labor migrating on varied opportunities specially on economic status and [positive/negative] impacts on males who migrate, while both [male/female] should appropriating and benefiting to the responsive of community needs.
- Boost a compulsory educational order to identify gender inequality and stereotypes in the curriculums, textbook reform, teaching materials, and teacher trainings. Although Identifying barriers to male teaching careers and encourage them to remain in education field.
- Punishes and penalize the gender-based violence, and provides funding for preventions, prohibitions, protection services and shelters for the victims.
- NGOs and other organizations should accomplish activities that raise awareness domestically and abroad. Assess to represent women stakeholders.
- Supporting factors which contribute to the success of businessmen, businesswomen. female entrepreneurs must expand their small-scale businesses. Reduce barriers to women entering in sectors like (manufacturing and information technology) that including competition, lack of knowledge, lower deployment on value chains.
- Boosting women's knowledge concerning loan requirements, risks, interest rates and contractual obligations, also reducing the female's fears of borrowing.
- Boosting women collaborations in the infrastructure development projects, water supply, environmental organizations, energy sector, renewable energy initiatives or energy technologies, and recycling programs.
- harmonization of Anti-Discrimination Law, Introduction of specific measures or actions in recruitment of male/female from minorities in the public institutions. Participation in the organized sports, women non-participation due to (lack of childcare, time, safe or lack of appropriate facilities, etc.).
- Engaging in gender equality especially for stakeholders, to viewing gender as only female's empowerment, or perceptions of masculinity should be as a high priority on gender norms. gender equality aims to improving the advancement of [male/female] engagements in political, social, economic and many other spheres.

FINDINGS

- Today majority of the society are educated, using varied technologies, having access to goods and services. Even people in less human development societies increasingly improving. Being longer in school are not translating to equivalent skills or equivalent capabilities. So, focus on the human development would be more essential in monitoring progresses and sustainability in future.
- Development is not guaranteed, crises, challenges, and conflicts reverse gains. Investments in the human securities to breakdown and setback of conflicts and vulnerabilities to sustain progresses and developments.
- Disaggregated assessments disclosing that the high inequalities toward human development. high inequalities are the substantial challenge to sustaining upcoming development.
- Disparities amongst [male/female] as a greater barrier to progressions or developments, holding reverse half even majority of the world's population.
- Each human life is valuable, each human being is countable, universalism is the principle concept

of sustainable development or human development. Sustainable development promises and goals that leave no one behind, universal perspectives are critical and crucial, as exclusive in the universe which unsustainability, inequality and unitability is growing.

- The research exploring [male/female] gender norms, beliefs, roles, rights, and conceptions of reproductive health-related intentions (son preference) or sexual, early marriage, household relationship dynamics, family planning and intimate partner violence.
- Rigid conceptions of gender are pervasive. entrenched in the minds of entire people. Mostly men in CAC regions are more likely agreeing with the rigid or traditional concepts of gender. Masculinity associated with the man's ability to assistance or support financially his family.
- Vast majority men are skeptical of women's rights or gender equality, overall, males than females were more likely stating negative attitudes concerning promotion of women rights.
- Majority of women still do care work, but men's participations of all caregiving works are lower. Over half of males ought to share housework and seek to providing care of children as important as financially providing. also, men's participation is not fulfilling as father if they are solely limited to economic roles. Over one third of men spend little time with their children due to work.
- Witnessing violence against family members (mother/sister.), experiencing the physical violence in childhood, large number of women tolerate violence due to keep or preserve her family together. Economic stress, and who have been depressed or stressed of not owning enough income or having much more works, use further violence. Also, lesser levels of the education more likely use violence. Only about 60% of male/female are aware of domestic violence laws.
- Traditional prospective of gender norms or roles remained strongly, woman's major tasks are taking care of kids, raise children, taking care of households or household chores, while men supporting financially. Although females 30% supporting financially, too easier, or appropriate works for females, if necessary. Also, women are required to be obedient to their husband and allowing him to behave and have a leading position. since women can raise children, suited to teaching or guiding roles, men are more active, having influential spirit or fighting spirit, they are better deserving for political positions and many other related posts consist of leadership skills, commanding or decision-making abilities. women mostly tolerated her husband's insults to preserve her family to devote her the tolerant, obedient and gentle person. Which reinforced the conception that divorce is dissolution for the family.
- Meaning and knowledge of gender equality, not supported publicly, majority of people are in favour of distribution of gender norms or roles traditionally. In which men can be the better business leaders rather women, politics are the men's business, also better at any other work. However, areas relevant to the women's nature is healthcare and culture.
- Numbers of data stated that females are not encouraged or motivated to involved in politics actively. Moreover, Women notice and perceive themselves rare in politics and more in business, also data shows that acceptable attitudes or virtues for women are the kindness and faithfulness to their families, while men should be the family's breadwinner. majority of citizenry heard about gender equality if gender equality does not achieve in some regions. Minor of them were in favor of quota orders and systems.
- Gender gap will still require large times minimum 10 decades to achieve full or high parity at this current speed and step. The report highlights the message to policymakers that countries that want to remain competitive and inclusive will need to make gender equality a critical part of their nation's human capital development. Learning amongst societies and (public/private) cooperation would be the critical elements of ending the gender gap

CONCLUSION

In this paper, we studied broadly the relationship between the gender inequality and sustainable development of transition economies in CAC region. We hypothesized 13 gender inequality ways which can harm the sustainable development of transition economies in CAC region. Out of our 13 claims for the

following 5 of them such as inequality in literacy; inequality education; maternal mortality rate; and inequality in freedom of choice; inequality in security, we find NO evidence to support our hypothesis rather, we do find that they were supporting the sustainable development of transition economies instead of harming.

Moreover, we found that; Gender inequality in "women share seat in parliament/government cabinet; participation in labor force; political choice and electoral opportunity; gross national income per capita; sex ratio preference; freedom of choice; gender discrimination in hiring; Share of female graduates in science, mathematics, engineering, manufacturing and construction" were the ways which harmed the sustainable transformation of transition economies in different levels in CAC region. Some or combination of them harmed Uzbekistan the most and Kazakhstan the least.

At the end of paper, we compared Azerbaijan and Kazakhstan economies against the effect of gender inequality and Our findings suggest that:

Increasing one unit in overall "gender Inequality" in Azerbaijan will be associated with an overall decrease of 0.2 unit in sustainability of economic transformation of Azerbaijan comparing to Kazakhstan, keeping all other variables constant. If Azerbaijan close the gender inequality gap, the economy will expand up to 20% comparing to status-quo.

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Enhancing Oil Recovery: Evaluating the Effectiveness of Polymer Injection in the Patos-Marinza Oilfield Using ResInsight Simulations

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Abstract – With the continuous increase in global demand for oil as one of the main sources of energy, it is essential to work to maximize oil production. One of the most applied chemical methods for increasing production in the oil industry is polymer injection. This way is a technique that aims to increase the viscosity of the water being injected to move more oil towards the production wells. The purpose of this study is the effectiveness of polymer injection in displacing oil compared to water injection and the influence of reservoir characteristics on formation sweep efficiency, including reservoir porosity and permeability. The resulting flow patterns after polymer injection exhibit several physical effects, such as: chemical adsorption, reduction of permeability and effective viscosity of the polymer solution, change of capillary pressure and change of relative permeability. The presentation of the injection scheme and the production curves were realized with ResInsight (Post Processing of Reservoir Simulations). The data for this work were obtained from the oil company Bankers Petroleum Albania Ltd. The results achieved by the injection of polymers are satisfactory because they ensure a high oil recovery coefficient at low cost in the Patos-Marinza oilfield, demonstrating a more efficient oil recovery.

Keywords – Polymer solution, Patos-Marinza oilfield, reservoir simulation, oil recovery

1. Introduction

The Patos-Marinëz oilfield is located in the central-southern part of Albania. It has been evaluated to be the largest land resource in Europe with geological reserves, discovered in 1928 by APOC (Anglo Persian Oil Co.). The production in this place until February 2014 was estimated at 3198 m^3/day from 450 active wells. [2] There are four main oil-bearing formations in this field: Gorani, Driza, Marinza and Bubullima. The Driza formation at a depth of 1200-1450 m is the largest hydrocarbon reservoir in the Patos-Marinez oilfield. Polymer injection was applied for the first time in Albania by the Bankers Petroleum company in 2013 in the Lower Driza and Marinza formation.[2] The results obtained were encouraging, because the production increased by 4.7% compared to the previous production. The main mechanism of polymer injection is that the dissolved polymer molecules increase the viscosity of the solution and enable the movement of water to push more oil through the reservoir. The polymer can be adsorbed on the surface of the reservoir rock, depending on the type of polymer, rock properties and solution, which will reduce the porosity and permeability of the reservoir rock formation [3]. Furthermore, the dilute polymer solution is in most cases pseudoplastic and therefore has lower viscosity near the injection wells where the fluid flow

rate gradient is high. Injection of polymer into the coating is considered a technology with well-proven results and relatively low economic and technical risks.

Figure 1: Polymer molecules dissolved in water. [3]

The molecules, illustrated in Figure 1 as black lines, are fully stretched and entangled with each other to increase the viscosity of the aqueous solution.

Polymers are chemical compounds of large molecular weight, consisting of repeating structural units, called monomers, linked together by covalent chemical bonds. [3, 21] They are in two main forms: biopolymers (polysaccharide) in powder form, while synthetic polymers such as partially hydrolyzed polyacrylamides consisting of straight flexible synthetic chains of acrylamide monomers are either powder or microemulsion.

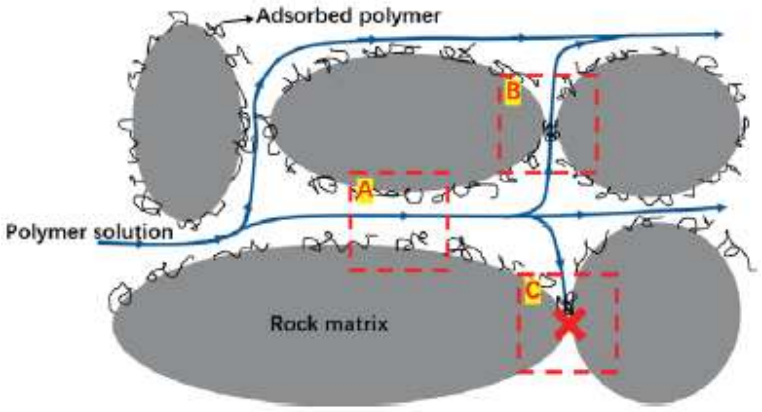

Figure 2: Illustration of polymer sorption in porous media [3]

The polymer molecules, shown in Figure 2 as black twisted lines, are attached to the surface of the rock particles. The blue lines and arrows indicate the flow path and direction of the polymer solution. [3, 21] The three zones A/B/C correspond to the absorption of the polymer solution after passing through pores of different sizes and their effects on the subsequent flowability. Zone A: Adsorbed polymer molecules causing increased flow resistance. Zone B: Molecules mechanically trapped by hydraulic cracks. Zone C: Molecules trapped by physical barriers.

The types of polymers mostly used in the petroleum industry are partially hydrolyzed polyacrylamide. Bankers currently uses Floopam 3630S polymer due to its low cost.

1.1 Scheme of injection of polymer solution

Injection schemes are mainly composed of one injection well and two production wells, illustrated in the figure below:

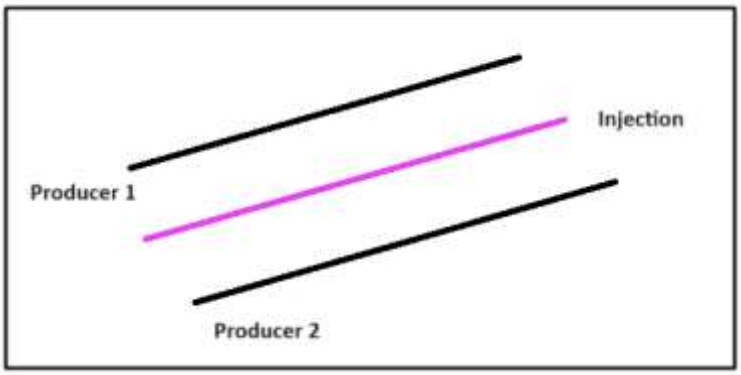

Figure 3: Polymer injection scheme PIP [2]

The parameters taken in the study are the elements of a trace (pattern). In the specific case PIP (Producer Injector Producer) These parameters are:

- Production (water/oil) of the first well $\mathbf{P_1}$
- Production (water/oil) of the second well $\mathbf{P_2}$
- Water + polymer Injected **I**
- Injection pressure $\mathbf{P_{inj}}$
- Injection start time **T**

1.2 Creation of the polymer solution

The polymer solution is created in a treating plant that is designed for this purpose. The plant serves to mix the powdered polymer with water thus forming a viscous liquid - with certain parameters based on the technical specifications for injection into the reservoir. [2, 9] The apparatus for the preparation of the polymer solution is composed of a mechanical agitator. Careful preparation of the polymer solution should avoid precipitates and guarantee a perfect flowing liquid. The following figures show the polymer solution preparation plant as well as the injection wells:

Figure 4: Polymer solution preparation and dilution unit (author)

Figure 5: Injection wells in the Patos-Marinez oilfield, Albania

1.3 Reservoir simulation problem formulation

The modeled reservoir includes petro-physical characteristics that can be adapted to understand the behavior of fluids in the reservoir under specific conditions. [3] Some of the parameters that can be adjusted to control polymer injection include: polymer concentration, viscosity, porosity, and reservoir permeability. [8, 21] ResInsight contains modules that provide various applications including enhanced oil recovery. It allows the user to use different calculation methods and change any parameter. Computational methods can be used to calculate saturations, pressures and the time required to run the simulation. From a mathematical point of view, reservoir simulation consists of partial differential equations and algebraic equations. [21] The partial differential equations are derived from the law of conservation of mass, momentum and energy while the algebraic equations describe the thermodynamic properties of the reservoir fluid and rocks. ResInsight will be the tool used in this work to evaluate fluid behavior over time for polymer injection. [3] The effect of some of the reservoir characteristics, such as porosity, permeability and saturation, will be tested to see how these parameters affect oil production.

2. Methodology

It is assumed that the fluid in the tank is in a state of local thermodynamic equilibrium and therefore the number of mass conservation equations will be equal to the number of fluid components. [4, 21] The simulation of the injection process of chemically processed waters requires an additional equation to describe the distribution of the concentration of the chemical.[8] The reservoir contains hydrocarbons that consist of different components that can be found in gaseous or liquid phase as well as both together.[4] Although, in many cases one or twodimensional (1D or 2D) fluid flow modeling is sufficient to predict the dynamic behavior of a reservoir.

In this case study, the movement of the polymer in the porous medium can be taken as a typical case of the multiphase model and assumed to be insoluble in oil. According to the law of conservation of mass, the equation can be presented in the following form: [8]

$$\frac{\partial}{\partial t}\left(\Phi S_w C_p + \rho_r(1-\Phi)C_a\right) = div\left(\hat{D}gradC_p - C_p\overrightarrow{V_w}\right) - q_w * C_{pi} \qquad (1)$$

Where:

C_p – Concentration of polymer in solution (kg/m^3)

ρ_r – rock density, (kg/m^3)

ρ_w– water density,

ρ_o– oil density

D – Dispersion coefficient, (m^2/day)

V_w – velocity in the liquid phase, (m/day)

C_{pi} – polymer concentration in produced water (kg/m^3)

C_a- polymer absorption

Φ- porosity, (fraksion)

S_w- water saturation

S_o- oil saturation

∇P– pressure change, psi

k_{rw}– relative water permeability, (md)

k_{ro}– relative oil permeability, (md)

The speed according to Darcy's law is given in equation (2)

$$\overrightarrow{V_w} = -\frac{kk_{rw}}{\mu_{p,eff}R_{kw}}(\nabla P - \rho_w g \nabla H) \quad (2)$$

For the injection of the polymer, the dispersion can be neglected because it has little influence on the oil extraction, therefore the equation will take the form: [4, 21]

$$\frac{\partial}{\partial t}\left(\Phi S_w C_p + \rho_r(1-\Phi)C_a\right) = -div\left(C_p\overrightarrow{V_w}\right) - q_w * C_{pi} \quad (3)$$

Since the polymer has an effect only on the water and oil phases, this means that the water and oil equations are modified in the form: [4, 8]

$$\nabla\left(\left(\frac{kk_{ro}}{\mu_o R_{ko}} + \frac{kk_{rw}}{\mu_{w,eff}R_{kw}}\right)\nabla P_o - g\left(\frac{\rho_o kk_{ro}}{\mu_o R_{ko}} + \frac{\rho_w kk_{rw}}{\mu_{w,eff}R_{kw}}\right)\nabla H\right) - \tilde{q}_{w+o} = \Phi C_f \frac{\partial P_0}{\partial t} \quad (4)$$

$$\nabla\left(\frac{kk_{ro}}{\mu_o R_{ko}}\nabla P_w\right) - g\nabla\left(\frac{\rho_w kk_{rw}}{\mu_{w,eff}R_{kw}}\nabla H\right) - \tilde{q}_w = \Phi\frac{\partial S_w}{\partial t} \quad (5)$$

Equation (4) and (5) present the theoretical model of polymer transport in the porous medium.

3. RESULTS AND DISCUSSIONS

For the reservoir defined by the contours of the studied area with dimensions of 2600x2000x90 meters, it is divided into separate blocks according to a new grid with dimensions of 35*35*9.

Cell size
X: 10
Y: 10
Z: 10

The results obtained from the simulation of the source are compared with the real data recorded in the field. In the oil industry, the predictive capacity of the simulator is chosen such that the predicted results approximate the real ones.

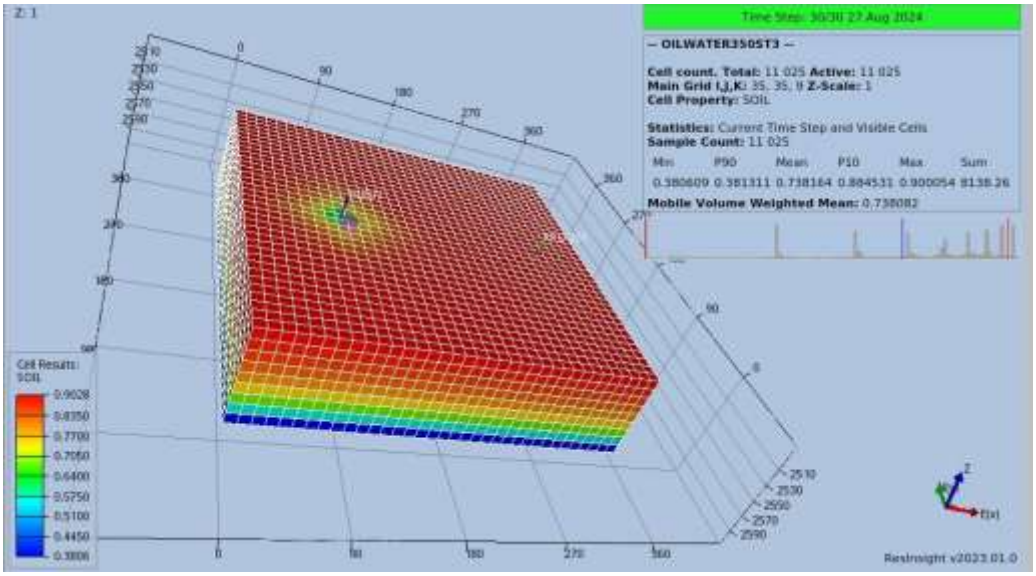

Figure 6. Injection well and production well modeling for oil saturation using ResInsight (author)

Figure 6 shows the modeling of the injection well and the production well for oil saturation, the knowledge of which is of great importance to calculate hydrocarbon reserves, to perform occasional balances during exploitation, as well as to determine the oil extraction of layer. In the injection well, the solution with determined values of the polymer concentration is injected depending on the viscosity of the oil measured at the well head. This amount injected provides the highest oil production and maximum production flow. The reason that higher concentrations give lower production values is explained by the fact that the polymer solution loses its injectability as the concentration (viscosity) increases.

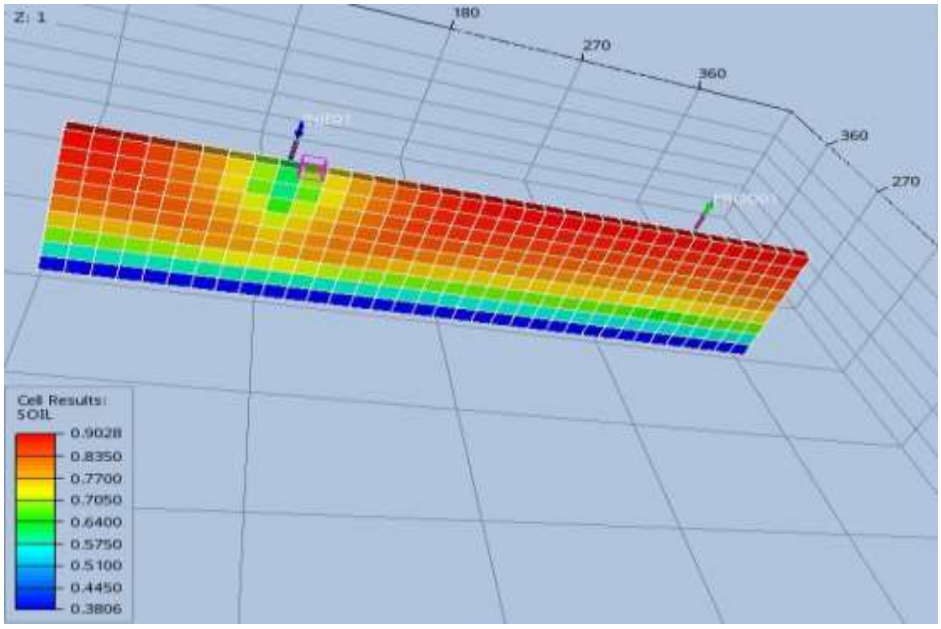

Figure 7: Representation of the injection well and the production well according to a horizontal section for oil saturation, realized in ResInsight (author)

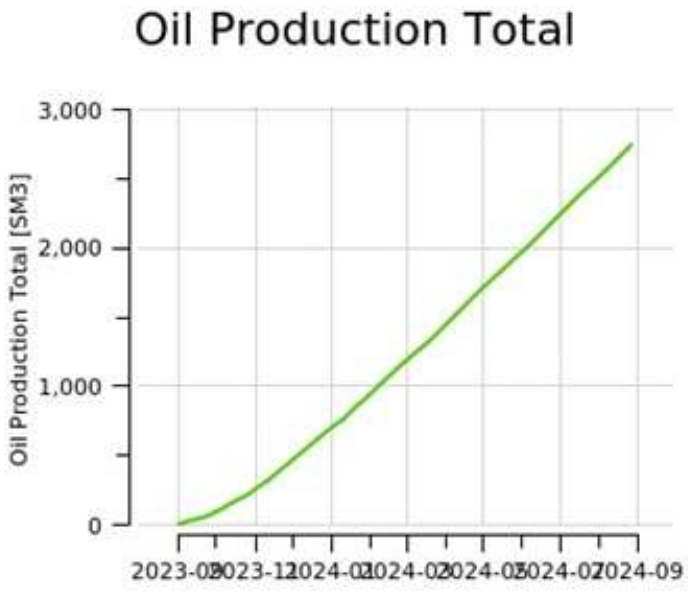

Figure 8: Chart of total oil production (m^3/day) for the forecast period (author)

From the graph, the amount of oil produced predicted for the next year (for 1 year) is small, which means that in addition to porosity and saturations with water and oil in this reservoir, a number of other factors also influence such as: permeability, injection pressure, physico-chemical properties of the reservoir fluid and the type of polymer that is injected. In all the scenarios of the study that we undertook, the maximum production would be ensured if the viscosity of the oil was 100 cp, but the Patos-Marinza oilfield is characterized by heavy oil, i.e. with high viscosity.

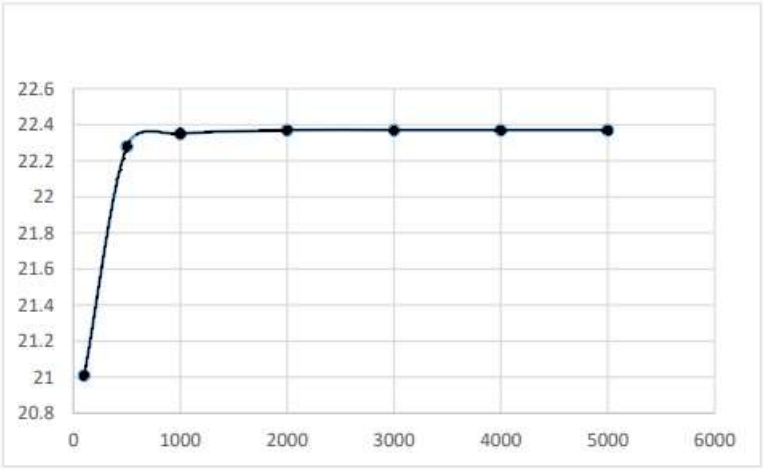

Figure 9: Oil flow rate depending on injection volume

We notice that up to the value of 2000 m^3/day there is an increase in the oil and water production with the increase in the injection volume and after this value the oil production values remain constant. This is

related to the fact that for a given pressure value we can inject a certain volume into the layer.

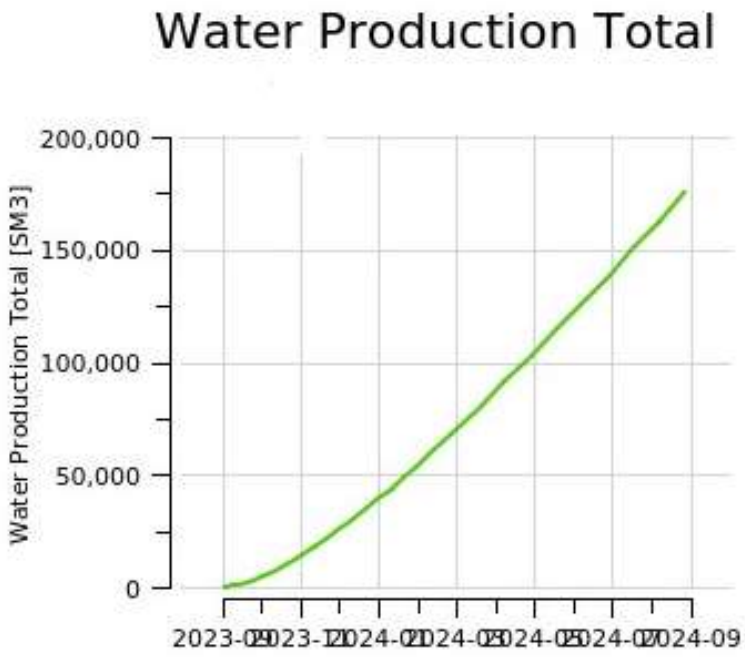

Figure 10: Graph of total water production for the forecast period (author)

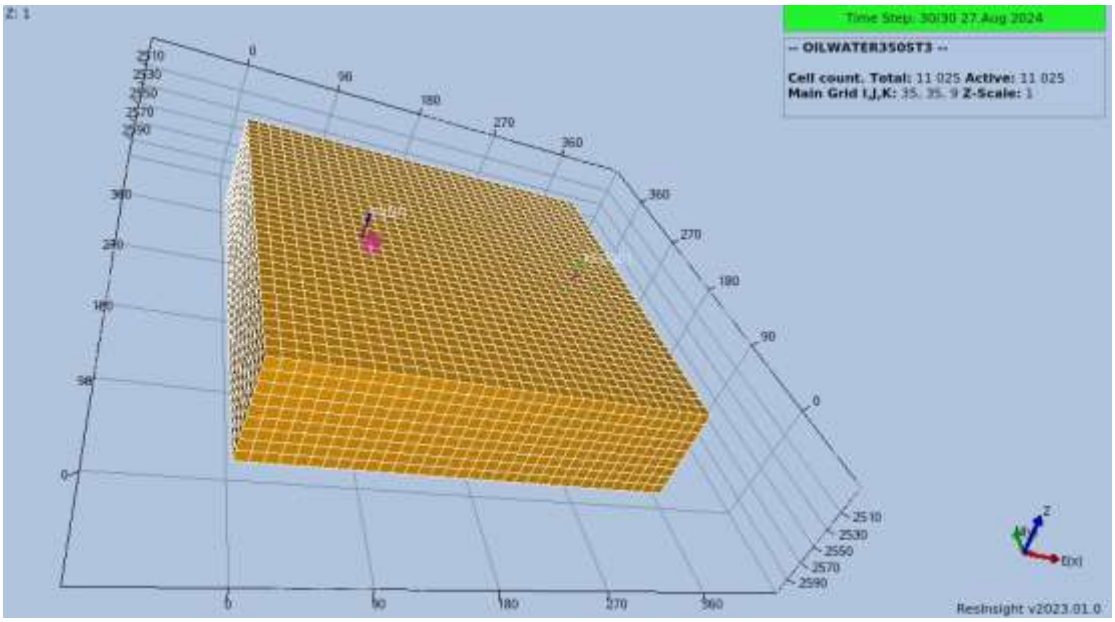

Figure 11: Representation of injection pressure realized in ResInsight (author)

Figure 12 shows that at the initial moment when we have not started the injection into the layer, then when the injection is started the pressure values start to increase further in the area near the injection well.

4. CONCLUSION

The oilfeld of Patos-Marinza after several decades of exploitation presents an unsuitable energy balance to continue exploitation with primary methods. In these conditions, the application of the polymer injection method as a layer action method becomes a necessity for further use. The effectiveness of the injection

depends on lithological-geological factors, the properties of the layer fluid and the type of polymer that is injected.

Polymer injection consists of injecting a mixture of water + polymer into the layer by means of an injection well. This solution will push the oil towards the production wells. The basic mechanism is the increase in water viscosity, which causes a decrease in the value of the mobility ratio between the displacement phase and the displaced phase, which would lead to higher values of the areal sweep efficiency.

It is also noted that with the increase in oil viscosity, the rate of water absorption also increases. This occurs up to a value of 47.63 m^3/day with a viscosity of 2000 cp, and then the change in water flow rate per unit of viscosity becomes negligible. Oil production decreases as its viscosity increases while that of water increases.

From the application of the polymer in the Patos Marine Site until the beginning of 2020, the coefficient of oil extraction increased by 19.32%, bringing its value to 27.6%, and the saturation with oil in this case is 57.5%.

Therefore this is a very promising technique in the future for a superior and long-term economic activity for the oil company Bankers Petroleum.

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ZERDEÇAL BOYAR MADDESİNİN KAĞIT BOYAMADA KULLANIMININ ARAŞTIRILMASI

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Özet – Bu çalışmada; insan sağlığına ve çevreye zarar vermeyen, eczacılık, gıda ve boya sektörlerinde önemli bir yeri olan zerdeçaldan, boyar madde elde edilme olanakları araştırılmıştır. Daha sonra Zerdeçal doğal boyar maddesi elde edilerek kağıt hamurları boyanmış ve bu hamurlardan kağıt üretimlerinin yapılması amaçlanmıştır. Zerdeçal doğal boyar maddesi, kağıt hamuru sulu süspansiyonuna bünyeden mordansız verilerek hamura homojen ve düzenli fikse olduğu ve boyanın kağıda tutunduğu gözlemlenmiştir. Boyanmış kağıtların optik test sonuçlarına göre Zerdeçal boyarmaddesinin kağıt hamurlarının boyanmasında kullanılabileceği sonuç ve kanaatine varılmıştır.

Anahtar Kelimeler – Zerdeçal, Boyar Madde, Kağıt Hamuru, Kağıt, Boyama

I. GİRİŞ

Kağıt yüzeylerinin güzel görünmesi, albenisinin artırılması ve farklı kullanım amaçları için kağıt ve kartonlar boyanarak değişik alanlarda değerlendirilmektedir. Boya; herhangi bir yüzeyin üzerinde fiziksel değişikliğe neden olan, kişinin tercihine göre tasarım veya yüzey koruma gibi alanlarda kullanılmak üzere üretilmiş doğal, sentetik ve medeni kimyasal maddelerdir. Boyar madde ise, kağıt, kumaş, elyaf vb. ürünlerin renkli ve boyalı hale getirilmesinde kullanılan maddelere denir. Boyarmadde genellikle çözelti veya süspansiyon halinde farklı boyama yöntem ve teknikleriyle hem yüzeyden hem de bünyeden uygulanırlar.

Dünyada nüfusun sürekli artması, insanların artan ihtiyaçları ve teknolojik gelişmelere bağlı olarak dünya ile paralel oranda ülkemizde de orman ürünlerine olan talep artmaktadır. Orman ürünleri en çok tüketilen endüstriyel üründür ve son yıllarda uygulama alanı oldukça çeşitlenmiştir [1]. Bu çeşitliliğin biride boyalı kağıt üretimidir. Kağıtlar yazı ve baskı için farklı renklerde boyalarla boyanarak üretilmektedir [2].

Kağıt ilk kez neredeyse iki bin yıl önce keşfedilmiş olmasına rağmen günlük hayatımızda önemli bir rol oynuyor [3]. Bilim ve teknolojinin gelişmesine temel oluşturan yazının icadıyla ve insanların bilgilerini, anılarını, buluşlarını ve tecrübelerini gelecek kuşaklara aktarılması sağlanmıştır. Yazının iki unsuru vardır;

bunlar kağıt ve boyadır [4]. Kağıt; nesiller arası deneyimlerin, olayların ve bilgilerin paylaşılması için en kolay yazı yüzeyidir [3].

Kağıt üretimi ilk olarak MS'de 105 yılında Çin'de başlamış, Orta Asya ve Orta Doğu üzerinden Avrupa'ya yayılmıştır. Malazgirt Savaşı'ndan sonra Anadolu'ya yerleşen Türklerin burada Kağıthaneler kurdukları biliniyor. Osmanlı'da yazma eser oluşturma aşamaları kağıdın amaca göre istenilen renge boyanması ile başlar [5]. Boyaların kalite standartlarını belirleyen ve uygunluğunun yetkili kişiler tarafından doğrulanması gerektiğini belirten Nizamname (yönetmelik), devletin boyaya ve üretimine verdiği önemin açık bir göstergesidir [6]. Geleneksel boyamacılık usta-çırak yöntemiyle atalardan nesillere aktarıldığı için, yapılan işin belgelenememesi, boyama hammaddeleri ve yöntemleri konusunda yeterli kaynağa ulaşımı zorlaştırmaktadır [7].

Bir cismin üzerine renk vermek veya onu korumak amacıyla uygulanan kaplamaya boyama denir [4]. Boyalar tekstil, kağıt, ahşap, deri gibi ürünleri renklendirmek için kullanılan maddeler olarak tanımlanabilir [7]. Doğal bitki boyaları bitkilerin sap, kabuk, çiçek, yaprak ve köklerinden elde edilebilmektedir. Bitkisel kökenli doğal boyalar tekstil, kağıt, ahşap, deri, mürekkep, gıda, kozmetik, ilaç gibi çeşitli uygulama alanlarında kullanılan yüksek kaliteli boyalardır Bu boyalardan yaygın olanlardan bir tanesi bitkilerden elde edilen doğal boyalardır. Kağıtlar, yazı ve baskı için farklı renklerde üretilmektedir [2]. Yapılan bilimsel araştırmalara göre sentetik boya üretiminde kullanılan bazı kimyasalların doğada uzun yıllar bozulmadan kalarak suyun ve toprağın fiziksel yapısını bozduğu, insan ve çevre sağlığına zarar verdiği tespit edilmiştir ve günümüzde doğal boyar maddelerin daha sağlıklı ve çevre dostu olduğu düşüncesi yaygın olduğundan kullanımları giderek artmaktadır [4].

Devletler de yeni koruma standartları getirmekte ve doğal boyalar, sentetik ve zararlı boyalara önemli bir alternatif malzeme olarak toplum tarafından talep edilmektedir. Sentetik boya üretim maliyetleri düşük olsa da, doğal boya kaynaklarının bolluğu, küresel pazarda rekabet edebilmesini sağlamaktadır [8]. Öncelikle yiyecek ve giyim sektörlerinde çevreye zarar vermeyen, toksik olmayan, antioksidan, anti kanserojen, antibakteriyel ve antialerjik bitkilerden elde edilen doğal boyar maddelere olan ilginin artmasıyla birlikte "yeşil dalga" trendi başladı [9]. Doğal boyama sonrası oluşan bitkisel atıkların çevreye zarar vermemesi nedeniyle enerji veya organik gübre elde edilebilmesi ve tekrar tekrar dönüştürülmesi sürdürülebilirlik konusundaki çalışmalara hız kazandırmıştır [10].

Zingiberaceae ailesinin önemli bir üyesi olan "Hint safranı", "zerdeçal" olarak da bilinir ve çok yıllık otsu bitki olup, sarı çiçekleri ve büyük yaprakları vardır. Memleketi Güney Asya, genellikle tropik kuşak boyunca yetiştirilir [11]. Zerdeçal bitkisinin %50-60 oranında sarı renk pigmentlerini Kurkumin köklerinde bulunur ve sarı rengin standardı olarak kullanılmaktadır. Sarı renginde ve parlaklığında fenolik maddeler içermesi belirleyici olmuştur [12]. "Safra kesesi hastalıkları, soğuk algınlığı, karaciğer hastalıkları,

romatizma tedavisinde ve kan temizleyici olarak kullanılır [13]. "Zerdeçal çayı, köri ve bazı sosların ana maddesi olarak tüketilir [14].

II. MATERYAL VE YÖNTEM

A. Materyal

Bu çalışmada; boyar madde yapımında kullanılan kurutulmuş toz zerdeçal piyasadan temin edilmiştir. Kağıt üretiminde kullanılan %70 kısa ve %30 uzun ağartılmış odun lifleri ve boyar maddelerin pH' ını nötralize etmek için sodyum hidroksit (NaOH) KSÜ Orman Endüstri Müh. Bölümünden temin edilmiştir.

B. Yöntem

Bu çalışmada kağıt hamuru üretimi için %70 kısa %30 uzun ağartılmış lifler Hollander yardımıyla 35±5 ^{o}SR derecesine kadar dövülmüştür. Bu çalışmada boyamada kullanılan kurutulmuş toz zerdeçal/su 1/6 oranında, karıştırılıp 12 saat bekletildikten sonra 200 mesh' lik elekten geçirilerek süzülmüştür. Elde edilen boyar maddesinin pH' ölçülerek %10'luk sodyum hidroksit çözeltisiyle nötralize edilmiştir. Daha sonra aşağıda Tablo 1' de belirtilen deney planına bağlı kalınarak liflerin boyama işlemleri yapılmış ve boyama sonrası 80 gr/m^2 (gramajında) yazı tabı kağıtları üretilmiştir (Şekil 1).

Şekil 1. Boyanın nötralize edilmesi ve Zerdeçal boyar maddesi ile yazı tabı kağıt üretimi.

Tablo 1. Yazı tabı kağıtlarına uygulanan boyama işlemlerine ait deney planı.

Deney No	Boyar Madde Türü	Boya Miktarı (mlt)
1	-	-
2	Zerdeçal	50
3	Zerdeçal	100
4	Zerdeçal	150

Zerdeçaldan elde edilen toz boyarmaddeler ile boyanan kağıtlar %50±2 bağıl nemde kondisyonladıktan sonra, aşağıda Tablo 2' de belirtilen testler, standartlara bağlı kalınarak kağıtların fiziksel ve optik özellik testleri yapılmıştır.

Tablo 2: Boyanmış kağıtlara uygulanan optik ve fiziksel testler ve standartları

Yapılan Testler	**Test Standartları**
Gramaj (gr/m^2)	TAPPI T 410 om-88 [15]
Kalınlık (µ)	TAPPI T 411 om-89 [15]
Kopma Uzunluğu (km)	TAPPI T 494 om-01 [15]
Patlama İndisi (kPa m^2 /gr)	TAPPI T 403 om-91 [15]
L*	ISO/CD 5631-1:2015 [16]
a*	
b*	
Sarılık (E313)	ASTM E313 [17]
Opaklık (%ISO)	ISO/DIS 2471:2008 [16]

III. BULGULAR

Bu çalışma kapsamında zerdeçal boyar maddesi ile boyanarak elde edilen yazı tabı kağıtları (Şekil 2) ve bu kağıtların fiziksel ve optik özelliklerine ait bulgular ise aşağıda Tablo 3'de verilmiştir.

Şekil 2: Zerdeçal boyar maddesi boyanarak üretilen yazı tabı kağıtları

Tablo 3: Boyanmış kağıtların fiziksel ve optik test sonuçlarına ait bulgular

Fiziksel ve Optik Testler	Boyasız (Kontrol)	Boya miktarı 50 mlt.	Boya miktarı 100 mlt.	Boya miktarı 150 mlt.
Gramaj (gr/m^2)	80	83	93	110
Yoğunluk (gr/cm3)	0.63	0.65	0.67	0.69
Hacimlilik (cm3/gr)	1.59	1.60	1.67	1.71
Kopma Uzunluğu (km)	4049	3450	3115	3102
Patlama İndisi (kPa m^2 /gr)	2.53	1.99	1.90	1.79
L*	71.61	72.18	72.65	72.81
a*	13.96	15.23	15.94	16.96
b*	56.26	64.25	64.39	65.26
Sarılık (E313)	2.29	107.0	114.52	117.31
Opaklık (%ISO)	97.87	99.33	99.67	99.87

IV. TARTIŞMA VE SONUÇLAR

Bu çalışmada, yukarıda Tablo 3 incelendiğinde 80 gr/m^2 (gramaj)' da boyasız beyaz kağıdına kıyasla; en düşük 2 numaralı kağıt 83 gr/m^2, en yüksek 4 numaralı kağıt 110 gr/m^2 oldukları tespit edilmiştir. Boyasız beyaz kağıda kıyasla; yoğunluk (gr/cm^3) en düşük 2 numaralı kağıt 0.65, en yüksek 4 numaralı kağıt 0.69 olarak tespit edilmiştir. Yoğunluğun tersi olan Hacimlilik (cm^3/gr) değeri ise en düşük 2 numaralı kağıtta 1.60 cm^3/gr, en yüksek 4 numaralı kağıt 1.71 cm^3/gr olduğu görülmüştür. Boya oranının artması ve dolayısıyla kağıtta kalan boyar madde miktarını da artırdığından gramaj, yoğunluk ve hacimlilik değerlerinin yükseldiği gözlemlenmiştir ve dolayısıyla kağıdın fiziksel özelliklerine olumlu yönde katkıda bulunmuştur.

Kağıdın mekanik özelliklerinden olan kopma uzunluğu en yüksek kontrol yani boyasız kağıtta, daha sonra boya oranı arttıkça genel olarak kopma uzunlukları azalmıştır. Yine kağıdın önemli mekanik özelliklerinden biride patlama indisi olup, en yüksek kontrol kağıdında, daha sonra boya oranı arttıkça genel olarak patlama indisinin azaldığı tespit edilmiştir. Boya oranının artışı kağıtların mukavemetini düşürdüğü ancak bu düşüşlerin bazı katkı maddeleri ile (nişasta ve reçine vb.) tolere edilebileceği değerlendirilmiştir.

Kağıtların CIE L*a*b* (*- 1976 CIE renk ölçüm standardı) renk ölçümleri Elrepho 3300 spektrofotometre ile D65 aydınlatma, 10° standart algılayıcı, d/0° geometri ve 5 mm ölçüm alanı kullanılarak gerçekleştirilmiştir. L*a*b değerleri renklerin parmak izleridir. Baskı kalitesini ölçmek açısından hayati öneme sahip olan bu değerler spektrofotometreler aracılığıyla ölçülür. L*a*b*, bir rengin aynı anda yeşil, kırmızı veya mavi ve sarı olamayacağı teorisine dayanan renk uzayının iyi dengelenmiş yapısıdır. Bunun sonucunda, kırmızı/yeşil ve sarı/mavi sıfatlarını tarif etmek için basit değerler kullanılabilir. CIE L*a*b*'da L* rengin açıklık ve koyuluğunu (100 ise açık, 0 ise koyu), a* kırmızı/yeşil (-a yeşil, +a kırmızı), b* sarı/mavi (-b mavi, +b sarı) değerini gösterir [18].

Genel olarak boyanmamış ve boyanmış kağıtların L* değerinin 70-75 aralığında olduğu rengin açık olduğunu göstermektedir. a* değerinin kağıdın kırmızı/yeşilliğini gösterdiği ve Tablo 3'de 14-17 arasında olduğu ve + değer olarak zerdeçal boyalı kağıtların kırmızı tona yöneldiği görülmektedir. b* değeri kağıdın sarı/mavi değerini göstermekte (-b mavi, +b sarı) olup, bu çalışmadaki kağıtların +b sarı renk yönünde değerler verdiği tespit edilmiştir.

Yalnız başına sarılık (E313) değeri, kontrol kağıdıyla (2.29) karşılaştırıldığında, zerdeçal boyar madde ile boyanan kağıtların sırasıyla 107.0, 114.52 ve 117.31 değerlerinde olduğu ve zerdeçalın sarı renk vermesinden kaynaklı olarak boya oranına bağlı artan değerler tespit edilmiştir.

Hem kontrol hem de boyalı kağıtların opaklık (%ISO) değerleri %97'nin üzerinde ve yüksek ve olumlu bir değer olarak tespit edilmiştir.

Sonuç olarak; zerdeçal boyar madde ile boyanan kağıt yüzeylerinde hardal sarısı renginin, açık ve koyu tonları elde edilmiştir. Elde edilen bu özgün ve orijinal rengin albenisi yönünden birçok alanda kullanabileceği değerlendirilmektedir. Ayrıca, zerdeçal boyar maddesinin kağıt boyamada kullanım alanı bulması durumunda üretimi; kolay bir şekilde tedarik edilebilmesi ve boya veriminin yüksek olması nedeniyle kağıt firmaları için sentetik boyalara alternatif önemli doğal ve çevre dostu bir boyar madde kaynağı olacaktır.

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Effect of Some Ecological Factors on Belowground Biomass in Oriental Spruce Stands

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Abstract **–** The underground areas of forests play a crucial role in their continued function and performance, and they have a significant impact on many ecosystem processes and functions. Root biomass is highly responsive to environmental changes and plays a crucial role as a carbon sink for various types of vegetation and land use systems. Oriental spruce (*Picea orientalis*) is a coniferous tree species that is naturally found throughout northeastern Turkey, and its natural distribution is largest in Artvin province. In this study, root sample were collected in oriental spruce stands distributed at different altitudes (700-1650 m) and aspect in Genya Mountain and Kafkasör locations in Artvin province, and its relationship with some ecological factors was examined. Samples were taken from four different sub-sampling points in the sample areas with the help of steel pipes of 6.4 cm diameter and 30 cm length. Total root biomass in oriental spruce stands ranged between 8.7 and 23.8 tones ha^{-1} (mean: 15.0±3.8 tones ha^{-1}), 69% of which was fine root (0-2mm), 20% was small root (2-5mm) and the remainder was coarse root (5-10mm). The t-test result revealed that fine root biomass increased by 22% and small root biomass increased by 54% in the sunny aspect compared to the shaded aspect. No correlation was found between elevation and root biomass, but a positive correlation was found between slope and coarse root biomass. Conclusion, the influence of ecological factors, such as slope and aspect, can influence the root biomass in the oriental spruce stand.

Keywords – Artvin, aspect, Picea orientalis, Root class,

I. GİRİŞ

Biyokütle çalışmaları ekosistemlerdeki madde dolaşımı ve ekosistem dinamiklerini anlamada önem taşımaktadır. Toprak üstü ve toprak altı biyokütle olarak iki kısma ayrılan biyokütle; orman, tarım ve çayır ekosistemlerinden faydalanmanın planlanmasında dikkate alınması zaruri olan önemli bir değişkendir. Çoğu araştırıcı biyokütle ile ilgili çalışmalarını çalışma kolaylığı açısından toprak üstü ile sınırlı tutmaktadır. Oysa toprak üstünde bitkiler sadece ışık için rekabet ederken, toprak altında su ve 20'ye yakın bitki besin elementi için rekabet etmektedir [1].

Yer altı sisteminin temel bir bileşeni olan kökler kılcal kök (0-2 mm), ince kök (2-5mm), kaba kök (5-10mm) ve kalın kök (≥10mm) olmak üzere çap sınıflarına ayrılabilir [2, 3]. Topraktan su ve bitki besin elementlerinin alımında en önemli rol üslenen kılcal köklerdir. Bu kökler kök yüzey alanını genişleterek bitkiler için gerekli su ve besin maddesi alımını kolaylaştırır.

Kök sistemlerinin yapısını çevresel ve genetik faktörlerin etkisi tespit eder. Toprak içinde köklerin dağılımı ve bu dağılımla ilgili bağıntıyı ve bitki besin maddeleri için köklerin çalışma kabiliyeti ve değişik baskılara dayanması ve verdiği tepkiler ilgi çekici ve merak konusudur [4].

Doğu ladini (*Picea orientalis Link*.) önemli asli ağaç türlerimizden biridir. Kök sistemi yayvan olup kök boğazından başlayarak birçok yan kökler bulundurur.

Bu çalışmada Artvin Genya dağı ve Kafkasör mevkilerindeki farklı yükselti ve bakıda yer alan doğu ladini meşcerelerinde kılcal, ince ve kaba kök biyokütlesinin belirlenmesi ve bazı ekolojik etmenler ile ilişkisine bakılması amaçlanmıştır.

II. MATERYAL VE YÖNTEM

A. Araştırma Alanının Tanıtımı

Araştırma alanı Artvin ili Merkez ilçesi sınırları içerisinde Genya dağı ve kafkasör bölgesinde yer almaktadır. Kuzey sınırı Artvin ilinin merkezi ve Çoruh nehri; Güney sınırını Genya dağı (1921 m); Doğu sınırını Tıvatget sırtı; Batı sınırını Cerat tepesi (1912 m) ve Salalet tepesi (1671 m) oluşturmaktadır.

Araştırma sahasına (ort. 1389 m) enterpole edilen Artvin Meteoroloji İstasyonunun verilerine (628 m) göre ortalama sıcaklık 8.3 ºC ve yıllık toplam yağış 1147 mm'dir. Ortalama toprak sıcaklığı (0-50 cm arası) ise 8.2 ºC civarıdır. Vejetasyon süresi boyunca sahaya yaklaşık 404 mm yağış düşmektedir.

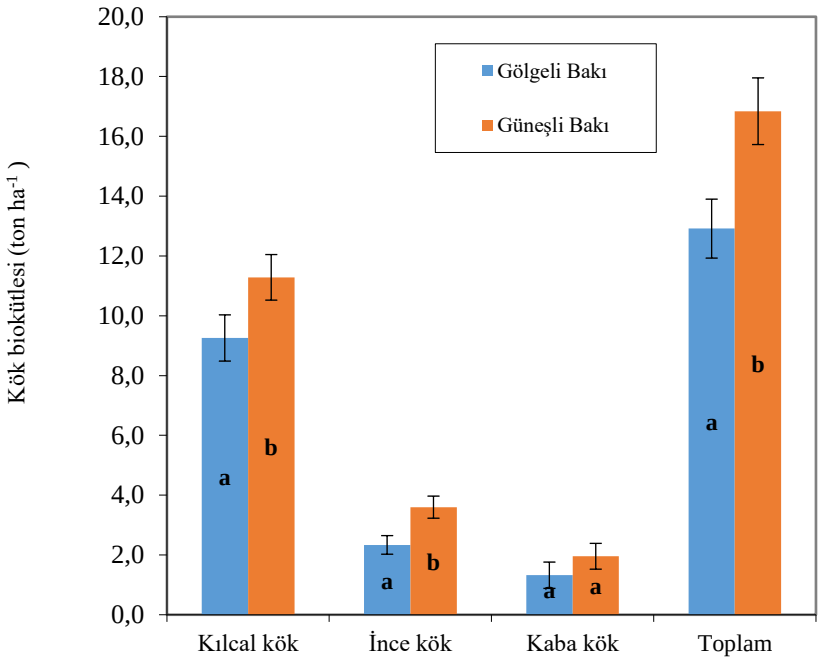
B. Yöntem

Araştırma alanı içerisinde saf ve normal kapalı doğu ladini meşçerelerinde tesadüfi olarak 20 x 20 m (400 m^2) büyüklüğünde 19 adet örnek alanı alınmıştır. Örnekleme alanlarının rakımı, üst boyu, eğimi ve bakısı ölçülmüştür. Ayrıca her örnek alanda 4 adet alt örnekleme yapılarak buralarda 6.4 cm çapında ve 30 cm boyunda çelik boru ve balyoz yardımıyla kök ihtiva eden toprak örnekleri alınarak poşetlenmiştir. Daha sonra laboratuvara getirilen örnekler bir gün suda bekletilerek, toprağın gevşemesi ve köklerden kolay ayrışması sağlanmıştır. Sonra bu örnekler bir leğene aktarılıp yıkanarak 0.2 mm'lik elekten süzülmüştür. Böylece topraktan arındırılan kökler 0-2 mm, 2-5 mm, ve 5-10 mm çap sınıflarına göre ayrılarak 65-70 ˚C sıcaklıkta 24 saat süre zarfında fırında bekletilerek kurutulmuştur. Kurutulan kökler 0,001 gr hassasiyetteki terazide tartılıp, gerekli dönüşümler yapılarak hektardaki kök kütlesi belirlenmiştir.

Verilerin istatistik değerlendirilmesinde SPSS (v.21) programı kullanılmıştır. Bakı grupları arasındaki farka *bağımsız örneklem t-testi* ile; ekolojik faktörler ile kök biyokütlesi arasındaki ilişkiye *Pearson* korelasyonu ve regresyon analizleriyle bakılmıştır ($P<0.05$).

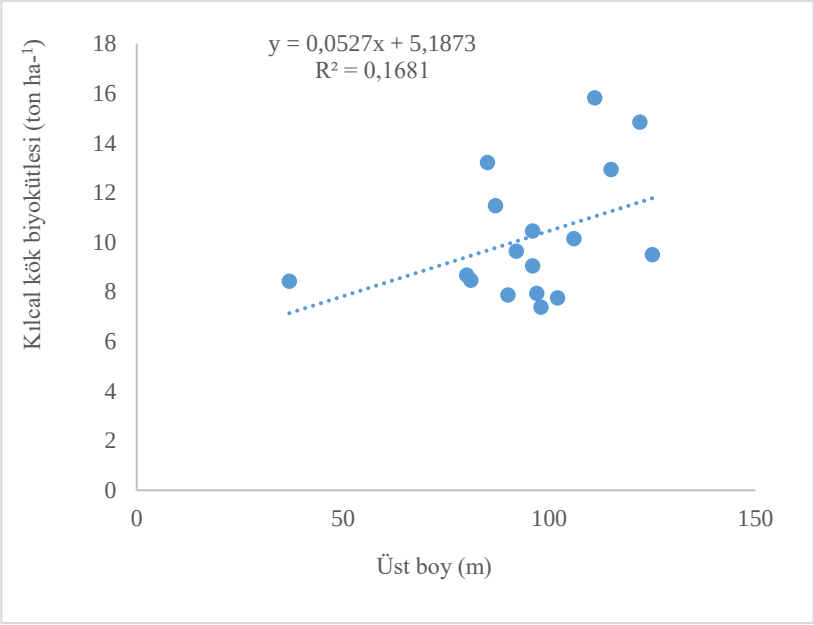
III. BULGULAR

Araştırma alanında toplam kök kütlesi (<10mm) 8.7 ile 23.8 ton ha^{-1} (ort: 15.0±3.8 ton ha^{-1}) arasında değişmektedir. Gölgeli bakılarda toplam kök kütlesinin % 72'i kılcal kök, % 18'i ince kök, % 10'u kaba kök iken; güneşli bakılarda %67'si kılcal, % 21'i ince ve % 12'si kaba kök sınıfında yer almaktadır. *T*-testi sonuçlarına göre kılcal kök [t (17)=2.05, p<0.049], ince kök [t (17)=2.58, p=0.02] ve toplam kök [t (17)=2.61, p=0.02] kütlesi bakılar arasında önemli farklılık gösterirken, kaba kök kütlesi bakıya göre değişmedi. Güneşli bakılar gölgeli bakılara göre kılcal, ince ve toplam kök kütleleri sırasıyla %22, % 54 ve % 30 daha fazlaydı (Şekil 1).



Şekil 1. Doğu ladini meçcerelerinde farklı sınıftaki kök biyokütlelerinin bakıya göre değişimi

Korelasyon analizine göre eğim ile sadece kaba kök kütlesi arasında pozitif yönde ilişki bulundu (r=0.46, p=0.049). Yükselti ile kök kütleleri arasında anlamlı ilişki bulunmadı. Üst boy ile kılcal kök arasında doğrusal fonksiyonlu zayıf bir ilişki vardı (r^2=0.17, F=2,87; Şekil 2).



Şekil 2. Doğu ladini meşcerelerinde üst boy-kılcal kök ilişkisi

IV. TARTIŞMA

Araştırma alanındaki ladin meşcerelerinde toplam kök kütlesi 15.0±3.8 ton ha^{-1}'dır. Aynı türde yapılmış bir çalışmalarda 11.6 ton ha^{-1} [5], başka bir çalışmada ise yaklaşık 18.5 ton ha^{-1} [6] toplam kök kütlesi bulunduğu belirtilmiştir. Bu çalışmada bulunan toplam kök kütlesi değeri literatür ile uyuşmaktadır. Ancak bu çalışmada kılcal ve ince kök kütlesi ortalama 10.3 ve 2.9 ton ha^{-1} olarak bulunmuşken, Akbaş [7] Nisan ve Kasım aylarında yaptıkları ölçümlerde bu değerleri sırasıyla yaklaşık 4.0 ve 3.3 ton ha^{-1}

olarak bulmuşlardır. Yazar kılcal ve ince kök değerlerinin düşük çıkmasını yetişme ortamı farklılığına bağlamıştır [7]. Zaten kılcal kökler mevsimsel olarak değişkendir ve yüksek döngü hızına sahiptir [8].

Gölgeli bakılara göre kök biyokütlesi güneşli bakılarda daha yüksek bulundu. Benzer sonuç doğu ladini [5, 6] ve doğu kayında [6, 9] yapılan çalışmalarda da elde edilmiştir. Bakılar arasındaki farklılığın nedeni güneşli bakıların belirli dönemlerde su ve besin maddesi arzı yönünden gölgeli bakılardan daha fakir olmasından kaynaklanabilir. Çünkü bitkiler fakir yetişme ortamlarında ürettikleri karbonhidratın büyük bir kısmını toprak altına harcayarak kök alanını genişletirler ve böylelikle ihtiyaç duyduğu su ve besin maddesine ulaşmaya çalışırlar [1].

Arazi eğimi ile kaba kök miktarı arasındaki pozitif ilişki; eğim arttıkça ağaçların ayakta durabilmek amacıyla daha fazla kaba veya kalın kök yapmasıyla açıklanabilir. Nitekim eğimli arazi koşulları kök yönlerini, yönelimlerini ve mimarisini önemli oranda etkileyebilmektedir [10].

Üst boy ile kılcal kök arasında zayıfta olsa pozitif yönde bir ilişki vardır. Bu ilişki kılcal kök kütlesinin % 12'sini yetişme ortamı verimliliği ile açıklanabileceğini gösterebilir.

V. SONUÇLAR

Doğu ladini toplam kök biyokütlesi (>10 mm) literatürle paralellik arz etmektedir. Güneşli bakılarda kök miktarı gölgeli bakılardan daha yüksektir. Arazi meyili, üst boy gibi ekololojik etmenler ile kök biyokütle arasında pozitif yönde ilişkiler bulunmuştur. Bu ilişkilerin sıhhatini artırmak için daha fazla örneklemeye ihtiyaç olduğu düşünülmektedir.

Bu çalışmada kalın kök biyokütlesi (>10 mm) ölçülememiştir. Sonraki çalışmalarda kalın kök kütlesini de dikkate alan çalışmaların yapılmasını ve kök kütlesi ile meşcere öğelerinin (yaş, ağaç sayısı, göğüs yüzeyi ve hacim vs.) ilişkisini modelleyen çalışmaların yapılması önerilmektedir.

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Özet **–** Afetler insanların canlarını ve mallarını yok eden, hayatta kalmayı başaran insanlara da büyük acılar yaşatan felaketlerdir. Afetlerin verdiği zararları en aza indirebilmek için afetlere daima hazırlıklı olmak gerekmektedir. Ayrıca afet anlarında ve sonrasında hızlı müdahale insan hayatını kurtarmada son derece önemlidir. Ülkemiz, doğal afetlerin yoğun olarak yaşandığı bir ülkedir. Bu nedenle ülkemizde, önceki dönemlerde yaşanan acı deneyimlerin gelecekte de yaşanmaması için çalışmalar yapılmaktadır. Ülkemizde afet kelimesi ile akla ilk gelen deprem olmaktadır. Ancak afet kavramı ülkemizin her bölgesinde farklı şekilde kendini göstermektedir. Afetler kimi bölgelerde deprem, kimi bölgelerde yangın, kimi bölgelerde ise sel olarak gerçekleşmektedir. Dolayısıyla alınacak önlemler de bölgesel olarak farklılık göstermektedir. Biz de bu çalışmamızda ülkemizde yaşanan bir sel felaketiyle ilgileneceğiz. Sel, dünyanın her yerinde olduğu gibi ülkemizde de kolayca afete dönüşerek büyük miktarda can ve mal kaybına neden olabilen bir doğal felakettir. Selin oluşumu, büyüklüğü ve verdiği zararların boyutu, önemli ölçüde selin gerçekleştiği bölgenin meteorolojik, jeolojik, biyolojik özellikleri ve insanların çeşitli etkinlikleriyle doğrudan ilgilidir. Bu çalışmada Kastamonu ilinde meydana gelen bir sel felaketi örnek olarak alınmıştır. Sel sonucu insanlar hayatını kaybetmiş, ulaşımda aksamalar yaşanmış, konutlar hasar görmüştür. Bizim de amacımız, gelecekte bölgede tekrar bir sel felaketi yaşanması durumunda, insanların selden etkilenmesini en aza indirmek için bölgeye yakın ve sel felaketinden etkilenmeyecek iki farklı toplanma bölgesi seçmektir. Bu iki bölgeye insanların tahliyesini en kısa mesafeden gerçekleştirmek için kooperatif oyun teorisinin bir dalı olan orman durumları kullanılarak hesaplamalar yapılmıştır. Dolayısıyla bu çalışma, oyun teorisi yaklaşımıyla Kastamonu ilimize farklı bir perspektiften yeni bir bakış açısı getirecektir.

Anahtar Kelimeler – Kooperatif Oyun Teorisi, Sel Durumları, Orman Durumları, Artanların Eşit Dağıtım Kuralları, Shapley Değeri

I. GİRİŞ

Seller hem ülkemizde hem de dünyada en etkili doğal afetler arasında yer almaktadır. Ülkemiz özellikle kış aylarında sel ve taşkın haberleri ile gündeme gelmektedir. Seller doğal ve beşeri özelliklerden kaynaklanmasının yanı sıra iklim değişikliğinin de etkisiyle günümüzde daha çok sayıda ve daha büyük ölçekte afetlere dönüşmektedir. Sel sonucu insanlar hayatlarını kaybedebilmekte, tarım alanları zarar görmekte, ulaşım ve haberleşme kesintiye uğramaktadır.

Ekonomik rekabetin, savaşların, seçimlerin ve çoğu zaman oyun olarak düşünmediğimiz daha birçok durumun, bir oyun gibi düşünülüp analiz edilebileceği fikriyle bilimsel bir metafor üzerine kurulu olan oyun teorisi, rasyonel ajanların etkileşime girmesiyle veya başka bir deyişle etkileşimli karar teorisinin kullanılmasıyla strateji seçiminin incelenmesidir [1].

Oyun teorisi, insan davranışlarını araştıran kendine özgü özellikleri olan disiplinler arası bir teoridir ve stratejik durumlarla ilgilenmektedir. Grup içerisindeki her birey tarafından yapılan tercihler aracılığıyla etkilenen bütün insan gruplarındaki durumları gösteren oyun teorisi karşılıklı iş birliğine dayanmaktadır [2]. Bu iş birliğinde oyun teorisi, her zaman kazançlı çıkmayı, zarar söz konusu olduğunda ise en az zararla çıkmayı ister.

Bu çalışma, beş bölümden oluşmaktadır. Birinci bölümde, sel durumlarından ve oyun teorisinden kısaca bahsedilmiştir. İkinci bölümde, kooperatif oyun teorisi ile ilgili temel kavramlar ve literatür özetleri verilmiştir. Üçüncü bölümde, orman durumlarından bahsedilmiştir. Dördüncü bölümde, orman durumlarıyla ilgili bir uygulama kooperatif oyun teorisi ile modellenmiştir. Beşinci bölümde ise, yaptığımız çalışmadan bahsedilmiştir.

II. KOOPERATİF OYUN TEORİSİ

Kooperatif oyun teorisi ile ilgili temel kavramlardan bu bölümde bahsedilecektir. [3], [4]-[5] referanslarında kooperatif oyun teorisi ile ilgili olarak detaylı bilgiler yer almaktadır.

Tanım 2.1. $\boldsymbol{n}$-kişilik bir kooperatif oyun $< \boldsymbol{N}, \boldsymbol{v} >$ ikilisinden oluşur. Burada $\boldsymbol{N} = \{\boldsymbol{1}, \dots, \boldsymbol{n}\}$ oyuncu kümesi $\boldsymbol{v}: \boldsymbol{2^N} \to \mathbb{R}$ karakteristik fonksiyondur. Karakteristik fonksiyon $\forall \boldsymbol{S} \subset \boldsymbol{N}$ koalisyonunu bir reel sayıya götürür yani $\forall \boldsymbol{S} \in \boldsymbol{2^N}$ için $\boldsymbol{v}(\boldsymbol{S})$ koalisyonunun değerini belirtir ve $\boldsymbol{v}(\emptyset) = \boldsymbol{0}$ olarak tanımlıdır.

Tüm kooperatif oyunlar ailesi G^N ile gösterilir. Bu aile lineer bir uzay oluşturur ve boyutu $2^n - 1$ dir.

Kooperatif oyun teorisindeki en temel problemlerden biri de tüm koalisyonlar oluşturulmasını takiben, elde edilen kazancın veya maliyetin nasıl paylaştırılacağıdır. Bu çözüm kavramlarına; [6] tarafından bulunan "von Neumann çözümü, [7] tarafından üretilen "kararlı kümeler", [3] tarafından üretilen "Shapley değeri'' örnek olarak gösterilebilir. Bu şekilde kooperatif oyun teorisindeki bir çözüm kavramı, asgari olarak bir $x = (x_i) \in \mathbb{R}^N$ ödeme vektörüne karşılık gelir. Kooperatif oyun teorisinde çözüm kavramından bahsetmek için aşağıdaki tanımlara değinilmelidir. Shapley değeri için önce marjinal katkı vektörünün tanımı verilmelidir.

Tanım 2.2. (Marjinal Katkı) $v \in G^N$ ve $\sigma \in \pi(N)$ olsun. $m^\sigma(v) \in \mathbb{R}^N$ marjinal katkı vektörü, $\forall i \in N$ için,

$$m_i^\sigma(v) \coloneqq v(P^\sigma(i) \cup \{i\}) - v(P^\sigma(i))$$

ile gösterilir.

Tanım 2.3. (Shapley Değeri) $v \in G^N$ oyun Shapley değeri olan $\Phi(v)$, bir oyunun marjinal vektörlerinin ortalamasıdır. Yani, $\Phi(v) = \frac{1}{n!} \sum_{\sigma \in \pi(N)} m^\sigma(v)$ dir.

Banzhaf değeri 1965 yılında Banzhaf tarafından bulunmuştur [8]. $\beta(v)$ notasyonu ile gösterilir.

Tanım 2.4. (Banzhaf Değeri) $\forall i \in N$ ve $v \in G^N$ için $\beta: G^N \to I(\mathbb{R}^N)$ olmak üzere $\beta_i(v) = \frac{\boldsymbol{1}}{\boldsymbol{2^{|N|-1}}} \sum_{\boldsymbol{i \in S}} v(S) - v(S \backslash \{i\})$ ile tanımlanır.

CIS ve $ENSC$ değerleri 1991 yılında Driessen ve Funaki tarafından bulunmuştur [9]. $CIS(v)$ ve $ENSC(v)$ notasyonları ile gösterilir.

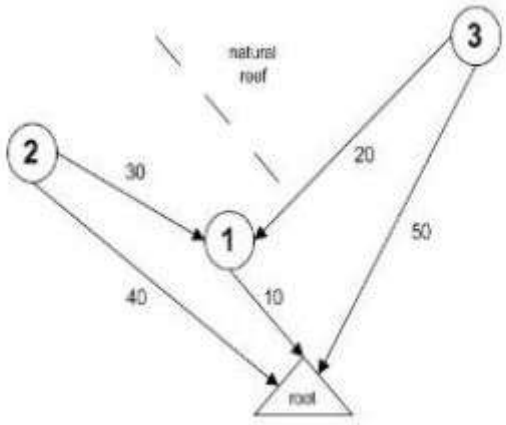
Tanım 2.5. (Kısıt Kümesinin Ağırlık Merkezi Çözümü) $\forall v \in G^N$, $\forall i \in N$ için $CIS: G^N \to \mathbb{R}^N$olmak üzere $CIS_i(v) = v(\{i\}) + \frac{1}{|N|}(v(N) - \sum_{j \in N} v(\{j\}))$ olarak tanımlanır.

Tanım 2.6. (Eşitlikçi Bölünemeyen Katkı Değeri) $\forall S \in 2^N$ için $ENSC: G^N \to \mathbb{R}^N$ olup $\forall i \in N$ için $ENSC_i(v) = -v(N\backslash\{i\}) + \frac{1}{|N|}(v(N) + \sum_{j \in N} v(N\backslash\{j\}))$ dir.

III. ORMAN DURUMLARI

Dağ etrafındaki evlerde yaşayan bir grup insan dikkate alalım. Bu insanlar evlerindeki kirli sudan kurtulmak için bir kanalizasyon sistemine bağlanmak istemektedir. Bu yüzden, kirli suyun çevreye verilmeden önce bir yerde toplanması gerekmektedir. Evler için bir çözüm, hemen kirli sudan kurtulmaktır, bundan dolayı evlerin su temizleyicisine bir kanalizasyon borusu ile bağlanmaları gerekmektedir. Her ne kadar, her evin su temizleyicisine direkt olarak bağlantısı olsa da, diğer evler vasıtasıyla da bağlantı olabilir.

Diğer yandan, aşağıdaki evlerden yukarıdaki evlere kirli suyu göndermek çok masraflı ve tehlikeli olabilir. Bunun birçok nedeni olabilir. Bu yüzden, sadece üstteki evlerden alttaki evlere suyun gönderilmesi mümkün olmaktadır. Olası bir durum Şekil 1'de verilmiştir.



Şekil 1. Olası bir dağ durumu [10]

Bu şekilde çizilen ağ, yönlü ağırlıklı çizgedir. Bu çizgenin köşeleri evler, kökü su temizleyicisi ve kenarları da kurulmasına izin verilen kanalizasyon borularıdır. Bu grafikteki sayılar, kanalizasyon borusunun kurulum maliyetini gösterir. Bazen üstteki evlerden alttaki evlere bağlantı mümkün olmayabilir. Önemli olan nokta, her bir evin kaynağa direkt olarak bağlantısının olmasıdır.

Bu çalışmada, dağ durumlarını orman durumlarına genişletiyoruz. Ayrıca bir orman durumunda maliyet paylaşımı problemiyle uğraşmak için kooperatif oyun teorisini kullanıyoruz. Çünkü kooperatif oyun teorisi bu tür problemleri çözmek için uygun araçlara sahiptir. Dahası, kooperatif oyun teorisi ve çözüm kavramları yöneylem araştırması, ekonomi, modern finans ve çevre yönetimi gibi alanlarda da geniş uygulanabilirliğe sahiptir.

[11], dağ durumlarıyla ilgili bir çalışma yapmıştır.

Şimdi bahsettiğimiz orman durumunun matematiksel tanımını verebiliriz.

Tanım 3.1. $(\mathbf{N}, \{\mathbf{0}\}, \mathbf{A}, \boldsymbol{\omega})$ şeklinde verilen bir dörtlü dikkate alalım. Burada; $\boldsymbol{N} = \{\mathbf{1}, \mathbf{2}, \dots, \boldsymbol{n}\}$ oyuncuların kümesi, $(\boldsymbol{N} \cup \{\mathbf{0}\}, \boldsymbol{A})$ köklü yönlü çizelge, $\boldsymbol{A} \subset \boldsymbol{N} \times (\boldsymbol{N} \cup \{\mathbf{0}\})$ kenarların kümesi ve 0'da köktür. Aynı zamanda, aşağıdaki F.1 ve F.2 şartlarının sağlandığını varsayalım.

F.1. (Direkt bağlanma imkanı) $\forall \boldsymbol{k} \in \boldsymbol{N}$ için, $(\boldsymbol{k}, \mathbf{0}) \in \boldsymbol{A}$ dır.
F.2. (Döngü olmaması) $\forall \boldsymbol{s} \in \boldsymbol{N}$ ve $(\boldsymbol{v_1}, \boldsymbol{v_2}) \in \boldsymbol{A}$, $(\boldsymbol{v_2}, \boldsymbol{v_3}) \in \boldsymbol{A}$,…, $(\boldsymbol{v_{s-1}}, \boldsymbol{v_s}) \in \boldsymbol{A}$ olacak şekilde $\boldsymbol{v_1}, \boldsymbol{v_2}, \dots, \boldsymbol{v_s} \in \boldsymbol{N} \cup \{\mathbf{0}\}$ için $(\boldsymbol{v_s}, \boldsymbol{v_1}) \notin \boldsymbol{A}$ dır.
Ayrıca, $\boldsymbol{\omega}: \boldsymbol{A} \to \mathbb{R}$ fonksiyonu $\boldsymbol{A}$ kümesi üzerinde negatif olmayan bir fonksiyondur.
F.3. (Kümesellik şartı) $\forall \boldsymbol{k} \in \boldsymbol{N}$ ve $\forall \boldsymbol{i}, \boldsymbol{j} \in \boldsymbol{N} \cup \{\mathbf{0}\}$, $\boldsymbol{i} \neq \boldsymbol{j}$: $(\boldsymbol{k}, \boldsymbol{i}) \in \boldsymbol{A}$, $(\boldsymbol{k}, \boldsymbol{j}) \in \boldsymbol{A} \Rightarrow \boldsymbol{\omega}(\boldsymbol{k}, \boldsymbol{i}) \neq \boldsymbol{\omega}(\boldsymbol{k}, \boldsymbol{j})$
F.3 şartı bize $\boldsymbol{k} \in \boldsymbol{N}$ nin en iyi bağlantısı olan $\boldsymbol{b}(\boldsymbol{k})$ yı bulma imkanı sağlar. Burada,

$$\boldsymbol{b}(\boldsymbol{k}) = \underset{\boldsymbol{i} \in \boldsymbol{N} \cup \{\mathbf{0}\}: (\boldsymbol{k}, \boldsymbol{i}) \in \boldsymbol{A}}{\boldsymbol{argmin}} \ \boldsymbol{\omega}(\boldsymbol{k}, \boldsymbol{i})$$

şeklinde tanımlanır.

F.1, F.2 ve F.3 özelliklerini sağlayan $(\boldsymbol{N}, \{\mathbf{0}\}, \boldsymbol{A}, \boldsymbol{\omega})$ dörtlüsüne orman durumu denir.

Her bir dağ sorunu, birden fazla kaynağın devreye konulmasıyla orman durumuna yol açar; burada $\boldsymbol{N}$, dağdaki evlerin kümesini, $\mathbf{0}$ su temizleyicisini ve $\boldsymbol{A}$ da

$$(\boldsymbol{i}, \boldsymbol{j}) \in \boldsymbol{A} \Rightarrow \boldsymbol{h}(\boldsymbol{i}) > \boldsymbol{h}(\boldsymbol{j})$$

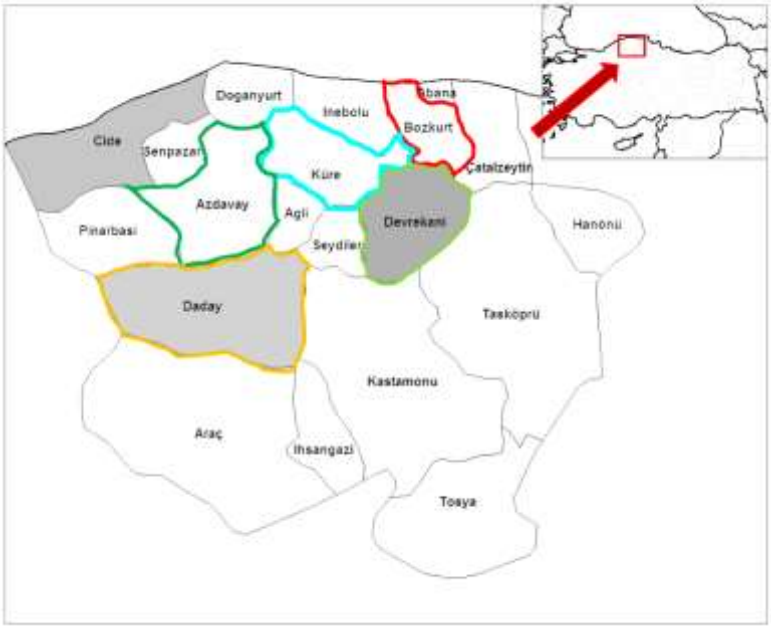
yer çekimi koşulu ile belirlenen bağlantıların kümesini gösterir. Buradaki; $\boldsymbol{h}(\boldsymbol{i})$, $\boldsymbol{i}$. evin yüksekliğidir. Ayrıca, $\boldsymbol{\omega}(\boldsymbol{i}, \boldsymbol{j})$, kanalizasyon borusuyla $\boldsymbol{i}$ ile $\boldsymbol{j}$ yi bağlama gideri olarak tanımlanır.

Diğer yandan, F.1 ve F.2 özelliklerini sağlayan $(\boldsymbol{N}, \{\mathbf{0}\}, \boldsymbol{A}, \boldsymbol{\omega})$ dağ durumu verildiğinde, burada $(\boldsymbol{i}, \boldsymbol{j}) \in \boldsymbol{A}$ olacak şekilde $\boldsymbol{h_0}: \boldsymbol{N} \cup \{\mathbf{0}\} \to \mathbb{N} \cup \{\mathbf{0}\}$ temel ağırlık fonksiyonu vardır. Buradaki $\boldsymbol{h_0}$ fonksiyonu aşağıdaki gibi tanımlanır:

$\boldsymbol{i} \in \boldsymbol{N} \cup \{\mathbf{0}\}$ için $\boldsymbol{h_0}(\boldsymbol{i})$, $\boldsymbol{i}$'den $\mathbf{0}$'a giden en uzun yolun uzunluğudur.

IV. UYGULAMA

Kastamonu ilinin yerleşim birimleri Şekil 2'de verilmiştir.

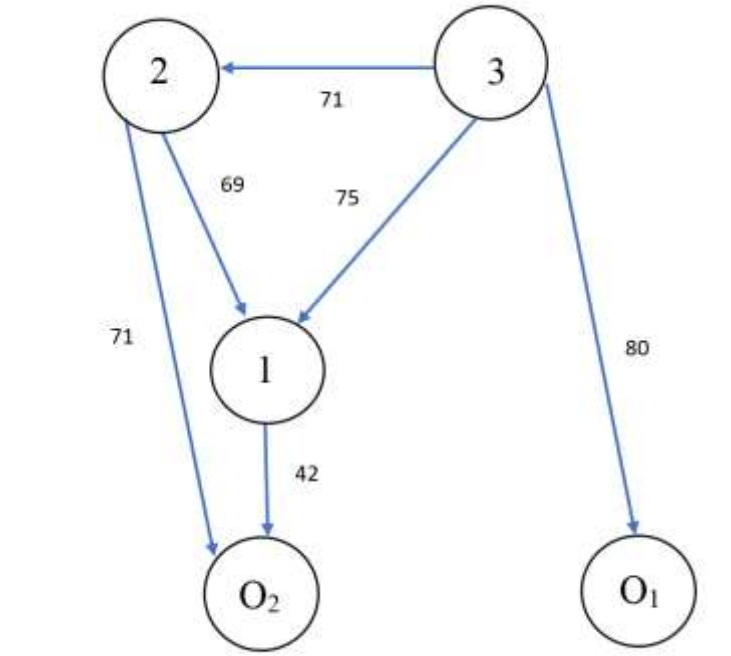


Şekil 2. Yerleşim birimleri

Sel felaketinin oluşumunda, belirli bir yer ve zamanda beklenilen yağış miktarını aşan ani ve/veya uzun süre etkili sağanak yağışlar etkili olmaktadır. Özellikle bölgenin kaldırabileceği su kapasitesinin aşılması ile büyük su kütlesinin eğimli araziden dökülmesi ve dere yatakları boyunca kontrolsüz biçimde akmasıyla sel ve taşkın olayları meydana gelmektedir. Dolayısıyla, yağış ve sıcaklıktaki ani değişimler sel felaketinin başlıca nedenlerindendir. T.C. İçişleri Bakanlığı Afet ve Acil Durum Yönetimi Başkanlığı Basın ve Halkla İlişkiler Müşavirliği (AFAD) tarafından 20.08.2021 tarihinde yapılan basın duyurusunda, 11 Ağustos 2021 tarihinde bir sel felaketi meydana geldiği bildirilmiştir. Kastamonu ilinde bu sel felaketinden etkilenen yerleşim birimleri ise Kastamonu ili Azdavay, İnebolu, Bozkurt, Küre ve Pınarbaşı ilçeleri olarak açıklanmıştır. Bu nedenle bu çalışmada Kastamonu ilinde selin meydana geldiği bölgeler olarak Bozkurt, Küre ve Pınarbaşı bölgeleri dikkate alınmıştır. Sel sonrası toplanma bölgeleri ise selin meydana geldiği bölgeye olan yakınlıkları nedeniyle Daday ve Devrekani bölgeleri olarak seçilmiştir. Daday ve Devrekani ilçesi aynı zamanda insanların tahliyesine kolaylıkla imkan verip barındırmaya yetecek ve afetzedeler için geçici konutlar kurmaya yetecek yüzölçümüne de sahiptir. Oyunda Kastamonu ilinde yeniden meydana gelebilecek sel durumunda selin olduğu üç bölgeden iki farklı toplanma bölgesine insan tahliyesi gerçekleştirilecektir. Sel durumunda afetzedelerin tahliyesinde orman durumu kullanılmıştır. Oyunda bölgeler arası yollar için bölgelerin birbirine yaklaşık uzaklıkları kullanılmıştır. Söz konusu yerleşim birimleri Şekil 2'de verilmiştir.

1	Küre
2	Bozkurt
3	Pınarbaşı
01	Daday
02	Devrekani

Orman durumuna ait oyun modeli Şekil 3'te verilmiştir.



Şekil 3. Oyun modeli

Bu oyuna ait sırasıyla Shapley değeri, Banzhaf değeri, CIS değeri ve $ENSC$ değerini bulalım.

Koalisyon değerleri

S	$\emptyset$	$\{1\}$	$\{2\}$	$\{3\}$	$\{1,2\}$	$\{1,3\}$	$\{2,3\}$	$\{1,2,3\}$
$v(S)$	0	42	71	80	111	117	142	182

şeklindedir.

Şimdi marjinal vektörleri Tablo 1'de gösterelim:

Tablo 1. Marjinal katkı vektörleri

σ	$m_1^\sigma(v)$	$m_2^\sigma(v)$	$m_3^\sigma(v)$
$\sigma_1 = (1,2,3)$	42	69	71
$\sigma_2 = (1,3,2)$	42	65	75
$\sigma_3 = (2,1,3)$	40	71	71
$\sigma_4 = (2,3,1)$	40	71	71
$\sigma_5 = (3,1,2)$	37	65	80
$\sigma_6 = (3,2,1)$	40	62	80

Shapley değeri:
$\Phi(v) = \frac{1}{3!}\sum_{\sigma\in\pi(3)} m^\sigma(v) = (\frac{241}{6}, \frac{403}{6}, \frac{448}{6})$ olarak bulunur.

Banzhaf değeri:
$\beta_i(v) = \frac{1}{2^{|N|-1}} \sum_{i\in S}(v(S) - v(S\backslash\{i\}))$ formülünden
$\beta(v) = (\frac{159}{4}, \frac{267}{4}, \frac{297}{4})$ olarak bulunur.

CIS değeri:
$CIS_i(v) = v(\{i\}) + \frac{1}{|N|}(v(N) - \sum_{j\in N} v(\{j\}))$ formülünden

$CIS(v) = (\frac{115}{3}, \frac{202}{3}, \frac{229}{3})$ olarak bulunur.

$ENSC$ değeri:
$ENSC_i(v) = -v(N\backslash\{i\}) + \frac{1}{|N|}(v(N) + \sum_{j\in N} v(N\backslash\{j\}))$ formülünden

$ENSC(v) = (42,67,73)$ olarak bulunur.

Modelimize ait kullandığımız tüm çözümler Tablo 2'de verilmiştir.

Tablo 2. Çözümler

Çözümler	**Küre**	**Bozkurt**	**Pınarbaşı**	**Vektörel Gösterim**
Shapley değeri	$\frac{241}{6}$	$\frac{403}{6}$	$\frac{448}{6}$	$(40,67,74)$
Banzhaf değeri	$\frac{159}{4}$	$\frac{267}{4}$	$\frac{297}{4}$	$(39,66,74)$
$\boldsymbol{CIS}$ **değeri**	$\frac{115}{3}$	$\frac{202}{3}$	$\frac{229}{3}$	$(38,67,76)$
$\boldsymbol{ENSC}$ **değeri**	42	67	73	$(42,67,73)$

V. SONUÇLAR

Bu çalışmada orman durumlarıyla çalışılmıştır. F.1, F.2 ve F.3 özelliklerine sahip orman durumları için optimal bağlantı problemleri çözülmüştür. Burada bir model oluşturulmuştur. Bu modelde oyuncularımız şehirler, kaynak ise toplanma bölgeleri olmuştur. Oyunda selin meydana geldiği üç farklı bölgeden iki farklı toplanma bölgesine insan tahliyesinin en kısa mesafeden ulaşımının sağlanması için kooperatif oyun teorisinin çözüm kavramları kullanılarak hesaplamalar yapılmıştır. Dolayısıyla, bölgede tekrar bir sel felaketi yaşanması durumunda afetzedelerin en yakın mesafeleri kullanarak toplanma bölgelerine tahliye edilmesi sağlanacaktır.

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THE ROLE AND APPLICATIONS OF BIOINFORMATICS IN PERSONALIZED MEDICINE

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Abstract – Personalized medicine is an approach aimed at tailoring treatments specifically for individuals based on their genetic, environmental, and lifestyle differences. This method seeks to determine the most appropriate treatment methods by considering the unique biological structure of patients. The fundamental factors increasing the importance of personalized medicine include rapid advancements in genetics and molecular biology. This field plays a significant role, particularly in the treatment of complex diseases such as cancer, cardiovascular disease, and neurodegenerative diseases. Bioinformatics is an interdisciplinary field where computer science and statistical methods are used in the collection, analysis, and interpretation of biological data. In personalized medicine, bioinformatics plays a crucial role in understanding the molecular basis of diseases through the analysis of genetic and genomic data. These tools and methods help in identifying genetic variations, drug discovery and development, and the formulation of treatment strategies. Bioinformatics tools include data platforms such as GATK, ANNOVAR, and PLINK, which are used in the processing and analysis of genetic data. Pharmacogenomic studies, cancer genomic research, and network biology methods, as bioinformatics applications, contribute to a better understanding of diseases and the development of personalized treatment methods. However, there are also some challenges in the application of personalized medicine. Data integration and management, the analysis of large data sets, and the heterogeneity of biological data are among these challenges. Solutions such as the standardization of data analysis methods and the use of artificial intelligence and machine learning techniques are proposed to overcome these issues. Consequently, the use of appropriate bioinformatics methods in personalized medicine will end the 'one size fits all' tradition and allow for the development of more specific treatments.

Keywords – Personalized Medicine, Bioinformatics, Data Analysis, Drug Discovery

I. INTRODUCTION

Personalized medicine refers to the customization of healthcare based on the genetic, environmental, and lifestyle differences of individuals. This medical approach aims to determine the most appropriate treatment methods by considering each patient's unique biological structure. The importance of personalized medicine lies in providing higher efficacy and accuracy in the diagnosis and treatment of diseases [1]. By tailoring treatment processes to the genetic profile of patients, this approach allows for the reduction of side effect risks and increases the success of treatments [2]. The potential of personalized medicine to revolutionize healthcare is supported by rapid advancements in the fields of genetics and molecular biology. The use of personalized medicine methods is particularly increasing in the treatment of complex diseases such as cancer, cardiovascular diseases, and neurodegenerative diseases [3]. The analysis of genomic data plays an important role in improving health outcomes by identifying individual disease risks and applying personalized preventive measures [4].

Bioinformatics is an interdisciplinary field where computer science and statistical methods are used for the collection, analysis, and interpretation of biological data. In personalized medicine, bioinformatics plays a critical role in understanding the molecular basis of diseases through the analysis of genetic and genomic data [5]. The processing of this data allows for the identification of individuals' genetic differences and the analysis of the effects of these differences on health [6]. Bioinformatics tools assist in the identification of genetic variations associated with diseases by using algorithms developed for the management and analysis of large data sets. This process increases the accuracy of genetic tests and enables the development of personalized treatment strategies [7]. Additionally, bioinformatics plays an important role in the drug discovery and development processes. The identification of molecular targets and the evaluation of the efficacy and safety of drug candidates are carried out more quickly and efficiently thanks to bioinformatics techniques [8].

The innovations offered by bioinformatics in personalized medicine enhance the quality and effectiveness of healthcare in areas such as early diagnosis of diseases, monitoring treatment responses, and developing new therapeutic approaches [9].

A. Bioinformatics Tools, Applications, and Methods Used in Personalized Medicine

In personalized medicine, bioinformatics plays a central role in the processes of processing, analysing, and transforming genetic data into clinical applications. The bioinformatics tools, applications, and methods used in these processes enable a better understanding of diseases and the development of treatment methods.

Bioinformatics Tools - Among the widely used bioinformatics tools in personalized medicine are gene sequencing and analysis platforms. For example, GATK (Genome Analysis Toolkit) is used to detect and analyse genetic variations. GATK has been widely adopted in genetic research due to its high accuracy and flexibility [10]. Similarly, ANNOVAR is commonly used for the annotation and functional analysis of genetic variants. This tool stands out as an important resource in evaluating the biological effects of variants [11]. Another important tool, PLINK, is used in the analysis of large-scale genomic data sets and is optimized for genetic association studies. PLINK offers comprehensive analysis capabilities for population genetics and biomedical research [12].

Bioinformatics Applications - Pharmacogenomic studies, which analyse gene-drug interactions, are among the leading bioinformatics applications. These studies enable the personalization of drug treatments based on patients' genetic profiles. For example, bioinformatics analyses related to CYP450 enzymes provide important information on drug metabolism and responses. CYP450 enzymes play a role in the metabolism of many drugs, and genetic variations in these enzymes explain differences in drug responses among individuals [13]. Cancer genomic studies make it possible to detect genetic changes in tumors and develop targeted therapies. For example, the TCGA (The Cancer Genome Atlas) project has provided comprehensive information on cancer biology by mapping genetic and epigenetic changes in various cancer types [14]. Such large-scale projects accelerate the integration of bioinformatics analyses into clinical applications.

Bioinformatics Methods - Bioinformatics methods used in personalized medicine include big data analytics and machine learning techniques in the analysis of genetic data. Machine learning algorithms are used to extract meaningful patterns and relationships from large genetic data sets. For example, deep learning methods have been used to identify complex patterns in genomic data and predict disease risks [15]. Network biology methods play an important role in the analysis of biological networks and gene-environment interactions. These methods enable the identification of genes and biological pathways involved in disease pathogenesis. The study by Barabasi demonstrates how network biology perspectives can be used to examine complex diseases and identify therapeutic targets within these networks [16].

In conclusion, the bioinformatics tools, applications, and methods used in personalized medicine play a critical role in transforming genetic information into clinical applications. These tools and methods contribute to a better understanding of diseases, increased treatment efficacy, and improved individual patient care.

B. Standardization of Bioinformatic Methods in Personalized Medicine

The standardization of bioinformatic methods in personalized medicine is crucial for the reliable and consistent analysis of individual patient data. Standardization ensures consistency in data collection, processing, and analysis processes, thereby enhancing the reproducibility of research and the reliability of results. The standards developed by the International Organization for Standardization (ISO) facilitate the conduct of bioinformatic tools and data analysis methods within certain protocols. These protocols cover a wide range of activities, from the collection and storage of biological samples to their analysis and sharing, thereby enhancing the reliability of biomedical research [17]. Digital biobanks, in particular, play a critical role in the standardization of bioinformatic methods. Biobanks integrate genetic and molecular data along with clinical data. Standardizing such data enables more accurate disease characterization and the development of personalized treatment approaches. Additionally, the secure storage and sharing of data collected through biobanks facilitate data exchange among research communities and promote global collaborations. Standardized protocols and data management systems enhance the functionality of biobanks, leading to higher quality and more reliable outcomes in biomedical research [18].

In conclusion, the standardization of bioinformatic methods in personalized medicine ensures accurate and consistent data analysis, increasing the reliability and reproducibility of research results. This contributes to a better understanding of diseases and the development of more effective treatment methods. The implementation of standardization processes also guarantees ethical and legal compliance while improving the quality and efficiency of research communities and clinical practices.

C. The Future of Bioinformatics in Personalized Medicine and New Developments

Recent advancements in the field of bioinformatics play a significant role in the future of personalized medicine. Innovative technologies, particularly digital twins, have the potential to enhance the delivery of healthcare services and improve patient outcomes. Digital twins create digital replicas of individuals by integrating various data sets such as genetic information, electronic health records, and patient reports. This comprehensive data integration allows healthcare professionals to better understand patients' health conditions, develop personalized treatment plans, and make data-driven decisions. The application of such technologies in healthcare is revolutionizing many areas, including early disease diagnosis, risk assessment, and remote patient monitoring [19].

These advancements in bioinformatics will lead to broader adoption of personalized medicine in the future. By 2030, technological developments in bioinformatics and personalized medicine will profoundly transform individuals' access to healthcare services and treatment processes. These innovations will enable healthcare systems to operate more flexibly and efficiently, facilitating significant breakthroughs in biomarker identification and the development of molecularly targeted therapies. Additionally, data sharing and global collaborations in biomedical research will increase, resulting in higher quality and more reliable research outcomes [20].

D. Challenges and Solution Proposals

Using individual genetic, environmental, and lifestyle data in the diagnosis and treatment of diseases can achieve more effective results. However, there are significant challenges in these areas. These include data integration and management, the analysis of large data sets, and the heterogeneity of biological data. For example, the process of integrating data from different sources and analyzing it consistently is quite complex [21]. Additionally, advanced algorithms and computational power are needed to understand the interaction of genetic and environmental factors [22].

Various solution proposals have been developed to overcome these challenges. The standardization of bioinformatics tools and data analysis methods can facilitate this process by increasing data sharing and comparability [23]. Additionally, artificial intelligence and machine learning techniques can accelerate the processing of large data sets and the interpretation of biological data [24]. Besides these technologies, encouraging interdisciplinary collaborations and ensuring data security and privacy can also contribute to the successful implementation of personalized medicine [25].

II. CONCLUSION

Personalized medicine is an approach that aims to tailor healthcare services based on individuals' genetic, environmental, and lifestyle differences. This medical approach seeks to determine the most suitable treatment methods by considering the unique biological structures of patients and has gained significant momentum thanks to rapid advancements in genetics and molecular biology. The critical role of bioinformatics in personalized medicine involves understanding the molecular basis of diseases, identifying genetic variations, accelerating the drug discovery and development processes, and formulating individualized treatment strategies. Bioinformatics tools and methods are indispensable for managing and accurately interpreting large datasets in the analysis of genetic and genomic data.

In conclusion, the effective use of bioinformatics methods in personalized medicine will end the "one-size-fits-all" approach in the medical field, enabling the development of more specific and effective treatment methods. This will lead to a better understanding of diseases, increased treatment efficacy, and improved individual patient care. In the future, the advancement and integration of bioinformatics tools and methods will expand the application scope of personalized medicine and greatly contribute to patients' treatment processes.

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1999 Marmara Depremi Sonrası Yalova Kent Merkezi Karayolu Ulaşımında Yaşanan Sıkıntıların Araştırılması

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Özet **–** Deprem afeti sonrası müdahalede ilk 72 saat çok kritiktir. Arama kurtarma, sağlık ekipleri, iş makineleri ve iaşe/ibate ve diğer yardım araçlarının afet bölgesine ulaşması afetzedeler için hayati önem taşır. Bu noktada afet bölgesinde bulunan ulaşımın özellikle ülkelerin en ücra yerlerine kadar yayılmış olan karayollarımızın açık olması elzemdir. Ancak deprem afeti nedeniyle hasar alan binalar ve diğer unsurlar yıkılarak bazı sokaklarda trafik akışını zayıflatır ya da durdurur. Bununla beraber afet sonrasında, afetzedelerin yaşadıkları şok ve duydukları panik hissi de ulaşımda sektelere neden olmaktadır. Örneğin afetzede vatandaş kendisi kurtulduğunda şehrin diğer bölgelerinde bulunan yakınlarına karayollarını kullanarak ulaşma isteği, o anki kaos ve kargaşanın büyümesine neden olmaktadır. Zaten şok ve panik ile hareket eden sürücüler bir de alıştıkları yolları kullanamama durumu ve etrafta yardım isteyenlerin sesleri veya yıkılan binaların görüntüsün oluşturduğu ruhsal hal, paniğin daha da büyümesine neden olacaktır. Bu sürücüler karayolu ulaşımının içinden çıkılmaz bir kargaşaya dönmesine sebebiyet vermektedir. Bu kargaşa ise karayolunu acil kullanması gereken araçları engellemekte ve can kaybının artmasına neden olmaktadır. Çalışma kapsamında afet anında insanların ulaşımdaki davranışının tespiti amaçlanmıştır. Bu konuda Yalova İlinde 1999 Marmara Depremini yaşamış insanlara anket yapılmış bu anket soruları kapsamında değerlendirme yapılarak Afet sırasındaki ulaşım davranışı hakkında bilgi elde edilmeye çalışılmıştır. Buna göre ankete katılanların %45'i deprem sonrasında araçla hareket ettiği, %65'nin toplanma alanlarını bilmediği, deprem sonrası ulaşımda panik yaşandığını görenlerin oranının %60 olduğu ve %61 trafik kurallarına uyulmadığı sonuçlarına ulaşılmıştır.
Bu veriler ışığında karayolu ulaşımı için alınacak önlemlere altlık oluşturacak bilgiler elde edilmeye çalışılmıştır.

Anahtar Kelimeler – Karayolu, Deprem, Ulaşım, Erişebilirlik, Afet

I. GİRİŞ

Toplumun tamamı veya belli kesimleri için fiziksel, ekonomik ve sosyal kayıplar doğuran, normal hayatı ve insan faaliyetlerini etkileyerek kesintiye uğratan hatta durduran, toplumun kendi olanakları ile baş etme kapasitesinin yeterli olmadığı doğa, teknoloji veya insan kaynaklı olaylar bütününe Afet denir. Afet bir olayın kendisi değil, doğurduğu sonuçtur [1]. Türkiye bulunduğu konumdan dolayı sık sık farklı doğal afet tiplerinden etkilenen bir ülkedir. Bu afetlerin başında depremlerin olduğu söylenebilir. Depremlerin yanı sıra heyelan, çığ, kaya düşmesi, sel su baskını vb. afetleri de yaşamaktadır. En çok yaşanan afet olarak deprem üzerinden değerlendirme yapıldığında 900 yılından itibaren kayıtlı 77 adet büyük deprem gerçekleşmiştir. Yaşanan afetler değerlendirildiğinde Türkiye Dünya'da yüksek afet riski taşıyan 4. Ülke olarak sıralanmaktadır [2].

Türkiye'de deprem riski bulunan yerler incelendiğinde ülkenin nüfusunun ve sanayisinin %98'i deprem riski altında bulunmaktadır [3]. Bu durum depremin şiddetini artırmaktadır. Zira deprem şiddeti, depremin büyüklüğünden farklı bir kavram olarak karşımıza çıkmakta ve insanların depremden etkilenmelerinin

ölçüsünü vermektedir. Örneğin ıssız bir çölde yaşanacak deprem çok büyük (Magnitüd) olsa da insan hayatına etkisi az olacağından şiddeti düşük olmaktadır, öte yandan kalabalık bir şehirde yaşanacak depremde etkilenen insan sayısının artmasıyla depremin şiddeti de artmaktadır. Bu nedenle insanların yoğun olduğu bölgelerde depremlere hazırlıklar önem arz etmektedir. Deprem diğer afetler gibi önlenebilir bir afet değildir [4]. Örneğin sel su baskınlarını önlemek için çözüm önerileri geliştirilebilir setler, ıslah duvarları ile akan suların tehlikesi azaltılabilir. Başka bir örnekte kaya düşmesi afetinin yaşandığı yerlerde kayalar sabitlenebilir veya düşmeye başladığında setler tarafından tutulabilir. Depremler ise öncesinde önlem alınarak engellenebilir bir afet değildir. Zira ortaya çıkan enerjinin ve etkilediği alanın büyüklüğü önlem çalışmalarının yapılmasını imkânsız hale getirmektedir. Deprem afeti önlenemeyen bir afet olması yanı sıra önceden alınacak önlem ve hazırlıklar ile can ve mal kaybı azaltılabilir. Binalarda yapılacak güçlendirmeler, ulaşım ağlarının güçlendirilmesi, afetten hemen sonra yapılacak müdahalelerin planlanması hatta daha önce afet olmuş gibi tatbik edilmesi onlarca insanın canını kurtarabilir. Türkiye'de bu konuda kısa adı TAMP olan Türkiye Afet Müdahale Planı yayınlamıştır [5]. Bu planda afetin hemen ardından müdahale aşamaları senaryolaştırılarak afet olmadan önce afet yaşanmış gibi çalışma imkânı vermektedir. Böylelikle elde edilecek tecrübe ile eksikler giderilmesi ve afet sırasında daha organize hareket edilmesini başka bir ifadeyle afetin hemen sonrasında oluşacak paniğin azaltılması ve koordineli çalışmanın sağlanması amaçlanmıştır. TAMP hizmet gruplarına ayrılarak çalışmalarını yürütmektedir [5]. Hizmet gruplarından biri Ulaşım Altyapı Hizmet grubudur. Bu grubun görevi afet bölgesine en hızlı ulaşımın sağlanması olarak özetlenebilir. Afet esnasında ve sonrasında insanlara ulaşarak hayat kurtarılması ve hayati ihtiyaçların sağlanması için özellikle ilk 72 saat çok önemlidir [6]. Yaşanan afetin ardından yapıların yıkılması, yolların hasar alması ve afetten etkilenen kişilerin panik ile trafik kurallarına uymaması ulaşımda sektelerin olmasına neden olacaktır. Araştırmacılar deprem afetinin ilk oluştuğu anda ulaşım yapılarında karmaşa yani düzenli ulaşımın en aza indirildiği bir dönem var olduğunu belirtmektedirler [7]. Bu yüzden acil durumlarda kullanılan yolların güvende tutulması ve afette erişebilirliği sağlamak için daha önceden alternatif yollar belirlenerek afette trafik planlanması yapılmalıdır. Ulaşım Altyapı Hizmet Grubu özet olarak bu hizmetlerin sağlanması ile ilgili sorumludur. Zira ulaşım sağlanamadığında enerji, güvenlik, yangın, arama kurtarma, sağlık ve diğer hizmet grupları da çalışması imkânsız hale gelmektedir. Bu nedenle afet anında ulaşımın iyi modellenmesi oldukça önem arz etmektedir. Hatta emniyetli açık alanlar, stratejik binalar, hayati altyapının yeterliliği ve dağılımı son olarak mevcut yol ağı ile erişebilirlik durumu kentin olası bir depreme karşı dirençliliğini ortaya koymaktadır. Ulaşım ağlarının afet yaşanması halinde erişilebilir olması ve trafik kapasite özelliklerini çevresel faktörler etkilemektedir. Bu faktörler başlıca karayolunun güzergahı, ağ sistemi, yolun kesiti, trafik kapasitesi, yol güzergahı boyunca arazideki kullanım şekli ve yolların yıkım olması durumunda kapanmasına yol açabilecek bina stoğu vb. gibi maddelerden bahsedilebilir [6]. Afet yaşandıktan sonra erişebilirliğin tespiti için kullanılan yöntemin en basiti bulunduğumuz konumdan erişim sağlanacak konuma olan kuş uçuşu mesafesidir [8].

TAMP gibi tatbikatlarla yapılacak çalışmaların verileri oldukça önemli olmakla beraber gerçek bir panik durumunun sağlanamaması nedeniyle yetersiz kalmaktadır. Örneğin deprem afeti sonrasında ulaşım için düşünüldüğünde tatbikatlarda insanlar deprem olmadığını bilerek hareket etmektedirler. Oysa depremin hemen ardından büyük sarsıntının şoku, yaralanma/ölümler, kurtarılma/kurtarma çalışmaları ve yakınlarına ulaşma ihtiyacı insanlarda paniğe yol açacağı aşikardır. Bu panik ile trafiğe çıkacak sürücülerde ise ulaşımı sekteye uğratacak beklenmedik davranışlar olacaktır. Bu çalışma kapsamında afet anında ulaşımda yaşanacak panik hakkında bilgi toplanması amaçlanmıştır. Afet esnasında oluşacak panik, afet yokken yapılan tatbikatlarda ne yazık ki değerlendirilmesi en imkânsız değişkendir. Çok fazla etkenden etkilenebilecek olan ulaşımdaki paniğin bazı bileşenleri şöyle sıralanabilir;

1. Yıkılan yapıların molozları nedeniyle kapanan yollar ve sürücülerin alıştıkları bu yolları kullanamıyor olması ancak yeterli bilgilendirme olmadığından bu yolları kullanmayı denemeleri.
2. Arama kurtarma çalışmaları ve araçları nedeniyle geçici kapanan yollar ve sürücülerin bu yolları kullanamıyor olması.

3. Afetzedelerin yaşadıkları şok ile bir yerlere ulaşmaya çalışmaları ancak şok halindeki sürücülerin beklenmedik davranışları
4. Afetzedelerin veya afetzede yakınlarının, afet bölgesindeki yakınlarına panik ile ulaşma ihtiyacı
5. Kontrolsüz ve plansız yardım ulaştırmaya çalışan insanların oluşturacağı trafik.
6. Çevresindeki anormal görüntülerden ve seslerden (ceset, kan, yıkılmış yapı, yardım çığlığı vb.) etkilenen ve bu etki ile araç kullanan veya yaya olarak trafikte bulunan kişiler.

Bu maddeler çoğaltılabilir bu maddeler ve benzer hususlar nedeniyle afet anında, daha önce tatbikatlarda hesaba katılmayan ulaşımda panik yaşanması kaçınılmazdır. Bu paniğin büyüklüğünün veya içeriğinin bilinmesi de bu paniğin önüne geçilmesi veya en azından etkisinin azaltılması açısından önemlidir. Bu çalışma kapsamında paniği oluşturacak hususlar hakkında bilgi toplanmaya çalışılmıştır. Bu noktada çalışmada 17 Ağustos 1999 Marmara Depremini Yalova İlinde yaşamış insanlara çeşitli sorulardan oluşmuş anket yapılmış, deprem sırasında ulaşımda yaşanan panik ile ilgili bilgi toplanmaya çalışılmıştır.

II. YÖNTEM

Bu çalışmada deprem afeti sırasında özellikle karayolu ulaşımda oluşan paniği tanımlayabilmek için 17 Ağustos 1999 Marmara depremini Yalova'da yaşamış kişilere aşağıdaki sorular yöneltilmiştir. Her bir sorunun soruluş amacı da yanında bilgi olarak verilmiştir.

1. Soru: 1999 Ağustos ayında yaşadığımız deprem sırasına bulunduğunuz binadan ayrıldıktan sonra bir yere hareket etme ihtiyacı duydunuz mu?

Bu soru kaç kişinin depremin hemen ardında ulaşma ihtiyacı duyduğunu ve harekete geçtiğini (yaya veya araçla) tespit için sorulmuş bir sorudur. Bu tespit bir nevi insanların harekete geçip geçmediği hakkında bizlere oran verecektir. Hareketin mesafesi ve yöntemine göre de diğer değerlendirmeler yapılacaktır.

2. Soru: Hareket ettiyseniz yaya olarak mı yoksa araç vasıtasıyla mı hareket ettiniz?

Anketin bu sorusu vasıtasıyla insanların trafiğe araçları ile mi çıktıklarını yoksa yaya olarak mı hareket ettikleri arasında ilişki kurulmaya çalışılmıştır. Yalova'da bulunan karayolu ağları eski yerleşime göre yapıldıktan sonra çevresine yeni yerleşim yerleri ve gelişen yaşam şartlarında araç sayısının artmasıyla taşıma kapasitesi ve trafik yükü artmıştır. Yalova trafiğinde normal bir günde mesai başlangıç ve bitiş saatlerinde bile yoğunluğun fazla olması nedeniyle araç kuyruklarının oluşması ve tıkanmalar yaşanmaktadır. Normal bir zamanda sadece işten çıkan ve sakin bir durumda olan sürücüler ile trafik bu kadar sıkışırken büyük bir depremi yaşamış yakınlarından haber almaya çalışmak ve enkazlardan güvenli bir yere ulaşmak için panikle araçlarına yönelen afetzedelerin trafiğe çıkmasıyla beraber yaşanacak olan tıkanmaların boyutu planlanandan büyük olacaktır. Karayolu akışını sadece araç trafiği engellemeyecektir. Trafiğin yanı sıra köprü ve viyadüklerde hasar oluşması veya yol zemininde oluşacak çökme ve diğer hasarlar söz konusu olabilmektedir. Yol kenarında bulunan levha, trafik ışıkları ağaçlar ve benzeri unsurların devrilmesi de yolu kullanan insanlara zarar vermesine ve yolun kapanmasına bu nedenle de acil kurtarma faaliyetlerini etkin olarak çalışmalarını etkiler [8].

3. Soru Hareket ettiyseniz ne kadar yol kat ettiniz?

Bu soru cevap şıkları olarak 3 uzunluk aralığının bulunduğu b. Buna göre 0-1 km, 1-5 km ve 5 km fazlası mesafelerde hareketin yapılıp yapılmadığı sorgulanmıştır. Gelen cevaplara göre diğer illerimize nazaran daha kısa mesafelerde ulaşım imkânları bulunan Yalova İlinde depremden insanların ne kadar uzun mesafeler kat ettikleri tespit edilecektir. Buradan deprem sırasında Yalova İlinde oluşabilecek trafik durumu hakkında da yorum yapılacaktır. Ayrıca 1 km'nin üzerindeki cevapların araçla yolculuğun verileri ile örtüşmesi de beklenmektedir.

4. Soru: Depremin hemen sonrasında trafikte panik var mıydı?

Ankettin bu sorusunda hissedilebilir bir panik varlığı araştırılmıştır. Depremin hemen ardından ulaşımda oluşacak problemlerin temel kaynaklarından biri de büyük felaketlerin insanlar üzerinde oluşturduğu etkidir. Bu soru ile bu etki araştırılmıştır.

5. Soru: Trafik kurallarına uymayan araç veya yayalar var mıydı?

Deprem afeti sırasında ulaşımı engelleyen faktörlerden biri de trafik kurallarına uyulmamasıdır. Bu soruda bu durum belirlenmeye çalışılmıştır. Bu soru ayrıca 4. Soru ile örtüşen verilere sahip olması beklenmektedir.

6. Soru: Sokak ve caddelerde ulaşımı kesintiye uğratan çeşitli engeller var mıydı? (Enkaz, araç, ağaç vb.)

Deprem afeti sonrasında oluşan sarsıntılardan dolayı yıkılan ağaç, bina ve benzeri diğer unsurların enkazlarının yol üzerine düşmesi durumunda trafiğin olağan akışında oluşacak aksaklıklar tahmin edilmeye çalışılmıştır. Ayrıca arama kurtarma çalışmaları, iş makinelerinin oluşturduğu kalabalık da engel olarak belirtilmiş ve alışılmış ulaşımın engellenip engellenmediği incelenmiştir.

7. Soru: İlk müdahale ekipleri ve arama kurtarma ekipleri çalışmasını engelleyen trafik yoğunluğu veya ulaşım sıkıntıları var mıydı? (Halkın trafikteki paniği veya yıkılmış yapıların enkazları vs.)

Depremin hemen sonrasında özellikle arama kurtarma ve sağlık ekiplerinin sahada rahat ulaşıma sahip olmaları hayati önem taşımaktadır. Bu soruda bu durum değerlendirilmeye çalışılmıştır.

8. Soru: Yalova Şehrinde merkez mahallerde insan yoğunluğu sizce arttı mı?

Yalova ili deprem sonrasında doğu batı ve güney yönlerinde büyümüş yeni imar alanları oluşturulmuştur. Buna rağmen şehrin km² başına düşen insan sayısının artıp atmadığının hissedilir bir farkı olup olmadığı sorulmuştur. Artan nüfus miktarıyla afet sonrasında oluşabilecek kötü durumların riski doğru orantılıdır. Bu orantı sebebiyle şehri etkileyen afet, nüfus yoğunluğu ve bu yoğunluğa göre ulaşım ağlarının yetersizliği birleştiğinde afetin etkisini arttırmaktadır [9].

9. Yalova Şehir Merkezinde araç sayısı sizce arttı mı?

Yalova ili deprem sonrasında doğu batı ve güney yönlerinde büyümüş yeni imar alanları oluşturulmuştur. Buna rağmen şehrin km² başına düşen insan sayısının artıp atmadığının hissedilir bir farkı olup olmadığı sorulmuştur. Artan nüfus miktarıyla afet sonrasında oluşabilecek kötü durumların riski doğru orantılıdır. Bu orantı sebebiyle şehri etkileyen afet, nüfus yoğunluğu ve bu yoğunluğa göre ulaşım ağlarının yetersizliği birleştiğinde afetin etkisini arttırmaktadır [9].

10. Soru: 1999 Yılı Ağustos ayından bugüne olası bir depremde trafikte oluşabilecek panik ve ulaşım sıkıntılarını engellemek için herhangi bir çalışma yapıldı mı?

Bu soru genel bir değerlendirme olup, insanların hissedebilecekleri bir farklılık olup olmadığı araştırılmıştır. Sorudaki asıl amaç ilgili yetkililerin çözüm üretip üretmedikleri değil halkın bu çözümleri bilip bilmediğinin araştırılmasıdır. Örneğin bir sonraki sorudaki acil durum toplanma alanları 1999 depremi sonrasında oluşturulduğu halde halkın toplanma alanlarını bilip bilmediği de incelenmiştir.

11. Soru: İkamet ettiğiniz adrese ait acil durumlar sonrasında gidilmesi gereken toplanma alanını biliyor musunuz?

Deprem sırasında insanlara kumanya, giysi, temizlik eşyası gibi ihtiyaçlarının hızlıca temin edilmesi ve insanların kendi tanıdıklarından haber alabilmeleri için toplanma alanları oldukça önemlidir. Toplanma alanları ayrıca trafiği rahatlatılması için de önem arz etmektedir. Bu soruda insanların toplanma alanlarını bilip bilmediği araştırılmıştır.

12. Soru: Depremde daha etkili ulaşım sağlanabilmesi için sizce nasıl önlemler alınmalıdır? (Örneğin sokak kenarında parklar, daha geniş sokaklar, kentsel dönüşüm hızlandırılması gibi)

Bu soruda insanların gözlemlerine dayalı teklifleri merak edilmektedir.

13. Soru: 1999 Ağustos tarihinde hangi yaş aralığındaydınız?

Bu soru aslında anketi dolduranın muhakeme kabiliyeti araştırılmak istenilmiştir. Depremi çocukluk hatırası olarak hatırlayan birinin dolduracağı anket yerine olgunlaşmış insanların doldurmuş olması arasında fark olacağından bu soru yöneltilmiştir.

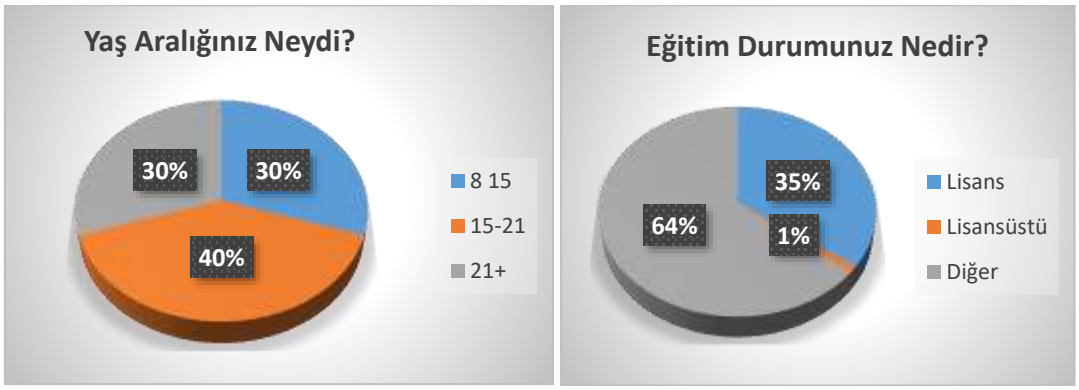
14. Soru: Eğitim Durumunuz Nedir?

Anketin son sorusunda temel amaç anketi dolduran kişinin tespit ve değerlendirmeleri bir eğitimin yönlendirmesi ile mi olup olmadığının incelenmesini amaçlamaktadır

III. BULGULAR

Anket çalışması Yalova Üniversitesi İnsan Araştırmaları Etik Kurulu /Bilimsel Araştırma ve Yayın Etiği Kurulu'na yapılan başvuru ile oluşturulmuştur. Bu kurul kararı ile Yalova ilinde toplam 211 kişi üzerinde yapılmıştır. Ankette elde edilen sonuçlar şu şekildedir;

İlk incelenen sorular anketin son iki sorusudur buna göre ankete katılanların yaşı ve eğitim durumları hakkında sonuçlar Şekil 1'de verilmiştir. Veriler incelendiğinde ankete katılanların yaklaşık %30'u 1999 Marmara Depremi sırasında 8-15 yaş aralığındadır. Geriye kalan %70'lik kısmı ise 15 yaşından büyüktür. Bu durum ankette sorulan geçmişe dayalı sorulara verilen cevapların belirli bir muhakeme süzgecinden geçtiğini göstermektedir. Yine ankete katılıp çoğu 1999 yılında yaşanmış deprem ile alakalı olan sorulara cevap veren kesimin %35'i lisans ve lisansüstü mezunudur. Geriye kalan %65'lık kısmı ise daha düşük seviyede eğitim almış kişilerden oluşmaktadır. Ankette 12. Soruda önerilen bazı teknik detayların da bu lisans ve lisansüstü eğitim görmüş insanların katkılarıyla zenginleştiği söylenebilir.



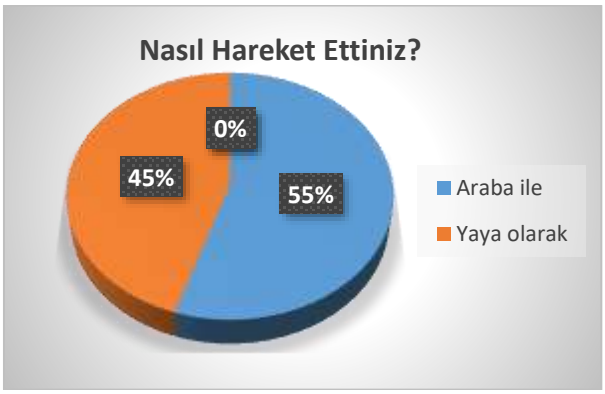
Şekil 1: 13.ve 14. Soru Yanıtları

Anketin ilk üç sorusu aslında birbiri ile bağlantılı sorular olup grafiksel olarak sonuçları verilmiştir. Buna göre 1. Soruda sorulan depremden hemen sonra bir yere hareket ettiniz mi sorusuna Şekil 2'de ankete katılanların %71'i evet cevabını vermiştir. Yalova ilinin 1999 Marmara Depremi sırasında nüfusu ile şimdiki nüfusu arasında yaklaşık 2 kat oran farkı vardır [10]. Son yıllarda (2008-2018) Yalova ili Türkiye'nin en hızlı nüfusu artan 2. Şehri unvanına da sahiptir [11]. Bu durum günümüzde yaşanabilecek benzer bir afet sırasında nüfusun yaklaşık %71'nin harekete geçeceğini hesaba katılması gerekliliğini ortaya koymaktadır. Araç hareketi olarak da bakıldığında da anketin 2. Sorusuna verilen cevaplarda Şekil 3'de 1999 Marmara depreminde neredeyse %46 oranında araç ile hareket olduğu anlaşılmaktadır. Yalova İl Merkezinin Marmara Denizine bakan kısmı eksi yerleşim birimlerini oluşturmakta olup yol genişlikleri oldukça düşmektedir. Ayrıca trafiğinin en önemli sıkıntılarından biri de sokak hatta caddelerin kenarına parke edilen araçlar oluşturmaktadır. Şekil 5'te görülen fotoğrafta Yalova Merkezin en işlek caddelerinden Ömer Faydalı Caddesinin gece 22:30'da çekilmiş fotoğrafı görülmektedir. Bölünmüş 2 şeritli yolda neredeyse her iki yönde birer şerit parke eden araçlarla kapanmaktadır. Gündüz ticari hayatın aktif olması nedeniyle park eden araçların sayısı artmakta bai durumlarda yan yana 2 şerit park eden araç olmaktadır. Günümüzde benzer bir deprem afeti sonrasında Yalova İlinde insanların %46 araç ile hareket etmesi durumunun da karşılaşacak trafik sıkışıklığı önceden önlem alınmaz ise oldukça büyük boyutta olacaktır. Asgari bir hesapta araçla harekete geçen %46 nüfus, yaklaşık şehirdeki araçların %30 temsil edildiği varsayıldığında günümüzde araç sayısına göre hesap yapılırsa şöyle bir manzara ile karşılaşılır; Yalova'da

TUİK 2023 verilerine göre 82 bin 546 adet araç kayıtlıdır [12]. Bu sayının %30'ü 24.764 adet araç yapmaktadır. Bu araçların her biri ortalama 5 m olduğuna sahip olduğu kabul edildiğinde trafikte afetin hemen sonrasında yaklaşık 124 km uzunluğunda araç kuyruğu oluşacağı hesaplanabilir. Aşağıda Şekil 6'da Yalova İlinin Google Earth görüntüsü verilmiştir. Bu görüntüde kuş uçucu İlin Çiftlikköy İlçesiyle birlikte batı doğu hattı 7,5 km Kuzey güney hattı ise sadece 3,5 km'dir. Depremde oluşan kuyruğu karayollarını kuş uçuşu hatlar ile belirlesek doğu batı yönünde 17 adet hat veya kuzey güney yönünde 35 hatta ihtiyaç vardır. Bu noktada yolda oluşan panik, trafik kurallarına uyulmaması, kontrolsüz yardıma gelen araçlar, kapanan sokak ve caddeler ile bu kuyruğun çok daha fazla olacağı aşikardır.

Şekil 2: 1. Soru Yanıtları

Şekil 3: 2. Soru Yanıtları



Şekil 4: 3. Soru Yanıtları

Şekil 5: Yalova İlinin en işlek caddelerinden birinin gece trafiği ve şerit kenarında park eden araçlar.

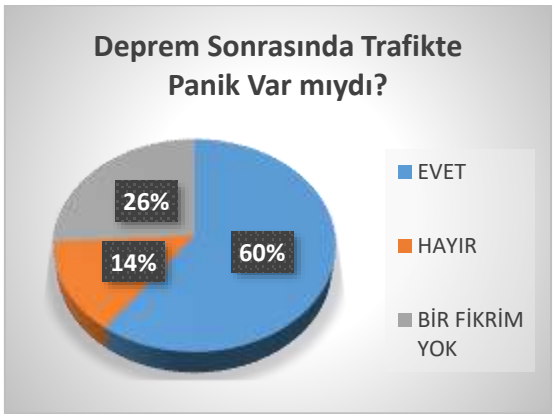
Şekil 6: Yalova İl Merkezinin kuş uçuşu mesafeleri.

Anketin 3. Sorusunda hareket mesafesi sorulmuştur. 1999 Marmara depreminde ankete katılan ve deprem sonrasında hareket eden insanların yaklaşık %46'i 0-1 km arası yani yaklaşık olarak yürüme mesafesi hareket ettiği Şekil 4'de de görülmektedir. Ancak %54 gibi ciddi bir kısmı 1 km'den fazla hareket ettiğini yine yaklaşık %21'lik kısmı 5 km'den de fazla hareket ettiğini anlaşılmaktadır. 5 km Yalova gibi küçük bir şehirde şehrin neredeyse başından sonuna bir harekettir. Ciddi bir kısım yapacakları bu mesafede hareket ile trafiği oldukça fazla kalabalıklaştıracaktır. Ayrıca bu trafiğin bilinmedik kapalı sokak ve cadde ihtimalleri ve kural ihlalleri ile artacağı da hesaba katılmalıdır, son yaşanan Maraş Depremlerinde benzer şekilde birçok sokak enkaz nedeniyle kapalı hale gelmiştir. (Şekil 7). Nitekim anketin diğer sorularında bu husus ile ilgili de tespitler bulunmaktadır.

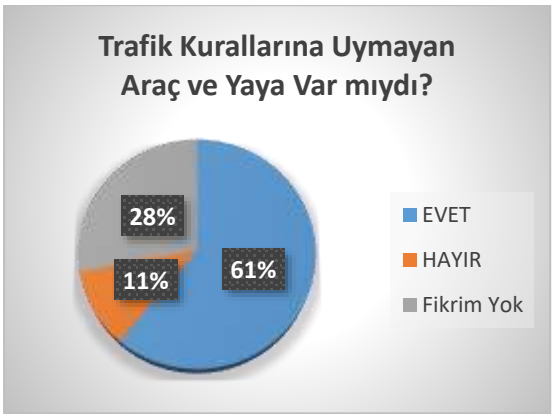
Şekil 7. Şubat 2023 tarihinde yaşanan Kahramanmaraş depremlerinde enkazlar nedeniyle trafiğe kapanan sokaklar

Ankette 4. ve 5. sorular trafikte yaşanan panik ve şok nedeniyle trafik kurallarına riayet edilip edilmeme durumunun tespiti ile alakalıdır. Şekil 8 ve 9'da grafik olarak 1999 Marmara Depreminde Yalova İlinde yaşayanların en az %60'nın trafikte panik olduğunu tespit ettiğini yine en az %61'inin da trafik kurallarına uyulmadığını belirttiği görülmektedir. Yukarıda belirtilen afet sonrası oluşabilecek trafik sıkışıklığının bir nedeni araçlar ile yola çıkılması ihtimali olduğu gibi bir diğeri de trafikte oluşabilecek panik ve şok durumu ve bu durumun doğal olarak insanlarda kurallara riayet ettirmeme hususudur. Şekil 8'de de görülebileceği

gibi çok ciddi oranlarda çıkan bu hususun engellenmesi ancak halka deprem sırasında trafiğe çıkılmamasının örgütlendirilmesi veya çıkılacaksa da nasıl davranılması gerektiğinin bilincinin verilmesi ile ve deprem riski olan şehirlerde sokak ve cadde boylarının genişletilmesi ile olabilir.

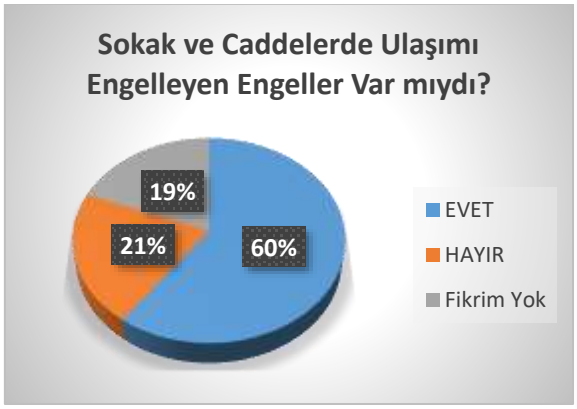


Şekil 8: 4. Soru Yanıtları



Şekil 9: 5. Soru Yanıtları

Ankette 6 ve 7. Sorular trafikte oluşan yoğunlaşmanın bir diğer nedeni ve sonucunda oluşan istenilmeyen durumu araştırmaktadır. 6. Soruda Şekil 10'de verildiği gibi yıkılan yapıların enkazları nedeniyle kapanan sokak ve caddelerin varlığını sorgulamaktadır. Bu soruya cevap verenlerin yaklaşık %60 böyle bir engelin olduğunu söylemekte, kalanların yaklaşık yarısı fikri olmadığını diğer yarısı da engelle karşılaşmadığını belirtmektedir. Sokak ve caddeleri kısmen veya tamamen kapatan engeller ile ilgili çalışmalar afet öncesinde yapılması gerekmektedir. Aksi halde yıkılan yapıların yolları kapaması ulaşımın tamamen aksamasına bazı bölgelere hiç ulaşılmamasına neden olacaktır. Bu noktada kentsel dönüşüm için belirlenecek risk durumuna ulaşımın olası afette aksamasının da değerlendirilmesi oldukça önemlidir. Şekil 11'de ise ilk müdahale ekiplerinin ulaşımda yaşadığı problem sorgulanmış ve soruya cevap verenlerin %70'i ilk müdahale ekiplerinin ulaşımın engelleyen durumlar olduğunu tespit etmiştir. Nitekim bu durum olası bir Marmara depremi sonrasında da yaşanacak büyük bir sıkıntı olup çözüm önerilerinin geliştirilmesi gerekmektedir. Kahramanmaraş depreminde de benzer şekilde yolların enkazla kaplandığı dolayısıyla ilk yardım ekiplerinin hareket kapasitesinin kısıtlandığı Şekil 7'de de gösterilmektedir.



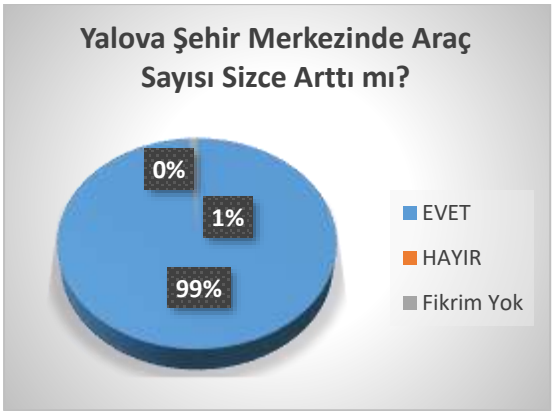
Şekil 10: 6. Soru Yanıtları

Şekil 11: 7. Soru Yanıtları

8 ve 9. Sorular 1999 depremi ile günümüzün kıyasını amaçlamaktadır. Ankete katılanlara 1999 yılından bugüne araç ve insan yoğunluğunun artışı ile ilgili bilgi sorulmuştur. Şekil 12'de grafikte verilen veriler incelendiğinde Yalova İl Merkezi hem güney hem doğu batı yönünde genişlemiş olmasına rağmen ankete katılanların yaklaşık %97'si insan yoğunluğunun artığını belirtmiştir. Yine ankete katılanların neredeyse tamamı araç yoğunluğunun da arttığını belirtmektedir. Oysa 1999 Marmara Depreminden sonra Yalova

İlinde yeni karayolu güzergahları yapılmış ve trafikte rahatlama sağlanmaya çalışılmıştır. Bu noktada özellikle ulaşım probleminin genel durumunun ve afet sonrası durumunun iyileştirilmesi için cazibe merkezlerinin şehir dışına taşınması ve planlamanın da afet durumu hesaba katılarak yoğunluğun dağıtılması ile yapılmasında fayda bulunmaktadır.

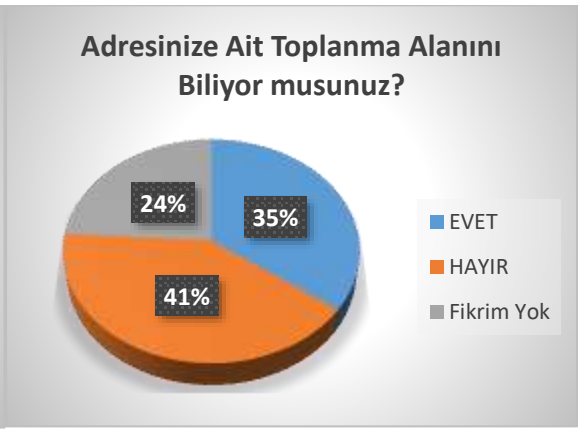
Şekil 12: 8. Soru Yanıtları



Şekil 13: 9. Soru Yanıtları

Ankette 10. Soruda vatandaşların deprem sonrası yapılan çalışmalardan haberlerinin olup olmadığı ile ilgili bilgi toplamayı hedeflemektedir. Şekil 14 incelendiğinde ankete katılanların yaklaşık %86 Hayır ve fikrim yok şıkkını seçerek çalışmalardan habersiz oldukları anlaşılmaktadır. Hemen akabinde sorulan 11. Soru da bu sonucu destekler niteliktedir. Toplanma alanlarını bilen vatandaş sayısı Şekil 15' de görüldüğü üzere yaklaşık %35 bandında kalmaktadır.

Şekil 14: 10. Soru Yanıtları



Şekil 15: 11. Soru Yanıtları

Son olarak ankette vatandaşlardan "Depremde daha etkili ulaşım sağlanabilmesi için sizce nasıl önlemler alınmalıdır?" şeklinde bir soru yöneltilmektedir. Çoktan seçmeli olmayan bu soruya verilen cevaplar hakkında yapılan yorumlarda şu cevaplar tespit edilmiştir;

1. Kentsel dönüşüm hızlandırılmalıdır
2. Daha geniş sokaklar planlanmalıdır
3. Deprem Sonrası için insanlara eğitimler verilmelidir.
4. Toplanma alanları artırılmalıdır
5. Şehir Planlanması Afete göre düzenlenmelidir
6. Park ve bahçeler artırılmalıdır.
7. Araç park alanları artırılmalıdır.
8. Tabela bilgilendirilmesi artırılmalıdır. (Toplanma alanlarına yönlendiren)
9. Toplu taşımanın teşvik edilerek özel araç sayısının azaltılmasına çalışılmalıdır.

10. Binaların sağlamlaştırılması sağlanmalıdır.
11. Sokak veya cadde kenarına parklar engellenmelidir.
12. Eski binaların yıkılmaları hızlandırılmalıdır.
13. Sosyal ağlar deprem durumunda bilinçli kullanımı sağlanmalıdır.
14. Ücretsiz otoparklar yapılmalıdır.
15. Karayollarında trafik şerit sayılarının artırılması
16. Yeni Karayolu ağları yapılmalıdır.
17. Yol kenarlarında yıkılma ihtimali bulunan ağaç, direk, levha gibi yapıların yıkılmayacak şekilde sabitlenmesi sağlanmalıdır.

Verilen cevaplarda en sık rastlanan cevap türü kentsel dönüşümün hızlandırılması hususudur. Nitekim Yalova Merkezinde bulunan, Bahçelievler, Süleyman Bey, Fevzi Çakmak, Rüstem Paşa gibi mahalleleri Yalova İlinin en eski ve en yoğun bölgelerini oluşturmaktadır.

Yine en sık verilen cevaplardan bir diğeri ise daha geniş sokakların planlanması hususudur. Yalova İl Merkezinde yol genişlikleri kaldırım dahil 5 metreye kadar düştüğü bölgeler bulunmaktadır. Bu sokakların sağında ve solunda bulunan eski yapılar deprem afeti sırasında yıkılması durumunda sokakların tamamı kullanılamaz hale gelmesi kaçınılmazdır.

Verilen diğer cevaplar da ilginç ve ortak kanaati dile getirir niteliktedir. Örneğin deprem öncesi ve sonrası verilmesi istenilen eğitimler, yol kenarında araç parklarının engellenerek trafik şeritlerinin park yeri olarak kullanılmasının kaldırılması, park bahçe ve toplanma alanlarının artırılması gibi hususlar Yalova İlinde daha önce deprem afeti yaşamış insanların bulunduğu tespitlerdir.

IV. SONUÇLAR

Yalova İli 3 büyükşehrin kesişim noktasında bulunan birçok önemli karayolun üzerinden geçtiği bir şehirdir. Ayrıca Yalova İli Türkiye'nin en hızlı nüfusu artan ikinci şehridir. Bu bilgiler ışığında yapılan çalışmada, 1999 Depreminde insanların %45'nin deprem sonrasında araçları ile hareket ettiği ve bu hareketin günümüzde yaşanması durumunda en az 122 km aracın bir anda trafiğe çıkması gibi bir sonuç olacağı tespit edilmiştir.

Yine Yalova ilinde Nüfusun en az %71 deprem sonrasında bir yerden bir yere hareket ettiği ancak nüfusun %65'nin toplanma alanlarını bilmediği de anket sonucunda anlaşılmaktadır.

Deprem sonrasında afetzedelerde panik ve afetin şoku kaçınılmaz bir durumdur. Nitekim ankette %60 oranında afetzedenin panik yaşadığı yine %61 oranında trafik kurallarına uyulmadığı hususu belirlenmiştir.

Yukarıda belirtilen hususların genel bir sonucu olarak arama kurtarma ekiplerinin %70'nin trafik engellerine takıldığı da belirlenmiştir.

Bu veriler ışığında, Yalova İlinde özellikle eski yerleşim birimlerinin hızlıca kentsel dönüşüme tabi tutulmasının gerektiği, bu gerekliliğin sadece yapı stoğunun eski ve deprem yönetmeliklerine uygun olmaması durumundan değil ayrıca deprem sonrası ulaşım için gerekli olduğu da anlaşılmaktadır.

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Barito Havzası Miyosen Yaşlı Kömürlü İstifinin Hidrokarbon Türüm Potansiyeli (Güney Kalimantan, Endonezya)

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Özet – Kömür, Endonezya'da bol bulunan ve son 20 yıldır ülkenin enerji ihtiyacı için daha yaygın kullanılan doğal bir kaynak olup, sadece geleneksel olarak ısı ve dolaylı olarak enerji üretilen bir yakıt olmayıp, doğal gaz ve petrol türetme potansiyeli de bulunmaktadır. Endonezya'daki büyük rezerve sahip bu kömürlerin hidrokarbon kaynak kaya potansiyelleri detaylı olarak incelenmemiştir. Bu nedenle, Barito Havzasındaki Miyosen yaşlı Warukin Formasyonu kömürlerin organik jeokimyasal ve organik petrografik değerlendirmeler ile hidrokarbon türüm potansiyellerinin belirlenmesi amaçlanmıştır. Kömür örnekleri hidrokarbon türümü için yeterli organik madde içeriğine sahiptir (ağırlıkça %46,87-55,16). Hidrojen İndeksleri (107-224 mg HC/g TOC) düşük olup, Tip III kerojen egemendir. Organik petrografik değerlendirmelerde kömürlerin bileşiminde %94-97 vitrinit, %3-5 liptinit ve %1 inertinit belirlenmiştir. Ortalama vitrinit yansıma değerleri minimum %0,21 Ro ile maksimum %0,26 Ro arasında değişmektedir. Tmax değerleri 385-414 ^{o}C arasında olup, Spor renkleri Batten (1-7) ölçeğinde düşüktür (3/4 ile 4) ve vitrinit yansıma verileriyle tutarlıdır. Vitrinit yansıması, T_{max} ve Spor renk verileri incelenen kömürlerin hidrokarbon türümü için olgunlaşmamış olduğunu göstermektedir. Organik madde içeriği petrol türümü için yeterli olsa da, kerojen tipi ve olgunlaşması uygun değildir. Bununla birlikte, incelenen kömürlerin önemli oranda gaz türüm potansiyeli bulunmaktadır.

Anahtar Kelimeler – Kömür, Petrol, CBM, Barito Baseni, Endonezya

I. GİRİŞ

Günümüz dünyasında toplumların gelişmişlik düzeyleri enerji kullanım oranları ile değerlendirilmektedir. Yüzyılı aşkın süredir birincil enerji kaynağı olarak kullanılan petrol, kömür ve doğal gaz gibi fosil yakıtların giderek artan kullanım oranları ve yenilenemeyen özellikleri, son yıllarda enerji güvenliği ve sürdürülebilir enerji kavramlarının önemini ortaya koymuştur. Tüm dünyada olduğu gibi Endonezya'da da petrol, kömür ve doğal gazı kaynaklı enerji talebi artmaktadır. Bunun başlıca nedenleri; nüfus artışı, ekonomik büyüme, enerji fiyatları ve hükümet politikalar olarak sıralanabilir. Endonezya'da enerji arzı ile enerji tüketimi arasındaki dengesizlik, ülkenin artan ekonomik faaliyetler nedeniyle ulaşım ve sanayi sektörlerindeki gelişim ve ulusal enerji güvenliği sorunları ülkede enerji konularını odak noktası haline getirmiştir (Teknoloji Değerlendirme ve Uygulama Ajansı, 2021).

Bu çalışmada olduğu gibi kömür sadece yenilenemeyen katı bir enerji kaynağı olmayıp, doğalgaz için önemli bir kaynaktır. Dünya'da birçok havzada (Gibsland Havzası, Avustralya; Mahakam Deltası, Endonezya; Turpan Havzası, Çin'deki birçok havzada olduğu gibi) sıvı hidrokarbon türüm potansiyeli için de önemlidir [1], [2]. Son yıllarda özellikle bu çalışma ile incelenmesi düşünülen kömürlere benzer özellikler sunan, genellikle Tersiyer yaşlı genç kömür oluşumları organik jeokimyasal, organik petrografik

değerlendirmeler ve hidrokarbon türüm potansiyelleri bakımından araştırmacıların ilgisini çekmekte ve diyajenez sürecinde hümik organik maddelerin gömülme etkisiyle petrol türetme potansiyellerinin olduğu belirtilmektedir [3], [4], [5], [6], [7].

Endonezya'da mevcut enerjiyi optimize etmek ve hidrokarbon üretim potansiyelini belirlemek için kömürlerde organik jeokimyasal analizlerin uygulanması çok önemlidir. Bu nedenle, Barito Havzasındaki Miyosen yaşlı Warukin Formasyonu kömürlü istifin organik jeokimyasal ve organik petrografik değerlendirmeler ile hidrokarbon türüm potansiyellerinin belirlenmesi amaçlanmıştır.

1.1. İnceleme Alanının Jeolojik Özellikleri

İnceleme alanının bulunduğu Endonezya, Avrasya Levhası, Hint-Avustralya Levhası ve Pasifik Levhası olmak üzere üç büyük levha sınırı arasında yer almaktadır. Çarpışan levhaların bir sonucu olarak Endonezya'da birçok dalma-batma zonu, volkanik zonlar ve jeolojik yapılar görülür. Enerji ve Maden Kaynakları Bakanlığı'na (2022) göre Endonezya, Batı Endonezya'dan (Sumatera) Doğu Endonezya'ya (Papua) kadar yayılan Tersiyer ve daha yaşlı 128 havza bulunmaktadır. Tektonik süreç sırasında, Güney Sumatra Havzası ile Güney Kalimantan'daki Barito ve Kutai Havzalarını içeren Sundaland'ın güney kesiminde önemli Senozoyik yaşlı kömür içeren sedimanlar oluşmuştur [8] (Şekil 1a).

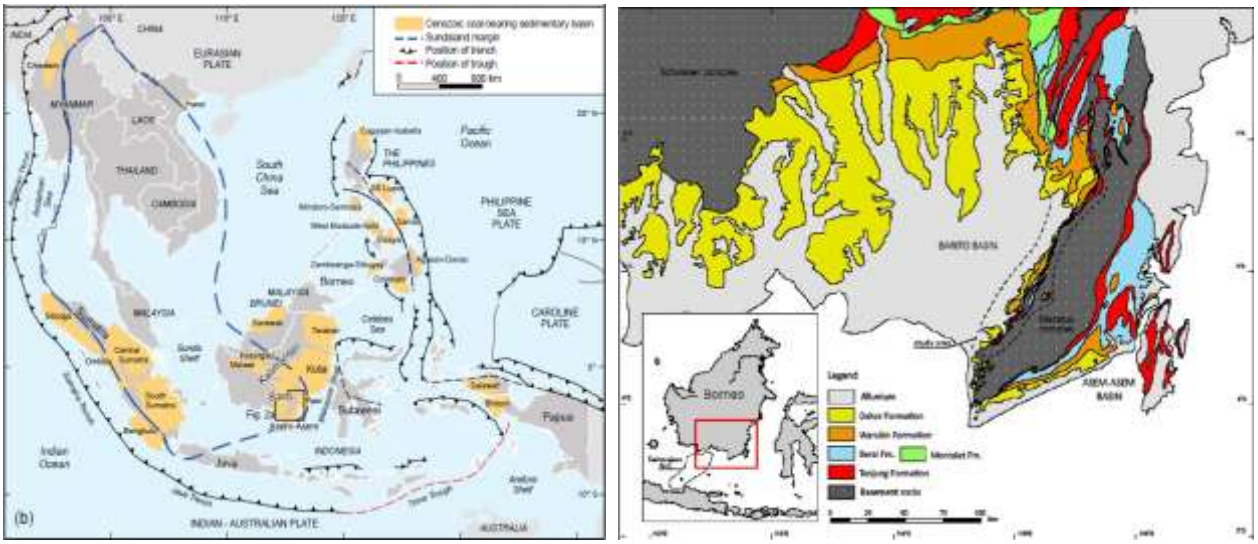
Endonezya Jeolojik Kaynaklar Merkezi'i verilerine göre Endonezya'daki kömür havzaları genellikle Sumatera ve Kalimantan adalarındadır [9] (Şekil 1a). Kalimantan'da, Kutai, Barito, Asem-Asem, Berau, Tarakan, Ketungau ve Malawi Havzalarında kömür istifi bulunur [9]. Özellikle Mahakam Deltası, Endonezya'nın Kalimantan bölgesinin doğu kıyısında yer alır ve organik maddece zengin şeyller, kömürlü şeyller ve kömürden oluşan bir istif hidrokarbon türümü için oldukça önemlidir.

Bu çalışma, Kalimantan'daki en büyük sedimanter havzalarından biri olan Barito Havzası'nda gerçekleştirilmiştir. Havzada, hidrokarbon araştırmaları da dahil olmak üzere jeolojinin farklı alanında birçok çalışma yapılmıştır [10], [11], [12].

Barito Havzası, Güney Kalimantan'dadır ve kuzeyinde Kutai Havzası ile sınırlıdır (Şekil 1). Satyana vd'ye [10] göre Paleojen'de, Orta Eosen alüvyal ve göl çökellerinden, Alt Tanjung Formasyonu'ndan riftleşmeyle eş zamanlı gelişen çökelleri ifade eden bir genişleme süreci bulunur. Transgresyon sürecinin bir sonucu olarak, Üst Tanjung Formasyonu'nda denizel şeyller çökelmiştir. Eosen kömürü, riftleşme rift sonrası faza geçiş aşamasında birikmiştir. Bu arada, rift sonrası dönem de ince kömür birikimleri oluşmuştur (Şekil 1b). Barito Havzası kömürleri Tanjung Formasyonu (Eosen yaşı) ve Warukin Formasyonu (Miyosen yaşı) içindedir. Transgresif Tanjung Formasyonu kalın ve yatay olarak geniş kömür damarları oluştururken, regresif Warukin Formasyonu, ince kömür damarları (genellikle <2 m) içeren denizel sedimanlardan oluşmaktadır [13]. Barito Havzası'ndaki Tanjung Formasyonu kömürlü istifinin hidrokarbon türüm potansiyeli bulunmaktadır [10].

Warukin Formasyonu, kumtaşı ve kömür katkılı çamurtaşı litolojileri ile karakteristiktir ve çökelme ortamı prodelta ile üst delta ovasıdır [14]. Birimde, 0,5 m ile >20 m arasında değişen kalınlıklarda kömürler bulunur. Kömürlerin kalorifik değeri < 6000 kcal/g' dir [15].

Barito Havzası'nda gelişen tektonizma petrol sistemi için etkin rol oynamıştır. Raharjo vd. [16], kömür damarı-A ile Warukin Formasyonunun kumtaşı fasiyesleri arasındaki dokanakta petrol sızıntısı belirlemiştir ve Warukin Formasyonu Orta Wara kömürünün kaynak kaya olarak önemli rol oynadığı saptanmıştır.



Şekil 1. İnceleme alanının yeri ve basitleştirilmiş genel jeoloji haritası [8].

II. MATERYAL VE YÖNTEM

Bu çalışma, Rantau sahasındaki kömür madeninde yapılmıştır. Açık ocak işletmeciliği devam eden 8 farklı kömür damarından (EL, EU, GU, GL, G1U, G1L, ML ve MU damarları) toplam 20 örnek alınmıştır. Kömür damarları kendi içinde homojen görünümlüdür, aynı litotip özellikleri ile karakterize edilir ve yaklaşık 2 m damar kalınlığına sahiptir. Örnekler laboratuvar koşullarında kurutulduktan sonra, toplam organik karbon, *Rock-Eval* pirolizi gibi organik jeokimyasal analizler ile kerojen analizi, vitrinit yansıması gibi organik petrografik analizlerle incelenmiştir. Analizler PT. GEOSERVICES, *Geological & Laboratory Services Division* (PTG) Jakarta'da 2023 yılında gerçekleştirilmiştir.

III. BULGULAR

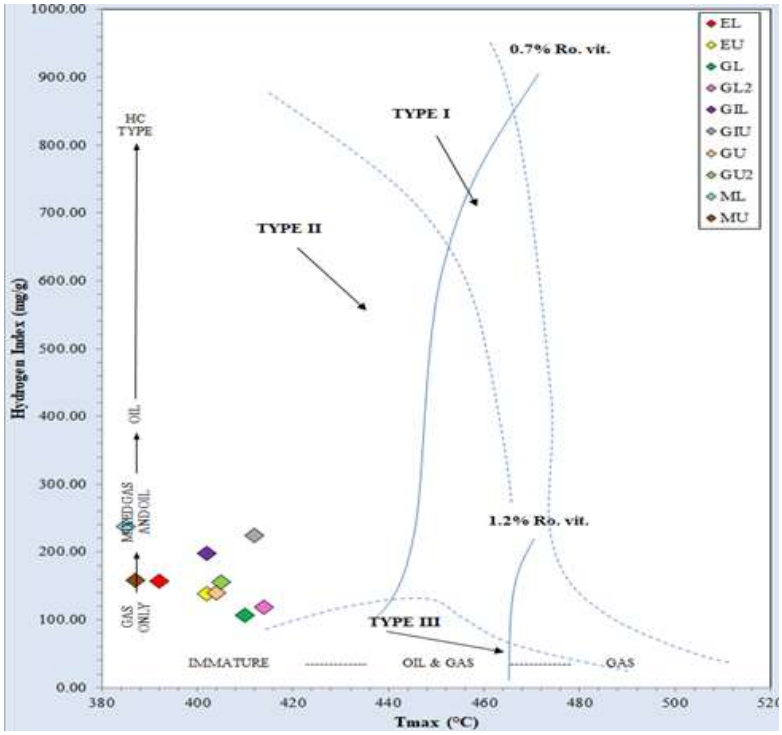
Kömür numuneleri için yapılan jeokimyasal analiz sonuçları bileşimin organik maddece zengin olduğunu göstermektedir (ağırlıkça %46,87-55,16). Ayrıca, bu sonuç, örneklerin potansiyel kaynak kaya olma ve hidrokarbon üretme potansiyelinin de mükemmel olduğunu da işaret etmektedir [17]. Kömür bataklıklarındaki çökelme ortamı da sınırlı su sirkülasyonu, oksijen içeriği yanısıra düşük yıkıcı bakteri aktivitesi nedeniyle organik madde zenginleşmesi için ideal ortamlardır.

Rock-Eval piroliz analizi sonuçlarına göre Hidrojen İndeksleri (107-238 mg HC/g TOC) ve S2/S3 oranı değeri (2,19-4,69 mg/gTOC) genel olarak düşüktür. S2 değerleri 55,25-113,85 mg HC/g kaya arasındadır (Tablo 1). Ancak, G1U ve ML örneklerinde Tip II/III kerojen de bulunmaktadır. Bu durum, kömürün çoğunlukla karadan gelen organik madde ile paralik bir bataklık ortamında çökeldiğine işaret eder. Ayrıca, gel-gitle deniz suyunun etkisi de söz konusudur. Transgresyon sürecinin gerçekleşmesi veya deniz seviyesinin yükselmesi, organik maddenin denizel fitoplankton, zooplankton, mikroorganizmalar (bakteriler) veya diğer deniz kaynaklı organik maddelerce (tip II kerojen) zenginleşmesini sağlamıştır (Tip II-III karışımı). HI-OI diyagramında (Şekil 2) ve HI-TOC (Şekil 3) da egemen olarak Tip III kerojen belirlenmiştir.

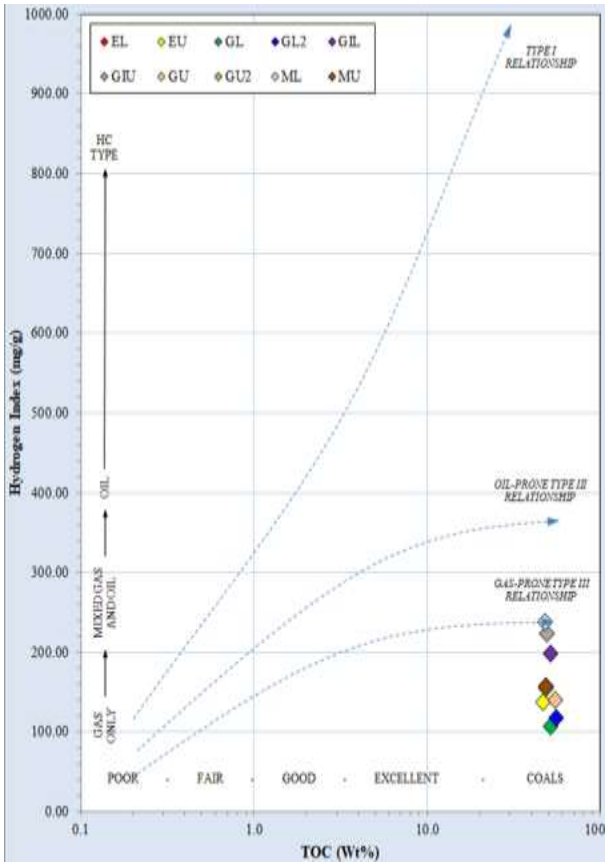
Tablo 1. İncelenen örneklerin TOC ve Rock-Eval Piroliz analizi sonuçları

No	Örnekler	TOK (%)	S1 (mg/g)	S2 (mg/g)	S3 (mg/g)	HI (mgHC/gTOC)	OI (mgHC/gTOC)	PI (mg/g)	Tmaks (°C)	S2/S3 (mg/g)	PY (mg/g)
1	EL	48.35	1.66	76.07	20.95	157	43	0.02	392	3.63	77.73
2	EU	46.87	4.86	64.72	22.5	138	48	0.07	402	2.88	69.58
3	GL	51.83	1.25	55.25	25.25	107	49	0.02	410	2.19	56.50
4	GL2	55.16	1.37	65.12	25.37	118	46	0.02	414	2.57	66.49
5	G1L	51.3	2.37	101.5	21.62	198	42	0.02	402	4.69	103.87
6	G1U	49.19	3.79	110.11	20.91	224	43	0.03	412	5.27	113.90
7	GU	54.78	2.87	76.78	22.64	140	41	0.04	404	3.39	79.65
8	GU2	48.23	2.65	74.57	21.44	155	44	0.03	405	3.48	77.22
9	ML	47.87	6.5	113.85	16.74	238	35	0.05	385	6.80	120.35
10	MU	48.49	1.44	76.44	16.77	158	35	0.02	387	4.56	77.88

İncelenen kömür örnekleri için kaydedilen ortalama vitrinit yansıma değerleri (Ro %), minimum %0,21 Ro ile maksimum %0,26 Ro arasında değişmektedir. Rock-Eval piroliz analizinde de Tmax değerleri 385-414 ^{o}C arasında belirlenmiştir. Spor renkleri Batten (1-7) ölçeğinde değerlendirildiğinde oldukça düşüktür (3/4 ile 4) ve vitrinit yansıma verileriyle tutarlıdır (Tablo 2). Vitrinit yansıma, Tmax ve spor renkleri incelenen örneklerin olgunlaşmamış özelliğini gösterir.



Şekil 2. Rantau kömürlerinin kerojen tiplerini gösteren HI-OI diyagramı

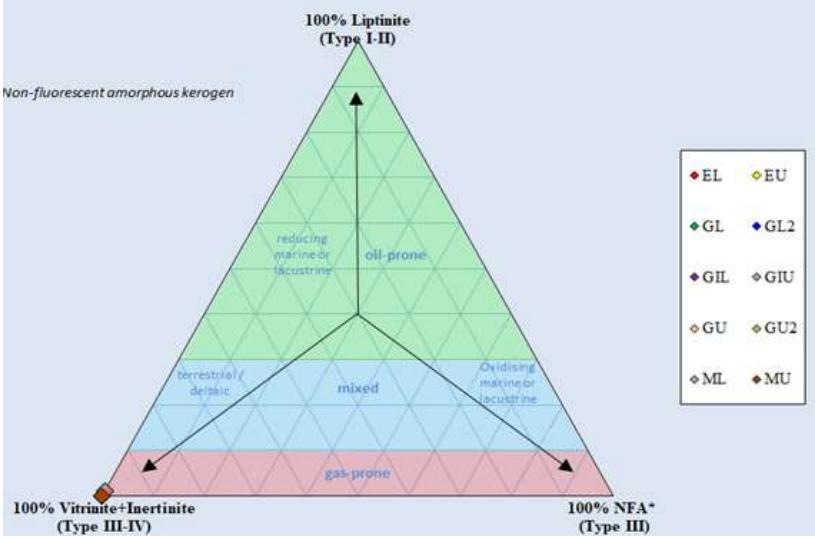


Şekil 3. Rantau kömürlerinin hidrokarbon türüm potansiyellerini gösteren HI-TOC diyagramı

Tablo 2. Rantau kömürlerinin Vitrinit Yansıması ve Batten ölçeğine göre Spor Renkleri

No	Örnekler	Vitrinit Yansıması			Kerojen ve SCI analizi				Kerojen
		#	Aralık	Ortalama	SCI	Vitrinit	Liptinit	Inertinit	Iyileşmesi
1	EL	47	0.20-0.39	0.26	3/4	94	5	1	Iyi
2	EU	50	0.20-0.33	0.24	3/4	95	4	1	Iyi
3	GL	49	0.20-0.34	0.25	4	97	3	-	Iyi
4	GL2	52	0.20-0.32	0.25	4	96	3	1	Iyi
5	GIL	55	0.20-0.30	0.24	3/4	95	4	1	Iyi
6	GIU	51	0.20-0.33	0.25	3/4	97	3	-	Iyi
7	GU	52	0.20-0.34	0.24	4	94	5	1	Iyi
8	GU2	50	0.20-0.30	0.25	4	96	4	-	Iyi
9	ML	40	0.21-0.30	0.23	4	94	5	1	Iyi
10	MU	56	0.15-0.29	0.21	4	97	3	-	Iyi

Kerojen petrografisi değerlendirmesinde 10 kömür örneğinin tamamında gözlenen maseral bileşimleri, ağırlıklı olarak vitrinit (%94-97), liptinit (%3-5) ve inertinit (%1) olup, gaz türüm potansiyelli kerojeni göstermektedir (Şekil 4).



Şekil 4. İncelenen kömürlerin petrografik bileşimleri ve hidrokarbon türüm potansiyelini gösteren diyagram

IV.SONUÇLAR

Bu çalışmada, Kalimantan Barito Havzasındaki (Endonezya) Miyosen yaşlı Warukin Formasyonu kömürlü istifi değerlendirilmiş ve kömürlerde organik jeokimyasal ve organik petrografik analizler ile hidrokarbon türüm potansiyeli incelenmiştir. Kömür örneklerinin hidrokarbon türümü için yeterli organik madde içeriği bulunmaktadır (ağırlıkça %46,87-55,16). Rock-Eval piroliz analizi sonuçlarına göre düşük Hidrojen İndeksleri (107-224 mg HC/g TOC) görülür. HI-OI diyagramında egemen olarak Tip III kerojen, bununla birlikte Tip II/III kerojen varlığı da belirlenmiştir. Organik petrografik değerlendirmede ise kömürlerin bileşiminde %94-97 vitrinit, %3-5 liptinit ve %1 inertinit saptanmıştır.

İncelenen kömür numuneleri için kaydedilen ortalama vitrinit yansıma değerleri minimum %0,21 Ro ile maksimum %0,26 Ro arasında değişmektedir. Olgunlaşmanın belirlenmesinde kullanılan diğer parametrelerden Tmax değerleri 385-414 ^{o}C arasında olup, Spor renkleri Batten ölçeğinde düşüktür (3/4 ile 4) ve vitrinit yansıma verileriyle tutarlıdır. Vitrinit yansıması, Tmax ve Spor renk verileri incelenen kömürlerin hidrokarbon üretimi için henüz olgunlaşmadığını göstermektedir. Organik madde içeriği petrol türümü için yeterli olsa da, kerojen tipi ve olgunlaşması petrol türümü için uygun değildir. İncelenen kömürlerin sadece gaz türüm potansiyeli bulunmaktadır.

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"Net Sıfır" Hedefinde Kömürün Değişen Rolü; Kömürlerin Nadir Toprak Element (NTE+Y) ve Sc İçerikleri, Türkiye'den örnekler

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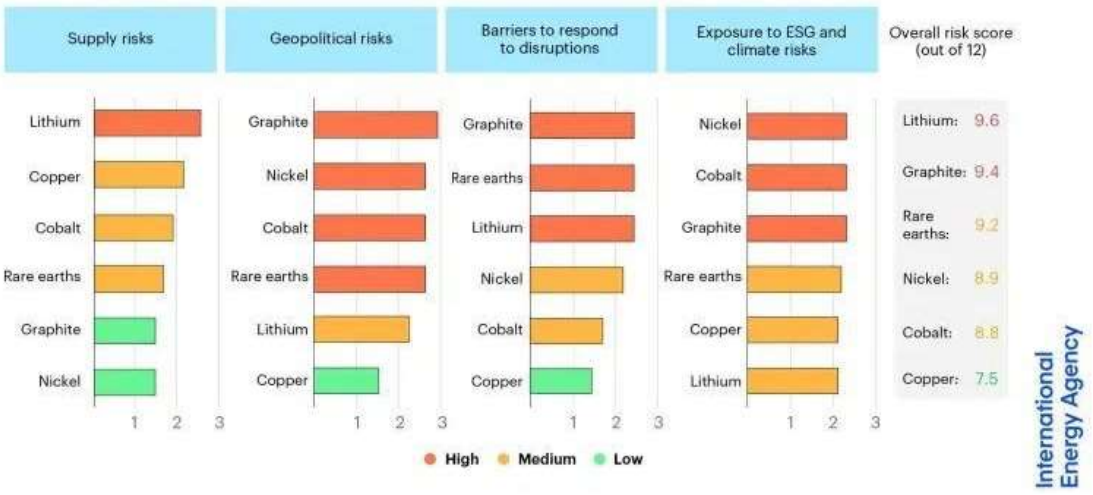
Özet – NTE (Nadir Toprak Elementleri + Y) ve Sc, enerji sektörü ve elektronik gibi yüksek teknoloji gerektiren alanlar için küresel olarak ihtiyaç duyulan stratejik malzemelerdendir. Son yıllarda, yenilenebilir enerji teknolojilerinin hız kazanması ile NTE'nin küresel talep ve arzı arasındaki uçurum artmıştır. Bu malzemelerin ithalatına büyük ölçüde bağımlı olan ülkeler için alternatif kaynak arayışları giderek daha önemli hale gelmiş, özellikle kömür ve kömür külü, NTE dahil birçok element için olası bir kaynak olarak kabul edilmeye başlamıştır. Bu çalışmada incelenen düşük ranklı Türk kömürleri ortalama 73,73 ppm (kuru kömür bazında) NTE bolluğuna sahiptir. NTE+Sc içerikleri, Dünya, ABD ve Çin kömürlerine göre daha yüksek olmasına rağmen, üretim açısından günümüz koşullarında ekonomik olmadığı ve gelecekte yeni üretim tekniklerinin geliştirilmesi ile potansiyel kaynaklar olarak dikkate alınabileceği söylenebilir.

Anahtar Kelimeler – Nadir Toprak Elementi, Yitriyum, Sc, Türk Linyitleri, Kritik mineraller.

I. GİRİŞ

Küresel ısınma ve sera gazı salımını, dolayısıyla iklim değişikliğine neden olan etkenleri azaltmayı amaçlayan "Net Sıfır" hedefi 2016 yılında Birleşmiş Milletler İklim Değişikliği Çerçeve Sözleşmesi kapsamında Paris Anlaşması ile gündeme gelmiştir. Bu anlaşmanın temelinde Dünya'nın ortalama sıcaklığının 1,5 ^{o}C ile sınırlı tutulması bulunur. Bu hedefe ulaşmak için öncelikle fosil yakıt bazlı enerji üretimi ve tüketiminde kullanılan yöntemlerin değiştirilmesi ve temiz enerji kaynaklarının (rüzgar, güneş, hidroelektrik gibi) birincil enerji kaynakları grubundaki payının arttırılması gerekmektedir. Hedeflenen "yeni ve temiz enerji" çağı ise yüksek teknoloji odaklı ve oldukça maliyetli bileşenleri temel almaktadır. Yenilenebilir enerji teknolojilerinin temelinde kritik mineraller bulunur ve bu grup içindeki Nadir Toprak Elementleri (NTE), temiz enerji ve yüksek teknoloji alanlarındaki geniş uygulama alanları (rüzgar türbinleri, elektrikli araçlar gibi) ve ekonomideki stratejik rolleri nedeniyle, hem Avrupa Komisyonu [1], [2] hem de ABD Enerji Bakanlığı (2011) tarafından kritik hammaddeler (malzemeler) içinde tanımlanmıştır [3]. Lityum, grafit, nadir toprak elementleri, nikel, kobalt ve bakırdan oluşan kritik mineraller gelecekte oluşması istenilen temiz enerji çağı için hayati öneme sahip kaynaklardır (Şekil 1).



Şekil 1. Kritik minerallerin farklı risk skorlarına göre karşılaştırması (IEA, Global Critical Minerals Outlook 2024, https://www.iea.org/events/global-critical-minerals-outlook-2024)

Geleneksel olarak NTE üretimi, monazit, ksenotim ve bastnasit veya iyon adsorbe killerden yapılmaktadır [4]. Rezerv alanları Çin, Brezilya, Vietnam ve Rusya gibi birkaç ülke ile sınırlıdır [5]. Dünyada tüketilen tüm nadir toprak elementlerin %80'inden fazlasını tedarik eden Çin, işleme teknolojisinde liderdir, küresel rezervlerin yaklaşık %50'sine sahiptir. Ayrıca, madencilik, ayırma, rafinaj ve üretimden oluşan NTE tedarik zincirini de kontrol etmektedir [6], [7], [8]. Ancak, değişen enerji sektörünün ihtiyaç duyduğu NTE için tek bir ülke ve kaynağa bağlı kalmak stratejik olarak doğru ve sürdürülebilir bir durum değildir ve her ülke kendi kaynaklarındaki potansiyeli araştırmak üzere ilgili kurumlarında çalışmaları başlatmıştır. Bu alternatif kaynakların başında da kömürlerin bileşiminde doğal olarak bulunan inorganik bileşim gelmektedir.

Başlıca ironi; yenilenebilir ve sürdürülebilir bir enerji çağı için bunun başlıca sorumlusu olan, fosil yakıtların en "kirli"sinin çarelerden birisi olarak görülmesidir.

Ülkemizin yaklaşık 19 Gt'a ulaşan, yüksek kül verimi ve toplam kükürt içeriğine sahip Senozoik yaşlı, düşük dereceli kömür rezervi bu kapsamda incelenmesi gereken kaynaklardır [9], [10]. Bu nedenle, farklı araştırmacılar ve yazarın kendi çalışmalarından derlenen verilerin değerlendirilmesi ile Türkiye'deki 26 adet düşük kaliteli kömür sahası örneklerinde kritik hammadde özellikleri yeni enerji çağı prospeksiyonuna göre yorumlanmıştır.

A. Kömürlerin NTE bileşimleri

Kömür, endüstriyel açıdan değerli, kritik elementlerin kaynağı olarak kullanılabilecek birçok metalik element içerir [11]. Küresel olarak hem kömür madenciliği hem de kullanım sırasında önemli miktarlarda maden atığı üretilmekte olup, bunların büyük bir kısmı ekonomik öneme sahip bileşenlerden oluşur. Kömürdeki nadir toprak elementleri çoğunlukla yüksek erime ve kaynama sıcaklığına sahip inorganik mineraller halinde oluşur [12], bu da bunların kömürün yanmasından sonra kül akışında zenginleşmesine olanak tanır [13], [14].

Kömürden veya kömür yakma külünden NTE'nin çıkarılması son on yılda oldukça popüler konular olmuştur [15], [16]. Her ne kadar bazı araştırma grupları pilot ölçekte ekstraksiyon deneylerini başarıyla gerçekleştirmiş olsa da [17], şu anda bu teknik bilgileri ticari ölçekte gerçekleştirmek hala zordur. Bunun temel nedeni reaktifler/enerji tüketiminin genel olarak yüksek maliyetleri ve düşük NTE geri kazanım oranlarıdır. Sun ve diğ., [18] ve Ketris ve Yudovich [19], kömürdeki 300 mg/kg REY içeriğinin madencilik

için minimum değeri oluşturduğunu belirtmektedir. Ortalama NTE+Sc verilerine dayanarak, dünya kömürlerinde toplam 68,5 milyon metrik ton olduğu tahmin edilmektedir [19], [20]. Bu, geleneksel maden yataklarında belirlenen rezervlerin yaklaşık %50'sine eşittir [21], [22]. ABD'deki Kentucky, Fire Clay kömürü [17], Çin'deki kömürler [23], [24] gibi anormal derecede yüksek NTE konsantrasyonuna sahip kömür damarları ve Rus Far East kömürünün [11], [25] umut verici NTE kaynakları olduğu bildirilmektedir.

II. MATERYAL VE YÖNTEM

Bu çalışma için farklı araştırmacılar tarafından yapılan 26 kömür sahasına ait eser element verileri ile yazarının yaptığı çalışma sonuçları birlikte değerlendirilmiştir (Tablo 1 ve Şekil 1). Kömür sahalarının seçiminde benzer jeolojik yaşta (Tersiyer) olmaları, verilerin tamamen kuru kömür bazlı analizler sonucu olması ve analizlerin aynı laboratuvarlarda yapılması dikkate alınmıştır.

Tablo 1. Bu çalışmada değerlendirilen kömür sahaları ve ilgili kaynakça, alan numaraları ([26]- [40])

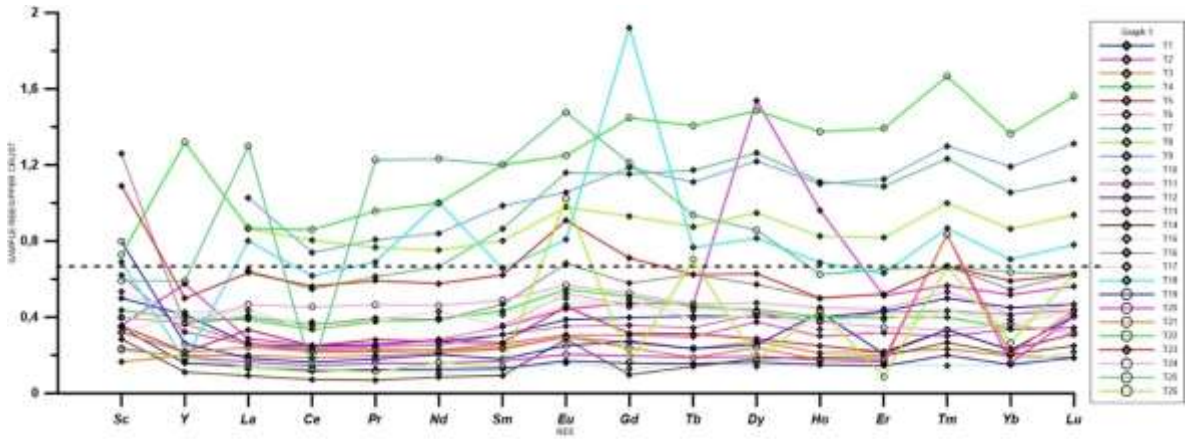
Coal Area	Referance	Area Code
Saray (Tekirdağ)	Eraslan & Ergün (2017)	T1
Pınarhisar (Kırklareli)	Eraslan & Ergün (2017)	T2
Afşin-Elbistan Outcrop (K.Maraş)	Cicioğlu & Karayiğit (2015)	T3
Afşin-Elbistan Well (K.Maraş)	Cicioğlu & Karayiğit (2015)	T4
Orhaneli (Bursa)	Karayiğit et al. (2003)	T5
Özyurt (Gümüşhane)	Saydam Eker et al. (2016)	T6
Kayadibi (Gümüşhane)	Saydam Eker et al. (2016)	T7
Tarhanas (Gümüşhane)	Saydam Eker et al. (2016)	T8
Manas (Bayburt)	Saydam Eker et al. (2016)	T9
Çan (Çanakkale)	Gürdal (2008)	T10
Arguvan (Malatya)	Yalçın Erik & Ay (2020)	T11
Gemerek (Sivas)	Yalçın Erik (2018)	T12
Divriği (Sivas)	Yalçın Erik (2019)	T13
Çilhoroz (Erzincan)	Yalçın Erik & Ay (2018)	T14
Ilgın (Konya)	Altunsoy et al. (2017)	T15
Çayırhan (Ankara)	Karayiğit et al. (2011)	T16
Işıklar (Muğla)	Karayiğit et al. (2017)	T17
Deniş (Muğla)	Karayiğit et al. (2017)	T18
Yeniköy (Muğla)	Çelik et al. (2017)	T19
Kangal (Outcrop)	Kalender & Karamazi (2017)	T20
Kangal (well/core sample)	Kalender & Karamazi (2017)	T21
Yatağan (Muğla)	Karayiğit et al. (2000)	T22
Seyitömer	Karayiğit et al. (2000)	T23
Tunçbilek (A3) (Kütahya)	Karayiğit et al. (2002)	T24
Tunçbilek (B4-5) (Kütahya)	Karayiğit et al. (2001)	T25
İsaalan (Balıkesir)	Karayiğit et al. (2017)	T26

III. BULGULAR

A. *Türkiye'deki düşük dereceli kömürlerin NTE özellikleri*

Bu çalışmada Seredin ve Dai [41] NTE sınıflandırması kullanılmış olup hafif (LREY), orta (MREY) ve ağır (HREY) gibi sınıflar ile kritik, kritik olmayan ve ekstrem grupları içermektedir

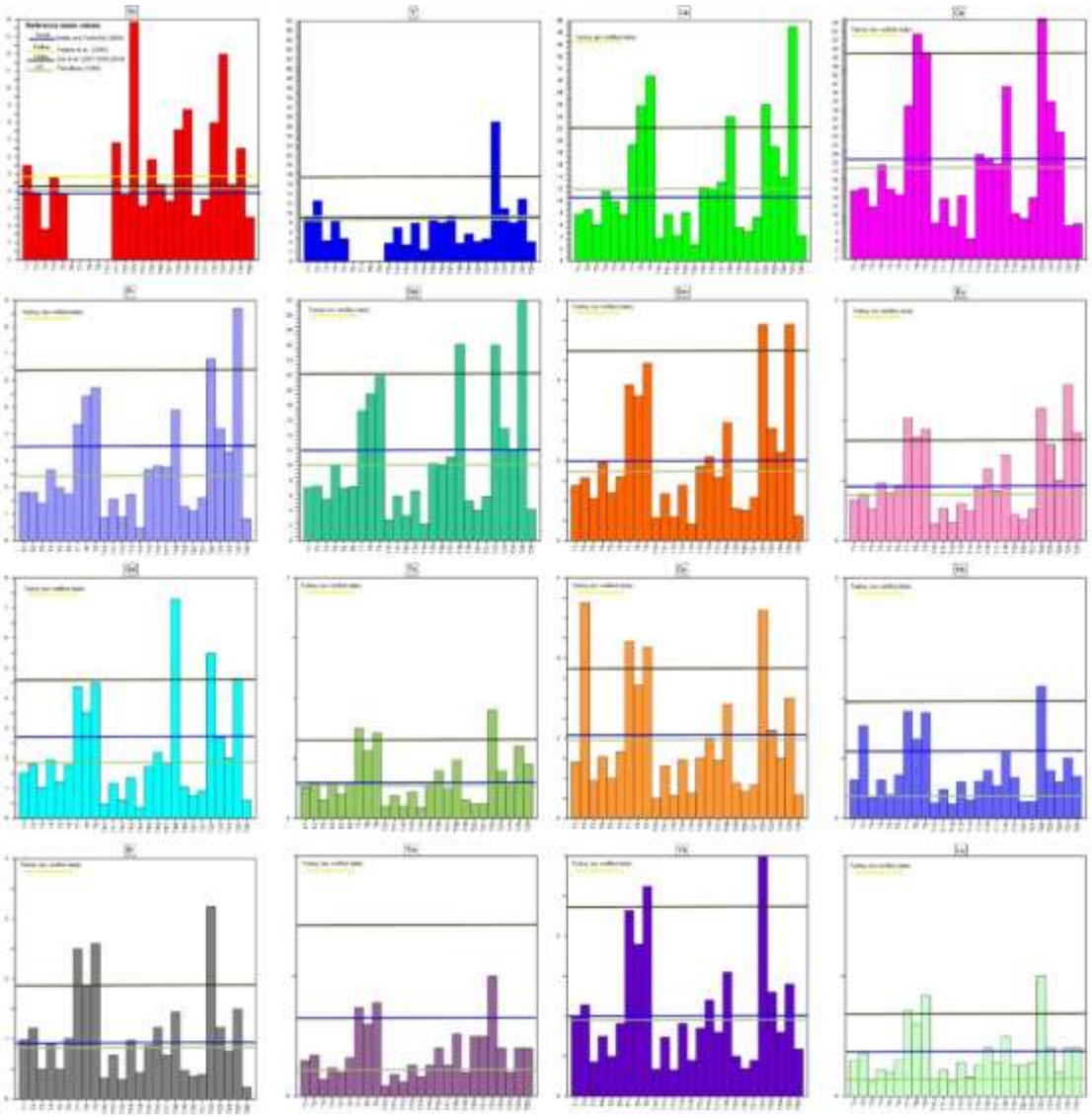
İncelenen kömürlerin sonuçlarına göre, toplam NTE konsantrasyonu 18,69 ppm-177,2 ppm arasında değişmektedir ve kömür ve kömür içeren litolojiler için toplam ortalama NTE + Sc bolluğu kuru tam kömür bazında 73,73 ppm (21,83 ila 185,20 ppm) olarak bulunmuştur (Şekil 2). Analiz edilen örneklerdeki ∑LREE değeri 10,11 ile 113,8 ppm (ortalama 48,12 ppm) arasındadır. İncelenen kömürlerdeki ∑LREE/∑HREE oranları 1,19 ile 11,48 (ortalama 3,36) arasında değişmekte olup, LREE'lerin HREE'lere göre zenginleştiğini göstermektedir. Türkiye'deki kömürlerin ortalama NTE bolluğu dünyadaki ortalama değerden biraz daha yüksek ve Çin kömürlerinden daha düşüktür [7], [19] (Şekil 3).



Şekil 2. İncelenen Kömürlerin Üst Kıta Kabuğu Normalleştirilmiş Nadir Toprak Elementi İçerikleri

IV. SONUÇLAR

Bu çalışmada, Türkiye'deki 26 adet Tersiyer yaşlı kömür sahası örneklerinin, nadir toprak element zenginliği değerlendirilmiş ve tüm kömürler bazında ∑NTE konsantrasyonunun 18,69 ile 177,2 ppm arasında değiştiği tespit edilmiştir. İncelenen kömür örneklerinde NTE zenginleşmesinin kömür bileşenlerindeki hem organik hem de inorganik maddelerle ilişkili olduğu belirlenmiştir. Üst kıtasal kabuğa göre normalleştirilmiş NTE içeriği, incelenen tüm örnekler için benzer bir kökeni işaret etmiş ve volkanik kül olarak tanımlanan olası NTE kaynaklarından biri olduğunu göstermiştir. Kömürden NTE çıkarma tekniklerinin gelişmesiyle birlikte bu elementlerin üretiminin artması ve temiz kömür teknolojilerinin yaygınlaşması çevresel açıdan büyük fayda sağlayacaktır. Türkiye için vazgeçilmez, güvenilir ve ucuz enerji kaynakları olan kömür ve kömür yan ürünlerinden elde edilen NTE ekonomik olarak katkı sunma potansiyeli yanısıra, kömürün çevresel etkilerinin azaltılması bakımından da hayati öneme sahiptir. Ülkemizde ve dünyadaki kömür ve kömür yan ürünleri potansiyel bir NTE kaynağıdır, ancak konsantrasyonları günümüz koşullarında geleneksel kaynaklara göre çok düşüktür ve ticari değere sahip olması için üretim teknolojilerinin iyileştirilmesi gerekmektedir.



Şekil 2. İncelenen kömürlerin nadir toprak elementlerinin konsantrasyonu (tam kömür bazında, ppm cinsinden) [19], ABD [42], Çin [23] ve Türk linyit [43] ortalamaları ile karşılaştırılma diyagramları.

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Geleneksel Olmayan Enerji Kaynağı Olarak Kömür; Kömür Kökenli Hidrokarbonlar

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Özet – Kömürün doğal gazın kaynağı olduğu uzun zamandır bilinen bir gerçektir ancak petrol ve kondanset için de kaynak olabileceği 1940'lı yıllardan sonra daha sık ifade edilmeye başlanmıştır. Genellikle kömürlerin %1-1,5 kadar atılabilir, göç edebilir ve kapanlanabilir özellikte sıvı hidrokarbon üretebilecek potansiyelli olduğu belirlenmiştir. İspatlanabilir ve potansiyel kömür kökenli petrol rezervleri çoğunlukla gölsel, akarsu, deltaik ve dalga ortamları ile ilişkilidir. Örneğin, Avustralya'da Gippsland ve Bass havzalarında, Yeni Zelanda'da Taranaki havzasında kömür ve kömürlü şeyller petrol üretmiştir. Buna karşın kömür kökenli petrol veya petrollü sıvıların oluşum miktarı veya dünya petrol rezervleri ile karşılaştırıldığında oldukça küçüktür ve dünyadaki tüm petrollerin bu kaynaktan türemiş olması da mümkün değildir. Bu çalışmada geleneksel olmayan bir kaynak kaya olarak kömürlerin petrol ve gaz türüm potansiyelleri değerlendirilerek, dünyadan bazı örnekler sunulacaktır.

Anahtar Kelimeler – Petrol, Kömür, Fosil Yakıt, CBM, Hidrokarbon

I. GİRİŞ

Enerji çeşitli kaynaklardan üretilebilmesine rağmen, en önemli kaynak, kömür, petrol ve doğal gaz olmak üzere fosil yakıtlardır. Ayrıca, bazı ülkelerin sosyoekonomik kalkınması ve uzun vadeli istikrarı tamamen petrol ve kömür kaynaklarından enerji üretimine ve bunun sürdürülebilir kullanımına bağlıdır. Fosil yakıtların tükenme riski ve küresel ölçekte homojen olmayan coğrafi dağılımı yeni kaynakların araştırılmasını gerekli kılmıştır. Bununla birlikte, sektördeki teknolojik gelişmeler sayesinde önceki yıllarda ekonomik olmadıkları gerekçesiyle işletilmeyen enerji kaynaklarının araştırılması ve üretimini de mümkün olmuştur. Geleneksel kaynaklara (konvansiyonel) göre daha teknoloji odaklı ve pahalı üretim yöntemleri gerektiren geleneksel olmayan enerji kaynakları (ankonvansiyonel kaynaklar) 2000'li yıllardan sonra ABD'de başlayan "şeyl gaz patlaması" ile daha dikkat çekici hale gelmiştir [1].

Petrol, kömür, doğal gaz gibi geleneksel hidrokarbon rezervuarları, hidrokarbonun harici bir kaynak kayadan gözenekli ve geçirgen rezervuar kayaya göçü ile karakterize edilirken, şeyl gaz, şeyl petrol, kömür kökenli gaz, ağır petrol / petrollü kumlar gibi geleneksel olmayan hidrokarbon rezervuarları aynı kaynak ve rezervuar kaya birimini paylaşmaktadır. Bu çalışmada, kömürlerin hidrokarbon (petrol ve doğal gaz) türüm potansiyelleri, dünyanın farklı alanlarında kömürlerde kapsam dahilinde yapılmış çalışmaların kısa bir değerlendirmesi ile sunulmaya çalışılmıştır.

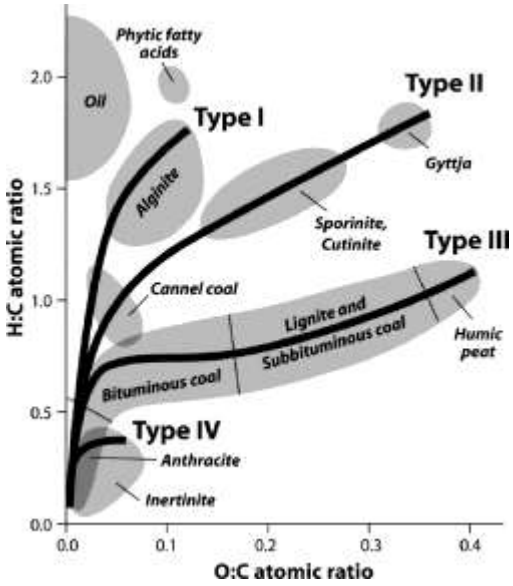
II.GELENEKSEL OLMAYAN BİR PETROL VE GAZ KAYNAK KAYASI; KÖMÜR

Petrolün kökenine dair birçok farklı görüş geçmişten itibaren öne sürülmüş olsa da organik madde kökenli oluşumu ifade eden ilk araştırmacılardan birisi Rus dehası Lomonosov'dur. 1763 tarihli "On the Strata of the Earth" (Dünyanın Tabakaları Üzerine) adlı kitabında, petrol ve doğal bitümün, yeraltı ısısı ve basıncı nedeniyle kömür ve bitki kalıntılarının dönüşümünden kaynaklandığını belirtmiştir. Bu araştırmadan sonra destekleyici veya karşı olan araştırmalar yapılsa da genel kanı, kömürün doğal gazın kaynağı olduğu noktasında birleşmiştir. Petrol ve kondensat için de kaynak olabileceği görüşü ise 1940'lı yıllardan sonra daha sık ifade edilmeye başlanmıştır [2], [3]. Yapılan araştırmalar kömürlerin genellikle %1-1,5 kadar atılabilir, göç edebilir ve kapanlanabilir özellikte sıvı hidrokarbon üretme potansiyeli olduğunu ispatlamıştır [4].

Bu kapsamda, organik maddeden itibaren hidrokarbon türüm potansiyelinin değerlendirme süreci kömür için de benzer şekilde yapılmış ve oluşum (türüm potansiyeli), atılma ve birikim olmak üzere üç ana başlıkta incelenmiştir.

2.1. Petrol türüm potansiyeli ve petrografik bileşim ilişkisi

Kömürün petrol potansiyel özelliğinin değerlendirilebilmesi için öncelikle organik bileşiminin tanımlanması ve incelenmesi gerekir. Kömürlerde tanımlanan maseraller başlıca; Vitrinitik, Liptinitik, İnertinitik olarak sınıflandırılır. Genellikle lipitçe zengin (eksinit) maseraller Tip I ve II kerojen olup, alginit/algal veya sapropelik organik bileşime sahiptir. Bu tip hidrojence zengin bileşenlerden oluşan kömürlerin petrol türetme potansiyelleri bulunur [5]. Buna karşın, kömürlerin büyük çoğunluğu odunsu veya vitrinitçe zengin organik maddelerden oluşur, oksijence zengin hümik (Tip III) kerojen olarak adlandırılır. Eksinit (resinit ve kütinitler) ve desmokollinit gibi vitrinit maseralleri diğer karasal organik maddelere göre hidrojence zengindir ve petrol türüm ve sıvı ürünleri atma potansiyeline sahiptir [6], [7] (Şekil 1). Bu nedenle organik maddelerin hidrojen içerikleri kömürlerin petrol türüm potansiyellerinin belirlenmesi için oldukça önemlidir.



Şekil 1. Hidrojen-karbon ve oksijen-karbon atom oranlarına göre farklı kerojen tiplerini ve kömür ve maseral gruplarının konumlarını gösteren van Krevelen diyagramı (Cornelius [8] 'den değiştirilerek)

Bir kömürün petrol türetebilmesi için bileşiminde olması gereken liptinit miktarına dair pek çok görüş bulunmaktadır. Örneğin, Hunt [7], hidrokarbon türümü için kömür bileşiminde olması gerekli liptinit+resinit oranını %15-20; Snowdon [8] yaklaşık %10; Mukhopadhyay ve Hatcher [9] minimum %15-20 ve Mukhopadhyay ve diğ., [10] ise %20-25 olarak belirtmiştir. Bu konudaki daha eski çalışmalarda, liptinitlerin petrol, vitrinitlerin gaz ve inertinitlerin ise herhangi bir türüm potansiyeline sahip olmadığı da açıklanmıştır [7]. Maseral tiplerini dikkate alan araştırmalardan birisi de Qin ve diğ., [11] tarafından yapılmıştır ve hidrokarbon oluşturma özelliklerine göre liptinit maserallerin önem sırasını, alginit, resinit, kütinit, sporinit, süberinit, vitrinit ve inertinit olarak ifade etmiştir. Vitrinitçe zengin, liptinitçe fakir Yeni Zelanda kömürlerinde yapılan incelemeler ise maseral bileşimlerinin kömürlerde sıvı hidrokarbon türümü için çok önemli bir özellik olmadığını göstermiştir. Benzer sonuçlar, Üst Kretase yaşlı (San Juan Havzası, New Mexico) kömürlerinde de belirlenmiştir [12]. Petersen ve Rosenberg [13] vitrinit grubu maserallerin bolluğu ve özellikle de kollodetrinit maserallerinin hümik kömürlerin kaynak kaya potansiyellerini kontrol eden faktörler olduğunu ifade etmiştir. Görüldüğü gibi, uzun zamandır devam eden bu araştırmalar henüz netliğe kavuşmamıştır ve devam edeceği de söylenebilir. Bu nedenle petrol türümü için kömür bileşimindeki maserallerin oranı hakkında genelleme yapmaktan ziyade alifatik karbonların bolluğuna göre türüm potansiyellerini değerlendirmek daha doğru olacaktır.

2.2. Kömür kökenli petrol oluşumu; atılma ve petrol penceresi

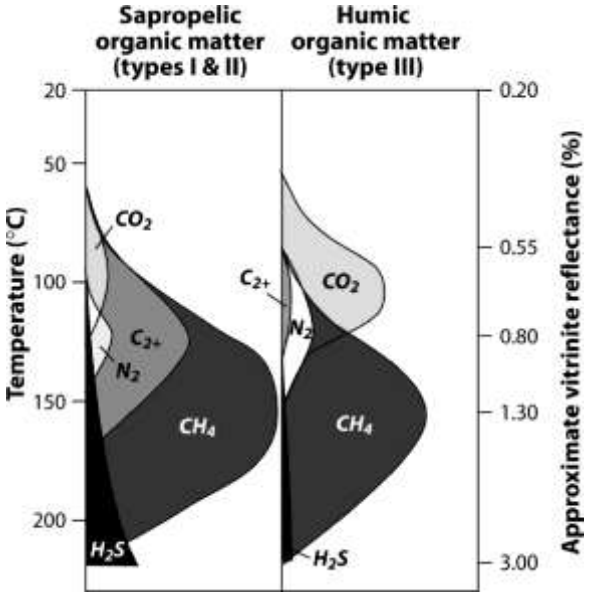
Kömürlerin adsorbsiyon ve absorbsiyon özellikleri petrolün göçü veya atılmasını önemli oranda etkiler [14], [15], [16], [17], [18]. Geleneksel petrol sisteminden farklı olarak, kömürlerdeki petrol oluşum aralığı Meksika körfezindeki Neojen yaşlı kömürler için Ro %0.8-1,8 arasında belirlenmiştir [19]. Bu petrol penceresi aralığı Danish North Sea-Sogne Baseni Bryne /Lulu formasyonundaki Jura yaşlı kömürler için de benzer şekilde bulunmuştur [20], [21]. Petersen ve Nytoft'a [18] göre kömürler için etkin petrol penceresi genç sedimanlarda geniş bir aralıktayken, Karbonifer yaşlı kömürlerde (hidrojence zengin) %0,9-1,75 aralığındadır. Bu konuda kömürün sapropelik veya hümik olması da hidrokarbon türüm süreci kadar önemlidir (Şekil 2).

Kömür bilindiği gibi doğal gaz için önemli bir kaynaktır ve kömürden üretilen gaz halindeki hidrokarbonlar genellikle kömür tabakası metanı veya kısaca kömür metanı (Coal Bed Methane, CBM) olarak adlandırılır. Kömürde absorbe olan hidrokarbon miktarı ile damar veya kömürlü istifin kalınlığının doğrudan ilişkisi yoktur. Zira kömürlü istif ne kadar kalın olursa içinde ardalanmalı olarak bulunan kırıntılı sediman miktarı artacağı için oluşan gaz ve sıvı hidrokarbonların drenajı için avantajlı bir özellik olacaktır [22], [23].

2.3. Birikim ve rezervuar özellikleri

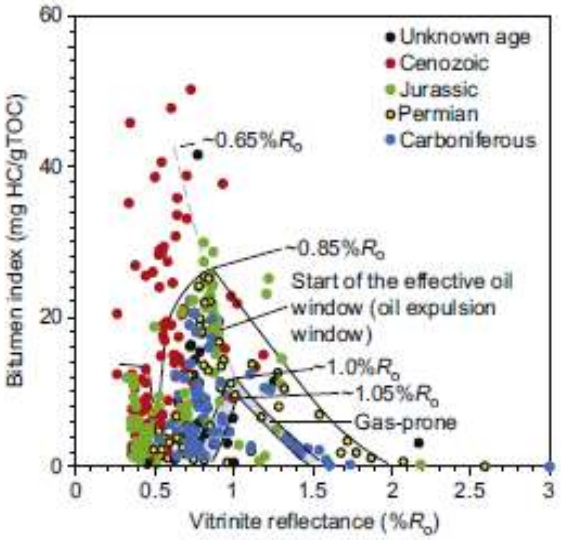
Kömür kökenli petroller genellikle Senozoyik yaşlı kaynak kaya ve rezervuarlarda bulunur. Clayton ve diğ., [6] jeolojik yaş dağılımlarının mumsu ham petrol oluşumuna karşılık geldiğini belirtirken, Petersen ve diğ., [16] bunu kömürün parafinik bileşimi ile ilişkilendirmiştir. Petrol türüm potansiyeli ve jeolojik yaş arasındaki doğrudan ilişki Avustralya-Asya bölgesindeki Senozoik yaşlı kömürlerden türeyen, Avustralya'da Bass ve Gippsland Basenleri, Yeni Zelanda da Taranaki Baseni, Endonezya'da Kutei Baseni gibi büyük petrol sahalarında incelenmiştir. Buna karşın, Karbonifer kömürleri Kuzey denizinde olduğu gibi genellikle büyük gaz birikimleri ile ilgilidir. Permiyen ve Jura yaşlı kömürlerle ilgili olarak, Birleşik Krallık-Norveç-Danimarka sektörlerini kapsayan Kuzey Denizi'ndeki bölge, Orta Jura kömürleri, Üst Permiyen sapropelik karbonatlar, Vestfaliyen kömürleri, Namuriyen şeylleri ve Devoniyen kömürleri dahil olmak üzere, akışkanlarla pozitif olarak ilişkilendirilebilecek çok sayıda kaynak kaya aralığını içerir.

Permiyen ve Jura yaşlı kömürlerden türeyen petrollere Avustralya Cooper Baseni ve Danimarka Kuzey Denizi'ndeki birikimler verilebilir. Petersen ve Nytoft'a [18] göre farklı jeolojik yaşlardaki kömürlerden farklı tiplerde hidrokarbon oluşmasının nedeni; paleocoğrafya, paleoiklim ve jeolojik etkilerdir.



Şekil 2. Sıcaklık ve termal olgunluk ile ilişkili olarak sapropelik ve hümik organik maddeden üretilen termojenik gazların oranlarını gösteren genelleştirilmiş diyagram (Hunt [7]'den değiştirilmiştir).

Şekil 3' de görüldüğü gibi Senozoyik kömürleri büyük oranda petrol türetmiştir. Bunlar düşük olgunluk düzeyinde (Ro %0,65) hidrokarbonu atmıştır ve geniş aralıkta etkin bir petrol penceresine sahiptir (Ro: %0,65-2,0). Jura, Permiyen ve Karbonifer kömürleri yüksek olgunluk indeksinde (Ro %0.85-0.90) etkin petrol penceresi başlangıcına ulaşırlar. Jura yaşlı kömürler, Karbonifer ve Permiyen kömürlerine göre daha sınırlı atılma etkinliğine ve büyük gaz türüm potansiyeline sahiptir. Karbonifer kömürlerinin etkin petrol penceresi gaz-kondansate aralığındadır. Jura kömürlerinden türeyen hidrokarbonlar Car ve Petersen [24] modeli için en iyi örneklerdir ve bunlar petrol ve gazı birlikte üretmiş ve atmıştır. Danimarka'daki (Kuzey Denizi-Central Graben) Karbonifer yaşlı kömürler, Avustralya'da Cooper Basenindeki Permiyen ve Jura yaşlı kömürler (Batı Çin'deki Tarim, Jungar, Turpan Basenlerinde) ile KD Çin'deki Bohai Körfezi havzasındaki Pensilvanian yaşlı kömürlerden oluşur [4], [25]. Bohai Körfezindeki Pensilvanian kömürleri petrol türüm potansiyeli yanısıra yüksek atılma etkinliği ve yüksek gaz türüm potansiyellidir.



Şekil 3. Farklı yaşlardaki kömürlerin vitrinit yansıması ile bitüm indeksi değerleri ilişkisi görülen bu diyagramında Senozoyik yaşlı kömürler daha yaşlı kömürlere göre petrol türüm potansiyeli bakımından daha elverişlidir [21]

Avustralya-Asya bölgesindeki kömür kökenli hidrokarbon birikimleri Paleosen-Miyosen yaş aralığındaki sedimanter istiflerde izlenir. Boreham ve diğ., [5]' ne göre paleoiklim, çökelim ortamları ve bitki gelişim ve türleri kömürlerden petrol oluşumunu etkileyen başlıca faktörlerdir. Avustralya-Asya bölgesinde, Kretase süresince tropikal iklimde angiosperm ve gymnospermlerin oldukça yaygın olması, bu süreç içinde oluşan kıyıdaki düzlük bataklıklarında veya boglarda karekteristik turbaları oluşturmuştur. Benzer durum Nijerya'daki Kretase yaşlı Anambra Baseni kömürlerinde de bulunmaktadır. Senozoyik zamanında oluşan bu kömürler daha dayanıklı, hidrojence zengin kütikül ve resinler gibi bileşenlerce zengindir [5].

III.KÖMÜRLERİN PALEO-ÇÖKELİM ORTAM ÖZELLİKLERİ

Önemli rezerve sahip kömür kökenli petroller çoğunlukla Avustralya'da Kretase-Paleosen yaşlı Gippsland ve Bass Basenlerinde olduğu gibi gölsel, akarsu, deltaik ve dalga ortamları ile ilişkili kömür istiflerindedir. Egemen olarak kıtasal ve geçiş çökelim ortamlarında olduğu kadar gölsel ortamlarda da çökelmiştir [5]. Buna karşın Eosen kömürlü istifinde (Yeni Zellanda Taranaki Basenindeki petrol ve kondansetin kaynağıdır) çökelim transgresif, dalga etkili kıtasal düzlük bataklıklarında gelişmiştir. Kömürler, özellikle gazların (CH_4 ve CO_2) kaynağı olmakla birlikte, oluşan gaz kömür içinde adsorblandığı için atılamaz.

IV. KÖMÜR KÖKENLİ BAZI PETROL SAHALARI

Taranaki Baseni, Yeni Zelanda

Taranaki Baseni, Yeni Zelanda'daki hidrokarbon üretiminin olduğu tek alandır. Karada ve deniz alanlarında kömürlü Eosen yaşlı Kapuni Grubu içindeki kumtaşları petrol, kondanset ve gaz türüm potansiyelleri bakımından önemlidir. Kapuni Grubu, silttaşı, çakıltaşı, kumtaşları ile kamalanmalar şeklinde gözlenen çamurtaşı, silttaşı, kömür, karbonatlı şeyl, kumtaşı ve konglomeratik kumtaşından oluşur. Bu alandaki kömürlerin yatay ve düşey stratigrafik dağılımları hidrokarbon türümü için tipik kaynak olduklarını göstermiştir [26]. Bölgede petrol ve kömürlerde yapılan organik jeokimyasal korelasyonlar ile petrol için farklı ve çoklu kaynak kaya (kömür) varlığı ve bunların daha sonra kumtaşı rezervuarlarına göç ettiği sonucuna varılmıştır.

Bass Baseni, Avustralya

Bu alanda keşfedilen hidrokarbonlar Geç Paleosen-Orta Eosen yaşlı kumtaşları içinde olup, Paleosen-Erken Eosen yaşlı kumtaşlarında da gaz belirlenmiştir [27]. Kömür fasiyesleri Erken Eosen-Erken-Orta Eosen'de yoğundur ve petrol için oldukça iyi kaynak kaya potansiyellidir.

Powder River Basin, Wyoming ve Montana, USA

Bu alanda akarsu kanal kumtaşları rezervuarları ile ardalanmalı kömür tabakaları ve daha ince taneli Paleosen yaşlı Fort Union Formasyonu bulunmaktadır [4].

Cook Inlet Baseni, Alaska, USA

Cook Inlet Baseninde Oligosen-Pliosen (Neojen) kömürlü istifi geleneksel gaz birikimi için tipik bir örnektir. Kömürler genellikle Altbitüm tipindedir ve Ro değeri %0,32-0,66 arasındadır. Kömürdeki gazlar biyojenik kökenlidir [4]. Bu sahadaki gazların büyük kısmı Miyosen-Pliosen yaşlı Sterling formasyonundan türemiştir.

Endonezya Basenleri

Endonezya'da Kutei ve Mahakam Deltasında, Miyosen-Pliyosen yaşlı deltaik sedimanlar bulunmaktadır ve bu alanda birçok petrol, gaz ve kondansate sahaları vardır [28], [29]. Peters ve diğ., [30]'e göre Orta-Üst Miyosen yaşlı kömür ve şeyller (kıyı düzlüğünde) Mahakam Deltası kara alanındaki mumsu petrolllerin kaynak kayasıdır. Ardjuna Baseni (KB Java) da keşfedilen yüksek mumsu ham petrollerin ise Oligosen yaşlı Talang Akar formasyonundan türediği belirtilmiştir [31].

Norveç Denizi

Haltenbanken ve Traenabenken bölgelerinde, Orta Norveç offshore alanında, Geç Jura yaşlı Spekk formasyonu denizel şeylleri ve Erken Jura yaşlı Are formasyonu kömür ve şeylleri olmak üzere başlıca iki kaynak kaya bulunmaktadır. Denizdeki ilk hidrokarbon keşiflerinden biri olan Midgard sahasındaki petrolün kaynağı Are formasyonudur. Benzer şekilde, Smorbukk Sor Sahası Alt Jura kömürlerinin atılan petrol ve gazın başlıca kaynağı olduğunu belirtmiştir [31].

Danish North Sea

Danish ve Kuzey Denizinin Norveç kıyısı güneyindeki sahalarda petrollerin çoğunun kaynak kayası Üst Jura yaşlı denizel şeyllerdir [32]. Bununla birlikte, günümüzde bu alanda Orta Jura yaşlı Bryne Formasyonundaki kömürlerin petrol potansiyelleri de ilgi çekmektedir [23], [30]. Bu kömür damarları, zaman zaman deniz etkisinde kalan, kıtasal düzlük ortamlarında çökelmiştir. Lulita ve Harald sahalarındaki petrol ve kondensatların [22] Bryne Formasyonu kömürlerinden, Norveç kısmındaki Trym kondensatlarının ise Orta Jura kömürlerinden kaynaklandığını belirtilmiştir [23].

V. TARTIŞMA VE SONUÇLAR

Kömürlerden hidrokarbon oluşum ve prosesleri yanısıra kaynak kaya potansiyellerinin de değerlendirilmesi oldukça zordur. 1970' ler ve 1980' lerin başlarında türüm potansiyellerinin petrografik bileşene bağlı olduğu görüşü yaygın olarak kabul görmüş ve liptinit içeriği sıvı hidrokarbon oluşumu için kritik faktör olarak değerlendirilmiştir. Hunt [7], kolaylıkla ölçülebilecek liptinit içeriği, hidrojence zenginlik, hidrojen indeksi ve atomik H/C oranı gibi bazı unsurları işaret etmiştir.

1990’ ların başında, petrografik bileşim ve py-GC ürünü hidrokarbonlar arasında çok düşük/zayıf bir ilişki olduğu belirlenmiştir. Ancak burada özellikle özütlenebilen hidrokarbon ürününün önemine vurgu yapılmaya başlanmıştır. Aslında, hidrokarbon serbestleşmesindeki gerçek kontrol unsurunun oluşum/türümden ziyade atılma olduğu görüşü daha çok kabul bulmuştur [33]. Bununla birlikte kömürden petrol türümü için kimyasal bileşimdeki hidrojen oranı, maserallerle ilişkisi, jeolojik yaş faktörü, paleocoğrafya, paleoiklim gibi unsurlar da araştırmacıların ilgi alanlarını oluşturmuştur.

Petrolün oluşumu ve korunması, organik malzemede yalnızca uygun lipidli yapıların varlığı ile sınırlı değildir. Oluşan sıvı ürünün (petrol) gaza dönüşmeden önce kaçabilmesini (göç) gerektirecek koşulların bulunması da gereklidir. Genel görünüm, ağırlık bazında liptinit, vitrinitten on kat, inertinitten ise yüz kat daha fazla petrol üretebilir potansiyelde olduğudur. Yaklaşık hesaplamalar, üretilen hidrokarbonların sadece %1'i kapanlarda birikmiş olsa bile, kömürlerin termal olgunlaşmasının Avustralya'nın Gippsland ve Cooper Havzalarındaki bilinen tüm petrol ve gaz rezervlerini açıklayabileceğini göstermektedir. Bu oldukça iddialı bir hesaplama ve iyi niyetli bir yaklaşım olarak düşünülebilir.

Bunun nedeni olarak, kömürlerin heterojen bileşimi ve karmaşık rezervuar özellikleri gösterilebilir. Jeolojik faktörler ticari hidrokarbon üretiminin yapıldığı sedimanter havzalar arasında önemli ölçüde farklıdır ve bu değişkenlik, kömür kökenli metan türümü depolama kapasitesini, hidrokarbon içeriğini ve üretim performansını etkilemektedir. Bu nedenle her havza ve her kömürün bu kapsamda ayrı ayrı değerlendirilmesi gerekir. Kömür içeren kaynak kaya istifleri diğer petrol kaynaklarına göre uzay ve jeolojik zaman açısından daha kısıtlıdır

Petrol ve gaz için kaynak kaya olarak kömür içeren istiflerin incelenmesi ve anlaşılması için sedimantolojik, paleobotanik ve jeokimyasal özelliklerini de dikkate alan çalışmalar devam etmektedir. Gelecekte sürdürülebilir enerji için yenilenebilir enerji kaynakları kadar, fosil yakıtlar da önemli olmaya devam edecektir.

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1988-2024 Yılları Arasındaki "Kömür Kaynak Kaya" Konusunda Yapılan Çalışmaların Bibliyometrik Analizi

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Özet **–** Bu çalışma, kömür kökenli hidrokarbon türümü ile ilgili Scopus veri tabanındaki dergilerde yayımlanan çalışmaların değerlendirilmesini amaçlamaktadır ve bu kapsamda bibliyometrik analiz yapılmıştır. Bibliyometrik analiz için R bibliyometrix kütüphanesinden Biblioshine ve VOSviewer yazılımları kullanılmıştır. Scopus veri tabanında yer alan toplam 74 çalışma analiz edilmiştir. Bu çalışmalarda 2019 yılında çalışmalarda artış olduğu belirlenmiştir. Sankey diyagramı anahtar kelime parametresinde “ordos basin”, ülke parametresinde Çin dikkat çekerken, “coal, source rock, gases”, en sık kullanılan anahtar kelimelerdir. Anahtar kelimelerin tema analizinde, "Hidrokarbon Keşfi ve Üretimi" ve "Rezervuar Karakterizasyonu" olarak tanımlanabilecek iki küme oluşmuştur. Trend konular arasında “kuqa depression” kelimesi son yılların en popüler anahtar kelimesidir. Kömür kaynak kaya çalışmaları geleneksel olmayan enerji kaynaklarının araştırılması sürecinde gelecekte de dikkat çekici olacaktır. Bu çalışma araştırmacılara literatürdeki boşlukları görmelerinde, araştırma yönlerinin geliştirilmesinde katkılar sağlayacaktır.

Anahtar Kelimeler – Kömür, CBM, Hidrokarbon, Ordos Basin, Bibliyometrik Analiz, VOSviewer

I. GİRİŞ

Petrol ve doğal gazın kökeni genellikle denizel organik maddelerin termal ve biyolojik ayrışmasından kaynaklanmaktadır [1], [2]. Bununla birlikte, kömür, ağırlıkça %50'den fazla organik madde içeriği ile sadece katı bir enerji kaynağı olarak sınırlandırılamaz ve önemli bir petrol ve doğal gaz kaynak kayasıdır [1], [2]. Kömür kökenli hidrokarbon araştırmaları uzun zamandır yapılmaktadır ve günümüzde geleneksel olmayan hidrokarbon kaynağı olarak değerlendirilmektedir [3], [4].

Petrol ve doğal gazın kökeni genellikle denizel organik maddelerin termal ve biyolojik ayrışmasından kaynaklanmaktadır [1], [2]. Bununla birlikte, kömür, ağırlıkça %50'den fazla organik madde içeriği ile sadece katı bir enerji kaynağı olarak sınırlandırılamaz ve önemli bir petrol ve doğal gaz kaynak kayasıdır [1], [2]. Kömür kökenli hidrokarbon araştırmaları uzun zamandır yapılmaktadır ve günümüzde geleneksel olmayan hidrokarbon kaynağı olarak değerlendirilmektedir [3], [4]. Kömür kaynaklı petrolün çıkarılması ve işlenmesi süreçlerini detaylandırmış, kömürün petrol ve doğal gazın alternatif bir kaynak olarak potansiyelini vurgulamıştır [5], [6].

Kömür kaynaklı hidrokarbonların çıkarılması ve rafine edilmesi için kullanılan teknolojileri sayesinde kömürün petrol ve doğal gaz endüstrisindeki rolünde önemli bir kaynak olduğu anlaşılmaktadır [7], [8]. Kömürün termal dönüşümünün petrol üretimindeki potansiyelini değerlendirirken, bir yandan kömür

kaynaklı petrolün ekonomik ve çevresel etkileri kaynağın sürdürülebilirliğini ön plana çıkarmaktadır [3], [9], [10].

Disiplinler arasında yaygın olarak kullanılmaya başlayan bibliyometrik analiz, analitik bilim dallarında verilerin belirli konular, alanlar, kurumlar ve ülkeler içindeki dağılım modelini tanımlar, akademik literatürün matematiksel ve istatistiksel teknikler yoluyla niceliksel analizine olanak tanıması nedeniyle gittikçe önem kazanan bir alandır.

Bu çalışma, 1988-2024 yılları arasında kömür kökenli petrol ve doğal gaz türüm potansiyelini araştıran çalışmaların genel değerlendirmesini bibliyometrik analiz ile gerçekleştirmeyi amaçlamıştır.

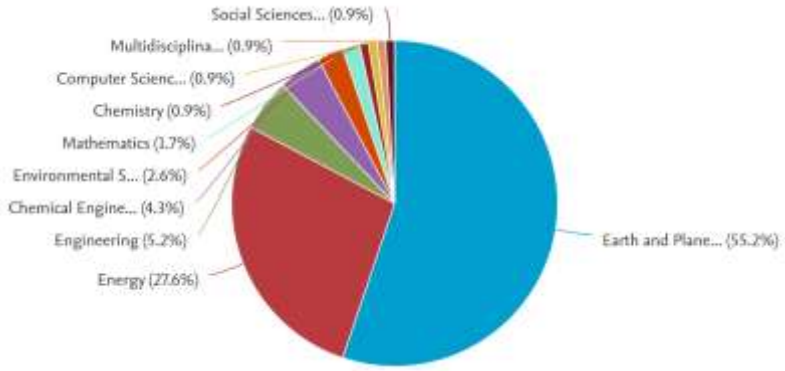
II. MATERYAL VE YÖNTEM

Bu çalışmada kullanılacak verilerin derlenmesi için Scopus veri tabanından "başlık, özet ve anahtar kelime" kriteri seçilerek, "coal source rock" kelimelerinin geçtiği, 29.04.2024 tarihine kadar yayınlanan tüm araştırmalar kaydedilmiştir. Analitik veri değerlendirmede araştırma sonuçlarını objektif ve mevcut bilimsel çıktıya göre değerlendiren, kapsamlı bir bakış açısı kazandırmayı hedefleyen bir yöntem olan Bibliyometrik analiz kullanılmıştır. Bunun için R bibliyometrix kütüphanesinden Biblioshine [11] ve VOSviewer yazılımları kullanılmıştır [12]. Kömür kaynak kaya konusundaki çalışmaların tümü (68 makale, 4 konferans özeti, 1 kitap ve 1 kitap bölümü) analize dahil edilmiştir.

III. BULGULAR

3.1. Dökümanların Konu Alanları

Scopus veri tabanında 46 kaynak ve 2000 döküman kömürlerin kaynak kaya özelliği ile ilgili çalışmaların analizi için değerlendirilmiştir. Şekil 1'e göre "kömür kaynak kaya çalışmalarında oransal büyüklük sıralamasına göre, yer bilimleri (%55,2), enerji (%27,6) ve mühendislik (%5,2) alanları bu konuya en fazla ilgi gösteren alanlar olmuştur.



Şekil 1: Dökümanların konu alanları

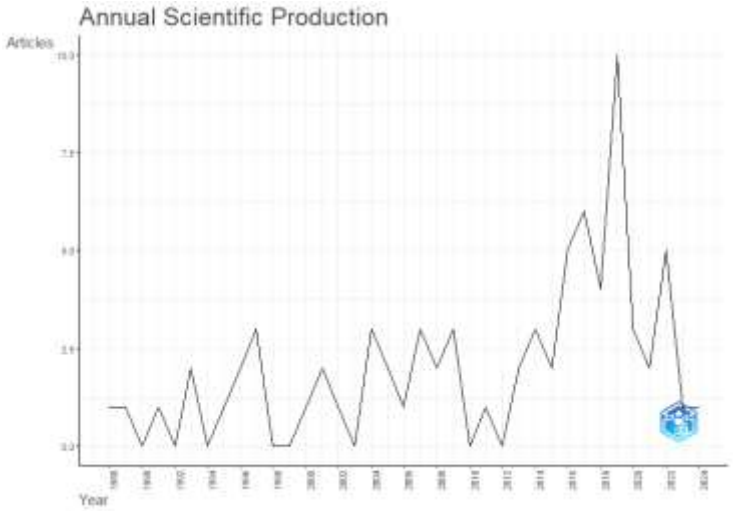
3.2. Çalışmalar Hakkında Temel Bilgiler

Şekil 2'de kömür kaynak kaya çalışmalarındaki temel bilgiler incelendiğinde, Scopus veri tabanından 1988:2024 yılları arasında 46 kaynakta (dergi, kitap, vb) kömür kaynak kaya ile ilgili 74 çalışma analiz edilmiştir. Bu çalışmalar yıllık %0 büyüme oranına sahipken, her belge ortalama 16,76 atıf almaktadır. 286 yazarın 5'i tek yazar olarak yayın yapmıştır. Belgelerdeki uluslararası ortak yazarlık oranı %10,81 'dir.

Şekil 2.Kömür Kaynak Kaya Çalışmalarındaki Temel Bilgiler

3.3. Yayınlarda Yıllık Artış

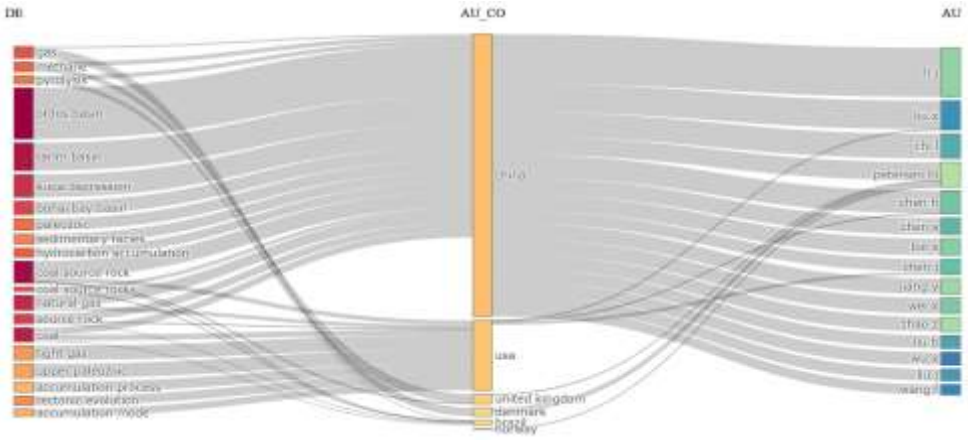
Şekil 3'e göre dünya çapında bilim insanları arasında yayın sayısı yıllara göre değişiklik göstermektedir. Yayın sayısı olarak; 2024'te 1, 2023'te 1, 2022'de 5, 2021'de 2 yayın yapılmıştır. Özellikle en fazla artış 2019 yılındadır ve 10 çalışma yapılmıştır.



Şekil 3. Kömür Kaynak Kaya Çalışmalarının Yıllara Göre Dağılımı

3.4. Sankey Diyagramı

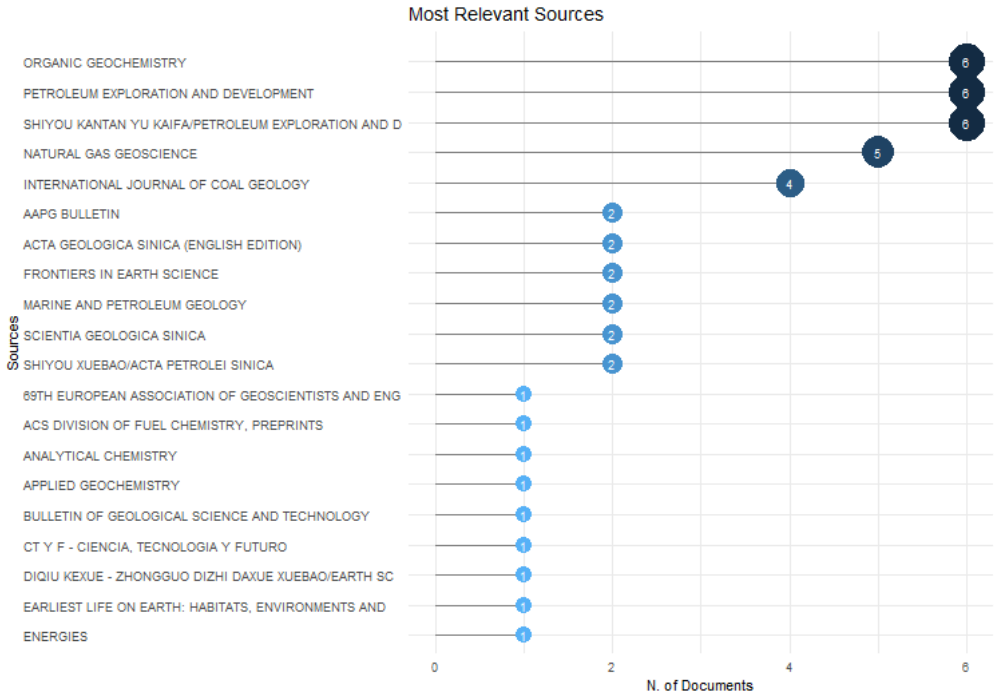
Şekil 4'te parametreler arasındaki ilişki büyüklüğü kutu simgesi ile gösterilmiştir. Anahtar kelimeye göre "Ordos basin", ülkede Çin ve yazar parametresinde ise Li J. önde gelmektedir.



Şekil 4. Anahtar Kelime, Ülke ve Yazar İçin Oluşturulan Sankey Diyagramı

4.5. Kömür Kaynak Kaya Çalışmalarında En Üretken Dergiler

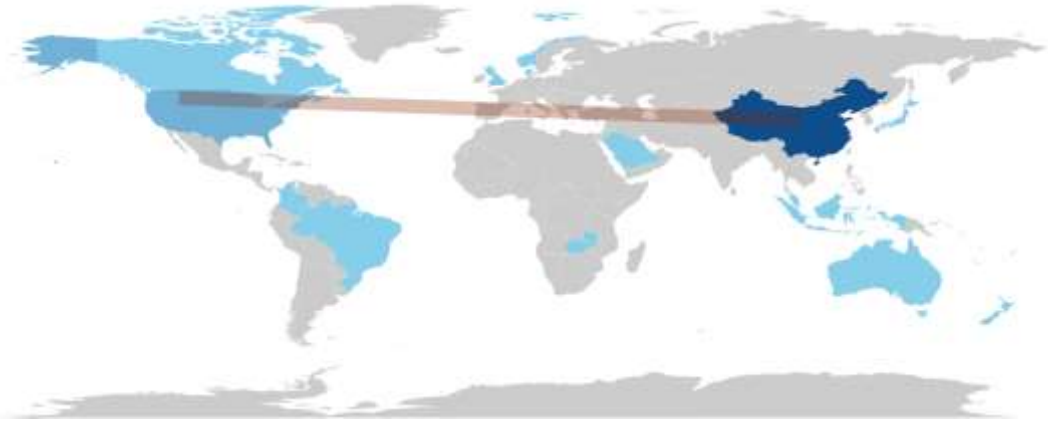
Şekil 5'e göre "Organic Geochemistry", "Petroleum Exploration and Development" ve "Shiyou Kantan Yu Kaifa/Petroleum Exploration and Development" dergisi 6 yayınla ilk sırada yer alırken, "Natural Gas Geoscience" dergisi 5 yayınla ikinci sırada ve "International Journal of Coal Geology" dergisi 4 yayınla üçüncü sırada yer almıştır.



Şekil 5. Bu konuda en çok yayın yapılan dergiler

3.6. En Üretken Ülkeler ve Ülkelerarası İşbirliği

Kömür kaynak kaya çalışmalarında Çin, 277 makaleyle ilk sırada yer alırken, ABD, 28 makaleyle ikinci sırada ve Birleşik Krallık 14 makaleyle üçüncü sırada yer almaktadır. Kömür kaynak kaya çalışmalarındaki ülkelerin işbirliği haritası şekil 6'da gösterilmiştir.

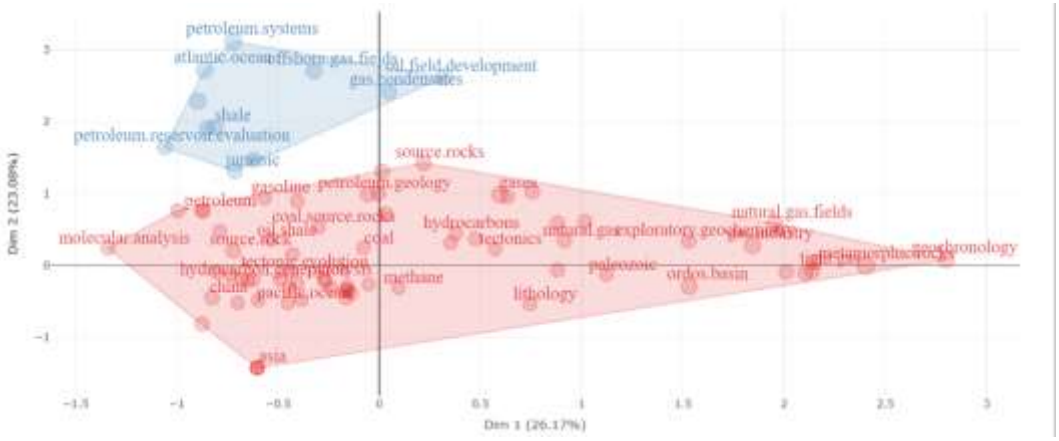


Şekil 6. En Çok İş birliği Yapan Ülkeler

Şekil 6'de verilen dünya işbirliği haritasına göre ABD ve Çin 4 çalışma ile en fazla işbirliği yapan ülkelerdir. Bu ülkeleri her birinde 1 ortak çalışma olmak üzere, Çin-Zambia, Danimarka- Norveç, ABD-Suudi Arabistan takip etmektedir.

3.7. Kavramsal Yapı Haritası

Anahtar kelimelere dayalı oluşturulan kavramsal yapı haritasında 2 küme belirlenmiştir. Birinci küme (kırmızı): başlıca "coal, source rock, gases, hydrocarbons, petroleum geology, pyrolysis, China, hydrocarbon generation", ikinci küme (mavi) "sandstone, shale, north sea, atlantic ocean, gas, condensates, petroleum, hydrocarbon" gibi kelimelerinden oluşmuştur (Şekil 7).



Şekil 7. Kavramsal Yapı Haritası

3.8. Trend Konular

Kömür kaynak kayası ile ilgili olarak 1988 ile 2024 arasında yapılan tüm çalışmaların analizinde, trend konular Tablo 1'de sunulmuştur. "kuqa depression" kelimesi 2019'nin birinci çeyreğinde, 2019'un ikinci çeyreğinde ve 2020'nin üçüncü çeyreğinde toplam 6 atıfla ilk sırada yer almıştır.

Trend konular "coal (33), source rock (23), gases (18), hydrocarbons (16), petroleum geology (14), pyrolysis (14), hydrocarbon generation (13), hydrocarbon reservoir (13), china (13), natural gas (12), coal deposits (10), petroleum reservoirs (8), gas industry (7), jurassic (7), source rock (6), shale (6), gas chromatography (6), kuqa depression (6), tarim basin (6), coal-source rocks (6), methane (6), geochemistry (6), kerogen (6)" şeklinde sıralanmaktadır.

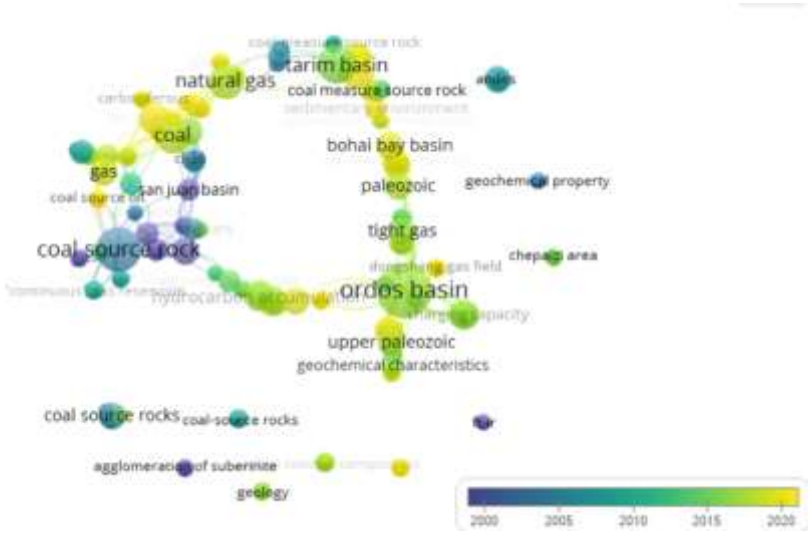
Tablo 1. Trend Konular

Konu ve anahtar kelime	Frekans	Yıl (1. Çeyrek)	Yıllık ortalama	Yıl (3. Çeyrek)
Kuqa depression	6	2019	2019	2020
Tarim basin	6	2019	2019	2019
Shale	6	2019	2021	2021
Coal-source rocks	6	2017	2020	2021
Gases	18	2016	2017	2019
Gas Chromatography	6	2016	2018	2019
Hydrocarbon reservoir	13	2015	2017	2019
Petroleum geology	14	2015	2018	2019
Gas industry	7	2014	2016	2018
Natural gas	12	2012	2018	2019
Source rocks	6	2009	2015	2018

Hydrocarbons	16	2009	2016	2018
China	13	2009	2019	2019
Methane	6	2009	2021	2022
Pyrolysis	14	2008	2014	2017
Coal deposits	10	2007	2014	2018
Petroleum reservoirs	8	2007	2016	2019
Hydrocarbon generation	13	2005	2015	2019
Jurassic	7	2003	2007	2016
Source rock	23	2003	2017	2019
Geochemistry	6	2002	2011	2016
Coal	33	2002	2014	2018
Kerogen	6	1995	2004	2014

3.9 Eş-Oluşum Anahtar Kelime Analizi

Anahtar kelimelerin zaman içindeki kullanımına göre eş oluşum haritası yapılmıştır ve açık renkler son yıllardaki çalışmaların ortak eş oluşumunu göstermektedir (Şekil 8). Son yıllarda kuqa depression coal, source rock, shale gibi kelimeler bu kapsamda ilk sıralarda yer almaktadır



Şekil 8. Anahtar Kelimelerin Zaman İçinde Kullanımına göre eş oluşumları

IV. SONUÇLAR

Bu çalışma, 1988-2024 yılları arasında kömürlerin hidrokarbon kaynak kaya potansiyellerini inceleyen çalışmaların bibliyometrik analizini yapılmış, gelecekteki trendi belirlemeyi amaçlamıştır. Objektif ve kapsamlı bir araştırma için WoS veritabanı kullanılmıştır ve bu konuda 74 adet yayın kaydedilmiştir. En fazla yayının 2019 yılında yapıldığı kömür kaynak kaya çalışmalarında, her yayının ortalama “16,76” atıf aldığı belirlenmiştir. "Organic Geochemistry" ve "Petroleum Exploration and Development" dergileri en çok yayın yapan ve en üretken dergiler olarak öne çıkmaktadır. Anahtar kelime analizinde "coal, source rock, gases, hydrocarbons, petroleum geology" en yaygın kullanılan kelimeler olmuştur. Bilimsel çalışmalarda konuyu ifade eAmerika ve Çin, en çok iş birliği yapan ülkelerdir. Kavramsal yapı haritasında iki küme oluşmuştur. Birinci kümede anahtar kelimelerin büyük kısmı doğal gaz ve petrolün yer altı kaynaklarını araştırma, çıkarma ve işleme süreçlerine odaklanmaktadır. İkinci küme kelimeleri ise genellikle petrol ve gaz rezervuarlarının yapısal ve jeolojik özelliklerine işaret ettiği için "Rezervuar Karakterizasyonu" veya "Rezervuar Analizi" olarak gruplanmıştır.

Sonuç olarak, kömür kökenli hidrokarbon türüm potansiyelini araştıran çalışmalar birçok ülkede devam etmektedir. Günümüzde enerji hızla artan enerji talebi, tükenen fosil yakıtlar ve sürdürülebilir enerji ihtiyacı bu tip geleneksel olmayan hidrokarbon kaynaklarının araştırılmasını gerekli kılmaktadır. Bu çalışma sonuçlarında da görüldüğü gibi kömürlerin sadece bir enerji kaynağı olarak düşünülmesinden ziyade alternatif katma değerlerinin de araştırılması yerinde olacaktır.

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Küreselleşme Sürecinde Devlet Egemenliğinin Dönüşümü: Yeni Güvenlik ve Savunma Politikaları

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Özet – Küreselleşme, özellikle güvenlik ve savunma politikaları bağlamında, geleneksel ulusal egemenlik kavramı üzerinde önemli bir etkiye sahip olmuştur. Bu çalışma, küreselleşme bağlamında devlet egemenliğinin değişen karakterini, yeni güvenlik ve savunma paradigmalarının oluşturulmasına odaklanarak incelemektedir. İlgili literatür ve vaka çalışmaları kapsamlı bir şekilde incelenerek bu değişimin ana itici güçleri ve sonuçları ele alınmaktadır. Çalışma, güvenlik ve savunma alanlarında devlet egemenliğinin evrimini etkileyen birçok bağlantılı unsuru ortaya koymaktadır. İlk olarak, ekonomik küreselleşme, devletler arasındaki karşılıklı bağımlılığı artırmış ve geleneksel egemenlik kavramlarının sınırlarını bulanıklaştırmıştır. Sınır ötesi güvenlik endişelerini başarıyla yönetmek için işbirlikçi güvenlik çerçevelerine ve çok taraflı askeri ittifaklara doğru bir eğilim olmuştur. İkinci olarak, özellikle bilgi ve iletişim teknolojilerindeki teknik gelişmeler, devlet dışı aktörlerin yayılmasını hızlandırmış ve bu aktörlerin devlet otoritesini ve egemenliğini yeni yollarla sorgulamalarına olanak sağlamıştır. Bu nedenle, devletler asimetrik tehditler karşısında uyarlanabilir ve çevik savunma taktikleri uygulamaya zorlanmaktadır. Ayrıca, araştırma, uluslararası kurumların ve normların güvenlik sektöründe devlet egemenliği üzerindeki etkisini incelemektedir. Küresel yönetişim sistemlerinin büyümesi ve uluslararası hukuk çerçevelerinin çoğalması, devletlerin güvenlik ve savunma konularında özerkliklerini sınırlamış ve uluslararası normlara ve standartlara artan bir bağlılık zorunluluğunu getirmiştir. Bu sorunlara yanıt olarak, uluslar esneklik ve işbirliğini önceliklendiren yeni güvenlik ve savunma stratejileri uygulamışlardır. Son olarak, bu çalışma, küreselleşmenin güvenlik ve savunma açısından geleneksel ulusal egemenlik kavramını derinden değiştirdiğini ileri sürmektedir. Uluslar, ulusal güvenliği sağlamada önemli bir rol oynamaya devam ederken, modern güvenlik endişelerinin artan karşılıklı bağımlılığı ve karmaşıklığı, değişen küresel dinamikler ışığında egemenliğin yeniden düşünülmesini gerektirmektedir. Devletler, işbirlikçi güvenlik çerçevelerini benimseyerek ve gelişen tehditlere uyum sağlayarak küreselleşmiş güvenlik sahnesinin zorluklarını etkili bir şekilde aşabilirler.

Anahtar Kelimeler – Devlet Egemenliği, Küreselleşme, Güvenlik Politikaları, Savunma Politikaları, Çok Taraflılık.

I. GİRİŞ

Devlet egemenliği, modern uluslararası ilişkilerin temel taşı olarak kabul edilir ve devletlerin iç ve dış işlerinde bağımsız hareket edebilme yetkisini ifade eder. Bu kavram, 1648 Vestfalya Barışı ile şekillenmiş olup, devletlerin kendi sınırları içerisinde mutlak otoriteye sahip olduğu fikrini pekiştirmiştir [1]. Egemenlik, tarihsel olarak devletin toprak bütünlüğünü ve politik bağımsızlığını koruma yeteneği olarak anlaşılmıştır [2]. Bu çerçevede, egemenlik, devletin iç işlerine müdahale edilmemesi prensibini içerir ve devletler arası ilişkilerde bir norm olarak kabul edilir.

Küreselleşme, devlet egemenliği kavramının yeniden değerlendirilmesini zorunlu kılmıştır. Ekonomik, politik ve teknolojik alandaki küresel entegrasyon, devletlerin egemenliklerini koruma ve sürdürme biçimlerinde önemli değişikliklere yol açmıştır [3]. Küreselleşme süreci, ulusal sınırların ötesine geçen

ekonomik ve sosyal ağların gelişimi ile karakterize edilir. Bu durum, devletlerin ekonomik politikalar ve güvenlik stratejileri üzerinde kontrol kaybına yol açmaktadır [4].

Küreselleşmenin egemenlik üzerindeki en belirgin etkilerinden biri, ulus-devletlerin ekonomik politikalarını küresel piyasa dinamiklerine uyumlu hale getirme zorunluluğudur. Uluslararası ticaret anlaşmaları ve küresel finans piyasaları, devletlerin ekonomi politikalarını sınırlayan faktörler haline gelmiştir [5]. Ayrıca, uluslararası örgütler ve çok uluslu şirketler gibi devlet dışı aktörler, egemenlik kavramının yeniden tanımlanmasını gerektirmiştir. Özellikle Avrupa Birliği gibi supranasyonel yapılar, üye devletlerin belirli yetkilerini devretmelerini ve egemenliklerini paylaşmalarını zorunlu kılmaktadır [6].

Bu çalışmanın temel amacı, küreselleşme sürecinin devlet egemenliği üzerindeki dönüştürücü etkilerini incelemek ve bu dönüşümün yeni güvenlik ve savunma politikalarına nasıl yansıdığını analiz etmektir. Küreselleşme, devletlerin sadece ekonomik politikalarını değil, aynı zamanda güvenlik ve savunma stratejilerini de yeniden şekillendirmektedir [7]. Geleneksel güvenlik tehditlerinin yanı sıra, terörizm, siber saldırılar ve iklim değişikliği gibi yeni tehditler, devletlerin güvenlik politikalarını daha karmaşık ve çok boyutlu hale getirmiştir [8].

Çalışmanın önemi, küreselleşmenin devlet egemenliği üzerindeki etkilerini anlamanın yanı sıra, devletlerin bu yeni güvenlik ortamına nasıl uyum sağladıklarını ortaya koymasında yatmaktadır. Bu bağlamda, çalışma, küreselleşme sürecinin güvenlik ve savunma politikalarına etkilerini analiz ederken, devletlerin egemenliklerini koruma ve sürdürme stratejilerini de değerlendirecektir.

Küreselleşme sürecinde, uluslararası işbirliği ve çok taraflılık giderek daha önemli hale gelmiştir. Devletler, ortak güvenlik tehditlerine karşı kolektif bir şekilde hareket etme gerekliliği duymaktadır. Bu durum, NATO gibi uluslararası güvenlik örgütlerinin rolünü ve önemini artırmaktadır [9]. Ayrıca, devletlerin siber güvenlik ve terörizmle mücadele konularında uluslararası işbirliği yapmaları, egemenlik kavramının yeniden yorumlanmasını zorunlu kılmaktadır [10].

Sonuç olarak, bu çalışma, küreselleşmenin devlet egemenliği üzerindeki dönüştürücü etkilerini ve bu dönüşümün yeni güvenlik ve savunma politikalarına yansımalarını detaylı bir şekilde ele alacaktır. Bu bağlamda, çalışma, devletlerin egemenliklerini nasıl yeniden tanımladıklarını ve küresel güvenlik ortamına nasıl uyum sağladıklarını ortaya koymayı amaçlamaktadır.

II. LİTERATÜR TARAMASI

A. *Devlet Egemenliği ve Küreselleşme Üzerine Teorik Çerçeveler*

Devlet egemenliği, modern uluslararası ilişkilerde merkezi bir rol oynar ve egemenlik kavramı, tarih boyunca çeşitli teorik yaklaşımlarla ele alınmıştır. Bu yaklaşımlar, egemenliğin tanımı, uygulanışı ve dönüşümü üzerine farklı perspektifler sunar. Geleneksel realist yaklaşım, egemenliği devletin toprak bütünlüğünü ve politik bağımsızlığını koruma yeteneği olarak tanımlar [11]. Realistlere göre, egemenlik devletin iç işlerine dış müdahalenin olmaması anlamına gelir ve devletler arası ilişkilerde mutlak bir ilke olarak kabul edilir.

Neoliberal ve liberal yaklaşımlar ise, egemenliğin mutlak olmadığını ve küreselleşme süreci ile birlikte egemenlik anlayışının değiştiğini savunur [6]. Bu yaklaşımlara göre, küreselleşme, devletler arasındaki karşılıklı bağımlılığı artırmış ve egemenlik kavramının yeniden tanımlanmasını zorunlu kılmıştır. Uluslararası kurumlar ve çok taraflı anlaşmalar, devletlerin egemenliklerini paylaşmalarını ve belirli alanlarda yetkilerini devretmelerini gerektirmiştir [3].

Konstrüktivist yaklaşım, egemenliğin sosyal olarak inşa edilmiş bir kavram olduğunu ve zamanla değişebileceğini öne sürer [12]. Konstrüktivistler, küreselleşme sürecinde devlet egemenliğinin uluslararası normlar ve değerler tarafından şekillendirildiğini savunurlar. Bu bağlamda, egemenlik kavramı, devletlerin küresel düzenin bir parçası olarak nasıl davrandıklarına bağlı olarak evrim geçirir.

B. *Küreselleşmenin Güvenlik ve Savunma Politikaları Üzerindeki Etkisi Hakkında Mevcut Araştırmaların İncelenmesi*

Küreselleşme süreci, devletlerin güvenlik ve savunma politikalarını derinden etkilemiştir. Ekonomik, teknolojik ve sosyal alandaki küresel entegrasyon, devletlerin güvenlik stratejilerini yeniden şekillendirmiştir. Küreselleşmenin güvenlik politikaları üzerindeki etkilerini inceleyen çalışmalar,

genellikle ekonomik küreselleşme ve güvenlik arasındaki ilişkiye odaklanır. Savunma politikaları üzerindeki etkiler ise, teknolojik gelişmeler ve sınır ötesi tehditlerle daha belirgin hale gelmiştir. Terörizm, siber saldırılar ve iklim değişikliği gibi yeni tehditler, devletlerin savunma stratejilerini daha karmaşık ve çok boyutlu hale getirmiştir [7]. Küreselleşmenin savunma politikaları üzerindeki etkilerini inceleyen çalışmalar, devletlerin bu tehditlere karşı uluslararası işbirliği ve çok taraflı stratejiler geliştirmeleri gerektiğini vurgular [8].

C. *Mevcut Literatürdeki Ana Tartışmalar ve Boşluklar*

Literatürde, küreselleşme ve devlet egemenliği arasındaki ilişki üzerine çeşitli tartışmalar mevcuttur. Bir yandan, küreselleşmenin devlet egemenliğini zayıflattığı ve devletlerin küresel güçlere boyun eğmek zorunda kaldığı savunulurken, diğer yandan devletlerin küresel süreçlere uyum sağlama ve egemenliklerini koruma yeteneklerini sürdürdükleri öne sürülmektedir [13]. Bu tartışma, küreselleşmenin devletler üzerindeki etkisinin farklı bağlamlarda nasıl değiştiğini anlamak için önemlidir. Güvenlik ve savunma politikaları bağlamında, literatürdeki ana boşluklardan biri, devletlerin yeni tehditlere karşı nasıl adapte olduklarına dair kapsamlı ampirik çalışmaların eksikliğidir. Terörizm, siber saldırılar ve iklim değişikliği gibi sınır ötesi tehditlerin devletlerin savunma politikalarını nasıl şekillendirdiği ve bu tehditlere karşı hangi stratejilerin geliştirildiği konularında daha fazla araştırmaya ihtiyaç vardır [10].

Bir diğer önemli tartışma, küreselleşme sürecinde uluslararası kurumların ve anlaşmaların devlet egemenliği üzerindeki etkisidir. Küresel yönetişim yapılarının, devletlerin egemenliklerini nasıl paylaştıkları ve yeniden tanımladıkları konusundaki araştırmalar, bu alandaki boşlukları doldurmak için kritiktir [6]. Örneğin, Avrupa Birliği gibi supranasyonel yapılar, üye devletlerin belirli yetkilerini devretmelerini ve egemenliklerini paylaşmalarını zorunlu kılmaktadır [9]. Bu tür yapılar, devlet egemenliğinin geleneksel anlayışlarını zorlamış ve yeni bir egemenlik paradigmasının ortaya çıkmasına yol açmıştır.

Sonuç olarak, literatür taraması, küreselleşme sürecinin devlet egemenliği üzerindeki dönüştürücü etkilerini ve bu dönüşümün güvenlik ve savunma politikalarına yansımalarını anlamak için kapsamlı bir temel sunmaktadır. Mevcut teorik çerçeveler ve ampirik çalışmalar, küreselleşmenin devlet egemenliğini nasıl yeniden şekillendirdiğini ve devletlerin bu yeni güvenlik ortamına nasıl uyum sağladıklarını ortaya koymaktadır. Ancak, literatürdeki boşluklar ve tartışmalar, bu alanda daha fazla araştırmaya ve derinlemesine analizlere ihtiyaç olduğunu göstermektedir.

III. KÜRESELLEŞME, GÜVENLİK VE SAVUNMA POLİTİKALARI

A. *Ekonomik Küreselleşmenin Ulusal Güvenlik Politikalarına Etkisi*

Küreselleşme, devletlerin ekonomik ve sosyal yapılarında köklü değişikliklere neden olmuştur. Ekonomik küreselleşme, sermaye hareketliliği, ticaretin serbestleşmesi ve çok uluslu şirketlerin etkisiyle ulusal ekonomilerin birbirine bağımlılığını artırmıştır [3]. Bu süreç, devletlerin ulusal güvenlik politikalarını da derinden etkilemiştir. Ekonomik küreselleşme, devletlerin ekonomik güvenliğini sağlama biçimlerini değiştirmiş ve ekonomik tehditlerin ulusal güvenlik üzerindeki önemini artırmıştır [5].

Ekonomik küreselleşmenin ulusal güvenlik politikalarına en belirgin etkilerinden biri, devletlerin ekonomik zayıflıklarının ve krizlerinin ulusal güvenlik tehditleri olarak görülmeye başlanmasıdır. Örneğin, 2008 küresel finansal krizi, birçok ülkede ekonomik istikrarsızlığa yol açmış ve bu durum, sosyal ve politik güvenlik tehditlerini tetiklemiştir [14]. Ekonomik krizler, işsizlik oranlarının artması, gelir eşitsizliğinin derinleşmesi ve sosyal huzursuzlukların artması gibi sonuçlar doğurarak, devletlerin iç güvenlik politikalarını yeniden şekillendirmelerine neden olmuştur.

Bununla birlikte, ekonomik küreselleşme, devletlerin enerji güvenliği politikalarını da etkilemiştir. Küresel enerji piyasalarındaki dalgalanmalar ve enerji kaynaklarına erişim sorunları, devletlerin enerji güvenliğini sağlama çabalarını artırmıştır [15]. Özellikle enerji ithalatına bağımlı olan ülkeler, enerji arz güvenliğini sağlamak için yeni stratejiler geliştirmek zorunda kalmışlardır. Bu durum, enerji güvenliği politikalarının ulusal güvenlik stratejilerinin merkezine yerleşmesine yol açmıştır.

B. *Uluslararası Kurumlar ve Anlaşmaların Güvenlik Stratejileri Üzerindeki Rolü*

Küreselleşme süreci, uluslararası kurumların ve anlaşmaların ulusal güvenlik stratejileri üzerindeki rolünü artırmıştır. Uluslararası kurumlar, devletlerin güvenlik politikalarını şekillendiren önemli aktörler haline gelmiştir. Birleşmiş Milletler (BM), NATO, Avrupa Birliği (AB) gibi uluslararası örgütler, küresel ve bölgesel güvenliği sağlama çabalarında kritik roller üstlenmektedir [8].

Birleşmiş Milletler, uluslararası barış ve güvenliği sağlama misyonu çerçevesinde çeşitli barış operasyonları ve insani müdahaleler yürütmektedir. BM'nin barış operasyonları, iç savaşlar, etnik çatışmalar ve diğer güvenlik tehditleri karşısında devletlerin güvenliğini sağlama çabalarına destek olmaktadır [16]. Bu operasyonlar, devletlerin egemenliklerini koruma ve iç güvenliklerini sağlama kapasitelerini artırmaktadır.

NATO, Soğuk Savaş sonrasında güvenlik stratejilerini yeniden tanımlamış ve küresel güvenlik tehditlerine karşı daha esnek ve kapsayıcı bir yaklaşım benimsemiştir. NATO'nun 2001 yılındaki 11 Eylül terör saldırılarının ardından terörizmle mücadeleye odaklanması, üye devletlerin güvenlik politikalarını da etkilemiştir [9]. NATO, siber güvenlik, enerji güvenliği ve kitle imha silahlarının yayılması gibi yeni tehditlere karşı ortak güvenlik stratejileri geliştirmektedir.

Avrupa Birliği, üye devletlerin güvenlik politikalarını koordine eden ve ortak savunma stratejileri geliştiren bir diğer önemli uluslararası aktördür. AB'nin Ortak Güvenlik ve Savunma Politikası (CSDP), üye devletlerin askeri ve sivil kapasitelerini bir araya getirerek, kriz yönetimi ve barışı koruma operasyonlarında etkin rol oynamaktadır [17]. AB, sınır güvenliği, terörizmle mücadele ve siber güvenlik gibi alanlarda ortak politikalar geliştirmekte ve üye devletlerin güvenlik tehditlerine karşı daha bütüncül ve entegre bir yaklaşım benimsemelerini sağlamaktadır.

C. *Küreselleşmeye Yanıt Olarak Güvenlik Politikalarını Uyarlayan Ülkelerin Vaka Çalışmaları*

Küreselleşmenin ulusal güvenlik politikaları üzerindeki etkilerini anlamak için çeşitli ülkelerin bu sürece nasıl yanıt verdiklerini incelemek faydalıdır. Aşağıda, küreselleşmeye uyum sağlamak için güvenlik politikalarını yeniden şekillendiren bazı ülkelerin vaka çalışmaları sunulmaktadır.

Birleşik Krallık, küreselleşmenin güvenlik üzerindeki etkilerine yanıt olarak, ulusal güvenlik stratejilerini yeniden tanımlamıştır. 2010 yılında yayımlanan Ulusal Güvenlik Stratejisi ve Stratejik Savunma ve Güvenlik İncelemesi, Birleşik Krallık'ın terörizm, siber saldırılar ve enerji güvenliği gibi yeni tehditlere karşı nasıl yanıt vereceğini belirlemiştir [18]. Bu strateji, Birleşik Krallık'ın uluslararası işbirliğini güçlendirme ve çok taraflı güvenlik mekanizmalarını destekleme amacını vurgulamaktadır.

Almanya, küreselleşmenin getirdiği güvenlik tehditlerine karşı proaktif bir yaklaşım benimsemiştir. 2016 yılında yayımlanan Beyaz Kitap, Almanya'nın güvenlik ve savunma politikalarını küresel tehditlere karşı uyarlama çabalarını yansıtmaktadır [19]. Almanya, siber güvenlik, terörizmle mücadele ve enerji güvenliği gibi alanlarda uluslararası işbirliğini artırmakta ve NATO ve AB çerçevesinde ortak güvenlik politikaları geliştirmektedir.

Japonya, küreselleşme sürecinde bölgesel ve küresel güvenlik tehditlerine karşı güvenlik politikalarını yeniden şekillendirmiştir. Japonya'nın 2013 Ulusal Güvenlik Stratejisi, Çin'in yükselişi ve Kuzey Kore'nin nükleer tehditleri gibi bölgesel güvenlik endişelerine yanıt vermektedir [20]. Japonya, ABD ile olan güvenlik ittifakını güçlendirmekte ve Asya-Pasifik bölgesinde güvenlik işbirliğini artırmaktadır.

Türkiye, küreselleşmenin getirdiği güvenlik tehditlerine karşı dinamik bir güvenlik politikası benimsemiştir. Türkiye'nin 2010 yılında yayımlanan Milli Güvenlik Strateji Belgesi, terörizm, sınır güvenliği ve enerji güvenliği gibi alanlarda ulusal ve uluslararası işbirliğini vurgulamaktadır [21]. Türkiye, NATO üyeliği çerçevesinde savunma politikalarını uyarlamakta ve bölgesel güvenlik tehditlerine karşı proaktif önlemler almaktadır.

Sonuç olarak, küreselleşme süreci, devletlerin güvenlik politikalarını derinden etkilemiştir. Ekonomik, teknolojik ve sosyal değişimler, ulusal güvenlik stratejilerinin yeniden tanımlanmasını gerektirmiştir. Uluslararası kurumlar ve anlaşmalar, devletlerin güvenlik politikalarını şekillendiren önemli aktörler haline gelmiş ve devletlerin küresel tehditlere karşı daha esnek ve kapsayıcı stratejiler geliştirmelerini sağlamıştır. Çeşitli ülkelerin vaka çalışmaları, küreselleşmenin güvenlik politikaları üzerindeki etkilerini anlamak için önemli örnekler sunmaktadır.

D. *Teknolojik Gelişmeler ve Küresel Bağımlılığın Savunma Stratejilerine Etkisi*

Küreselleşme süreci, teknolojik gelişmelerin hızlanmasına ve devletler arasındaki küresel bağımlılığın artmasına yol açmıştır. Bu durum, savunma politikalarının yeniden şekillendirilmesini zorunlu kılmıştır. Özellikle bilgi ve iletişim teknolojilerindeki ilerlemeler, savunma stratejilerinin dijitalleşmesini ve modernleşmesini sağlamıştır [22]. Bu teknolojik gelişmeler, devletlerin savunma kapasitesini artırmış ancak aynı zamanda yeni güvenlik tehditlerini de beraberinde getirmiştir.

Teknolojik gelişmeler, savunma sanayisinin ve askeri teknolojilerin hızlı bir şekilde ilerlemesine neden olmuştur. Örneğin, insansız hava araçları (İHA'lar) ve yapay zeka destekli savunma sistemleri, modern savaş alanlarında önemli bir rol oynamaktadır [23]. Bu teknolojiler, devletlerin askeri operasyonlarını daha etkili ve düşük maliyetli hale getirmiştir. Ancak, bu gelişmeler aynı zamanda siber güvenlik tehditlerini artırmış ve devletlerin siber savunma stratejilerini güçlendirmelerini gerektirmiştir [24].

Küresel bağımlılık ise, devletlerin savunma stratejilerini karmaşıklaştırmıştır. Küreselleşmenin getirdiği ekonomik ve ticari bağımlılıklar, devletlerin savunma politikalarını daha esnek ve çok boyutlu hale getirmiştir. Örneğin, enerji kaynaklarına olan bağımlılık, enerji güvenliğini savunma politikalarının merkezine yerleştirmiştir [15]. Enerji arzının kesintiye uğraması, ulusal güvenlik açısından ciddi bir tehdit olarak görülmekte ve devletler, enerji kaynaklarına erişimi güvence altına almak için çeşitli stratejiler geliştirmektedir.

E. *Sınır Ötesi Tehditlerin Savunma Politikaları Üzerindeki Etkisi*

Küreselleşme süreci, sınır ötesi tehditlerin artmasına ve çeşitlenmesine neden olmuştur. Terörizm, siber savaş ve kitlesel göçler gibi sınır ötesi tehditler, devletlerin savunma politikalarını yeniden şekillendirmiştir [8]. Bu tehditler, geleneksel savunma stratejilerinin ötesine geçmeyi ve daha kapsamlı güvenlik yaklaşımlarını benimsemeyi gerektirmiştir.

Terörizm, küresel bir tehdit olarak, devletlerin savunma politikalarında önemli değişikliklere yol açmıştır. 11 Eylül 2001 saldırıları, terörizmin küresel bir tehdit olarak algılanmasını sağlamış ve birçok devlet, terörle mücadele stratejilerini güçlendirmiştir [25]. Devletler, terörizmi önlemek ve terörist ağları yok etmek için istihbarat paylaşımı, sınır güvenliği ve askeri müdahaleleri içeren kapsamlı stratejiler geliştirmiştir.

Siber savaş, modern savunma politikalarının merkezinde yer alan bir diğer önemli tehdit olarak öne çıkmaktadır. Siber saldırılar, devletlerin kritik altyapılarına ve bilgi sistemlerine zarar verme potansiyeline sahiptir [10]. Bu nedenle, devletler siber savunma kapasitelerini artırmak ve siber güvenlik stratejilerini güçlendirmek için önemli yatırımlar yapmaktadır. Siber savaş, sadece askeri değil, aynı zamanda ekonomik ve sosyal güvenliği de tehdit eden bir unsur olarak görülmektedir.

Kitlesel göçler, küreselleşmenin bir diğer sonucu olarak, devletlerin sınır güvenliği ve savunma politikalarını etkilemiştir. Savaşlar, iç çatışmalar ve ekonomik krizler nedeniyle milyonlarca insanın yerinden edilmesi, ulusal güvenlik için ciddi bir tehdit oluşturmaktadır [26]. Devletler, mülteci akınlarını yönetmek ve sınır güvenliğini sağlamak için çeşitli stratejiler geliştirmekte ve uluslararası işbirliğini artırmaktadır.

F. *Küreselleşme Çağında Devletler Tarafından Benimsenen Yeni Savunma Politikaları*

Küreselleşme sürecinde, devletler yeni savunma politikaları geliştirerek değişen tehdit ortamına uyum sağlamaya çalışmaktadır. Aşağıda, küreselleşme çağında devletler tarafından benimsenen bazı yeni savunma politikaları örnekleri sunulmaktadır.

ABD, küreselleşmenin getirdiği yeni tehditlere karşı savunma politikalarını sürekli olarak güncellemektedir. 2018 yılında yayımlanan Ulusal Savunma Stratejisi, büyük güç rekabetine ve siber güvenlik tehditlerine odaklanmaktadır [27]. ABD, savunma harcamalarını artırarak, ileri teknoloji askeri sistemler ve siber savunma kapasitelerini güçlendirmektedir.

Çin, küreselleşme sürecinde askeri modernizasyon ve teknolojiye büyük yatırımlar yapmaktadır. Çin'in 2019 Ulusal Savunma Beyaz Kitabı, siber güvenlik, uzay savunması ve deniz güvenliği gibi alanlarda stratejik önceliklere vurgu yapmaktadır [28]. Çin, "Bir Kuşak, Bir Yol" girişimi çerçevesinde askeri varlığını ve küresel etkisini artırmaya yönelik politikalar geliştirmektedir.

Rusya, küresel tehditlere karşı savunma politikalarını proaktif ve saldırgan bir yaklaşımla şekillendirmektedir. 2014 yılında yayımlanan Askeri Doktrin, NATO'nun genişlemesi ve ABD'nin küresel etkisi gibi tehditlere odaklanmaktadır [29]. Rusya, siber savaş, hibrit savaş ve enerji güvenliği gibi alanlarda stratejik kapasitelerini güçlendirmektedir.

Hindistan, küreselleşmenin getirdiği güvenlik tehditlerine karşı savunma politikalarını yenilemektedir. 2015 yılında yayımlanan Ulusal Güvenlik Stratejisi, terörizm, siber güvenlik ve deniz güvenliği gibi alanlarda önceliklere vurgu yapmaktadır [30]. Hindistan, savunma harcamalarını artırarak, askeri modernizasyon ve teknolojiye büyük yatırımlar yapmaktadır.

Sonuç olarak, küreselleşme süreci, devletlerin savunma politikalarını derinden etkilemiş ve yeni tehditlerle başa çıkmak için kapsamlı stratejiler geliştirmelerini zorunlu kılmıştır. Teknolojik gelişmeler, siber savaş, terörizm ve kitlesel göçler gibi sınır ötesi tehditler, devletlerin savunma stratejilerini yeniden şekillendirmiştir. Çeşitli ülkelerin savunma politikaları örnekleri, küreselleşme çağında savunma stratejilerinin nasıl evrildiğini ve yeni tehditlere nasıl uyum sağlandığını göstermektedir.

IV. ZORLUKLAR VE SONUÇLAR

A. *Küreselleşmenin Devlet Egemenliğine Getirdiği Zorluklar*

Küreselleşme süreci, devlet egemenliği kavramını köklü bir şekilde değiştirmiştir. Devletlerin sınırlar üzerindeki kontrolü, küresel ekonomik, politik ve sosyal dinamikler tarafından giderek daha fazla zorlanmaktadır. Bu bağlamda, devlet egemenliği, küreselleşmenin getirdiği bir dizi zorlukla karşı karşıya kalmıştır.

Birinci zorluk, sınırlar üzerindeki kontrolün kaybıdır. Küreselleşme, sermaye, mal, hizmet ve insanların ulusal sınırlar arasında serbestçe hareket etmesini sağlamıştır [3]. Bu durum, devletlerin sınırlarını kontrol etme yeteneğini zayıflatmış ve sınır güvenliği konusundaki endişeleri artırmıştır. Örneğin, Avrupa Birliği'nde Schengen Bölgesi uygulaması, üye devletler arasında sınır kontrollerinin kaldırılmasına ve sınır güvenliğinin ortak bir sorumluluk haline gelmesine yol açmıştır [31].

İkinci zorluk, devlet dışı aktörlerin artan etkisidir. Çok uluslu şirketler, uluslararası sivil toplum örgütleri ve terörist gruplar gibi devlet dışı aktörler, küresel siyasette önemli rol oynamaya başlamışlardır [4]. Bu aktörler, devletlerin egemenliklerini zayıflatan ve ulusal güvenlik politikalarını karmaşıklaştıran dinamikler yaratmaktadır. Özellikle çok uluslu şirketler, ekonomik küreselleşmenin itici güçleri olarak, devletlerin ekonomik politikalarını ve düzenlemelerini etkileyebilmektedir.

Üçüncü zorluk, bilgi ve iletişim teknolojilerinin hızlı gelişimidir. İnternet ve dijital teknolojiler, devletlerin bilgi akışını kontrol etme yeteneğini zayıflatmıştır [32]. Bu durum, siber güvenlik tehditlerini artırmış ve devletlerin dijital egemenliklerini koruma çabalarını zorlaştırmıştır. Siber saldırılar, devletlerin kritik altyapılarına zarar verebilecek kapasitededir ve bu nedenle siber savunma stratejileri geliştirilmesi gerekmektedir [24].

B. *Ulusal ve Uluslararası Güvenlik Üzerindeki Sonuçlar*

Küreselleşmenin devlet egemenliğine getirdiği zorluklar, ulusal ve uluslararası güvenlik üzerinde önemli sonuçlar doğurmuştur. Bu sonuçlar, devletlerin güvenlik politikalarını yeniden şekillendirmelerine ve yeni stratejiler geliştirmelerine yol açmıştır. Ulusal güvenlik açısından, küreselleşme süreci, devletlerin iç güvenlik tehditleriyle başa çıkma kapasitesini zorlamaktadır. Terörizm, siber saldırılar ve organize suçlar gibi sınır ötesi tehditler, ulusal güvenlik politikalarını daha karmaşık ve çok boyutlu hale getirmiştir [8]. Devletler, bu tehditlere karşı koymak için daha etkin istihbarat paylaşımı, sınır güvenliği ve siber savunma stratejileri geliştirmektedir.

Uluslararası güvenlik açısından, küreselleşme, devletler arasındaki karşılıklı bağımlılığı artırmıştır. Bu bağımlılık, uluslararası işbirliği ve çok taraflılık gereksinimini doğurmuştur. Uluslararası kurumlar, devletlerin güvenlik politikalarını koordine eden ve kolektif güvenlik stratejileri geliştiren önemli aktörler haline gelmiştir [6]. Örneğin, Birleşmiş Milletler ve NATO gibi örgütler, uluslararası barış ve güvenliği sağlama misyonları çerçevesinde çeşitli barış operasyonları ve insani müdahaleler yürütmektedir.

C. *Zorlukların Üstesinden Gelmede Bölgesel ve Küresel Yönetişimin Rolü*

Küreselleşmenin getirdiği zorluklarla başa çıkmak ve devlet egemenliğini korumak için bölgesel ve küresel yönetişim yapıları önemli bir rol oynamaktadır. Bu yapılar, devletlerin karşı karşıya kaldığı sınır ötesi tehditlere karşı kolektif çözümler geliştirmelerine olanak tanımaktadır.

Bölgesel yönetişim, devletlerin ortak güvenlik tehditlerine karşı birlikte hareket etmelerini sağlamaktadır. Avrupa Birliği, bu bağlamda önemli bir örnek teşkil etmektedir. AB'nin Ortak Güvenlik ve Savunma Politikası (CSDP), üye devletlerin askeri ve sivil kapasitelerini bir araya getirerek, kriz yönetimi ve barışı koruma operasyonlarında etkin rol oynamaktadır [17]. Bu politika, üye devletlerin güvenlik tehditlerine karşı daha bütüncül ve entegre bir yaklaşım benimsemelerini sağlamaktadır. Küresel yönetişim ise, uluslararası kurumlar ve anlaşmalar aracılığıyla devletlerin güvenlik politikalarını koordine etmektedir. Birleşmiş Milletler, uluslararası barış ve güvenliği sağlama misyonu çerçevesinde önemli bir rol oynamaktadır. BM'nin barış operasyonları, iç savaşlar, etnik çatışmalar ve diğer güvenlik tehditleri karşısında devletlerin güvenliğini sağlama çabalarına destek olmaktadır [16]. Ayrıca, NATO, siber güvenlik, enerji güvenliği ve terörizmle mücadele gibi alanlarda ortak güvenlik stratejileri geliştirmektedir.

Bölgesel ve küresel yönetişim yapıları, devletlerin küreselleşmenin getirdiği zorluklarla başa çıkmalarını kolaylaştırmaktadır. Bu yapılar, devletlerin egemenliklerini koruma ve sürdürme kapasitelerini artırmakta ve küresel güvenlik ortamına uyum sağlamalarına yardımcı olmaktadır. Ancak, bu süreçte uluslararası işbirliğinin ve çok taraflılığın önemi büyüktür. Devletler, küresel tehditlere karşı daha etkili stratejiler geliştirebilmek için işbirliğini ve koordinasyonu artırmak zorundadır. Sonuç olarak, küreselleşme süreci, devlet egemenliği ve güvenlik politikaları üzerinde derin etkiler yaratmıştır. Sınırlar üzerindeki kontrolün kaybı, devlet dışı aktörlerin artan etkisi ve bilgi ve iletişim teknolojilerinin hızlı gelişimi, devletlerin egemenliklerini zorlamaktadır. Bu zorluklar, ulusal ve uluslararası güvenlik üzerinde önemli sonuçlar doğurmuş ve devletlerin güvenlik politikalarını yeniden şekillendirmelerine yol açmıştır. Bölgesel ve küresel yönetişim yapıları, bu zorlukların üstesinden gelmede önemli bir rol oynamaktadır ve devletlerin karşı karşıya kaldığı sınır ötesi tehditlere karşı kolektif çözümler geliştirmelerine olanak tanımaktadır.

V. VAKA ÇALIŞMALARI

A. *Almanya: Yenilikçi Güvenlik ve Savunma Politikaları*

Almanya, küreselleşme sürecinde egemenlik, güvenlik ve savunma politikalarında önemli değişiklikler yaşamış bir ülke olarak öne çıkmaktadır. İkinci Dünya Savaşı sonrası dönemde savunma politikasını barışçıl çözümler ve uluslararası işbirliği üzerine inşa eden Almanya, son yıllarda güvenlik politikalarında önemli değişiklikler yapmıştır. 2016 yılında yayımlanan "Beyaz Kitap", Almanya'nın güvenlik ve savunma politikalarını yeniden tanımlamış ve modern tehditlere karşı daha proaktif bir yaklaşım benimsemiştir [19].

Almanya'nın yeni savunma stratejisi, siber güvenlik, terörizm ve bölgesel istikrarsızlık gibi küresel tehditlere odaklanmaktadır. Özellikle siber güvenlik alanında yapılan yatırımlar, Almanya'nın dijital altyapısını koruma kapasitesini artırmıştır. Ayrıca, Almanya NATO çerçevesinde kolektif savunma politikalarına katkıda bulunmakta ve Avrupa Birliği'nin Ortak Güvenlik ve Savunma Politikası'na (CSDP) aktif olarak katılmaktadır. Bu durum, Almanya'nın uluslararası güvenlik işbirliğine verdiği önemi göstermektedir [17].

B. *Türkiye: Dinamik ve Bölgesel Güvenlik Yaklaşımı*

Türkiye, küreselleşmenin getirdiği güvenlik ve savunma tehditlerine karşı dinamik bir yaklaşım benimsemiştir. Jeopolitik konumu gereği, Türkiye, terörizm, mülteci krizleri ve bölgesel çatışmalar gibi birçok güvenlik tehdidiyle karşı karşıya kalmaktadır. Bu bağlamda, Türkiye'nin güvenlik ve savunma politikaları, hem ulusal hem de bölgesel tehditleri ele alacak şekilde şekillenmiştir.

2010 yılında yayımlanan Milli Güvenlik Strateji Belgesi, Türkiye'nin terörizmle mücadele, sınır güvenliği ve enerji güvenliği gibi önceliklerini belirlemiştir [21]. Türkiye, Suriye krizi ve mülteci akınına karşı proaktif önlemler almış, sınır güvenliğini artırmış ve uluslararası işbirliğini güçlendirmiştir. Ayrıca, Türkiye'nin NATO üyeliği çerçevesinde savunma politikalarını uyarlaması ve bölgesel güvenlik tehditlerine karşı aktif rol oynaması dikkat çekicidir.

C. *Japonya: Barışçıl Güvenlik Politikalarından Proaktif Savunmaya*

Japonya, küreselleşme sürecinde güvenlik ve savunma politikalarında önemli değişiklikler yapmıştır. İkinci Dünya Savaşı sonrası dönemde barışçıl ve savunmacı bir politika izleyen Japonya, son yıllarda bölgesel tehditlere karşı daha proaktif bir yaklaşım benimsemiştir. 2013 yılında yayımlanan Ulusal Güvenlik Stratejisi, Japonya'nın güvenlik politikalarını yeniden tanımlamış ve Çin'in yükselişi ile Kuzey Kore'nin nükleer tehditlerine odaklanmıştır [20].

Japonya, ABD ile olan güvenlik ittifakını güçlendirmiş ve Asya-Pasifik bölgesinde güvenlik işbirliğini artırmıştır. Ayrıca, Japonya'nın savunma harcamalarını artırarak askeri kapasitelerini geliştirmesi, modern savaş teknolojilerine yatırım yapması ve siber güvenlik stratejilerini güçlendirmesi dikkat çekicidir. Bu durum, Japonya'nın bölgesel ve küresel güvenlik tehditlerine karşı daha hazırlıklı olma çabalarını yansıtmaktadır.

D. *Rusya: Geleneksel Güvenlikten Hibrit Savaşa*

Rusya, küreselleşmenin getirdiği güvenlik tehditlerine karşı savunma politikalarını yeniden şekillendiren bir diğer önemli aktördür. Rusya, geleneksel güvenlik yaklaşımlarından hibrit savaş stratejilerine geçiş yaparak, modern tehditlere karşı daha esnek ve kapsamlı bir savunma politikası benimsemiştir. 2014 yılında yayımlanan Askeri Doktrin, NATO'nun genişlemesi ve ABD'nin küresel etkisi gibi tehditlere odaklanmaktadır [29].

Rusya'nın hibrit savaş stratejileri, siber saldırılar, dezenformasyon kampanyaları ve enerji politikaları gibi unsurları içermektedir. Özellikle siber savaş kapasitesinin artırılması, Rusya'nın uluslararası alanda etkisini genişletme çabalarını yansıtmaktadır. Ayrıca, Rusya'nın enerji güvenliği politikaları, Avrupa'ya olan enerji arzını stratejik bir silah olarak kullanma potansiyelini göstermektedir [33].

E. *ABD: Küresel Güç Rekabeti ve Yeni Güvenlik Stratejileri*

Amerika Birleşik Devletleri, küresel güvenlik tehditlerine karşı savunma politikalarını sürekli olarak güncellemektedir. 2018 yılında yayımlanan Ulusal Savunma Stratejisi, ABD'nin büyük güç rekabetine ve siber güvenlik tehditlerine odaklanmasını öngörmektedir [27]. ABD, savunma harcamalarını artırarak, ileri teknoloji askeri sistemler ve siber savunma kapasitelerini güçlendirmektedir.

ABD'nin yeni savunma stratejisi, Çin ve Rusya gibi büyük güçlerle rekabeti, siber saldırılara karşı savunma kapasitesinin artırılmasını ve terörizmle mücadeleyi içermektedir. Ayrıca, ABD'nin küresel güvenlik ittifaklarını güçlendirme çabaları, NATO ve Asya-Pasifik'teki müttefiklerle olan işbirliğini pekiştirmektedir. Bu durum, ABD'nin küresel güvenlik mimarisinde liderlik rolünü sürdürme çabalarını yansıtmaktadır.

F. *Karşılaştırmalı Analiz: Farklı Yaklaşımlar ve Sonuçlar*

Yukarıda incelenen ülkeler, küreselleşmenin getirdiği güvenlik ve savunma tehditlerine karşı farklı yaklaşımlar benimsemiştir. Almanya, barışçıl ve uluslararası işbirliğine dayalı bir strateji geliştirirken, Türkiye dinamik ve bölgesel tehditlere odaklanan bir yaklaşım benimsemiştir. Japonya, barışçıl politikalardan proaktif savunmaya geçiş yapmış, Rusya ise hibrit savaş stratejileri geliştirmiştir. ABD ise büyük güç rekabeti ve küresel güvenlik ittifaklarını güçlendirme üzerine yoğunlaşmıştır. Bu farklı yaklaşımlar, küreselleşmenin getirdiği güvenlik tehditlerine karşı devletlerin nasıl farklı stratejiler geliştirdiğini göstermektedir. Her ülkenin coğrafi, politik ve ekonomik koşullarına göre şekillenen bu stratejiler, ulusal güvenlik politikalarının çeşitliliğini ve karmaşıklığını ortaya koymaktadır. Karşılaştırmalı analiz, küreselleşmenin devlet egemenliği ve savunma politikaları üzerindeki etkilerini anlamak için önemli bir perspektif sunmaktadır.

VI. TARTIŞMA

A. *Vaka Çalışmaları ve Genel Analiz Bulgularının Sentezi*

Küreselleşme süreci, devlet egemenliği, güvenlik ve savunma politikalarında köklü değişikliklere yol açmıştır. Almanya, Türkiye, Japonya, Rusya ve ABD gibi ülkeler üzerinde yapılan vaka çalışmaları, bu değişikliklerin çeşitli biçimlerde tezahür ettiğini göstermektedir. Almanya, küreselleşmenin getirdiği yeni

tehditlere karşı uluslararası işbirliğini ve savunma politikalarını modernize etme çabalarını öne çıkarırken, Türkiye, jeopolitik konumu gereği dinamik ve bölgesel odaklı bir güvenlik stratejisi benimsemiştir. Japonya, barışçıl politikalarından proaktif savunma stratejilerine geçiş yapmış, Rusya ise hibrit savaş teknikleri ve siber güvenlik tehditlerine karşı kapsamlı stratejiler geliştirmiştir. ABD, büyük güç rekabeti ve küresel güvenlik ittifaklarını güçlendirme çabalarını sürdürerek, savunma stratejilerini sürekli olarak güncellemiştir.

Bu vaka çalışmaları, devletlerin küreselleşmenin getirdiği çeşitli tehditlere karşı nasıl farklı stratejiler geliştirdiğini ve uyum sağladığını göstermektedir. Örneğin, Almanya'nın güvenlik politikalarını yeniden tanımlaması ve NATO ile işbirliğini artırması, devletlerin küresel tehditlere karşı kolektif savunma stratejileri geliştirme gerekliliğini vurgulamaktadır [19]. Benzer şekilde, Türkiye'nin bölgesel tehditlere karşı dinamik bir güvenlik politikası benimsemesi, devletlerin jeopolitik konumlarının güvenlik stratejilerini nasıl şekillendirdiğini göstermektedir [21].

B. *Sonuçların Mevcut Teoriler ve Çerçeveler Bağlamında Yorumlanması*

Küreselleşme sürecinin devlet egemenliği üzerindeki etkileri, uluslararası ilişkiler teorileri ve egemenlik kavramları çerçevesinde değerlendirildiğinde, çeşitli perspektifler ortaya çıkmaktadır. Realist teori, devletlerin egemenliklerini koruma ve güvenliklerini sağlama çabalarını vurgularken, liberal ve neoliberal teoriler, küresel işbirliğinin ve uluslararası kurumların önemini ön plana çıkarmaktadır [6],[11]. Konstrüktivist yaklaşımlar ise, egemenliğin sosyal olarak inşa edilmiş bir kavram olduğunu ve küresel normlar ve değerler tarafından şekillendirildiğini savunmaktadır [12].

Almanya'nın uluslararası işbirliğine dayalı güvenlik politikaları, liberal teorilerin öngördüğü gibi, devletlerin karşılıklı bağımlılık ve işbirliği yoluyla güvenliklerini artırabileceklerini göstermektedir. Almanya'nın NATO ve AB çerçevesinde güvenlik stratejileri geliştirmesi, liberal ve neoliberal yaklaşımların doğruluğunu desteklemektedir [17]. Diğer yandan, Türkiye'nin dinamik ve bölgesel odaklı güvenlik stratejisi, realist teorinin öngördüğü şekilde, devletlerin jeopolitik konumları ve ulusal çıkarlarına göre hareket ettiğini göstermektedir.

Japonya ve Rusya'nın savunma politikalarındaki değişiklikler, konstrüktivist yaklaşımların savunduğu gibi, devletlerin küresel normlar ve tehdit algıları tarafından şekillendirildiğini ortaya koymaktadır. Japonya'nın barışçıl politikalarından proaktif savunma stratejilerine geçişi, bölgesel tehditlerin algılanış biçiminin güvenlik politikalarını nasıl etkilediğini göstermektedir [20]. Rusya'nın hibrit savaş stratejileri ve siber güvenlik politikaları ise, modern tehditlerin devletlerin savunma stratejilerini nasıl yeniden tanımladığını göstermektedir [29].

C. *Devlet Egemenliği ve Küresel Yönetişim İçin Daha Geniş Sonuçların Tartışılması*

Küreselleşme süreci, devlet egemenliği ve küresel yönetişim için daha geniş sonuçlar doğurmuştur. Devletlerin egemenliklerini koruma çabaları, uluslararası işbirliği ve çok taraflılık gereksinimini artırmıştır. Uluslararası kurumlar ve anlaşmalar, devletlerin güvenlik politikalarını koordine eden ve kolektif güvenlik stratejileri geliştiren önemli aktörler haline gelmiştir. Birleşmiş Milletler, NATO ve Avrupa Birliği gibi kurumlar, uluslararası barış ve güvenliği sağlama misyonları çerçevesinde önemli roller üstlenmektedir.

Uluslararası işbirliği ve çok taraflılık, küreselleşmenin getirdiği sınır ötesi tehditlere karşı etkili stratejiler geliştirmede kritik öneme sahiptir. Devletler, terörizm, siber saldırılar ve iklim değişikliği gibi küresel tehditlerle başa çıkmak için uluslararası işbirliğini artırmak zorundadır. Bu bağlamda, küresel yönetişim yapıları, devletlerin karşı karşıya kaldığı güvenlik tehditlerine karşı kolektif çözümler geliştirmelerine olanak tanımaktadır [8].

Ancak, küresel yönetişim yapılarının etkinliği, devletlerin ulusal çıkarları ve egemenlik kaygıları ile dengelenmelidir. Devletler, egemenliklerini koruma ve ulusal güvenliklerini sağlama çabalarını sürdürürken, aynı zamanda uluslararası işbirliği ve çok taraflılık ilkelerini benimsemelidir. Bu durum, devletlerin güvenlik politikalarını daha esnek ve uyumlu hale getirmelerini gerektirmektedir.

Sonuç olarak, küreselleşme süreci, devlet egemenliği ve güvenlik politikaları üzerinde derin etkiler yaratmıştır. Vaka çalışmaları, devletlerin küresel tehditlere karşı nasıl farklı stratejiler geliştirdiğini ve uyum sağladığını göstermektedir. Bu stratejiler, devletlerin jeopolitik konumları, ulusal çıkarları ve küresel tehdit algıları tarafından şekillendirilmektedir. Mevcut teoriler ve çerçeveler bağlamında

değerlendirildiğinde, küreselleşmenin devlet egemenliği ve küresel yönetişim için önemli sonuçlar doğurduğu görülmektedir. Devletler, küresel tehditlere karşı daha etkili stratejiler geliştirebilmek için uluslararası işbirliği ve çok taraflılık ilkelerini benimsemeli ve güvenlik politikalarını daha esnek ve uyumlu hale getirmelidir.

VII. SONUÇLAR

Bu çalışmada, küreselleşme sürecinin devlet egemenliği, güvenlik ve savunma politikaları üzerindeki dönüştürücü etkileri incelenmiştir. Almanya, Türkiye, Japonya, Rusya ve ABD gibi ülkeler üzerinde yapılan vaka çalışmaları, küreselleşmenin devletlerin egemenlik kavramını nasıl yeniden tanımladığını ve güvenlik stratejilerini nasıl etkilediğini göstermektedir. Temel bulgular şu şekilde özetlenebilir:

Küreselleşme, devletlerin sınırlarını kontrol etme yeteneğini zayıflatmıştır. Serbest ticaret, sermaye hareketliliği ve insan göçleri, devletlerin sınır güvenliğini sağlamada karşılaştığı zorlukları artırmıştır.

Çok uluslu şirketler, uluslararası sivil toplum örgütleri ve terörist gruplar gibi devlet dışı aktörler, küresel siyasette önemli rol oynamaya başlamış ve devletlerin egemenliğini zayıflatmıştır.

Bilgi ve iletişim teknolojilerindeki ilerlemeler, devletlerin bilgi akışını kontrol etme yeteneğini zayıflatmış ve siber güvenlik tehditlerini artırmıştır.

Küresel tehditlere karşı etkili stratejiler geliştirmek için uluslararası işbirliği ve çok taraflılık gereksinimi artmıştır. Uluslararası kurumlar ve anlaşmalar, devletlerin güvenlik politikalarını koordine eden ve kolektif güvenlik stratejileri geliştiren önemli aktörler haline gelmiştir.

Bölgesel ve küresel yönetişim yapıları, devletlerin küresel tehditlere karşı kolektif çözümler geliştirmelerine olanak tanımaktadır. Avrupa Birliği, NATO ve Birleşmiş Milletler gibi kurumlar, uluslararası barış ve güvenliği sağlama misyonları çerçevesinde kritik roller üstlenmektedir.

Bu bulgular, küreselleşmenin devlet egemenliği ve güvenlik politikaları üzerinde derin etkiler yarattığını ve devletlerin bu yeni güvenlik ortamına uyum sağlamak için çeşitli stratejiler geliştirdiğini göstermektedir.

Devletler, küresel tehditlerle başa çıkmak için uluslararası işbirliğini artırmalı ve çok taraflı güvenlik anlaşmalarına daha fazla önem vermelidir. Özellikle terörizm, siber güvenlik ve iklim değişikliği gibi küresel tehditler, uluslararası işbirliği olmadan etkili bir şekilde yönetilemez.

Devletler, güvenlik politikalarını daha esnek ve uyarlanabilir hale getirmelidir. Küreselleşme süreci, hızlı değişen tehditler ve dinamik güvenlik ortamları yaratmaktadır. Bu nedenle, güvenlik stratejileri, yeni tehditlere hızla yanıt verebilecek şekilde tasarlanmalıdır.

Devletler, siber güvenlik kapasitelerini artırmak için daha fazla yatırım yapmalı ve siber tehditlere karşı kapsamlı savunma stratejileri geliştirmelidir. Siber saldırılar, ulusal güvenlik için ciddi bir tehdit oluşturmaktadır ve bu alanda uluslararası işbirliği de kritik öneme sahiptir.

Devletler, bölgesel güvenlik işbirliklerini teşvik etmeli ve komşu ülkelerle ortak güvenlik stratejileri geliştirmelidir. Bölgesel tehditler, bölgesel işbirliği ile daha etkili bir şekilde yönetilebilir.

Akademisyenler, küreselleşmenin güvenlik ve savunma politikaları üzerindeki etkilerini daha derinlemesine araştırmalıdır. Özellikle devlet dışı aktörlerin ve teknolojik gelişmelerin bu politikalar üzerindeki etkisi üzerine daha fazla çalışma yapılmalıdır.

Farklı ülkelerin güvenlik ve savunma politikalarını karşılaştıran çalışmalar, küreselleşmenin etkilerini anlamak için önemli bir kaynak olabilir. Karşılaştırmalı analizler ve vaka çalışmaları, devletlerin farklı stratejiler geliştirdiğini ve bu stratejilerin sonuçlarını ortaya koyabilir.

Akademisyenler, uluslararası işbirliği ve çok taraflılık konularında daha fazla araştırma yapmalıdır. Küresel tehditlerin yönetimi, uluslararası işbirliğini ve çok taraflılık mekanizmalarını gerektirmektedir.

Siber güvenlik tehditlerinin devlet egemenliği üzerindeki etkileri üzerine daha fazla araştırma yapılmalıdır. Bu araştırmalar, devletlerin siber güvenlik kapasitelerini nasıl artırdığını ve uluslararası siber güvenlik işbirliklerini nasıl geliştirdiğini inceleyebilir.

İklim değişikliğinin güvenlik politikaları üzerindeki etkileri üzerine daha fazla çalışma yapılmalıdır. İklim değişikliği, doğal afetler ve kitlesel göçler gibi yeni güvenlik tehditleri yaratmakta ve devletlerin bu tehditlere karşı nasıl yanıt verdiğini anlamak önemlidir.

Devlet dışı aktörlerin (çok uluslu şirketler, uluslararası sivil toplum örgütleri, terörist gruplar) güvenlik politikaları üzerindeki etkileri üzerine daha fazla araştırma yapılmalıdır. Bu aktörlerin devlet egemenliğini nasıl etkilediği ve devletlerin bu etkilere nasıl yanıt verdiği incelenmelidir.

Farklı bölgelerdeki güvenlik dinamikleri ve bölgesel güvenlik işbirlikleri üzerine daha fazla çalışma yapılmalıdır. Özellikle Orta Doğu, Asya-Pasifik ve Afrika gibi bölgelerdeki güvenlik tehditleri ve işbirlikleri üzerine yapılan araştırmalar, bölgesel güvenlik stratejilerini anlamak için önemli olabilir.

Sonuç olarak, küreselleşme süreci, devlet egemenliği ve güvenlik politikaları üzerinde derin etkiler yaratmıştır. Devletler, küresel tehditlere karşı daha etkili stratejiler geliştirebilmek için uluslararası işbirliği ve çok taraflılık ilkelerini benimsemeli ve güvenlik politikalarını daha esnek ve uyumlu hale getirmelidir. Gelecek araştırmalar, küreselleşmenin getirdiği zorlukları ve fırsatları daha iyi anlamak için kritik öneme sahiptir.

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Küreselleşme ve Ulusal Kimlik: Kültürel Çatışma ve Entegrasyon

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Özet – Bu çalışma, modern küreselleşmiş dünyada küreselleşme ile ulusal kimlik arasındaki karmaşık bağı, kültürel çatışma ve entegrasyon dinamiklerine vurgu yaparak incelemektedir. Küreselleşme, topluluklar ve kültürler arasındaki bağlantıyı artırırken, aynı zamanda ulusal kimliğin geleneksel kavramlarını zorlamakta ve hem çatışma hem de entegrasyon potansiyeli yaratmaktadır. Bu çalışma, sosyoloji, kültürel çalışmalar ve uluslararası ilişkiler teorisine dayanan disiplinlerarası bir yaklaşım benimseyerek, küreselleşmenin ulusal kimliği nasıl oluşturduğunu ve yeniden şekillendirdiğini analiz etmektedir. Çalışma, küreselleşmenin kültürel homojenlik ve çeşitlilik üzerindeki etkilerine bakarak başlamaktadır. Bir yandan, kitle iletişim araçlarının ve tüketim kültürünün gelişmesiyle küreselleşme, dünya çapında bir kültürel manzaranın ortaya çıkmasına yol açarak belirli ulusal kültürel kimlikleri azaltmıştır. Diğer yandan, küreselleşme, kültürel etkileşimi ve hibritleşmeyi teşvik ederek, yerel ve küresel unsurları birleştiren yeni kültürel ifade biçimlerinin doğmasına neden olmuştur. Bu ikilem, küreselleşmeyi ulusal kimlik için bir tehdit olarak görenler ile kültürel zenginleşme kaynağı olarak görenler arasında zorluklar yaratmaktadır. Ayrıca, araştırma, küreselleşme bağlamında kültürel mücadelenin ulusal kimlik üzerindeki etkisini incelemektedir. Topluluklar daha çeşitli ve kozmopolit hale geldikçe, kültürel anlatılar ve semboller üzerindeki rekabet kızışmakta ve dil, din ve miras gibi konularda anlaşmazlıklara yol açmaktadır. Ancak, kültürel gerilimlere rağmen, küreselleşme kültürel entegrasyon ve hibritleşme için fırsatlar sunmaktadır. Son olarak, bu çalışma, küreselleşmenin ulusal kimliği hem bozucu hem de dönüştürücü şekillerde değiştirdiğini öne sürmektedir. Küreselleşme, ulusal kimliğin geleneksel kavramlarını dış etkilere ve kültürel hibritleşmeye maruz bırakarak zorlamakla birlikte, aynı zamanda kültürel entegrasyon ve yeni kolektif kimlik biçimlerinin gelişimi için de fırsatlar sunmaktadır. Politikacılar ve paydaşlar, küreselleşmiş bir toplumda ulusal kimliğin karmaşıklığını ve değişkenliğini tanıyarak, kültürel küreselleşmenin getirdiği sorunlar ve olanaklarla daha iyi başa çıkabilirler.

Anahtar Kelimeler – Devlet Egemenliği, Küreselleşme, Güvenlik Politikaları, Savunma Politikaları, Çok Taraflılık.

I. GİRİŞ

Küreselleşme, uluslararası ilişkiler ve sosyoloji literatüründe geniş çapta ele alınan bir kavram olup, genellikle ekonomik, politik, kültürel ve teknolojik etkileşimlerin dünya çapında artan karşılıklı bağımlılığını ifade eder. Küreselleşme süreci, 20. yüzyılın ikinci yarısında hız kazanmış ve özellikle Soğuk Savaş'ın sona ermesiyle birlikte daha belirgin hale gelmiştir [1]. Bu süreç, ticaretin serbestleşmesi, iletişim ve ulaşım teknolojilerindeki gelişmeler, sermaye hareketliliğinin artması ve uluslararası örgütlerin rolünün genişlemesiyle desteklenmiştir [2].

Tarihsel olarak, küreselleşme çeşitli aşamalardan geçmiştir. İlk küreselleşme dalgası, 19. yüzyılın sonu ve 20. yüzyılın başında yaşanmış, bu dönemde uluslararası ticaret ve göç hareketleri artmıştır. Ancak, Birinci Dünya Savaşı ve Büyük Buhran ile bu süreç duraklamıştır. İkinci Dünya Savaşı sonrası dönemde, özellikle Bretton Woods sistemi ile uluslararası ekonomik işbirliği yeniden canlanmış ve küreselleşme süreci hız kazanmıştır [3]. Küreselleşmenin en belirgin özelliklerinden biri, ulusal sınırların öneminin

azalması ve uluslararası etkileşimlerin artmasıdır. Küresel tedarik zincirleri, çok uluslu şirketler ve dijital teknolojiler, ülkeler arasındaki ekonomik ve sosyal bağları güçlendirmiştir. Ancak, bu süreç aynı zamanda eşitsizlikler, kültürel homojenleşme ve yerel kimliklerin erozyonu gibi olumsuz sonuçlar da doğurmuştur [4]. Ulusal kimlik, bir toplumun ortak tarih, kültür, dil ve değerler etrafında şekillenen kolektif kimliğini ifade eder. Bu kimlik, bir ulusun bireylerine aidiyet duygusu kazandırır ve onların toplum içindeki rollerini tanımlar. Ulusal kimlik, aynı zamanda siyasi ve sosyal bütünlüğün sağlanmasında kritik bir rol oynar [5].

Ulusal kimlik kavramı, 18. ve 19. yüzyıllarda modern ulus devletlerin ortaya çıkışıyla birlikte önem kazanmıştır. Bu dönemde, milliyetçilik hareketleri, ulusal kimliklerin şekillenmesinde ve devletlerin meşruiyetlerini sağlamasında merkezi bir rol oynamıştır [6]. Ulusal kimlik, bireylerin kendilerini belirli bir ulusa ait hissetmeleri ve bu aidiyet duygusunun toplumsal ve politik düzeyde ifade edilmesiyle oluşur.

Ulusal kimlik, yalnızca kültürel ve tarihi bağlamda değil, aynı zamanda siyasi bir araç olarak da önemlidir. Devletler, ulusal kimlik üzerinden siyasi bütünlük ve sosyal dayanışma sağlamaya çalışır. Bu bağlamda, eğitim sistemleri, medya ve diğer toplumsal kurumlar, ulusal kimliğin inşasında ve sürdürülmesinde önemli roller oynar [3]. Küreselleşme süreci, ulusal kimliklerin korunması ve sürdürülmesi üzerinde önemli etkiler yaratmıştır. Küresel etkileşimler ve kültürel değişimler, ulusal kimliklerin yeniden tanımlanmasını gerektirmiştir. Bir yandan, küreselleşme yerel kültürlerin ve kimliklerin erozyonuna yol açarken, diğer yandan yerel ve ulusal kimliklerin güçlendirilmesi için yeni fırsatlar da sunmaktadır [2]. Bu çalışmanın temel amacı, küreselleşme sürecinin ulusal kimlik üzerindeki etkilerini ve bu bağlamda ortaya çıkan kültürel çatışma ve entegrasyon dinamiklerini incelemektir. Küreselleşmenin ulusal kimlikleri nasıl dönüştürdüğünü anlamak, hem akademik literatürdeki boşlukları doldurmak hem de politikacılar ve toplum liderleri için önemli politika önerileri sunmak açısından kritiktir.

II. LİTERATÜR TARAMASI

A. Küreselleşme ve Ulusal Kimlik Üzerine Teorik Çerçeveler

Küreselleşme ve ulusal kimlik arasındaki ilişki, çeşitli teorik çerçeveler aracılığıyla ele alınmıştır. Bu teorik çerçeveler, küreselleşmenin ulusal kimlik üzerindeki etkilerini farklı perspektiflerden analiz eder. Teorik yaklaşımlar genellikle üç ana kategoride incelenebilir: modernist, etnik ve postmodernist yaklaşımlar.

Modernist Yaklaşımlar: Modernist teorisyenler, ulusal kimliklerin modern çağın ürünleri olduğunu ve ulus-devletlerin inşası sürecinde oluşturulduğunu savunur. Bu yaklaşıma göre, ulusal kimlikler, sanayileşme, kitle iletişim araçları ve eğitim sistemleri gibi modern kurumlar aracılığıyla inşa edilir [7].

Etnik Yaklaşımlar: Etnik teorisyenler, ulusal kimliklerin tarihsel ve kültürel kökenlere dayandığını savunur. Bu yaklaşım, ulusal kimliklerin etnik köken, dil, din ve ortak kültürel miras gibi unsurlarla şekillendiğini vurgular. Ulusal kimliklerin etno-sembolik yaklaşımla anlaşılabileceğini ve tarihsel kökenlerinin modern ulus-devletlerin oluşumunda kritik bir rol oynadığını belirtilmiştir [5].

Postmodernist Yaklaşımlar: Postmodernist teorisyenler, küreselleşme sürecinde ulusal kimliklerin değişen ve akışkan yapısını vurgular. Bu yaklaşıma göre, küreselleşme, ulusal kimliklerin homojenleşmesine ve yerel kimliklerin erozyonuna yol açabilir. Ancak, aynı zamanda yerel kimliklerin ve kültürel çeşitliliğin korunması için yeni fırsatlar da sunar [8]. Bu yaklaşım, küreselleşmenin hem küresel hem de yerel düzeyde kimlikleri nasıl dönüştürdüğünü incelemektedir.

B. Kültürel Çatışma ve Entegrasyon Süreçlerine Dair Mevcut Araştırmaların İncelenmesi

Kültürel çatışma ve entegrasyon süreçleri, küreselleşmenin ulusal kimlikler üzerindeki etkilerini anlamak için önemli bir araştırma alanıdır. Mevcut araştırmalar, kültürel çatışma ve entegrasyonun farklı boyutlarını ve bu süreçlerin ulusal kimlikler üzerindeki etkilerini incelemektedir.

Kültürel Çatışma: Kültürel çatışma, farklı kültürel kimliklere sahip gruplar arasındaki anlaşmazlıkları ve çatışmaları ifade eder. Küreselleşme süreci, kültürel çeşitliliği artırmış ve farklı kültürel kimlikler arasındaki etkileşimleri yoğunlaştırmıştır. Huntington, medeniyetler çatışması tezinde, küreselleşmenin kültürel ve dini farklılıkları artırarak çatışmalara yol açabileceğini savunur. Bu bağlamda, kültürel çatışma, ulusal kimliklerin korunması ve sürdürülmesi için bir tehdit olarak görülmektedir [9].

Kültürel Entegrasyon: Kültürel entegrasyon, farklı kültürel kimliklere sahip grupların bir arada yaşama ve uyum sağlama süreçlerini ifade eder. Küreselleşme sürecinde, kültürel entegrasyon politikaları, göçmenler ve yerli halklar arasındaki uyumu teşvik etmek için önem kazanmıştır. Entegrasyon stratejileri, ulusal kimliklerin korunması ve küresel dinamiklere uyum sağlanması açısından kritik öneme sahiptir [10].

C. *Literatürdeki Ana Tartışmalar ve Boşluklar*

Küreselleşme ve ulusal kimlik üzerine literatürde çeşitli tartışmalar ve boşluklar bulunmaktadır. Bu tartışmalar, küreselleşmenin ulusal kimlikleri nasıl etkilediği, kültürel çatışma ve entegrasyon süreçlerinin nasıl işlediği ve bu süreçlerin ulusal kimlikler üzerindeki uzun vadeli etkileri üzerine odaklanmaktadır.

Küreselleşmenin Ulusal Kimlikler Üzerindeki Etkisi: Literatürde, küreselleşmenin ulusal kimlikler üzerindeki etkisi konusunda farklı görüşler bulunmaktadır. Bir yanda, küreselleşmenin kültürel homojenleşmeye ve yerel kimliklerin erozyonuna yol açtığı savunulurken, diğer yanda küreselleşmenin yerel ve ulusal kimlikleri güçlendirdiği ve kültürel çeşitliliği teşvik ettiği savunulmaktadır [2], [11].

Kültürel Çatışma ve Entegrasyon Süreçleri: Kültürel çatışma ve entegrasyon süreçleri üzerine yapılan araştırmalar, bu süreçlerin karmaşıklığını ve çok boyutluluğunu ortaya koymaktadır. Ancak, bu süreçlerin ulusal kimlikler üzerindeki uzun vadeli etkileri konusunda daha fazla araştırmaya ihtiyaç vardır. Özellikle, kültürel çatışma ve entegrasyonun farklı bağlamlarda nasıl işlediği ve bu süreçlerin ulusal kimliklerin korunması ve sürdürülmesi üzerindeki etkileri hakkında daha fazla ampirik veri gerekmektedir [9], [10].

Politika ve Uygulama Stratejileri: Küreselleşme sürecinde ulusal kimliklerin korunması ve kültürel çatışmaların yönetimi için etkili politika ve uygulama stratejileri geliştirilmesi gerekmektedir. Literatürde, farklı entegrasyon politikalarının ve kültürel çatışma yönetimi stratejilerinin etkinliği konusunda daha fazla araştırma yapılması gerektiği vurgulanmaktadır. Bu bağlamda, politika yapıcılar için somut öneriler sunacak araştırmalara ihtiyaç vardır [12].

Sonuç olarak, küreselleşme ve ulusal kimlik üzerine yapılan araştırmalar, bu iki kavram arasındaki karmaşık ilişkiyi anlamak için önemli bir temel sunmaktadır. Ancak, literatürdeki tartışmalar ve boşluklar, bu alanda daha fazla araştırma yapılması gerektiğini göstermektedir. Özellikle, küreselleşmenin ulusal kimlikler üzerindeki uzun vadeli etkileri, kültürel çatışma ve entegrasyon süreçlerinin işleyişi ve bu süreçlerin politika ve uygulama stratejileri üzerindeki etkileri konularında daha fazla ampirik araştırma gerekmektedir.

III. KÜRESELLEŞME VE ULUSAL KİMLİK

A. *Küreselleşmenin Ulusal Kimlik Üzerindeki Etkileri: Homojenleşme vs. Heterojenleşme*

Küreselleşme süreci, ulusal kimliklerin korunması ve dönüşümünde iki temel eğilim yaratmıştır: homojenleşme ve heterojenleşme. Homojenleşme, küreselleşmenin kültürel çeşitliliği azaltarak, tekdüze bir küresel kültür oluşturma eğilimidir. Bu süreçte, yerel kültürler ve ulusal kimlikler, küresel kültür unsurlarının etkisiyle erozyona uğrayabilir [13]. Özellikle küresel medya, ticaret ve iletişim araçları, Batı kültürünün ve yaşam tarzının dünya genelinde yayılmasını sağlamaktadır. Bu durum, yerel kimliklerin ve kültürel farklılıkların azalmasına yol açabilir [14]. Buna karşılık, heterojenleşme, küreselleşmenin kültürel çeşitliliği teşvik ederek, yerel ve ulusal kimliklerin korunması ve yeniden canlanmasına olanak tanıyan bir süreçtir. Küreselleşme, farklı kültürlerin karşılıklı etkileşimini artırarak, kültürel çeşitliliği ve yerel kimliklerin güçlenmesini destekleyebilir [15]. Örneğin, kültürel ürünlerin ve fikirlerin dünya genelinde dolaşımı, yerel kimliklerin küresel düzeyde tanınmasına ve değer kazanmasına katkıda bulunabilir.

B. *Küreselleşme Sürecinde Ulusal Kimliklerin Korunması ve Değişimi*

Küreselleşme sürecinde ulusal kimliklerin korunması ve değişimi, karmaşık ve çok boyutlu bir süreçtir. Ulusal kimlikler, küresel dinamiklerin etkisi altında yeniden şekillenmekte ve bazen dönüşüme uğramaktadır. Bu süreçte, devletler ve toplumlar, ulusal kimliklerini koruma ve sürdürme çabalarını farklı stratejilerle desteklemektedir.

Devlet Politikaları ve Eğitim: Devletler, ulusal kimliklerin korunması için eğitim sistemleri, medya ve kültürel politikalar aracılığıyla çeşitli stratejiler geliştirmektedir. Eğitim sistemleri, ulusal tarih, dil ve kültürün öğretilmesi yoluyla ulusal kimliklerin sürdürülmesinde kritik bir rol oynar [5]. Medya ve kültürel

politikalar ise, ulusal kimliklerin görünürlüğünü ve etkisini artırarak, küresel kültürel etkiler karşısında yerel kimliklerin korunmasını destekler.

Kültürel Direnç ve Yeniden Canlanma: Toplumlar, küreselleşmenin getirdiği kültürel değişimlere karşı direnç gösterebilir ve yerel kimliklerini yeniden canlandırabilirler. Kültürel direnç, küresel kültür unsurlarına karşı yerel kültürel değerlerin ve uygulamaların korunması anlamına gelir [11]. Bu süreçte, yerel festivaller, sanat ve el sanatları gibi kültürel etkinlikler, ulusal kimliklerin korunmasına ve güçlendirilmesine katkıda bulunur.

Diaspora ve Kültürel Köprüler: Diaspora toplulukları, küreselleşme sürecinde ulusal kimliklerin korunması ve küresel düzeyde tanınması için önemli bir rol oynar. Diasporalar, kültürel köprüler kurarak, hem anavatanları ile bağlarını sürdürmekte hem de bulundukları ülkelerde ulusal kimliklerini tanıtmaktadırlar [16]. Bu durum, ulusal kimliklerin küresel düzeyde korunması ve tanınmasına katkıda bulunur.

C. Vaka Çalışmaları: Küreselleşme ile Ulusal Kimliğin Çatıştığı ve Entegrasyon Sağlandığı Örnekler

Çin, küreselleşmenin ulusal kimlik üzerindeki etkilerini yönetmede dikkat çekici bir örnektir. Çin hükümeti, ekonomik küreselleşmenin getirdiği fırsatları değerlendirirken, ulusal kimlik ve kültürel değerleri korumak için çeşitli politikalar geliştirmiştir. Bu politikalar arasında, Çin dili ve kültürünün eğitim sisteminde güçlendirilmesi, Çin geleneklerinin ve festivallerinin teşvik edilmesi yer almaktadır [17]. Ancak, küresel etkilerin artmasıyla birlikte, genç nüfus arasında Batı kültürünün etkileri de belirgin hale gelmiştir. Bu durum, ulusal kimlik ve küresel kültür arasında bir denge kurma çabalarını gerektirmektedir.

Fransa: Fransa, küreselleşme sürecinde ulusal kimlik ve kültürel değerlerin korunması için aktif politikalar benimseyen bir diğer ülkedir. Fransız hükümeti, dil ve kültür politikaları aracılığıyla Fransız kimliğini korumaya çalışmaktadır. Örneğin, Fransızca'nın kullanımını teşvik eden dil politikaları ve Fransız kültürünü tanıtan kültürel programlar bu çabaların bir parçasıdır [21]. Aynı zamanda, Fransa'da göçmen topluluklarının entegrasyonu sürecinde kültürel çeşitlilik ve ulusal kimlik arasında bir denge sağlama çabaları da dikkat çekicidir.

Hindistan, küreselleşme sürecinde kültürel çeşitlilik ve ulusal kimliğin bir arada var olabildiği bir örnek olarak öne çıkar. Hindistan, çok kültürlü yapısı ve çeşitli etnik, dilsel ve dini gruplarıyla küreselleşmenin getirdiği kültürel etkileşimleri yönetmektedir. Hindistan hükümeti, ulusal kimliği güçlendirmek için kültürel çeşitliliği ve yerel kimlikleri koruyan politikalar geliştirmiştir [18]. Küreselleşmenin ekonomik ve kültürel etkileri, Hindistan'da hem kültürel çatışmalara hem de entegrasyon süreçlerine yol açmıştır.

Türkiye, küreselleşme sürecinde ulusal kimlik ve kültürel değişim dinamiklerini yönetmede önemli bir örnektir. Türkiye, Batı ile Doğu arasında bir köprü işlevi görmesi nedeniyle kültürel çeşitliliği ve ulusal kimliği koruma çabaları ile dikkat çeker. Türk hükümeti, ulusal kimliği güçlendirmek için eğitim, kültür ve medya politikaları geliştirmektedir [20]. Aynı zamanda, küreselleşmenin etkisiyle genç nüfus arasında Batı kültürünün yayılması ve bu durumun ulusal kimlik üzerindeki etkileri tartışılmaktadır.

Küreselleşme süreci, ulusal kimlikler üzerinde hem homojenleştirici hem de heterojenleştirici etkiler yaratmaktadır. Homojenleşme eğilimi, küresel kültür unsurlarının yerel ve ulusal kimlikler üzerindeki etkisini artırırken, heterojenleşme eğilimi, yerel kimliklerin ve kültürel çeşitliliğin korunmasını ve yeniden canlanmasını desteklemektedir. Devlet politikaları, kültürel direnç ve diaspora toplulukları, ulusal kimliklerin korunması ve sürdürülmesinde kritik roller oynamaktadır. Çin, Fransa, Hindistan ve Türkiye gibi ülkeler üzerinde yapılan vaka çalışmaları, küreselleşmenin ulusal kimlikler üzerindeki etkilerini ve bu etkilerin yönetiminde kullanılan stratejileri göstermektedir. Bu süreçte, ulusal kimliklerin korunması ve küresel dinamiklere uyum sağlanması için dengeli ve esnek politikalar geliştirilmesi önem taşımaktadır.

D. Küreselleşmenin Kültürel Çatışmalara Yol Açan Dinamikleri

Küreselleşme, farklı kültürel kimlikler ve değerler arasındaki etkileşimi artırarak, kültürel çatışmalara yol açan bir dizi dinamik yaratmıştır. Küreselleşme süreci, ekonomik, politik ve sosyal alanlarda hızlı değişimlere neden olarak, yerel ve ulusal kimliklerin sınanmasına ve yeniden tanımlanmasına yol açmaktadır [1]. Bu süreçte, küresel ve yerel değerler arasındaki gerilimler, kültürel çatışmaların temel dinamiklerinden biridir.

Ekonomik Küreselleşme ve Kültürel Çatışma: Ekonomik küreselleşme, piyasa ekonomisinin ve kapitalist üretim biçimlerinin dünya genelinde yayılmasını sağlamıştır. Bu durum, yerel ekonomilerin ve kültürel pratiklerin küresel piyasa dinamiklerine uyum sağlama zorunluluğunu doğurmuştur. Yerel ekonomilerin küresel piyasa koşullarına adapte olması, kültürel değerlerin ve toplumsal normların değişmesine yol açabilmekte ve bu değişim, kültürel çatışmaları tetikleyebilmektedir [2].

Politik Küreselleşme ve Kültürel Çatışma: Politik küreselleşme, ulus-devletlerin egemenlik alanlarının küresel yönetişim yapıları ve uluslararası kurumlar tarafından sınırlandırılması anlamına gelmektedir. Bu durum, ulusal kimlik ve egemenlik üzerinde önemli etkiler yaratmakta ve yerel kültürel değerlerin korunması ile küresel normlar arasındaki çatışmaları artırmaktadır. Özellikle, insan hakları, demokrasi ve hukukun üstünlüğü gibi evrensel değerler ile yerel gelenekler ve kültürel pratikler arasındaki gerilimler, kültürel çatışmalara yol açabilmektedir [11].

Sosyal Küreselleşme ve Kültürel Çatışma: Sosyal küreselleşme, bilgi ve iletişim teknolojilerinin yaygınlaşması ve kültürel ürünlerin küresel ölçekte dolaşımı ile karakterizedir. Küresel medya, popüler kültür ve dijital platformlar, kültürel kimliklerin ve değerlerin hızla yayılmasını sağlamakta ve farklı kültürel gruplar arasında etkileşimleri artırmaktadır. Ancak, bu etkileşimler, kültürel homojenleşmeye ve yerel kimliklerin erozyonuna yol açarak, kültürel çatışmaları tetikleyebilmektedir [14].

E. Etnik, Dini ve Dilsel Farklılıkların Çatışma Kaynakları Olarak Rolü

Etnik, dini ve dilsel farklılıklar, kültürel çatışmaların en önemli kaynaklarından biridir. Küreselleşme süreci, bu farklılıkların daha belirgin hale gelmesine ve kültürel kimlikler arasındaki gerilimlerin artmasına yol açmaktadır.

Etnik Farklılıklar: Etnik kimlikler, kültürel çatışmaların temel kaynaklarından biridir. Küreselleşme, etnik gruplar arasındaki ekonomik ve sosyal farklılıkları derinleştirebilir ve bu durum, etnik çatışmalara yol açabilir. Etnik grupların kültürel hakları, dil kullanımı ve siyasi temsil gibi konular, küreselleşme sürecinde önemli çatışma alanları olarak öne çıkmaktadır [22].

Dini Farklılıklar: Dini kimlikler ve inanç sistemleri, kültürel çatışmaların bir diğer önemli kaynağıdır. Küreselleşme süreci, farklı dini gruplar arasındaki etkileşimi artırarak, dini kimliklerin korunması ve ifade edilmesi konularında çatışmalara yol açabilir. Özellikle, küresel normlar ile yerel dini pratikler arasındaki gerilimler, kültürel çatışmaları tetikleyebilir [9].

Dilsel Farklılıklar: Dil, kültürel kimliğin önemli bir bileşenidir ve dilsel farklılıklar, kültürel çatışmaların kaynaklarından biridir. Küreselleşme, bazı dillerin küresel iletişim aracı olarak yaygınlaşmasına yol açarken, yerel dillerin ve lehçelerin korunmasını zorlaştırabilir. Dilsel asimilasyon ve dil hakları konuları, kültürel çatışmaların önemli bileşenleridir [19].

F. Kültürel Çatışma Örnekleri ve Analizleri

Çin'in Uygur Türklerine yönelik politikaları, kültürel çatışmanın çarpıcı bir örneğidir. Çin hükümeti, Uygur Türklerinin kültürel kimliklerini ve dini pratiklerini baskı altında tutmakta ve asimilasyon politikaları uygulamaktadır. Bu durum, Uygur Türklerinin kültürel kimliklerini koruma çabaları ile Çin hükümetinin entegrasyon politikaları arasında ciddi çatışmalara yol açmaktadır [23]. Uygur Türklerinin kültürel ve dini kimliklerinin bastırılması, uluslararası alanda insan hakları ihlalleri olarak ele alınmakta ve küresel tepki çekmektedir.

Fransa'da Müslüman toplulukların kültürel ve dini pratikleri, kültürel çatışmaların bir diğer örneğidir. Laiklik prensibine sıkı sıkıya bağlı olan Fransız hükümeti, kamusal alanlarda dini sembollerin kullanımını sınırlamakta ve bu durum, Müslüman topluluklar ile devlet arasında gerilimlere yol açmaktadır [24]. Başörtüsü yasağı ve helal gıda düzenlemeleri gibi konular, Fransa'da kültürel çatışmaların merkezinde yer almaktadır.

Myanmar'da Rohingya Müslümanlarına yönelik şiddet ve ayrımcılık, kültürel çatışmanın trajik bir örneğidir. Myanmar hükümeti ve Budist gruplar, Rohingya Müslümanlarını ülkenin kültürel ve etnik dokusuna tehdit olarak görmekte ve bu durum, ciddi insan hakları ihlallerine ve etnik temizliğe yol açmaktadır [25]. Rohingya krizinde, etnik ve dini kimliklerin korunması mücadelesi, kültürel çatışmanın merkezinde yer almaktadır.

Türkiye'de Kürt meselesi, kültürel çatışmanın önemli bir örneğidir. Kürtlerin dil ve kültürel hak talepleri, Türk devleti ile Kürt toplumu arasında uzun yıllardır devam eden bir çatışma kaynağıdır. Türkiye'de Kürtçe'nin kullanımı, kültürel ifade özgürlüğü ve siyasi temsil gibi konular, kültürel çatışmaların merkezinde yer almaktadır [26]. Son yıllarda yapılan reformlar ve barış süreci girişimleri, bu çatışmanın çözümüne yönelik önemli adımlar olsa da, kültürel çatışmanın tamamen çözüldüğü söylenemez.

Küreselleşme süreci, farklı kültürel kimlikler arasındaki etkileşimi artırarak, kültürel çatışmaların ortaya çıkmasına neden olmaktadır. Ekonomik, politik ve sosyal küreselleşme dinamikleri, yerel ve ulusal kimlikler üzerinde baskı oluşturarak, kültürel çatışmaları tetiklemektedir. Etnik, dini ve dilsel farklılıklar, kültürel çatışmaların en önemli kaynakları arasında yer almaktadır. Çin ve Uygur Türkleri, Fransa ve Müslüman topluluklar, Myanmar ve Rohingya krizi, Türkiye ve Kürt meselesi gibi örnekler, küreselleşmenin kültürel çatışmalara nasıl yol açtığını ve bu çatışmaların ulusal kimlikler üzerindeki etkilerini göstermektedir. Bu bağlamda, kültürel çatışmaların yönetimi ve çözümü için uluslararası işbirliği ve insan haklarına dayalı politikaların geliştirilmesi büyük önem taşımaktadır.

G. Küreselleşme Sürecinde Kültürel Entegrasyonun Dinamikleri

Küreselleşme, farklı kültürel kimliklerin ve toplulukların birbirleriyle daha yoğun ve sürekli etkileşimde bulunmasına neden olmuştur. Bu süreç, kültürel entegrasyonun dinamiklerini şekillendiren çeşitli faktörlerin ortaya çıkmasına yol açmıştır. Kültürel entegrasyon, farklı kültürel kimliklerin ve grupların bir arada yaşama, karşılıklı anlayış ve işbirliği geliştirme süreçlerini ifade eder. Küreselleşmenin kültürel entegrasyon üzerindeki etkilerini anlamak için, ekonomik, sosyal ve politik dinamikleri göz önünde bulundurmak gereklidir.

Ekonomik Dinamikler: Küreselleşme sürecinde ekonomik entegrasyon, kültürel entegrasyonun da önemli bir bileşenidir. Uluslararası ticaret, göç ve çok uluslu şirketlerin faaliyetleri, farklı kültürel grupların bir araya gelmesini ve etkileşimde bulunmasını sağlamaktadır. Ekonomik faaliyetler, kültürel değişim ve entegrasyonu hızlandırarak, farklı kültürel gruplar arasında ortak çıkarlar ve işbirliği alanları yaratır [1].

Sosyal Dinamikler: Küreselleşme sürecinde, bilgi ve iletişim teknolojilerinin gelişmesi, kültürel entegrasyonun sosyal dinamiklerini önemli ölçüde etkilemiştir. Sosyal medya, internet ve dijital platformlar, kültürel bilgilerin ve pratiklerin hızlı bir şekilde yayılmasını ve benimsenmesini sağlamaktadır. Bu durum, farklı kültürel kimliklerin ve değerlerin daha geniş kitleler tarafından tanınmasını ve kabul edilmesini kolaylaştırır [27].

Politik Dinamikler: Küreselleşme sürecinde, uluslararası kurumlar ve anlaşmalar, kültürel entegrasyonu teşvik eden politik dinamikler arasında yer alır. Birleşmiş Milletler, Avrupa Birliği ve UNESCO gibi uluslararası kuruluşlar, kültürel çeşitliliği ve entegrasyonu destekleyen politikalar geliştirmektedir. Bu politikalar, kültürel hakların korunması, eğitim ve dil politikaları, göçmenlerin entegrasyonu gibi konuları kapsamaktadır [28].

H. Kültürel Entegrasyon Politikaları ve Stratejileri

Kültürel entegrasyonun sağlanması için geliştirilen politikalar ve stratejiler, toplumların sosyal uyumunu ve kültürel çeşitliliği koruma amacını taşır. Bu politikalar ve stratejiler, farklı kültürel grupların bir arada yaşayabilmesi ve karşılıklı anlayış geliştirmesi için çeşitli yaklaşımlar içermektedir.

Eğitim Politikaları: Eğitim, kültürel entegrasyonun sağlanmasında kritik bir rol oynar. Çok kültürlü eğitim programları, farklı kültürel kimliklerin ve değerlerin tanınmasını ve anlaşılmasını teşvik eder. Eğitim kurumları, öğrencilerin kültürel farkındalıklarını artırarak, kültürel çeşitliliği ve hoşgörüyü destekleyen bir ortam yaratır [29].

Dil Politikaları: Dil politikaları, kültürel entegrasyonun sağlanmasında önemli bir strateji olarak öne çıkar. Çok dilli eğitim programları ve dil kursları, farklı dilsel grupların birbirleriyle iletişim kurmasını ve uyum sağlamasını kolaylaştırır. Bu politikalar, dilsel çeşitliliği koruma ve farklı dillerin eşit şekilde tanınmasını sağlamayı amaçlar [19].

Göç ve Entegrasyon Politikaları: Göçmenlerin entegrasyonu, kültürel entegrasyonun sağlanmasında önemli bir konudur. Göç ve entegrasyon politikaları, göçmenlerin topluma uyum sağlamalarını ve kültürel kimliklerini koruyarak katkıda bulunmalarını teşvik eder. Bu politikalar, çalışma izinleri, eğitim fırsatları, sağlık hizmetleri ve sosyal katılım gibi alanları kapsar [30].

İ. Başarılı Kültürel Entegrasyon Örnekleri ve Sonuçları

Kültürel entegrasyonun başarılı bir şekilde gerçekleştirildiği çeşitli örnekler, farklı kültürel grupların bir arada yaşama ve işbirliği yapma süreçlerini göstermektedir. Bu örnekler, kültürel entegrasyon politikalarının ve stratejilerinin etkinliğini ortaya koyar.

Kanada: Kanada, çok kültürlü toplum yapısıyla, başarılı kültürel entegrasyon örneklerinden biridir. Kanada hükümeti, çok kültürlülük politikaları aracılığıyla farklı kültürel grupların kültürel kimliklerini korumalarını ve topluma uyum sağlamalarını teşvik etmektedir. Çok kültürlü eğitim programları, dil kursları ve göçmenlerin entegrasyonu için sağlanan destekler, Kanada'nın kültürel çeşitliliği ve sosyal uyumunu artırmaktadır [31].

Avustralya: Avustralya, göçmenlerin entegrasyonu ve kültürel çeşitliliğin korunması konusunda başarılı bir diğer örnektir. Avustralya hükümeti, göçmenlerin topluma uyum sağlamalarını ve kültürel kimliklerini korumalarını teşvik eden çeşitli politikalar geliştirmiştir. Dil kursları, eğitim programları ve sosyal hizmetler, göçmenlerin entegrasyonunu desteklemektedir. Bu politikalar, Avustralya'nın kültürel çeşitliliğini ve sosyal uyumunu güçlendirmektedir [32].

İsveç: İsveç, göçmenlerin entegrasyonu ve kültürel çeşitliliğin teşvik edilmesi konusunda başarılı politikalar geliştiren bir ülkedir. İsveç hükümeti, göçmenlerin dil öğrenme, eğitim ve istihdam fırsatlarına erişimini sağlamak için çeşitli programlar uygulamaktadır. İsveç'te, kültürel çeşitliliğin korunması ve sosyal uyumun artırılması için yerel yönetimler ve sivil toplum kuruluşları da aktif rol oynamaktadır [33].

Bu örnekler, kültürel entegrasyonun başarılı bir şekilde gerçekleştirildiği toplumların sosyal uyum ve kültürel çeşitlilik açısından ne kadar zenginleşebileceğini göstermektedir. Kültürel entegrasyon politikaları ve stratejileri, toplumların bir arada yaşama ve işbirliği yapma kapasitelerini artırarak, toplumsal barış ve uyumun sağlanmasına katkıda bulunmaktadır.

Küreselleşme süreci, farklı kültürel kimliklerin ve grupların bir arada yaşama ve işbirliği yapma ihtiyaçlarını artırmıştır. Bu süreçte, kültürel entegrasyonun dinamikleri ekonomik, sosyal ve politik faktörler tarafından şekillendirilmektedir. Eğitim, dil ve göç politikaları gibi stratejiler, kültürel entegrasyonun sağlanmasında kritik rol oynamaktadır.

Kanada, Avustralya ve İsveç gibi ülkeler, kültürel entegrasyonun başarılı örnekleri olarak öne çıkmaktadır. Bu ülkeler, çok kültürlülüğü teşvik eden ve göçmenlerin topluma uyum sağlamasını kolaylaştıran politikalar geliştirmiştir. Bu politikalar, kültürel çeşitliliği ve sosyal uyumu güçlendirerek, toplumların bir arada yaşama ve işbirliği yapma kapasitelerini artırmaktadır.

Sonuç olarak, kültürel entegrasyon, küreselleşme sürecinde toplumsal barış ve uyumun sağlanması için hayati öneme sahiptir. Farklı kültürel grupların bir arada yaşama ve işbirliği yapma süreçleri, eğitim, dil ve göç politikaları gibi stratejilerle desteklenmelidir. Bu bağlamda, uluslararası işbirliği ve kültürel çeşitliliği teşvik eden politikalar, küreselleşmenin getirdiği zorlukları aşmada önemli bir rol oynayacaktır.

IV. TARTIŞMA

A. *Vaka Çalışmaları ve Genel Analiz Bulgularının Sentezi*

Bu çalışmada, küreselleşme sürecinin ulusal kimlik üzerindeki etkileri, kültürel çatışma ve entegrasyon süreçleri bağlamında ele alınmıştır. Kanada, Avustralya, İsveç, Çin, Fransa, Myanmar ve Türkiye gibi ülkeler üzerinde yapılan vaka çalışmaları, küreselleşmenin ulusal kimlikler üzerinde hem homojenleştirici hem de heterojenleştirici etkiler yarattığını göstermektedir. Bu ülkeler, kültürel çatışma ve entegrasyon dinamiklerini yönetmek için çeşitli stratejiler geliştirmiştir.

Kanada ve Avustralya, çok kültürlülük politikaları aracılığıyla kültürel entegrasyonu teşvik eden ve göçmenlerin topluma uyum sağlamasını kolaylaştıran başarılı örneklerdir. Kanada'da çok kültürlü eğitim programları ve dil kursları, kültürel çeşitliliği ve sosyal uyumu artırmaktadır [31]. Avustralya ise göçmenlerin entegrasyonu için dil kursları, eğitim programları ve sosyal hizmetler sunarak kültürel çeşitliliği desteklemektedir [32].

Çin ve Fransa, ulusal kimliklerini koruma çabaları ile dikkat çeken ülkeler arasındadır. Çin, Uygur Türkleri gibi azınlık gruplara yönelik asimilasyon politikaları uygularken, aynı zamanda Çin dili ve kültürünü güçlendirme çabalarını sürdürmektedir [17]. Fransa ise laiklik prensibi çerçevesinde dini

sembollerin kullanımını sınırlamakta ve bu durum, Müslüman topluluklarla devlet arasında gerilimlere yol açmaktadır [24].

Myanmar'da Rohingya krizinin ve Türkiye'de Kürt meselesinin ele alınması, etnik ve dini farklılıkların kültürel çatışmalara nasıl yol açtığını göstermektedir. Myanmar'da Rohingya Müslümanlarına yönelik şiddet ve ayrımcılık, ciddi insan hakları ihlallerine ve etnik temizliğe yol açmıştır [26].

B. Sonuçların Mevcut Teoriler ve Çerçeveler Bağlamında Yorumlanması

Küreselleşme sürecinin ulusal kimlik üzerindeki etkileri, uluslararası ilişkiler ve sosyoloji teorileri bağlamında farklı şekillerde yorumlanabilir. Modernist teoriler, ulusal kimliklerin modern çağın ürünleri olduğunu ve küreselleşmenin bu kimlikleri erozyona uğrattığını savunur [7].

Postmodernist yaklaşımlar, küreselleşmenin ulusal kimlikleri hem homojenleştirdiğini hem de yerel kimliklerin yeniden canlanmasına olanak tanıdığını vurgular [8]. Küreselleşme sürecinde bilgi ve iletişim teknolojilerinin yaygınlaşması, kültürel bilgilerin hızlı bir şekilde dolaşımını ve benimsenmesini sağlamış, bu da kültürel çeşitliliğin korunmasına katkıda bulunmuştur [27].

C. Küreselleşme, Ulusal Kimlik ve Kültürel Çatışma/Entegrasyon İçin Daha Geniş Sonuçların Tartışılması

Küreselleşme sürecinde ulusal kimliklerin korunması, kültürel çatışmaların yönetimi ve kültürel entegrasyonun sağlanması, toplumsal barış ve uyum için kritik öneme sahiptir. Küreselleşme, farklı kültürel kimlikler ve topluluklar arasındaki etkileşimi artırarak, hem fırsatlar hem de zorluklar yaratmaktadır.

Kültürel Çeşitliliğin Korunması: Küreselleşme, kültürel çeşitliliğin korunması ve yerel kimliklerin güçlendirilmesi için yeni fırsatlar sunar. Uluslararası kurumlar ve anlaşmalar, kültürel hakların korunmasını ve kültürel çeşitliliğin teşvik edilmesini desteklemektedir. UNESCO'nun kültürel çeşitliliği koruma konusundaki çalışmaları, bu bağlamda önemli bir örnektir [28].

Kültürel Çatışmaların Yönetimi: Kültürel çatışmaların yönetimi, ulusal kimliklerin korunması ve toplumsal uyumun sağlanması için hayati öneme sahiptir. Bu bağlamda, çatışma çözümü ve barış inşası süreçlerinde kültürel farkındalık ve hoşgörünün artırılması gereklidir. Eğitim, medya ve sivil toplum kuruluşları, kültürel çatışmaların yönetiminde önemli roller oynayabilir [29].

Kültürel Entegrasyonun Teşvik Edilmesi: Kültürel entegrasyonun teşvik edilmesi, göçmenlerin ve farklı kültürel grupların topluma uyum sağlamasını kolaylaştırır. Eğitim, dil ve göç politikaları gibi stratejiler, kültürel entegrasyonun sağlanmasında etkili araçlardır. Kanada ve Avustralya gibi ülkeler, kültürel entegrasyon politikalarıyla başarılı örnekler sunmaktadır [31], [32].

Sonuç olarak, küreselleşme süreci, ulusal kimlik, kültürel çatışma ve entegrasyon dinamikleri üzerinde derin etkiler yaratmaktadır. Vaka çalışmaları, farklı ülkelerin bu süreçte karşılaştığı zorlukları ve geliştirdiği stratejileri göstermektedir. Mevcut teoriler ve çerçeveler bağlamında, küreselleşmenin ulusal kimlikler üzerindeki etkileri ve kültürel çatışma/entegrasyon süreçleri daha iyi anlaşılabilir. Küreselleşme, toplumsal barış ve uyumun sağlanması için uluslararası işbirliği ve kültürel çeşitliliği teşvik eden politikaların geliştirilmesini gerektirmektedir.

V. SONUÇ

Bu çalışma, küreselleşme sürecinin ulusal kimlikler üzerindeki etkilerini, kültürel çatışma ve entegrasyon dinamikleri bağlamında ele almıştır. Temel bulgular şu şekilde özetlenebilir:

Küreselleşme ve Ulusal Kimlik: Küreselleşme, ulusal kimlikler üzerinde hem homojenleştirici hem de heterojenleştirici etkiler yaratmaktadır. Küresel kültür unsurları, yerel kimliklerin erozyonuna yol açarken, aynı zamanda yerel kimliklerin korunması ve yeniden canlanması için yeni fırsatlar sunmaktadır.

Kültürel Çatışma: Küreselleşme, farklı kültürel kimlikler arasındaki etkileşimi artırarak kültürel çatışmalara yol açan dinamikler yaratmıştır. Etnik, dini ve dilsel farklılıklar, kültürel çatışmaların temel kaynakları arasında yer almaktadır. Myanmar'daki Rohingya krizi ve Türkiye'deki Kürt meselesi gibi örnekler, bu çatışmaların ciddi sosyal ve politik sonuçlara yol açabileceğini göstermektedir.

Kültürel Entegrasyon: Küreselleşme sürecinde başarılı kültürel entegrasyon örnekleri, toplumsal barış ve uyumun sağlanması için kritik öneme sahiptir. Kanada, Avustralya ve İsveç gibi ülkeler, çok kültürlülük politikaları ve entegrasyon stratejileri ile kültürel çeşitliliği desteklemekte ve sosyal uyumu artırmaktadır.

Bu bulgular, küreselleşmenin ulusal kimlikler, kültürel çatışmalar ve entegrasyon süreçleri üzerindeki karmaşık ve çok boyutlu etkilerini ortaya koymaktadır. Küreselleşme, toplumsal dinamikleri yeniden şekillendirirken, ulusal kimliklerin korunması ve kültürel çatışmaların yönetimi için yeni stratejiler geliştirilmesini gerektirmektedir.

Politikacılar İçin Öneriler:

1. Kültürel Çeşitliliği Destekleyen Politikalar: Politikacılar, kültürel çeşitliliği ve çok kültürlülüğü destekleyen politikalar geliştirmelidir. Eğitim, dil ve kültür politikaları aracılığıyla farklı kültürel kimliklerin korunması ve tanınması teşvik edilmelidir.
2. Göçmen Entegrasyonu: Göçmenlerin topluma uyum sağlamalarını kolaylaştırmak için kapsamlı entegrasyon politikaları uygulanmalıdır. Dil kursları, eğitim programları ve sosyal hizmetler, göçmenlerin entegrasyonunu desteklemelidir.
3. Çatışma Yönetimi ve Barış İnşası: Kültürel çatışmaların önlenmesi ve yönetimi için etkin çatışma çözümü ve barış inşası stratejileri geliştirilmelidir. Bu bağlamda, kültürel farkındalık ve hoşgörünün artırılması önemlidir.

Akademisyenler İçin Öneriler:

1. Küreselleşme ve Ulusal Kimlik Üzerine Araştırmalar: Akademisyenler, küreselleşmenin ulusal kimlikler üzerindeki etkilerini daha derinlemesine incelemelidir. Bu araştırmalar, küresel ve yerel dinamiklerin ulusal kimlikler üzerindeki etkilerini anlamak için kritik öneme sahiptir.
2. Kültürel Çatışma ve Entegrasyon Dinamikleri: Kültürel çatışma ve entegrasyon süreçlerinin karmaşıklığını ve çok boyutluluğunu anlamak için daha fazla ampirik araştırma yapılmalıdır. Bu araştırmalar, kültürel çatışmaların kaynaklarını ve entegrasyon stratejilerinin etkinliğini değerlendirmeye yönelik olmalıdır.
3. Politika ve Uygulama Stratejileri: Akademisyenler, kültürel entegrasyon ve çatışma yönetimi konularında politika yapıcılara yol gösterici öneriler sunmalıdır. Bu bağlamda, farklı ülkelerin entegrasyon stratejileri ve kültürel çatışma yönetimi uygulamaları incelenerek karşılaştırmalı analizler yapılmalıdır.

Gelecek Araştırmalar İçin Öneriler:

1. Küreselleşmenin Uzun Vadeli Etkileri: Küreselleşmenin ulusal kimlikler üzerindeki uzun vadeli etkileri üzerine daha fazla araştırma yapılmalıdır. Bu araştırmalar, küreselleşme sürecinin toplumsal dinamikler üzerindeki kalıcı etkilerini anlamak için önemlidir.
2. Etnik ve Dini Çatışmalar: Etnik ve dini farklılıkların kültürel çatışmalara yol açma dinamikleri üzerine derinlemesine çalışmalar yapılmalıdır. Bu bağlamda, etnik ve dini kimliklerin korunması ve çatışma yönetimi stratejileri incelenmelidir.
3. Dijital Kültür ve Entegrasyon: Dijital teknolojilerin ve sosyal medyanın kültürel entegrasyon üzerindeki etkileri araştırılmalıdır. Dijital platformların külürel çeşitliliği ve entegrasyonu nasıl etkilediği ve bu bağlamda hangi stratejilerin geliştirilebileceği incelenmelidir.
4. Politika Etkinliği ve Uygulama: Kültürel entegrasyon ve çatışma yönetimi politikalarının etkinliği ve uygulanabilirliği üzerine daha fazla ampirik araştırma yapılmalıdır. Bu çalışmalar, politika yapıcılar için somut ve uygulanabilir öneriler sunarak, toplumsal barış ve uyumun sağlanmasına katkıda bulunabilir.

Sonuç olarak, küreselleşme süreci, ulusal kimlikler, kültürel çatışmalar ve entegrasyon dinamikleri üzerinde derin etkiler yaratmaktadır. Bu çalışma, küreselleşmenin karmaşık ve çok boyutlu etkilerini anlamak için kapsamlı bir çerçeve sunmaktadır. Politikacılar ve akademisyenler, kültürel çeşitliliği destekleyen politikalar ve stratejiler geliştirerek, toplumsal barış ve uyumu sağlama yolunda önemli adımlar atabilirler. Gelecek araştırmalar, küreselleşmenin ulusal kimlikler üzerindeki etkilerini daha iyi anlamak ve bu etkileri yönetmek için gerekli bilgileri sağlayacaktır.

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Examining Employees' Job Satisfaction and Life Satisfaction in the Context of the S-O-R Model

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Abstract – The concepts of job stress, burnout, life satisfaction and job satisfaction, which complement and give meaning to each other in business life, are very important concepts that extend from the workplace to the home. Stress is a reality of modern working life. It causes many negative effects on the employees by creating positive or negative results at the point of achieving organizational goals, which employees encounter on an organizational scale and affect them physiologically, psychologically and mentally. The aim of this study is to examine job satisfaction and life satisfaction of employees in the context of the S-O-R model. The effects of job stress on burnout and burnout on job satisfaction and life satisfaction are examined in this study. Data were collected from 216 employees using an online survey. Jamovi software was used to analyses the data obtained. The results of structural equation modeling show that job stress has a significant and positive effect on burnout, while burnout has a significant and negative effect on both job satisfaction and life satisfaction. The results obtained are discussed and implications drawn.

Keywords – S-O-R Model, Job Stress, Burnout, Job Satisfaction, Life Satisfaction

I. INTRODUCTION

Job stress, which has a great importance on employees in business life, is described as a psychological reaction that arises as a result of the combination of problems arising from their own life and problems arising from the work environment while fulfilling their duties and responsibilities in the workplace [1].

Researches indicate that work stress causes many negative consequences in employees, including mental, physical, emotional and social [2-3]. One of these negative consequences is burnout. Burnout is an important syndrome that affects both work and private life. Burnout causes problems such as absenteeism, tardiness, quitting, apathy towards work [4-5-6], helplessness, hopelessness, restlessness, emotional exhaustion [7-8-9] and has negative effects on job satisfaction and life satisfaction of employees.

The theoretical basis of this study was based on the Stimulus-Organism-Response (S-O-R) paradigm by Mehrabian and Russell [10]. The S-O-R model suggests that external environmental inputs from the exposed environment trigger internal emotions and lead to the resulting behavior (response) [11]. In the paradigm, stimulus (S) represents environmental stimuli, organism (O) represents mental or emotional process, and response (R) represents reactions and decisions [12].

In this study, response represents employees' job satisfaction and life satisfaction as a response to job stress. According to the S-O-R model, job stress as a stimulus (S) affects burnout (O) and burnout causes negative effects on employees' job satisfaction and life satisfaction (R).

II. THEORY FRAMEWORK AND HYPOTHESES

The relationship between job stress and burnout: Job stress is a feeling of both mental and physical discomfort that can affect the performance and organisational efficiency of employees at all levels of organisations [13]. Burnout, which can be expressed as 'depletion of mental and physical energy' in individuals, occurs as a result of the long-term effects of factors arising from work and work environment that cause stress in the work environment [14]. Burnout arising from work stress can reduce physical and cognitive resources and prevent efficient and effective work [15]. Prolonged and ineffective stress in the workplace seems to be related to burnout. Burnout is also accepted as the last step in the stress process [16]. In their study, Avşaroğlu et al. stated that burnout is a reaction that manifests itself as low personal achievement, loss of effectiveness and productivity as a result of chronic occupational stress in response to work stress [17]. In another study, burnout is explained as a long-term reaction to interpersonal emotional stress in the workplace [18]. Many studies in the literature and conducted for different occupational groups such as clergy [19], police [20], health personnel [21], teachers [22], correctional officers [23], bankers [24], financial advisors [25], restaurant managers [26] draw attention to the existence of a positive significant relationship between job stress and burnout. Based on this information, the H_1 was formulated as follows:

H_1: Job stress has a significant and positive effect on burnout.

The relationship between burnout and job satisfaction: Job satisfaction is an attitudinal process that expresses the employee's feelings of satisfaction towards his/her job, which can change over time and is dynamic [27]. Burnout is a commonly used term in the literature such as emotional exhaustion, depersonalisation and reduced personal accomplishment [28]. It mainly refers to three types of syndromes an individual who experiences burnout due to his/her occupation cannot be expected to be happy with his/her job, because occupational burnout is a function of dissatisfaction with work. Therefore, it is inevitable to experience job dissatisfaction due to occupational burnout [29]. Studies in the literature reveal that burnout has negative effects on job satisfaction. According to Wang et al. depersonalisation and emotional burnout negatively affect job satisfaction [30]. In particular, it has been revealed in the studies that emotional burnout is the most important sub-dimension, triggers other dimensions and negatively affects job satisfaction [31-32]. In another study, there is a negative relationship between the dimensions of occupational burnout; depersonalisation, decrease in personal accomplishment and emotional burnout and job satisfaction [33]. Based on this information, the H_2 was formulated as follows:

H_2: Burnout has a significant and negative effect on job satisfaction.

The relationship between burnout and life satisfaction: Satisfaction is the fulfilment of an individual's expectations, needs, desires and demands. Life satisfaction covers the whole life of the individual and all dimensions of life [34]. Life satisfaction is the situation or result obtained as a result of the comparison of a person's expectations and what he has [35]. For this reason, it is foreseen that people with high life satisfaction level will have higher work performance and productivity in the organisations they work in [36]. In the researches, it is found that high degree of burnout causes various psychological problems such as anxiety, depression, sleep disturbance, etc. in employees and negatively affects life satisfaction [37]. Many studies in the literature indicate a negative significant relationship between burnout and life satisfaction [38-39-40]. The relationship between the gender of employees and burnout and life satisfaction has been addressed in many studies, and different results have been obtained. While some of the studies have found that gender has no significant effect on the relationship between burnout and life satisfaction [41-42], some studies have found that the gender factor is significant in this relationship [43-44]. Based on this information, the H_3 was formulated as follows

H_3: Burnout has a significant and negative effect on life satisfaction.

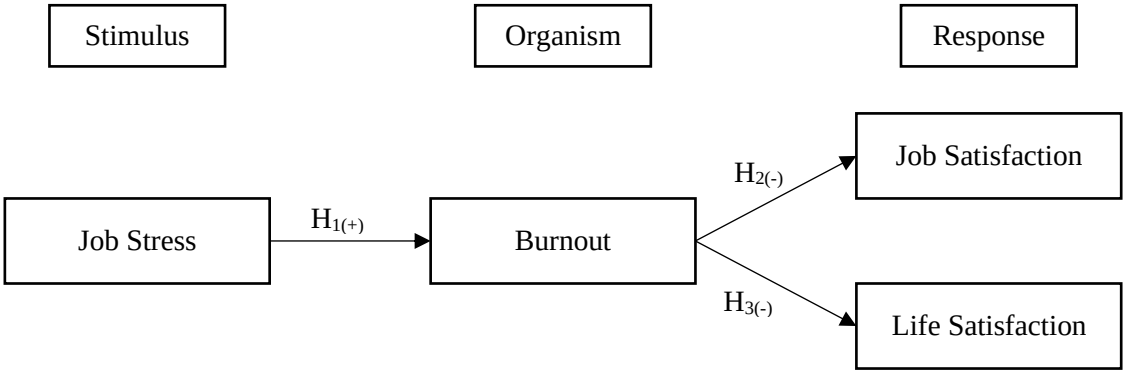

Figure 1. Research Model

III. MATERIALS AND METHOD

The items of the scales for job stress [45], burnout [46], job satisfaction and life satisfaction [47] were adapted from previous studies for use in this study. Data were collected from public and private sector employees through an online survey. Data were collected from a total of 216 employees. The sample size of this study is greater than 200, and a sample size of 200 people is the recommended sample size for running structural equation modelling [48].

Harman's one-factor test result was found to be 49.8%. Since this value is less than 50%, it should be accepted that there is no common method variance bias problem for the obtained data set [49]. In addition, according to the results of the correlation matrix in Table 5, it is possible to state that there is no common method variance bias problem for the data set, as the correlation coefficient between both variables is less than .90 [50]. The results of the statistical analyses carried out with the Jamovi software are presented on the following pages [51].

IV. RESULTS

According to Table 1, among the 216 employees, there are more males (Counts=145; 67.1 %), those aged 29-43 (Counts=136; 63.0%), those with a bachelor's degree (Counts=103; 47.7%), those whose monthly income varies between 20001-40000 TL (Counts=88; 40.7%), those employed in the private sector (Counts=123; 56.9%), those who have worked more than one job (Counts=132; 61.1%), and those with 1-5 years of sector experience (Counts=74; 34.3%).

Table 1. Frequency Analysis

Group		**Counts**	**% of Total**	**Cumulative %**
Gender	Female	71	32.9 %	32.9 %
	Male	145	67.1 %	100.0 %
Age	12-28 years old	66	30.6%	30.6%
	29-43 years old	136	63.0%	93.5%
	44-59 years old	14	6.5%	100.0%
Education Level	Primary/secondary education	13	6.0%	6.0%
	High school	33	15.3%	21.3%
	Associate degree	27	12.5%	33.8%
	Bachelor's degree	103	47.7%	81.5%
	Master's/Ph.D.	40	18.5%	100.0%
Monthly Income	0-20000 TL	61	28.2%	28.2%
	20001-40000 TL	88	40.7%	69.0%
	40001-60000 TL	54	25.0%	94.0%
	60001-80000 TL	7	3.2%	97.2%
	80001-10000 TL	4	1.9%	99.1%
	>100000 TL	2	0.9%	100.0%
Working Sector	The public sector	93	43.1%	43.1%
	The private sector	123	56.9%	100.0%
First Job?	Yes	84	38.9%	38.9%
	No	132	61.1%	100.0%

Sector experience	<1 years	39	18.1%	18.1%
	1-5 years	74	34.3%	52.3%
	6-10 years	42	19.4%	71.8%
	11-15 years	36	16.7%	88.4%
	16-20 years	11	5.1%	93.5%
	>20 years	14	6.5%	100.0%

Table 2 shows the results of the confirmatory factor analysis. First, it can be seen that the model fit measures (χ^2/df=2.063; p<.001; CFI=0.931; TLI=0.924; SRMR=0.0504; RMSEA=0.0702) are acceptable or good fit [52-53]. On the other hand, the "standardized estimate" indicators of the factors are above 0.50 and are supported [54-55-56].

Table 2. Confirmatory Factor Analysis

Factor Loadings								
Factor	**Indicator**	**Estimate**	**SE**	**95% Confidence Interval**		**Z**	**p**	**Standardized Estimate**
				Lower	**Upper**			
Job Stress	Job Strees 1	0.736	0.0757	0.587	0.884	9.72	< .001	0.613
	Job Strees 2	0.978	0.0706	0.840	1.117	13.85	< .001	0.797
	Job Strees 3	1.151	0.0717	1.011	1.292	16.06	< .001	0.876
	Job Strees 4	1.045	0.0738	0.900	1.190	14.16	< .001	0.808
	Job Strees 5	1.091	0.0699	0.955	1.228	15.62	< .001	0.861
	Job Strees 6	0.948	0.0738	0.803	1.093	12.84	< .001	0.756
	Job Strees 7	0.681	0.0742	0.535	0.826	9.18	< .001	0.586
Burnout	Burnout 1	1.001	0.0691	0.866	1.137	14.49	< .001	0.815
	Burnout 2	0.946	0.0627	0.823	1.069	15.10	< .001	0.837
	Burnout 3	1.104	0.0629	0.981	1.228	17.56	< .001	0.916
	Burnout 4	1.142	0.0644	1.016	1.269	17.73	< .001	0.922
	Burnout 5	1.208	0.0708	1.069	1.347	17.05	< .001	0.901
	Burnout 6	0.871	0.0637	0.746	0.996	13.67	< .001	0.783
	Burnout 7	0.956	0.0769	0.805	1.107	12.43	< .001	0.733
	Burnout 8	0.974	0.0704	0.836	1.112	13.83	< .001	0.789
	Burnout 9	0.896	0.0740	0.751	1.042	12.11	< .001	0.719
	Burnout 10	0.972	0.0732	0.828	1.115	13.27	< .001	0.767
Job Satisfaction	Job Satisfaction 1	0.926	0.0641	0.801	1.052	14.46	< .001	0.822
	Job Satisfaction 2	0.895	0.0665	0.765	1.026	13.46	< .001	0.783
	Job Satisfaction 3	0.988	0.0600	0.871	1.106	16.47	< .001	0.891
	Job Satisfaction 4	0.997	0.0660	0.867	1.126	15.10	< .001	0.844
	Job Satisfaction 5	0.891	0.0694	0.755	1.027	12.83	< .001	0.759
Life Satisfaction	Life Satisfaction 1	0.875	0.0679	0.742	1.008	12.89	< .001	0.766
	Life Satisfaction 2	0.902	0.0623	0.780	1.024	14.48	< .001	0.829
	Life Satisfaction 3	0.940	0.0626	0.817	1.063	15.00	< .001	0.848
	Life Satisfaction 4	0.799	0.0630	0.676	0.923	12.69	< .001	0.757
	Life Satisfaction 5	0.758	0.0659	0.629	0.887	11.51	< .001	0.706

Model Fit											
Test for Exact Fit				**Fit Measures**							
χ^2	**df**	χ^2/df	**p**	**CFI**	**TLI**	**SRMR**	**RMSEA**	**RMSEA 90% CI**		**AIC**	**BIC**
								Lower	**Upper**		
654	317	2.063	< .001	0.931	0.924	0.0504	0.0702	0.0625	0.0778	14182	14480

The results of the reliability analysis are presented in Table 3. The internal consistency of scale reliability can be checked by calculating Cronbach's Alpha [57] and Omega [58] reliability coefficients. However, for multidimensional scales and in cases where factor loadings are unequal, the omega reliability coefficient is recommended, based on the factor analysis model [59]. As Alpha (α) and Omega

(ω) reliability coefficients were calculated to be greater than 0.70 [60], all scales are reliable. It is also supported that the scales have convergent validity as the AVE values are greater than 0.50 [61].

Table 3. Reliability Analysis

Reliability indices									
Scale	**Mean**	**Standard Deviation**	**Cronbach's α**	**Ordinal α**	**McDonald's ω**	**ω_1**	**ω_2**	**ω_3**	**AVE**
Job Stress	3.00	0.998	0.906	0.923	0.907	0.911	0.911	0.910	0.643
Burnout	2.56	1.040	0.953	0.968	0.954	0.955	0.955	0.966	0.759
Job Satisfaction	3.35	0.987	0.911	0.932	0.912	0.911	0.911	0.912	0.737
Life Satisfaction	2.82	0.910	0.887	0.911	0.888	0.892	0.892	0.897	0.681

The data obtained have a normal distribution according to the normality test results shown in Table 4. This is because the values of skewness and kurtosis in Table 4 are between ±1 [55]. As the data obtained showed a normal distribution, Pearson correlation analysis was carried out. In addition, structural equation modeling was performed to test the research model.

Table 4. Normality Test

Descriptives				
	Job Stress	**Burnout**	**Job Satisfaction**	**Life Satisfaction**
N	216	216	216	216
Missing	0	0	0	0
Mean	3.00	2.56	3.35	2.82
Standard error mean	0.0679	0.0705	0.0672	0.0619
Median	3.00	2.45	3.60	2.80
Mode	2.00	2.00	4.00	3.20
Sum	648	553	723	610
Standard deviation	0.998	1.04	0.987	0.910
Minimum	1.00	1.00	1.00	1.00
Maximum	5.00	5.00	5.00	5.00
Skewness	0.0343	0.274	-0.512	-0.0500
Standard error skewness	0.166	0.166	0.166	0.166
Kurtosis	-0.959	-0.851	-0.374	-0.478
Standard error kurtosis	0.330	0.330	0.330	0.330

Table 5 shows that there is a significant and positive correlation between job stress and burnout as well as job satisfaction and life satisfaction. However, the significant correlation of job stress and burnout with both job satisfaction and life satisfaction is negative.

Table 5. Correlation Matrix

Correlation Matrix					
		Job Stress	**Burnout**	**Job Satisfaction**	**Life Satisfaction**
Job Stress	Pearson's r	—			
	df	—			
	p-value	—			
	95% CI Upper	—			
	95% CI Lower	—			
	N	—			
Burnout	Pearson's r	0.787***	—		
	df	214	—		
	p-value	< .001	—		
	95% CI Upper	0.833	—		
	95% CI Lower	0.730	—		
	N	216	—		

Job Satisfaction	Pearson's r	-0.561***	-0.635***	—	
	df	214	214	—	
	p-value	< .001	< .001	—	
	95% CI Upper	-0.463	-0.547	—	
	95% CI Lower	-0.646	-0.708	—	
	N	216	216	—	
Life Satisfaction	Pearson's r	-0.451***	-0.586***	0.695***	—
	df	214	214	214	—
	p-value	< .001	< .001	< .001	—
	95% CI Upper	-0.338	-0.491	0.758	—
	95% CI Lower	-0.552	-0.667	0.619	—
	N	216	216	216	—
Note. * p < .05, ** p < .01, *** p < .001					

The results of structural equation modeling presented in Table 6 show that the model fit indices are good [52-53]. The results in Table 6 show that job stress has a significant and positive effect on burnout (β=0.860; p< .001), while burnout has a significant and negative effect on both job satisfaction (β=-0.792; p< .001) and life satisfaction (β=-0.724; p< .001).

Table 6. Structural Equation Modeling

Parameters Estimates

Dependent	Predictor	R^2	Estimate	SE	95% Confidence Intervals		β	β 95% Confidence Intervals		z	p
					Lower	Upper		Lower	Upper		
Burnout	Job Stress	0.740	1.188	0.0892	1.013	1.363	0.860	0.819	0.901	13.3	< .001
Job Satisfaction	Burnout	0.514	-0.688	0.0484	-0.783	-0.594	-0.717	-0.792	-0.643	-14.2	< .001
Life Satisfaction	Burnout	0.402	-0.615	0.0524	-0.717	-0.512	-0.634	-0.724	-0.545	-11.7	< .001

Model Test

χ^2	df	χ^2/ df	p
424	319	1.345	< .001

Fit Indices

SRMR	RMSEA	95% Confidence Intervals		RMSEA p	CFI	TLI	NFI	RFI	GFI
		Lower	Upper						
0.050	0.039	0.028	0.049	0.970	0.999	0.999	0.995	0.995	0.996

V. DISCUSSION AND CONCLUSION

As it is known, today's competitive environment requires employees to work intensively with a focus on performance and productivity. Job stress, burnout, job satisfaction and life satisfaction are concepts that are frequently involved in working life and are related to each other.

In general, job stress, which is fed by individual and organisational sources, affects employees physically and psychologically and causes burnout, which manifests itself as physical, mental and emotional exhaustion [62]. Low job satisfaction, which is generally evaluated together with burnout and expressed as the pleasure and happiness of the employee in working life, causes negative consequences for the organisation by reducing the performance and productivity of the employees' commitment to work [63]. In addition, burnout creates intense and continuous anxiety in employees and negatively affects the satisfaction of employees from life [64].

Within the framework of the model created for this study and as a result of the analyses, it was determined that job stress has a significant and positive effect on burnout in parallel with the literature, while burnout has a significant and negative effect on both job satisfaction and life satisfaction.

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Arktik Alan ve Derin Sularda Petrol ve Gaz Aramacılığı ve Küresel İklim Değişikliği İlişkisi

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Özet **–** Fosil yakıtların geleceği hakkındaki görüşler farklı olsa da yeni alanların ve kaynakların araştırılması gerektiği de bir gerçektir ve gelişen teknoloji bunları mümkün hale getirmektedir. Örneğin, Arktik bölgeler ve derin su arama programları ile yeni petrol sahalarını aranmaya başlamıştır. Bu projeler, yeni kaynak alanlar bulabilmek amacıyla başlatılan, genellikle milyarlarca dolarlık sermaye gerektiren ve genellikle en az beş yıl sonra ilk finansal getirisi olan yatırımlardır. Petrol konusunda akıllara ilk olarak Ortadoğu gelse de, kutuplar ciddi miktarda petrol kaynaklarına sahiptir ancak Uluslararası sözleşmeler, iklim değişikliğinin en çok etkilediği alanlardan olan Arktik bölgede petrol çalışmalarının önünü bir nebze (şimdilik) kesmektedir. Teknolojide derin su alanlarındaki keşiflere izin veren inanılmaz gelişmeler sayesinde Amerika Birleşik Devletleri, Batı Afrika ve Brazilya deniz alanları ile Meksika Körfezi'nde 2.000 metrelik su derinliklerinde üretim yapmaktadır. Kuzey Denizi'nin Elgin-Franklin'inde olduğu gibi, deniz tabanının 6.000 metre altındaki bazı derin rezervuarlardan zaten başarıyla yararlanılmaktadır. Keşfedilmemiş derin su kaynaklarının % 40'ının 2.000 – 3.000 metre arasında bir su derinliğinde ve %30'un 3000 - 4000 metre arasında olduğu tahmin edilmektedir. Gelecekte bu aramacılık faaliyetlerinin devamını küresel iklim değişikliği ve petrol sektörü arasındaki mücadele belirleyecektir.

Anahtar Kelimeler – Petrol, Arktik alan, Kuzey Kutbu, Derin deniz aramacılığı, FLNG

I. GİRİŞ

Küresel ısınma etkisi nedeniyle fosil yakıtların enerji sektöründeki geleceği hakkındaki görüşler farklı olsa da, petrol ve kömür dünya enerji ihtiyacını karşılayan en önemli kaynaklar olmaya devam etmektedir. Tükenebilir kaynaklar olmaları geleceğe yönelik arz-talep dengesi riskini düşündürmekle birlikte, esas sorun, Dünyada bilinen ve kolay ulaşılabilir geleneksel (konvansiyonel) petrol ve gaz sahalarının azalmasıdır. 2008 yılından sonra şeyl gaz ile ivme kazanan geleneksel olmayan kaynaklar petrol sektöründe yeni bir açılıma neden olmuştur. 2010 yılından sonraki teknolojik gelişmelerin de etkisiyle geçmişte varlığı bilinen veya tahmin edilen, ancak ekonomik olmadığı için uzak durulan sahalar da petrol sektörünün ilgi alanına girmiştir. Örneğin, Arktik bölgeler ve derin su arama programları için araştırmalar daha da yoğunlaşmış, ekonomik, politik ve ülkeler arası gündemi oluşturmuştur. Bu projeler, yeni kaynak alanlar bulabilmek amacıyla başlatılan, genellikle milyarlarca dolarlık sermaye gerektiren ve genellikle en az beş yıl sonra ilk finansal getirisi olan yatırımlardır. Bireysel projeler için bu yüksek, başlangıç yatırımı gereksinimleri, en büyük şirketlerin bile, ortaklıklar, ortak girişimler ve diğer risk azaltma teknikleri yoluyla risk yayıldığında bile kumar gibi görünmesine neden olmaktadır ve risk düzeyi oldukça yüksektir.

Kazakistan'da Kashagan sahasının gelişimi bahsedilen ön yatırım sorunlarına bir örnektir [1]. Hazar Denizi'nin sığ su alanında bulunan Kashagan Sahasının tahmini rezervi yaklaşık 10 milyar varildir. Aslında, rezerv alan o kadar sığdadır ki, alanın geliştirilebilmesi için açık deniz ve kara teknolojilerinin birlikte ve bu alan için özel olarak tasarlanması gerekir. Bu nedenle sahanın gelişimi derin su ortamı kadar pahalıdır.

Kuzey Kutbu, daha bilinen bir alan olarak Arktik bölge, ise uluslararası ekonomi, politika hatta çevre gibi farklı dallarda bileşenlerin dünya çapında konuşulduğu bir alandır. Bu alanda dünyada keşfedilmemiş geleneksel hidrokarbon kaynaklarının yaklaşık %25'inin bulunduğu, ayrıca küresel gaz kaynaklarının da neredeyse dörtte birinin olduğu tahmin edilmektedir. Koruma sözleşmelerinin olmasına karşın birçok petrol şirketi, gözünü Arktik bölgelerdeki petrol kaynaklarına dikmiş durumdadır. Örneğin, 2007'de, iki Rus denizaltısı, Arktik Okyanusu'ndaki Lomonosov Sırtı olarak bilinen bir kıta sahanlığına bayraklarını asarak girmiştir kısa süreli uluslararası krize neden olmuştur.

Teknolojide derin su alanlarındaki keşiflere izin veren inanılmaz gelişmeleri sayesinde ABD'nin yeni sondaj çalışmalarının yarısı artık denizlerdedir. GPS sistemleri ve devasa iticiler tarafından yerinde tutulan, dibe oturmayan sondaj gemileri, 2000 metre su derinliğindeki okyanustan aşağı inen sondaj tijleri ve daha sonra 5000 metre veya daha fazla derinliklerin delinebilmesi olağanüstü gelişmelerdir. Kuzey Denizi'nin Elgin-Franklin'inde olduğu gibi, deniz tabanının 6.000 metre altındaki bazı derin rezervuarlardan zaten başarıyla yararlanılmaktadır. Ayrıca, 9.000 metre derinliğe ulaşan kuyular, Amerika Birleşik Devletleri Meksika Körfezi için planlama aşamasındadır [2], [3].

Bu tip sahalar günümüzde Amerika Birleşik Devletleri, offshore Batı Afrika ve Brazilya açık su alanlarında, Meksika Körfezi'nde 2000 metrelik su derinliklerinde üretim yapmaktadır. Mevcut dünya rekoru yaklaşık 3000 metredir. Derin su operasyonları büyük teknik ve mühendislik zorlukları yanısıra çok yüksek maliyet oluşturur ve sadece çok verimli rezervuarlar için uygun olan yerlerde yapılmaktadır. Keşfedilmemiş derin su kaynaklarının % 40'ının 2.000 – 3.000 metre arasında bir su derinliğinde ve %30'un 3.000 – 4.000 metre arasında olduğu tahmin edilmektedir.

II. DERİN SULARDA PETROL VE GAZ ARAMACILIĞI

Geleceğin petrol ve gaz arama bölgeleri olacağı tahmin edilen derin su alanları, tipik olarak 200 m'yi aşan dikey su derinliğinin altında hidrokarbon içeren formasyonları içerir. Bu derinliklerde bulunan rezervuarlardan hidrokarbon üretimi, hem karada hem de daha sığ sularda bulunan rezervuarlara göre teknik ve maliyet olarak oldukça farklıdır. Başlangıçta arama ve üretim için deneyimlenenlere kıyasla önemli miktarda ek mühendislik zorlukları ortaya çıkar. Hidrokarbonların keşfedildiği maksimum su derinliği günümüzde 3.000 m'nin üzerindedir. IEA, 2000 ve 2009 [4] yılları arasında bulunan tüm rezervlerin yarıdan fazlasının derin deniz keşifleri olduğunu ve bu gözleme dayanarak, gelecekte çok daha fazlasının bulunmasının muhtemel olduğunu belirtmektedir.

Derin sularda hidrokarbon arama ve üretimi, deniz tabanındaki valfler gibi çok sayıda elektromekanik öğenin karada kurulacak sistemlerle uzaktan çalıştırılmasını gerektirir. Buna ek olarak, doğal alanların hidrokarbon üretiminin zorluklarından korunması gerekliliği nedeniyle de operasyonlar daha da karmaşık hale gelmektedir.

Aslında, denizde birden fazla rezervuarı deniz altı altyapıları aracılığıyla yüzer bir depolama gemisi olabilecek tek bir üretim ünitesine bağlamak veya 100 km'yi aşan mesafelerde çok fazlı akışı kullanarak doğrudan kıyıya boruyla bağlamak mümkündür. Derin suda çalıştırılan özel bir üretim ünitesi, yüzey kurulumu ve platformu dengelemek için hareket eden eşdeğer tendonlarla deniz tabanına sabitlenir.

Bu tür mekanik cihazlar yaklaşık 2.000 m'ye kadar su derinliklerinde çalışabilmektedir. Daha büyük su derinliklerinde operasyon, yüzer, üretim, depolama ve boşaltma gemilerinin (FPSO kısaltmasıyla bilinir) kullanılmasını gerektirir. FPSO'lar deniz altı tesislerine kablolar ve boru şeklindeki muhafazalarla bağlanmaktadır ve son zamanlarda sondaj yapma kabiliyetini içerecek şekilde daha da geliştirilmiştir [4]. Suyun, kumun ve katıların, gaz ve diğer sıvıların ayrılması ve uzaklaştırılmasının yanı sıra ilk gaz arıtımı deniz tabanında gerçekleştirilebilir ve doğal gaz hidratlarının oluşumu da dahil olmak üzere sonraki akış güvencesi zorluklarını önemli ölçüde azaltır [5].

2.1 Yüzer Sıvılaştırılmış Doğal Gaz Tesisleri

Petrol ve doğal gaz işleme tesislerinin yüzer üretime dahil edilmesi, elde edilen hidrokarbonun maliyetini önemli ölçüde azaltır: bu, üretilen sıvıları kıyıya getirmeye yönelik altyapının oluşturulmasını gerektirir. Bu kapsamda 1990'ların sonunda Woodside Energy'ye ait olan Northern Endeavour adlı gemi gibi büyük FPSO'lar (petrol depolama kapasitesi 2003103 m3) faaliyete geçmiştir [6, 7]. 2007 yılında Norveç'in Melkøya Adası'nda mavnaya monteli bir LNG üretim treninin inşası ve işletilmesi de önemli bir geçiş adımı olmuştur. 2011 yılında Shell, Kuzey Batı Avustralya kıyılarındaki Prelude projesinin bir parçası olarak dünyanın ilk gerçek FLNG tesisini inşa edeceğini duyurmuştur [8].

Bir FLNG gemisi için potansiyel olarak gerekli olan işleme birimleri; giriş gazı sıkıştırması ve sıvı stabilizasyonu; asit gazının uzaklaştırılması; gazın dehidrasyonu ve gerekirse cıvanın uzaklaştırılması; gazdan ağır hidrokarbonun (molar kütlesi propana eşit ve ondan daha büyük olan moleküller) çıkarılması; sıvı petrol gazı (LPG) ve yoğuşma ürünlerinin ayrıştırılması ve geri kazanılması; zayıf gazın kriyojenik sıvılaştırılması; ve potansiyel olarak LNG ürününden nitrojen atılması şeklinde sıralanabilir [9]. İşlemenin kapsamı, kısmen besleme gazının özelliklerine ve işlenmiş ürünlerin varış noktasına bağlıdır.

Bir FLNG gemisi ile karadaki benzer LNG tesisi arasındaki önemli bir fark, ikincisinin genellikle işlenmiş doğal gazın başka bir amaç için iletilebileceği bir boru hattına sahip olmasıdır. Normalde bir FLNG tesisi, depolanan LNG'den çıkan ürünü işlemek ve yeniden sıvılaştırmak için gereken kompresörleri de içeren, geminin yakıt gereksinimlerini büyük ölçüde aşan herhangi bir doğal gazın bertaraf edilmesini gerektirir.

III. ARKTİK ALANDA PETROL VE GAZ ARAMACILIĞI

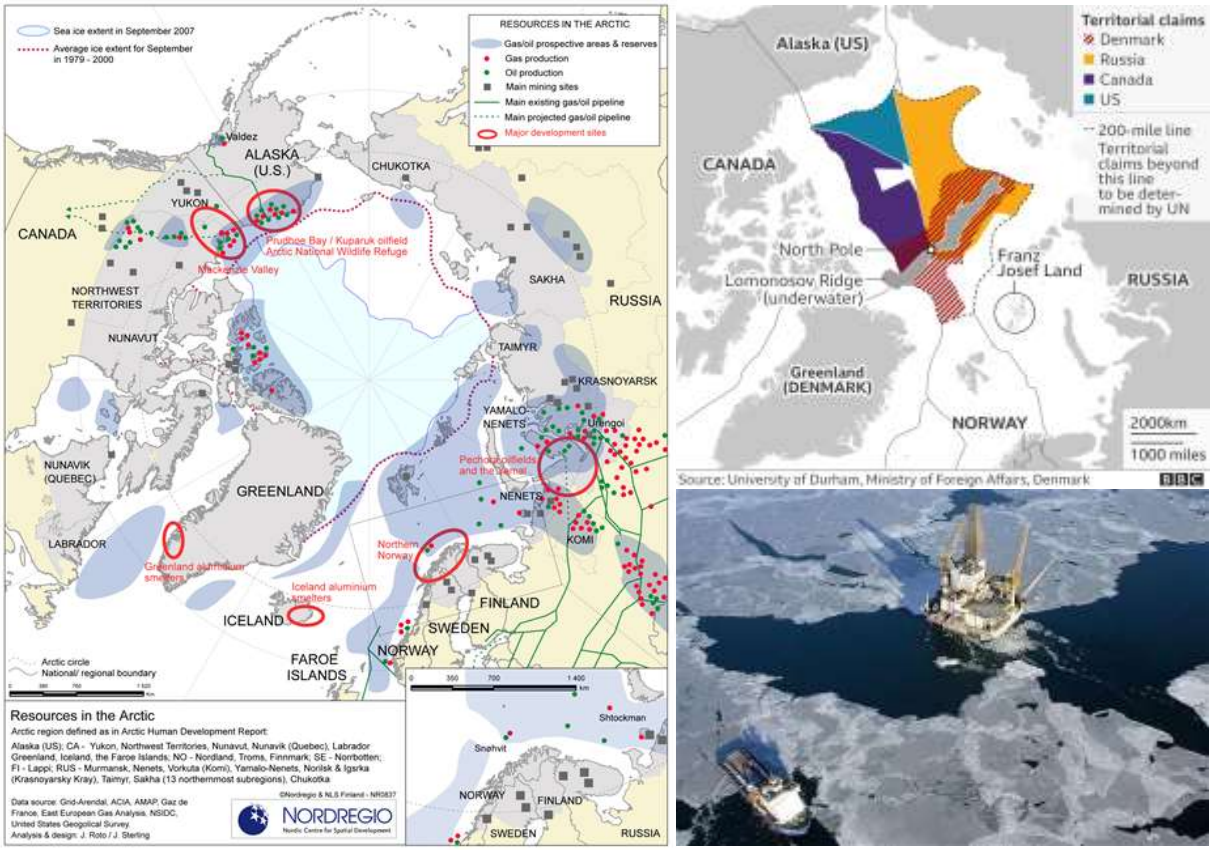
Arktik, Kuzey Amerika, Avrupa ve Asya'nın birbirlerine en yakın olduğu bölgedir. Politik anlamda gerçek bir varlığı olmadığı iddia edilse de sekiz bölge ülkesinin ortak sınırlarını paylaştığı bir coğrafyayı temsil etmektedir (Şekil 1). Kuzey Kanada, Alaska, Grönland'ın doğu kıyısı, Barents Denizi, Okhotsk Denizi, Kara Denizi veya Chukchi Denizi gibi yerler Arktik ortamlardır.

Arktik bölgesi, 9 milyon kilometrekarelik kısmı karada olmak üzere, toplamda yaklaşık 27 milyon kilometrekarelik alandan oluşur. Rusya, Amerika Birleşik Devletleri (ABD), Kanada, Danimarka, İzlanda, Norveç, İsveç ve Finlandiya olmak üzere 8 ülke 1996 yılında Ottawa Deklarasyonu ile çevresel koruma ve sürdürülebilir kalkınmayı desteklemek amaçlarıyla hükümetler arası nitelikteki Arktik Konseyi'ni kurmuştur. Aslında doğrudan Arktik okyanusuna kıyıdaş olan ülkeler Rusya, ABD, Kanada, Norveç ve Danimarka'dır (Grönland). Bu ülkeler Arktik beşlisi olarak adlandırılır. Bu ülkeler dışında, bölgeye ilgisi olan ve Arktik Konseyi'nde gözlemci statüsünde yer alan 13 bölge dışı ülke (Çin, Japonya, Güney Kore, Almanya, Fransa, Birleşik Krallık, vb.), 13 hükümetler arası ve parlamentolar arası örgüt ve 12 hükümet dışı örgüt de bulunmaktadır. Bölgenin rekabet alanı haline gelmesini sağlayan iki temel etken enerji kaynakları ve deniz ticaret yollarıdır.

Kuzey Kutbu, önemli miktarda doğal gaz ve petrol kaynakları içermektedir [11], [12], [13]; Amerika Birleşik Devletleri Jeoloji Araştırmaları (USGS), kalan küresel doğal gaz kaynağının hacimce %25-30 unun Kuzey Kutbu'nda bulunduğunu ileri sürmektedir [14], [15], [16]. Ayrıca, Kuzey Kutbu'ndaki keşfedilmemiş petrolün 500 Exajoule (EJ) olduğunu belirtmiştir; bu, 2015 yılında dünya ham petrol üretiminin yaklaşık üç katıdır. Doğal gaz sıvıları da dahil olmak üzere Kuzey Kutbu'nda keşfedilmemiş gaz miktarı ise 1850 EJ yani 2015 yılında dünyanın brüt gaz üretiminin yaklaşık 11 katıdır. Bu durum aslında bölgede sınırı olan ülkeler açısından durumun ne kadar stratejik olduğunu da açıkça ifade eder.

Arktik petrol ve gaz potansiyelinin yaklaşık %84'ü kıyıda olup, petrol ve gazın sırasıyla %22 ve %69'u Rusya'da bulunmaktadır (Şekil 2). Arktik; ABD Arktik bölgesinde %40 ve %12 (gaz); Grönland Arktik bölgesinde %21 ve %10 (gaz); Kanada Arktik bölgesinde %13 ve %5 (gaz); Norveç Arktik bölgesinde ise %4 ve %4 (gaz) potansiyeli bulunur.

Bu alanda başlatılacak projelerle uzun yıllar sürecek petrol arama ve üretim süreçlerinin doğal çevre üzerindeki etkisinin kontrol altına alınabilmesi ve küresel iklim değişikliği başta olmak üzere doğal dengeye en az zarar vermesi koşuluyla, bu kaynakları keşfetme ve üretme konusunda açık bir neden mevcuttur.



Şekil 1. Arktik alan sınırı ve petrol ve gaz alanları

Bununla birlikte, Kuzey Kutbu'ndaki keşifler, çevresel etkiyle ilgili konuların yanı sıra, doğal gaz hidratı içerebilen veya gaz için örtü kaya eşdeğeri olan permafrostun delinmesini de gerektirdiği için daha da karmaşık hale gelmektedir.

Kuzey Kutbu bölgelerindeki operasyonlar, buzdağları ve buz kütleleri nedeniyle büyük risklere sahiptir: Kuzey Kutbu'nun düşük ortam sıcaklığına ek olarak, 2 m/s2'e kadar hızlara ulaşabilen buzun hareketi de başka bir zorluktur.

Arktik hidrokarbon kaynaklarının geliştirilmesinde, deniz altı tesislerinin kullanımı da dahil olmak üzere, derin sular için geliştirilen yöntemler kullanılır; Kuzey Kutbu'nda operasyona yönelik açık deniz petrol sahası yapılarına yönelik standartlar da mevcuttur [17]. Bu ortamda karşılaşılan şartlar yıllık üretim süresini sınırlayabilmektedir. Ancak platform ve ilgili altyapı için yapay bir ada inşa edildiğinde Arktik açık deniz üretimi yıl boyunca elde edilme şansı da bulunmaktadır. Özellikle endişe verici olan, Arktik deniz tabanı su sıcaklığının -273,15 K olabilmesidir ve bu sıcaklık, akış güvencesi açısından önemli sorunlarla sonuçlanacak hidratlar ve wax oluşumuna yol açmaktadır.

Arktik'in uzaklığı, iklimin sertliği, hareketli deniz buzu ve sürüklenen buzdağları, petrol ve gazı güvenli bir şekilde çıkarmak için büyük bir lojistik zorluk oluşturmaktadır. Bu alanlarda birçok sınırlayıcı etken olmakla birlikte en önemlisi maliyettir. Arktik alanlardaki bir operasyon ortalama iklim ve coğrafya özelliklerine sahip yerlerdeki eşdeğer projelerin üç ila beş katı arasında yüksek maliyete sahiptir.

3.1. Bölgede devam eden aramacılık faaliyetleri

Arktik bölgede Rusya, Kanada, ABD ön plana çıkmakla birlikte, Rusya sahip olduğu geniş kıta sahanlığı ve uzun kıyı şeridi ile avantajlı durumdadır. USGS verilerine göre Yamal ve Gydan yarımadaları rezerv açısından ön plandadır. Çünkü bu alanlarda yaklaşık 35,7 milyar metreküpten fazla doğal gaz ve 2,3 milyon tondan fazla petrol ve kondensat bulunur.

Rusya Federasyonu'nun Arktik bölgesindeki büyük petrol ve doğal gaz alanlarının keşifleri 1962'de Tazovskoye gaz sahasının açılmasıyla başlamıştır. Günümüzde, petrol ve gaz üretimi başlıca Nenets Özerk Okruğu, Yamalo-Nenets Özerk Okruğu ve Komi Cumhuriyeti'nin kuzey kesiminde yoğunlaşmıştır. Hidrokarbonlar açısından zengin açık deniz alanları, Rusya Federasyonu açık deniz alanlarında Peçora, Kara, Laptev Denizi ve Doğu Sibirya Denizi, Norveç- Rusya Federasyonu kıta sahanlığında Barents Denizi, Rusya ile ABD arasındaki açık deniz alanları, Bering Denizi ve Çukçi Denizi yer almaktadır. 1990'lı yıllarda petrol faaliyetleri kapsamında Rusya'nın ConocoPhillips, Total ve Norsk Hydro gibi birçok uluslararası enerji şirketiyle yaptığı anlaşmalarla faaliyetlerine devam etmektedir. Üretilen petrol miktarının toplam 100 milyon tondan fazla olduğu belirtilmektedir [19].

Zorlu iklim koşulları ve mevcut altyapı eksikliğine rağmen, Rusya Federasyonu Arktik bölgesindeki enerji çalışmalarına devam etmektedir. 2012'den bu yana, Gazprom ve Rosneft şirketleri ile yan kuruluşu Gazprom Neft'in Rus Arktik bölgesi açık denizine erişimi bulunmakta ve lisanslar bu şirketlerce verilmektedir [19]. Günümüzde kıyıdan 60 km uzaklıkta yer alan Barents Denizi'nin güneydoğu kesimindeki Prirazlomnoye sahası, Arktik bölgesi açık denizde bulunan tek petrol üretim sahasıdır.

2000'li yılların başından itibaren Rusya doğal gaz kapsamındaki faaliyetlere daha çok önem vermektedir. Bu doğrultuda Rusya'nın Arktik bölgesindeki LNG faaliyetlerinde Yamal ve Arktik olmak üzere iki önemli proje dikkat çeker. Rusya Enerji Bakanlığı'na göre, 2017 yılında gerçekleşen LNG ihracatı, dünya toplamının yaklaşık yüzde 4'üne karşılık gelen 11,7 milyon ton (16 milyar metreküp) olmuştur, bunun Rus doğal gaz ihracatındaki payı ise yüzde 6,5'tur.

Gaz ve petrol üretimi Batı Sibirya'da, örneğin Yamburg sahasında ve ayrıca Amerika Birleşik Devletleri'nde Prudhoe Körfezi bölgesinde gerçekleştirilmeye devam etmektedir. Rusya'nın Arktik bölgedeki petrol ve gaz ile ilgili girişimlerinin genel çerçevesi "2035 Yılına Kadar Arktik'teki Rusya Federasyonu Devlet Politikasının Temel İlkeleri" başlıklı yayımlamış olduğu resmi strateji belgesinde belirtilmiştir. Belgede "önümüzdeki on beş yıl boyunca Rus Arktik bölgesindeki hidrokarbonların çıkarımını genişletmeye ve çıkarılan hidrokarbonların küresel pazarlara dağıtımının geliştirilmesine yönelik faaliyetlere odaklanılmıştır" şeklindeki ifadeler gelecekteki yönelimlere ışık tutacak özelliktedir [20].

IV. TARTIŞMA VE SONUÇLAR

İklim değişikliğinin deniz buzu kalınlığı üzerindeki etkileri, yeni su yollarının açılması, açık denizdeki Arktik kaynaklara erişimi de dikkat çekici ve ulaşılabilir hale getirmektedir. Bu kaynakların kullanılma derecesi deniz buzu koşullarına, teknoloji maliyetlerine, uluslararası enerji piyasalarına ve düzenleyici ortama bağlı olacaktır. Küresel enerji pazarlarıyla etkileşimleri ve emisyon azaltma senaryolarını göz önünde bulundurarak, iklim değişikliği altında deniz buzu kaybının mekansal-zamansal kalıplarının gelecekteki Arktik açık deniz petrol ve gaz çıkarımı üzerindeki etkilerini araştırmak bilim adamlarının en önemli görevi olmalıdır. Bir "fosil yakıtlı gelişme" senaryosu olan SSP5 kapsamında yapılan çalışmalara göre, deniz buzu kaybının etkilerinin Arktik açık deniz petrol üretimi için gazdan daha büyük olduğu belirtilmektedir [18]. SSP5 kapsamında, 2100 yılına kadar Arktik açık deniz petrol ve gazının gelecekte çıkarılması, petrol ve gaz piyasalarına yaklaşık 0,8-2,6 EJ/yıl katkı sağlaması mümkündür, ancak küresel petrol ve gaz piyasaları üzerinde büyük etkileri muhtemelen büyük olmayacaktır. Şaşırtıcı bir şekilde, düşük karbonlu bir küresel iklim değişikliği senaryosu (Net Zero), daha yoğun emisyona sahip geleneksel olmayan petrol üretimini dengelemek için dünyadaki birçok doğal dengenin bozulması pahasına Arktik açıklarında petrol üretimini planlamaktadır.

Yakın gelecekte, küresel iklim değişikliği etkileri daha belirgin olduğunda ve bölgede aramacılık fırsat mı? tehdit mi? İkilemi yaşandığında, sonucun ne olacağını çevre savunucularının belirlemeyeceği de oldukça nettir..

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Metamalzemelerle Yama Antenlerin Performanslarının Artırılması

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Özet – Metamalzemeler, doğada bulunmayan elektromanyetik özellikler sergileyen yapay olarak üretilmiş malzemelerdir. Bu benzersiz özellikler, Metamalzemelerin bileşenlerinin özel olarak yapılandırılma şeklinden kaynaklanmaktadır. Pratik olarak, metamalzemeler birkaç birim hücreden oluşur ve her birim hücre, alt dalga boyu yapılandırılmış elemanlardan oluşan bir dizi içerir. Mikroşerit anten olarak da bilinen yama antenler, küçük boyutları ve hafiflikleri nedeniyle yaygın olarak kullanılan düşük profilli antenlerdir. Ancak, yama antenler dar empedans bant genişliği, sınırlı radyasyon çapraz polarizasyon ayrımı ve düşük kazanç gibi bazı dezavantajlara sahiptir. Metamalzemeler, bu dezavantajları giderme ve benzersiz elektromanyetik özelliklerinden yararlanarak yama antenlerin performansını artırma potansiyeline sahiptir. Metamalzemeler, yama antenlerin tasarımına entegre edilerek özellikle bant genişliği ve kazanç artırımı gibi önemli avantajlar sağlar. Bu entegrasyon, kablosuz haberleşme, radar sistemleri, uydu haberleşmesi ve biyomedikal uygulamalar gibi birçok alanda yama antenlerin tasarımı ve kullanımında yeni olanaklar sunmaktadır. Örneğin, metamalzemelerin negatif kırılma indisi gibi özellikleri, sinyal yayılımını ve anten verimliliğini artırarak daha geniş bir frekans aralığında daha yüksek performans elde edilmesini sağlar. Gelişmiş metamalzeme özelliklerinin kullanımı, yama antenlerin performansını önemli ölçüde artırmıştır. Bu amaçla, farklı türde metamalzemeler, yaygın anten problemlerini ele almak ve yama antenlerin genel yeteneklerini geliştirmek için kullanılmıştır. Ayrıca, metamalzemelerin miniaturizasyon avantajı, antenlerin daha kompakt ve taşınabilir olmasını sağlar. Bu çalışma, yama anten performansını artırmak için metamalzemelerin uygulanmasındaki son gelişmelere genel bir bakış sunmaktadır. Metamalzemelerle yapılan bu yenilikçi tasarımlar, modern haberleşme sistemlerinde ve ileri teknoloji uygulamalarında daha etkili ve verimli anten çözümleri sunarak, gelecekteki araştırma ve geliştirme çalışmalarına ışık tutmaktadır.

Anahtar Kelimeler – Metamalzemeler, yama anten, elektromanyetik, anten kazancı, bant genişliği, boyut azaltma

I. GİRİŞ

21. yüzyılın başından itibaren, kablosuz haberleşme sistemlerinin gelişimi ve yaygınlaşması, yüksek performanslı, kompakt ve maliyet etkin antenlere olan talebi önemli ölçüde artırmıştır. Bu ihtiyaçlar doğrultusunda mikroşerit anten olarak da bilinen yama antenler, basit yapıları, düşük profilleri, hafiflikleri ve üretim kolaylıkları sayesinde, özellikle mikro dalga ve milimetre dalga bantlarında birçok uygulamada tercih edilen bir anten türü olmuştur. Yama antenler, genellikle üst yüzeyinde ışımayı sağlayan metal bir yama, alt tarafında metalik bir toprak düzlemi ve bu iki katman arasında yer alan bir dielektrik alt tabakadan (substrat) oluşur. Kablosuz haberleşmede önemli bir yere sahip olan bu antenlerin, temel zayıf yönleri olan dar bant genişliği, düşük kazanç ve zayıf yönlendirme yetenekleri, çeşitli uygulamalarda performans sınırlamalarına neden olabilmektedir. Bu sınırlamaların üstesinden gelmek için metamalzemeler önemli bir rol oynar. Bu ileri teknoloji malzemeler, doğada bulunmayan elektromanyetik

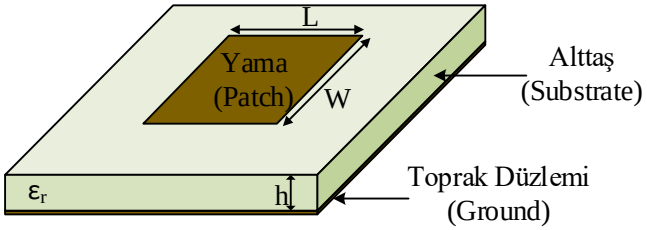
özellikler sunarak antenlerin dar bant genişliği, düşük kazanç ve zayıf yönlendirme gibi temel zayıf yönlerini iyileştirir [1-3].

Metamalzemeler, elektromanyetik dalgaları istenen şekilde manipüle etmek için tasarlanmış yapay malzemelerdir. Bu malzemeler, genellikle mikro ve nano ölçekte yapılan düzenli yapılarla karakterizedir. Bu yapılar, elektromanyetik dalgaların geçişini değiştirerek, geleneksel malzemelerin sahip olmadığı özellikler sergilerler. Metamalzemelerin en önemli özelliklerinden biri, elektromanyetik dalgaları istenen şekilde yönlendirebilmeleridir. Bu özellikleri, anten tasarımında önemli avantajlar sağlamaktadır. Metamalzemelerin özelleştirilebilir yapısı, anten tasarımında bant genişliğini artırma, kazancı ve verimliliği optimize etme, çevresel etkilere karşı direnci artırma gibi bir dizi avantajlar sunmaktadır. Ayrıca, metamalzemelerin antenlerin boyutunu küçültme potansiyeli, antenlerin daha kompakt ve taşınabilir olmasını sağlayarak uygulama alanlarını genişletebilir. Metamalzemelerin yama antenlerle entegrasyonu, sadece anten performansını artırmakla kalmaz, aynı zamanda yeni ve yenilikçi haberleşme teknolojilerinin geliştirilmesine de olanak tanır. Örneğin, metamalzemelerin kullanımıyla çoklu giriş ve çıkış (MIMO) sistemlerindeki anten sayısının artırılması ve daha karmaşık haberleşme algoritmalarının uygulanması mümkün hale gelir. Bu da daha güçlü ve güvenilir kablosuz haberleşme ağlarının oluşturulmasına olanak tanır. Ancak, metamalzemelerin yama antenlerle entegrasyonuyla ilgili üretim zorluğu, yüksek maliyet ve antenlere uygulamasının karmaşık olabilmesi gibi bazı kısıtlar ve zorluklar da bulunmaktadır [3-5].

Bu çalışmada, metamalzemelerin yama antenlerin performansını nasıl artırabileceği kapsamlı bir şekilde incelenmiştir. Yama antenlerin dar bant genişliği, düşük kazanç ve zayıf yönlendirme gibi temel sınırlamalarının, metamalzemeler kullanılarak nasıl aşılabileceği ele alınmıştır. Metamalzemelerin sağladığı negatif kırılma indisi, yüksek elektromanyetik geçirgenlik ve empedans eşleşmesi gibi özellikler, antenlerin kazancını, bant genişliğini ve yönlendirme kabiliyetlerini önemli ölçüde iyileştirir. Metamalzemeler, yama antenlerin daha geniş frekans aralıklarında çalışabilmesini sağlayarak haberleşme sistemleri, radar ve uydu haberleşme gibi uygulamalarda performans artışı sağlar. Bu çalışma, metamalzemelerin anten teknolojilerinde sunduğu potansiyeli ve gelecekteki araştırma yönlerini ortaya koyarak, yama antenlerin performans optimizasyonu için önemli bir referans kaynağı olmayı amaçlamaktadır.

II. YAMA ANTENLER

Kablosuz haberleşme sistemlerinin kilit bileşeni olan antenler, elektromanyetik dalgaları hava ortamına yayan ve bu sayede veri taşıyan bilgilerin elektromanyetik ışıma aracılığıyla aktarılmasını sağlayan bir cihazdır. Antenler, kablosuz ekipmanların giriş ve çıkışında bir ara yüz işlevi görür. İdeal bir antenin maliyetinin düşük, üretiminin kolay ve yeni nesil ince cihazlar için elektriksel olarak küçük olması gerekmektedir. Mikroşerit anten olarak da bilinen yama antenler, genellikle dielektrik bir zemin üzerine yerleştirilen ve ışıyıcı bir metal yama ile bu yamanın altına yerleştirilen metal bir toprak düzleminden oluşur. Geleneksel antenlerde yamanın şekli genellikle dikdörtgen, daire ve üçgen gibi düzenli geometrik şekillere sahip olsa da günümüzde karmaşık tasarımlar da olmak üzere pek çok farklı yapıda olabilmektedir. Yaygın olarak gümüş, altın veya bakır gibi yüksek iletkenlik özelliklerine sahip metallerin kullanıldığı iletken kısımlar (yama ve toprak düzlemleri) için grafen gibi yapay malzemeler de kullanılmaktadır. Günümüzde, mobil haberleşmeden askeri haberleşmeye, tıbbi görüntüleme sistemlerinden hava ve uzay araçlarına kadar birçok alanda yaygın olarak kullanılan bu antenlerin performansını etkileyen temel faktörler arasında, yamanın boyutları, alttaş (substrat) malzemesinin özellikleri, yamanın şekli, toprak düzlemi geometrisi ve kullanılan iletken malzemenin türü sayılabilir. Bunlar, antenin verimliliği, kazancı, bant genişliği ve yönlülük özelliklerini belirlemede kritik öneme sahiptir. Şekil 1'de genel yapısı verilen yama antenlerin çalışma prensibi, yamanın ve toprak düzleminin arasında oluşan elektrik alanlarından kaynaklanır. Bu elektrik alanları, "saçak alanlar" olarak adlandırılır ve dielektrik malzemenin dışına çıktığında ışıma meydana getirir. Dolayısıyla, yamanın ve toprak düzleminin geometrisi, antenin radyasyon özelliklerini doğrudan etkiler [1-2].



Şekil 1. Yama anten genel yapısı

Bu antenlerin avantajları arasında taşınabilirlik, hafiflik, düşük maliyetli üretim ve basit montaj gibi özellikler bulunmaktadır. Ancak, düşük güçte ışıma, yüksek kayıplar, dar bant genişliği ve düşük kazanç gibi dezavantajlar da mevcuttur. Bu dezavantajları aşmak için çeşitli düzeltme ve iyileştirme yöntemleri geliştirilmektedir.

III. METAMALZEMELER

Gelişmekte olan teknolojiler, mümkün olanın sınırlarını zorlamak için her zaman daha iyi ve daha verimli malzemeler arayışındadır. Bu arayış, çok fazla ilgi ve araştırma uyandıran yapay malzemeler olan metamalzemeleri ortaya çıkarmıştır. Doğal malzemelerin aksine, metamalzemelerin benzersiz avantajları ve özellikleri vardır. Bu özel nitelikler, kimyasal bileşimlerinden ziyade nano ölçekli yapılarının bir sonucu olan benzersiz elektromanyetik özelliklerinden kaynaklanmaktadır. Metamalzemelerin dikkat çekici bir özelliği, elektromanyetik dalgalar üzerinde olağanüstü bir kontrol sağlayan negatif kırılma elde etme yetenekleridir [4-5].

A. Metamalzemelerin Tarihsel Süreci

Metamalzeme yapılarına yönelik araştırmalar, 19. yüzyılın sonlarına kadar uzanmaktadır. Elektromanyetik özellikleri yapay olarak üretme çabaları, 1898'de Bose ve 1914'te Lindman'ın öncü çalışmalarıyla başlamıştır. Bu araştırmacılar, milimetre dalga ve mikrodalga bölgelerinde yapay kiral yapılar olarak adlandırabileceğimiz yapıları incelemişlerdir [6-7]. Ancak, bu alandaki ciddi çalışmalar 1940'lar, 1950'ler ve 1960'larda "yapay dielektrikler" üzerine yapılan önemli araştırmalarla hız kazanmıştır. Kock'un metalik geciktirme lensleri üzerine yaptığı çalışmada bu fikir özetlenmiştir. Kock, yapay dielektrik malzemelerin, gerçek bir dielektrik maddenin moleküllerinde meydana gelen süreçlerin daha büyük ölçekte yeniden üretilmesiyle elde edilebileceğini belirtmiştir [8]. Bu, metalik elemanların üç boyutlu bir dizi halinde düzenlenmesiyle, dielektrik malzemenin kristal yapısının taklit edilmesi anlamına gelmektedir. Bu çalışmalar, araştırmacılara doğada kolayca bulunmayan olağanüstü elektromanyetik özelliklere sahip yeni bir malzeme sınıfı konusunda ilham verdi. Genellikle metamalzemeler olarak bilinen bu özel malzemelerin içerisinde oluşan elektrik ve manyetik alanlar, permittivite ve permeabilite gibi iki etkili ortam parametresini etkiler. Kompleks malzemelerde aynı frekans bandında negatif permittivite ve permeabilite araştırılmış, 1968'de Veselago tarafından bu konuyla ilgili teorik çalışmalar yapılmıştır [9]. 20. yüzyılın sonlarında Pendry ve arkadaşlarının yaptıkları çalışmalarda, yüksek frekanslarda negatif permittiviteye sahip yapay malzeme üretme olasılığı, metal tel örgülerin periyodik bir düzenlemesi kullanılarak gösterilmiştir [10]. 2000'li yılların başında ise, mikrodalga rejiminde bölünmüş halka rezonatörleri (SRR'ler) ve bakır şeritlerin kombinasyonunu kullanarak kompozit bir ortamın varlığı deneysel olarak doğrulanmıştır [11]. Metamalzemelerin varlığı, elektromanyetik teori alanındaki araştırmacıları, radyasyon ve yayılma ile ilişkili olarak çeşitli uygulamalar için farklı uygulamalar tasarımı konusunda teşvik etmiştir. Bu uygulamalar arasında radar sistemleri [12], soğurucular [13], lensler [14], filtreler [15], sensörler [16], biyomedikal uygulamalar [17] ve antenler [18-28] bulunmaktadır.

B. Metamalzemelerin Sınıflandırılması

Doğada bulunanlardan farklı özelliklere sahip olan yapay olarak tasarlanmış metamalzemelerin elektromanyetik özellikleri, elektriksel geçirgenlik (ε) ve manyetik geçirgenlik (μ) ile tanımlanır. Elektriksel ve manyetik geçirgenlik kavramları, bir malzemenin elektrik ve manyetik alanlarda nasıl

davrandığını açıklarken; pozitif veya negatif değerler alabilmektedir. Hem elektrik hem de manyetik geçirgenlik negatif olduğunda, malzeme çift negatif (DNG) olarak adlandırılır. Bu tür malzemeler, sentetik (yapay) bir malzemedir ve doğada bulunmaz. Pozitif ε ve μ'ye sahip malzemelere çift pozitif (DPG) denir. Bu özellikler birçok plazmada görülebilir. Sadece ε ifadesi pozitif olan malzemeler epsilon pozitif (EPG) malzeme olarak adlandırılmaktadır. Benzer şekilde, sadece negatif manyetik geçirgenliğe sahip malzemeler de, μ negatif (MNG) malzeme olarak adlandırılır. EPG ve MNG şeklindeki negatif malzemeler, tek negatif (SNG) malzemeler olarak da bilinir. Ayrıca, elektromanyetik dalgaların hızının dalga boyuna bağlı olmaksızın malzemenin içinden geçerken sabit kalması özelliğine sahip sıfır indeks malzeme (ZIM) olarak adlandırılan bir malzeme sınıfı daha vardır. Bu malzemelerde, elektriksel geçirgenlik (ε) ve manyetik geçirgenlik (μ) sıfıra yakın veya sıfıra eşit olduğu için elektromanyetik dalgaların grup hızı ve faz hızı aynıdır ve dolayısıyla ışık malzeme içinde hiçbir sapma olmadan düz bir çizgide ilerler. Bu özellik, geleneksel malzemelerdeki gibi kırılma veya yansıma olmadığı anlamına gelir. Bu tür malzemeler, fotonik cihazlar ve optik haberleşme sistemleri gibi alanlarda tercih edilmektedir [3-5].

IV. METAMALZEMELERİN YAMA ANTENLERDE KULLANIMI

Metamalzemelerin yama antenlerle entegrasyonu, anten performansını önemli ölçüde iyileştirme potansiyeline sahiptir. Yama antenlerin temel zayıflıkları arasında yer alan dar bant genişliği, düşük kazanç ve zayıf yönlendirme yetenekleri, metamalzemeler kullanılarak büyük ölçüde giderilebilir. Metamalzemelerin bu avantajları, negatif kırılma indisi, yüksek elektromanyetik geçirgenlik ve empedans eşleşmesi gibi özelliklerinden kaynaklanmaktadır.

A. Bant Genişliğini Artırma

Yama antenlerin dar bant genişliği, belirli frekans aralıklarında sınırlı performans göstermelerine neden olur. Metamalzemeler, bu bant genişliğini artırmada önemli bir rol oynar. Metamalzemeler, antenin rezonans frekansını ayarlayarak ve daha geniş bir frekans aralığında çalışmasını sağlayarak bant genişliğini artırır. Bu, özellikle geniş bant uygulamaları için önemlidir ve haberleşme sistemlerinde daha yüksek veri iletim hızları sağlar. Geniş bant genişliği, yüksek performanslı haberleşme sistemleri için yüksek veri hızlarını sağlar ve aynı bantta birden fazla cihazın eşzamanlı olarak bağlanmasına olanak tanır. Bu nedenle, geniş bantlı antenler, 5G ve gelecekteki 6G haberleşme sistemleri için popüler araştırma konularıdır [18-19].

Mikrodalga yama antenlerinin bant genişliğini artırmak için metamalzemelerin kullanıldığı birçok teknik önermiştir. Bu çalışmalarda, metamalzemeler antenin ön veya arka yüzeyine eklenerek geniş bant gereksinimi karşılanır. Bir çalışmada, mikroşerit yama antenine manyeto-elektro-dielektrik düzlemsel dalga kılavuzlu metamalzemeler (MED-WG-MTMs) yüklenmiştir ve 3.5 GHz rezonans frekansında bant genişliğinde %207 oranında keskin bir iyileşme sağlanmıştır [20]. Başka bir çalışmada, ultra geniş bant metamalzemenin yüklenmesiyle 3.84–22.7 GHz frekans aralığında çalışacak bir mikroşerit yama anteni tasarlanmıştır [21]. X-bant uygulamaları için başka bir anten tasarımında, elektromanyetik bant boşluğu (EBG) yapısı ve metalik halkalarla antenin bant genişliği 1.6 GHz'e kadar artırılmıştır [22]. Ayrıca, farklı metamalzeme şekilleri ve geometrileri kullanılarak bant genişliğini artırıldığı çalışmalarda bulunmaktadır [23-24].

B. Kazancı Artırma

Yama antenlerin düşük kazanç ve verimlilik sorunları, metamalzemeler kullanılarak iyileştirilebilir. Metamalzemelerin negatif kırılma indisi ve yüksek elektromanyetik geçirgenlik özellikleri, antenin kazancını ve verimliliğini artırır. İki aynı frekans, genlik ve polarizasyona sahip ancak farklı fazlarda olan dalgaların z yönünde bir ortamda yayıldığında girişime neden olması, kazancın artırılmasını zorlaştırabilir. Bu girişimden kaçınarak aynı fazda bir dalga elde etmek kazancın artırılmasını sağlar. Bu, antenin daha güçlü sinyaller yaymasına ve daha uzun mesafelerde haberleşme sağlamasına olanak tanır. Metamalzemeler antenlerin alt yüzeyine yerleştirildiğinde, yansıtıcı olarak işlev görür. Buradan yansıyan elektromanyetik dalgalar, antenin yayılım dalgaları ile yapıcı girişime girer ve bu da yüksek kazançlı bir

yanıtla sonuçlanır. Ayrıca, metamalzemeler toplu endüktif ve kapasitif yüzeyler olarak da işlev görür, bu da anten bant genişliği ve kazancı açısından büyük bir avantaj sağlar [25-26].

Bazı metamalzeme yapıları, antenin ışıyıcı yaması ile aynı substratına eklenerek antenle aynı düzlemde bulunur. Bu tasarım metodolojisinde, ışıyıcı yamanın geri saçılımı minimize edilir ve nispeten yönlü bir radyasyon deseni gözlemlenir [27]. Metamalzeme lens kullanılarak ışıyan elektromanyetik dalgaların antenin yüzeyinde hapsederek de yama antenlerde kazanç artırılabilir. Antenin yamasına uygun bir mesafede yerleştirilen iki katmanlı bir metamalzeme lensin kullanıldığı bir çalışmada, anten kazancı 4.58 dBi'den 7.89 dBi'ye çıkararak kazançta %70 iyileşme sağlanmıştır [28]. Ayrıca, terahertz (THz) uygulamalarında grafen ve SiO2 gibi malzemelerin kullanıldığı metamalzemeler ile de antenlerde kazanç artışı sağlanmaktadır. Yapılan bir çalışmada, grafen yüklü bir katmanın THz frekansında çalışan çok katmanlı bir antenle entegre edilmesi ile anten kazancında %100 kadar bir iyileşme sağlanmıştır [29].

C. Boyut Azaltma

Metamalzemelerin kullanımı, yama antenlerin boyutunu küçültme potansiyeline de sahiptir. Böylelikle antenlerin daha kompakt ve taşınabilir olmasını sağlanır. Daha küçük boyutlu antenler, mobil cihazlar ve taşınabilir haberleşme ekipmanları gibi alanlarda kullanım kolaylığı sağlar. Ayrıca, metamalzemelerin esnek yapısı, antenlerin farklı yüzeylere ve cihazlara entegre edilmesini kolaylaştırır. WIMAX bant spektrumunda çalışan bir mikroşerit yama anteni sunulan çalışmada, antenin toprak düzleminde tasarımın küçültülmesine olanak tanıyan dairesel bir slot halkası eklenmiştir. Tasarıma entegre edilen LC rezonatörler, kompakt bir boyut elde edilmesini sağlamıştır [30]. Bir başka çalışmada, metamalzemenin antene eklenmesiyle, antenin boyutunun yarım ve tam topraklama düzlemi durumlarında sırasıyla %28 ve %70 oranında küçüldüğü gösterilmiştir [31].

D. İzolasyon Artırma

Günümüz ve gelecek teknolojilerde, yüksek veri hızları ve yüksek kaliteli hizmetler için çoklu anten sistemleri gereklidir. Çoklu giriş ve çıkış (MIMO) sistemleri, daha yüksek veri iletim hızları ve daha güvenilir haberleşme sağlar. Ancak, MIMO sistemlerde antenlerin birbirine yakın yerleştirilmesi nedeniyle ortak kuplaj (izolasyon) sorunu ortaya çıkar. MIMO anten sistemlerinin izolasyonunu artırmak için, anten elemanları arasındaki mesafenin artırılması gibi yöntemler kullanılır. Ancak, bu yöntem cihazların boyutunu artırdığı için, gelecekteki kompakt haberleşme cihazlarında kullanılamaz. Metamalzemeler, antenlerin birbirinden bağımsız çalışmasını ve daha az girişimle daha yüksek performans elde edilmesini sağlar. Bu, özellikle yeni nesil kablosuz haberleşme teknolojileri için büyük bir avantajdır [32-35].

V. SONUÇLAR

Bu makalede, metamalzemelerin yama antenlerin performansını nasıl artırabileceği kapsamlı bir şekilde incelenmiştir. Yama antenlerin temel zayıflıkları olan dar bant genişliği, düşük kazanç ve zayıf yönlendirme yetenekleri, metamalzemelerin benzersiz elektromanyetik özellikleri kullanılarak önemli ölçüde iyileştirilebilmektedir. Metamalzemeler, bant genişliğini artırma, kazancı yükseltme ve anten boyutlarını küçültme gibi birçok avantaj sağlar. Ayrıca, MIMO sistemlerde anten elemanları arasındaki izolasyon sorunlarını azaltarak daha yüksek veri iletim hızları ve daha güvenilir haberleşme imkanı sunar. Metamalzemelerin anten teknolojilerinde sunduğu bu potansiyel, yeni ve yenilikçi haberleşme teknolojilerinin geliştirilmesine de olanak tanır. Ancak, metamalzemelerin yama antenlerle entegrasyonu ile ilgili üretim zorlukları, yüksek maliyetler ve uygulama karmaşıklıkları gibi bazı kısıtlar ve zorluklar da bulunmaktadır. Gelecekteki araştırmalar, bu zorlukların üstesinden gelmeye ve metamalzemelerin sunduğu avantajları daha geniş bir yelpazede uygulamaya odaklanmalıdır. Bu çalışma, metamalzemelerin anten teknolojilerinde sağladığı katkıları ve gelecekteki araştırma yönlerini ortaya koyarak, yama antenlerin performans optimizasyonu için önemli bir referans kaynağı olmayı amaçlamaktadır. Bu alandaki araştırmalar ilerledikçe, yama antenlerin iyileştirilmesi için metamalzemelerin daha yenilikçi kullanımlarının ortaya çıkması beklenmekte ve bu da metamalzemelerin kablosuz haberleşme teknolojisinin evriminde temel bir bileşen olarak konumlarını daha da sağlamlaştırmaktadır.

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A Comparison of SVM Kernel Functions for Android Malware Classification

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Abstract – Portable mobile devices are increasingly being used in a variety of multi-purpose applications involving many human activities. There is a huge increase in software supporting the android operating system, which has a large market both in terms of complexity and volume. In this increase, malicious software has a share as well as well-intentioned software. Security vulnerabilities in Android mobile devices pose major problems in terms of user privacy. For these reasons, researchers need to detect and classify malware developed for the Android operating system. To contribute to the solution of these problems, a study was conducted on the detection and classification of malicious software using 4 different kernel structures of the Support Vector Machine (SVM) algorithm. Within the scope of this study, a dataset with 241 feature values, which is an up-to-date dataset in the field, was used. In the dataset, firstly, missing, incorrect, or misrepresented data were removed. Afterwards, scaling was performed to perform normalization. The data obtained after this preprocessing step was randomly divided into training and test data according to the cross-validation 5 value. The best results were obtained from the SVM kernel named Radial Basis Function (RBF), while close results were obtained from the Linear kernel and Polynomial kernel. The worst results were obtained from the Sigmoid kernel. As a result of the experimental studies, performance results between 90% and 99% were obtained.

Keywords – Malware, Android, SVM, SVM kernel types, Classification

I. INTRODUCTION

As the use of mobile applications has increased, the importance of operating systems for managing mobile applications has also increased. Today, android, one of the popular mobile operating systems, has become widely used [1]. There is also an increase in threat software that infects android operating systems with tools such as advertisements as they are used [2]. More than 46% of malware is found on the android operating system. After 2010, the share of malware damaging cell phones is reported to have increased by 400 [3]. Mobile malware targets mobile devices such as cell phones, tablets and portable devices integrated with the android operating system. Considering that millions of android operating system mobile applications are uploaded to play store areas every day, this area is an important market for malware [4]. In addition to malware-infected devices, companies attach great importance to this issue due to damage to areas such as play store and app store [2].

Due to the fact that devices with the Android operating system are more affordable than mobile devices with other operating systems, they are the target of much more malware or malicious software. In its report on software that damages mobile devices, Mcafee has developed new methods that will make it difficult to detect mobile attacks with various techniques and approaches such as cryptocurrencies, backdoors, empty port structures of cybercriminals who develop malware [5]. For these reasons, there is a need for new approaches and methods to close security gaps.

With the great development momentum of machine learning algorithms, a sub-field of artificial intelligence, there is a great increase in malware applications and activities developed by the android operating system [6]–[9]. The danger increases when malware has online identifiers, such as the IP address that identifies the mobile device. Cybersecurity is one of the key emerging approaches to the detection and classification of malware attacking portable and mobile devices [10]. Successful detection of cyber threats leads to improvements in recently more popular topics such as the Internet of Things. Otherwise, there will be major problems in building smart home systems with the Internet of Things, which has a large commercial volume. In any home, workplace or industrial environment controlled by the Internet of Things, it is a great disaster if a boiler that provides natural gas distribution is controlled by malware. Chauhuri et al. [2], conducts research on cyber security measures that should be taken for smart devices using the Internet of Things. Taheri et al. proposed federated learning alongside the detection of malware written under the android operating system [11]. This architecture is based on generative adversarial network architecture with two sides: participant and server. This architecture is based on generative adversarial network based network defence software to detect vulnerabilities at the participant and server side. Angelo et al. propose permission maps that combine android permissions and their corresponding severity levels to restrict the scope of malware activity [12]. Permission maps have been reported to make significant contributions to the use of convolution neural network-based software, which is one of the most important stakeholders of deep learning architecture.

Li et al. use deep learning based methods to detect data damaging the android operating system. By comparing ten different neural network configurations in this classification, they achieved high performance values [13]. Xie et al. developed an approach that can classify applications written for the android operating system as benign and malignant [14]. They also performed a comparison by classifying with different machine learning approaches such as naïve bayes, decision trees, random forest, kNN. Li et al developed a method that classifies malicious software written for the android operating system with a deep learning-based classifier by obtaining various attributes from the notification file and source code. Different static attributes such as application components, filters, suspicious java methods, objective filters were used as attributes. Aonza et al. presented a deep learning based approach for detecting malware and malicious software on mobile devices [15]. Angelo et al. presented a hybrid method based on convolution neural network and recurrent neural network to group bad and malicious spellings among themselves [15].

The main contributions of this article to the literature are presented below:

- Performing comparative classification of malware developed by cybercriminals targeting the Android operating system using different SVM kernels
- Experimental studies were carried out on a malware dataset generated to damage the android operating system using different kernel methods.

The following sections of the paper are organized as follows. The second section describes in detail the dataset used in the paper. It also describes the methods used to conduct experimental studies on this dataset. In the third section, the experimental studies carried out in the paper are discussed.

II. MATERIALS AND METHOD

The dataset used in this paper contains 241 features and 4665 sample events. This dataset is known as the TUNADROMD dataset in the literature. The studies in the literature using this dataset are presented in [16]–[19]. These studies show that the dataset is up-to-date and is a new dataset in the field. Classification of good and malicious software targeting the android operating system was performed using the specified dataset [20], [21]. After the basic preprocessing steps in the dataset, it was divided into training and test according to the cross validation 5 value. Afterwards, SVM classification algorithm was performed according to RBF, linear, poly, and sigmoid based kernel types.

SVM is a statistical machine learning technique designed to optimise desired parameters. SVM is used in both classification and regression problems and has been used in many studies in the literature. SVM supports generalisation to avoid overfitting and minimise the learning rate. At the same time, SVM is

based on a structural risk minimisation technique [22]. SVM minimises the sum of errors to ensure a good integration between the data and the target [22], [23].

The formulae of the SVM kernel functions that are mainly used are presented in Equations 1-4. Amara et al. perform a comparative analysis of SVM kernel functions for character recognition [24]. It also mentions the equations in Equations 1-4.

$$K(x_i, x_j) = (x_i, x_j) \quad (1)$$

$$K(x_i, x_j) = (\gamma x_i, x_j + coef)^d \quad (2)$$

$$K(x_i, x_j) = exp^{-\gamma|x_i - x_j|^2} \quad (3)$$

$$tanh(\gamma x_i, x_j + coef) \quad (4)$$

The *C* margin value in the SVM parameters is an adjustment parameter that controls the balance to minimise the classification error [23], [25].

III. Experimental Results and Discussion

In this section, the performances of RBF, linear kernel, polynomial and sigmoid kernel types of SVM algorithm are compared. The results obtained in the experimental studies performed by accepting the *C* value of the RBF kernel as 1, 100 and 1000 parameter values are shown in Table 1.

Table 1. Performance results obtained with RBF Kernel

Kernel types	C	Class	Precision	Recall	F1 score
RBF	1	Goodware	0.97	0.95	0.96
RBF	1	Malware	0.99	0.99	0.99
Accuracy			0.9830		
RBF	100	Goodware	0.99	0.99	0.99
RBF	100	Malware	1.00	1.00	1.00
Accuracy			0.9955		
RBF	1000	Goodware	0.99	0.99	0.99
RBF	1000	Malware	1.00	1.00	1.00
Accuracy			0.9955		

The results obtained in the experimental studies by accepting the *C* value of the linear kernel as 1, 100 and 1000 parameter values are shown in Table 2.

Table 2. Performance results obtained with Linear kernel

Kernel type	C	Class	Precision	Recall	F1 score
Linear	1	Goodware	0.95	0.95	0.96
Linear	1	Malware	0.99	0.99	0.99
Accuracy			0.9794		
Linear	100	Goodware	0.96	0.99	0.97
Linear	100	Malware	1.00	0.99	0.99
Accuracy			0.9884		
Linear	1000	Goodware	0.96	0.99	0.97
Linear	1000	Malware	1.00	0.99	0.99
Accuracy			0.9875		

The results obtained in the experimental studies by accepting the *C* value of the polynomial kernel as 1, 100 and 1000 parameter values are shown in Table 3.

Table 3. Performance results obtained with polynomial kernel

Kernel type	C	Class	Precision	Recall	F1 score
Poly	1	Goodware	0.97	0.92	0.95
Poly	1	Malware	0.98	0.99	0.99
Accuracy			0.9776		
Poly	100	Goodware	0.97	0.97	0.97
Poly	100	Malware	1.00	0.99	0.99
Accuracy			0.9875		
Poly	1000	Goodware	0.97	0.98	0.97
Poly	1000	Malware	1.00	0.99	0.99
Accuracy			0.9892		

The results obtained in the experimental studies by accepting the *C* value of the sigmoid kernel as 1, 100 and 1000 parameter values are shown in Table 4.

Table 4. Performance results obtained with sigmoid kernel

Kernel type	C	Class	Precision	Recall	F1 score
Sigmoid	1	Goodware	0.75	0.79	0.77
Sigmoid	1	Malware	0.95	0.94	0.94
Accuracy			0.9068		
Sigmoid	100	Goodware	0.73	0.81	0.77
Sigmoid	100	Malware	0.95	0.93	0.94
Accuracy			0.9095		
Sigmoid	1000	Goodware	0.73	0.81	0.86
Sigmoid	1000	Malware	0.91	0.91	0.91
Accuracy			0.9095		

Fig. 1a shows the confusion matrix output of the SVM algorithm using the linear kernel type with regularisation value *C* 1, while Fig. 1b shows the ROC curve output of the SVM algorithm using the linear kernel type with a regularisation value of *C* 1.

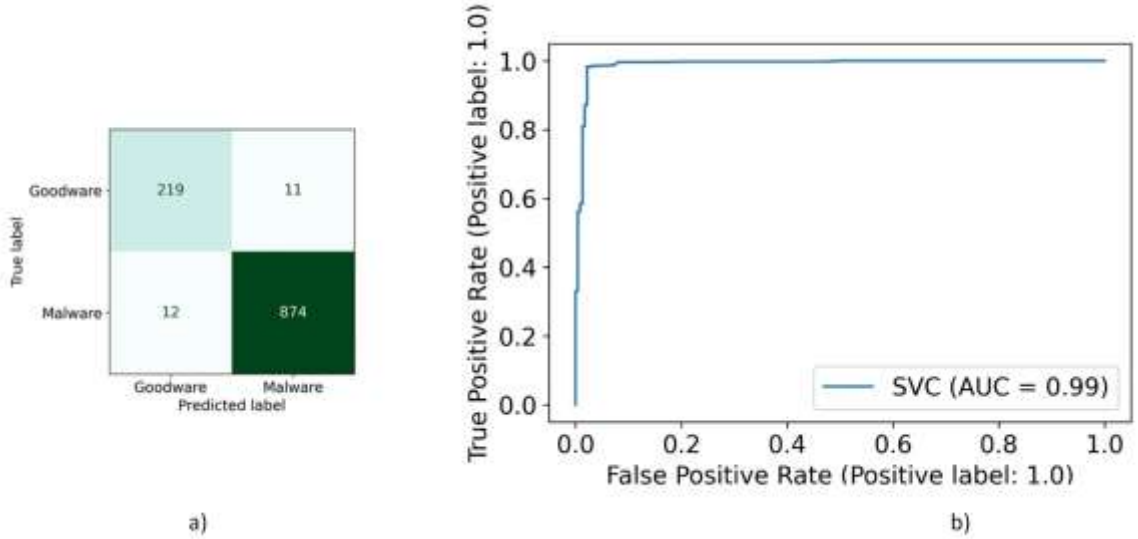

Fig. 1. a) confusion matrix results b) roc curve results of the SVM algorithm with Linear Kernel type and c=1 parameter values

Fig. 2a shows the confusion matrix output of the SVM algorithm using the linear kernel type with a regularisation value of *C* 100, while Fig. 2b shows the ROC curve output of the SVM algorithm using the linear kernel type with a regularisation value of *C* 100.

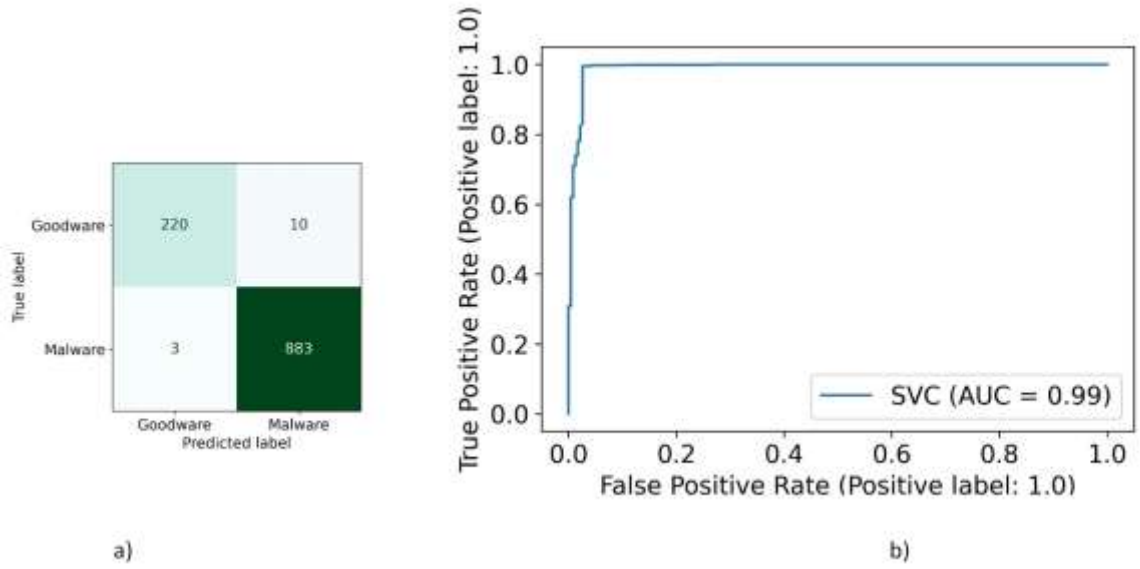

Fig. 2. a) confusion matrix results b) roc curve results of the SVM algorithm with Linear Kernel type and c=100 parameter values

Fig. 3a shows the confusion matrix output of the SVM algorithm using the linear kernel type with a regularisation value of *C* 1000, while Fig. 3b shows the ROC curve output of the SVM algorithm using the linear kernel type with a regularisation value of *C* 1000.

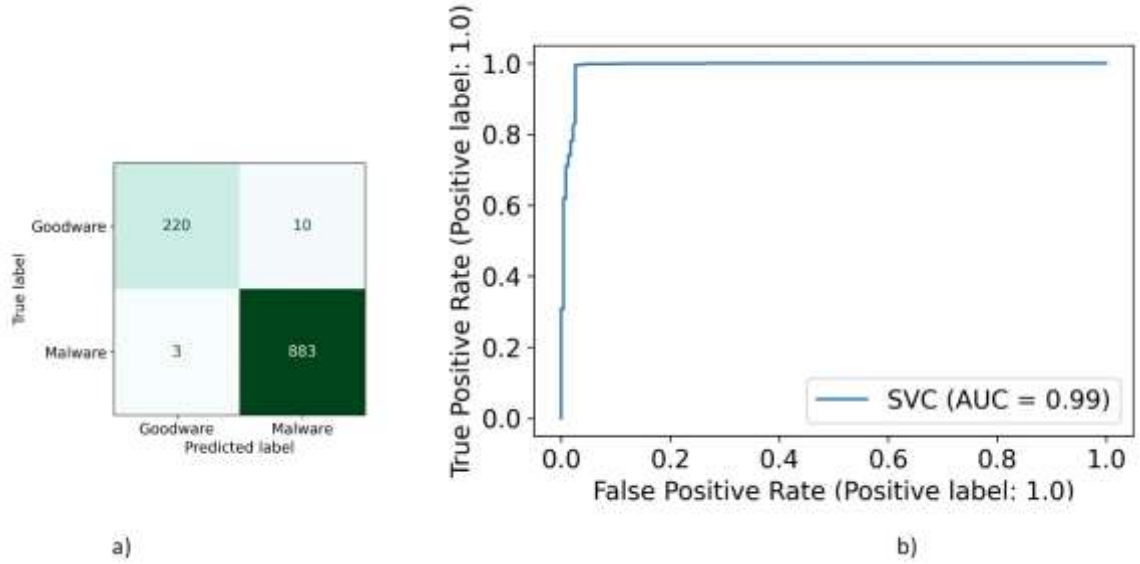

Fig. 3. a) confusion matrix results b) roc curve results of the SVM algorithm with Linear Kernel type and c=1000 parameter values

Fig. 4a shows the confusion matrix output of the SVM algorithm using the polynomial kernel type with a regularisation value *C* 1, while Fig. 4b shows the ROC curve output of the SVM algorithm using the polynomial kernel type with a regularisation value of *C* 1.

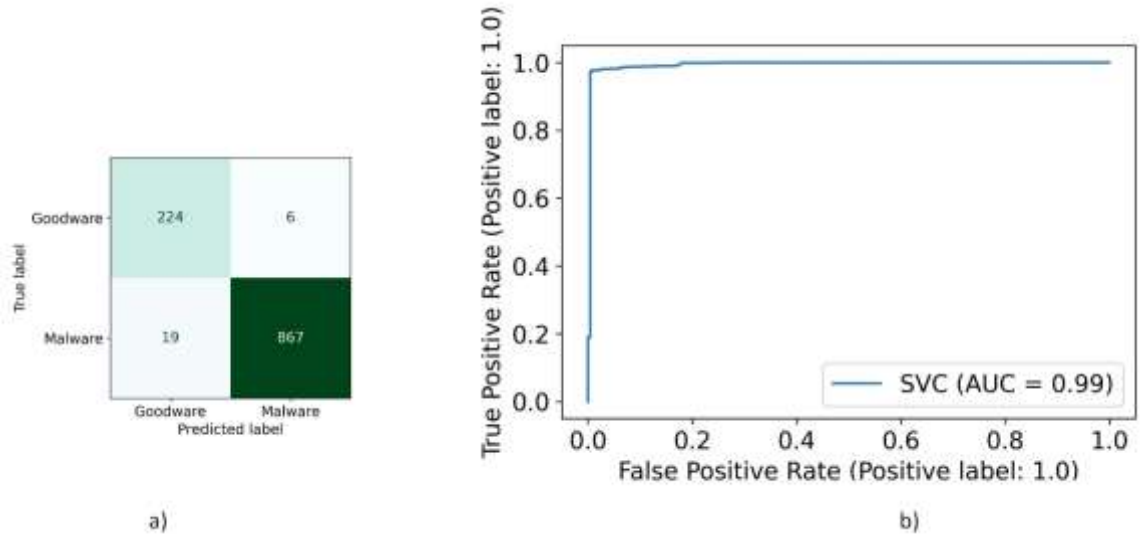

Fig. 4. a) confusion matrix results b) roc curve results of the SVM algorithm with polynomial kernel type and c=1 parameter values

Fig. 5a shows the confusion matrix output of the SVM algorithm using the polynomial kernel type with a regularisation value of *C* 100, while Fig. 5b shows the ROC curve output of the SVM algorithm using the polynomial kernel type with a regularisation value of *C* 100.

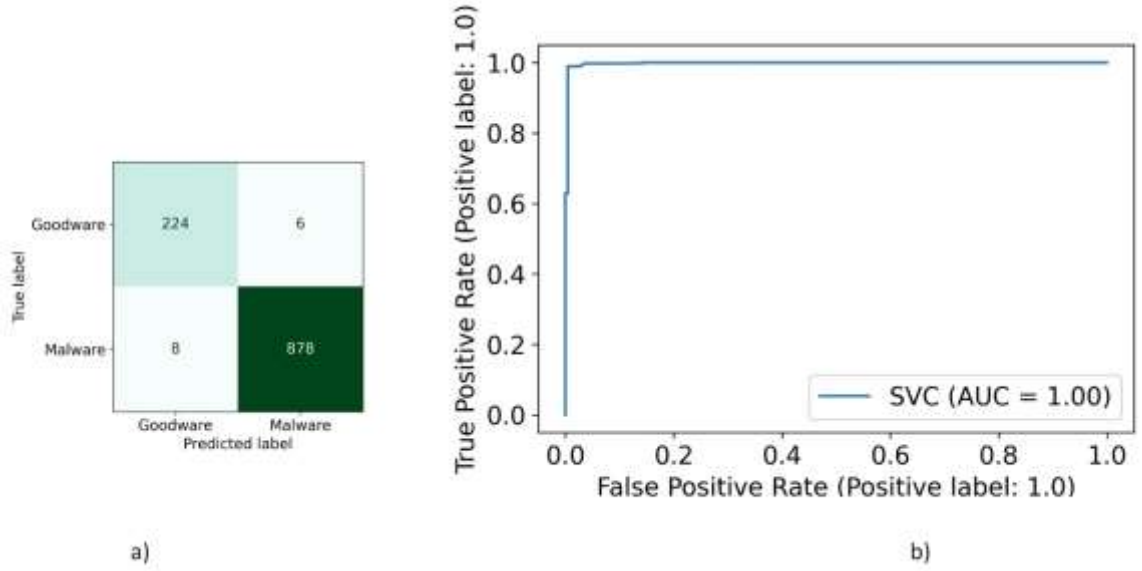

Fig. 5. a) confusion matrix results b) roc curve results of the SVM algorithm with polynomial kernel type and c=100 parameter values

Fig. 6a shows the confusion matrix output of the SVM algorithm using the polynomial kernel type with a regularisation value *C* 1000, while Fig. 6b shows the ROC curve output of the SVM algorithm using the polynomial kernel type with a regularisation value of *C* 1000.

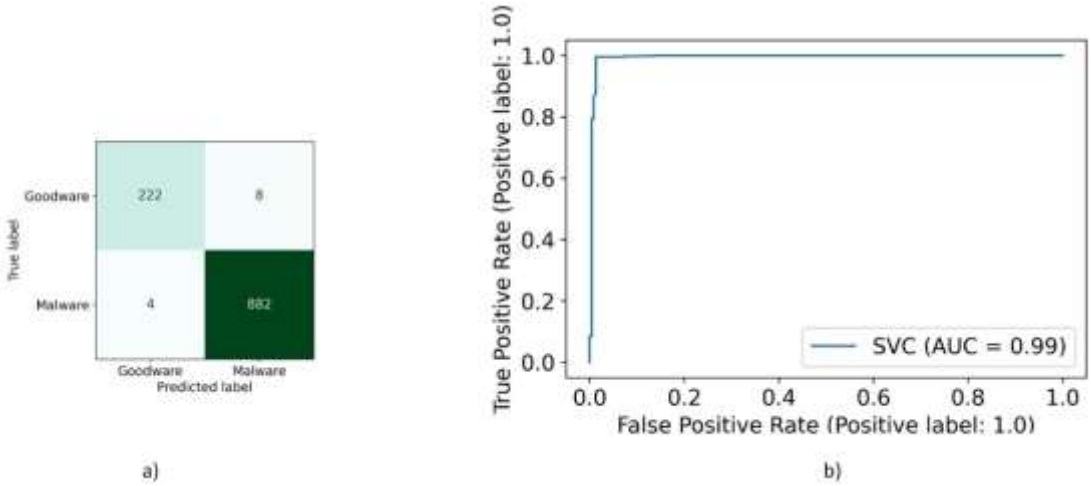

Fig. 6. a) confusion matrix results b) roc curve results of the SVM algorithm with Poly Kernel type and c=1000 parameter values

Fig. 7a shows the confusion matrix output of the SVM algorithm using the sigmoid kernel type with a regularisation value *C* 1, while Fig. 7b shows the ROC curve output of the SVM algorithm using the sigmoid kernel type with a regularisation value of *C* 1.

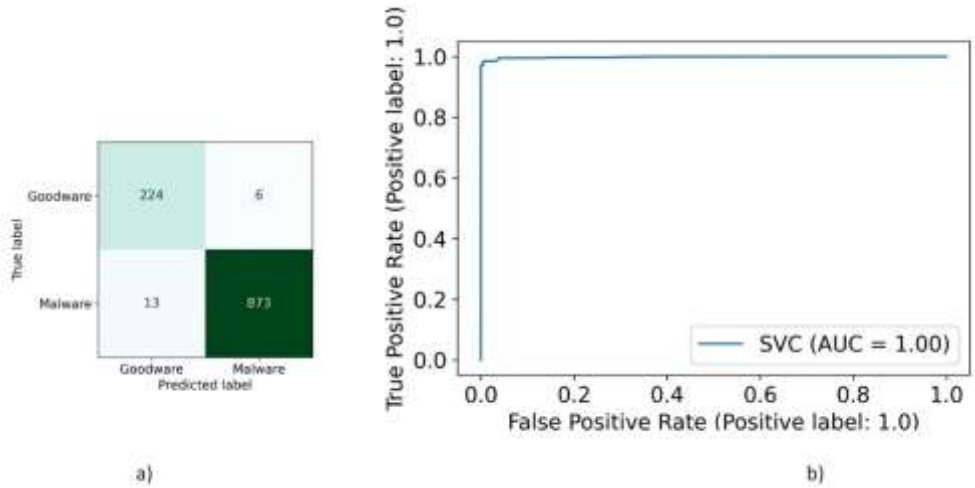

Fig. 7. a) confusion matrix results b) roc curve results of the SVM algorithm with Sigmoid Kernel type and c=1 parameter values

Fig. 8a shows the confusion matrix output of the SVM algorithm using the sigmoid kernel type with a regularisation value of *C* 100, while Fig. 8b shows the ROC curve output of the SVM algorithm using the sigmoid kernel type with a regularisation value of *C* 100.

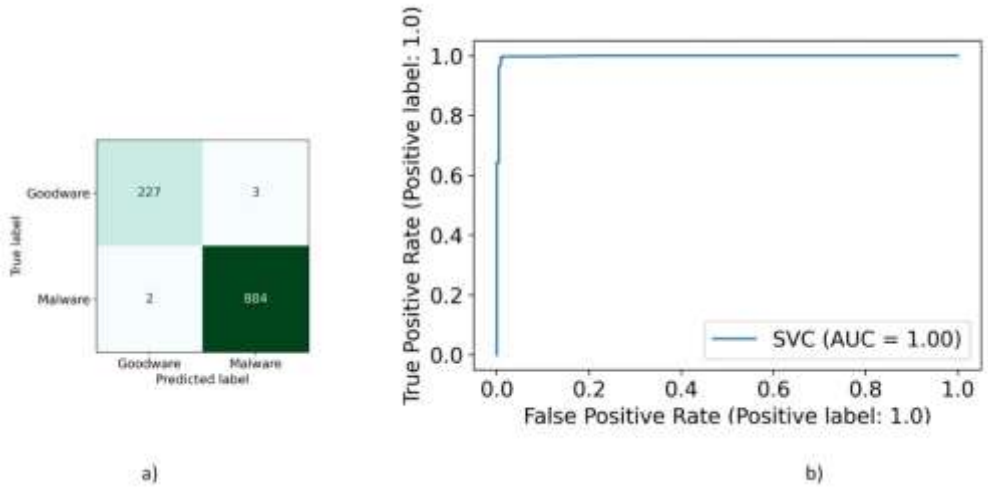

Fig. 8. a) confusion matrix results b) roc curve results of the SVM algorithm with Sigmoid Kernel type and c=100 parameter values

Fig. 9a shows the confusion matrix output of the SVM algorithm using the sigmoid kernel type with a regularisation value *C* 1000, while Fig. 9b shows the ROC curve output of the SVM algorithm using the sigmoid kernel type with a regularisation value of *C* 1000.

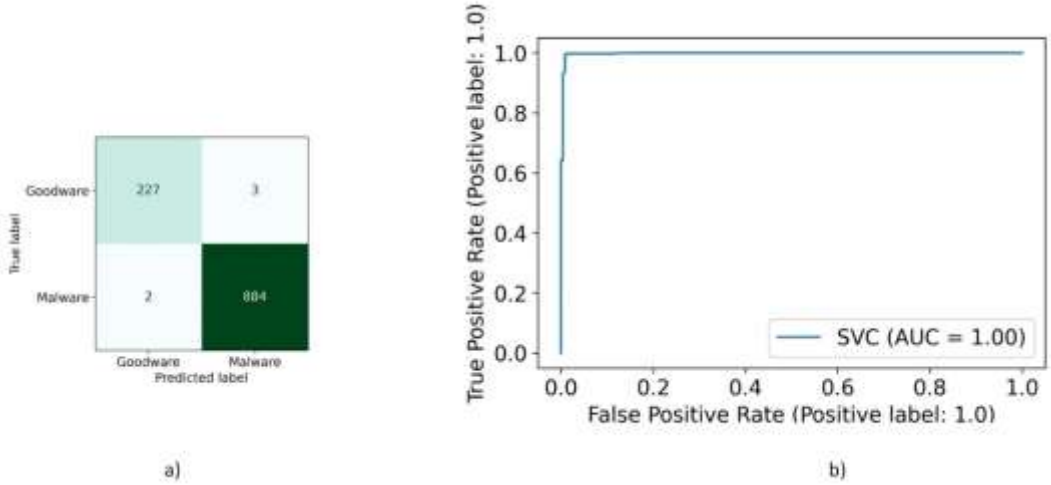

Fig. 9. a) confusion matrix results b) roc curve results of the SVM algorithm with sigmoid kernel type and c=1000 parameter values

Among the SVM kernel types, the RBF kernel gave the best performance, while the sigmoid kernel type gave the worst result.

IV. CONCLUSION

Android, one of the largest global mobile operating systems with frequent updates, is used in many countries. For this reason, it is a system that is targeted by many malicious cyber criminals from outside. In this study, the classification results obtained with 4 different kernel types of the SVM method running on the dataset known as TUNADROMD dataset on the publicly published Kaggle platform are shared. RBF kernel parameterization gives the best result when the parameterization value is 1000, while linear kernel type parameterization gives a good performance result when both 100 and 1000. Polynomial kernel type gives a result close to *C* value 100 when *C* value is 1000, but gives the worst result when *C* value is 1 compared to *C* values 100 and 1000. Sigmoid kernel type gives 8% less performance result compared to other kernel types. It provides results close to each other in all values of *C* value. As a result of the

performance results obtained, it can be said that malware written according to the android operating system can be successfully detected and classified.

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User Opinion on Factors Impacting Mobility of Multilane Highway

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Abstract **–** In developing Asian countries, open-access multilane highways are crucial in the overall highway networks. These highways are characterized by high access density, design inconsistencies, and other operational features that differentiate them from controlled-access multilane highways. While significant attention has been directed towards understanding the factors affecting mobility on these highways in recent decades, such considerations remain limited in the context of Pakistan. Therefore, this research aims to discern primary mobility metrics and the influencing factors based on user perspectives. So, in the research methodology, about 34 factors were extracted from the literature with the consults of highway experts and operators. A total of 120 road users were interviewed one-to-one through a questionnaire-based survey. The results revealed that respondents tend to give higher scores to most factors considering speed/travel time as a performance measure than for LOS/capacity; this implies that speed/travel is more sensitive to mobility influencing factors than the level of service or capacity. The findings of this study are expected to assist highway authorities in understanding how road users perceive road serviceability so that they can respond properly to their needs.

Keywords: User Opinion, Open access highways, Multilane highways, Performance Measures, Mobility factors

1 Introduction

Traffic flow on open-access multilane highways has been greatly impacted in recent years by increasing accessibility, changing land-use patterns, and growing urbanization. Regulatory organizations must pinpoint the precise areas that need to be addressed to enhance general mobility on these thoroughfares. A thorough analysis of road users' perceptions of highway mobility and the factors that influence it is necessary for an effective plan. Recent research has investigated how road users perceive the key aspects that determine their views of the quality of their journey/trip. Conversely, the Highway Capacity Manual [1] highlights the need for more study in this area. This study evaluates and identifies the features that affect how road users perceive the mobility of open-access multilane highways. Speed is an important factor in evaluating highway operations and decision-making processes [2] According to [3], travel time and speed are performance measures for analysis and decision-making on open-access multilane highways, as perceived by road users. Evaluation of speed and Travel time is very useful to both transportation experts and successfully communicate information to a variety of road users [4]. Furthermore, [5] found that sticking to the posted speed limit, keeping the intended speed, and performing lane changes without discomfort were the three most important aspects. Besides this, level of service (LOS), a qualitative assessment technique, has been in use for over four decades [6]. It endeavors to elucidate the current definition and evaluation of highway mobility within local contexts. Additionally, the study aims to establish the precision and dependability of mobility performance metrics, while also examining the interpretation and application of these metrics by user experts. Furthermore, an exhaustive compilation of factors influencing mobility, derived from literature, is prioritized based on their relative

impact and overall frequency. The study's findings will yield guidelines for both highway designers and operators.

2 Research Methodology

Figure 1 Research Methodology

The main objective of this research is to identify and examine primary mobility measures and the factors impacting open-access multilane highways. The approach is divided into three phases. In the first, the literature was reviewed to understand current definitions, measurement techniques, and influencing factors on multilane open-access highway mobility. In the second section, field experts and highway operators were consulted to identify and rank the factors that impact multilane highway mobility. The third portion of the study includes a pilot survey that assisted in the finalization of the main questionnaire. The questionnaires were designed with the definition of mobility and the factors that impact it in mind. Respondents assessed each of the four most often used mobility measures separately: capacity, speed, route duration, and level of service. A total of 34 mobility-influencing factors were selected for further examination from the literature while keeping the study's goal in mind, as shown in **Table 1**.

2.1 User Questionnaire Development

The study's second objective is to assess how users perceive mobility and the factors impacting mobility based on their opinions. Therefore, road user questionnaires were developed and separated into three main sections. The first section consists of the respondent's demographic details, including gender, level of education, the vehicle they drive, possession of a driving license, and total driving experience. The second section, named Part I, had eight questions to evaluate how users define and quantify mobility. At the same time, the third section named Part II consists of scaling point questions related to different factors impacting mobility as shown in **Table 3**.

2.2 Validity Test

Before initiating the user questionnaire, an important aspect is to determine whether the questions asked are appropriate for addressing the objectives. For this reason, a validity test is undertaken for both Parts I and II of the questionnaire using the most accepted approach of Content Validity Index (CVI) interviews with experts [7]. Section-level CVI (S-CVI) and Question-level CVI (Q-CVI) are determined using a relevance scale ranging from 0 to 1, as indicated in Table 3. A question is considered relevant if the Q-CVI is larger than 0.80, which is calculated using the average evaluations of all experts. If the Q-CVI is between 0.70 and 0.80, the query has to be corrected. The query is deleted if the Q-CVI is less than 0.70 [8].

Table 1 Proposed Mobility Influencing Factors Based on Frequency

S/no	Factor	Frequency
1	Access density	13
2	Heavy traffic	11
3	Speed limit	11
4	Lane Width	11
5	Degree / Length of a curve	9
6	Shoulder width	8
7	Roadside development	8
8	Roadway	8
9	Number of Lanes	7
10	Grade	6
11	Median type	5
12	Median Width	5
13	Pavement condition	5
14	Roadside object density/Distance	5
15	Road signs	5
16	Roadside parking	5
17	Lateral clearance	4
18	Horizontal curve	4
19	Superelevation	4
20	Intersection	3
21	Driver characteristics	3
22	Pavement Markings	3
23	vehicle characteristics	3
24	Sight distance	3
25	Sidewalk	3
26	Pedestrian Traffic	2
27	Bus Stops	2
28	Vertical curve	2
29	law Enforcement	2
30	Safety Barriers	1
31	Service road	1
32	U-turns	1
33	Slow-moving vehicles	1
34	Driving Behavior	1

The authors observed that various components have a similar impact on mobility with almost identical characteristics, so those were combined into a group factor. For example, roadside objects, roadside parking, and parking at bus stops were incorporated into the roadside resistance factor. So, a total of 23 proposed factors were identified for further evaluation based on qualitative, quantitative, literature score, and Relative important index.

Table 2 Ranking of Mobility Influencing Factors Based on Literature Score

Factor	Qualitative Scale	Qualitative Score	Literature Score	RII
Access Density	High	5	0.282	1
Lane Width	High	5	0.239	2
Speed limit	High	5	0.239	3
Heavy Traffic	High	5	0.217	4
Roadway width	High	5	0.173	5
Roadside development	High	5	0.173	6
Median type	High	5	0.108	7
Median Width	High	5	0.108	8
Pavement condition	High	5	0.108	9
Roadside parking	High	5	0.108	10
Road signs	High	5	0.108	11
Shoulder width/condition	Medium	3	0.104	12
Number of Lanes	Medium	3	0.091	13
Sidewalk	High	5	0.065	14
Roadside object Distance	Medium	3	0.065	15
Driver behavior	High	5	0.065	16
Vehicle characteristics	High	5	0.065	17
Lateral clearance	Medium	3	0.052	18
Pedestrian Traffic	High	5	0.043	19
Pavement Markings	Medium	3	0.039	20
Bus Stops	Medium	3	0.026	21
U-turns	High	5	0.021	22
Slow vehicles*	High	5	0.021	23

A qualitative scale of low to high was used and later converted to a qualitative score as top 33.33% = 5; Middle 33.33% = 3; Bottom 33.33% = 1. Further, the relative importance index (RII) was calculated based on the literature score showing the importance of a particular factor in literature, as presented below in **Table 2.**

Table 3 Validity of Questionnaire by Experts

Question no	Part-I		Part-II	
	Question	**Q-CVI**	**Question**	**Q-CVI**
1	Valid driving license	1	Pavement width	1
2	Traffic rules, regulations, and road signs	0.88	Accessibility	0.75
3	Break traffic rules	1	Median	0.88
4	Average distance you travel	1	Pavement condition	1
5	Define mobility	1	Pedestrian Activity	1
6	Criteria of travel conditions	0.79	Roadside resistance	0.75
7	Able to drive at Posted speed	0.96	Shoulder	1
8	Rank the overall quality of travel	1	Roadside development	1
9	Reduction in Speed	1	Signs and markings	0.79
10		0.96	Safety	0.38
11			Speed limit	0.96
12			Law enforcement	0.54
13			Driver characteristics	0.81
14			Traffic composition	0.79
15			Geometry	1
16			Vehicle characteristics	0.65
Q-CVI Range		**0.79-1.00**		**0.54-1.00**
S-CVI Mean		**0.95**		**0.83**
Overall-CVI		**-**		**0.87**

The questionnaire's overall CVI is 0.87, exceeding the 0.80 cutoff, according to the validity findings. As a result, no additional expert review was required as shown in **Table 3**. No questions were removed from Part I because they all received scores above the 0.7 threshold. However, because the questions about safety (Q-CVI = 0.38), law enforcement (Q-CVI = 0.54), and vehicle characteristics (Q-CVI = 0.65) in Part II of the user questionnaire were scored below the 0.7 threshold, they were omitted from the survey. Further discussion was held to determine how to incorporate the experts' recommendations for the questions with CVI scores between 0.71 and 0.80. Primary input from all the experts is that the entire

survey was lengthy, so performance measures should be combined into (speed and travel time) and (capacity and level of service) as they are interrelated, and it reduces the time of the survey. Second, most experts suggested that grouped factors including accessibility, roadside resistance, and signs and markings should be separately evaluated as each element within the group has a different impact on road travelers. Third, important feedback provided by the field experts was the addition of two local factor mobility impacting factors, i.e., transverse raised pavement markers (Cat eye) and traffic entrance from any point on the highway. The experts also suggested adding "driver familiar with the road" in compliance with the HCM level of service methodology. So, based on the suggestions from the experts, a total of 21 factors were finalized for the user questionnaire.

2.3 Data Collection

There are various methods of obtaining road user opinion surveys, including web-based surveys, Questionnaire surveys, Video-based surveys, etc. After considering the advantages and disadvantages of each technique, it was decided that each participant should be personally interviewed to get a complete and sincere response. It also ensured the inclusion of a variety of road users. Considering the understanding level of road users, the questionnaire is simplified to the best possible level, and simple question wording was used to make the user understand the technical terminologies. When a respondent chose to answer verbally, the author wrote their answer on the questionnaire without intervening.

Identifying the population and selecting a sample depending on the research topic is crucial for data collection. Pakistan's National Highway (N-5) accounts for 65% of the country's traffic and is an exceptional example of an open-access, multilane road with diverse traffic [9]. Therefore, a section of 442 km was taken as a sample that passes along big cities and is distributed across two country regions. The population (25088 veh/day) used for calculating the sample size of drivers was based on average daily traffic (ADT) measured at 15 different locations on the highway for both north and southbound traffic on various days of the week.

$$Ns = (Np)(p)\,(1-p) \,/\, (Np-1)\,(B/C)2 + (p)\,(1-p) \qquad (1)$$

For a population (Np) of 25088, observations (Ns) were calculated for an error margin (B) of 7 % with 90% certainty (C), whereas 70% of respondents (p) were expected to answer in a specific way, the minimum required sample size was calculated as 117 (Dillman, 2007). Therefore, 120 road users were interviewed based on simple random sampling so that each road user within the target population has an equal chance of being included in the sample [10]. A total of 120 road users were interviewed, wherein 55% were private vehicle users, whereas 23% and 22% were commercial and heavy vehicle users. The main particulars of participants are (a) 89% were male; (b) 63% had a driving experience between 5–20 years (c) 51% had the education level of bachelor's or above strengthening the accuracy of results as drivers with higher levels of education background have a better understanding of the scenario [11].

3 Results and Discussion

3.1 Reliability test

Table 4 Reliability Test Results

Scale	Cronbach Alpha Value	Reliability
Speed/Travel Time	0.76	Good
LOS/Capacity	0.84	Good
Overall	0.86	Good

Cronbach's alpha is considered an adequate measure of internal consistency. Cronbach's alpha was calculated for each scale separately as shown in **Reliability test**

*Table 4***.** A low Cronbach's alpha on a scale indicates no relationship between the items, indicating that item summarization is not unjustified. A score of 0.6 to 0.7 is usually considered adequate for a questionnaire, while more than 0.7 is considered good and dependable [12].

3.2 Part-I Analysis

Table 5 Percentage Response to Each Question of Part I

Question	**Options**	**Percentage**
How well do you know "traffic rules, regulations, and road signs"?	100%	35.5
	75%	35.8
	50%	27.9
	25%	0.8
How often do you "break" traffic rules and regulations?	Never	19.2
	Not often	40.0
	Often	8.3
	Very often	1.7
What is the "average distance you travel" on N-5 (GT road)? (km /day)	<50	14.2
	50-100	39.2
	100-200	16.7
	>200	30.0
How do you define "mobility" on N-5 (GT road)?	Speedy travel	25.8
	Free flow movement	10.0
	Travel comfort	31.7
	less delay	30.8
What are your "criteria" for excellent or poor travel conditions?	Total travel time	26.7
	Average travel speed	34.2
	Less congestion	30.8
	More lanes less traffic	8.3
How often can you drive at "posted speed" on N-5 (GT road)?	Never	10.0
	Not often	40.8
	Often	36.7
	Very often	12.5
How would you rank the overall quality of travel on N-5 (GT road)?	Very Poor	10.0
	Poor	20.0
	Fair	45.0
	Good	25.0
How much reduction in "Speed limit" is acceptable in rush hours? (km/hr.)	5	10.8
	10	21.7
	20	31.7
	30	25.0
	40	10.8

This section summarizes the analysis results carried out on the data obtained from part I of the questionnaire. The responses to each question for all three driver groups together are outlined in ***Table 5.***

Part-II Analysis

Table 6 Mean Ratings and Ranks of Factors Influencing Mobility

Factors	Performance Measure								Combined	
	Speed/Travel time				LOS/Capacity					
	Average	SD	Variance	Rank	Average	SD	Variance	Rank	Average	Rank
Heavy traffic	8.28	1.68	2.84	2	8.00	2.11	4.47	2	8.14	1
Road Width	7.84	2.17	4.72	4	8.32	1.63	2.65	1	8.08	2
Road condition	8.37	1.59	2.52	1	7.57	2.27	5.16	4	7.97	3
Traffic entrance from any point	7.87	1.97	3.90	3	7.93	1.99	3.96	3	7.90	4
Illegal parking on the roadside	7.38	2.05	4.19	8	7.55	1.60	2.56	5	7.47	5
Slow vehicles	7.83	1.51	2.27	5	6.94	1.97	3.87	9	7.39	6
Number of connecting roads	7.31	2.06	4.23	10	7.43	1.78	3.16	6	7.37	7
Pedestrians	7.63	1.90	3.62	6	6.93	1.75	3.05	10	7.28	8
Number of U-turns	7.32	1.81	3.28	9	7.19	1.74	3.02	7	7.25	9
Cat Eyes	7.58	1.40	1.96	7	6.34	2.26	5.11	13	6.96	10
Turning lanes	7.03	1.61	2.61	11	6.86	1.54	2.37	11	6.94	11
Improper lane use by drivers	6.69	1.82	3.30	12	7.16	2.02	4.08	8	6.93	12
Unfamiliar with road	6.53	2.14	4.57	13	6.14	2.27	5.14	14	6.33	13
Roadside area	5.93	2.80	7.81	15	6.39	1.91	3.65	12	6.16	14
Geometry	6.50	2.01	4.03	14	5.44	2.71	7.33	17	5.97	15
Bus stops and parking at bus stops	5.87	2.57	6.60	16	5.65	3.05	9.28	16	5.76	16
Roadside shoulder	5.63	2.36	5.58	17	5.82	2.32	5.39	15	5.72	17
Warning signs	4.48	3.25	10.58	18	4.87	2.58	6.65	20	4.68	18
Median type	4.13	3.09	9.56	20	4.95	2.92	8.50	18	4.54	19
Roadside objects	4.18	2.93	8.57	19	4.88	2.37	5.60	19	4.53	20
Signs and Markings	3.44	2.96	8.75	21	3.63	2.27	5.13	21	3.53	21

This section contains the analysis of the data collected in Part II of the questionnaire. The mean rating of valid responses for the 21 factors is summarized by performance measures individually and for all three groups (private, commercial, heavy vehicles) together, in **Table 6**. The overall rating average for speed/travel time is 6.53; for LOS/capacity, it is 6.47. The mean rating for all factors exceeds 5.0 except warning signs, median type, roadside objects, and signs and markings when considered together without distinguishing between two performance measures. On top of the list are heavy traffic, road width, and road condition, all rated about 8.0 on average, respectively. The least significant are road signs and markings with an average value of less than 4.0, followed by roadside objects and median type. Road condition and road width were the highest-rated factors for speed and LOS individually, with mean ratings for both measures as 8.37 and 8.32, respectively. However, one more factor that is rated above 8.0 in both cases is heavy traffic.

4 Conclusion

The objective of this study was to characterize mobility and the variables influencing it on an open-access multilane highway based on users' opinions. Questionnaires were developed, and parameters related to highway mobility were collected from the literature to meet the objectives, with additional parameters also included based on local conditions. The investigation of mobility definition from user questionnaires disclosed no specific definition of mobility. Still, an appropriate description might be "comfortable and fast travel from one location to another." Similarly, the reviews on mobility performance measures revealed that no single measure would satisfy all the needs and identify all aspects. Nonetheless, it can be said that the two performance metrics that are important and simple to comprehend for both groups are speed and travel time.

Another important outcome of this study is the identification of the factors impacting mobility on multilane-divided highways. The top ten rated factors are road design elements followed by traffic composition, and road user Behavior, including pedestrians. Overall, respondents tend to give higher scores to most factors considering speed/travel time as a performance measure than do for LOS/capacity; this implies that speed/travel is more sensitive to mobility influencing factors than the level of service or capacity. Even though this study is particular to Pakistan, its outcomes could be valid and applicable to others with similar transportation systems and infrastructure conditions (e.g., India, Bangladesh, and Sri Lanka). These findings assist transportation agencies in identifying the critical elements so they can direct their efforts toward improving mobility on highways. Even though the study identified the factors impacting mobility, there are a few limitations to the experimental design used in this study. First, the sample size of the questionnaire survey is limited, focusing on a particular group of respondents. Second, as the focus of the study was on the level terrain of multilane highways, the road geometry has not been studied in detail. Still, other highway sections with different geometric attributes should be considered in later studies. The result of this study is likely to help the highway authorities to know what road users think about road serviceability so that they can respond to the needs of road users appropriately.

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Therapia: A Turkish Depression Detector Using Language Models

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Abstract **–**Depression is a persistent challenge, often surrounded by social stigma and cultural barriers. Many individuals fail to grasp the magnitude of the mental distress they are experiencing. Even when they recognise their need for professional help, they are often reluctant to seek it due to cultural barriers. To overcome these long-standing stigmas and barriers, it is important to take action that has a broad impact. This study focuses on the development of a tool, Therapia, which provides a platform for people to easily identify if they have symptoms of depression and seek help if necessary. Using fine-tuned language models, users will receive output indicating whether their text has an underlying tone of depression. For the experimental setup, we translate an English depression dataset into Turkish. Experimental results indicate that the fine-tuned Turkish Electra model achieves the highest F1 score of 0.918 compared to different language models, SVM and MultinomialNaiveBayes methods.

Keywords – Turkish, Depression Detector, Dataset, Electra, Language Model

I. INTRODUCTION

Mental health, particularly depression, is a persistent challenge [1], often surrounded by social stigma and cultural barriers. The latest statistics reveal that millions of people suffer from one of these mental health complaints [2]. Society is so accustomed to avoiding discussions about depression that some individuals fail to grasp the extent of the mental distress they are experiencing. Even when they do recognise their need for professional help, cultural barriers often prevent them from seeking it. To overcome these long-standing stigmas and barriers, it is important to take action that has a broad impact.

Users share their feelings on social media platforms, and there are also clinical notes containing patients' mental states. These rich text resources can be analysed through natural language processing by adapting information extraction and mental health monitoring [3]. As an example, Depression: Reddit Dataset [4] provides approximately 7000 cleaned reddit posts including text and label features. Texts are extracted from Reddit posts related to depression, and the label indicates whether a text is classified as depression or not.

This study focuses on the development of a tool, Therapia, which provides a platform for people to easily identify if they have symptoms of depression and seek help if necessary. Users of Therapia can submit any content in text form, including their thoughts, poems, writings, and text messages in Turkish. To train machine learning methods and fine-tune language models, we first translate the depression dataset [4] with an open-source large language model adapted to the task of neural machine translation [5]. We train machine learning methods such as SVM and MultinomialNaiveBayes and fine-tune different language models on the translated and corrected Turkish depression dataset. After predicting the results of the user's input using these models, users receive informed outputs indicating whether their text

has an underlying tone of depression. In addition, these outputs can be observed by mental health professionals to verify the accuracy of the preliminary assessment.

II. MATERIALS AND METHOD

Our web-based application includes machine-learning models that detect users' depression. The first type of models used the Python programming language and libraries such as Scikit-Learn and NLTK. Additionally, tools such as the Pandas library for data preprocessing and CountVectorizer for text mining were used. To fine-tune language models, we apply BERT [6], DistilBERT [7], RoBERTa [8], Electra [9] models incorporating the MDZ Digital Library team (dbmdz) at the Bavarian State Library open sources a cased model for Turkish [10].

A. Neural Machine Translation

The model developed for depression detection was created with anonymized user input collected from social media platforms (Reddit and Twitter). The length of the Turkish translated dataset [11] is about 2000, which is good for accuracy scores and testing. During the creation of the data set to overcome language barriers and perform an effective analysis in Turkish, the collected data was converted from English to Turkish with various translation tools. After the translation process, a series of checks were made on the texts obtained and linguistic inconsistencies and erroneous data were eliminated.

In the process of constructing a dataset for depression detection, initial translation efforts utilized Google Translate and Cambridge Dictionary. However, when the desired consistent translations were not obtained, the dataset was placed at an endpoint via the Therapia application so that domain experts could correct it manually. Table 1 shows the examples of unexpected translations:

Table 1. Error analysis of neural machine translation

In Original Dataset	**Llama2 [10] translation**	**After correction**
"…panick attack…"	panik saldırısı	panik atak
"… shortness of breath…"	nefes kesimi	nefes darlığı
"would anyone like to chat or maybe even voice chat i m just feeling like a total mess at the moment"	herkes sohbet etmek isterse belki de ses söylemek isterse ben şu anda tamamen karışık hissediyorum	herhangi biri sohbet etmek veya belki de sesli sohbet etmek ister mi? Şu anda tam bir karmaşa gibi hissediyorum.
"…i am currently prescribed these..."	ecza verdim	reçetelendirildim

After the correction of the translated texts, usernames in the dataset were anonymized. Many methods were tried for this process, the modules tried and the results in order: (1) re: attempted to use regular expressions (regex) to capture and anonymize usernames. The approach was logically aimed at capturing the annotation ('@') at the beginning of usernames and anonymizing the captured word. This approach could not be implemented because the usernames in the dataset do not contain the "@" annotation. That's why this approach was abandoned. (2) Transformers have very useful functionalities for NLP (such as AutoModelForTokenClassification, pipeline). The AutoModelForTokenClassification class loads a pre-trained token classification model with the specified model name. In this case, "savasy/bert-base-turkish-ner-cased" [12] is a model trained to recognize named entities (Named Entity Recognition, NER) such as name, place, organization on Turkish texts. AutoTokenizer is used for tokenization (word fragmentation) operations suitable for this model.

B. *Therapia Tool*

The Therapia web application is meticulously designed to offer users a robust and responsive experience through a thoughtful combination of cutting-edge technologies. Each component has been carefully chosen to contribute to the overall efficiency, scalability, and user-friendliness of the platform. At the heart of our system lies Node.js, meticulously selected as the backend framework. Renowned for its adept handling of asynchronous tasks, Node.js is instrumental in managing server-side operations with efficiency and speed. It assumes the crucial responsibility of processing user requests, orchestrating data-handling processes, and serving as the foundational backbone of our application. The choice of Node.js reflects our commitment to a responsive, high-performance backend.

The AI service, a pivotal element in our application, is crafted using Python in conjunction with state-of-the-art Natural Language Processing (NLP) and Machine Learning (ML) frameworks. This amalgamation empowers our system to discern and interpret user inputs, providing advanced functionalities such as natural language pattern recognition and machine learning predictions. Python's versatility, coupled with the richness of available libraries, positions it as the ideal choice for implementing intricate AI features that elevate the overall intelligence of our application.

In developing the AI-powered depression analysis application, we carefully selected a set of technologies that align with our objectives for robustness, scalability, and user responsiveness. Our application architecture leverages a combination of modern development frameworks and tools, each chosen for their proven reliability and supportive ecosystems. Figure 1 shows the predicted outcome for a registered user as an example.

Fig. 1 Example of AI feedback for a registered user

III. RESULTS

To compare machine and deep learning models fairly, we transform the Turkish translated dataset into a balanced form. After the transformation, the dataset contains 1000 training or fine-tuning texts, including equally sized samples labelled as depressed and not depressed. Similarly, the test dataset consists of 101 samples for each label, and a total of 202 texts with their labels.

Table 2. Comparison of the models

Model	F1	Accuracy
SVM	0.84	0.84
MultinomialNB	0.89	0.89
DistilBERT	0.909	0.915
BERT	0.917	0.921
RoBERTa	0.905	0.911
Electra	0.918	0.921

Table 2 denotes the experimental results as F1 score and accuracy for SVM and MultinomialNB as the machine learning methods. We also use the Huggingface transformers [13] to fine-tune the DistilBERT, BERT, RoBERTa and Electra models. As shown in Table 2, the transformer models are superior to SVM and MultinomialNB in terms of both F1 and accuracy scores. Among these transformer models, Electra achieves the same accuracy score as the BERT model, but it achieves slightly better performance considering the F1 score. Table 3 shows text samples from the test dataset considering their actual and predicted labels.

Table 3. Error analysis of predicted samples

Turkish Test Data	English Test Data	Actual Label	Predicted Label
dışarı çıkmam gerekiyor ama çok tembelim	…	Not Depressed	Not Depressed
Bugün buraya yetişemedim, yarın kar yağacak diyorlar, ne saçma, bu Tennessee, burada kışın bile kar yağmaz	…	Not Depressed	Depressed
sonunda bunu denemeye karar verdim ve bana şans dileyin.	…	Depressed	Depressed

IV. CONCLUSION

This study proposes the Therapia as an application that aims to reach individuals who refuse to seek help due to social pressure and similar problems. The depression detection functionality will initially be developed in Turkish. In the results obtained from the data allocated for the test, it was observed that most of the results were accurate for the transformer models, but the Electra achieves a slightly better F1 score, among others. As a future direction, we will investigate the metaphors [14] and their effect on the detection of depression in Turkish texts. Furthermore, we will work on different mental health issues in Turkish.

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Sınıflardaki Karanlık Yüz: Yabancı Dil Öğretmen Adaylarının Unutamadığı Etik İhlaller

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Özet – Bu çalışmada Necmettin Erbakan Üniversitesi A.K. Eğitim Fakültesi Pedagojik Formasyon Birimi tarafından yürütülen öğretmenlik Meslek Etiği dersinde öğretmen adaylarının öğrencilik hayatları boyunca yaşadıkları etik olmayan durumların belirlenmesi ve tartışmaya sunulması amaçlanmıştır. Ayrıca çalışmanın bir diğer amacı etik ihlallerin temel etik ilkelerle ilişkisini incelemektir. Çalışmaya toplam 51 (Almanca ve İngilizce) yabancı dil öğretmeni adayı katılmıştır. Katılımcılara "öğrencilik yaşamınızda maruz kaldığınız etik dışı olay/lar var mıdır?" şeklinde açık uçlu soru yöneltilmiştir. Öğrencilerden alınan görüşler daha sonra "Temel Etik İlkelere ilişkin Tanımlar" kapsamında tasnif edilmiştir. Bazı durumlarda karşılaşılan etik ihlaller birden fazla tanımı karşıladığı görülmüş ve bu durum etik ilkelere ilişkin tanımlardan birden fazlasının ihlali olarak değerlendirilmiştir. Araştırma nitel araştırma yöntemi kapsamında fenomenoloji deseni ile yapılandırılmış, öğrenci görüşleri içerik analizi yapılarak analiz edilmiştir. Araştırma sonucuna göre katılımcıların çoğu sağlıklı ve güvenli bir ortamın sağlanmadığını ifade etmişlerdir. İkinci sırada yer alan profesyonellik ilkesi ihlali öğretmenlerin duygularına çabuk kapılıp sınıf terk etme, yaşanılan bir olaya aşırı tepki gösterme gibi sorunları ortaya çıkarmıştır. Üçüncü sırada bulunan saygı ilkesi ihlali öğrencilerin öğretmen tarafından akranlarının önünde hakarete uğradıklarını, rencide edici cezalar aldıklarını göstermektedir. Tarafsızlık, eşitsizlik ve adaletsizlik ilkelerin ihlali kapsamında öğretmenlerin öğrenci kayırdığı, sınav notlarında keyfiyetle davrandığı gibi problemler bulunmaktadır. Ayrıca dile getirilen ihmallerde öğretmenlerin mesleklerinin getirdiği sorumluluklardan kaçtığı da dikkat çekmektedir.

Anahtar Kelimeler – etik, meslek etiği, öğretmenlik mesleği, öğrenciler, etik ihlaller

I. GİRİŞ

Etik kavramını İnayet Aydın "Çok farklı tanımlara konu olsa da en genel anlamda etik, insan tutum ve davranışlarının iyi-kötü, doğru-yanlış açısından değerlendirilmesidir" [1] şeklinde tanımlamaktadır. Etik ve ahlak kavramları biri birinden ilki felsefi boyutunu ifade ettiği, diğerinin ise davranışa aktarılması biçiminde anlaşılması gerektiği ayırt edilir. İnayet Bunu vurgulamak için İonna Kuçuradi'nin şu sözünü alıntılar: "Etik bilgisi kavramlar hakkında düşünmeyi ve onların davranışlarımıza doğru bir biçimde yansımasını sağlar" [2], [3]. Buna göre "Etik sözcüğü bir kimsenin düşünce ve eylemlerinde neyi iyi, neyi kötü saydığı ile ilgili ve bağlantılı olarak davranışlarının sınırlarını ifade eden bir kavramdır. Bu anlamda etik davranan kişi, iyi ve kötü arasında ayrım yapabilen kişidir. Etik değerler, bireylerin davranışlarının etik sınırlarını oluşturmada onlara yardım eder. Etik davranan bir kişi olmak erdemler açısından gelişmiş ve savunduğu değerlerle yaşamak anlamına gelmektedir" [4].

Dünyada Öğretmenlik Meslek Etiği İlkeleri kapsamında "60'tan fazla ülkede eğitim-öğretim çalışanları için etik ilkeler belirlendiğini" belirten Aydın, "Öğretmenlerin, en temel kamu hizmetlerinden olan,

yüksek düzeyde kamusal değer üreten ve topluma hizmet motivasyonu gerektiren bir mesleğin üyeleri olmaları ve bu anlamda görevlerini yerine getirirken, toplumun en değerli varlıkları olan çocukların kendilerine emanet edildiğinin bilincinde; mesleğe olan güveni artıracak bir tutum içinde; öğrencilere, velilere, mesleğe, meslektaşlara ve topluma karşı meslek etiği değer, ilke ve kurallarına uygun şekilde davranmalarının" beklendiği gerekçesiyle "Türk Milli Eğitim sisteminde 24.06.2015 tarihli ve 97202150/730.06/6531543 sayılı Millî Eğitim Bakanlığı Genelgesi (2015/21) ile "Eğitimciler için Mesleki Etik İlkeler" belirlenmiştir. Bu genelge ile ilk kez ülkemizde eğitimciler için etik kodlar kabul edil"diğini [5] hatırlatır.

Bu bağlamda Temel Etik İlkelere İlişkin Tanımlar'a (Profesyonellik, Hizmette sorumluluk, Adalet, Eşitlik, Sağlıklı ve güvenli bir ortamın sağlanması, Yolsuzluk yapmamak, Dürüstlük-doğruluk ve güven, Tarafsızlık, Saydamlık, Mesleki bağlılık ve sürekli gelişme, Saygı, Kaynakların etkili kullanımı) yönelik olarak öğretmen adaylarında farkındalık yaratmak amacıyla bu çalışma ele alınmıştır.

II. ARAŞTIRMA YÖNTEMİ VE DESEN

Çalışmada nitel araştırma yöntemi kullanılmıştır. Nitel araştırma, bir sorunun doğasını araştırmaya, yorumlamaya ve anlamaya yönelik bir yöntemdir ve bu süreçte sorgulayıcı, yorumlayıcı ve sorunun doğal bağlamını anlama yaklaşımlarına başvurur [6].

Çalışma deseni olarak Fenomenoloji seçilmiştir. Fenomenolojik model insanların belirli bir fenomen veya kavram hakkındaki içgörülerini, duygularını, bakış açılarını ve algılarını ifade etmelerine olanak tanıyan nitel bir araştırma desenidir [7]. En kapsamlı anlamıyla fenomenoloji, bir kişinin yaşadığı deneyimlerin bütününü ifade eder [8].

A. Araştırma Problemi

Öğretmen adaylarının, öğrencilik hayatlarında karşılaştıkları etik olmayan davranışlar nelerdir?

Alt Problem

Bu durumları temel etik ilkeler açısından nasıl değerlendirmektedirler?

B. Araştırmanın Örneklemi

Araştırmanın örneklemini 51 İngilizce ve Almanca formasyon öğrencisi oluşturmaktadır.

C. Veri Toplama

Araştırmada veriler açık uçlu soru sorularak yapılan anket aracılığıyla toplanmıştır. Öğretmen adaylarına "öğrencilik yaşamınızda maruz Kaldığınız etik dışı olay/lar var mıdır?" Varsa nelerdir? şeklinde yazılı soru yöneltilmiştir. Anketin geçerliliğini sağlamak adına anket kâğıdına isim yazmamaları istenmiştir.

D. Veri Analizi

Çalışmada veri analizi içerik analiz yapılarak gerçekleştirilmiştir. İçerik analizi, kitaplar, gazeteler, yemek kitapları, şarkılar, politik konuşmalar, reklamlar veya resimler gibi her türlü iletişim içeriğini analiz ederek insan davranışının dolaylı olarak incelenmesini sağlayan bir tekniktir. Bu şekilde, genellikle bir kişi veya grubun bilinçli ve bilinçsiz inançları, tutumları, değerleri ve fikirleri ortaya çıkarılabilir [9].

Açık uçlu anket yoluyla toplanan veriler belirli analiz adımları takip edilerek çözümlenmiştir. Önce kodlar oluşturulmuş, daha sonra benzer kodlar bir araya getirilmiş ve etik ilkeler başlıkları altında kategorilere ayrılmıştır. Verilerin sınıflandırılması, daha etkili bir şekilde analiz edilmesini ve yorumlanmasını sağlamaktadır [10].

III. BULGULAR

Öğretmen adaylarının maruz kaldıkları etik ihlaller içerik analizi yoluyla analiz edilmiş ve "Temel Etik İlkelere ilişkin Tanımlar" kapsamında kategorilendirilmiştir. Bazı durumlarda karşılaşılan etik ihlaller birden fazla tanımı karşılamıştır. Örneğin, bir katılımcının ifadesinde yer alan öğretmenin dersi iyi dinlemiyor diye sınıfı terk etmesi durumu temel etik ilkelerine ilişkin tanımlardan hem profesyonellik ilkesine hem de hizmette sorumluluk ilkesine aykırı bir durumdur. Profesyonel bir öğretmen o anda sınıfı terk etmek yerine öğrencilerin derse tekrar odaklanmasını sağlayacak stratejilerde bulunur. Aynı zamanda bu tür bir durum öğretmenin mesleğinin getirdiği sorumluluktan kaçması durumu olarak ta nitelendirilebilir. Bu çalışmada da buna benzer durumlar etik ilkelere ilişkin tanımlardan birden fazlasının ihlali olarak değerlendirilmiştir.

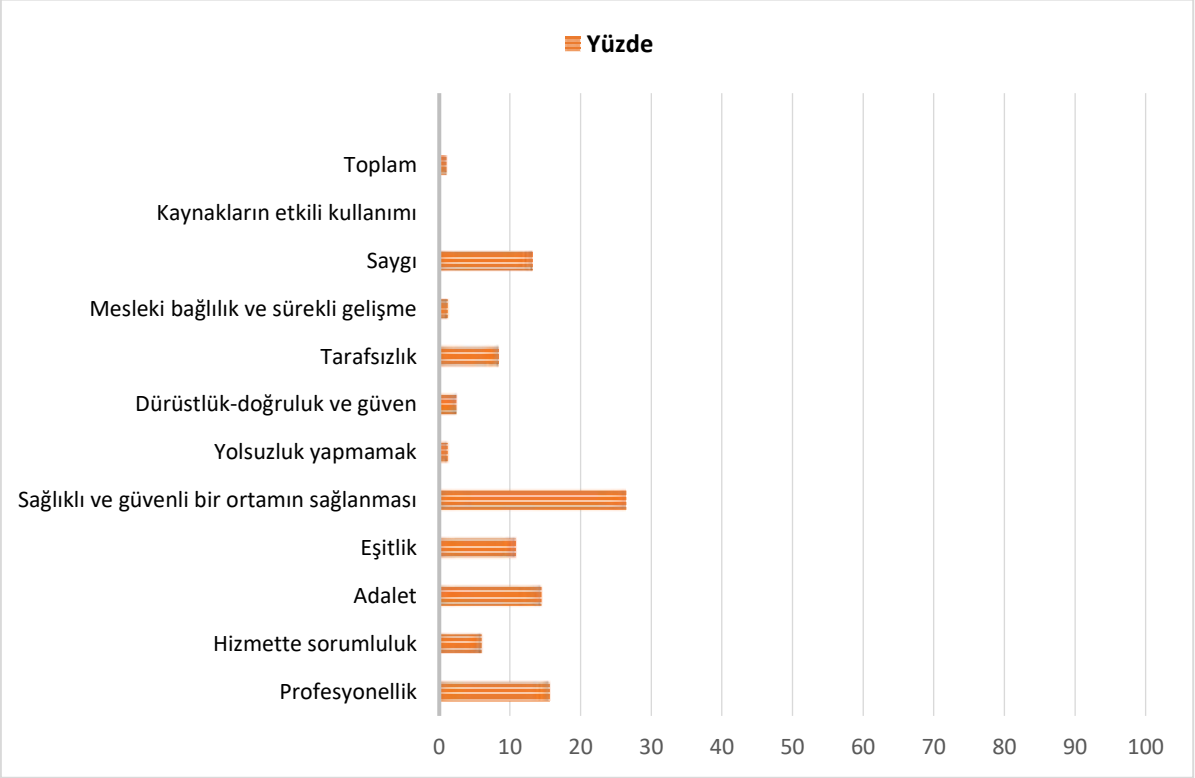
Tablo 1: Öğretmen adaylarının dile getirdiği etik sorunlar

İhlal edilen etik ilke tanımı	**Frekans**	**Yüzde**
Profesyonellik	13	15.66%
Hizmette sorumluluk	5	6.02%
Adalet	12	14.46%
Eşitlik	9	10.84%
Sağlıklı ve güvenli bir ortamın sağlanması	22	26.51%
Yolsuzluk yapmamak	1	1.20%
Dürüstlük-doğruluk ve güven	2	2.41%
Tarafsızlık	7	8.43%
Mesleki bağlılık ve sürekli gelişme	1	1.20%
Saygı	11	13.25%
Kaynakların etkili kullanımı	0	0
Toplam	**83**	**100%**

Çalışmaya katılan 51 öğretmen adayı toplamda 83 etik ihlalden bahsetmiştir. Tablo incelendiğinde en çok yapılan etik ihlal 26.83% ile sağlıklı ve güvenli bir ortamın sağlanması ihlalidir. Bu etik ihlal kapsamındaki öğrenci görüşleri incelendiğinde öğrencilerin şiddete maruz kaldığı aynı zamanda sınıf önünde rencide edildikleri ortaya çıkmaktadır.

İkinci sırada yer alan etik ihlal 15.66% ile profesyonelliktir. 14.46% ile 3. Sırada yer alan etik ihlal Adalettir. Saygı 13.25% ile 4. Sırada yer alırken, Eşitlik ilkesi 10.84% ile 5. Sıradadır. Tarafsızlık 8.43%, hizmette sorumluluk 6.02%, Yolsuzluk yapmamak, Dürüstlük-doğruluk ve güven ile Mesleki bağlılık ve sürekli gelişme ilkeleri 1.20% ile en az yapılan etik ihlallerdendir. Öğretmen adayları kaynakların etkili kullanımına yönelik etik ihlal ile karşılaşmamışlardır.

Şekil 1: Karşılaşılan etik sorunlar yüzdelik dağılımı



Aşağıda etik ilke tanımlarına yönelik yapılan ihlallerden birer tane öğrenci görüşü örneği verilmiştir..

A. *Sağlıklı ve güvenli bir ortamın sağlanması*

İlkokul 1. Sınıf öğrencisiyken, bazı problemlerden dolayı okula geç başladım. İlkokul öğretmenim X, eşinden yeni ayrılmış ve psikolojik problemleri olan bir bayandı. Bir gün bana bütün alfabeyi sayfalarca yazmamı istemişti. Tek bir günde diğerleriyle aynı seviyede olmam ve onlara yetişmem için. Ancak ben sadece T harfine kadar yazabildim. Öğretmen beni tahtaya kaldırdı. Defteri yüzüme fırlattı ve hakaret etmeye başladı. Ben ağlayınca sınıfa arkamı dönmemi ve tek ayak üzerinde durmamı istedi. Annem ertesi gün konuşmaya gitti ama öğretmen annemi dinlemeden sınıftan çıktı. Sonrasında ilkokul öğretmenim değişti

Yukarıda ifade edilen durumda sağlıklı ve güvenli bir ortamın sağlanması ilkesi ihlal edilmiş, öğrenci sağlıklı bir öğrenim ortamından mahrum bırakılmıştır. Ayrıca bu durum incelendiğinde sadece bu ilkenin değil aynı zamanda öğrenciyi tüm sınıfın önünde rencide ettiği için saygı ilkesi de ihlal edilmiştir.

B. *Profesyonellik*

Yukarda sözü geçen bu durumda da öğretmen sınıfın kendisini dinlemediğini hissettiği anda, dikkatlerini kendisine çekecek stratejiler geliştirebilirdi. Sınıfı terk etmek öğrencilere verilen bir cezadan çok, dersi dinlemek istemeyenler için ödül niteliğinde bir tavırdır.

C. *Adalet*

Vize sınavından 70 aldığım dersin final sınavında iyi çalışamadığım için boş kâğıt verip çıktım, bütünlemeye kalmak istediğimi söyledim ama hocamız bana 35 verip cc ile geçirdi.

Öğretmen bu durumda öğrencinin bütünleme sınavına girme hakkını elinden almış ve adaletsiz bir tutum içinde davranmıştır.

D. Saygı

Bundan yaklaşık 7-8 yıl önce bir İngilizce öğretmenim vardı. En sevdiğim ders olan İngilizce o adamın dersiydi. Okulun ilk başlarında derse katılıyordum ve seviyordum. Fakat bir gün durup dururken bilemediğim soruyu aşağılayarak, dalga geçer gibi muamele ederek aslında kendini küçük düşürdü. Yanıma gelip defterimi kontrol ederken bir hışımla defterimi çöpe fırlattı. Zaten olgunluğa erişmemiş, işini severek yapmadığı her halinden belli olan bu şahıs bana ve diğer arkadaşlarıma karşı da kötü ve kaba davranmış olsa da ben her zaman İngilizceyi sevdim.

Yukarda katılımcının ifade ettiği durum etik ilke ihlallerinden saygıya karşılık gelmektedir. Öğretmen yanlış yaptı diye bir öğrencinin defterini yırtma gibi bir hakka sahip değildir. Örnek olması gereken öğretmenin sergilediği bu tutum tam anlamıyla saygısızlıktır.

E. Eşitlik

İlkokul 4. Sınıfta aynı anda bütün bir okulu idare etmekte olan sınıf öğretmenimizin çalışkan öğrencilere yaptığı ayrımcılık gözle görülür bir ayrımcılıktı. Bazen çalışkan bir öğrenciye hediyeler getiriyordu. Bazen de bilgisayarı sadece onun kullanmasına izin veriyordu. Ben o zamanlar küçük olduğum için hep çalışkan olmak için çalışıyordum. Çalışkan olmak hep ayrıcalık gibi görünüyordu. Bence böyle şeyler eğitim kurumlarında yaşanmamalı her öğrenciye eşit davranılmalıdır.

F. Tarafsızlık

Tesettüre yeni girdiğim zamanlar benim sağ görüşlü bir insan olduğumu düşünerek herkesin içinde beynine oksijen gitmiyor dedi. Öğretmen olarak daha doğrusu insan olarak yüreklerde güzel bir iz bırakmak isterim.

İdeolojik ya da siyasi, her ne sebepten olursa olsun öğretmen dersinin dinlenmesi ve verimli geçmesi için tüm öğrencileri kucaklayacak bir tutum içinde olmalıdır.

G. Hizmette sorumluluk

Lisede dil bölümündeki İngilizce öğretmenimiz X hanım, derslere dair anlatım yapmıyordu. Onun sınıfa gelip bizi üniversite sınavına hazırlamaktansa, yanında 8 yaşında oğluyla gelip ders dışı konular konuşmasını hep bana ve sınıfımıza karşı yapılmış bir haksızlık olarak görmüşümdür. Bundan dolayı o öğretmenimin hiçbir zaman mesleğini layığıyla yerine getirdiğini düşünmedim.

Yukarıda bahsi geçen durumda da söz konusu öğretmen öğretmenlik mesleğinin gereği olan hizmeti sunmamış kendisine öğretim için ayrılan dersi ders dışı konulara ayırmıştır.

H. Yolsuzluk yapmamak

Lise yıllarımda Dil bölümü seçmiştim ve en başta dil sınıfı çok keyifliydi. Daha sonra dil öğretmenimiz sınıfta birçok haksızlık yaptı ve sınavı kazanmayı sadece kendisinden özel ders aldığımız durumda başarabileceğimizi söyledi. Özel ders verdiği öğrenci x üniversitesini kazandı.

Burada belirtilen öğretmen mesleğini kendi çıkarları doğrultusunda kullanmış, okulu bir araç görerek maddi gelir elde etmeyi amaçlamıştır. Sahip olduğu akademik bilgiyi extra özel dersler yoluyla aktararak bir bakıma yolsuzluk yapmıştır.

İ. Dürüstlük-doğruluk ve güven

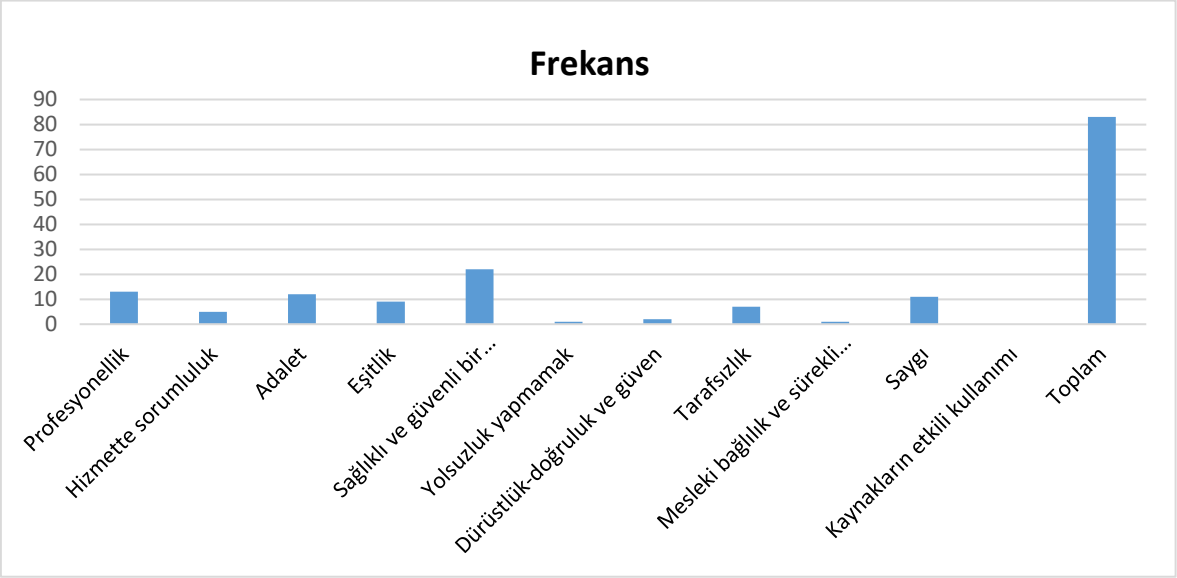
11. sınıftayken hocamız sınav sonuçlarını sınıfta söylüyordu. Benim sınavdan 35 aldığımı söyledi. Sınavım iyi geçmişti ve 35 almadığımdan emindim. Normal olarak kâğıdıma bakmak istedim. Hoca da kağıdıma bakarsam fazladan verdiği puanları alacağını söyledi. Ben de kaybedecek neyim var ki diyerek kağıdıma baktım. Kâğıdın üstünde 75 yazıyordu. Hocam 75 almışım dedim, hocanın bana şaka yaptığını düşündüm fakat hoca bana fazladan verdiğini söylediği 15 puanı geri aldı ve sırama geri oturduğumda 60 almıştım.

Öğretmen öğrencinin aslında hak etmiş olduğu vermeyerek sırf kâğıdına bakmak istedi diye notunu düşürmüş, doğru olmayan tavır sergilemiş ve öğrencinin güvenini sarsmıştır.

J. Mesleki bağlılık ve sürekli gelişme

6. sınıfta Türkçe dersinde proje ödevlerini toplayan arkadaşıma, projeleri evde unuttuğu için yaklaşık 15 dk azarlayıp ne kadar sorumsuz olduğu ondan hiçbir şey olmayacağını söylemişti.

Öğretmen aslında kendi sorumluluğunu öğrenciye yüklemiş ve öğrenci verdiği yükümlülüğünü unuttu diye herkes önünde rencide etmiştir. Öncelikle mesleki bağlılık ve sürekli gelişme ilkesini ihlal etmiş, aynı zamanda saygı ilkesini de beraberinde ihlal etmiştir.



Şekil 2. Karşılaşılan Etik Sorunlar Frekans Dağılımı

IV. TARTIŞMA VE SONUÇ

İngilizce ve Almanca Formasyon öğrencilerinden oluşan 51 kişilik katılımcı bu zamana kadar uğradıkları etik ihlalleri açık uçlu ankete verdikleri yanıtlarla dile getirmişlerdir. Bulgulardan çıkarılan sonuca göre katılımcıların çoğu sağlıklı ve güvenli bir ortamın sağlanmadığını ifade etmişlerdir. Bu öğrencilerin dönütleri ayrıntılı bir şekilde incelendiğinde, cetvel, sopa hatta özel yapılmış vurma aleti ile şiddete maruz kaldıklarını ortaya koymaktadır. İkinci sırada yer alan profesyonellik ilkesi ihlali öğretmenlerin duygularına çabuk kapılıp sınıf terk etme, yaşanılan bir olaya aşırı tepki gösterme gibi sorunları ortaya çıkarmıştır. Üçüncü sırada bulunan saygı ilkesi ihlali öğrencilerin öğretmen tarafından akranlarının önünde hakarete uğradıklarını, rencide edici cezalar aldıklarını göstermektedir. Tarafsızlık, eşitsizlik ve adaletsizlik ilkelerin ihlali kapsamında öğretmenlerin öğrenci kayırdığı, sınav notlarında keyfiyetle davrandığı gibi problemler bulunmaktadır. Ayrıca dile getirilen ihmallerde öğretmenlerin mesleklerinin getirdiği sorumluluklardan kaçtığı da dikkat çekmektedir.

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Anne Sütü İçerik Değerlendirmesi ve Alternatif Sütler

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Özet - Anne sütü her bebeğin kendisine özel üretilen eşsiz besindir. Bu sebeple sağlıklı bir büyüme ve gelişme periyodu için, her bebeğin kendi annesinin sütüyle beslenmesi en ideal beslenmedir. Fakat bazı durumlarda (hastalık, tedavi, kayıp, kişisel-sosyal alanda destek yetersizliği, emzirmek istememe vs.) anne sütüyle besleme mümkün olmayabilir. Böyle durumlarda alternatif besin olarak formül mamalar, içerik olarak ise keçi ve inek sütü ürünleri sıklıkla kullanılan içeriklerdendir. Aynı zamanda ek gıdaya geçişle birlikte bu tarz alternatif sütler bebek beslenmesine direkt olarak da dahil edilebilmektedirler. Her ne kadar formül mamalar içerik olarak ihtiyaca özgü olarak üretilip, anne sütüne benzetilmeye çalışılsalar da keçi, inek sütü gibi alternatif besinler ve anne sütü arasında ciddi içerik farklılıkları bulunmaktadır. Bu çalışmada anne sütünün içeriği ve keçi, inek sütleri gibi alternatif beslenmede değerlendirilen sütlerin benzeşen/farklılaşan yönleri değerlendirilmiştir.

Anahtar Kelimeler: Anne sütü, Bebeklerde beslenme, Bebek beslenmesinde alternatif sütler, Hemşirelik, Pediatri Hemşireliği

GİRİŞ

Anne sütü her annenin kendi bebeği için, gelişim dönemlerine özgü olarak ürettiği özel bir besindir. Anne sütü büyüme ve gelişme için gerekli olan çok sayıda canlı hücre, hormon, aktif enzim yapısı, antikor ve daha pek çok zengin içeriği bünyesinde barındırmaktadır. Bu özel besinin içeriği de bebeğin haftasına, gün içerisindeki emzirme dilimine, emzirmenin baş ya da sonunda olunmasına göre değişim gösterebilmekte, genel olarak kolostrum, geçiş sütü ve olgun süt olarak üç kategoride değerlendirilmektedir [1], [2].

Kolostrum, doğum sonu ilk beş gün süresince salgılanan süttür ve yüksek beta karoten içeriği dolayısıyla koyu sarı bir renge sahiptir. Protein içeriği oldukça yüksek olan kolostrumun olgun süte kıyasla enerji, yağ ve laktoz içeriği daha düşüktür. Vitamin olarak; A, E, çinko ve eser elementler, mineral olarak ise; sodyum, klor ve magnezyum oranı oldukça yüksek olan kolostrumun olgun süte kıyasla potasyum ve kalsiyum oranı daha düşüktür. Kolostrumun en önemli özelliklerinden birisi de bol miktarda antikor ve anti-enfektif protein içeriğidir. Kolostrumun bu özelliği sayesinde bebekler, doğumla birlikte tanıştıkları, hastalık etkeni olabilecek birçok mikroorganizmaya karşı bağışıklık kazanmaktadırlar.

Geçiş sütü, doğumu takiben 5 ve 15. günler arası salgılanan süttür. Kolostruma kıyasla laktoz, enerji ve yağ oranı daha yüksek olan sütün, protein oranı ise daha düşük olarak değerlendirilmektedir.

Olgun süt, doğumdan iki hafta sonra salgılanmaya başlayan ve emzirme bitimine kadar da salgılanım süreci devam eden süttür. Olgun sütte de emzirmenin başı veya sonunda olunmasına göre sütün içeriği değişiklik göstermektedir. Ön süt bebeğe daha çok su, laktoz ve diğer besinleri sağlarken, son süt ise daha yağlı, enerji sağlayıcı ve kilo alımı için gerekli olan kısımdır. Bu sebeple bebekler her bir memede en az 15 dk olacak şekilde tutulmalı, bebeklerin istedikleri ve son sütü de alabilecekleri kadar emzirilmelidirler [3].

Emzirilmeyen/emzirilemeyen bebeklerde alternatif besin olarak sıklıkla formül mamalar kullanılmaktadır. Formül mamaların üretiminde keçi ve inek sütleri sıklıkla kullanılan sütlerdir. Aynı zamanda emzirilen bebeklerde de ek gıdaya geçişle birlikte bu sütler bebek beslenmesine dahil edilebilmektedirler [4], [5], [6]. Bu sebeple bebeklerde büyüme ve gelişme parametrelerinin sağlıklı bir şekilde sürdürülmesi için alternatif sütlerin besin içeriklerinin bilinmesi de önemlidir. Bu çalışmada anne sütünün içerik analizi değerlendirilmiş ve alternatif süt olarak sıklıkla kullanılan keçi ve inek sütlerinin anne sütü ile besin içeriği olarak kıyasına yer verilmiştir.

Anne Sütü İçerik Değerlendirmesi

Anne sütü bir bebeğin beslenmesi için en uygun, bütün ihtiyaçları tek başına karşılayabilecek kadar zengin bir içeriğe sahip eşsiz bir besindir.

Anne sütünün makrobesin içeriği;

- Protein 0.9 - 1.2 gr/dl
- Laktoz 6.7 – 7.8 gr/dl
- Yağ 3.2 – 3.6 gr/dl
- Enerji 65 – 70 kcal/dl' dir.

Anne sütü protein içerikleri; kazein, lizozim, alfa-laktalbumin, laktoferrin, salgısal düzeyde immünglobülin A, serum albümin, esansiyel aminoasitler, folat, D ve B12 vitamini, tiroksin ve kortikosteroid bağlayan proteinler, amilaz, lipaz gibi enzimler ve biyoaktif proteinlerden (epidermal büyüme faktörü, insülin, prolaktin) oluşmaktadır. Anne sütündeki proteinlerin %40 gibi büyük bir çoğunluğunu kazein (miçellerinin çapları küçük), özellikle beta kazein ve whey oluşturmaktadır. Whey proteinleri ve laktoferrin (bakteriyostatik) daha çok enfeksiyonla mücadelede etkilidir. Whey proteinleri alfa-laktalbumin, laktıferrin, lizozim ve immunglobulinlerden oluşmaktadır. Esansiyel aminoasitlerden olan taurin ise safra asidi konjugasyonunda işlevseldir [7], [8].

Karbonhidratlar anne sütünde, başlıca glukoz ve galaktozdan sentezlenir ve laktoz formundadır. Laktoz kolay sindirilmesinin yanı sıra yavaş da sindirildiği için yenidoğanlarda kan şekeri

düzenlenmesinde önemli bir yere sahiptir. Bağırsak bakterileri laktozu laktik aside dönüştürür ve bu dönüşüm patojen mikroorganizmaların enfeksiyon oluşturmasını engeller. Galaktolipidlerin yapısına katılan laktoz, beyin gangliositlerinin yapı ve işlevsel proteinlerini oluşturarak santral sinir siteminin gelişimine de katkı sağlamaktadır. Glikoprotein ve oligosakkaritler de laktozlardan sonra anne sütünde bulunan karbonhidratlardandır. Oligosakkaritlerin bellek oluşum süreci, nöronlar arası iletim ve transaminasyonda görevleri bulunmaktadır. Aynı zamanda oligosakkaritlerin bağırsak mikrobiyom yapısına destek ve probiyotik özelliğiyle anti-enfektif katkısı da bulunmaktadır [1].

Yağlar, anne sütünde enerji sağlayıcı (%35-55) olarak önemli bir göreve sahiptirler. Anne sütünde bulunan yağ yapısı küçük moleküllü ve kolay emilen trigliserit (%97) formundadır. Anne sütünde lipaz enzimi de bulunur ve bu enzim yağların metabolize edilmesini kolaylaştırır. Anne sütü eikosapentoenoik (EPA), linoleik (LA), alfa linolenik (ALA) ve doksahekzaenoik asit (DHA) gibi yağ asitleri içermektedir. Bu yağ asitleri hücre membran yapısına katılır, yağda eriyen vitamin ve hormonların taşınmasında da görev alır. Anne sütü alan bebeklerde plazma kolesterol düzeyleri yüksektir ve bu durum lipid metabolizmasının erken aktive olmasını sağlarken hiperlipidemi ve ateroskleroz gibi durumlara karşı koruyuculuk sağlamaktadır [2], [4], [8], [9].

Anne Sütü ve Alternatif Sütler

Bebek beslenmesinde ilk 6 ay tek başına sonraki 18 ay ise ek gıdayla birlikte en uygun beslenme anne sütüyle yapılandır. Fakat zaman zaman anne sütüyle beslenmenin sağlanamadığı, bebeklerde farklı beslenme tiplerine geçildiği dönemler olabilmektedir. Bu durum bazen zorunluluktan (HIV pozitif, ilaç bağımlılığı, galaktozemi, annenin kansere yönelik kemoterapi alıyor olması veya kaybı gibi) bazense annenin emzirmek istememesi sonucunda ortaya çıkabilmektedir. Bu durumlarda genellikle ilk altı ay formül mamalar kullanılmaktadır. Ek gıdaya geçişle birlikte aileler beslenmeye alternatif sütleri dahil edebilmektedir. Alternatif sütlerin besin içerikleri anne sütüne kıyasla farklı içeriğe sahiptirler. Bebek beslenmesinde alternatif süt olarak genellikle keçi ve inek sütü kullanılmaktadır [10], [11], [12].

Tablo 1. Anne Sütü ve Alternatif Sütlerin Besin İçeriklerinin Makro Düzeydeki Değerlendirmesi

Süt İçeriği (%)	Kolostrum	Olgun Süt	Keçi Sütü	İnek Sütü
Enerji (kcal)	58	70	67	66
Protein (g)	2.3	0.9	2.9-3.4	3.2
Yağ (g)	2.9	4.2	3.8	3.7
Laktoz (g)	5.3	7.3	4.1	4.7
Kolesterol (mg)	27	14-16	11	14
Ig A (mg)	364	142-1000	30-80	140
Ig G (mg)	_	40	100-400	590

Kaynak: [1], [3], [11].

Protein içeriği açısından daha fakir gibi görünen anne sütü, keçi ve inek sütlerine kıyasla daha dengeli ve sindirim kolay proteinler içerdiği için, bebekler için daha faydalıdır. Anne sütüyle gerçekleştirilen beslenmede, immatür olan böbreklerdeki atık yükleri dengelenir ve böylelikle de böbreklerin korunması sağlanmış olur. Sindirimi zor olan kazein ve whey protein oranları keçi ve inek sütünde daha yüksektir. Anne sütünde bulunmayan ve alerji insidansı yüksek olan β-laktoglobulin yine inek sütünde yüksek oranlarda bulunmaktadır. Keçi ve inek sütüyle beslenen bebeklerde bu yükseklikliklerin hastalık oluşumunu tetikleyebileceği düşünülmekte, Tip I diyabet ve alerji insidanslarıyla ilişkilendirilmektedir [5], [13]. Dünya alerji örgütü (World Allergy Organization-WAO), [14] inek sütüyle ilgili alerjilerin bebeklerde sık görüldüğünü (5/1) ve yine alerjiye bağlı olarak bebeklerde; atopik dermatit/egzama, ürtiker , kolik, ishal, kusma, tekrarlayan hışıltı ve rinit gibi istenmeyen durumların görülebileceğini bildirmektedir.

İnsan, keçi ve inek sütlerindeki yağlar genellikle trigliserit yapısındadır fakat yağ asidi bileşimleri değişiklik gösterir. İnsan sütünde diğer sütlere kıyasla doymamış yağ asidi oranı daha fazladır. Anne sütündeki linoleik asit ve alfa-lineloik asit, bu asitlerin dönüşümüyle oluşan araşidonik asit (AA), eikozapantoenoik asit (EPA) ve dekosaheksaenoik asit (DHA) anne sütünde bulunurken, keçi ve inek sütünde bulunmamaktadır. Özellikle göz, beyin gibi organların gelişimi için çok önemli olan yağ asitleri, büyüme – gelişme faaliyetlerinin düzenlenmesi, inflamatuvar yanıt, bağışıklık ve fonksiyonel gelişim için de elzemdir. Sütte laktoz formunda bulunan karbonhidrat oranı, anne sütünde daha fazladır. Keçi ve inek sütünde bulunmayan ve anne sütünde yer alan oligosakkaridler sayesinde bebekler bağırsak enfeksiyonlarına karşı da koruyuculuk kazanırlar [5], [10], [11], [13], [15].

Tablo 2. Anne Sütü ve Alternatif Sütlerin Vitamin İçeriği Açısından Değerlendirmesi

Sütlerin Vitamin Değerleri (%, mg)	Kolostrum	Olgun Süt	Keçi Sütü	İnek Sütü
Vitamin A	89	67	**48**	**37**
Vitamin D	_	0.05-0.1	**0.06-0.1**	**0.2**
Vitamin E	1280	315	**0.05**	**0.08**
Vitamin K	0.23	0.21		
Folik Asit	_	5.5-8.5	**1**	**5**
Vitamin B12	200	26	**0.065**	**0.51**
Vitamin C	_	**5**	**1.1**	**1**

Kaynak: [1], [10].

Tablo 3. Anne Sütü ve Alternatif Sütlerin Mineral İçeriği Açısından Değerlendirmesi

Sütlerin Mineral Değerleri (%, mg)	Kolostrum	Olgun Süt	Keçi Sütü	İnek Sütü
Kalsiyum	**23**	**28**	**134**	**112**
Magnezyum	**3.4**	**3**	**16**	**11**
Sodyum	**48**	**18**	**41**	**42**
Potasyum	**74**	**58**	**181**	**145**
Demir	**45**	**40**	**0.3**	**0.1**
Çinko	**540**	**120**	**0.3**	**0.4**

Kaynak: [1], [5], [10].

Anne sütü bebekler için yeterli vitamin (D ve K hariç) ve mineral (Ca ve Fe hariç) değerlerine sahiptir. Anne sütü, keçi ve inek sütüne kıyasla C, D ve A vitamini bakımından daha zengindir. Sodyum, K, Ca ve P içeriği yüksek olan keçi ve inek sütleri bebeklerde solut yük fazlalığı oluşturur ve böbreği zorlayabilir [3], [5], [10], [11], [15].

Anne sütü zengin içeriğine rağmen bazı vitamin ve mineraller açısından da eksikliklere sahiptir. Anne sütünde Fe oldukça düşüktür fakat emiliminin diğer sütlere kıyasla daha iyi olması 4. ay bitimine kadar ihtiyaç hissettirmez. Bu aydan sonra ise bebeğe düzenli takviye verilmelidir. Anne sütü kalsiyum oranı da düşüktür fakat kalsiyum / fosfor (2/1) oranının uygunluğu kemik, eklem ve kıkırdak gelişimi için yeterli desteği sağlar. Anne sütünde D ve K vitaminleri de bulunmaz. Bu sebeple K vit doğum sonu, D vit ise doğumdan bir yaşına kadar 400 Ü/gün olacak şekilde kullanılmalıdır [1].

Bider-Canfield ve arkadaşlarının (2011) anne sütü alan bebeklerde çocukluk çağı obezitesine karşı koruyuculuğunu araştırdıkları çalışmada; 6 aydan uzun süreli emzirmenin bebeklerde, 2 yaş çocukluk obezitesine karşı koruyuculuğunun olduğu tespit edilmiştir. Demmelmair ve arkadaşlarının (2024), formül mamalarda kullanılan keçi ve inek sütünün anne sütüne kıyasla plazma sfingomiyelinleri ve karnitin esterleri düzeylerini kıyasladıkları çalışmada anne sütü ile diğer sütlerden üretilen formül mamalar arasında farklılıklar bulunmuştur. Aynı çalışmada aynı zamanda kolesterol metabolizması ve lipoprotein düzeylerinde de farklılıklar tespit edilmiştir. George ve arkadaşlarının (2023) anne sütü ile keçi ve inek sütünü lipit profili ve gelişim desteği açısından inceledikleri çalışmalarında, anne sütü plazma lipit bileşenlerinin (eter lipidleri) diğer sütlere kıyasla oldukça yüksek oranda olduğu ve bu durumunda bebeklerin gelişim ve korunmalarına ciddi katkı sağlayacağı belirtilmektedir. Zhou ve arkadaşlarının (2014) keçi ve inek sütünden üretilen formül mamaları, bebeklerdeki plazma bileşenleri ve gelişim parametreleri üzerinden değerlendirdikleri çalışmalarında her iki mama türüyle beslenen bebeklerde benzer plazma değerleri (aminoasit düzeyleri ve kan biyobelirteçlerinde farklılıklar bulunmuş ama istatistiksel anlamlılık tespit edilmemiş) ve gelişim parametreleri tespit etmişlerdir.

SONUÇ

Anne sütü yenidoğan bebeklerin beslenmesinde, optimal düzeyde büyüme ve gelişmenin sürdürülmesi için gerekli olan tüm sıvı ve besin öğelerini içeren, yeterli seviyede enerji sağlayan yegane besindir. Anne sütü, doğal, sindirimi kolay, biyoyararlılığı yüksek, zengin içeriğe sahip ve her bebek için gelişim dönemi ihtiyaçlarına özgü olarak üretilen benzersiz bir besindir. Anne sütüne kıyasla keçi ve inek sütleri protein, yağ, şeker, kalsiyum, sodyum, potasyum, magnezyum, sülfür ve fosfor gibi değerler açısından farklılıklara sahiptir. Bebek beslenmesinde gereğinden fazla olan her bir besin, vitamin ve mineral içeriği bebeklerde solüt yükü arttırabilmekte ve böbrekleri zorlayabilmektedir. Kısa vadede organlarda zorlanmaya sebep olabilecek olan sütler uzun vadede de gelişimin yeterli seviyelerde olmaması, daha fazla enfeksiyon riski, obezite, diyabet gibi hastalıklarda artış zekâ gelişiminde gerilik gibi etkileri görülebilmektedir. Her ne kadar bazı durumlarda emzirmenin sürdürülmesi mümkün olmasa da anne sütü en uygun besindir.

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Emzirme ve Kazanımları

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Özet - Bir bebeğin beslenmesinde optimal gelişim kriterlerini sağlayabilmek için en uygun olan beslenme tipi her bebeğin kendi annesi tarafından emzirilmesi ve böylelikle anne sütüne ulaşmasıdır. Tıbbi bir gerekçe olmadığı sürece bebeklerin doğum sonu ilk altı ay sadece emzirilmesi, altı aydan sonra ise ek gıdayla birlikte iki yaşa kadar eylemin sürdürülmesi önemlidir. Gerek uluslar arası gerekse ulusal düzeylerde birçok farklı sebepten ötürü halen birçok bebek emzirilmemektedir. Bu sebepler bazen tıbbi gerekliliklerden dolayı ortaya çıksa da aile ve sosyal çevreyle ilgili faktörler de emzirmenin kesintiye uğraması ya da bırakılmasında etkili olabilmektedir. Erken dönem başlatılan ve iki yaşına kadar devam edilen emzirmelerde, öncelikle bebek sağlığı, sonrasında ise anne ve toplum sağlığı adına pek çok kazanım sağlanmaktadır. Erken dönem emzirmeyle birlikte bebeklerin optimal büyüme ve gelişmesi, hastalıklardan korunması, anne bebek bağlanma süreci ve güven duygularının desteklenmesi gibi daha birçok kazanım sağlanabilmektedir. Emzirme eyleminin bebek haricinde anne ve toplum sağlığına da katkıları bulunmaktadır. Sağlık kurumlarında anne ve bebekle teması olan sağlık profesyonellerinin emzirmenin önemi noktasında farkındalıklarının yüksek olması, gerektiği durumlarda eğitim ve danışman rollerini üstlenmeleri anne, bebek ve toplum sağlığı için önemlidir. Bu çalışma emzirme ve kazanımlarının önemini bir kez daha vurgulamak amacıyla gerçekleştirilmiştir.

Anahtar Kelimeler: Emzirme, Emzirmenin Kazanımları, Bebeklerde Beslenme, Hemşirelik, Pediatri Hemşireliği

GİRİŞ

Emzirme, tıbbi bir gerekçe olmadığı sürece, doğumu takiben ilk yarım saat içerisinde başlatılması ve özellikle ilk altı ay tek başına, sonrasında ise ek gıdayla birlikte iki yıl devam ettirilmesi gereken bir eylemdir. Emzirmenin başlatılmasında en uygun zaman dilimi olarak ifade edilen doğum sonu ilk yarım saatte bebek, birinci reaktif dönemdedir. Birinci reaktif dönemdeki bebeklerde ağlama, emme, bağırsak sesleri gibi emzirme için gerekli olan aktiviteler yeterli düzeydedir. Bu sebeple erken dönem emzirme eyleminin başlatılması ve emzirmenin sürdürülebilirliği için birinci reaktif dönem uygun zaman dilimidir. Erken dönemde emzirme başlatılamayan bebeklerde 3-4 saatlik inaktif dönem başlar ve bu dönemde bebeği uyandırmak ya da emzirmek oldukça güçtür. Bu durumda, bebeklerde hipoglisemi görülme riski artış göstermektedir [1], [2]. Erken dönem başlatılan emzirme eylemiyle birlikte annenin her iki göğsü de uyarılmalıdır. Göğüslerin uyarılmasıyla birlikte, annede süt üretiminin başlatılması uyarılırken, emzirmenin uzun vadede sürdürülebilirliği de desteklenecektir. Başarılı bir emzirme ile bebeklerin

optimal büyüme ve gelişmeleri desteklenirken, aynı zamanda mortalite ve morbidite görülme riski de azaltılmış olacaktır. Emzirme bebek beslenmesinde en uygun beslenme tipidir, bu eylem bebeğe sağladığı fayda kadar da anne sağlığı ve aile ekonomisinin desteklenmesine katkı sunmaktadır. Doğum sonu dönemde emzirme, bebeklere sağlıklı yaşam için ihtiyaç duydukları tüm besinleri sağlayan, bebeklerin büyüme ve gelişmesini destekleyen, bebek ve çocuk sağlığını geliştiren beslenme şeklidir [3], [4]. Bebeklerde yeterli ve dengeli beslenmenin sağlanılması için en ideal beslenme tipi emzirmedir. Emzirmeyle birlikte bebeklerin anne sütü alması ilk altı ay suya bile gereksinim olmadan bebeğin bütün ihtiyaçlarını karşılamaktadır. Anne sütü zengin içeriğiyle birlikte, sindirimi de henüz immatür sistemlere sahip bebekler için en kolay olan süttür. Bebeklerin her istediğinde ya da en geç 3-4 saatte bir emzirilmesi önerilmektedir. Bebek emzirme işleminde her memede en az 15 dk aktif emzirilerek tutulmalı ve bebeğin ön/son sütü alması sağlanılmalıdır. Başarılı bir emzirme ile bebeğin ihtiyaç duyduğu kalori kazanımı elde edilmektedir [5], [6], [7].

Bebek sağlığı için çok önemli bir yere sahip olan emzirme ve anne sütüne her bebeğin sahip olabilmesi için, uluslararası çapta Dünya Sağlık Örgütü (World Health Organization-WHO) ve Birleşmiş Milletler Çocuklara Yardım Fonu (United Nations International Children's Emergency Fund -UNICEF), bu kurumların kararları doğrultusunda ise ülkemiz Sağlık Bakanlığı her türlü girişim ve uygulamaları yönetmektedirler. Hastanelerde emzirmenin desteklenilmesi için WHO ve UNİCEF tarafından küresel çapta "Bebek Dostu Hastane Girişimi" 1992 yılında başlatılmıştır [8]. Yine emzirme oranlarının iyileştirilmesine yönelik 2002 yılında "Bebek Beslemesine Yönelik Küresel Strateji" aynı kurumlar tarafından oluşturulmuştur. Bu stratejilerle birlikte başarılı emzirmeye ulaşmak için on adım formülize edilmiştir fakat günümüzde halen emzirme oranları hedeflenilen düzeylerden çok daha düşüktür [7], [9]. Dünya Sağlık Örgütü' nün ilk altı ay için emzirilen bebek oranları 2017 verilerinde, uluslararası lansmanda % 40 olarak değerlendirilirken, 2023 yılına gelindiğinde ise bu oran %48' e yükselmiştir [10], [11]. Ülkemizde ise bu oran Türkiye İstatistik Kurumu (TÜİK) tarafından %88.5 olarak açıklanmaktadır [12].

Başarılı Emzirme İçin On Adım

Doğum ve yenidoğan üniteleri gibi bebeğin emzirilmesiyle ilişkili olabilecek bütün sağlık kuruluşları ve görevli personelin aşağıdaki kurallara uymasının gerektiği belirtilmektedir.

1. Sağlık kuruluşunda çalışan tüm sağlık personeline düzenli olarak iletilecek, yazılı bir emzirme politikasının oluşturulması

2. Hazırlanan politikada yer alan ilkelerin yürütülmesi ve gerekli olan becerilerin kazanımı için eğitim programları hazırlamak

3. Hamile kadınların doğum öncesi emzirmenin yararları ve uygulanması konularında bilgilendirilmelerinin sağlanılması

4. Doğum sonrası ilk yarım saatin içerisinde emzirmenin başlatılmasına yardım etmek

5. Emzirmenin nasıl yapılacağını göstermek, anne ve bebeğin ayrı kalmalarının gerektiği sağlık sorunlarında emzirmenin sürdürülebilirliğiyle ilgili bilgileri vermek

6. Herhangi bir hastalığa bağlı tıbbi bir gereksinim olmadığı sürece bebeğe anne sütünden başka herhangi bir yiyecek ya da içecek vermemek

7. Doğum sonu tıbbi gereklilikler dışında, anne ve bebeğin ayrılmadan ve sürekli aynı odada kalmasını sağlamak

8. Annenin isteğe bağlı olarak emzirmesini özendirmek

9. Anne sütü alan bebeklerde biberon ya da yalancı emzik gibi emzirmenin sürdürülmesini engelleyebilecek herhangi bir şey vermemek

10. Emzirmenin taburculuk sonrası da sürdürülebilirliği, sorunları çözebilmeleri, bebek ve annelerin kontroller için gidebilecekleri sağlık kurumları ve emzirme destek grupları hakkında bilgilendirilmelerinin sağlanması şeklindedir [5], [13].

Emzirme Tekniği

Başarılı emzirme ve süreklilik, iyi bir eğitimle birlikte annenin kendine olan güvenin desteklenmesiyle mümkündür. Her anne emzirme konusunda eğitim almalı ve gerektiği durumlarda danışmanlık hizmetine ulaşabilmelidir. Bebek ve anne adına en iyi faydalanım, sürecin de iyi bir şekilde yönetimi için ilk emzirmelerde hazırlık, planlama ve destek önemlidir [14].

Emzirme öncesi;

- Anneye emzirmeyle ilgili gerekli eğitimler verildikten sonra, emzirmenin önemi de vurgulanılarak işlem hazırlıklarına geçilmelidir.
- Emzirme işlemi için ilk etapta mahremiyete uygun, sessiz, sakin bir ortam ve uygun zamanlamanın planlanmış olması gerekmektedir.
- Annenin kendine güven duyması ve hazır oluşluğu desteklenmelidir
- Bebeğin uyanık, altı temiz ve aranma davranışı sergiliyor oluşuna dikkat edilmelidir.
- Uyuma süresi 3 saati geçen yenidoğanlar, hipoglisemi riskinden dolayı emzirmek için uyandırılmalıdır.
- Anne ve yenidoğan hemşiresi emzirme öncesi ellerini yıkamalı ve hijyen kurallarına dikkat etmelidirler

Emzirme eylemine anneye rahat edeceği, sırt destekli bir pozisyon verilerek başlanılır. Annenin bebeği nasıl tuttuğu başarılı emzirme için önemlidir. Uygun emzirme pozisyonları, kucak, ters kucak, futbol ve yatarak emzirme şeklindedir fakat eğer ki annenin kendisini rahat hissettiği, etkili emzirmeyi de engellemeyecek bir başka pozisyon varsa o da desteklenebilir.

Kucak (beşik) pozisyonu; bebek yatay konumda, yüzü memeye dönük olacak şekilde annenin tek koluna yerleştirilir. Bebeğin başı annenin kolunun iç dirsek kısmında, poposu ise aynı kolun elinin içerisinde olacak şekilde yatırılır. Sıklıkla kullanılan bu pozisyonda diğer el memeyi tutmak için kullanılır.

Ters kucak; bebek kucak pozisyonuna göre tam ters konumda tutulur. Bebeğin başı avuç içine poposu ise kol içine doğru yatırılır, bebek memeye dönüktür. Diğer el yine memeyi tutmakta kullanılır.

Futbol tutuşu; ters kucak tekniğine benzer olan bu teknikte bebek koltukaltına doğru ayakları gelecek şekilde kaydırılır. Bebeğin başı yine annenin avuç içine gelecek şekilde yerleştirilir. Çoklu doğumlarda ya da sezaryen doğumlarda tercih edilebilir.

Yatarak emzirme; annenin yan yatar pozisyonda baş ve sırtı yastıkla desteklenir. Bebek anneye dönük olacak şekilde yan konumda yatırılır. Anne bebeğe rahat hissettiği koluyla destek olur [2], [5], [15].

Hangi pozisyon tercih edilirse edilsin, bebeğin tüm vücuduyla anneye dönük olması, bebeğin poposuyla birlikte tüm vücut desteklenmesi, bebeğin boynunun düz ya da hafif geriye doğru olması, annenin dik ve rahat edeceği şekilde oturması, bebeği kendisine yaklaştırması önemlidir. Anne ve bebek için en uygun olan pozisyon seçildiğinde, meme başının bebeğin ağzına yerleştirilmesine geçilir. Memeyi tutturmak için bebeğin uyanması, aranması ve anneyi tanımasına zaman tanınmalıdır. Meme ucu ya da süt bebeğin dudaklarına dokundurulmalı, bebek ağzını açınca areolanın alınabilen kadarı ağza yerleştirilmeli ve bebeğin emmesi takip edilmelidir. Bebeğin etkili bir şekilde emebilmesi için memeyi doğru kavraması gerekmektedir. Memeyi doğru kavrayan bebeğin ağzı geniş, alt dudağı dışa dönük, çenesi annenin memesi ile temas halinde, yanakları yuvarlak ve dolgun, areolanın büyük kısmı bebeğin ağzındadır. Emzirme esnasında anne memesini C tekniğiyle tutup, bebeğin burnu açık olacak şekilde desteklemelidir. Bebek her bir memede istediği kadar (en az 15 dk) kalacak şekilde emzirilmeli ve bebeğin son sütü de alması sağlanmalıdır. Annenin sütünün çok olduğu durumlarda her emzirmede dönüşümlü olarak değişim yapmak kaydıyla tek meme verilebilir. Emzirme sırasında etkili bir emzirme sağlanıp sağlanmadığı takip edilmelidir. Etkili emzirmede; bebeğin sütü yutuşu duyulabilir ya da görülebilir, çene kasları aktif hareket eder, göğüs yumuşar, bebek memeyi kendi isteğiyle bırakır, anne için emzirme süreci rahat ve zevklidir [16], [17].

Yenidoğanlarda etkili ve başarılı emzirme uzun günlük kilo alımı ile takip edilmektedir. Yenidoğanlar ilk haftalarda doğum kilolarının %7-10' unu kaybederler ve bu durum fizyolojik kayıp olarak tanımlanır. Bu bebeklerin 10-14. günlerde doğum tartısına ulaşması ve kilo alımının devam etmesi beklenilir. Günlük tartının mümkün olmadığı durumlarda, bebeğin günde 6-8 kez idrar yapıyor oluşu ve aylık en az 500 gr kilo alması normal olarak değerlendirilir. Bebek her ağladığı ve istediğinde

emzirilebileceği gibi, yenidoğanlarda hipoglisemi riski bulunduğundan uyuma süresi 2-3 saati geçerse de uyandırılıp emzirilmelidir [14], [15], [16], [17].

Emzirmenin Kesilmesi Gereken Durumlar

Sağlıklı bir büyüme ve gelişim süreci için her bebeğin anne sütü alması elzemdir fakat bazı durumlarda bebeği korumak adına, emzirmeye kısa süreli ara verilmesi ya da emzirmenin bırakılması gerekebilir.

Annede aşağıdaki sorunlardan herhangi birisi varsa bebeğin emzirilmemesi gerekir;

- HIV olması durumu
- İlaç bağımlılığı
- Tedavisiz aktif Tbc
- Galaktozemi

Anne için aşağıdaki durumlardan herhangi birisi söz konusu ise emzirmeye geçici olarak ara verilmesi gerekebilir;

- Radyoaktif izotop tedavisi
- Antimetabolit tedavisi
- Kanser kemoterapisi [16]

Bütün bu tıbbi gerekliliklerin dışında, zaman zaman başka sebeplerden dolayı da emzirmenin kesintiye uğradığı veya bırakıldığı görülebilmektedir. Johnston ve Esposito (2007)' nun çalışmalarında, annelerin kişilik özellikleri, kişisel ve sosyal destek faktörlerinin eksikliği, sosyal alan ve çalışan anneler için iş yerinde karşılaşılan güçlükler, annelerin tam zamanlı çalışması gibi durumların emzirmeyi olumsuz etkileyebileceği belirtilmektedir. Doğum türünün de erken dönem emzirmeyi sekteye uğratabileceği, bu durumun da emzirme öz yeterlilik düzeyleri ve sürdürülebilirliği etkileyebileceği belirtilmektedir [19].

Emzirmenin Kazanımları

Bebek Açısından;

- Büyüme ve gelişmeyi destekleyecek en iyi besindir
  - Doku ve organlarda olgunlaşmayı sağlar
  - Anne-bebek ilişkisini güçlendirir
  - Bebeğin fiziki, ruhsal, zekâ ve entellektüel gelişimini destekler
  - Algılayıcı zihinsel yapıları, dil ve motor gelişimi destekler
  - Çene ve diş gelişimi için katkıları vardır
  - Dikkat eksikliği ve otizm gibi nörogelişimsel hastalıklar için koruyuculuk sağlar
  - Bebeğin mikrobiyom yapısını geliştirdiği için bağışıklık sistemini destekler

- Akut ve kronik hastalıklara karşı koruculuğu vardır (Alt solunum yolu hastalıkları, otitis media, idrar yolu enfeksiyonları, gastroenterit, nekrotizan enterokolit, crohn's hastalığı, hipertansiyon, diyabet, lösemi, obezite, alerjik hastalıklar ve ani bebek ölüm sendromu vb.) [7], [15], [20]

Sean Deoni ve arkadaşlarının (2013) emzirilen bebeklerde zekâ gelişimini sorgulamak için gerçekleştirdikleri çalışmada 10. aya kadar emzirilen bebeklerde myelinizasyonla birlikte beyaz cevher alanının gelişiminin daha fazla olduğu bulunmuştur. Yine Dangat ve Joshi (2023)' nin çalışmasında da emzirme ile zekâ gelişimi arasında pozitif yönlü bir ilişkinin bulunduğundan bahsedilmektedir. Ghozy ve arkadaşlarının (2020) otizm spektrum bozukluğu (OSB) ve emzirme ilişkisini araştırdıkları meta-analiz çalışmalarında OSB ve emzirme arasında emzirilme oranlarına paralel negatif yönlü ilişki saptanmıştır. Yine aynı çalışmada özellikle 24 ay emzirmenin OSB riskinin azaltılmasında oldukça önemli olduğu vurgulanmaktadır. Yang ve arkadaşlarının (2024) emzirilen bebeklerde, akut bir vaskülit olan Kawasaki hastalığının görülme riski ile ilişki değerlendirdikleri meta-analiz çalışmalarında emzirme ve Kawasaki hastalığı arasında negatif yönlü bir ilişki bulunmuştur. Bider-Canfield ve arkadaşları (2011), 6 aydan uzun süreli emzirmenin bebeklerde 2 yaş çocukluk obezitesine karşı koruyuculuğunun olduğu tespit etmişlerdir. Kramer ve arkadaşları (2009) ise bebeklik dönemi emzirilen ve emzirilmeyen çocukların 6,5 yaşındaki antropometrik ölçümlerinde farklılıkların bulunmadığını ve obezitenin erken dönemi kapsayabileceği de belirtmektedirler.

Anne Açısından;

- Over, meme, endometrium gibi kanserler karşı koruyucudur
- Osteoporozdan korur
- Oksitosinin uterus kasılması sağlamasıyla toparlanma sürecine yardım eder
- Kontrasepsiyon sağlar
- Annenin kilo vermesine yardımcıdır
- Annelik duygusunun gelişmesine destek sağlar
- Anne-bebek arası bağı güçlendirir
- Doğum sonu psikiyatrik rahatsızlıkların görülme sıklığını azaltır
- Emzirme doğal sakinleştiricidir, anne kaynaklı istismar ve ihmaller açısından koruyucu etki oluşturur [7], [27]

Lojander ve arkadaşları (2024), başarılı ve sürdürülebilir bir emzirme için erken dönemde annelerin emzirmeyle ilgili eğitimlere katılmalarının önemli olduğunu vurgulamaktadır. Yine aynı çalışmada ilk bebeğine sahip olan kadınlarda desteğin daha önemli olduğu, destek faktörlerinin güçlendirilmesi ve danışmanlığın sürdürülmesinin önemi vurgulanmaktadır. Ljungberg ve arkadaşları (2024), babaların emzirme problemlerinde eşlerine destek olmalarının süreci kolaylaştıracağı fakat babaların da danışmanlığa ihtiyaç duydukları belirtilmektedir. Burton ve arkadaşlarının (2024), fotoses

temelli emzirmeyi destekleyen çevre ortamlarının etkinliğini değerlendirdikleri bir çalışmada; emzirmenin algılanan ortama göre konfor düzeyi ve duyguları etkileyebileceğini, bu durumun da emzirme başarısına etki edebileceğini belirtmektedirler. Aynı çalışmada emzirmenin desteklenmesi ve sürdürülebilirliği için sağlık kurumları dışında kafe, restoran gibi mekanlarda da emziren anneler için destek alanlarının oluşturulmasının sürece olumlu katkı sağlayacağı belirtilmektedir. Benzer bir diğer çalışmada da Furness ve arkadaşları (2022), sosyal alanda emzirme davranışları, konfor alanı ve duygusal etkilenimleri araştırdıkları çalışmalarında; sosyal alanlarda emzirme desteğinin yetersiz olduğu, konfor alanının düştüğü ve duygusal olarak olumsuz etkilenimlerin görüldüğünü belirtmektedir. Tchakounte ve arkadaşlarının (2024) şiddetin fiziksel, duygusal ve cinsel boyutlarında emzirmenin etkilenim düzeylerini araştırdıkları çalışmada; özellikle duygusal ve cinsel şiddetin var olduğu durumda emzirmenin erken dönem başlangıcında sorun yaşanabileceği belirtilmektedir.

Anne sütünün anne, bebek için sağladığı faydaların yanı sıra; ekonomik, kolay ulaşılabilir, her zaman taze üretilir ve mikroorganizma kontaminasyon riskinin bulunmaması da birer avantaj sağlamaktadır. Başarılı bir emzirme ile anne ve bebek sağlığının desteklenmesi, aile sağlığının iyileştirilmesi ve sürdürülmesi aynı zamanda da daha sağlıklı gelecek nesillerin oluşumunun desteği ile toplum sağlığının desteklenmesini gibi kazanımlar sağlanmaktadır. Bütün bu sebeplerle tıbbi bir gerekçe olmadıkça anne sütü bir bebeğin beslenmesinde her zaman öncelikli besin olmalı ve her bebek annesi tarafından önerilen sürelerce emzirilmelidir [6], [13], [28].

SONUÇ

Başarı bir emzirmeyle birlikte bebeklerin özellikle ilk altı aylık dönemde anne sütüyle beslenmesi, onlar için optimum büyüme ve gelişmenin sağlanmasında elzemdir. Emzirmeyle birlikte bir bebeğin ihtiyaç duyabileceği bütün sıvı, enerji, besin ihtiyaçları karşılanabilir. Anne sütü aynı zamanda bir bebek için biyoyararlılığı yüksek, sindirimi kolay, solüt yükü dengeli ve dönem ihtiyaçlarına göre içeriği değişen özel bir besindir. Başarılı bir emzirmeyle birlikte bebeğe sağlanacak olan faydaların yanı sıra anne ve toplum sağlığı için de kazanımlar elde edilmektedir. Bu kazanımlar; gelişimsel, psikolojik, sosyal ve ekonomik alanlarda gerçekleşmektedir. Bu sebeple sağlık kurumlarında yer alan profesyonellerin, özellikle de pediatri hemşirelerinin emzirmeyi teşvik edici yönde tavır sergilemeleri, bu süreçte eğitimci ve danışman rollerini aktif bir şekilde kullanmaları bebek, anne, aile ve toplum sağlığının geliştirilmesi ve sürdürülmesi için önemlidir.

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Otomotiv Yan Sanayinde Kalite Güvence: İstatistiksel Süreç Kontrolü ve Süreç Yeterlilik Analizinin Rolü

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Özet – Bu çalışma, yoğun rekabetin yaşandığı günümüz iş dünyasında firmaların ayakta kalabilmesi için ürün kalitesini artırmalarının kaçınılmaz olduğunu vurgulamaktadır. Bu amaçla, istatistiksel kalite kontrol teknikleri kullanılarak ürünlerin kalite düzeyi sürekli izlenmekte ve iyileştirilmektedir. Araştırma, Konya'da bulunan bir otomotiv yan sanayi firmasının üretim sürecindeki mafsal istavrozu üst torna operasyonunda dış çap ölçümlerinin kontrol altında olup olmadığını incelemektedir. Geçekleştirilen analizlerde süreç yeterliliği Cp ve Cpk indisleri yardımıyla değerlendirilmiştir. Ayrıca, $\bar{X}$ ve R kontrol şemaları kullanılarak mevcut süreç incelenmiştir. Sonuçlar, ilgili sürecin kontrol altında olduğunu ve istikrarlı bir şekilde işlediğini göstermiştir. Çalışmada ulaşılan bulgular, modern iş dünyasında kalite güvenceyi sağlamak amacıyla ilgili yöntemlerin istikrarlı bir şekilde kullanımının önemini göstermektedir.

Anahtar Kelimeler – İstatistiksel Süreç Kontrol, X-R Kontrol Grafiği, Süreç Yeterliliği, Kalite Güvence

I. GİRİŞ

Günümüz iş dünyasında, rekabetin yoğunluğu ve teknolojinin hızla gelişmesiyle birlikte, şirketlerin ürün kalitesini artırma ve süreçlerini istikrarlı bir şekilde kontrol etme ihtiyacı artmıştır. Bu durum, müşteri beklentilerinin artması ve pazardaki değişimlerin hızlanmasıyla daha da belirgin hale gelmiştir. Şirketler, ürünlerinin kalitesini artırarak müşteri memnuniyetini sağlamak ve pazarda rekabetçi kalabilmek için sürekli olarak iyileştirme çabalarını sürdürmektedirler. Bu bağlamda, istatistiksel süreç kontrolü (SPC) giderek daha fazla önem kazanmaktadır. SPC, süreçlerin değişkenliklerini izlemek, analiz etmek ve sürekli olarak iyileştirmek için kullanılan önemli bir anlayış haline gelmiştir. Bu teknikler, süreçlerdeki hataları en aza indirgemek, ürün kalitesini sürekli olarak izlemek ve iyileştirmek için değerli birer kaynak olarak görülmektedir. Özellikle, modern üretim ortamlarında karmaşık süreçlerin yönetimi ve kontrolü için SPC vazgeçilmez bir araç konumundadır. Kalite kontrol grafikleri, SPC'nin en önemli araçlarından birisidir ve bir sürecin istatistiksel olarak kontrol altında olup olmadığını değerlendirmek için kullanılmaktadır. SPC teknikleri işletmelerin kalite yönetiminde, sürekli gelişim ve rekabet avantajı elde etmede kritik bir rol üstlenmektedir [1]. Elevli ve Behdioğlu (2006) çalışmalarında bir termik santral için üretilen kömürlerin kalorifik değerlerinin istatistiksel olarak analiz edilmesi amacıyla kalite kontrol grafiklerinden yararlanmışlardır [2]. Bir sürecin yeterliliğini incelemek amacıyla kullanılan Cp ve Cpk indisleri, sürecin ne kadar istikrarlı ve güvenilir olduğunu belirlemek açısından önemlidir [3]. Czarski vd. (2007) çalışmalarında istatistiksel yöntemlerin mühendislik alanında önemini vurgulamışlardır. Ayrıca, çelik üretim işleminin, Cp ve Cpk indislerini kullanarak etkin bir şekilde değerlendirilebileceğini belirtilmişlerdir [4].

Bu çalışmada, bir otomotiv yan sanayi firmasında üretilen mafsal istavrozu üst torna operasyonunda dış çap ölçümleri $\bar{X}$ ve R kontrol grafikleri ile incelenmiştir. Ayrıca üretim sürecinin yeterliliği Cp ve Cpk indisleri ile değerlendirilmiştir.

II. MATERYAL VE YÖNTEM

Bu çalışma, Konya ilinde faaliyet gösteren bir otomotiv yan sanayi firmasında üretilen mafsal istavrozu üst torna operasyonunda dış çap ölçümlerinin istatistiksel kalite kontrol teknikleri kullanılarak değerlendirilmesini amaçlamaktadır. Bu bağlamda, istatistiksel süreç kontrolü ve süreç yeterliliği analizleri temel alınarak süreç performansı değerlendirilmiştir.

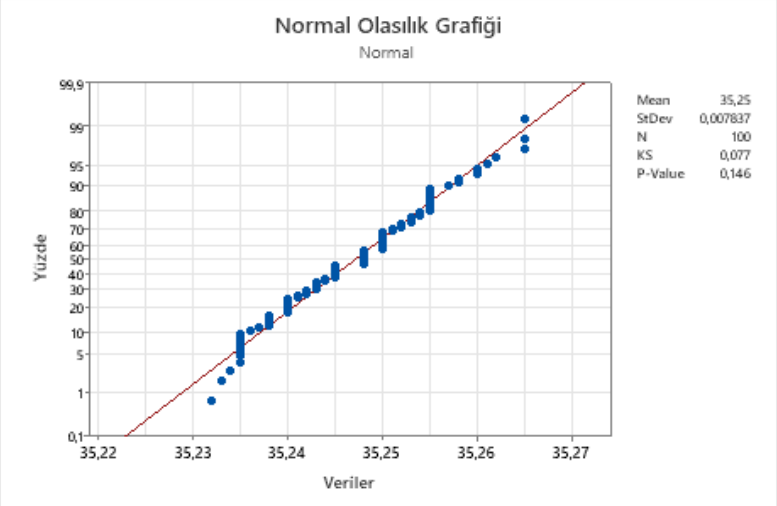
Veri toplama adımında öncelikle, süreçte dış çap ölçümü için kullanılan cihazlar belirlenerek kalibrasyonları yapılmıştır. Ölçüm sürecinde, belirli bir zaman diliminde üretilen mafsal istavrozlarından rastgele seçilerek numunelerin dış çap ölçümleri düzenli olarak kaydedilmiştir. $\bar{X}$ ve R kontrol grafiklerinin oluşturulmasında ve süreç yeterlilik analizinde Minitab paket programından yararlanılmıştır. Ölçümler, 2024 Mayıs ayında, sabah molasından önce, sabah molasından sonra, yemek molasından sonra ve akşam molasından sonra olmak üzere, günde 4 defa rastgele seçilen 5'er adet ürün alınarak oluşturulan alt gruplar üzerinde gerçekleştirilmiştir.

III. BULGULAR

Mafsal istavrozu dış çap ölçülerinin normal dağılıma sahip olup olmadığı Kolmogorov-Smirnov testi ile analiz edilmiştir (Şekil 1). Bu istatistiksel test için belirlenen hipotezler aşağıda yer almaktadır:

H_0: Verilerin dağılımı normal dağılıma sahiptir.

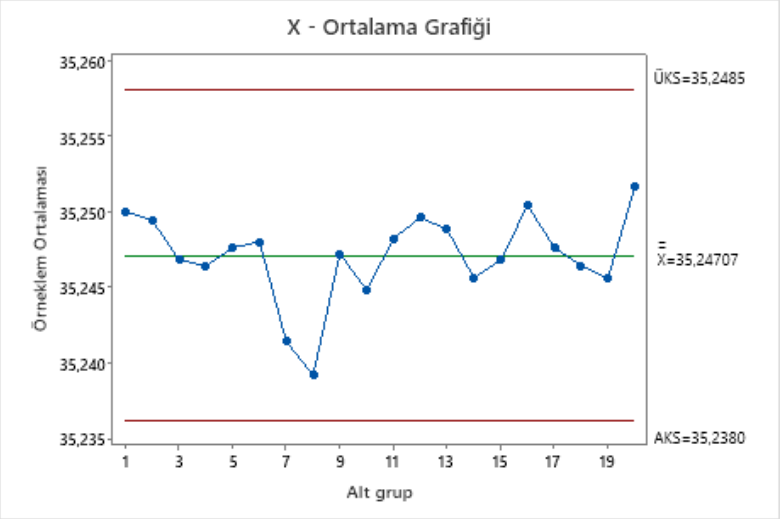
H_1: Verilerin dağılımı normal dağılıma sahip değildir.



Şekil 1. Mafsal istavrozu dış çap ölçümlerine ilişkin normal olasılık grafiği

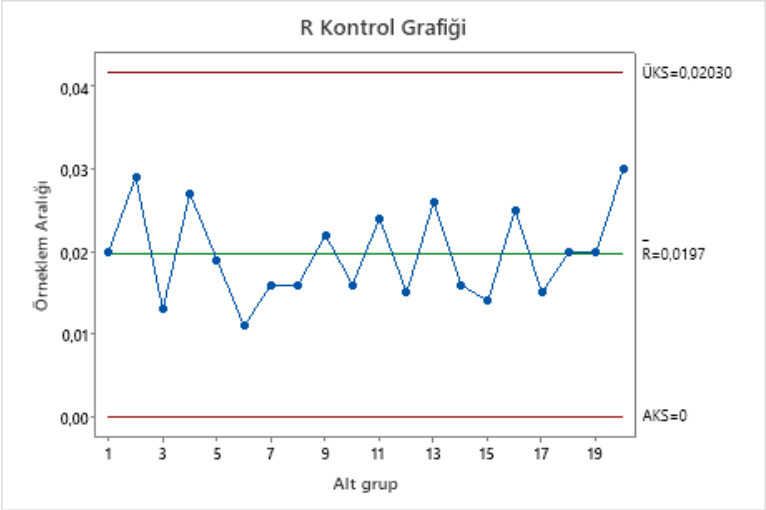
Kolmogorov-Smirnov testi sonuçlarına göre, mafsal istavrozu dış çapına ait ölçüm değerleri için test istatistiği 0,077 ve p-değeri 0,146 olarak hesaplanmıştır. Bu sonuçlar, %5 anlamlılık düzeyinde, H_0 hipotezini kabul etmemizi gerektirmektedir. Buna göre, verilerin normal dağılıma sahip olduğu hipotezi kabul edilir.

Şekil 2'de mafsal istavrozu dış çap ölçümlerine ilişkin ortalama grafiği yer almaktadır. Grafikte her bir alt gruptan elde edilen ortalama değerlerin zamana göre çizildiği noktalar ve bu noktaların ortalamasını (genel ortalama) gösteren bir çizgi yer almaktadır. Grafikte, ÜKS üst kontrol sınırını, AKS ise alt kontrol sınırını ifade etmektedir.



Şekil 2. Mafsal istavrozu dış çap ölçümlerine ilişkin X – Ortalama grafiği.

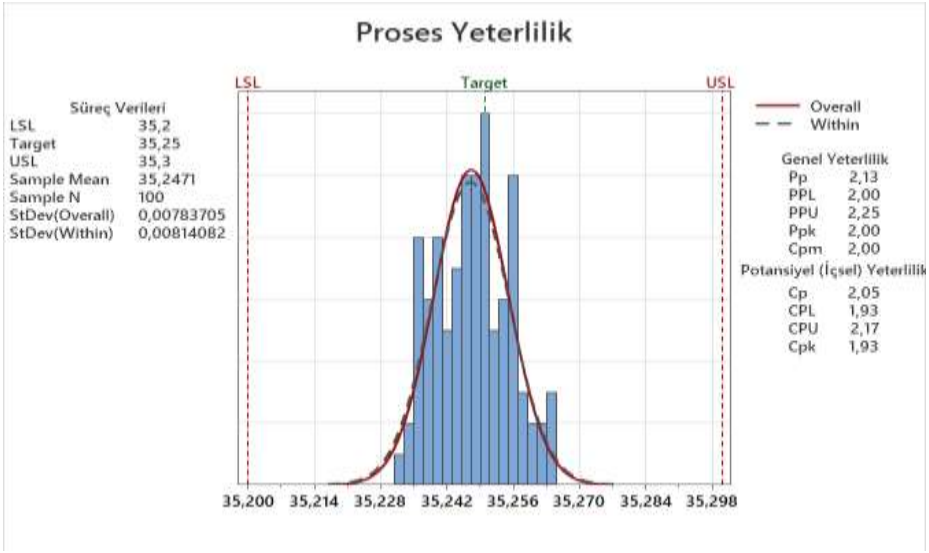
X-ortalama şemasından elde edilen sonuçlar, mafsal istavrozunun dış çap ölçümlerinin ortalama 35,24707 mm, üst kontrol sınırının 35,2485 mm ve alt kontrol sınırının da 35,2380 mm değerinde olduğunu göstermektedir. Alt grup ortalamalarının ÜKS ve AKS arasında yer alması ve belirgin bir eğilim gözlemlenmemesi sürecin kontrol altında olduğunu göstermektedir.



Şekil 3. Mafsal istavrozu dış çap ölçümlerine ilişkin R Kontrol grafiği.

Şekil 3'te mafsal istavrozu dış çap ölçümlerine ilişkin R kontrol grafiği yer almaktadır. Grafikte her bir alt gruptan elde edilen aralık değerlerinin zamana göre çizildiği noktalar ve bu noktaların ortalamasını gösteren bir orta çizgi yer almaktadır. Buna göre, mafsal istavrozunun dış çap ölçümlerinin R-değeri ortalama 0,0197 mm'dir. Grafikte üst kontrol sınırı 0,02030 mm ve alt kontrol sınırı 0,00 mm olarak hesaplanmıştır. Değişim aralığı ÜKS ve AKS'nin arasında yer almaktadır ve belirgin bir eğilim gözlemlenmemektedir. Buna göre sürecin kontrol altında olduğu yorumu yapılabilmektedir.

Cp ve Cpk indisleri süreç yeteneğini analiz etmek için kullanılan önemli araçlardır. Cp indisi, süreç yayılımının tolerans sınırları içerisinde kaldığını gösteren bir ölçüdür. Cp indisinin 1'den büyük olması gerekmektedir, yani süreç yayılımı tolerans sınırları içerisinde olmalıdır. Cpk indisi ise sürecin merkez noktasının tolerans sınırlarına olan uzaklığı hakkında bilgi verir. Cpk indisinin de 1'den büyük olması gerekmektedir, yani süreç orta noktası tolerans sınırlarının ortasında yer almalıdır [5].



Şekil 4. Mafsal istavrozu dış çap üst torna operasyonuna ait süreç yeterlilik analizi

Şekil 4'te mafsal istavrozu dış çap üst torna operasyonuna ait süreç yeterlilik analizi sonuçları verilmiştir. Cp indisi 2,05 ve Cpk indisi 1,93 olarak hesaplanmıştır. Cp=2,05 olması süreç yayılımının 35,2 mm-35,3 mm olan tolerans sınırları dahilinde olduğunu göstermektedir. Cpk=1,93 olması süreç orta noktasının tolerans sınırları dahilinde olduğunu göstermektedir. Cp ve Cpk indisleri 1'den büyük olduğu için, süreç yeterliliği kabul edilebilir seviyededir. Yani, süreç spesifikasyon sınırlarını karşılamaktadır. Cp ve Cpk indislerinin birbirine yakın değerler aldığı görülmektedir. Bu da süreç ortalamasının hedef değere yakın konumlandığını göstermektedir.

IV. TARTIŞMA

Çalışma bulgularından, üretim sürecinin kontrol altında olduğu ve süreç yeterliliğinin yüksek olduğunu anlaşılsa da kalite kontrol faaliyetlerinin sürekliliğinin sağlanması gerekliliği göz ardı edilmemelidir. Bu anlayış müşteri memnuniyetinin artmasına, ürünlerin güvenilirliğinin sağlanmasına ve firmanın rekabet avantajının korunmasına önemli katkılar sağlayacaktır. Kaliteli ve tutarlı üretim, özellikle otomotiv yan sanayi gibi yüksek hassasiyet gerektiren sektörlerde büyük bir önem arz etmektedir.

Bu çalışmanın bulguları, istatistiksel süreç kontrolü ve süreç yeterliliği analizlerinin otomotiv yan sanayi gibi hassas üretim süreçlerinde uygulanabilirliğini ve etkinliğini göstermektedir. Kontrol grafikleri ve süreç yeterliliği indekslerinin kullanımı, üretim süreçlerinin izlenmesi, değerlendirilmesi ve iyileştirilmesi açısından büyük fayda sağlamaktadır. Bu yöntemlerin sistematik bir şekilde uygulanması, işletmelerin kalite yönetiminde daha bilinçli ve verimli kararlar almasına yardımcı olmaktadır.

V. SONUÇLAR

Bu çalışmada, Konya ilinde faaliyet gösteren bir otomotiv yan sanayi firmasında üretilen mafsal istavrozu üst torna operasyonunda dış çap ölçümleri istatistiksel kalite kontrol teknikleri kullanılarak değerlendirilmiştir. Elde edilen sonuçlar, sürecin istatistiksel olarak kontrol altında olduğunu ve süreç yeterliliğinin kabul edilebilir seviyede olduğunu göstermiştir. Çalışmadan ulaşılan sonuçlar:

- $\bar{X}$ ve R kontrol grafikleri kullanılarak yapılan analizlerde, sürecin kontrol altında olduğu tespit edilmiştir.
- Cp ve Cpk indisleri, süreç yeterliliğinin kabul edilebilir seviyede olduğunu ve sürecin spesifikasyon sınırlarını karşıladığını göstermiştir.
- Firmada kalite kontrol faaliyetlerinin sürekliliğinin sağlanması, müşteri memnuniyetinin artmasına, ürünlerin güvenilirliğinin sağlanmasına ve firmanın rekabet avantajının korunmasına önemli katkılar sağlayacaktır.

Bu çalışmanın sonuçları, işletmelere süreçlerini etkili bir şekilde kontrol etme ve ürün kalitelerini artırma konusunda değerli bilgiler sunmaktadır. Süreç kontrolü, işletmelerin kalite yönetiminde stratejik kararlar almalarına yardımcı olmaktadır ve rekabet avantajı elde etmelerini sağlamaktadır.

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Interval-Valued Fuzzy Bézier Curve Approximation and its Numerical Example

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Abstract **–**Modeling a curve by using collected data is a challenging process. Most data that are collected will be affected by noise and uncertainty environment. In this paper, interval-valued fuzzy Bézier curve (IVFBC) approximation model will be introduced. Firstly, interval-valued fuzzy control point is defined and introduced. Later, interval-valued fuzzy Bézier curve is developed by blending interval-valued control point with the Bézier blending function. Lastly, The data points or interval-valued fuzzy control points of the basis function is converted into curve that called as IVFBC. With the interval-valued fuzzy concept and its relations, some numerical example can be translated using the introduced model. It shows how one can manipulate these interval-valued fuzzy control points so that they accurately model uncertain data that lies underneath them. The findings suggest that interval-valued fuzzy Bézier curve representation offers improved accuracy, reliability and flexibility when compared to conventional techniques for dealing with uncertainty data. Such application domains like computer graphics, data fitting or engineering design often involve uncertainties which need to be addressed within research approaches like mathematical modeling or methods. Thus, this study integrates fuzzy concepts into Bézier curve approximation making it possible to resolve uncertainty issues associated with this type of approximations which could be utilized in such areas as computer graphics, data fitting or engineering design. In geometric modeling and approximation, this methodology lays down important groundwork providing a platform upon which other applications of fuzzy technology shall be built across different industries.

Keywords – Interval-valued Fuzzy set, Bézier curve, Interval-valued fuzzy control points, approximation method, fuzzy geometric modeling.

I. INTRODUCTION

The fuzzy set theory was developed by [1] Zadeh in 1965 to handle uncertainty. Interval-valued fuzzy sets first were proposed by Zadeh as an extension of fuzzy sets in 1975 [2]). This variation represents the Membership degree values as ranges of numbers than individual values. The advantage of using interval-valued fuzzy sets has been demonstrated in dealing with the uncertainty in a better way as compared to the conventional fuzzy sets. Interval-valued fuzzy sets have been investigated from different viewpoints. Son [3] proposed the concept of interval-valued fuzzy soft sets which describe the values of membership degrees more loosely. In related work, Bustince [4] emphasized the importance of these sets in soft computing, especially in dealing with particular problem solving. The concept was further generalized to hesitant by

Verma [5] who expanded the concept to hesitant interval-valued fuzzy sets, introducing novel operations and properties. Together, these studies emphasize the adaptability and utility of interval-valued fuzzy sets across diverse domains. Given the widespread research and application of interval-valued fuzzy sets, on approximate reasoning [6-7], medical diagnosis [8], multivalued logic [9], decision making [10-12] and image processing [13-14]. Therefore, it is crucial to incorporate interval-valued fuzzy sets in various applications, including fuzzy geometric modeling.

Geometric Modeling is a fundamental application of Computer-Aided Design (CAD) systems, which provides mathematical descriptions of geometric elements for the purpose of representing and manipulating graphical images on a computer screen [15]. Geometric modeling is important for its role in visual representation when developing new designs and modifications, as well as for pre-production testing; that has an economic impact on the cost and time. It is this that makes Bézier techniques so effectively convert some of the complex mathematical matters into a very intuitive and geometric form. A Bézier curve is a way to easily and visually represent a geometric form, developed by Pierre Bézier [16] and properties introduced by Paul de Casteljau [17] that used Bernstein polynomials to define its curve and surface characterization along with the algorithm now known as the de Casteljau algorithm. The relationship between Bernstein polynomials and Bézier curves was discovered by Forrest [18].A geometric perspective on examining Bernstein polynomials is achieved by expressing them as functional Bézier curves. Wahab et al. [19] introduced a geometric modeling concept based on fuzzy numbers theory. They proposed fuzzy control points for fuzzy curves and fuzzy surface models for Computer-Aided Geometric Design (CAGD). The study explored properties related to approximating fuzzy control points using fuzzy Bézier, fuzzy B-spline, and fuzzy NURBS. Several years later, some researchers apply the same concept of integrating fuzzy set theories with geometric model such as [20-23]. A geometric

The concept of interval-valued fuzzy numbers will be explained and defined to show the fundamental theorems. In the following section, interval-valued fuzzy control points will be introduced and defined in the next section. These control points are blended with Bézier basis functions to model the interval-valued fuzzy Bézier curve approximation.

II. PRELIMINARIES

This section introduces the basic concepts of interval-valued fuzzy sets, including interval-valued fuzzy numbers, interval-valued fuzzy relations, and interval-valued fuzzy points.

Definition 1 *[1] Let a fuzzy set A is defined on a universe X as follows*

$$A = \{\langle x, \mu_A(x)\rangle \mid x \in X\} \tag{1}$$

where $\mu_A(x): X \to [0,1]$ *is the membership function A. The membership value* $\mu_A(x)$ *describes the degree of belongingness of in A.* Figure 1 shows an example of fuzzy set *A*.

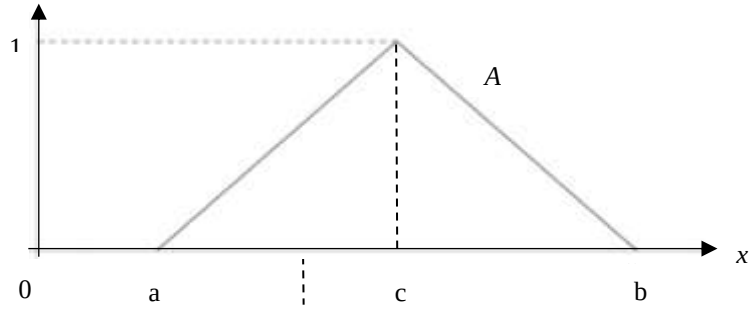

Fig. 1 Fuzzy set *A*

Definition 2 *[2] Let an interval-valued fuzzy set (IVFS) $\tilde{A}$ in X be*

$$\tilde{A} = \left\{ \left\langle x, \underline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{A}}(x) \right\rangle \mid x \in X \right\} \tag{2}$$

where $\underline{\mu}_{\tilde{A}}(x)$ and $\overline{\mu}_{\tilde{A}}(x)$ are the lower and upper bound of the membership degree respectively with the following condition

$$0 < \underline{\mu}_{\tilde{A}}(x) \le \overline{\mu}_{\tilde{A}}(x) \le 1 \tag{3}$$

The concept of interval-valued fuzzy numbers is from both fuzzy set theory and possibility theory. The theory. Fuzzy numbers was initially introduced in [6]. Definitions 3 and 4 illustrate the interval-valued fuzzy number and the normal triangular interval-valued fuzzy number, respectively.

Definition 3 *An interval-valued fuzzy number (IVFN) $\tilde{A}$ is defined as*

i. *normal where there is any $x_0 \in R$ such that $A(x_0) = [1,1]$*

ii. *convex for the memberships $\underline{\mu}_{\tilde{A}}(x)$ and $\overline{\mu}_{\tilde{A}}(x)$ where $\underline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \underline{\mu}_{\tilde{A}}(x_1), \underline{\mu}_{\tilde{A}}(x_2)$ and $\overline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \overline{\mu}_{\tilde{A}}(x_1), \overline{\mu}_{\tilde{A}}(x_2)$ for $\forall x_1, x_2 \in R, \lambda[0,1]$*

iii. *$\underline{\mu}_{\tilde{A}}(x)$ and $\overline{\mu}_{\tilde{A}}(x)$ are upper semi-continuous*

iv. *the support of $\underline{\mu}_{\tilde{A}}(x)$ and $\overline{\mu}_{\tilde{A}}(x)$ are bounded that is the closure of $\left\{ x \in R : \underline{\mu}_{\tilde{A}}(x) > 0 \right\}$ and $\left\{ x \in R : \overline{\mu}_{\tilde{A}}(x) > 0 \right\}$ are bounded.*

Definition 4 *Suppose that from [23], define the normal triangular interval-valued fuzzy number $\tilde{A}$ to be represented by two fuzzy numbers $\underline{A}_x = (\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}})$ and $\overline{A}_x = (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})$:*

$$\tilde{A} = [\underline{A}_x, \overline{A}_x]$$

$$\tilde{A} = [(\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}}), (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})] \tag{4}$$

where $\overline{a}_1 \le \underline{a}_1$, $\underline{a}_3 \le \overline{a}_3$ and $\underline{w}_{\tilde{A}} = \overline{w}_{\tilde{A}}$ while $\underline{a}_2 = \overline{a}_2$ is a crisp value and $\underline{w}_{\tilde{A}}$ and $\overline{w}_{\tilde{A}}$ are the heights of $\underline{A}_x$ and $\overline{A}_x$. The IVFN can be shown in Fig. 2.

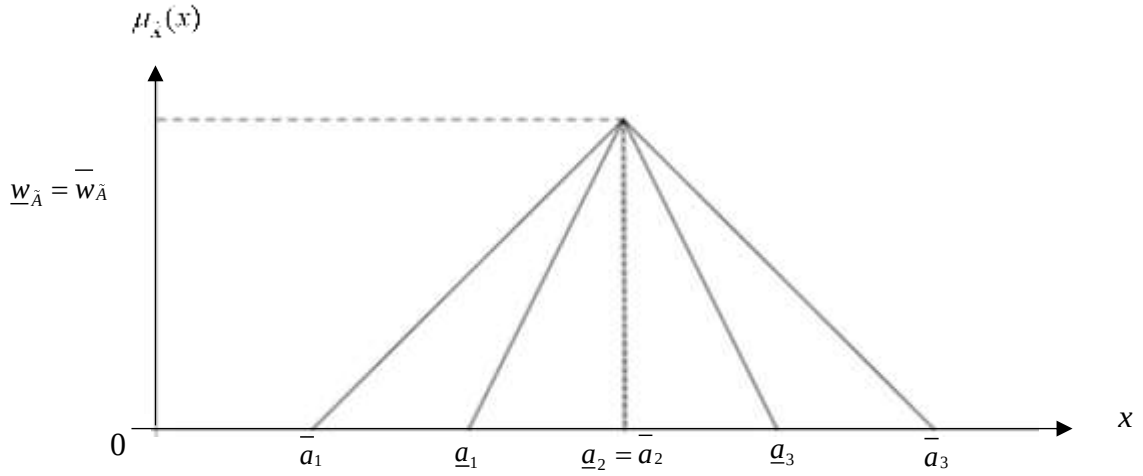

Fig. 2 The normal triangular interval-valued fuzzy number

Interval-valued fuzzy relation has been studied in [25-26]. The concept of the interval-valued fuzzy relation (IVFR) used as a connection between the definition of interval-valued fuzzy numbers (IVFN) and the representation of interval-valued fuzzy data points.

Definition 5 [27] *Let X and Y be non-empty sets and interval-valued fuzzy relation R. Let* $X, Y \subseteq R$ *be universal sets, then*

$$\tilde{R} = \left\{ \underline{R}(x,y), \overline{R}(x,y) \mid (x,y) \in X \times Y \right\} \tag{5}$$

where $\underline{R} : X \times Y \to [0,1]$ and $\overline{R} : X \times Y \to [0,1]$.

Definition 6 *Let* $S, R \in IVFR(X \times Y)$, *then for every* $(x,y) \in X \times Y$ *we can define*

$$S(x,y) \le R(x,y) \Leftrightarrow \underline{S}(x,y) \le \underline{R}(x,y) \le \overline{S}(x,y) \le \overline{R}(x,y) \tag{6}$$

where there are operations on the supremum and infimum in IVFR $(X \times Y)$ respectively as below

$$(S \vee R)(x,y) = \left[\max\left(\underline{S}(x,y), \underline{R}(x,y)\right), \max\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{7}$$

$$(S \wedge R)(x,y) = \left[\min\left(\underline{S}(x,y), \underline{R}(x,y)\right), \min\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{8}$$

III. Interval-valued Fuzzy Bézier Curve Approximation Model

The data points utilized to shape a Bézier curve are called as control points. The control points is denoted by $P_i = P_0, P_1, \ldots, P_i$. Fuzzy control point has been defined in [19].

A. Interval-Valued Fuzzy Bézier Control Point

From the definition of interval-valued fuzzy set, interval-valued fuzzy number and interval-valued fuzzy relation, the IVCP is written as follows.

Definition 7 *Let the interval-valued fuzzy set (IVFS) of* $\tilde{P}$ *in space S such that the set of interval-valued fuzzy control point (IVFCP) is defined as*

$$\tilde{P} = \left\{ \tilde{P}_i \right\}_{i=0}^{n} \tag{9}$$

where there exists membership functions of lower left and right, crisp value, and upper left and right bound respectively $\mu_{\tilde{P}}^{\underline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{\overline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{C} : S \to [0,1]$, $\mu_{\tilde{P}}^{\underline{R}} : S \to [0,1]$ *and* $\mu_{\tilde{P}}^{\overline{R}} : S \to [0,1]$.

In the geometric model, the interval-valued fuzzy control point is combined with the basis function of Bézier curve approximation. The interval-valued fuzzy Bézier control points in Equation (9) consists control points with lower left, $\tilde{P}_i^{\underline{L}}$, upper left, $\tilde{P}_i^{\overline{L}}$, crisp value, $\tilde{P}^{C}$, lower right, $\tilde{P}_i^{\underline{R}}$, and upper right, $\tilde{P}_i^{\overline{R}}$.

B. Interval-Valued Fuzzy Bézier Curve

Definition 8 *Let* $\tilde{P}$ *be a IVFCP with* $\tilde{P} = P_i : i = \{0,1,2,\ldots,n\}$, *hence the interval-valued fuzzy Bézier curve (IVFBC) is defined as*

$$\tilde{B}(t) = \sum_{i}^{n} \tilde{P}_i J_{n,i}(t), 0 \le t \le 1 \tag{10}$$

where Bernstein polynomials denoted as $J_{n,i}(t) = \binom{n}{i} t^i (1-t)^{n-i}$ *and the binomial coefficients is* $\binom{n}{i} = \frac{n!}{i!(n-i)!}$.

The IVFBC in equation (10) consists of :

$$\tilde{B}^{\underline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{L}}J_{n,i}(t),0\le t\le 1 \tag{11}$$

$$\tilde{B}^{\overline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{L}}J_{n,i}(t),0\le t\le 1 \tag{12}$$

$$\tilde{B}^{C}(t)=\sum_{i}^{n}\tilde{P}_i^{C}J_{n,i}(t),0\le t\le 1 \tag{13}$$

$$\tilde{B}^{\underline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{R}}J_{n,i}(t),0\le t\le 1 \tag{14}$$

$$\tilde{B}^{\overline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{R}}J_{n,i}(t),0\le t\le 1 \tag{15}$$

where $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left IVFBC, upper left IVFBC, crisp IVFBC, lower right IVFBC, and upper right IVFBC respectively.

IV. Modeling of Interval-valued Fuzzy Bézier Curve (IVFBC) Approximation Model

This section will model the interval-valued fuzzy Bézier curve (IVFBC) approximation model for $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left, upper left, crisp, lower right, and upper right of IVFBC respectively with the degree *n=4* since the models are in cubic case. Table 1 shows the IVFCP with their membership values. At the end of this section will demonstrate an algorithm to construct the IVFBCs approximation model.

Table 1. IVCP with the values of their membership

$\tilde{P}_0^4$ \ $\mu_{\tilde{A}}(x)$	0.3	0.5	0.3	0.7	0.8
$\tilde{P}_i^{\overline{L}}$	1.0	1.5	8	12.5	13
$\tilde{P}_i^{\underline{L}}$	2.5	3.0	10	13.5	14
$\tilde{P}_i^{C}$	11	11.5	18	20.5	21
$\tilde{P}_i^{\underline{R}}$	19	19.5	25	27.5	28
$\tilde{P}_i^{\overline{R}}$	20	20.5	27	28.5	29

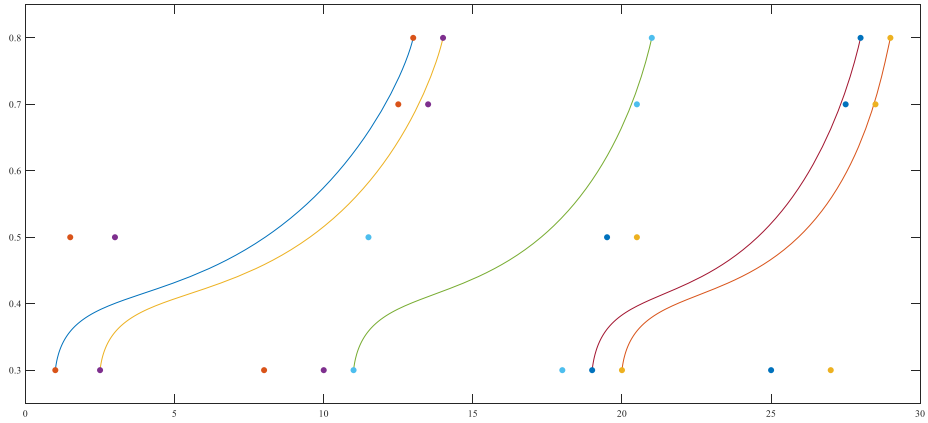

Fig. 3 Interval-valued fuzzy Bézier curve (IVFBC) approximation models

Table 1 shows an example of IVFCP with its corresponding degree of membership degree lower left, upper left, crisp value, lower right and upper right. While figure 3 is the illustrated curve where the IVFCP

is blended with the basis function of Bézier in the geometric model as in equation (10). Figure 3 shows the lower left IVFBC in yellow curve, next to it is the upper left IVFBC with blue curve. At the centre is the crisp IVFBC. While on the right obviously with red and orange curve are the lower right IVFBC and upper right IVFBC respectively.

The algorithm resulting in IVFBC is as follows:

Step 1: The interval-valued fuzzy control points (IVFCP) is determined using .
Step 2 : The interval-valued fuzzy control point is blended with the basis function of Bézier curve approximation in the geometric model using where the membership functions of lower and upper bound is determined.
Step 3 : The data points or IVFCP of the basis function is interpreted into curve that called as IVFBC.

V. CONCLUSION

This paper has introduced interval-valued fuzzy Bézier method where the IVFCP is used as data points. The method has shown that the interval-valued fuzzy data problem has been applied to the geometric modelling. The method and result will be contribute to the fuzzy geometric modeling application on visualization uncertainty data. The examples with practically calculated numbers confirm that the offered method may be effectively implemented. This research shows that there is ample potential for further development and usage of the interval-valued fuzzy methods in curve modeling and relative fields. The flexibility and applicability of the offered method indicate that it may find application in solving real-life problems during data analysis and decision-making. A notable example is Computer-Aided Design and Computer-Aided Manufacturing systems; interval-valued fuzzy Bézier curve approximation to represent and manipulate shapes and contours are excellent for uncertain shapes and contours. This can involve situations where the input data is imprecise, or the specifications are uncertain. Another illustration is pattern recognition tasks that involve imprecision or uncertainty; such as object recognition, gesture recognition, shape analysis in images and videos. In all these situations, interval-valued fuzzy Bézier curves can be used to operate on uncertain and imprecise data that are commonly found in real-world problems.

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Karıştırmalı Döküm Yöntemi ile Üretilen Al 7075/B_4C Kompozitlerde B_4C Oranı ve Boyutunun Abrasif Aşınmaya Etkisi

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Özet – Alüminyum kompozit malzemeleri, alüminyumun hafiflik, sağlamlık, işlenebilme yeteneği ve yüksek korozyon direnci gibi özellikleri nedeniyle günümüzde yaygın olarak savunma sanayi ve havacılık gibi birçok endüstride kullanılmaktadır. Bu çalışmada, Alüminyum 7075 matris malzemesine farklı takviye oranları ve farklı tanecik boyutlarından oluşan B_4C partikülleri karıştırmalı döküm yöntemi kullanılarak eklenmiştir ve üretilmiştir. Döküm işlemi sürecinde, alüminyum matris malzemesi pota içerisinde 750-800 °C'de eritilmiştir. Sonrasında tavlanan B_4C partikülleri pota içerisine alınarak homojen hale gelene kadar karıştırılıp hazırlanan kum kalıplara dökülmüştür. Hazırlanan numuneler torna tezgahında yüzey işlemlerinden geçirilmiştir. Homojen dağılımını incelemek için elektron mikroskopu (SEM) kullanılmıştır. Yapılan sertlik deneyleri sonucunda en yüksek sertlik değerinin %4 100 µm bor karbür takviyeli alüminyum kompozit olduğu gözlemlenirken abrasif aşınma deneylerinde ise en düşük aşınma değerleri yine %4 B_4C takviyeli numunelerden elde edilmiştir. Üretilen kompozit yapıların aşınmasında en önemli faktörün ilk sırada B_4C takviye miktarı, daha sonda partikül boyutu olduğu genel sonucuna varılmıştır.

Anahtar Kelimeler – Kompozit malzeme, bor karbür (B_4C), alüminyum 7075, karıştırmalı döküm, brinel sertlik ve aşınma

I. GİRİŞ

Kompozit malzemeler, iki veya daha fazla malzemenin çeşitli yöntemler ile birleştirilerek üretilmesiyle oluşan yeni malzemelerdir. Kompozit malzemeler, matris malzeme ve takviye malzemesi olarak karşımıza çıkmaktadır. Matris malzemesinin görevi, takviyeleri bir arada tutmak ve malzemenin şekilsel bütünlüğünü korumaktır. Takviye malzemesi ise, matris malzemesinin iyileştirilmesi istenilen özelliklerini geliştirmek amacıyla kullanılır [1]. Metal matrisli kompozitler, 1950'lerin sonu 1960'lı yılların başında önem kazanarak geliştirilmeye başlanılmıştır. Metalik malzemeler içerisinde matris malzemesi olarak en yaygın kullanılan malzeme Alüminyum ve Alüminyum alaşımları olarak gözlemlenmektedir. Bunun sebebine bakacak olursak, doğada çok bulunması, hafif olması, yüksek spesifik mukavemete sahip olması, ısıl ve elektriksel özelliklerinin iyi olması ve çözelti sertleştirmesi ve yaşlandırması gibi mukavemeti arttırmaya yönelik işlemlerin uygulanmasına imkan vermesi başlıca nedenleri olarak sayılabilir. Takviye elemanı olarak, fiber, visker veya partikül gibi farklı formlarda, alüminyum oksit (Al_2O_3), silisyum karbür (SiC), titanyum karbür (TiC), karbon (C), titanyum diborür (TiB_2) ve bor karbür (B_4C) kullanılmaktadır. Bor karbür, dünya üzerinde elmas ve kübik yapılı bor nitrürden sonra bilinen en sert üçüncü malzeme olarak karşımıza çıkmaktadır. Alüminyumun kolay elde edilebilir olması, düşük yoğunluklu olması ve uygun üretim şartları altında B_4C ile tepkime oluşturması nedeniyle takviye elemanı olarak B_4C tercih edilmektedir [4]. Metal matrisli kompozitler özellikleri gereği genellikle otomotiv sektöründe, savunma sanayisinde, elektrik-elektronik teknolojisinde, uzay ve havacılık sektörlerinde kullanılmaktadır. B_4C takviyeli alüminyum kompozit malzemesi, infiltrasyon (sızdırma) yöntemi, sıkıştırma döküm, karıştırmalı (vortex) döküm ve toz metalurjisi yöntemi gibi çeşitli üretim yöntemleri kullanılarak üretilebilmektedir. Farklı takviye oranlarında ve tanecik boyutlarında B_4C takviyeli alüminyum 7075 kompozit malzemelerin

üretimi ve karakterizasyonu üzerine yapılan çalışmaların incelendiği literatür çalışmalarından bazıları şunlardır;

A. Baradeswaran ve A. Elaya Perumal çalışmalarında, 16 µm ile 20 µm partikül boyutlarında ve hacimce %5, %10, %15, %20 oranlarında B_4C tozu ile Alüminyum 7075 malzemeleri kullanarak, B_4C takviyeli alüminyum kompozit malzemeyi döküm yöntemi ile üretmişlerdir. 850 °C'de eritilen alüminyum sıvı karışımına eklenen B_4C partikülleri mekanik karıştırma ile 500 devir/dakika hızında karıştırılmıştır ve ıslatma sorunu çözebilmek için B_4C partiküllerin hacimce aynı oranda K2TiF6 akısı eklenmiştir. Aşınma hızının saf matris malzemeye göre daha düşük olduğu gözlemlenmiş ve sürtünme katsayısının B_4C partikül içeriği arttıkça azaldığı görülmüştür [2].

F. Toptan ve I. Kerti çalışmalarında, 2 farklı partikül boyutlarında B_4C tozu kullanarak Al/B_4C kompozit malzemeleri döküm yöntemi ile üretilmiştir. Döküm işlemi sırasında B_4C hacmi ile orantılı olarak K2TiF6 akısı eklenmiş ve sabit sıcaklıkta 5 dakika bekletildikten sonra metal bir kalıba dökümü yapılmıştır. Karıştırma yapılmayan dökümlerde toz karışımının çöktüğü ve döküm kabiliyetinin azaldığı görülmüştür. Aynı zamanda partikül boyutunun artması daha homojen bir yapı oluşturduğu gözlemlenmiştir [3].

R. Yakut çalışmasında, SiC, B_4C ve AA5754-AA7075 olmak üzere 2 farklı matris malzemesi kullanmıştır. Homojen dağılımı sağlamak için yarı karıştırma yöntemi kullanarak farklı takviye oranlarında AA5754/B_4C, AA7075/B_4C kompozitleri ve AA7075/SiC/B_4C hibrit kompozitlerini üretmiştir. Yapılan mikroyapı analizleri ile takviye ve matris arasında mekanik ve kimyasal bağ oluştuğu gözlemlenmiştir [4].

B. Ravi ve ark. çalışmalarında, çalışmalarında AA6061-B_4C kompozit malzemesini karıştırma döküm yöntemi kullanarak 100x100x10 mm boyutlarında plakalar olarak üretmişlerdir. 25 µm boyutunda ve ağırlıkça %5 ve %10 oranında B_4C kullanılmıştır. Mekanik karakterizasyonları ve testleri yapıldıktan sonra B_4C partiküllerinin ağırlık yüzdesinin artmasıyla birlikte çekme mukavemeti ve sertliğinin arttığı görülmüştür [5].

Bu çalışmanın amacı, farklı partikül boyutlarında ve takviye oranlarında B_4C takviye malzemesinin ve Al7075 matris malzemesinin karıştırılmalı döküm yöntemi ile üretilmesi ve yapılacak abrasif aşınma deneyleriyle takviye malzemesi olan B_4C'ün kompozit yapıların aşınma davranışına etkisinin incelenmesidir.

II. MATERYAL VE YÖNTEM

Deneysel çalışmada alüminyum 7075 alaşımı ve 44 µm, 100 µm ve 150 µm boyutlarında B_4C partikülleri kullanılmıştır. Alüminyum 7075 matris malzemesini döküm cihazımızın potasının içerisine aldıktan sonra 750 °C'de eritilmiştir. Eriyen alüminyumun içerisine 300 °C'de ön tavlama işlemine tabi tutulan B_4C partikülleri eklenmiştir. Kompozit karışım ortalama 500 rpm hızda 10 dakika boyunca karıştırılmıştır. Daha sonra hazırlanmış olan kalıplara döküm işlemi yapılmıştır. Yapılan deneylerde 3 farklı tanecik boyutlu B_4C takviye elemanı, takviye oranlarına göre %1, %2 ve %4 olarak 3 farklı oranda kullanılarak toplamda 9 farklı karışıma göre kompozit döküm işlemi yapılmıştır. Matris ile takviye arasındaki ıslatılabilirliği arttırabilmek adına %1 oranında saf Mg eklenmiştir. Bir tanesi saf alüminyum 7075 malzemeden olmak üzere toplamda 10 adet döküm yapılmıştır. Karıştırmalı döküm işlemleri için Kırıkkale Üniversitesi Meslek Yüksekokulu laboratuvarında bulunan karıştırmalı döküm cihazı kullanılmıştır (Şekil 1).

Şekil 1. Karıştırmalı döküm cihazı ve eritme işlemi

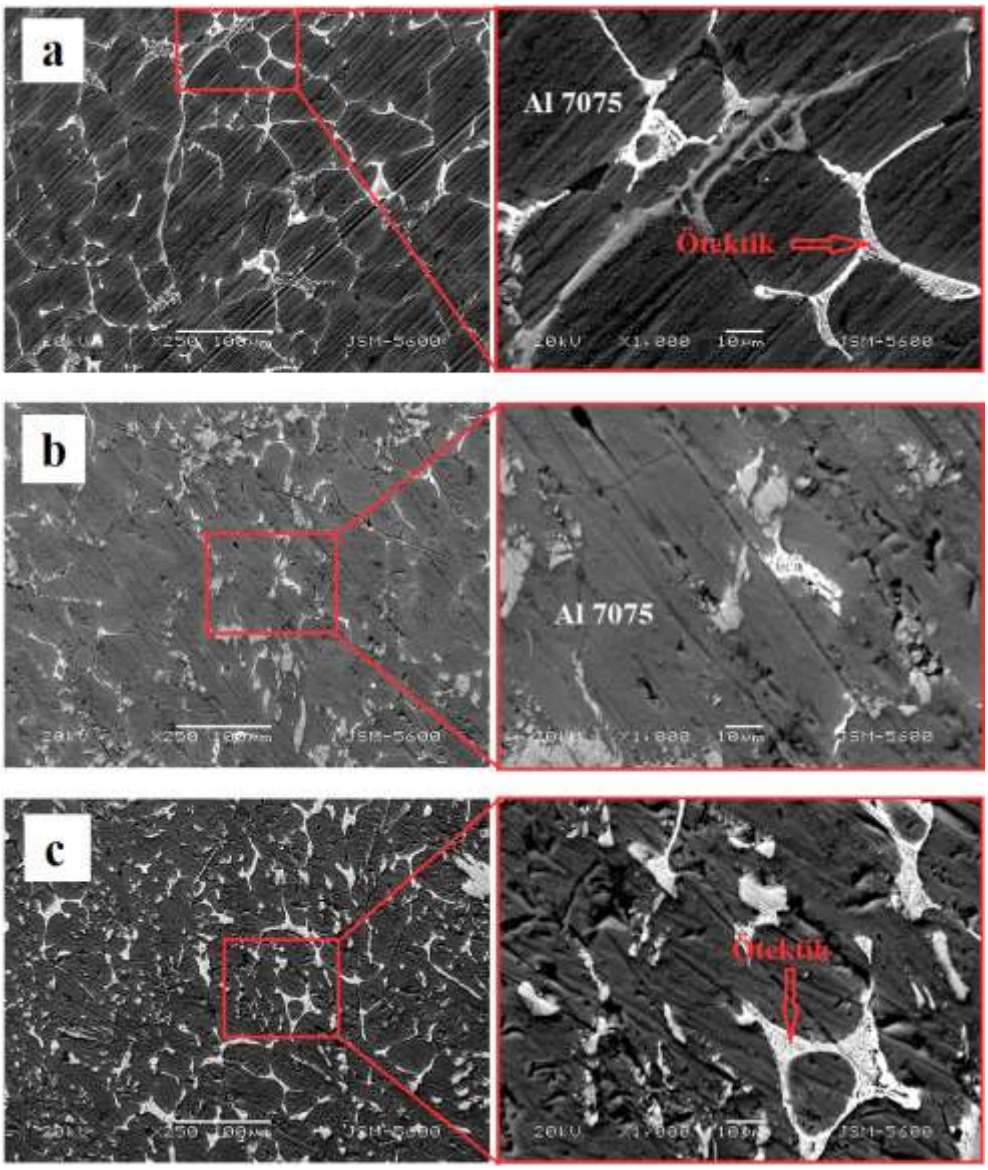
Üretilen numuneler yapılacak test ve ölçümler için talaşlı işlem uygulanarak istenilen boyutlara getirilmiştir (Şekil 2).

Şekil 2. Dökümü yapılan numunelerin torna tezgahında işlenmesi

III. BULGULAR VE TARTIŞMA

A. Mikroyapılar

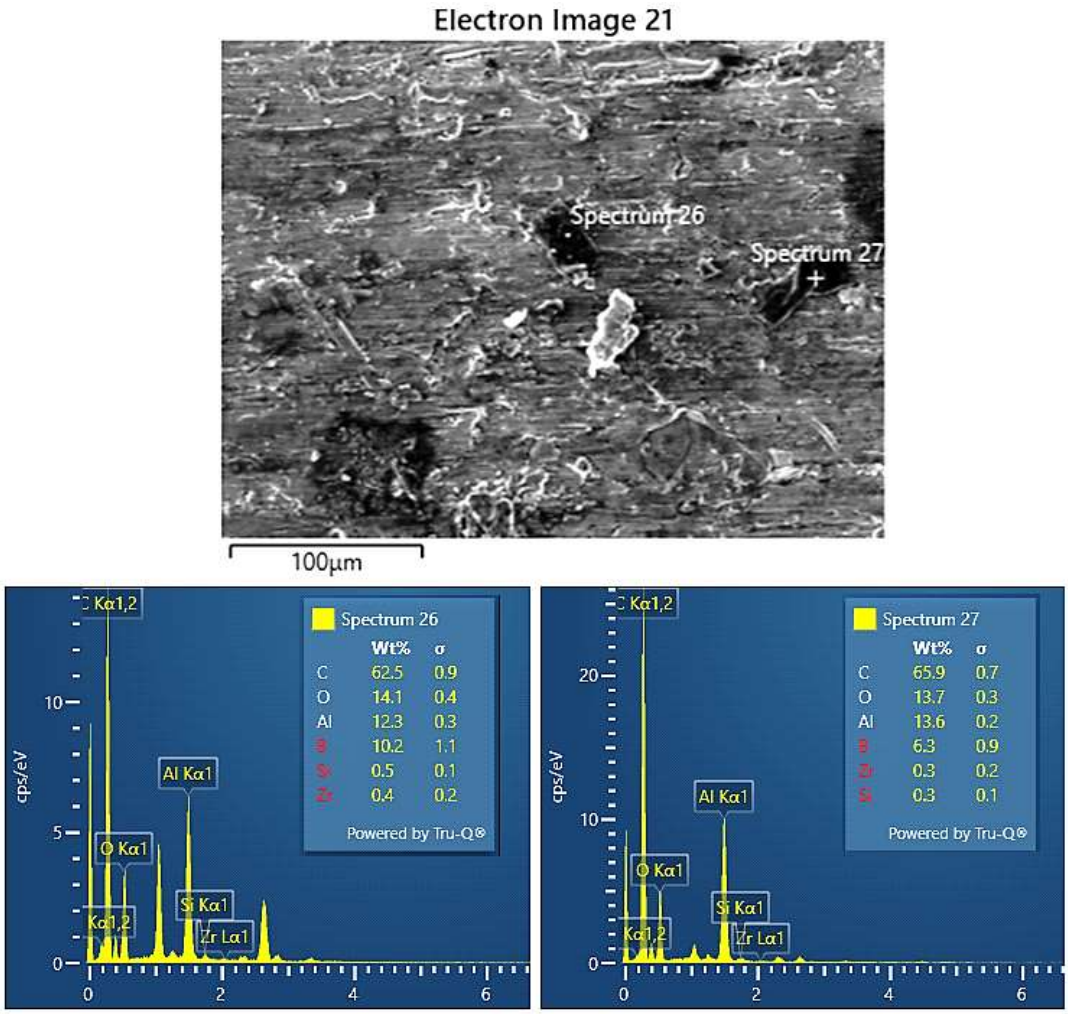
%1, %2 ve %4 B_4C takviyeli Al7075 kompozitlerin mikroyapılarını değerlendirmek amacıyla çekilen taramalı elektron mikroskobu (SEM) görüntüleri Şekil 3'te verilmektedir.



Şekil 3. Al7075/B_4C kompozit yapılar a) %1 B_4C takviyeli b) %2 B_4C takviyeli c) %4 B_4C takviyeli

Şekil 3'deki SEM görüntülerine bakıldığında, Al7075 matris içerisindeki B_4C miktarının artmasına bağlı olarak, yüzey kalitesinin giderek kötüleştiği söylenebilir. Özellikle tane sınırlarının daha düzensiz bir hal aldığı anlaşılmaktadır. Alüminyum içerisinde yer alan seramik esaslı B_4C takviye parçacıklarının çok farklı termal davranışı ve yüzey enerjileri, döküm sonrasındaki soğuma sürecinde kompozit yapıyı etkilediği değerlendirilmiştir. Yapılarda görünen koyu alanların matris malzemesi α-Al fazı, beyaz renkteki damarımsı oluşumların ise ötektik yapıları temsil ettiği değerlendirilmektedir [6-9].

Kompozit yapı içerisinde yer alan B_4C takviye parçacıklarının elementel olarak belirlenmesi için SEM görüntülemeleri sırasında EDS element analizleri de yapılmıştır. Şekil 4'te örnek EDS analizi verilmektedir.



Şekil 4. EDS element analizi

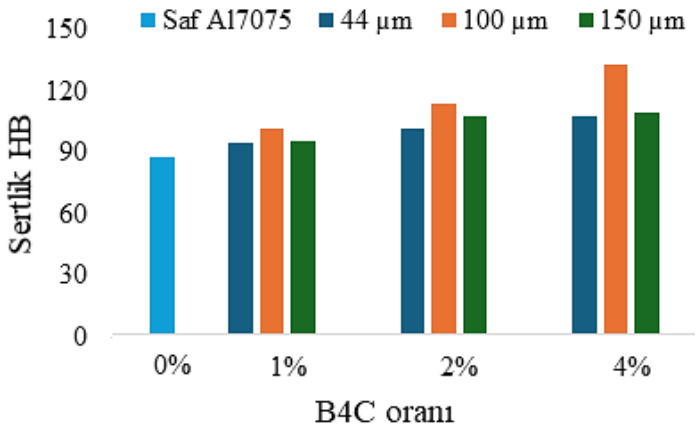
Şekil 4'de görüldüğü üzere Spektrum 26 ve Spektrum 27'de yer alan yapılarda B_4C'yi oluşturan bor ve karbon elementlerinin varlığı anlaşılmaktadır. Dikkat çeken diğer husus ise kompozit yapıda oldukça fazla yer alan oksijendir. Açık atmosferde yapılan döküm işleminde kompozit yapının oksijenle temasından dolayı oksitlenme meydana gelmiştir. Özellikle alüminyum gibi oksijeni çok seven metallerde bu duruma sıklıkla rastlanmaktadır.

B. Sertlik analizi

Üretilen bor karbür takviyeli alüminyum numunelerin brinell sertlik deneyleri Prüftechnik KB 750 cihazı kullanılarak yapılmıştır. Test aşamasında 2,5 mm çapında yuvarlak uç kullanılmıştır. Numune parçalara 187,5 N 'luk bir kuvvet uygulanmıştır. Her bir numune için 5 defa yapılan deneyler sonucunda ortalaması alınarak sonuçlara bakılmış olup elde edilen değerler Tablo1 ve Şekil 5'teki grafiklerde gösterilmektedir.

Tablo 1. Al 7075/B_4C kompozitlere ait ortalama Brinell sertlik değerleri

B_4C oranı	**44 µm**	**100 µm**	**150 µm**
1%	92,8	100	94
2%	99,7	112,3	106
4%	106	131	108
Saf Al7075	85,9		



Şekil 5. Brinell Sertlik Deneyi Sonuçları

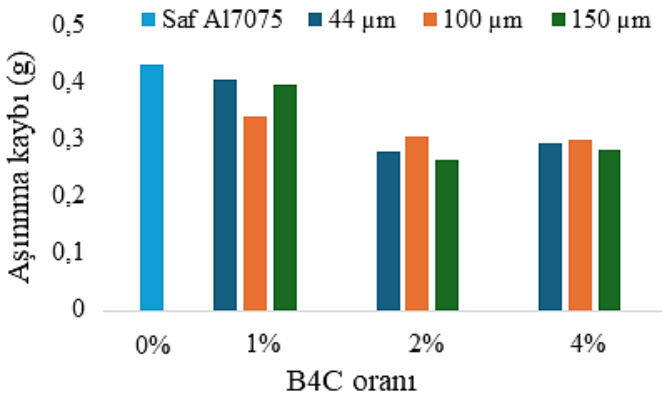
Yukarıdaki sonuçlara göre alüminyum içerisindeki bor karbür yüzdesinin artmasıyla sertliğin arttığı gözlemlenmiştir. Bunun yanı sıra en yüksek sertlik değerinin %4 100 µm bor karbür takviyeli alüminyum kompozit numunede ölçülmüştür. B_4C takviye malzemesi boyutuna göre bakıldığında tüm takviye oranlarında en yüksek sertlik değerlerinin 100 µm tane boyutundaki numunelerden elde edildiği anlaşılmaktadır. Bu sonuç, en iyi takviye dağılımının 100 µm boyutunda meydana geldiğini ve kompozit yapı içinde en az gözenekliliğinde yine 100 µm boyutunda B_4C takviyeli kompozit yapılarda oluştuğu değerlendirmesini yaptırmaktadır.

C. Abrasif Aşınma

Sertlik deneyi sonrası numuneler temizlenerek aşınma deneyine hazırlanmıştır. Aşınma deneyi için 320C silisyum karbür zımpara kullanılmıştır. Zımparanın dönüş hızı 135 rpm olarak ayarlanmıştır. Numunenin zımpara üzerinden 210mm çaptan başlayarak 50 mm çapa 2 rpm ilerleme hızı ile 2 tur attırılmıştır. Test öncesi hassas terazi yardımıyla tartılan numuneler, aşınma testleri sonrası tekrar tartılarak aşınma sonucu oluşan kayıplar hesaplanmıştır. Söz konusu kayıplar tablo 2 ve Şekil 6'daki grafiklerde gösterilmiştir.

Tablo 2. Aşınma deneyi sonuçları

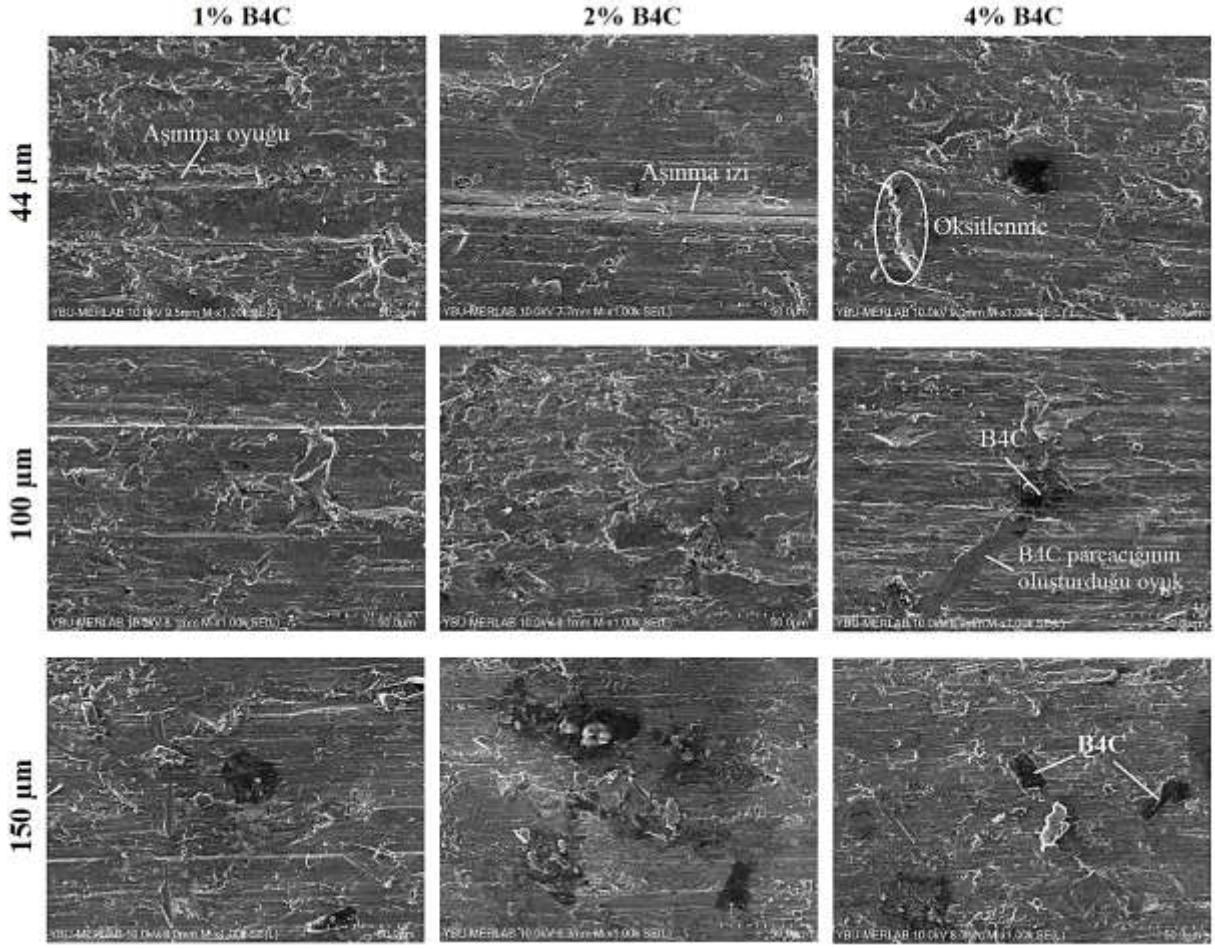
B_4C oranı	**44 µm**	**100 µm**	**150 µm**
1%	0,4064	0,3425	0,3997
2%	0,2798	0,3055	0,267
4%	0,2937	0,3011	0,2827
Saf Al7075	0,4325		



Şekil 6. Aşınma Deneyi Sonuçları

Şekil 6'da yer alan sonuçlara göre alüminyum içerisindeki bor karbür yüzdesinin artmasıyla aşınmanın azaldığı gözükmektedir. Elde edilen sonuçlara göre aşınmanın en az olduğu numunenin %2 150 µm bor karbür takviyeli alüminyum kompozit olduğu gözlemlenmiştir. Aşınmayı etkileyen çok sayıda faktör vardır. Malzemenin sertliği de bunlardan birisidir. Bu çalışmada üretilen kompozit yapılar içerisinde en düşük sertlik değerleri %1 B_4C takviyeli numunelerden ölçülmüştür. Elde edilen aşınma miktarlarına bakıldığında ise en yüksek aşınma değerleri yine %1 B_4C takviyeli numunelerde meydana gelmiştir. Bu durumda aşınma kayıpları üzerinde en etkili faktörün kompozit yapıların sertlik değerleri olduğu değerlendirilmiştir. Kompozit yapı içerisindeki çok sert fazda olan B_4C takviye miktarının artmasına bağlı olarak aşınma miktarları azalmıştır.

Aşınma deneyi sonrası yüzeylerin mikroyapılarını incelemek amacıyla SEM mikroskobunda görüntüleri çelikmiş ve EDS analizleri yapılmıştır. Şekil 7'de elde edilen görüntülerden örnekler yer almaktadır.



Şekil 7. Aşınma deneyi sonrası SEM görüntüleri

Şekil 7'deki SEM görüntülerine bakıldığında, biri birinden çok farklı bir yüzey yapısının olmadığı ilk etapta söylenebilir. Ancak B_4C takviye miktarının en fazla olduğu %4 B_4C takviyeli numunelerin yüzeyinde ikinci bir deformasyon mekanizmasının oluştuğu anlaşılmaktadır. B_4C miktarı ve boyutunun artmasıyla birlikte, aşındırıcı zımpara tanelerinin yanında, yapı içerisinde yer alan B_4C tanelerinin de koparak uzaklaşırken kompozit numunenin yüzeyinde aşındırma etkisi yaptığı görülmektedir. Tüm numune yüzeylerinde abrasif aşınma mekanizmasının etkili olduğu ve aşındırıcı zımparadaki 320 mesh tane büyüklüğündeki aşındırıcı partiküllerin yüzeyde ince aşınma çizgileri ve yer yer oyukları meydana getirdiği değerlendirilmektedir. Pin on disk yöntemiyle gerçekleştirilen abrasif aşınma testlerinin atmosfere açık ortamda yapılması nedeniyle, tüm kompozit numune yüzeylerinde oksit tabakalarının oluştuğu görülmektedir.

IV. SONUÇLAR

Bu çalışmada, farklı takviye oranları (%1, 2 ve 4) ile farklı tanecik boyutlarında (44, 100 ve 150 µm) karıştırmalı döküm yöntemi kullanılarak üretilen bor karbür takviyeli alüminyum kompozit malzemesinin ıslatabilirliğini arttırmak amacıyla saf Mg kullanılmıştır. Döküm işlemi açık atmosferli bir ortamda yapıldığı için oksitlenmelerin oluştuğu gözlemlenmiştir. Yapılan SEM testlerinde oksijen miktarının oldukça fazla olduğu tespit edilmiştir. Bununla birlikte Alüminyum içerisindeki B_4C miktarının artmasıyla yüzey kalitesinin kötüleştiği ve tane sınırlarının daha düzensiz bir hal aldığı görülmüştür.

Yapılan sertlik testlerine göre bor karbür tanecik boyutunun ve yüzdelik oranının artmasıyla brinell sertlik değerlerinin arttığı görülmüştür. Aynı zamanda 100 µm tanecik boyutlu kompozit malzemelerde en yüksek sertlik değerler gözükürken en düşük artış değerlerini 44 µm tanecik boyutlu kompozit malzemelerde görmekteyiz. Bu sonuç, en iyi takviye dağılımının 100 µm tanecik boyutunda meydana geldiğini ve kompozit içinde en az gözenekliliğin oluştuğu değerlendirmesini yaptırmaktadır.

Yapılan abrasif aşınma deneyinde, bor karbür yüzdesinin artmasıyla aşınmanın azaldığı lakin %2'den %4 oranlı kompozit numunelere geçerken aşınmanın azalmadığı aksine azda olsa arttığı, 100 µm boyutundaki malzemede neredeyse aynı olduğu görülmüştür. Elde edilen sonuçlara göre aşınmanın en az olduğu malzemenin %2 150 µm B_4C takviyeli alüminyum kompozit olduğu görülmüştür. B_4C miktarı ve boyutunun artmasıyla, aşındırıcı zımpara tanelerinin yanında, yapı içerinde yer alan B_4C tanelerinin de koparak numunenin yüzeyinde aşındırma etkisi yaptığı görülmektedir. Bu sebeple partiküllerin yüzeyde ince aşınma çizgileri ve yer yer oyuklar meydana getirdiği değerlendirilmektedir. Deneyin atmosfere açık ortamda yapılması nedeniyle, tüm kompozit numune yüzeylerinde oksit tabakaların oluştuğu görülmektedir.

TEŞEKKÜR

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Modeling of Interval-Valued Fuzzy Cubic Bézier Curve Approximation Method for Uncertainty Data

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Abstract **–** Modeling curves with data arising from uncertain environments is inherently challenging because of noise and underlying uncertainties. This paper presents a novel approach to approximate cubic Bézier curves through an interval-valued fuzzy method designed specifically for dealing with data uncertainty. Central to this method is the establishment of the foundation elements for constructing the Bézier curve which are in the form of interval-valued fuzzy control points. These fuzzy control points, when integrated into the traditional Bézier blending function, will yield a fuzzy Bézier curve that can effectively capture input data imprecision and variability. Interval-valued fuzzification allows a more flexible and accurate representation of the curve by accommodating uncertainties unattended by standard techniques. This study aims to delve into the theoretical framework that underpins the interval-valued fuzzy cubic Bézier curve approximation method by outlining its mathematical formulations and relationships. Furthermore, numerical examples are provided which will help to illustrate the application and advantages of this model in practice. It is through these examples that we can see how such a technique does not only translate uncertain data into reliable curve approximations but also shows its potential to be applied in engineering, computer graphics, and data analysis among others. By employing the interval-valued fuzzy approach and its associated relationships, the model can translate into some numerical examples.

Keywords – Interval-valued fuzzy set, interval-valued fuzzy Bézier curve, interval-valued fuzzy control point, Bézier curve approximation, fuzzy geometric modeling.

I. INTRODUCTION

The fuzzy set theory, introduced by Zadeh in 1965 [1], was developed to address uncertainty. A decade later, Zadeh expanded on this notion by introducing interval-valued fuzzy Sets (IVFS) as an extension of the fuzzy set theory where the values representing membership degrees are specified as intervals rather than single values [2]. This approach has been proven to be more effective in capturing uncertainty compared to traditional fuzzy sets. Research into IVFS has taken various paths. Son [3] introduced interval-valued fuzzy soft sets for more flexible membership representation. Bustince [4] highlighted their importance in soft computing for specific problems. Verma [5] further extended this concept to hesitant interval-valued fuzzy sets, introducing new operations and properties. Collectively, these studies demonstrate the adaptability and usefulness of IVFS across multiple domains. IVFS have been widely researched and applied in fields

such as approximate reasoning [6-7], medical diagnosis [8], multivalued logic [9], decision making [10-12], and image processing [13-14]. Therefore, incorporating IVFS into applications like Fuzzy geometric modeling is one of big potential in some industries.

Geometric modeling is one of the most important uses of Computer-Aided Design (CAD) systems that essentially entails the use of mathematical descriptions of geometric elements for representing and manipulating graphical images on a computer screen [15]. This procedure supports the visualization of ideas, alterations in designs, and preproduction tests thereby improving cost and time efficiency. Bézier techniques simplify intricate mathematical ideas into an intuitive geometric representation. Pierre Bézier [16] invented the Bézier curve which is a fundamental basis for geometric modeling with properties that were later developed by Paul de Casteljau [17] using Bernstein polynomials in conjunction with the de Casteljau algorithm. Forrest's [18] work discovered how Bernstein polynomials relate to Bézier curves. The functional expression of a Bézier curve provides us with geometrical perspectives on Bernstein Polynomials. Wahab et al. [19] introduced a fuzzy number theory-based geometric modeling concept through which they proposed fuzzy control points for fuzzy curves and surface models in Computer-Aided Geometric Design (CAGD). Furthermore, such concepts were applied by different researchers who combined principles from set theories and geometric models based on fuzziness [20-22].

The next part is to discuss interval-valued fuzzy numbers as well as define them to establish some basic theorems, also interval-valued fuzzy control points will be introduced. The proposed method will show how the interval-valued fuzzy control points blended with Bézier basis functions to create a framework for approximating uncertain data.

II. PRELIMINARIES

This section provides fundamental definitions of interval-valued fuzzy sets, encompassing interval-valued fuzzy numbers, interval-valued fuzzy relations, and interval-valued fuzzy points.

Definition 1 *[1] Let a fuzzy set A is defined on a universe X given as*

$$A = \{\langle x, \mu_A(x)\rangle \mid x \in X\} \tag{1}$$

where $\mu_A(x): X \to [0,1]$ *is the membership function A. The membership value* $\mu_A(x)$ *describes the degree of belongingness of in A.* Figure 1 shows an example of fuzzy set *A.*

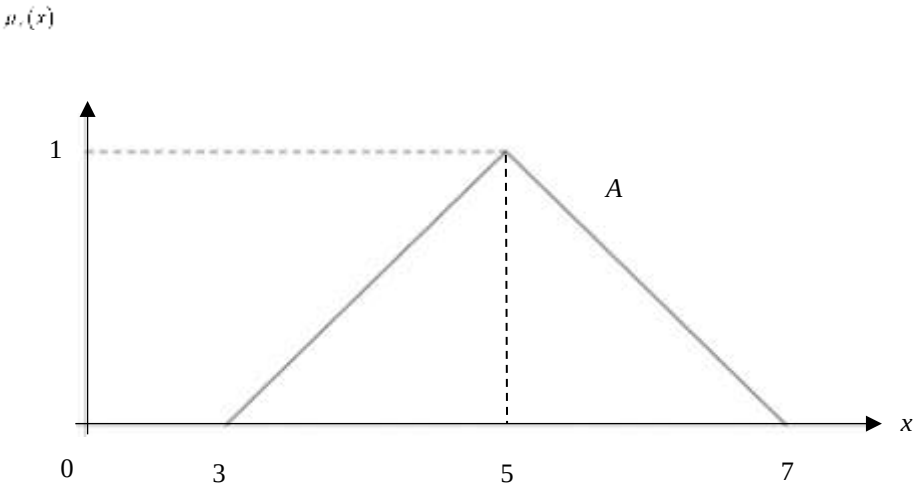

Fig. 1 Fuzzy set *A*

Definition 2 *[2] Let an interval-valued fuzzy set (IVFS)* $\tilde{A}$ *in X given as*

$$\tilde{A} = \left\{ \left\langle x, \underline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{A}}(x) \right\rangle \mid x \in X \right\} \tag{2}$$

where $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are the lower and upper bound of the membership degree respectively on which fulfil the following condition*

$$0 < \underline{\mu}_{\tilde{A}}(x) \le \overline{\mu}_{\tilde{A}}(x) \le 1 \tag{3}$$

The idea of interval-valued fuzzy numbers has emerged from both fuzzy set theory and possibility theory. The concept of fuzzy numbers was initially introduced in [6]. Definitions 3 and 4 illustrate the interval-valued fuzzy number and the normal triangular interval-valued fuzzy number, respectively.

Definition 3 *An interval-valued fuzzy number (IVFN)* $\tilde{A}$ *is defined as*

i. *normal where there is any* $x_0 \in R$ *such that* $A(x_0) = [1,1]$

ii. *convex for the memberships* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *where* $\underline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \underline{\mu}_{\tilde{A}}(x_1), \underline{\mu}_{\tilde{A}}(x_2)$ *and* $\overline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \overline{\mu}_{\tilde{A}}(x_1), \overline{\mu}_{\tilde{A}}(x_2)$ *for* $\forall x_1, x_2 \in R, \lambda[0,1]$

iii. $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are upper semi-continuous*

iv. *the support of* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are bounded that is the closure of* $\left\{ x \in R : \underline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *and* $\left\{ x \in R : \overline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *are bounded.*

Definition 4 *Suppose that from [23], define the normal triangular interval-valued fuzzy number* $\tilde{A}$ *to be represented by two fuzzy numbers* $\underline{A}_x = (\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}})$ *and* $\overline{A}_x = (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})$ *:*

$$\tilde{A} = [\underline{A}_x, \overline{A}_x]$$

$$\tilde{A} = [(\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}}), (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})] \tag{4}$$

where $\overline{a}_1 \le \underline{a}_1$, $\underline{a}_3 \le \overline{a}_3$ and $\underline{w}_{\tilde{A}} = \overline{w}_{\tilde{A}}$ while $\underline{a}_2 = \overline{a}_2$ is a crisp value and $\underline{w}_{\tilde{A}}$ and $\overline{w}_{\tilde{A}}$ are the heights of $\underline{A}_x$ and $\overline{A}_x$. The IVFN can be shown in Fig. 2.

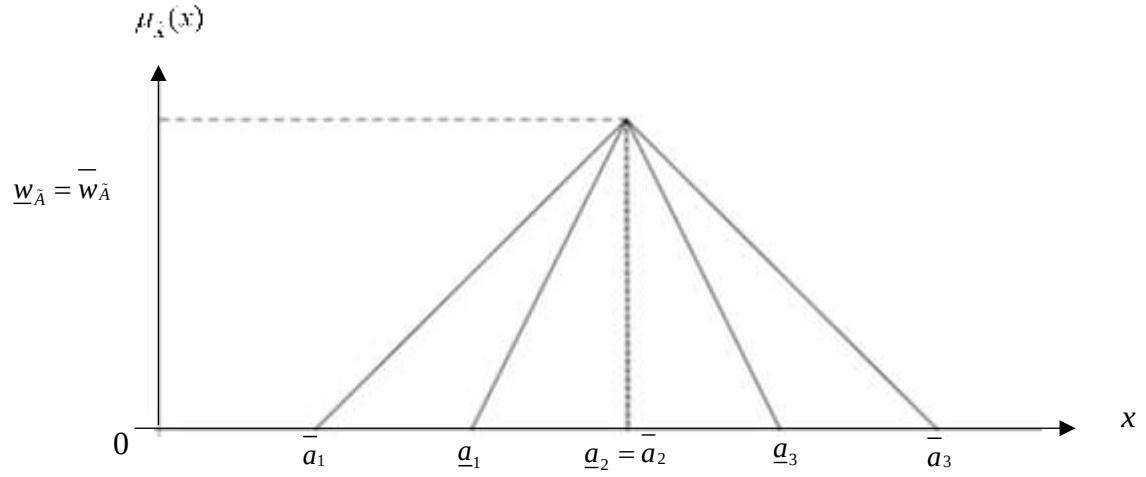

Fig. 2 The normal triangular interval-valued fuzzy number

Interval-valued fuzzy relation has been studied in [24-25]. The introduction of the interval-valued fuzzy relation (IVFR) acts as a bridge, linking the definition of interval-valued fuzzy numbers (IVFN) with the representation of interval-valued fuzzy data points.

Definition 5 [26] *Let X and Y be non-empty sets and interval-valued fuzzy relation R. Let* $X, Y \subseteq R$ *be universal sets, then*

$$\tilde{R} = \left\{ \underline{R}(x,y), \overline{R}(x,y) \mid (x,y) \in X \times Y \right\} \tag{5}$$

where $\underline{R} : X \times Y \to [0,1]$ and $\overline{R} : X \times Y \to [0,1]$.

Definition 6 *Let* $S, R \in IVFR(X \times Y)$, *then for every* $(x,y) \in X \times Y$ *we can define*

$$S(x,y) \le R(x,y) \Leftrightarrow \underline{S}(x,y) \le \underline{R}(x,y) \le \overline{S}(x,y) \le \overline{R}(x,y) \tag{6}$$

where there are operations on the supremum and infimum in IVFR $(X \times Y)$ respectively as below

$$(S \vee R)(x,y) = \left[\max\left(\underline{S}(x,y), \underline{R}(x,y)\right), \max\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{7}$$

$$(S \wedge R)(x,y) = \left[\min\left(\underline{S}(x,y), \underline{R}(x,y)\right), \min\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{8}$$

III. Interval-valued Fuzzy Bézier Curve Approximation Model

The data points utilized to shape a Bézier curve are termed control points. The control points is denoted by $P_i = P_0, P_1, \ldots, P_i$. Fuzzy control point has been defined in [19].

A. *Interval-Valued Fuzzy Cubic Bézier Control Point*

From the definition of interval-valued fuzzy set, interval-valued fuzzy number and interval-valued fuzzy relation, the IVCP is written as follows.

Definition 7 *Let the interval-valued fuzzy set (IVFS) of* $\tilde{P}$ *in space S such that the set of interval-valued fuzzy control point (IVFCP) is defined as*

$$\tilde{P} = \left\{ \tilde{P}_i \right\}_{i=0}^{n=4} \tag{9}$$

where there exists membership functions of lower left and right, crisp value, and upper left and right bound respectively $\mu_{\tilde{P}}^{\underline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{\overline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{C} : S \to [0,1]$, $\mu_{\tilde{P}}^{\underline{R}} : S \to [0,1]$ *and* $\mu_{\tilde{P}}^{\overline{R}} : S \to [0,1]$.

In the geometric model, the interval-valued fuzzy control point is combined with the basis function of Bézier curve approximation. The interval-valued fuzzy Bézier control points in Equation (9) consists control points with lower left, $\tilde{P}_i^{\underline{L}}$, upper left, $\tilde{P}_i^{\overline{L}}$, crisp value, $\tilde{P}^C$, lower right, $\tilde{P}_i^{\underline{R}}$, and upper right, $\tilde{P}_i^{\overline{R}}$.

B. *Interval-Valued Fuzzy Cubic Bézier Curve*

Definition 8 *Let* $\tilde{P}$ *be a IVFCP with* $\tilde{P} = P_i : i = \{0,1,2,3,4\}$, *hence the interval-valued fuzzy cubic Bézier curve (IVFCBC) is defined as*

$$\tilde{B}(t) = \sum_{i}^{n} \tilde{P}_i J_{n,i}(t), 0 \le t \le 1 \tag{10}$$

where Bernstein polynomials denoted as $J_{n,i}(t) = \binom{n}{i} t^i (1-t)^{n-i}$ *and the binomial coefficients is* $\binom{n}{i} = \frac{n!}{i!(n-i)!}$ *where the n values is up until 4 since it is cubic function.*

The IVFCBC in equation (10) consists of :

$$\tilde{B}^{\underline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{L}}J_{n,i}(t),0\le t\le 1 \tag{11}$$

$$\tilde{B}^{\overline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{L}}J_{n,i}(t),0\le t\le 1 \tag{12}$$

$$\tilde{B}^{C}(t)=\sum_{i}^{n}\tilde{P}_i^{C}J_{n,i}(t),0\le t\le 1 \tag{13}$$

$$\tilde{B}^{\underline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{R}}J_{n,i}(t),0\le t\le 1 \tag{14}$$

$$\tilde{B}^{\overline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{R}}J_{n,i}(t),0\le t\le 1 \tag{15}$$

where $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left IVFCBC, upper left IVFCBC, crisp IVFCBC, lower right IVFCBC, and upper right IVFCBC respectively.

IV. Modeling of Interval-valued Fuzzy Cubic Bézier Curve (IVFCBC) Approximation Model

This section will model the interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation model for $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left, upper left, crisp, lower right, and upper right of IVFCBC respectively with the degree *n=3* since the models are in cubic case. Table 1 shows the IVFCP with their membership values. At the end of this section will demonstrate an algorithm to construct the IVFCBCs approximation model.

Table 1. IVCP with the values of their membership

IVFCPs					**Membership degrees**
$\tilde{P}_i^{\underline{L}}$	$\tilde{P}_i^{\overline{L}}$	$\tilde{P}_i^{C}$	$\tilde{P}_i^{\underline{R}}$	$\tilde{P}_i^{\overline{R}}$	
-2	-1	0	1	2	0.7
-1	0	1	2	3	0.2
0	1	2	3	4	0.9
1	2	3	4	5	0.3

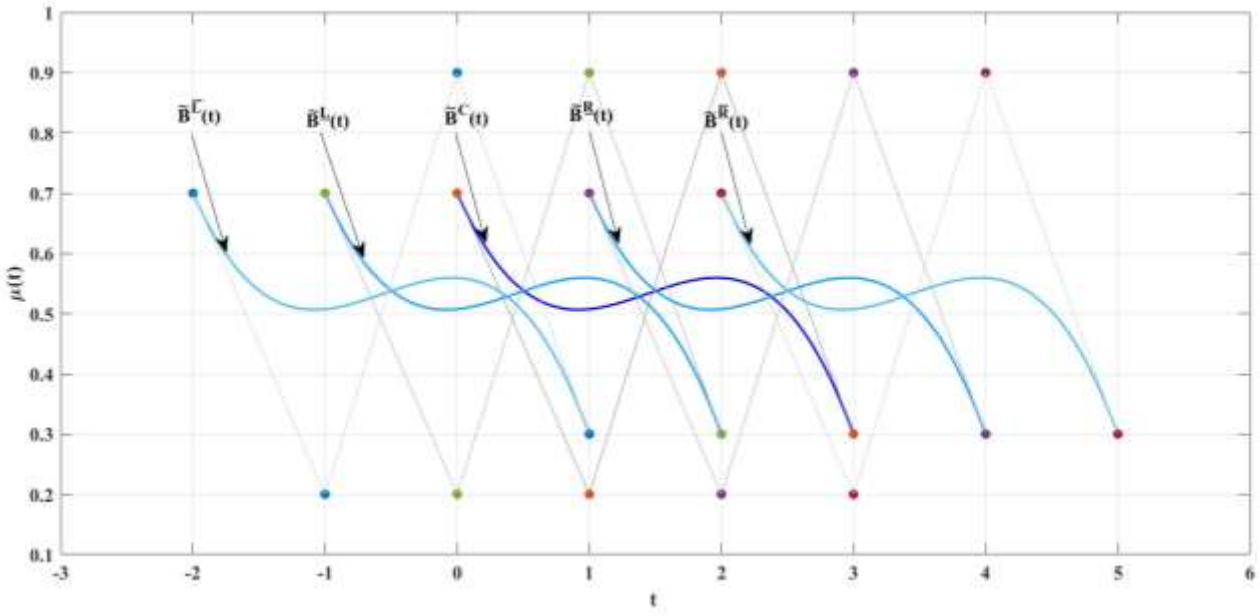

Fig. 3 Interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation models

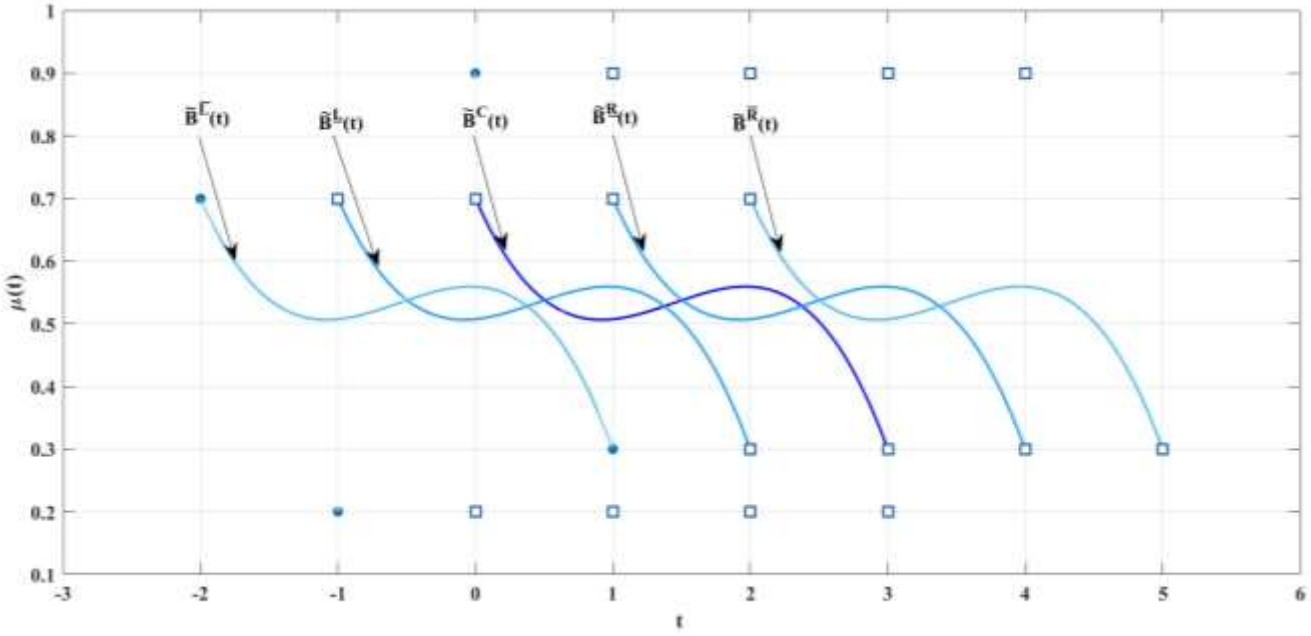

Fig. 4 Interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation models without control polygons

Figure 3 shows how the control polygon will impact the behavior of the curves based on the IVFCPs. Figure 4 illustrates IVFCBC without a control polygon. The curves in the illustration estimate the IVFCP because this study used an approximation method. The following is an algorithm for constructing the IVFCBC:

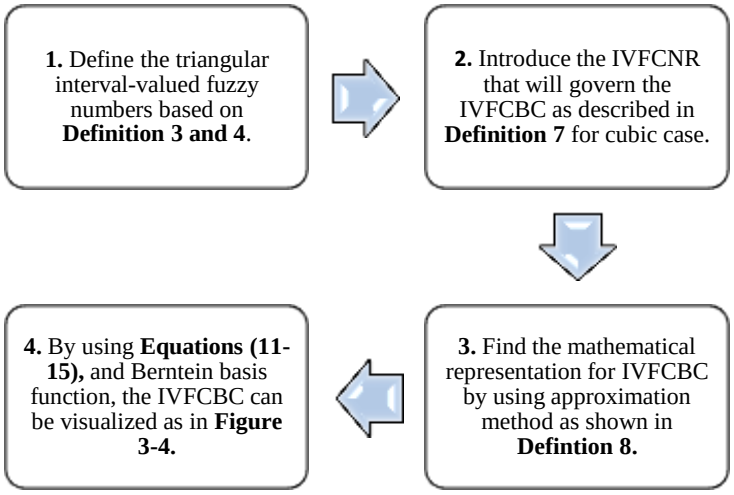

Fig. 5 An algorithm for construct IVFCBC

V. CONCLUSION

In this paper we presented a new optimal method to represent curves under uncertainty using interval-valued fuzzy cubic Bézier curve. By introducing an interval-valued fuzzy set here, the method enriches the classical cubic Bézier curve that becomes more capable of describing data uncertainty and imprecision.

The proposed approach can be an effective alternative for system problems dealing with uncertainty data, which are ordinary in some real-world applications involving computer-aided geometric design, data visualization, and signal processing. In summary, the interval-valued approximate method of fuzzy cubic Bézier curves reveals a major breakthrough in fuzzy modelling and curve approximation. It provides an effective framework for handling and expressing uncertainty in different contexts thereby improving precision and dependability of data-based models and approximations.

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Çimento Hamurunun Priz Süresi ve Erken Yaş Performansına Plastik Tozunun Etkisi

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Özet **–**Üretim sürecinin birçok basamağında çevresi ve sürdürülebilir kabul edilmeyen çimentoya, ikame yan ürün arayışı son yıllarda hız kazanmıştır. Geleneksel çimento (klinker-yarı mamul) üretilirken gerekli olan ısı ihtiyacı fosil yakıtlardan karşılanır ve bu süreçte çevre kirliliği kaçınılmazdır. Çimentoya alternatif ürün olarak özellikle sanayi yan ürünü ya da geri dönüşüm ürünü kullanımı önemlidir. Bu anlamda uçucu kül, yüksek fırın cürufu, silis dumanı ve geri dönüştürülmüş beton ve türevlerinin kullanımı yaygındır. İkame ürünler normal kıvam ve priz süreleri üzerine etkilidir. Bu etkilerden yola çıkarak çoğu zaman beton ya da harç türevlerinin fiziksel, mekanik ve durabilite özellikleri hakkında ön değerlendirmeler yapılabilir. Bu amaçla bu deneysel çalışma kapsamında, alternatif ürün arayışına yönelik olarak plastik tozunun çimentoya kütlece ikame durumunun uygunluğu araştırılmıştır. % 0-5-10-15-20-25 oranlarında plastik tozunun ikame edildiği 6 farklı çimento hamuru ile normal kıvam ve priz süreleri tespit edilmiştir. Ayrıca üretilen karışım tasarımlarına bağlı kalarak her karışım için 3'er adet toplamda 18 adet 50x50x50 mm ayrıtlı küp numune üretilmiştir. 7 gün kirece doygun su kürü ile olgunlaştırılan küp numuneler üzerinde bir takım fiziksel tespitler yapıldıktan sonra eksenel basınç dayanımları belirlenmiştir. Deneysel çalışma verilerine göre plastik tozunun çimentoya ikamesinin normal kıvam ve priz sürelerinin yanı sıra erken yaş fiziksel özellikleri ve eksenel basınç dayanımına etkisi olduğu tespit edilmiştir.

Anahtar Kelimeler – Plastik tozu, normal kıvam, priz süreleri, eksenel basınç, fiziksel özellikler

I. GİRİŞ

Çimento üretimiyle ilişkili çevre sorunlarının temelinde; enerji tüketimi ve ortaya çıkan fabrika emisyonları bulunmaktadır. Doğal kaynakların sınırlı olması ve çevre sorunlarının bertarafındaki zorlu süreçler çimentoya ikame ürün arayışını kaçınılmaz kılmaktadır [1]. Puzolanlar doğal ya da yapay olmanın yanı sıra özellikle sanayi yan ürünü ya da geri dönüşüm prosesleri ile sürece dahil edilmeleri anlamında sürdürülebilir kabul edilir [2–4]. Çimentoya ikame edilen ürünlerin kütlece değişimi esastır ve ekonomik katma değerin yanı sıra CO_2 emisyonunu dolaylı olarak azaltmaktadır [5]. Puzolanlar hidratasyon ile açığa çıkan $Ca(OH)_2$ ile reaksiyon süreci sonrası ilave bağlayıcılar oluşturur. Bu durum geçirimliliği azaltır ve durabiliteyi iyileştirir [6,7]. Çimentoya alternatif olarak kullanılacak ürünlerin puzolanik aktivitesi önemli bir kriterdir ve puzolonik aktivite değerlendirilirken mikroyapı, kimyasal analiz, normal kıvam ve priz sürelerinin tespiti en sık başvurulan yöntemlerdir. Çoğu fiziksel, mekanik ve durabilite ölçütü, normal kıvam ve priz süreleri ile de doğrudan ya da dolaylı olarak ilişkilidir [8,9].

Atık malzemeler çok geniş bir yelpazede değerlendirilse de bunların çoğu beton ve harç elemanlarda kullanıma uygun değildir. Bu sebeple çimentolu bağlayıcının bir parçası veya agrega olarak kullanılacak ikame ürünlerin kullanım öncesi iyi bir değerlendirme sürecine ihtiyacı vardır. İkame ürünlerin üretim sonucunda sunduğu değişimin yanı sıra üretim sürecindeki davranışı ve etkileri de önemlidir. İkame ürünler genellikle reaktif ve inert maddeler olarak sınıflandırılmaktadır. Özellikle PÇ'ye puzolanik reaksiyon

yapma kabiliyeti olan ürünlerin ikame edilmesi, harç matrisini ve çimento agrega ara yüzeyini güçlendirerek dayanım ve dayanıklılığını artırabilmektedir [8]. Bu ürünlerin önemli diğer fonksiyonları ise ürün boyutu, parçacık boyutundaki dağılım ve özgül yüzey alanına bağlı olarak mikrodolgu etkisi olarak sıralanabilir. Bu anlamda yeterli performansın tahsisi üretim sonrası ürünlerin daha boşluksuz ve daha yüksek dayanımlı olmasını sağlamaktadırlar [10]. Alternatif ürün skalasında olan ve çok sık tercih edilen cüruf ve türevlerinin puzolonik aktivitesi ürünün inceliğinden büyük oranda etkilenir [11]. Ayrıca bu ürünlerin temin sürecindeki soğutma yöntemi de önemli bir diğer etkendir [12].

Polietilen Tereftalat (PET) şişeler, hafifliğinden taşıma ve kullanım kolaylığına kadar birçok avantajından dolayı muadili ürünlere göre daha fazla tercih edilmektedir. Özellikle ABD ve Kanada gibi yoğun nüfusu ülkelerin artan tüketim ihtiyacını karşılayan PET şişeler [13], günümüzde gelişmiş ve gelişmekte olan birçok ülkede de yüksek oranda kullanılır ve buna bağlı olarak da çevresel bir tehdit olarak kabul edilmektedir. Atık PET ürünler diğer ekonomik hacme sahip atık ürünler gibi ekonomik değere sahiptir ve geri dönüşümü önemlidir. Bu ekolojik ve ekonomik sürecin sürdürülebilirliği kaçınılmazdır. Geri dönüştürülmüş PET ürünlerin inşaat sektöründe kullanımı çoğunlukla agrega alternatif ya da lif katkı ürünü şeklidedir [14–19]. Bu hali ile çoğu zaman plastik lif ve çimento matrisi arasında zayıf bağlar oluşmaktadır. Bu olgunun en önemli sonuçlarından biri de iç mikro çatlaklardır [20,21]. Ayrıca atık PET ürünlerin çimentoya ikame durumlarının incelendiği çalışmalar sınırlıdır [22].

Bu çalışmada plastik tozu çimentoya %0-%25 bandında ikame edilerek 6 farklı çimento hamuru üretilmiştir. Tüm çimento hamurları ile normal kıvam ve priz süreleri tespit edildikten sonra tasarımdaki normal kıvam su oranına bağlı kalınarak her karışım için 3'er adet küp numune üretilmiş ve bu numuneler ile bir takım fiziksel tespitler ile eksenel basınç dayanımı deneyi gerçekleştirilmiştir.

II. MATERYAL VE YÖNTEM

Deneysel çalışmada üretilen 6 farklı karışımda CEM-I 42.5R çimento [23], çimentoya ikame plastik tozu ve saf su, kullanılmıştır (Şekil 1.a). CEM-I 42.5R çimentonun teknik özellikleri Tablo 1'de verilmiştir. Plastik tozu CEM-I 42.5R'ye %0, 5, 10, 15, 20, 25 oranlarında ikame edilmiş ve bu değişim ile hazırlanan çimento hamurlarıyla normal kıvam ve priz süreleri tespit edilmiştir (Şekil 1.b). Normal kıvam su ihtiyacı tespit edilen çimento hamurlarının karışım miktarına bağlı kalarak her ikame durumu için 3'er adet 50x50x50 mm ayrıtlı küp numune üretilmiştir (Şekil 1.c). Tablo 2, 500 gram (g) toz malzeme ile üretilen çimento hamurlarında kullanılan malzeme miktarını vermektedir. Küp numuneler 24 saat sonra kalıplardan çıkarılmış gerekli kodlamalar yapılarak 7 gün kirece doygun su kürü ile 20 °C (±2) sıcaklıkta olgunlaştırılmıştır. Küp numuneler ile etüv kurusu birim hacim ağırlık, porozite ve eksenel basınç dayanımı deneyleri gerçekleştirilmiştir. Şekil 1 çalışmada kullanılan materyal ve deneysel çalışmaya dair görseller içermektedir.

Tablo 1. CEM-I 42.5R Çimentonun özellikleri

Kimyasal bileşim (%)	CaO	63.57
	SiO_2	19.34
	Al_2O_3	3.75
	Fe_2O_3	4.15
	MgO	2.9
	SO_3	3.15
	K_2O	0.81
	Na_2O	0.41
Kızdırma kaybı		1.92
Blaine (cm^2/g)		3804
Özgül ağırlık (g/cm^3)		3.15

Şekil 1. Materyal ve deneysel uygulama

Tablo 2. Çimento hamuru karışım tasarımı

Karışım	Çimento (g)	İkame Miktarı (g)	İkame Oranı (%)	Su (g)
M1	500.0	00.0	0	156.0
M2	475.0	25.0	5	153.0
M3	450.0	50.0	10	151.5
M4	425.0	75.0	15	150.0
M5	400.0	100.0	20	150.0
M6	375.0	125.0	25	148.0

A. Normal kıvam ve priz sürelerinin tayini

Deneysel çalışma 20 °C (±2) sabit sıcaklık ve %65 nispi nem oranına sahip laboratuvar ortamında gerçekleştirilmiştir. Çalışmada kullanılan laboratuvar tipi mikser, hassas terazi, vicat aleti ilgili standartları sağlayacak niteliktedir [24]. Çalışmada kullanılan laboratuvar tipi mikser 2 dm^3 kapasitelidir. Ayrıca tüm sıvı ve toz malzemenin miktarı 0.01 hassasiyetli tartı ile tespit edilmiştir.

Vicat aleti, düz bir tabla ve tabla eksenine dik açı ile hareket edebilen, ayarlanabilir silindir mil ve bu mili tutan sistemden oluşmaktadır. Uygulanacak deneysel çalışmaya bağlı olarak milin alt ucuna vicat sondası ya da vicat iğnesi takılmaktadır. Milin etken ağırlığı 300 g, vicat sondasının etkili uzunluğu 50 (± 1mm) ve çapı 10,00(± 0,05mm)'dir. Kesik koni şeklindeki vicat hunisinin derinliği 40,0 (± 0,2) mm; üst iç çapı 70(± 5) mm ve alt iç çapı ise 80 (± 5) mm'dir. Her çimento hamuru karışımı hazırlanırken kullanılan toplam toz malzeme miktarı 500 g'dır.

Miksere önce toz malzeme sonra su eklenerek 140 ± 5 devir / dk hızda 30 saniye karıştırılmış ve akabinde mikser 15 sn durdurulup karıştırma kabının yan çeperlerindeki malzeme karışıma dahil edilecek şekilde spatula ile toplanmıştır. Karışım kabı tekrar miksere yerleştirilmiş ve 285 ± 10 devir/dk hızda 2,5 dakika çalıştırılmıştır. İlgili bağlantı ve parçaları (cam, vicat sondası ve vicat hunisi) yağlanmış ve vicat aletinin hareketsiz, sabit bir zeminde konumlanması sağlanmıştır. Sondanın cam plaka üzerine tam olarak indirilmiş konumu taksimatlı gösterge üzerinde sıfırı verecek şekilde ayarlanarak mikserden alınan karışım yağlanmış vicat hunisine sıkıştırma ya da şişleme yapılmadan, çimento hamuru huni üst yüzeyi ile aynı seviyede olacak şekilde yerleştirilmiş ve fazla hamur temizlenmiştir. Vicat aletine yerleştirilen çimento hamurunun üst yüzeyine kadar kontrollü şekilde sonda indirilip ve bırakıldıktan sonra vicat sondasının kendi ağırlığı ile çimento hamuruna serbest batış yapması beklenmiştir. Sonda ucunun bırakıldığı andan itibaren 30 sn sonrasındaki batma miktarı göstergeden okunmuştur. Normal kıvam için su miktarı sondanın vicat hunisinin altındaki cam levhaya 5-7 mm kalıncaya kadar battığı miktarı temsil etmektedir. Üretilen çimento hamuruna sondanın batma miktarı ilgili standart aralığını sağlayana kadar su miktarı değiştirilmek suretiyle her defasında yeniden karışım hazırlanmıştır [24].

Normal kıvam sınır değer aralığını sağlayan vicat hunisindeki çimento hamuru priz sürelerinin tespiti için kullanılmıştır. Piriz başlama süresinin belirlenmesinde kullanılan vicat iğnesi vicat aletine takıldıktan sonra huni alt yüzeyinden 3-5 mm batma derinliğinin sağlandığı süre piriz başlama sürresi olarak kaydedilmiştir.

Aynı çimento hamuru ile priz sonu sürenin belirlenmesi için vicat iğnesi değiştirilmiş ve hamur üst yüzeyinden 0.05 mm'den daha az batmanın sağlandığı ana kadar işlem belirli süre aralıkları ile tekrarlanmıştır. Her tekrarda daha önce iğne batırılmış bölgelerden ve huni dış çeperine 1 cm kadar uzaklığın sağlandığı noktalardan batma derinliği belirlenmiştir.

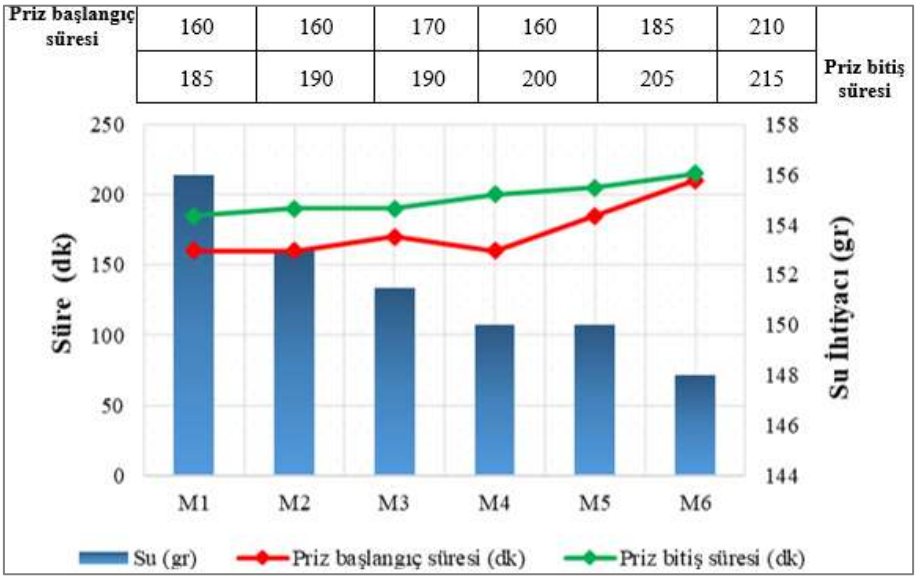
B. *Birim hacim ağırlık, porozite ve eksenel basınç dayanımın tayini*

7 gün su kürü sonrası küp numunelerin öncelikle "su içinde asılı ağırlığı" sonrasında "yüzeyi kuru suya doygun numune ağırlığı" tespit edilmiş ve numuneler 24 saat 110 °C'de hava sirkülasyonlu etüvde sabit ağırlığa gelene kadar bekletilmiş ve oda sıcaklığına geldikten sonra "etüv kurusu ağırlığı" tespit edilmiştir.

Küp numuneler ile etüv kurusu birim hacim ağırlık ve porozite oranı tespit edildikten sonra 250 kN kapasiteli üniversal basınç dayanımı test pres makinesi ile 1 kN/s basınç yükü uygulanarak eksenel basınç deneyi gerçekleştirilmiştir [25]. Tüm karışımlar için 3'er adet küp numuneden elde edilen sonuçların ortalaması alınmıştır.

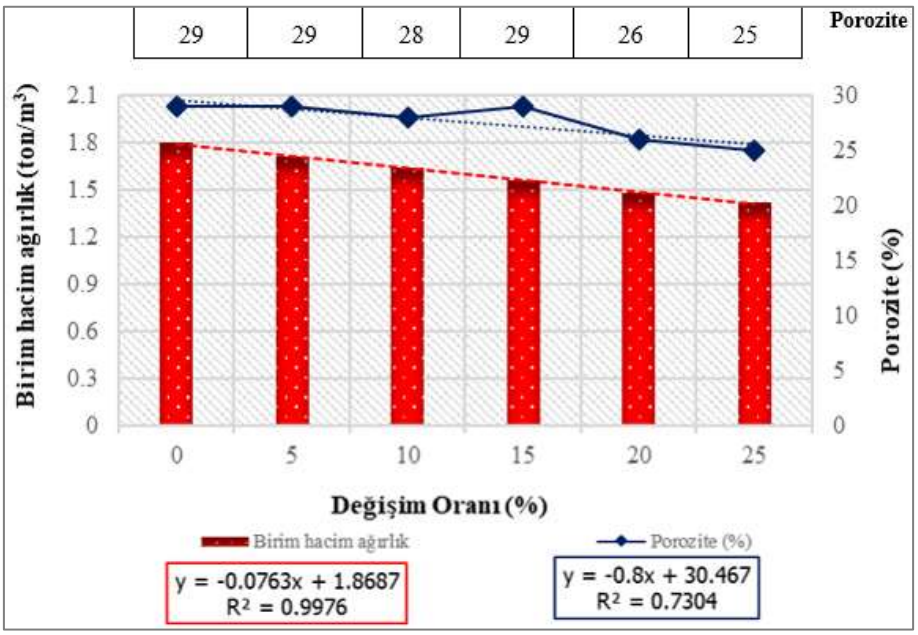
III. BULGULAR

Priz başlama ve priz sonu sürelerinin plastik tozunun çimentoya ikame durumları için değerlendirmesi Şekil 2'de sunulmuştur. TS EN 197-1 standardında CEM I 42,5R çimento hamurunun priz başı süresi ≥60 dk olarak sınırlandırılmıştır [23]. Tamamı CEM I 42,5R ile tasarlanan M1 referans karışımında bu süre 160 dk'dır ve sınır değerleri sağlamaktadır. Ancak plastik tozunun çimentoya ikame edilmesi priz başı ve priz sonu süresini uzatmaktadır. Artan plastik tozu ikamesi ile priz başlama süresi de artmakta ve en uzun priz başlama süresi %25 ikame içeren M6 setinde sağlanmaktadır. Referans setinden M4 setine kadar priz başlama süresi aralığı 160-170 dk bandında iken M5 ve M6 karışımı için daha belirgin bir süre artışı kaydedilmiştir. Şekil 2'de verilen priz bitiş süreleri incelendiğinde; referans seti ile M3 seti aralığında 185-190 dk bandında kaydedilen priz sona erme süresinin; M4, M5 ve M6 karışımları için referans setine oranla sırasıyla 15, 20, 30 dk uzadığı görülmektedir. Priz başlama süresi için M5 (%20) ve priz sona erme süresi için M4 (%15) sonrasındaki plastik tozu ikame oranları için priz sürelerindeki artış belirgindir. Bu veriler benzer çalıma verileri ile örtüşmektedir Çünkü hidrolik özelliği olmayan ikame ürünlerin çimento hamurunun priz süresini uzatması beklenen bir durumdur [26]. Artan plastik tozu miktarı ile su ihtiyacı azalmakta ve en düşük değerini 148 g ile M6 karışımında vermektedir. S/Toz Malzeme oranı M6 karışımında yaklaşık %29 oranındadır. Ayrıca tüm karışımlarda S/ Toz Malzeme oranı %31'in altında değer almaktadır.



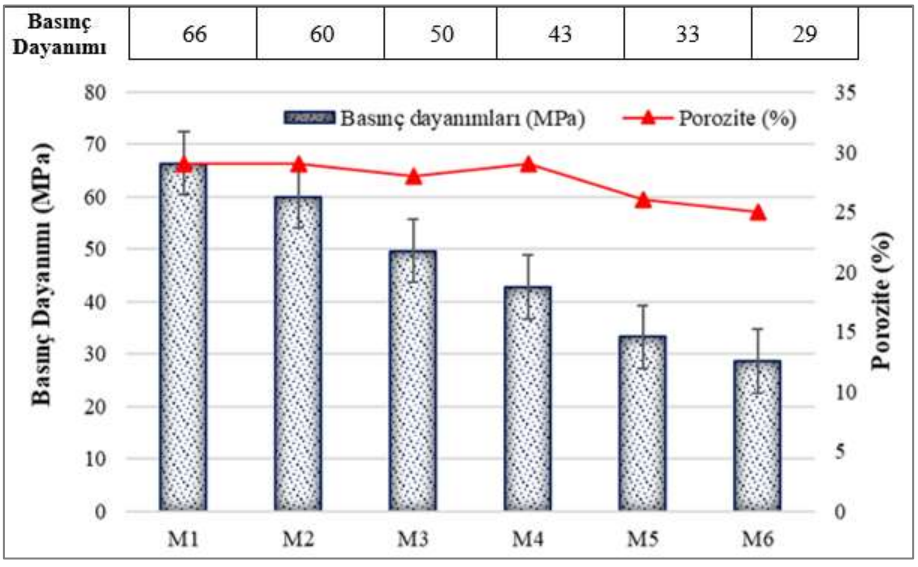
Şekil 2. Priz süreleri ve Normal kıvam su ihtiyacı

Çimento hamurlarında çimentoya ikame edilen plastik tozunun etüv kurusu birim hacim ağırlık ve porozite üzerindeki etkisi Şekil 3'te verilmiştir. Plastik tozunun çimento hamurunda artan miktarı ve çimentonun azalan miktarına bağlı olarak etüv kurusu birim hacim ağırlık azalmaktadır. En yüksek birim hacim ağırlık değeri referans setine aittir. 375 g çimento ve 125 g plastik tozu kullanılarak üretilen M6 setinde etüv kurusu birim hacim ağırlık değeri en düşük değerini alır. Aynı çimento hamurunun porozite oranı da tüm ikame durumları içinde en düşük değeri vermektedir. Ayrıca porozite oranı tüm karışımlar için %25-29 aralığında değer almaktadır.



Şekil 3. Birim hacim ağırlık ve porozite sonuçları

Porozite ve eksenel basınç dayanımı arasındaki ilişkinin plastik tozunun ikame durumu için değerlendirmesi yapılmış ve grafiksel gösterimi Şekil 4'te sunulmuştur. Artan plastik tozu miktarı ve azalan çimento miktarına bağlı olarak eksenel basınç dayanımı azalan bir eğilim sergilemektedir. En yüksek ve en düşük eksenel basınç dayanımı sırasıyla 66 ve 29 MPa'dır. Plastik tozundaki artış eksenel basınç dayanımı negatif yönde etkilemektedir. Plastik tozunun eksenel basınç üzerindeki bu azaltıcı etkisi mevcut çalışma verileri ile benzerlik sergiler [27].



Şekil 4. Eksenel basınç dayanım (MPa) ve porozite sonuçları

IV. SONUÇLAR

Bu deneysel çalışmada çimentoya %0-%25 bandında plastik tozu ikame edilmiş ve 6 farklı çimento hamuru üretilmiştir. Tüm değişim oranları için normal kıvam ve priz sürelerinin yanı sıra aynı karışım oranları ile üretilen 50x50x50 mm ayrıtlı küp numunelerin 7 günlük su kürü sonrası fiziksel özellikleri ve eksenel basınç dayanımı tespit edilmiştir. Çalışma verilerine göre;

Plastik tozunun artan ikamesi normal kıvam su ihtiyacını azaltmaktadır. Ayrıca priz başlama ve priz bitiş süreleri referans karışımında (M1) sırasıyla 160 ve 185 dk iken, en fazla plastik tozunun ikame edildiği çimento hamurunda (M6) sırasıyla 210, 215 dk'dır. Priz başlama ve priz bitiş süresi için sırasıyla M5 (%20) ve M4 (%15) plastik tozu ikame oranlarının üzerindeki ikame durumlarında süre artışları belirgindir.

Porozite oranı en düşük ve en yüksek oranı sırasıyla M6 ve M1 setinde sağlamaktadır. Plastik tozu porozite oranını azaltıcı etkiye sahiptir. Ayrıca karışım tasarımındaki artan plastik tozu miktarı ile birim hacim ağırlık M1 karışımından M6 karışımına yaklaşık % 21 oranında kayıp ile kaydedilmiştir. Tespit edilen priz sürelerinin işlenebilirlik açısından herhangi bir dezavantaj yaratmayacağı kanısı oluşsa da plastik tozunun eksenel basınç dayanımını azaltıcı etkisi belirgindir. En yüksek eksenel basınç dayanımı M1 karışımı ile 66 MPa iken en düşük eksenel basınç dayanımı değeri referans karışımına göre yaklaşık %56 kayıp ile M6 setinde 29 MPa olarak kaydedilmiştir.

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WC-9Co5Cr1Ni kompozit kaplamanın kaymalı aşınma karakteristiği

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Özet – Bu çalışma, WC-9Co5Cr1Ni kaplamaları üzerindeki farklı kayma yüklerini araştırmayı amaçlamaktadır. Bu amaçla Al2O3 aşındırıcı bilye WC-9Co5Cr1Ni kompozit kaplamaya 4N, ve 12N yükler altında uygulanmıştır. WC-9Co5Cr1Ni kompoziti, AISI 304 altlık malzeme üzerine yüksek hızlı oksijen yakıt (HVOF) yöntemiyle biriktirildi. Aşınma testleri ASTM G99-04'e uygun olarak disk üzerinde bilyalı bir tribometre üzerinde oda sıcaklığında gerçekleştirildi. Kaplama testlerinin sonuçlarını incelemek için aşınan yüzeyler optik profilometre ile ölçüldü ve aşınma hacimleri hesaplandı. Aşınma öncesi ve sonrası yüzey pürüzlülüğü ve mikroyapı değişiklikleri elektron mikroskobu ile incelendi. Ortaya çıkan aşınma izleri optik profilometre ile incelenerek aşınma karekteristiği tahmin edildi. Kaplama tozlarının ve sprey kaplamanın faz özellikleri XRD ile bulundu.

Anahtar Kelimeler – Aşınma, WC kaplama, HVOF, mikroyapı

I. GİRİŞ

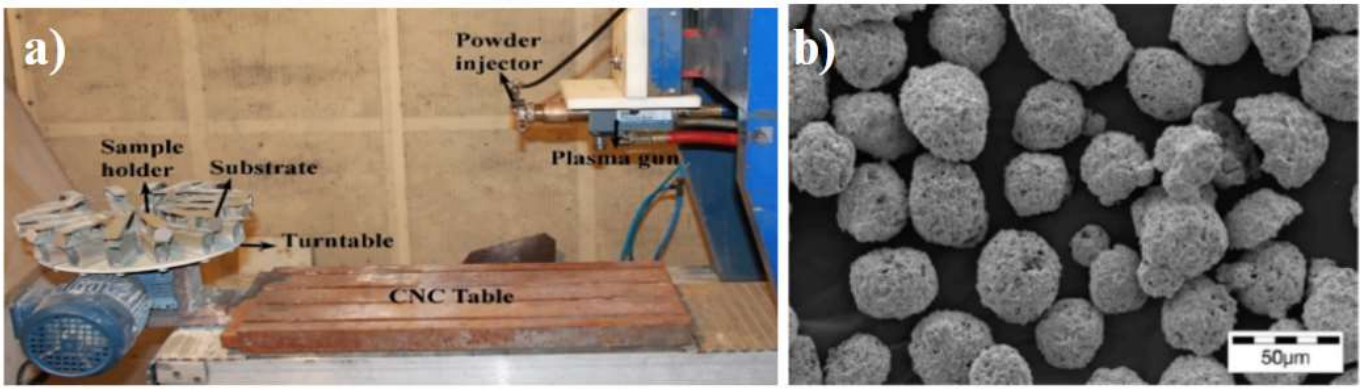
WC kaplamaları genellikle metalik bir bağlayıcı içerisine dahil edilen tungstenli karbür parçacıklarından oluşur. Kobalt (Co) veya nikel (Ni) en sık kullanılan bağlayıcılardır. Kaplamanın sertliğini korurken dayanıklılığını arttırırlar. Tungstenli karbür ve bağlayıcının bileşimi ve bütünlüğü, kaplamanın mekanik nitelikleri ve aşınma direnci üzerinde önemli bir etkiye sahiptir. Artan tungsten karbür (WC) içeriği genellikle sertliği ve aşınma direncini artırırken, daha yüksek bağlayıcı içeriği tokluğun ve darbe direncinin artırılmasına yardımcı olur. WC-12Co birçok durumda, özellikle aşındırıcı ortamlarda olağanüstü aşınma direnci gösterir. Bununla birlikte sistemin performansı, özel kullanım durumuna ve çevresel koşullara bağlı olarak değişiklik gösterebilir. Aşınma performansını optimize etmek ve WC-12Co'dan üretilen bileşenlerin servis ömrünü uzatmak, dikkatli malzeme seçimi, tasarım hususları ve bakım teknikleri gerektirir [1]. WC-Co kaplamaların mikro yapısı ve mekanik özellikleri, belirli uygulamalara uygunluğunun belirlenmesi açısından çok önemlidir. Metaller arasındaki ara bağlantı kaplamasının mikro yapısı ve mekanik özellikleri, WC çapının boyutu, kalıcı fazın yerleşimi, kalıntılar, çatlaklar, yabancı maddeler ve karbürler gibi faktörlerden doğrudan etkilenir. Bu faktörler kaplamanın tokluğunu ve aşınma direncini belirlemede çok önemli bir rol oynamaktadır [2]. WC-12Co semente karbürler, olağanüstü aşınma dirençleri ve yüksek sıcaklıklara dayanabilme yetenekleri nedeniyle çeşitli işleme, kesme ve delme uygulamalarında yaygın olarak kullanılmaktadır. Ayrıca, termal püskürtmeyle uygulanan tungsten karbür-kobalt (WC-Co) kaplamalar, havacılık, metalurji, enerji ve elektrik enerjisi üretimi gibi çeşitli endüstrilerdeki aşınmaya dirençli parçaların yüzeylerini korumak için yaygın olarak kullanılmaktadır [3], [4] [5].

Yüksek hızlı oksijen yakıtı (HVOF) alev püskürtme tekniği karbür bazlı kaplamaların üretiminde yaygın olarak kullanılır. Agresif ortamlarda aşınma davranışı ve korozyon direnci açısından mükemmel sonuçlar verir. Atmosferik plasma spreyleme tekniğiyle karşılaştırıldığında, HVOF şunları sağlar: daha yüksek parçacık hızı ve daha düşük parçacık sıcaklığında gerçekleştirilir. Bu özellikler metalik bağlayıcının oksidasyonunu önler ve kaplamanın ömrünü uzatır[6], [7]. Çalışmada, WC-9Co5Cr1Ni ticari tozu HVOF yöntemi ile AISI304 paslanmaz çelik üzerine başarılı bir şekilde kaplandı. Daha sonra kaplamalar aşınma

cihazı ile alümina top kullanılarak 140 m aşındırıldı. Aşınma sonrasında mikro yapı, aşınma miktarı ve sürtünme katsayısı incelendi.

II. MATERYAL VE YÖNTEM

Sulzer Metco firması tarafından üretilen ticari WOKA 3618 tozu (WC-9Co5Cr1Ni) tedarik edildi. Toz, -75+45 µm arasında değişen parçacık boyutlarına sahipti. Altlık olarak AISI 304'ten (Ø25 x 5mm^2) yapılmış paslanmaz çelik plaka kullanıldı. Altlık malzemeler kaplamanın daha iyi tutunabilmesi için alümina ile yaklaşık 50 cm mesafeden 90° açı ile kumlandı. Kumlama işlemi sonrasında yüzeyi pürüzlülüğünün artırılması ve kirlerin giderilmesi amaçlandı. Metco DJ2700 HVOF tabancası bilgisayar kontrollü 3 eksenli bir robota tutturulup kendi etrafında dönebilen tablaya oturtulan altlıkları 200 mm/dk hızla besledi.



Şekil 1. a) HVOF kaplama resmi, b) kaplanan WOKA3618 toz

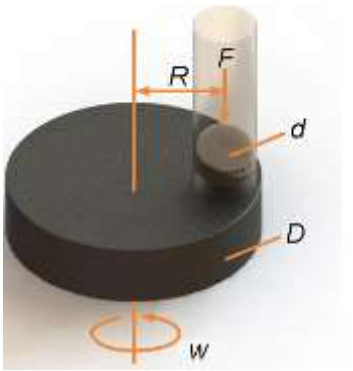
Şekil 1a'da kaplama sistemi resim olarak verildi. HVOF kaplama Tablo 1'de listelenen koşullar kullanılarak yapıldı. Şekil 1b'de kaplanan ticari tozun mikro resminde küresel boyutta olduğu görülmektedir.

Table 1. HVOF kaplama parametreleri

Parametreler	**Değerler**
Sprey mesafesi (mm)	75
Akım (A)	400
Birincilgaz akış oranı, Ar (scfh)	90
İkincil gaz akış oranı, H_2 (scfh)	15
Taşıyıcı gaz akış oranı, Ar (scfh)	13.5
Dönem hızı (tabla) (Hz)	40

A. Aşınma Testi

Kaplamaların kayma aşınma direnci, ASTM G99-04 yönergeleri takip edilerek pin-on-disk cihazı (Nikon, Fransa) ile yapıldı. Aşınma testi, Şekil 2'de gösterilen bir düzenek kullanılarak bir topun bir disk boyunca kaydırılmasıyla gerçekleştirildi. Kullanılan alüminyum oksit bilyaların çapı 6 mm ve kaplama disklerinin çapı 25 mm'dir.

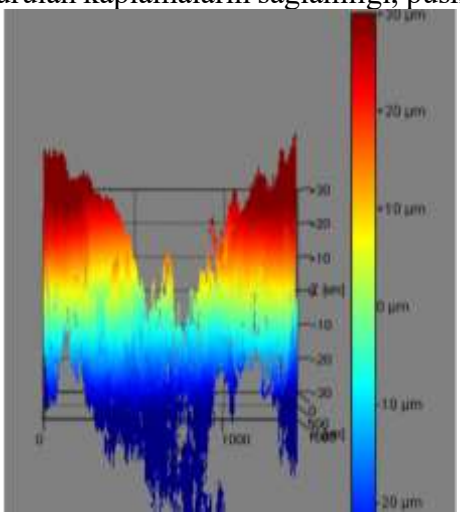


Şekil 2. Pin-on-disk test düzeneği

Şekil 2'de F normal yük, d aşındırıcının çapı, D disk çapı, R aşındırıcı topun temas ettiği çap, w diskin dönme hızını ifade etmektedir. Testten önce tüm kaplanan numuneler, yüzey durumlarını standartlaştırmak için sırasıyla 400, 800 ve 1000 partikül boyutundaki zımpara kâğıdı kullanılarak zımparalandı. Testten önce yüzey pürüzlülüğü, her numune için ortalama Ra<0.2 µm olduğundan emin olmak için yüzeyin üç farklı yerinden ölçüm alındı. Kuru sürtünme testi için 4N ve 30mm s-1 kayma hızı kullanıldı. Her numune, bir daire boyunca toplam 140 m'lik kayma mesafesinde koşturuldu. Aşınma direnci testi sırasında cihazın kendi yazılımı kullanılarak sürtünme katsayısı ve sürtünme kuvveti ölçüldü. Aşınma testinden sonra, aşınma izlerinin yüzey morfolojisini analiz etmek için beyaz ışıklı bir optik yüzey profilometresi MitutoyoCor'un MitutoyoSurfttestSj-500 kullanıldı. Aşınma hacmini hesaplamak için Denklem 1 kullanıldı [8].

$$\textbf{Equation:1}\ \textit{Hacim oranı}\ \frac{mm^3}{Nm} = \frac{Hacim\ kaybı\ (mm^3)}{Aşınma\ mesafesi\ (m)\ x\ Uygulanan\ Yük\ (N)}$$

Şekil 3'te görüldüğü gibi profilometre yardımıyla aşınma hacmi hesaplanmıştır. Atmosferik plazma püskürtme tekniği kullanılarak oluşturulan kaplamaların sağlamlığı, püskürtme hızıyla orantılı olarak artar.



Şekil 3. Optik profilometre resmi

B. *Mikro yapı incelemesi ve XRD analizi*

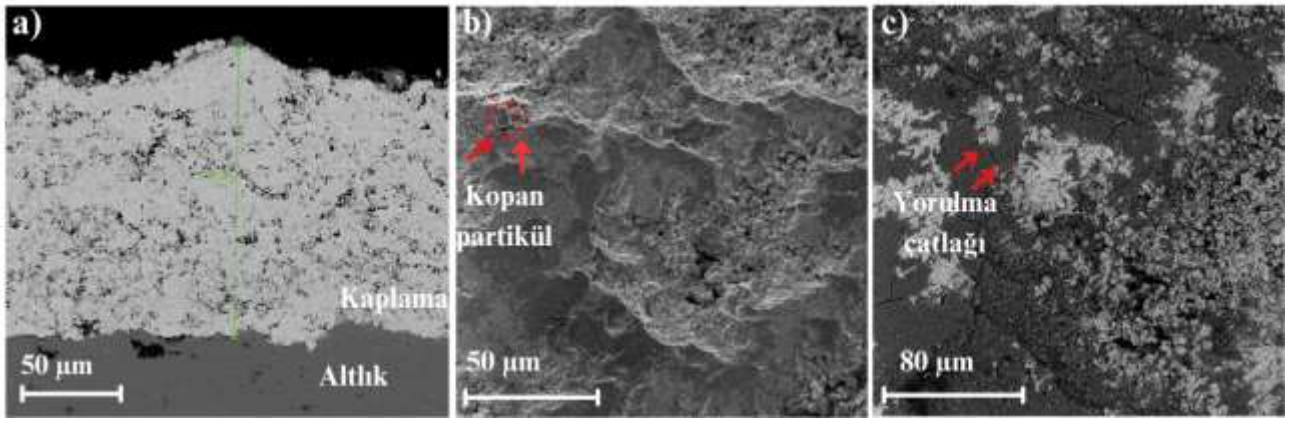
Kaplamaların mikro yapıları elektron ve optik mikroskopi teknikleri kullanılarak analiz edildi. Kaplamanın uygulanmasının ardından, yüzeyin ve kesitin mikro resimlerini çeşitli büyütmelerde yakalamak için elektron mikroskobu kullanıldı. Aşınma testi sonrasında yüzey pürüzlülük değerlerini ve element dağılımını analiz etmek için elektron mikroskobu kullanıldı. SEM çalışmalarında aşınma tipinin özelliklerini anlamak için farklı dedektörler kullanılmıştır. EDS analizleri aşınma izleri için haritalama

yöntemi kullanılarak gerçekleştirildi. Yüzey pürüzlülüğü, 5 µm yarıçap kullanılarak yüzey üzerinde en az beş farklı yerden ölçümler alınarak bulundu. Kullanımın ardından aşınmış izler Şekil 3'te gösterildiği gibi Optik 3D topografya tekniği kullanılarak incelenmiş ve dört farklı aşınma profili resimleri elde edilmiştir.

X-ışını kırınımı kullanılarak, kaplama sonrasında malzemedeki faz değişiklikleri incelenmiştir (XRD). WC-9Co5Cr1Ni tozunun ve kaplamanın, X-ışını kırınım çalışması, 2°=10-90° parametrelerinde ve 5° dk^{-1} tarama hızında gerçekleştirildi.

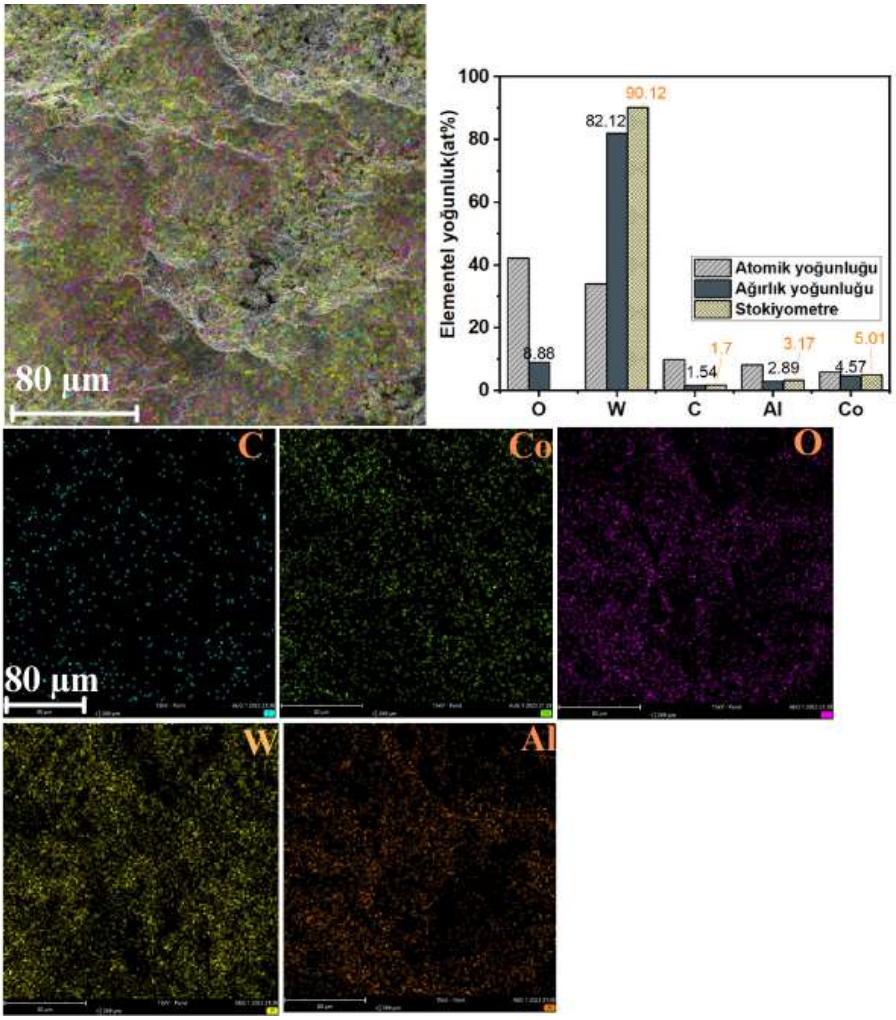
III BULGULAR ve TARTIŞMA (RESULTS AND DISCUSSIONS)

Kaplama sonrasında kaplamaların kesit resminde kaplama kalınlığının yaklaşık 140 µm olduğu ve ara yüzeyde herhangi bir hata olmadığı görülmektedir (Şekil 4.a). Kesit resminde, porozitler ve farklı fazların varlığı görülmektedir. HVOF yöntemi her ne kadar yoğun bir mikro yapı oluşturmak için uygun olsa da üretilen kaplamada yaklaşık %4 civarında porozite gözlemlendi. Porozite varlığı, toz boyutu ve mikro yapı aşınma dayanımını doğrudan etkilemektedir. Şekil 4b ve c'de 4 N yük altında oluşan aşınma sonrasında elde edilen SEM resimleri görülmektedir. SEM resimlerinde aşınma çatlakları ve aşınan yüzeyler görülmektedir. Oluşan çatlaklar sürekli yük altında meydana gelen yorulma çatlakları olduğu söylenebilir. Şekil 4b'de bir parçanın kopartılıp yer değiştiği gözlemlendi. Kayma aşınması olarak da bilinen adhesiv aşınma, iki katı yüzey birbiri üzerinde kaydığında pürüzlülükler veya yüksek noktalar arasındaki lokalize bağlanma nedeniyle malzeme transferine neden olduğunda meydana gelir. Bu bağlar koptuğunda, malzemenin bir yüzeyden diğerine yapışmasına neden olarak bileşenlerin aşınmasına ve yıpranmasına neden olabilirler. Adhesiv aşınma, kayan yüzeyler arasındaki tutunma bağlantıların oluşması ve ardından kırılması ile karakterize edilir.



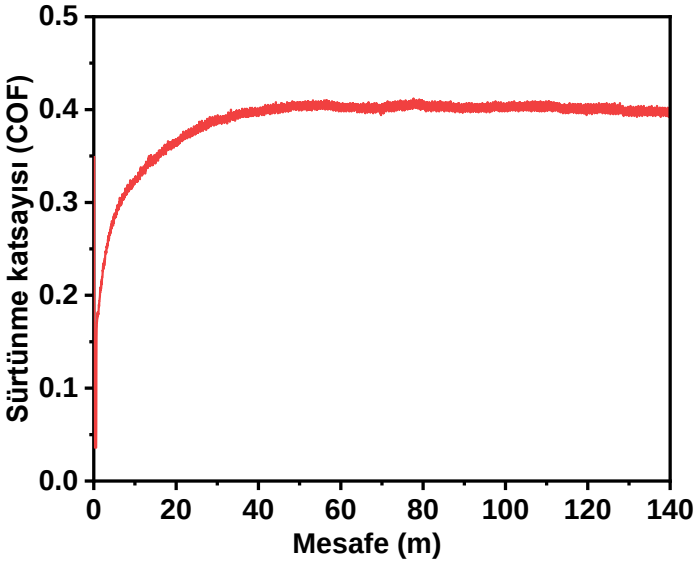
Şekil 4. SEM resimleri; a) HVOF WC kaplamanın kesit resmi, b) 4N yük altında aşınan yüzeyin ikincil elektron mikroskobu ile resmi, c) 4N yük altında aşınan yüzeyin geri dağılım elektron mikroskobu ile resmi

Şekil 5'de aşınan yüzeyden alınan EDS haritalama sonuçları verilmiştir. Elde edilen sonuçlarda Cr ve Ni elde edilememiştir. Muhtemel nedeni kaplama içerisinde varlığının az miktarda olmasıdır. Ayrıca aşındırıcıdan bol miktarda Al elementinin aşınmış yüzeye geçtiği görülmüştür. Al elementinin oksijenle yaptığı bileşik oranı %3.17 civarında olduğu bulunmuştur. Bu durumda abrsif aşınma mekanizması olduğundan bahsetmek mümkündür. Bu durumda, abrasif kaplamadan söz etmek mümkündür. Çünkü abrasif aşınma, bir yüzey ile sert parçacıklar veya pürüzler arasındaki göreceli hareketin neden olduğu bir tür mekanik aşınmadır. Bu tür aşınma, serbest hareket edebilen veya bir yüzeye sabitlenebilen bu sert parçacıkların veya pürüzlerin bir malzeme üzerinde kayarak veya yuvarlanarak yüzeyden malzemeyi çıkarmasıyla meydana gelmesi anlamına gelmektedir. Aşındırıcı aşınma, en yaygın aşınma biçimlerinden biridir ve mekanik bileşenlerin performansını ve ömrünü önemli ölçüde etkileyebilir. Dahası şekil 5'te Al elementinin aşınma profiline uygun bir şekilde dağılım gösterdiği görülmektedir. Şekil 3'teki resimde görülen profillerden aşınma miktarı hesaplandığında 4N yük için yaklaşık 0.018±0.06 mm^3/Nm aşınma miktarı hesaplandı.

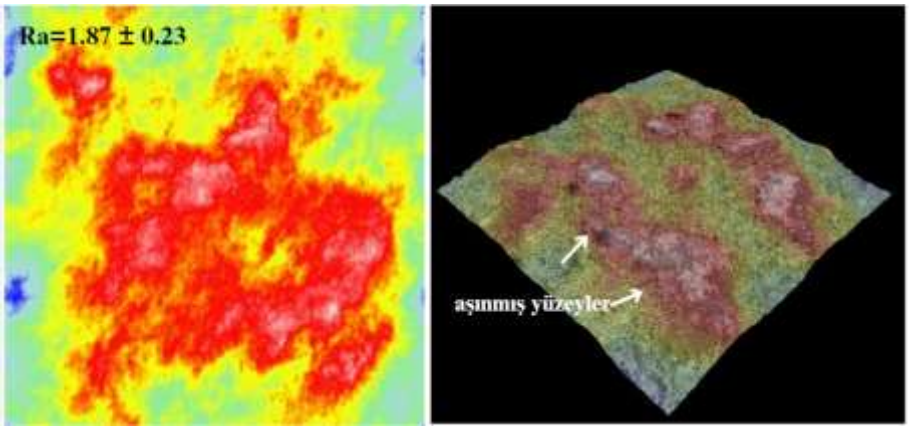


Şekil 5. Aşınan yüzeyin EDS haritalama sonuçları

Şekil 6'da 4N yük altında oluşan sürtünme katsayısı sonucu verildi. Sürtünme katsayısı yaklaşık 0.4 olarak bulundu. Wang ve arkadaşlarının yapmış oldukları benzer bir çalışmada [7], sürtünme katsayısı 0.4 civarında çıkmıştır. Sürtünme katsayısı grafiği ilk 40 metreye kadar düzenli olarak artmış 40 metreden sonra kararlı bir düzlemde devam etmiştir.

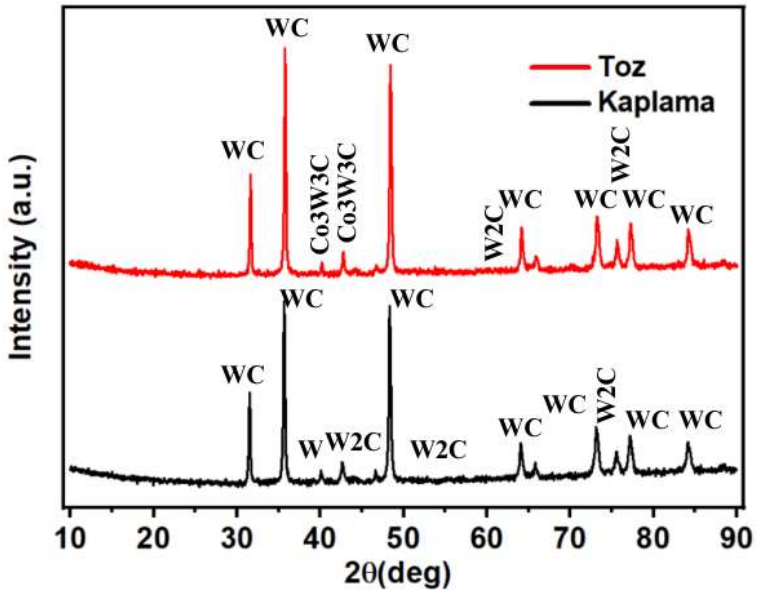


Şekil 6. Sürtünme katsayısı grafiği



Şekil 7. Aşınma sonrasında yüzey pürüzlülüğü

Şekil 7'de aşınmış yüzeylerin yüzey pürüzlülükleri 20 farklı yerden rastgele elektron mikroskobu ile alındı. Aşınma testi öncesi ortalama yüzey pürüzlülüğü değeri 0.2 µm küçük iken aşınma testi sonrasında ortalama yüzey pürüzlülüğü (Ra) değeri 1.87±0.23 µm civarında bulundu. Bu durumda abrasif aşınma mekanizmasını destekler niteliktedir. Şekil 7'de görülen kırmızı bölgeler tepeleri daha açık renkler ise derinlikleri ifade etmektedir. Yüzey pürüzlülüğündeki "Ra", örnekleme uzunluğu içindeki ortalama çizgiden ölçülen yüzey yüksekliği sapmalarının mutlak değerlerinin aritmetik ortalamasını temsil eden, yaygın olarak kullanılan bir parametredir. Başka bir deyişle Ra, belirli bir değerlendirme uzunluğu boyunca ortalama çizgiden mutlak sapmaların ortalamasıdır. Aşınma deneyi sonrasında yüzeyde bozulmalar olduğu sürtünme ve aşınmadan kaynaklı malzeme kayıpları görülmektedir.



Şekil 8. XRD sonuçları; a) WOKA 3618 toz, b) kaplama

WC-Co tozunun püskürtülmesi sırasında parçacıkların dekarbürizasyona tabi tutularak toplam karbon içeriğinin azalmasına neden olduğu daha önceki çalışmalarda bildirilmiştir. WC dönüşümünün kapsamı, başlangıç tozu tipi (boyut, morfoloji ve karbür boyutu), püskürtme işleminin türü, ortamdaki oksijen miktarı ve püskürtme parametreleriyle ilişkilendirilmiştir [6], [7], [9]. Şekil 8'te gösterilen kaplamanın ve kaplanan tozun XRD grafikleri görülmektedir. Şekil 8a'da kaplama tozunda oluşan başlıca fazların WC ve W_2C olduğu görülmektedir. Şekil 8b'de WC'nin hem de biriktirme sırasında oluşan dekarbürize kırılgan W_2C fazları görülmüştür. Bu kırılgan fazlar, azalan tokluk ve genel aşınma direnciyle ilişkilendirilebilir. Sert kırılgan fazlar mikro yapıda diğer fazların çevrelerinde normal olarak dağılmış olup, plakalar arasında zayıf bir arayüze yol açmaktadır. Çok fazla WC fazı tüketimi olmadan sert kristalli fazların ve sert kristalli Co'nun oluşumu, daha yüksek aşınma direncine ve tokluğa sahip kaplama üretimi sağlar [10], [11], [12] .

IV SONUÇLAR

WC-9Co5Cr1Ni sert kompozit kaplama AISI304 paslanmaz çelik üzerine kaplanmıştır. XRD sonuçlarında W2C ve CoO fazlarının yanı sıra W2C, W ve Co3W3C gibi farklı fazların da oluştuğu gözlendi. Paslanmaz çelik ile kaplama arasındaki ara yüzey bağının güçlü olduğu ve ortalama gözeneklilik değerinin %4 olduğu tespit edildi. Aşınma sonrasında 4N yük altında 0.018±0.06 mm^3/Nm'lik bir aşınma oranı ve 0.4 sürtünme katsayısı bulundu. Abrasif ve adhesiv aşınma mekanizmaları her elde edilen SEM resimlerinden ve EDS sonuçlarından bulundu.

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Some results on generalized nonexpansive mappings

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Abstract – Let $(X, \|\cdot\|)$ be a Banach space. The mapping $T: X \to X$ is nonexpansive if

$$\|Tx - Ty\| \leq \|x - y\|$$

for all $x, y \in X$. A point $p \in X$ is a fixed point of T if $Tp = p$. Let $F(T)$ denote the set of fixed points of T. Fixed point theory is one of the important theories with widespread use in mathematics, engineering, medicine and many other fields. Many problems in these fields can be represented by solving a nonlinear equation. Finding a fixed point of nonlinear mappings is an important problem and various algorithms have been used by many researchers. Picard iteration [1] is one of the most common methods used to find the fixed point of contraction mappings. Since this iteration method is insufficient to converge to the fixed points of nonexpansive mappings, more general iteration methods such as Krasnosel'skiĭı [2], Schaefer [3] and Mann [4] have been expressed.

The aim of this study is to express and prove some convergence theorems for mappings that satisfy the (E) condition, which is a more general mapping class that includes the nonexpansive mapping class.

Keywords – fixed point, condition (E)*, iteration method, Opial property, Banach space*

1 Introduction and preliminaries

Fundamental results regarding fixed points of nonexpansive mappings have an important place in functional analysis ([1], [2], [3], [4], [5]). Many researchers have defined different generalizations of nonexpansive mappings and have made important contributions to the field of fixed point theory on such mapping classes ([6], [7], [25], [26]).

In 2011, Garcia-Falset et al. [5] introduced the following class of mappings:

Definition 1 *([5]) Let D be a subset of a Banach space X such that $D \neq \varnothing$. A mapping $T : D \to D$ is said to satisfy condition (E_μ) on D if there exists $\mu \geq 1$ such that*

$$\| x - Ty \| \leq \mu \| x - Tx \| + \| x - y \|, \quad \forall x, y \in \mathcal{D}.$$

A mapping T satisfies condition (E) on D whenever T satisfies (E_μ) for some $\mu \geq 1$.

In the literature, many studies can be seen on nonexpansive mappings classes that satisfy the condition (E), see ([29, 30, 31]).

A point $q \in X$ is a fixed point of T if $T(q) = q$. Let $F(T)$ denote the set of fixed points of T. Fixed point theory is one of the important theories with widespread use in mathematics, engineering, medicine and many other fields. Many problems in these fields can be represented by solving a nonlinear equation. Finding a fixed point of nonlinear mappings is an important problem and various algorithms have been used by many researchers. Picard iteration [28] is one of the most common methods used to find the fixed point of contraction mappings. Since this iteration method is insufficient to converge to the fixed points of nonexpansive mappings, more general iteration methodshave been expressed by many authors ([8, 9, 10, 11, 12, 14, 15, 16, 17], [27]).

Now, we will give some of them as follows:

i) In 2020, Ali and Ali [21] introduced an iteration as follows: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$\begin{cases} z_n = T\big((1-\beta_n)x_n + \beta_n T x_n\big) \\ y_n = T z_n \\ x_{n+1} = T y_n \end{cases} \qquad (1.1)$$

where $\{\alpha_n\}$ is a sequence in [0,1].

ii) In 2020, Abdeljawad et al. [24] introduced an iteration as follows: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$\begin{cases} z_n = (1-\beta_n)x_n + \beta_n T x_n, \\ y_n = T z_n, \\ x_{n+1} = T\big((1-\alpha_n)T x_n + \alpha_n T y_n\big), \end{cases} \qquad (1.2)$$

where $\{\alpha_n\}$ and $\{\beta_n\}$ are sequences in [0,1].

iii) In 2021, Ahmad et al. [22] introduced an iteration as follows: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$\begin{cases} z_n = (1-\beta_n)x_n + \beta_n T x_n \\ y_n = (1-\alpha_n)T z_n + \alpha_n T^2 z_n \\ x_{n+1} = T y_n \end{cases} \qquad (1.3)$$

where $\{\alpha_n\}$ and $\{\beta_n\}$ are sequences in [0,1].

iv) In 2022, Shukla et al. [23] introduced an iteration as follows: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$\begin{cases} y_n = (1-\alpha_n)x_n + \alpha_n T x_n \\ x_{n+1} = T^k y_n \end{cases} \qquad (1.4)$$

where $\{\alpha_n\}$ is a sequence in [0,1] and k is a fixed natural number.

Now we will give below some basic definitions and lemmas that we will use in our main results.

Definition 2 *([18]) A Banach space X is said to be uniformly convex if for each $\eta \in (0,2]$ there is a $\lambda > 0$ such that for every two elements x, y in X,*

$$\left.\begin{array}{l} \| x \| \leq 1 \\ \| y \| \leq 1 \\ \| x - y \| > \eta \end{array}\right\} \text{implies} \frac{1}{2} \| x + y \| \leq (1 - \lambda).$$

Definition 3 *([19]) A Banach space X is said to have Opial's property if for each sequence $\{x_n\}$ in X which weakly converges to $q \in X$ and for every $p \in X - \{q\}$ it follows that*

$$\limsup_{n\to\infty} \|x_n - q\| < \limsup_{n\to\infty} \|x_n - p\|.$$

Lemma 1 *([5]) Let D be a nonempty subset of a Banach space X which has the Opial property. Let $T: D \to D$ be a mapping satisfying condition (E). Suppose $\{x_n\}$ is a sequence in D such that $\{x_n\}$ converges weakly to q and $lim_{n\to\infty} \|x_n - Tx_n\| = 0$. Then, $Tq = q$. That is, $I - T$ is demiclosed at zero.*

Lemma 2 *([5]) Let D be a nonempty subset of a Banach space X and $T: D \to D$ satisfies condition (E) with $F(T) \neq \varnothing$. Then, T is quasi-nonexpansive.*

Lemma 3 *([20]) Let X be a uniformly convex Banach space and $\{\alpha_n\}$ be any sequence satisfying $0 < a \leq \alpha_n \leq b < 1$ for all $n \geq 1$. Assume that $\{x_n\}$ and $\{y_n\}$ are any sequences of X such that*

$$\limsup_{n\to\infty} \|x_n\| \leq d$$

$$\limsup_{n\to\infty} \|y_n\| \leq d$$

and

$$\limsup_{n\to\infty} \|(1 - \alpha_n)x_n + \alpha_n y_n\| = d$$

hold for some $d \geq 0$. Then $\lim_{n\to\infty} \|x_n - y_n\| = 0$.

2 Main Results

Motivated by the above, in this part, we introduce a new algorithm and prove some weak and strong convergence results for mapping satisfying (E)-condition in uniformly convex Banach spaces.

Our algortihm is as follows:

$$\begin{cases} y_n = T^k\big((1-\beta_n)x_n + \beta_n T x_n\big) \\ x_{n+1} = T^k\Big((1-\alpha_n)T^{k-1}y_n + \alpha_n T^k y_n\Big) \end{cases} \qquad (2.1)$$

where $\{\alpha_n\}$ and $\{\beta_n\}$ are sequences in [0,1], and k is a fixed natural number.

Lemma 4 *Let D be a nonempty closed convex subset of a Banach space X and $T: D \to D$ a mapping satisfying condition (E) with $F(T) \neq \emptyset$. Let $\{x_n\}$ be a sequence defined by 2.1. Then the following assertions hold:*

(1) $\lim_{n\to\infty}\|x_n - q\|$ exists for each $q \in F(T)$,

(2) $\lim_{n\to\infty} d(x_n, F(T))$ exists, where $d(q, F(T))$ denotes the distance from q to $F(T)$.

Proof. (1) Suppose that q is a fixed point of T. Using 2.1 and Lemma 2, we obtain

$$\begin{aligned} \|x_{n+1} - q\| &= \left\|T^k\Big((1-\alpha_n)T^{k-1}y_n + \alpha_n T^k y_n\Big) - q\right\| \qquad (2.2)\\ &= \left\|T^k\Big((1-\alpha_n)T^{k-1}y_n + \alpha_n T^k y_n\Big) - T^k q\right\| \\ &\le \|(1-\alpha_n)T^{k-1}y_n + \alpha_n T^k y_n - q\| \\ &\le (1-\alpha_n)\|T^{k-1}y_n - q\| + \alpha_n\|T^k y_n - q\| \\ &\le (1-\alpha_n)\|y_n - q\| + \alpha_n\|y_n - q\| \\ &= \|y_n - q\| \end{aligned}$$

and

$$\begin{aligned} \|y_n - q\| &= \left\|T^k\big((1-\beta_n)x_n + \beta_n T x_n\big) - q\right\| \qquad (2.3)\\ &= \left\|T^k\big((1-\beta_n)x_n + \beta_n T x_n\big) - T^k q\right\| \\ &\le \|(1-\beta_n)x_n + \beta_n T x_n - q\| \\ &\le (1-\beta_n)\|x_n - q\| + \beta_n\|T x_n - q\| \\ &\le (1-\beta_n)\|x_n - q\| + \beta_n\|x_n - q\| \\ &= \|x_n - q\|. \end{aligned}$$

If we combine 2.2 and 2.3, we obtain

$$\|x_{n+1} - q\| \le \|y_n - q\| \qquad (2.4)$$

$$\leq \|x_n - q\|.$$

Therefore, $\{\|x_n - q\|\}$ is bounded below and nonincreasing, and hence, $\lim_{n\to\infty}\|x_n - q\|$ exists for each $q \in F(T)$.

(2) We know that $d(x_n, F(T)) = \inf\{\|x_n - q\| : q \in F(T)\}$. Since $\lim_{n\to\infty}\|x_n - q\|$ exists for each $q \in F(T)$ in (1), $\lim_{n\to\infty} d(x_n, F(T))$ exists.

Theorem 1 *Let $D \neq \varnothing$ be a closed convex subset of a uniformly convex Banach space X. We assume that T satisfies the condition (E) on D with $F(T) \neq \emptyset$. Moreover, let $\{x_n\}$ be a sequence defined by 2.1. Then $lim_{n\to\infty}\|Tx_n - x_n\| = 0$.*

Proof. Let $F(T) \neq \varnothing$ and $q \in F(T)$. From Lemma 4, we know that the sequence $\{x_n\}$ is bounded and $\lim_{n\to\infty}\|x_n - q\|$ exists. We suppose that

$$\lim_{n\to\infty}\|x_n - q\| = l. \qquad (2.5)$$

From 2.3 and 2.5, we have

$$\limsup_{n\to\infty}\|y_n - q\| \leq \limsup_{n\to\infty}\|x_n - q\| = l. \qquad (2.6)$$

Using Lemma 4 and 2.6, we have

$$\limsup_{n\to\infty}\|Tx_n - q\| \leq \limsup_{n\to\infty}\|x_n - q\| = l. \qquad (2.7)$$

From 2.2, we know that

$$\|x_{n+1} - q\| \leq \|y_n - q\|. \qquad (2.8)$$

Therefore,

$$l \leq \liminf_{n\to\infty}\|y_n - q\|. \qquad (2.9)$$

Using 2.6, 2.9 and 2.1, we get

$$l = \lim_{n\to\infty}\|y_n - q\|$$

$$= \lim_{n\to\infty}\left\|T^k\left((1-\beta_n)x_n + \beta_n Tx_n\right) - T^k q\right\|$$

$$\leq \lim_{n\to\infty}\|(1-\beta_n)x_n + \beta_n Tx_n - q\|$$

$$= \lim_{n\to\infty} \|(1-\beta_n)(x_n - q) + \beta_n(Tx_n - q)\|$$

$$\leq \lim_{n\to\infty} [(1-\beta_n)\|x_n - q\| + \beta_n\|Tx_n - q\|]$$

$$\leq \lim_{n\to\infty} [(1-\beta_n)\|x_n - q\| + \beta_n\|x_n - q\|]$$

$$= l.$$

Hence,

$$\lim_{n\to\infty} \|(1-\alpha_n)(x_n - q) + \alpha_n(Tx_n - q)\| = l. \quad (2.10)$$

From 2.6, 2.7, 2.10 and Lemma 3, we have

$$\lim_{n\to\infty} \|x_n - Tx_n\| = 0. \quad (2.11)$$

Theorem 2 *Let X be a uniformly convex Banach space, D and T be the same as in Lemma 4 with $F(T) \neq \emptyset$. Let $\{x_n\}$ be a sequence defined by 2.1. If X satisfies the Opial property, then $\{x_n\}$ converges weakly to a point in $F(T)$.*

Proof. From Lemma 4 and Theorem 1, we know that the sequence $\{x_n\}$ is bounded and the limit $\lim_{n\to\infty}\|Tx_n - x_n\| = 0$. Since X is a uniformly convex Banach space, there exists a subsequence $\{x_{n_i}\}$ of $\{x_n\}$ which converges weakly to a point in $F(T)$. Call it q, that is, $x_{n_i} \to q$ as $i \to \infty$. From the demiclosedness principle of $I - T$ (using Lemma 1), we have $q \in F(T)$. Now, we will show that $\{x_n\}$ converges weakly to q. Let's assume the opposite, that is, let the sequence $\{x_n\}$ not converge weakly to q. In that case, there exists a subsequence $\{x_{n_j}\}$ of $\{x_n\}$ and $p \in C$ such that $\{x_{n_j}\}$ converges weakly to p and $p \neq q$. Again from Lemma 1, we obtain that $q_2 \in F(T)$. Using Lemma 4 and Opial property, we obtain that

$$\lim_{n\to\infty} \|x_n - q\| = \lim_{i\to\infty} \|x_{n_i} - q\| < \lim_{i\to\infty} \|x_{n_i} - p\|$$

$$= \lim_{n\to\infty} \|x_n - p\| = \lim_{j\to\infty} \|x_{n_j} - p\|$$

$$< \lim_{j\to\infty} \|x_{n_j} - q\| = \lim_{n\to\infty} \|x_n - q\|,$$

which is a contradiction. Then, $q = p$. Therefore, $\{x_n\}$ converges weakly to $q \in F(T)$.

Theorem 3 *Let X be a uniformly convex Banach space, D and T be the same as in Lemma 4 with $F(T) \neq \emptyset$. If $\{x_n\}$ is a sequence generated by 2.1, then $\{x_n\}$ converges to an element of $F(T)$ if and only if $liminf_{n\to\infty} d(x_n, F(T)) = 0$ or $limsup_{n\to\infty}\, d(x_n, F(T)) = 0$.*

Proof. The necessity is clear. Conversely, suppose that $\liminf_{n\to\infty} d(x_n, F(T)) = 0$ and $q \in F(T)$. Using Lemma 4, we have that $\lim_{n\to\infty}\|x_n - q\|$ exists for each $q \in F(T)$. This implies that $\lim_{n\to\infty} d(x_n, F(T)) = 0$. Now, we will show that $\{x_n\}$ is a Cauchy sequence in D. Since $\lim_{n\to\infty} d(x_n, F(T)) = 0$, for a given $\varepsilon > 0$, there exists $n_0 \in \mathbb{N}$ such that for each $n \geq n_0$,

$$d(x_n, F(T)) < \frac{\varepsilon}{2}.$$

From above inequality, we write

$$\inf\{\|x_n - q\| : q \in F(T)\} < \frac{\varepsilon}{2}. \qquad (2.12)$$

From (2.12), we obtain that $\inf\{\|x_{n_0} - q\| : q \in F(T)\} < \frac{\varepsilon}{2}$. Then, there exists $q \in F(T)$ such that

$$\|x_{n_0} - q\| < \varepsilon/2.$$

For $m, n \geq n_0$, we get

$$\begin{aligned}
&\|x_{n+m} - y_n\| \leq \|x_{n+m} - q\| + \|x_n - q\| \\
&\leq \|x_{n_0} - q\| + \|x_{n_0} - q\| \\
&= 2\|x_{n_0} - q\| \\
&< \varepsilon.
\end{aligned}$$

This implies that $\{x_n\}$ is a Cauchy sequence in D. Since D is a closed subset of a Banach space X, D is a complete Banach space. That is, there exists a point $p \in C$ such that $\lim_{n\to\infty} x_n = p$. Then, $\lim_{n\to\infty} d(x_n, F(T)) = 0$ gives that $d(p, F(T)) = 0$. Since the set of fixed points of quasi nonexpansive mappings (Lemma 2) is closed, we have $p \in F(T)$. This completes the proof of the theorem.

Now, we will give the concept of condition (I) in order to prove the next theorem.

Definition 4 *([13]) Let D be a nonempty subset of a normed space X. A mapping $T: D \to D$ is said to satisfy condition (I) if there exists a nondecreasing function $g: [0,\infty) \to 0,\infty)$ satisfying $g(0) = 0$ and $g(t) > 0$ for all $t \in (0,\infty)$ such that $\|x - Tx\| \geq g(inf_{p\in F(T)}\|x - p\|)$ for all $x \in D$.*

Theorem 4 *Let X be a uniformly convex Banach space, D and T be the same as in Lemma 4 with $F(T) \neq \emptyset$. If $\{x_n\}$ is a sequence generated by 2.1, then $\{x_n\}$ converges strongly to an element of $F(T)$ provided that T satisfies the condition (I).*

Proof. From Theorem 1, we know that

$$\lim_{n\to\infty} \|x_n - Tx_n\| = 0.$$

Thus, using the definition of condition (I), we have

$$\lim_{n\to\infty} d(x_n, F(T)) = 0.$$

Since the conditions in the hypothesis of Theorem 3 are satisfied, therefore, the sequence $\{x_n\}$ converges strongly to a fixed point of T.

Theorem 5 *Let X be a uniformly convex Banach space, D and T be the same as in Lemma 4 with $F(T) \neq \emptyset$. Let $\{x_n\}$ be a sequence defined by 2.1. If the range of D under T is contained in a compact subset of X, then the sequence $\{x_n\}$ strongly converges to a fixed point of T.*

Proof. Since $T(D)$ is a compact set, there exists a subsequence $\{Tx_{n_i}\}$ of $\{Tx_n\}$ that strongly converges to $q \in D$. From the triangle inequality, we obtain

$$\|x_{n_i} - q\| \leq \|x_{n_i} - Tx_{n_i}\| + \|Tx_{n_i} - q\|.$$

Using Theorem 1, we can say that $\|x_{n_i} - Tx_{n_i}\| \to 0$ as $j \to \infty$. So, from above the inequality, we have $x_{n_i} \to q$ as $j \to \infty$. Since the mapping T satisfies condition (E), we get

$$\|x_{n_i} - Tq\| \leq \mu\|x_{n_i} - Tx_{n_i}\| + \|x_{n_i} - q\|.$$

Taking limsup as $j \to \infty$ at the above inequality, we get

$$\limsup_{j\to\infty} \|x_{n_i} - Tq\| \leq \mu \lim_{j\to\infty} \|x_{n_i} - Tx_{n_i}\| + \limsup_{j\to\infty} \|x_{n_i} - q\|.$$

This implies that $Tq = q$. From Lemma 4, it follows that $\lim_{n\to\infty}\|x_n - q\|$ exists. Thus, the sequence $\{x_n\}$ strongly converges to a fixed point of T. This completes the proof of the theorem.

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Yeşil Altyapı ve Ekosistem Hizmetleri İlişkisinin Kent ve Peyzaj Mimarlığı Bağlamında Değerlendirilmesi

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Özet **–** Yeşil altyapı yaklaşımı, doğal ve kısmen-doğal alanların, yeşil alanların ve ekosistemlerin planlanmasını, sürdürülebilir kentsel planlamayı ve gelişimi destekleyen yaklaşım olarak tanımlanmaktadır. Bu sürdürülebilir kentsel planlamayı kapsayan yaklaşımın amaçlarının; ekosistem hizmetlerinin sağlanması, biyolojik çeşitliliğin korunması ve yaşam kalitesinin artırılması olduğu bilinmektedir. Ekosistem hizmetleri ise doğanın insanlar için sağladığı yararlar olarak tanımlanmaktadır. Ekosistem hizmetleri; su ve kaynaklarının yönetimini, hava kalitesinin arttırılmasını, iklim düzenlemelerini ve iklim değişikliğine uyumu, biyoçeşitliliğin korunmasını ve yaşam kalitesinin arttırılmasını içerisinde barındırmaktadır. Peyzaj mimarlığı meslek disiplini, yeşil altyapının planlanmasında, tasarımında ve uygulanmasında rol almakta, ekosistem hizmetlerinin maksimum düzeyde sağlanmasını amaçlamaktadır. Bu çalışma kapsamında, yeşil altyapı ve ekosistem hizmetlerinin ilişkisi kent ve peyzaj mimarlığı bağlamında incelenmekte; yeşil altyapının sürdürülebilir kent gelişimine katkıları ve peyzaj mimarlarının bu süreçteki önemi vurgulanmaktadır.

Anahtar Kelimeler – Yeşil altyapı, ekosistem hizmetleri, peyzaj mimarlığı, kentleşme, kentsel ekosistem hizmetleri

I. GİRİŞ

Son yıllarda hızla artan kentleşme sebebiyle kent sınırlarının genişleyeceği öngörülmektedir. Bu nedenle, doğal ve kültürel peyzaj niteliklerini bünyesinde barındıran kentler baskıya maruz kalmakta ve değişim-dönüşüm sürecine girmektedir. Kentsel peyzaj alanlarına zamanla artan ilginin 'yeşil altyapı' kavramının sürdürülebilirlik etmenleri arasında yer almasına sebep olduğu bilinmektedir [1,2].

Yeşil altyapı kavramının ekolojik sürdürülebilirliğe faydasına ek olarak; tarihi, arkeolojik ve mimari mirasın korunma altına alınmasına yardımcı olduğu; mekân üretimini, kritik toplum kaynaklarını ve yerel peyzaj kimliğinin bozulmasını önlediği ve güçlendirdiği bilinmektedir [1,2].

Açık ve yeşil alanların kenti ve kentliyi; ekolojik, sosyo-kültürel ve ekonomik yönlerden olumlu olarak etkilediği bilinmektedir. Yeşil alanların zamanla azalması, kent ve kentlinin yaşam kalitesini düşürmenin yanı sıra sağladıkları hizmetlerden mahrum kalmamıza sebep olmaktadır [2].

Enerji, su ve kanalizasyon, boru hatları ve katı atık toplama gibi klasik altyapı planlama düzenlemeleri kentlerde yaşanan sorunlarla yalnız mücadele edememektedir. Bu sebeple birbirleri ile daha fazla bütünleşecek düzenlemeler tercih edilmektedir. Çoğu çalışmada üzerinde durulduğu gibi, her iki altyapının planlamasına ihtiyacımız bulunmaktadır. Yeşil altyapının tasarlanması ve planlanması, yaşam kalitesinin arttırılmasında ve sağlıklı bir çevrenin yaratılmasında en önemli yollardan olduğu bilinmektedir. Sürdürülebilir yaşam mekanları oluşturarak, mekân üretimine de katkı sağlamaktadır [2].

Kent ve bölge ölçeğinde yapılan araştırmalarda yeşil altyapı kavramı, ekosistemlerin iyiliğini koruyan, biyoçeşitliliğin muhafazasına yardımcı olan ve kentlilere – bölgede yaşayan insanlara yararlı ekolojik ve alansal bir yaklaşım olarak tanımlanmaktadır. Bu nedenle yeşil altyapı, kent- bölgeler içerisindeki ekolojik yansımaları toplumsal yararlanmaya çevirerek, ekosistem hizmetleri bakımından değerlendirilmesine

olanak sağlamaktadır. Bunun için yeşil altyapı kavramı, geniş kapsamlı olarak ekosistem hizmetlerinin stratejik olarak tasarlanmak, planlamak ve yönetilmesi için bir araç olarak dikkat çekmektedir.

Yeşil altyapı yaklaşımları ve ekosistem hizmetleri gibi başlıca amacı kentlerdeki yeşil alanları artırmak, bu alanların birbirleriyle ve kırsal bölgelerde bulunan yeşil alanlarla bağlantısını kuvvetlendirmek, yaban hayatını kent yaşamına dahil ederek doğayı kent içine entegre etmeyi hedefleyen yaklaşımlar giderek daha fazla önem kazanmaktadır [3].

Bu çalışmada, yeşil altyapı ve ekosistem hizmetleri kent ve peyzaj mimarlığı açısından değerlendirilecek, yeşil altyapının ve ekosistem hizmetlerinin sürdürülebilir kent gelişimine katkıları ve peyzaj mimarlarının bu süreçteki önemi vurgulanacaktır.

A. Yeşil Altyapı Yaklaşımı

Altyapı kelimesi çoğunlukla gri altyapı ile ilişkilendirilmekte; yol, kanalizasyon ve hatlar ile ya da sosyal altyapı olarak da bilinen okul, cezaevi ve hastane ile bağdaştırılmaktadır [4,5].

"Yeşil altyapı yaklaşımı", ekosistem içerisinde bulunan kırsal ve kentsel alanlarda biyolojik çeşitliliği muhafaza eden ve yöneten, ekosistem hizmetlerini sağlayabilen ayrıca doğal, kısmi doğal ve kültürel alanlar arasında bağlantılar kuran yaklaşım olarak geçmektedir.

Yeşil altyapı yaklaşımının uygulamaları; temiz hava ve su sağlamaktan toprak koruma ve erozyon önlemeye, yağmur suyunun etkin kullanımından sel ve taşkın risklerinin azaltılmasına, karbon emisyonlarının düşürülmesinden kentlerde ısı adası etkisini önlemeye kadar geniş bir yelpazede fayda sağlamaktadır [3]. Bu avantajlarının yanı sıra, yasal çerçeve ve maaliyet bakımından dezavantajları da bulunmaktadır (Tablo 1).

Benedick ve McMahon (2006)'nın görüşüne göre yeşil altyapı; doğal ekosistemin işlevselliğini koruyarak, insana faydalı, birbiriyle ilişkili yeşil alan bağlantılarıdır, bu ilişki çekirdek alanlar, tampon bölge ve koridorlarla oluşturulmaktadır [3].

Bilimsel çalışmalarda yeşil altyapı kavramı üç farklı perspektifte ele alınmaktadır. Bu perspektifler, yeşil altyapının doğal süreçlerden elde edilen hizmetler ve faydalarla benzerlik taşıyan, ekosistem hizmetleri sağladığını ve geleneksel altyapılara kıyasla daha sürdürülebilir bir alternatif sunduğunu, aynı zamanda bağlantılı yeşil alanları içerdiğini vurgulamaktadır [6].

Yeşil altyapı planlaması ise farklı ölçeklerde gerçekleştirilmektedir. Benedict and McMahon'a (2006)'nın görüşüne göre; havzalar, bölgeler ya da yerel olmak üzere farklı ölçeklerde peyzaj çalışmaların da idari ve politik sınırların ötesinde uygulanabilmekte, parsel düzeyinden ilçe, il veya bölge ölçeğine kadar farklı seviyelerde tasarlanabilmektedir.

Parsel ölçeğinde; konutların ve iş merkezlerinin etrafında yeşil alanların tasarlanması ve planlanması, ilçe ölçeğinde, var olan parkları birbirleriyle ilişkilendiren yeşil koridorlar oluşturarak bağlantı kurma anlamını taşımaktadır. İl ya da bölge ölçeğinde ise; ormanları, yaylaları ve diğer doğal alanları birbirine bağlayan peyzaj bağlantılarını korumayı veya yoksa oluşturmayı kapsamaktadır [4,7].

Tablo 1. Yeşil altyapı yaklaşımının avantaj ve dezavantajları

AVANTAJLAR	DEZAVANTAJLAR
Problemlere ekolojik ve sürdürülebilir çözüm imkanı sunmaktadır.	Uygulama ve sonrası bakım maaliyetleri iyi planlanmadığı durumlarda dezavantajlı durumlar oluşmaktadır.
Multidisipliner yapısı ile peyzaj mimarlığının diğer mesleklerle birlikte çalışmasına imkan sağlamaktadır.	Multidisipliner çalışmanın sonucunda her kesimin aynı duyarlılıkta katılımı zor ve zaman alıcı olmaktadır.
Eğitimde ve meslek çalışmalarında disiplinler arası çalışmaya olanak sağlamaktadır.	Yasal ve idari çerçeve – yetki problemlerinin olduğu bilinmektedir.
Koşullara göre farklı işlevsel yönleri bulunmaktadır.	Mevcut kent yapısına sonradan kurgulanan yeşil altyapının entegre edilmesi zor olabilmektedir.
Yenilikçi koşul ve projelere imkan sunmaktadır.	Büyük ve kalabalık kentlerde yeşil altyapı için alan bulmak zor olabilmektedir.
Yeşil ve gri altyapı birbirini desteklediği için uzun süre dayanıklı olmaktadır.	

Ekolojik tabanlı ve sürdürülebilir çalışmaları kapsamaktadır.
Kent ve kentlinin iklim değişikliğine uyum sürecini hızlandırmaktadır.

B. Ekosistem Hizmetleri

"Ekosistem hizmetleri" kavramının kökeni 1970'li yıllara uzanmaktadır fakat kullanımının yayılmasının 1990'lı senelerde arttığı bilinmektedir [8,9].

"Ekosistem Hizmetleri" kavramı ilk kez Daily tarafından "İnsan hayatının sürdürülebilmesi için doğal ekosistemler ve türlerin gerçekleştirdiği durum ve süreçler" olarak tanımlanmaktadır.

Costanza ve diğerleri, ekolojik işlevlerden sağlanan faydaları vurgularken, De Groot vd., hem süreçlerden hem de işlevlerden elde edilen faydaları vurgulamaktadır. Boyd ve Banzhaf ise, ekosistem hizmetlerin sadece doğrudan faydalarını belirtmektedir.

Ekosistem hizmetleri kavramının, Birleşmiş Milletler Binyıl Ekosistem Değerlendirmesi (MEA) raporu ile daha sık kullanılmaya başlandığı bilinmektedir. MEA da ekosistem hizmetleri, doğal sermaye olarak geçmekte; doğal sermayenin insan faaliyetleriyle gelecek kuşakları desteklemesinin azaldığını vurgulamaktadır [9].

Daha önce yapılan tanımlamalar ışığında ekosistem hizmetleri; insanlara ekosistem fonksiyonlarından elde edilen yararlar veya insanların iyiliği için ekosistemlerin doğrudan ve dolaylı yararları olarak tanımlanmaktadır [9].

Ekosistem hizmetlerinin çeşitli örnekleri arasında gıda tedariki ve tatlı su gibi ürünlerin yanı sıra sellerin önlenmesi, toprak erozyonunun azaltılması, salgın hastalıkların kontrolü ve doğal alanlarda rekreasyonel faaliyetlerin desteklenmesi gibi düzenleyici ve destekleyici hizmetler de bulunmaktadır. Kültürel ve ekosistem hizmetleri insanlara maddi olmayan faydalar sunarken, tedarikçi hizmetler maddi faydaları ifade eder, düzenleyici ve destekleyici hizmetler ise diğer hizmetlerin sürdürülebilirliğini sağlarken doğrudan ve dolaylı olarak sağlanan faydalar olarak tanımlanmaktadır [10].

Hızla artan kentleşme ve beraberinde artan nüfus, kentsel yaşam alanlarındaki ekosistem hizmetlerini ve biyoçeşitliliği etkileyeceğinden ekosistem hizmetlerine talep artacağı öngörülmektedir [10,11]. Ekosistem hizmetlerine olan talep insanların ihtiyaç ve isteklerinin yanı sıra sosyo-ekonomik özelliklerden de etkilenmektedir [10,12].

MEA raporunda, ekosistem hizmetleri; kaynak sağlayan, düzenleyen, kültürel ve destekleyen hizmetler olmak üzere 4 ana grup ve 30 kategoride sınıflandırılmaktadır (Tablo 2).

TEEB raporunda ise ekosistem hizmetleri; kaynak sağlayan, düzenleyici, kültür ve konfor ve habitat hizmetleri olmak üzere 4 ana grup ve 22 kategoride sınıflandırılmaktadır (Tablo 3)[10].

Tablo 2. MEA sınıflandırması

KAYNAK SAĞLAYAN HİZMETLER	**DÜZENLEYEN HİZMETLER**	**KÜLTÜREL HİZMETLER**	**DESTEKLEYEN HİZMETLER**
-Biyokimyasallar ve tıbbi ürünler -Dekoratif kaynaklar -Genetik kaynaklar -Tatlı su -Biyolojik hammadde -Gıda	-İklim düzenleme -Zararlı kontrolü -Su akışı kontrolü -Erozyon kontrolü -Polenleme -Salgın hastalık kontrolü -Doğal risk azaltma -Hava kalitesi düzenleme -Su arıtımı ve atık kontrolü	-İlham -Rekreasyon ve ekoturizm -Bilgi sistemi -Kültürel miras değeri -Eğitim değeri -Estetik değerler -Kültürel çeşitlilik -Manevi ve etik değerler -Sosyal ilişkiler -Yer ve mekân hissi	-Besin döngüsü -Toprak formasyonu -Birincil üretim -Fotosentez -Su döngüsü

Tablo 3. TEEB sınıflandırması

KAYNAK SAĞLAYAN HİZMETLER	DÜZENLEYEN HİZMETLER	KÜLTÜREL HİZMETLER	HABİTAT HİZMETLER
-Gıda -Hammadde -Süs kaynakları -Genetik kaynaklar -Su -Tıbbi kaynaklar	-Su akışı kontrolü -Hava temizleme -Erozyon önlemi -Atık arıtımı -Biyolojik kontrol -Bozulmaları önleme veya hafifletme -Tozlaşma -Toprak verimliliğin devamlılığı -İklim düzenleme	-İlham -Rekreasyon ve turizm -Kültür, sanat ve tasarım için ilham -Manevi deneyim -Bilişsel işlem için bilgi -Estetik bilgi	-Yaşam döngüsünün devamlılığı -Gen havuzu koruma

C. Kentsel Ekosistem Hizmetleri

Günümüzde dünya nüfusunun %56.2'si kentlerde yaşamakta ve bu oranın 2050 yılında %68'lere kadar artacağı öngörülmektedir [9,13].

Kentleşme; kişilerin arazi kullanımını, ulaşımı, endüstri ve tarımsal üretimi, tüketimi ve faaliyet şekillerini farklılaştırdığından doğal kaynakları negatif etkilemektedir. Günümüz kentlerinin yayılması ve dağınık genişlemesi de doğal habitatları olumsuz etkilemektedir.

Kent ekosistemlerinde sosyo-ekonomik ve politik hizmetlerin sağlandığı bilinmektedir. İnsan - doğa etkileşimli bir ekolojik sistemdir, içinde yer aldığı coğrafyanın içerdiği peyzajlara göre karakterize edilmektedir. Bu sebeple kent ekosistemi, maddi karşılığı olan veya olmayan ekosistem hizmetleri üretmektedirler. Kent ekosistemlerinin hizmet üretme yeteneği, kentsel peyzaj bileşenlerinin varlığına ve organizasyonuyla bağlantılı olduğu bilinmektedir [9,14,15].

II. YEŞİL ALTYAPI VE EKOSİSTEM HİZMETLERİ İLİŞKİSİ

Ekosistem hizmetlerini destekleyerek; insanlara fayda sağlayan, biyolojik çeşitliliği koruyan, ekosistemin dayanıklılığını arttırmak için ekolojik ve mekânsal bir kavram olan yeşil altyapı ekosistem hizmetleri ile ilişkilendirilmektedir [3]. Bu bağlantıda yeşil altyapı, sürdürülebilir kentler için ekosistem hizmetlerini kullanarak temellendirilmektedir [16].

Ekosistem hizmetleri; taşkınları önleme, yüzey suyunu kullanma ve doğal su kaynaklarını koruma ve yağmur suyu yönetimi gibi farklı alanlarda yer almaktadır [17,18].

Kentlerin sürdürülebilirliğinin planlanmasında, alan kullanımı bakımından önemli olan ekosistem hizmetleri ve yeşil altyapı projeleri, birçok gelişmiş ülkede kentsel planlama süreçlerinde aktif bir şekilde kullanılmaktadır [3].

Kentlerde ekosistem hizmetleri, doğa ve kentlilerle birlikte üretilen yeşil altyapı yaklaşımı ile sağlanmaktadır. Bu yöntem ile arazi kullanım planı, kent alanındaki ekosistem hizmetlerinin sağlanması, yenilenmesi açısından önemli bir rol oynamaktadır [3,16].

Ahern ve ark.'ın görüşüne göre yeşil altyapı, arazi kullanım planlarının oluşturulmasında önemli bir rol oynamakta ve oluşan arazi karakterlerine bağlı olarak çeşitli ekosistem hizmetleri sunmaktadır. Kent sisteminin yeşil altyapı ile düzenlenmesi, arazi kullanımı planlarını etkileyerek dolaylı olarak ekosistem hizmetlerini etkilemektedir [3,16].

D. İklim Değişikliğinde Yeşil Altyapı ve Ekosistem Hizmetleri

Küresel iklim değişiminin etkilerini azaltmak ve dünyamızın ısınmasının artmasını önlemek için sürdürülebilir ve ekolojik yöntemleri baz alan çözümlerin kentsel yaşam alanlarında kullanılması önemli rol oynamaktadır. Bu sebeple, ekosistemlerden sağlanan ekosistem hizmetlerinin niteliğini ve niceliğini artıracak bir çözüm olarak ortaya çıkan yeşil altyapı yaklaşımı, kentsel planlama aracı olarak ekosistemleri destekleyen ve geliştiren bir yaklaşım olarak kabul edilmektedir. [19].

Biyoçeşitlilik; tür, ekosistemler ve gen bakımından, geçmişten günümüze kadar gelen doğal bir birikim olarak tanımlanmaktadır. Ekosistemler ise bu kritik birikimin öğeleri arasında bulunmaktadır [19,20].

Ekolojik dengenin oluşturulmasındaki önemi düşünüldüğünde dışarıdan yanlış müdahaleler sonucunda zarar gören ekosistemler yaptığı işlevini yitirmekte ve biyolojik çeşitlilik için risk oluşturmaktadır. Ekosistemlere yapılan bu dışarıdan müdahalelerin sonucu olarak iklim değişikliği karşımıza çıkmaktadır. Küresel iklim değişimi canlı türlerin yayılış alanlarını etkilemenin yanı sıra nesillerinin tükenme riskini ortaya çıkarmaktadır [19].

Sıcaklığın artışıyla ortaya çıkan buzulların erimesi, hassas yaşam alanlarına zarar vermekte ve doğal ekosistemlerden sağlanan ekosistem hizmetlerini ve bu hizmetlerin verimini azaltmaktadır [19].

Yapılan çalışmalarda, gelecek yıllarda iklim değişikliği senaryolarına göre kentlerde artacak sıcaklık ile birlikte şiddetli fırtınalar, deniz seviyesinde yükselme ve yağış artışı olacağı tahmin edilmektedir. Yeşil altyapının planlaması, ortaya çıkacak olan küresel iklim değişikliği etkilerine uyum sağlama sürecine katkıda bulunmaktadır [18,19].

Yeşil altyapı kavramı bir süreci ifade etmektedir. Bu nedenle ekolojiyi temel alan planlamada sürdürülebilir yöntemlerin geliştirildiği bir yaklaşım olarak yeşil altyapı kısmen doğal, doğal ve kültürel alanların bağlantılarını kurgulayarak çevre sorunlarına ekolojik çözümler üretmektedir [19,21].

Birbirleriyle fonksiyonel bağlantılar oluşturacak şekilde planlanmış, yeşil alanları barındıran yeşil altyapı sisteminin sağladığı ekosistem hizmetleri, iklim değişikliğinin görülen ve olası etkilerini azaltmaktadır. Kentlerde iklim değişikliği etkilerinin azaltılmasında, düzenleyici ekosistem servisleri önem taşımaktadır.. Hava ve toprak kalitesinin iyileştirilmesi, iklim düzenleme, doğal afetlerin etkisini azaltma, suyun arıtılması, atık yönetimi, polenizasyon/tozlaşma ya da biyolojik parçalanma düzenleyici servisler arasında olduğu bilinmektedir [22].

E. Yeşil Altyapının ve Ekosistem Hizmetlerinin Peyzaj Mimarlığıyla İlişkisi

Yeşil altyapı ve ekosistem hizmetlerinin peyzaj mimarlığı arasındaki ilişkiyi anlamlandırmak, sürdürülebilir ve yaşanabilir alanlar yaratmada önem taşımaktadır. Peyzaj mimarları, yeşil altyapıyı bir bütün olarak ele almakta ve ekosistem hizmetlerini en üst düzeye çıkarmak için çeşitli stratejiler kullanmaktadır. Bunlar; doğal alanları koruma, su yönetimi, yeşil alan bağlantıları ve iklim değişikliği ile mücadele olduğu bilinmektedir (Tablo 4).

Tablo 4. Peyzaj mimarlığının yeşil altyapı yaklaşımında yeri [23]

Doğal Alanların Korunması ve Restorasyonu	Doğal alanların korunması ve restorasyonu, biyoçeşitliliği artırarak ekosistem hizmetlerinin devamlılığını sağlamaktadır.
Sürdürülebilir Su Yönetimi	Sürdürülebilir su yönetimi, su kaynaklarının korunmasını ve su kalitesinin iyileştirilmesini içermektedir. Peyzaj mimarları, yağmur suyu yönetimini, geçirgen yüzeyleri ve yeşil altyapı çözümlerini tasarlar – uygular bu şekilde su yönetimini desteklemektedirler.
Kentsel Yeşil Alanlar ve Bağlantılılık	Kentsel yeşil alanlar, insan sağlığı, yaşam kalitesi ve refahı önem taşımaktadır. Peyzaj mimarları, yeşil koridorlar ve bağlantılı yeşil alan ağları tasarlayarak ekosistem hizmetlerini artırmaktadır.
İklim Değişikliği ile Mücadele	Yeşil altyapı, karbon emisyonlarını azaltarak ve iklim değişikliğinin etkilerini azaltmaktadır. Peyzaj mimarları, karbon yutakları oluşturmak için bitkilendirme ve yeşil çatılar gibi farklı çözümler geliştirmektedir.

F. Yeşil Altyapının Peyzaj Mimarlığında Uygulamaları

Yeşil altyapının peyzaj mimarlığındaki uygulamaları, şehirlerin sürdürülebilir, yaşanabilir ve dirençli hale gelmesinde kritik bir rol oynamaktadır. Çevresel, sosyal, ekonomik ve estetik yararlar sağlayarak kentlerin daha sağlıklı hale gelmesine katkıda bulunmaktadır. Bu uygulamalar; yeşil çatılar, yağmur bahçeleri, restorasyon projeleri ve su yönetimi gibi çeşitli yöntemleri içermektedir (Tablo 5).

Peyzaj mimarları, bu uygulamaları bütünleştirerek şehirlerin sürdürülebilir gelişimine katkıda bulunarak, insanların doğa ile uyum içinde yaşamasını sağlamaktadır. Bu nedenle, yeşil altyapının peyzaj mimarlığındaki uygulamaları, geleceğin kentlerinin planlanmasında önemli olduğu öngörülmektedir.

Tablo 5. Yeşil altyapı uygulamaları [24,25]

Yeşil Çatılar ve Yeşil Duvarlar	Enerji verimliliğini artırır, ısı adası etkisini azaltır ve biyolojik çeşitliliği destekler.
Yağmur Bahçeleri ve Biyofiltreler	Bu uygulamalar, yağmur suyunun doğal yollarla süzülmesini ve depolanmasını sağlar, böylece su kalitesini iyileştirir ve taşkın riskini azaltır.
Permeable (Geçirgen) Yüzeyler	Suyun zemine sızmasını ve doğal su döngüsüne katılmasını sağlar, böylece taşkın riskini azaltır ve su kaynaklarını korur.
Kentsel Yeşil Alanlar ve Koridorlar	Biyolojik çeşitliliği destekler, rekreasyon alanları sağlar ve insanların doğa ile bağlantı kurmasına yardımcı olur.
Kent Tarımı ve Gıda Ormanları	Şehirlerde yerel gıda üretimini artırır ve toplulukları doğa ile bağlantılı hale getirir.
Doğal Parklar ve Rezervler	Biyolojik çeşitliliği korur ve doğal ekosistemleri destekler. Bu alanlar, aynı zamanda rekreasyon ve eğitim fırsatları sunar.
Ekolojik Restorasyon Projeleri	Bozulmuş doğal alanların iyileştirilmesini ve ekosistemlerin yeniden canlandırılmasını amaçlar.
Su Yönetimi ve Sulak Alanlar	Suyun doğal olarak filtrelenmesine ve depolanmasına yardımcı olur, böylece su kalitesini artırır ve biyolojik çeşitliliği destekler.

III. YEŞİL ALTYAPI VE EKOSİSTEM HİZMETLERİ BAĞLAMINDA GELİŞTİRİLEN PROJE ÖRNEKLERİ

G. Türkiye den Örnekler

Türkiye, son zamanlarda yeşil altyapı ve ekosistem hizmetleri alanında çeşitli projelere imza atmaktadır (Tablo 6). Bu projeler içerisinde; kent parkları ve yeşil alanların yenilenmesi ve yenilenebilir enerji kaynaklarının kullanımının arttırılması yer almaktadır. Özellikle büyük şehirlerdeki yeşil alanların artırılması ve mevcut alanların korunması, kentlerin ve kentlinin yaşam kalitesini artırmakta ve sürdürülebilirliği desteklemektedir.

Tablo 6. Yeşil altyapının sağladığı ekosistem hizmetlerine Türkiye'den örnekler [22]

Kadıköy Kurbağalıdere Islah Projesi	İstanbul'un Kadıköy ilçesindeki Kurbağalıdere'nin ekosistem hizmetlerini iyileştirmek ve çevresel sorunları çözmek amacıyla yapılmıştır. Ekosistem Hizmetleri: • Su Yönetimi: Su kalitesinin iyileştirilmesi ve taşkın riskinin azaltılması, • Biyolojik Çeşitlilik: Doğal habitatların korunması, • Rekreasyon: Yürüyüş yolları, parklar ve dinlenme alanları ile kentli için rekreasyon alanları oluşturmak hedeflenmektedir.
İstanbul Kuzey Ormanları	İstanbul'un kuzeyinde bulunan büyük bir ormanlık alan olup, şehrin en önemli doğal kaynaklarından olduğu bilinmektedir. Biyoçeşitliliği koruma, su kaynaklarının yönetimi, hava kalitesinin iyileştirilmesi ve iklim değişikliği ile mücadele gibi farklı ekosistem hizmetleri sunmaktadır. Ekosistem Hizmetleri: • Karbon Depolama: Karbon yutağı olarak iklim değişikliği ile mücadeleye katkı, • Biyolojik Çeşitlilik: Flora ve fauna çeşitliliğinin korunması, • Su Kaynakları Koruma: Yeraltı suyu kaynaklarının korunması ve yağmur suyunun süzülmesi-geri kazanımı hedeflenmektedir.
	Hem doğal hem de tarımsal ekosistem hizmetleri sağlayan bir alandır. Ekosistem Hizmetleri:

Ankara Atatürk Orman Çiftliği	• Gıda Üretimi: Organik tarım ve hayvancılık faaliyetleri, • Eğitim ve Farkındalık: Tarım ve doğa ile ilgili eğitim programları, • Rekreasyon: Halkın doğa ile iç içe zaman geçirebileceği rekreasyon alanları oluşturmayı hedeflemektedir.
İzmir Mavişehir Sulak Alanı	İzmir'in değerli doğal alanlarından biridir ve çeşitli ekosistem hizmetleri sunar. Sulak alanlar, suyu filtreleme, biyolojik çeşitliliği destekleme, iklim düzenleme ve rekreasyon gibi sayıca ve çeşitçe fazla ekosistem hizmeti sağlamaktadır. Ekosistem Hizmetleri: • Su Arıtma: Doğal sulak alanların suyu filtrelemesi ve temizlemesi, • Biyolojik Çeşitlilik: Kuş türleri ve diğer yaban hayatı için önemli, • Rekreasyon ve Eğitim: Rekreasyon alanları ve ekolojik eğitim alanlarını korumayı ve oluşturmayı hedeflemektedir.

H. Dünya dan Örnekler

Dünya genelinde yeşil altyapı ve ekosistem hizmetlerine odaklanan birçok proje bulunmaktadır (Tablo 7). Bu projeler arasında, kentlerin yeşil altyapılarını geliştirmesi, koruma ve restorasyon projeleri, su kaynaklarını yönetme ve yenilenebilir enerji kaynaklarını etkin kullanma bulunmaktadır. Özellikle küresel iklim değişimi ve çevre sorunlarıyla mücadele kapsamında planlanan bu projeler, sürdürülebilirlik ve yaşam kalitesi bakımından önem taşımaktadır. Bu projeler, ulusal topluluklar ve uluslararası kuruluşlara kadar geniş çalışma ağı ve katılımı teşvik etmekte, yaşanabilir bir dünya bırakma hedefine katkı sağlamaktadır.

Tablo 7. Yeşil altyapının sağladığı ekosistem hizmetlerine Dünya'dan örnekler [22]

New York High Line Park (ABD)	Manhattan'da yer alan bir kentsel yeşil alandır. Bu park, çeşitli ekosistem hizmetleri sağlayarak çevresel, sosyal ve ekonomik faydalar sunmaktadır. Ekosistem Hizmetleri: • Yeşil Alan: Şehirde yoğun yapılaşma arasında bir yeşil alan ile biyolojik çeşitliliği artırmayı, • Rekreasyon: halka açık bir rekreasyon alanları, • Isı Adası Etkisini Azaltma: Kent ısı adası etkisini azaltmayı hedeflemektedir.
Cheonggyecheon Akarsu/Nehir Restorasyonu (Güney Kore)	Seul'de bulunan ve şehir merkezinin yeniden canlandırılması amacıyla dere yatağının restorasyonuyla gerçekleştirilen önemli bir kentsel dönüşüm projesidir. Ekosistem Hizmetleri: • Su Yönetimi: Dere boyunca suyun doğal yollarla temizlenmesi ve taşkın riskinin azaltılması, • Rekreasyon: Yeşil bir koridor ve yürüyüş yolları sağlamak • Biyolojik Çeşitlilik: Yerel bitki ve hayvan türlerinin yeniden canlandırmayı hedeflemektedir.
Kopenhag C40 Yeşil Çatı Politikası (Danimarka)	Yeşil çatılar, farklı ekosistem hizmetleri ile kentlerin iklim değişimi ile mücadelesine, biyolojik çeşitliliğin korunmasına ve yaşam kalitesinin artırılmasına yardımcı olmaktadır. Ekosistem Hizmetleri: • Isı Adası Etkisini Azaltma: Yeşil çatılar ile sıcaklığın düşürülmesi, • Su Yönetimi: Yağmur suyunun toplanması ve doğal yollarla süzülmesi,

	• Biyolojik Çeşitlilik: Yeşil çatılarda çeşitli bitki türlerinin yetiştirilmesi ve yaşam alanları oluşturmak hedeflenmektedir.
Singapur Bahçeleri (Singapur)	Singapur'un önemli bir turistik ve çevresel simgesi olan büyüleyici bir doğal park ve botanik bahçesidir. Bu proje, kentsel yeşil alanların artırılması ve sürdürülebilirlik ilkeleri kapsamında yapılmıştır. Ekosistem Hizmetleri: Karbon Depolama: Yoğun bitkilendirme ve ağaçlandırma ile karbon emilimi, Biyolojik Çeşitlilik: Çeşitli bitki türleri ve ekosistemlerin sergilenmesi, Rekreasyon ve Eğitim: Tematik bahçeler ve açık hava müzelerinin oluşturulması hedeflenmektedir.

IV. SONUÇLAR

Bu çalışma, yeşil altyapının sağladığı ekosistem hizmetleri ile peyzaj mimarlığı disiplini arasındaki çok yönlü ilişkiyi irdelemeyi amaçlamaktadır. Yeşil altyapı, doğanın sunduğu hizmetlerin kent hayatına entegrasyonunu temsil etmektedir. Peyzaj mimarlığı bu ilişkide planlama, tasarım ve yönetim aşamalarında rol almaktadır. Çalışma sonucu elde edilen bulgular, yeşil altyapı yaklaşımının ve peyzaj mimarlığının; sürdürülebilir kentleşme, ekolojik denge, biyolojik çeşitlilik, yaşam kalitesi ve insan refahı üzerinde önemli etkileri olduğunu ortaya koymaktadır.

Yeşil altyapı sistemleri, ekosistem hizmetlerinin sağlanmasında kritik rol oynamaktadır. Bu hizmetler kendi arasında düzenleyici, destekleyici, tedarik edici ve kültürel hizmetler olarak sınıflandırılmaktadır. Yeşil alanlar, hava-su kalitesini iyileştirilmesi ve ısı adası etkisinin azaltılması ile düzenleyici hizmetler arasında yer almaktadır. Biyolojik çeşitliliği destekleyen habitatlar sağlayarak destekleyici hizmetler de sunmaktadır. Kültürel hizmetler ise rekreasyon, estetik ve ruhsal iyilik için önem taşımaktadır. Tedarik edici hizmetler ise gıda üretimi ve doğal kaynakların temini olarak açıklanmaktadır. Bu hizmetlere sürdürülebilir ve yaşanabilir kentler için gerek duyulmaktadır.

Peyzaj mimarlığı disiplini; yeşil altyapının planlanması, tasarımı ve uygulanmasında çok yönlü yaklaşımı ile çevresel, estetik ve sosyal açıdan önem taşımaktadır. Peyzaj mimarları, kentin sürdürülebilirlik hedeflerine ulaşmada yenilikçi tasarım önerileriyle yeşil altyapının etkinliğini arttırmaktadır. Gelecekte yeşil altyapı ve peyzaj mimarlığı arasındaki ilişkinin güçlendirilmesi gerektiği bilinmektedir. Bu bağlamda,

- Yeşil altyapıyı destekleyen yönetmeliklerin geliştirilmesi gereklidir, somut adımlar atılmalıdır.
- Peyzaj mimarları ve diğer disiplinlerin eğitimlerinde ekosistem hizmetlerinin ve yeşil altyapının önemi vurgulanmalıdır.
- Kamuoyunun yeşil alt yapı konusundaki farkındalığı artırılmalıdır.
- Yeni teknolojiler ile yenilikçi tasarım yaklaşımları benimsenmeli, potansiyel en üst seviyeye çıkarılmalıdır.
- Projelerin başarısını arttırmak için planlama ve uygulama süreçlerine halk katılımı teşvik edilmelidir.

Sonuç olarak, peyzaj mimarlığı meslek disiplini kentlerin daha yaşanabilir, sağlıklı ve dirençli hale gelmesinde ve sürdürülebilir kentsel gelişim de önemli roller üstlenmektedir. Önümüzdeki yıllarda, bu konudaki çalışmaların arttırılması hem ekosistemleri korumakta hem de yaşam kalitesi için önem taşımaktadır.

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Classification of Potato Diseases Using Deep Convolutional Neural Networks

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Abstract – Potato is an important staple food cultivated globally. It is very important to detect early the occurrence of potato leaf diseases to keep the yield and quality of the crop, avoid economic losses, and contribute to food security. Proper timing of disease control also benefits the environment by reducing the total amount of pesticides needed. Pathogens cause potato leaf diseases, resulting in substantial yield losses. This will help enable farmers to take timely steps to minimize crop loss. However, standard diagnostic techniques are not only time-consuming and expensive but also still rely on trained professionals.

Over the past several years, various studies have explored the use of machine learning and deep learning algorithms for plant disease detection, with a special focus on Convolutional Neural Networks (CNN) due to their huge success in image recognition. Most prior research, however, involves only small-scale data, few disease classes, and does not measure model generalization for real-world applications. In this research, the performance of three deep learning models (ResNet, InceptionV3, and VGG16) was assessed to recognize plant leaf diseases, using potato leaf diseases as a model case.

Based on our analysis, the InceptionV3 model secured the top rank with the highest accuracy and F1-score of 98.00%, respectively, in predicting ten different potato leaf diseases, as represented in the Potato Plant Disease dataset. Our findings support the effectiveness of CNN-based architectures in supporting early disease detection for agricultural engineers and farmers and suggest a broader applicability of CNN-based models to solve other agricultural problems. The results clearly suggest that the best model for real-world applications might be InceptionV3 due to optimal performance and low inference time.

Keywords – Potato Leaf, Disease Detection, Plant Disease,Deep Learning

I. INTRODUCTION

Detection and treatment of plant diseases in agriculture are critical for high crop yield and sustainable farming. Advances in automation technology allow for the early detection of diseases, enabling timely intervention and minimizing crop losses. This study proposes a new deep learning model that accurately classifies plant leaf diseases for the agriculture and food industries. The model employs an innovative convolutional neural network (CNN) architecture to detect plant diseases on potato leaves. The CNN extracts key features from input images by applying filters, reducing dimensions while preserving essential details in the images. The extracted data is then used for classification [1].

Deep learning, which has made significant advances in image recognition, is successfully applied in detecting diseases on potato leaves. Pre-trained deep neural network models, especially Convolutional Neural Networks (CNNs), are widely used for such problems. For example, CNN architectures like

ResNet, VGG, Inception, and others have shown success in recognizing and classifying diseases in potato leaf images.

The use of deep learning techniques in identifying diseases on potato leaves offers various benefits for farmers and the agricultural industry. Early detection and intervention enable farmers to quickly address and prevent the spread of diseases, thus minimizing damage. This increases crop yield and profitability. Automated disease diagnosis saves time and labor costs, making agricultural operations more efficient. It also promotes environmental sustainability by reducing excessive chemical use and lowers costs. Deep learning also provides enhanced monitoring and reporting, allowing farmers to better track field health and make informed decisions [2].

In this study, a deep learning model based on a Convolutional Neural Network (CNN) method was developed to classify multiple disease groups, including scab, rust, and their combinations. Algorithms such as DenseNet201, MobileNetV2, ResNet50V2, ResNet101V2, and ResNet152V2 were used as the proposed approach. The method was tested on a high-difficulty dataset containing different levels of lighting, noise, and non-homogeneous backgrounds, achieving an accuracy rate of 97% [2].

This study used convolutional neural networks (CNNs) to classify potato leaf diseases. As a finding, the model identified diseases like Early Blight and Late Blight with 99.1% accuracy. This high accuracy highlights the potential of deep learning to enhance food security and reduce economic losses in agriculture through automatic disease management [4].

A study using data collected from the Central Punjab region of Pakistan proposed a multi-level deep learning approach combining the YOLOv5 segmentation technique with a CNN. The model achieved 99.75% accuracy on this dataset. It outperformed existing models in terms of accuracy and computational cost, significantly improving early disease detection in potato plants [5].

This article focuses on detecting plant leaf diseases using convolutional neural networks (CNNs). A dataset consisting of 9,127 images was used. CNN models achieved high accuracy rates in detecting plant leaf diseases. The model showed successful results in performance metrics such as accuracy, F1 score, recall, and precision [6].

Research using Vision Transformers (ViT) and CNN models in this study showed significant advancements in detecting plant leaf diseases. ViT models demonstrated effectiveness by increasing accuracy rates in disease detection [6].

This study addresses the advantages and limitations of deep learning models (Vision Transformer, DCNN, CNN, RSNSR-LDD, DDN, YOLO) used for detecting plant leaf diseases. Various deep learning models were used to diagnose different plant diseases, generally achieving high accuracy rates. Performance metrics used in existing studies included accuracy, precision, and recall [7].

This study detects diseases on tomato leaves using a deep learning-based EfficientNet model. In tests on 18,161 leaf images, the EfficientNet-B7 model achieved 99.95% accuracy in binary classification, 99.12% in six-class classification, and 99.89% in ten-class classification. This research shows that segmentation models (U-net and Modified U-net) can improve accuracy in disease detection [8].

This study detects plant diseases using pre-trained CNN models such as DenseNet-121, ResNet-50, VGG-16, and Inception V4. In experiments using the PlantVillage dataset, the DenseNet-121 model showed the highest success with an accuracy rate of 99.81%. This study reveals that deep learning models can achieve high success when tuned with the right parameters [9].

In this study, a deep learning-based mobile system was developed to detect diseases on maize leaves. This system classifies diseases using deep convolutional neural networks (CNNs) and provides accurate results. Such mobile-based systems offer practical application, especially under field conditions [10].

This study examined the performance of various deep learning-based models in detecting plant diseases. Models such as CNN and RNN were used in this study, and the results showed that these methods could detect diseases with high accuracy rates. The advantage of these models is that they perform well when trained on large datasets [11].

This study developed a model that integrates Leaky ReLU and ResNet architecture to detect diseases on plant leaves. Experiments on the Plant Village dataset showed that the model achieved 94.56% accuracy,

93.48% precision, and 92.83% F1-score. This demonstrates that the model performs well in detecting plant diseases [12].

This study used the YOLOv4 model to detect diseases on plant leaves. In tests on a new dataset, the model achieved a 99% accuracy rate. However, the model misclassified some early-stage infections as healthy, indicating the need for more comprehensive datasets and improvements [13].

This study used the federated learning method to detect various plant diseases. This approach combined information from different data sources, creating more general and highly accurate models [14].

The use of deep learning techniques in identifying diseases on potato leaves offers various benefits for farmers and the agricultural industry. Early detection and intervention enable farmers to quickly address and prevent the spread of diseases, thus minimizing damage. This increases crop yield and profitability. Automated disease diagnosis saves time and labor costs, making agricultural operations more efficient. It also promotes environmental sustainability by reducing excessive chemical use and lowers costs. Deep learning also provides enhanced monitoring and reporting, allowing farmers to better track field health and make informed decisions. Overall, using deep learning in diagnosing potato leaf diseases increases agricultural efficiency and supports farmers in growing healthy, high-yield crops.

Early detection of potato leaf diseases is critical for maintaining crop yield and quality, preventing economic losses, and ensuring food security. Traditional diagnostic methods are time-consuming and costly. However, deep learning models, especially InceptionV3, have high accuracy rates in identifying potato leaf diseases. These results are important for agricultural engineers and farmers, demonstrating that the InceptionV3 model is the most suitable choice for real-world applications.

II. Materials and Method

A. *Dataset Description*

The dataset used for the effective detection of diseases on potato leaves is the publicly available Potato Leaf Disease Dataset, consisting of 4,072 leaf images categorized into three groups: early blight, healthy, and late blight. Each of the three classes has its own training, testing, and validation structure. The data in this structure is listed in the tables below (Table 1, Table 2, Table 3).*Figures and Tables*

Table 1: Statistical Data of the Training Class in the Potato Dataset

Potato Leaf Disease	Total	Train(%)
Early Blight	1303	40.08
Healthy	816	25.10
Late Blight	1132	34.82

Table 2: Statistical Data of the Testing Class in the Potato Dataset

Potato Leaf Disease	Total	Test(%)
Early Blight	162	40.0
Healthy	102	25.19
Late Blight	141	34.81

Table 3: Statistical Data of the Validation Class in the Potato Dataset

Potato Leaf Disease	Total	Valid(%)
Early Blight	163	39.18
Healthy	102	24.52
Late Blight	151	36.30

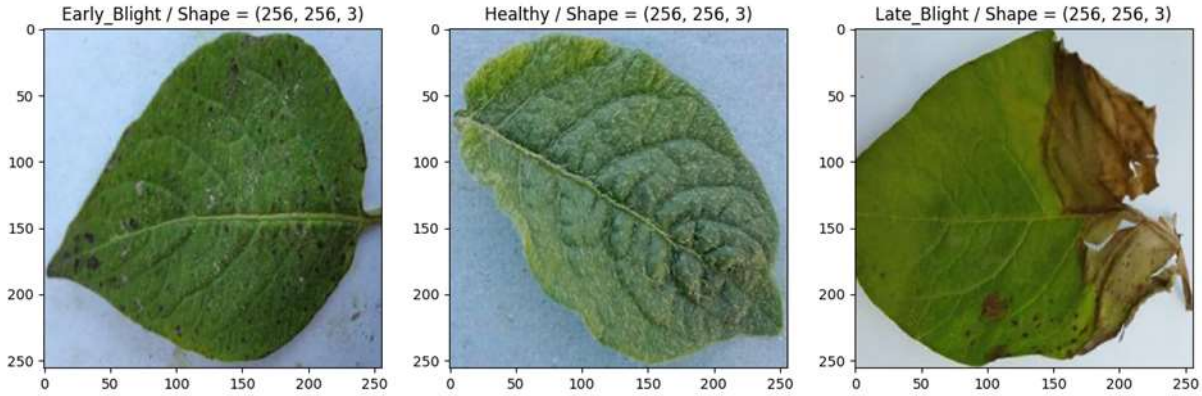

Figure 1 - Potato Leaves with Early Blight, Healthy, and Late Blight

Deep Learning

Deep learning is a subclass of machine learning. It employs many layers of nonlinear processing units for feature extraction and transformation. Each successive layer replaces the previous one and takes the output as input. In deep learning, there exists a structure based on learning features or representations at multiple levels from the data. High-level features are derived from low-level features, forming a hierarchical representation. This representation learns multiple levels of abstractions corresponding to different representation levels. Deep learning primarily relies on learning from data representation. When considering the representation of an image, features such as density values per pixel, edge clusters, or specific shapes can be considered. Some of these features better represent the data than others. At this stage, deep learning methods offer advantages by employing effective algorithms for hierarchical feature extraction that represent data best, rather than relying on manually crafted features.

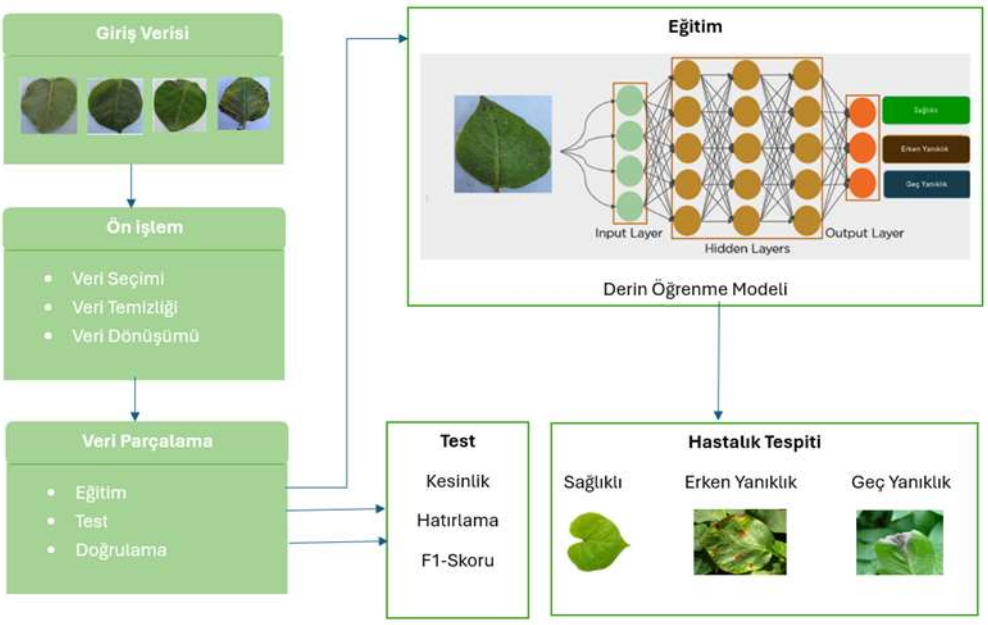

Figure 2- Training Model

III. RESULTS

In this study, we utilized commonly used CNN models in the literature for object classification to train and evaluate their performances on potato leaf diseases within the Potato Disease dataset. The models were evaluated using the parameter values and hyperparameters of Convolutional Neural Network (CNN). Rapid identification of numerous plant diseases is crucial for optimal production, and early diagnosis in the case of potato leaf diseases provides farmers with the power to immediately control the spread of the disease and minimize crop loss. Experimental results demonstrating the classification of potato leaf diseases in the Potato Disease dataset derived from potato leaf images are presented in the following tables.

Table 4. InceptionV3 model results on the potato disease dataset

Potato Leaf Disease	Precision	Recall	F1-Score
Early Blight	95.00%	100.00%	96.00%
Healthy	99.00%	92.00%	93.00%
Late Blight	96.00%	99.00%	98.00%
Macro Average	98.00%	97.00%	98.00%
Weighted Average	98.00%	98.00%	98.00%

Table 5. VGG16 model results on the Potato Disease dataset

Potato Leaf Disease	Precision	Recall	F1-Score
Early Blight	90.00%	86.00%	88.00%
Healthy	82.00%	88.00%	85.00%
Late Blight	89.00%	88.00%	88.00%
Macro Average	87.00%	88.00%	87.00%
Weighted Average	88.00%	87.00%	87.00%

Table 6. Xception model results on the Potato Disease dataset

Potato Leaf Disease	Precision	Recall	F1-Score
Early Blight	98.00%	91.00%	95.00%
Healthy	94.00%	79.00%	86.00%
Late Blight	82.00%	97.00%	89.00%
Macro Average	91.00%	89.00%	90.00%
Weighted Average	91.00%	90.00%	90.00%

When Table 1 is examined, it can be seen that all deep learning models have an accuracy of over 98.00%. Among the CNN-based models, ResNet34 and DenseNet-121 models, which have the same accuracy values, have significantly higher metric values compared to ResNet-50, VGG16, and Xception models.

While the InceptionV3 model has an accuracy and F1 score of 98.00%, the VGG16 model has an accuracy and F1 score of 87.00%.

In light of the findings, considering confusion matrices, it is observed that the Inception_v3 model performs better than other models in diagnosing potato leaf diseases in the Potato Disease dataset derived from potato leaf images, and the VGG16 architecture performs better than other models.

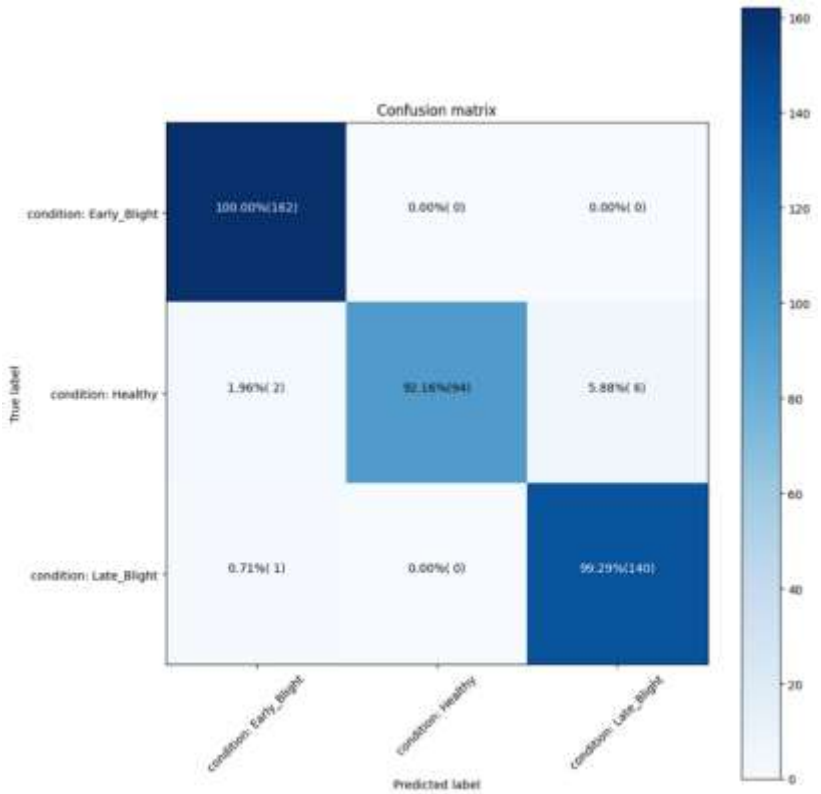

Figure 3- Complexity Matrix Values, 3 models (InceptionV3, VGG16, Xception)

As shown in Figure 3, it predicts 100% of the data on early blight data, which consists of 162 data points. On the 94 data points that are healthy, it obtains a result of 92.16%. In the dataset of late blight, it achieves a prediction value of 99.29% on 140 potato leaf data points.

Table 7. Comparison with proposed models on potato leaf image dataset [3]

Referans	Yıl	Method	Kesinlik(%)
Rozaqi et al	2021	VGG16	95.00
		CNN - Sederhana	80.00
		Inception-V3	78.00
		ResNet-50	78.00
Singh & Kaur	2020	K-Means + SVM	95.99
Sarker et al.	2022	CNN	93.00
		ResNet	97.00
		VGG19	84.00
Sharma et al.	2021	SVM	92.90
		KNN	86.40
		DT	78.70
Ahmed & Yadav	2023	DenseNet-121	95.00
Nanehkaran et al	2023	AlexNet	90.00
		GoogleNet	92.33
		ZFNet	89.33
		CNN	91.33
		Le Network (LeNet)	91.00

Table 7 provides the results obtained from different studies on the detection of potato leaf diseases using various algorithms. The above studies indicate that for better results, more detailed research is needed in this field.

IV. DISCUSSION AND CONCLUSION

The integration of general image processing methods with deep learning algorithms enables the detection of plant diseases at various stages of a plant's life cycle. These systems streamline efforts by automating the analysis and diagnosis process, contributing to a healthier and more sustainable environment for plants, while also helping to mitigate the threat of extinction for various plant species. The key findings of this study can be summarized as follows: The proposed model achieved an impressive accuracy of 98.00% in detecting diseases in potato leaves. The performance of the model was exceptional, with precision (0.98), recall (0.97), and F1-score (0.98) values indicating excellent prediction accuracy. The CNN model attained high accuracy within a reasonable number of epochs (4 iterations). Compared to studies in the literature, the proposed model obtained approximately similar values. Future research should focus on creating well-designed and easily accessible datasets covering a wider range of diseases to further enhance existing methods.

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Evaluation of Belen's Tourism Potential from the perspective of Local Authorities[1]

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Abstract - This research comprises individuals vested in various sectors within Belen district which is located in Hatay. Semi-structured interviews were conducted using prepared forms with questions to understand Belen's tourism potential from the perspective of local authorities, gathering insights from local authorities. A semi-structured interview form consisting of 4 questions for the authorized person at the Belen District Governorship and 6 questions for Belen Municipality representative was used to obtain the opinions of local administrations. Data analysis was conducted to align with the study objectives. Information was sourced from interviews with relevant individuals who have been working in Belen District Governorship and Belen Municipality.

The findings highlight the significance of local authorities' knowledge and awareness, the city's image, plateau tourism, and gastronomy in contributing to Belen district's economy. However, the research also shows that in Belen, there are shortcomings in promotion, advertising, and tourism infrastructure.

Based on these insights, recommendations were put forth to enhance tourism in Belen district and guide future research endeavors.

Keywords – Tourism, culture, interviews, Belen, Hatay

[1] This article is extracted from my master thesis which is in progress entitled "Evaluation of Tourism Potential of Belen (Hatay) District", supervised by Thesis Iskenderun Technical University, Institute of Graduate Studies, Department of Tourism and Hotel Management.

I. INTRODUCTION

Throughout history, people's desire to travel has been on an ever-increasing trend. When the desire to travel is supported by individuals' increased income and free time, a significant flow of tourism is generated worldwide. Increased travel activity has a significant impact on local and global economies and provides an important source of income for countries and regions. Recognizing this, regions are making efforts to generate revenue by utilizing their touristic attractions.

Tourism, in its basic definition, refers to the travel of people outside their permanent place of residence, usually for the purpose of rest and vacation without financial gain or economic concerns [1]. They meet their psychological and socio-cultural needs such as learning. Tourism, which makes great economic contributions and is called tourism event is characteristic of a fundamental economic function of our time [2].

Tourism is a part of activities that include seeing natural beauties and historical monuments, participating in cultural activities, visiting relatives, health and recreation. Such travel and visits are usually not motivated by material concerns. Those who stay in a place for a short period of time, visit for reading purposes or simply transit are generally not considered tourists. Tourism has an economic and industrial dimension. Developments in tourism stimulate progress in areas such as industry, transportation and agriculture and create huge job opportunities. Tourism services are usually offered on a seasonal basis and concentrated within a certain season [3]. With the development of alternative tourism types, people are using the plateaus more for recreation and tourism purposes. People go to the plateaus to experience nature, desire for silence and serenity, photo-safari, observing plant species, nature walks, experiencing rural life rituals, highland festivals, mountain and winter sports touristic visits for purposes such as participating in activities [4].

In this research, it is aimed to identify and evaluate the potential of tourism resources of Belen district of Hatay province from the perspective of local authorities and to discover the possibilities of utilization. It is understood that this research will contribute significantly to the Belen district of Hatay province. In this context, it is seen that it will especially contribute to the local economy. In-depth examination of the tourism potential of Belen district of Hatay will make significant contributions to local economic development. This research will help the district to develop more effective strategies in the field of tourism and increase income among the people.

In addition, it is understood that this research will also contribute to the development of the tourism sector. The evaluation of the research and reaching its results will increase the competitiveness of the district in the tourism sector by determining the potential of the district from the perspective of local authorities. This will increase the tourism revenues of the district and contribute positively to the local economy and employment.

II. MATERIALS AND METHOD

The research data were obtained through semi-structured interview method. There are three different interview methods in the literature: structured, semi-structured and unstructured interviews. In this study, the semi-structured interview technique was preferred. This method was chosen because of its advantages such as its flexibility and the ability to expand the questions according to the flow of the interview [5].

The data obtained were evaluated using the content analysis method. In the content analysis process, the data are examined in detail, similarities are found and codes and themes are created; then these findings are interpreted in a meaningful way and presented to the reader. The content analysis process is usually carried out in four steps:

1. The data coding stage analyzes the information obtained and tries to divide it into sections in a meaningful way and to determine the conceptual meaning of each section. The researcher codes, i.e.

names, the parts that define important parts (words, sentences, paragraphs, etc.) so that they form a meaningful whole on their own.

2. In the stage of determining themes, themes that can explain the data at a general level are determined based on the codes obtained in the first stage and the codes are divided into certain groups. At this stage, it is important to find common points between the codes.
3. In the stage of organizing the data according to codes and themes, the researcher organizes the data in a model. The data are described and interpreted based on certain facts and organized according to the model. The researcher's personal opinions and comments are not taken into account at this stage; the collected information is presented to the reader in an objective manner.
4. At the stage of interpreting the results, the researcher tries to understand the collected data and draw conclusions. The relationships between the data are explained, cause-effect relationships are examined and the results obtained are explained with their meaning [6].

A. Data Collection and Analysis

This research aims to examine and evaluate the tourism potential of Belen. In this section, the data collected from the local authorities were compiled and analyzed. In order to determine the validity criteria of the research questions, the research questions were verified through interviews with 3 academicians who are experts in their fields and necessary checks were made on the language. Then, the necessary permissions were obtained from the İskenderun Technical University Scientific Research and Publication Ethics Board with the decision numbered 118588 dated 07.12.2023 and the field research was started.

In this study, a semi-structured interview form was prepared and the opinions of the representatives in the local authorities in Belen about the tourism potential were taken. In semi-structured interviews, participants should not be asked too many questions [7]. Basic interview the number of questions is kept quite limited and deriving follow-up and probe questions from them is the main feature of the semi-structured interview [8].

The questions to be asked to each local authorities' representative in the semi-structured interview form are grouped and the questions asked are as follows:

For the representative of Belen Municipality:

1. Can you evaluate Belen in terms of tourism?
2. Do you think that the infrastructure services of the region are sufficient for the development of Belen's tourism potential?
3. What can you say about the contributions of Belen's current tourism potential to the district?
4. What are the type(s) of tourism that should be developed in Belen?
5. Are there places where tourists can have fun in Belen? If there are, what can you say about these places?
6. Does Belen have problems about tourism? If yes, what can be done to overcome Belen's problems in tourism?

For the representative of Belen District Governorship:

1. Can you evaluate Belen in terms of tourism?
2. Does Belen have a rich potential in terms of tourism? If yes, which tourism potentials stand out?
3. What are the tourism activities that Belen needs investment and promotion?
4. Does Belen have problems in tourism? If yes, what can be done to overcome Belen's problems in tourism?

The interviews were conducted in accordance with ethical rules, provided that the participants allowed the use of a voice recorder in their workplaces to make them feel comfortable. Voice recordings were taken considering the large number of participants and equal conditions. It was stated that each participant had knowledge of audio recording.

All interviews were conducted face-to-face and audio recordings or notes were taken depending on the participant's consent and comfort. The notes and audio recordings obtained from the interviews were transcribed for content analysis.

The interview results were matched with the audio recordings and determined to be accurate and reliable. Therefore, the audio recordings that the researcher had with the permission of the participants were accepted as the criterion of accuracy and reliability. Face-to-face interviews were conducted using a semi-structured technique and only focused on the research topic by excluding non-research conversations.

III. RESULTS

In this part of the findings section, the representatives were asked: Can you evaluate Belen in terms of tourism? Does Belen have a rich potential in terms of tourism? If yes, which tourism potentials stand out? The analysis of the questions is included. When the answers given to these questions are evaluated, it can be concluded that there are many tourism areas that can attract attention in Belen. Some of the tourism potentials mentioned in the interviews are shown in Table 1.

Table 1. Tourism Potential in Belen

Natural Places	**Gastronomy**	**Historical Places**	**Others**
Observation Deck	Belen Tava	Abdurahman Paşa Tomb	Shopping
Submarine	Kömurçukuru Molasses	Kanuni Sultan Süleyman Caravanserai	Cultural values
Güzelyayla Plateau	Local Products	Kanuni Sultan Süleyman Mosque	Handicrafts
Atik Plateaau		Tosyalı Mosque	Festivals
Soğukoluk Plateau		Armenian Church	
		‘Martyrs’ Monument	
		Bakras Castle	

A. Evaluation of Belen Tourism Potential

It is seen that gastronomy has important impact in Belen tourism.

P1: “Belen has one of the richest and most delicious cuisines in Türkiye. There are restaurants on the road that offer the original flavors of Hatay cuisine. Local dishes, especially our “Belen Tava”, allow local and foreign visitors to experience the flavors unique to our region."

In addition to the richness of Belen's culinary culture, representatives of local authorities mentioned tourism potential of Belen is highland tourism and Belen's natural beauties. The participants expressed their knowledge and thoughts on this issue as follows:

P1: “Considering that Hatay has rich natural beauties in general, Belen also stands out in this regard. Especially in rural and mountainous areas, highland tourism is suitable in Soğukoluk plateau."

P2: “It is a region suitable for tourism with its nature, weather and easy transportation. New tourists come mostly for highland tourism."

P3: “It is in a good position due to its location on the Belen pass of Hatay province, the Amik Plain, and its highland location (Atik, Güzelyayla, Müftüler Neighborhood) that appeals to the sea and coastal areas.”

P4: “We can attract more tourists by using camping areas due to its nature and beauties.

The statements about Kanuni Sultan Süleyman Caravanserai and Abdurahman Paşa Tomb are as follows:

P2: “...The caravanserai can be transferred to a good operator and brought into tourism.”

P4: “...These roads, historical roads need to be revitalized which is near Abdurahman Paşa Tomb”

In addition to Kanuni Sultan Süleyman Caravanserai and Abdurahman Paşa Tomb, which are the historical texture of Belen, it is mentioned that local products can contribute to the tourism potential as follows:

P4: “Thanks to the richness of our local products, we can stand out in terms of tourism”.

While mentioning that local products can attract the attention of tourists and that they also create tourism potential, the participants also mentioned that a shopping tourism can be created in Belen district with the sale of these and similar products:

P2: “As well as handicrafts and shopping tourism focusing on bazaars where traditional handicrafts and souvenirs are sold...”

They also mentioned that cultural values of Belen, some historical values such as mosques, churches, tombs, monuments and castles can be evaluated in terms of tourism.

P1: “There are historical mosques (Kanuni Sultan Süleyman Mosque and Tosyalı Mosque), Armenian Church in Belen. These places can be interesting places to visit for history buffs."

P2: “However, the ‘Martyrs’ Monument”, Bakras Castle and “Abdurahman Paşa Tomb” built in the could attract the attention of our people and local tourists."

He stated that the festivals organized in Belen district can bring the local, cultural texture of Belen to the forefront and this can create a potential for district tourism as follows:

P1: “Festival and event tourism based on festivals, cultural events and special events organized throughout the year. Such events can be used to introduce local culture and traditions to tourists."

P3: “It is a great opportunity for not only local people but also foreigners. Such events can be used to introduce local culture and traditions to tourists."

B. Evaluation of Deficiencies in the Development of Belen's Tourism Potential

The local authorities were asked questions such as “Do you think that the infrastructure services of the region are sufficient for the development of Belen's tourism potential? What are the problems of Belen in terms of tourism?”. Some of the problems that prevent the tourism potential of Belen district from becoming more apparent and developing were expressed during these interviews. The main problems and deficiencies in the development of the tourism potential of Belen district are shown in Table 2. based on the reasons put forward by the respondents.

Table 2. Problems Affecting Tourism in Belen District

Promotion	Lack of advertising	Lack of promotion
Transportation	Transportation difficulties	Lack of parking space
Accommodation	Lack of accommodation	
Infrastructure	Inadequate infrastructure	
Protection of cultural resources	Inadequate protection of cultural resources	

P1: “Of course, there are some problems in our district as in every district. The lack of an effective promotion that will announce Belen's touristic potential to a wide audience..."

P4: “Unfortunately, the biggest problem of our district is the lack of promotion and advertisement. After successful and adequate promotion, I think that the interest in Belen will increase considerably.... ...Unfortunately, it does not receive the attention it deserves because it is not promoted enough to attract tourists."

It is seen that lack of accommodation and inadequate infrastructure have a negative impact on tourism in the district:

P1: “.... Transportation to Belen is difficult or insufficient. Lack of sufficient number of accommodation facilities in Belen. Infrastructure deficiencies in touristic areas, such as insufficient basic services such as toilets."

P2: “There is tourism potential, but we have not been able to reveal it. I think the biggest reason is the lack of infrastructure and lack of advertising. We have problems with transportation, as well."

It is understood from the statements of the participants that the inadequate infrastructure in Belen district, the lack of accommodation and the difficulty of transportation are obstacles to the revival of tourism. In the previous section, attention was drawn to the existence of cultural resources that create tourism potential in the district, but the participants mentioned that efforts to protect these resources were lacking:

P1: “Lack of sustainable protection of environmental and cultural resources in touristic areas...”

P2: “If our historical places such as ‘Bakras Castle’ are restored, we can bring more tourists to the district.... In addition, we are weak in handcraft and shopping tourism, which focuses on bazaars where traditional handicrafts and souvenirs are sold.”

Participants emphasized the need to protect cultural sites in order to revitalize tourism activities in Belen and appeal to more tourists.

Lack of promotion: Representatives pointed out that the most important deficiency of the current tourism in Belen is the lack of promotion and advertising activities. There is a common view among the participants that more tourists can be attracted to the district with adequate promotion.

P1: “Developing effective marketing strategies to promote the touristic destination, utilizing digital media and social media platforms, participating in tourism fairs, etc. to introduce Belen to a wider audience.”

P2: “We can attract more tourists to our district by promoting bird watching tourism. In addition, although the potential of highland tourism is sufficient, there is not enough promotional work."

P2: “...I think the biggest reason is that we are lacking in advertising.”

P4: “I think that after successful and sufficient promotion, the interest in Belen will increase considerably. For example, by being in contact with tour companies, we can provide accommodation in our district and bring more tourists to our district.”

C. Evaluation of the Contribution of Belen's Tourism Potential to the District

In order to understand how the current tourism in Belen contributes to the district, the participants were asked; “What can you say about the contributions of Belen's current tourism potential to the district?” “Are there places where tourists can have fun in Belen? If so, what can you say about these places?” “What kind of contribution (social, economic, etc.) does Belen's current food and beverage potential have to the district?”

The answers of the representatives of local authorities mostly indicate that highland tourism, gastronomy, the business and economic contributions of Belen's local products to the district are significant sources of income. In addition to these, it is also understood that festivals will play a role in the promotion of Belen if they are organized, and that the observation terrace and birdwatching transit point offer economic contributions and opportunities to keep Belen tourism alive while creating an alternative to tourism.

Plateau tourism: It can be said that the fact that people are in search of plateaus in the hot summers of Hatay keeps Belen district at an important point in terms of local plateau tourism. It is understood that the economic income and employment offered by plateau tourism bring a certain amount of income to the district.

P2: .... “the potential of highland tourism is sufficient”.

P3: “The main places where the people of the region stay seasonally as seasonal plateaus in the summer months.”

P4: “Because it is cool in summer, people come from nearby districts to stay during the summer.”

When we asked the participants “Does Belen have a rich potential in terms of tourism? If yes, which tourism potentials stand out?” Representatives of municipality mentioned that:

P1: “Thanks to gastronomy, Belen tradesmen make a living. Belen cuisine is one of the richest and unique cuisines in Turkey. Belen can focus on gastronomy tourism with this rich culinary culture. Organizing local restaurants, cooking workshops and gourmet tours can contribute more to the district."

It was also stated that the contribution that gastronomy offers and can offer to the district is significant, but there are few places and opportunities where Belen cuisine is put into service for tourists.

Observation Terrace: The observation terrace, operated by Belen District Governorship which was funded “Eastern Mediterranean Development Agency” provides an opportunity for those on the road route to stay and rest, enjoy the nature of Belen and the sea of Iskenderun, while attracting tourists to the district and adding vitality to tourism.

P1: “We have an observation terrace and a municipal cafe where you can sit with your families, spouses and friends.”

The participant has also mentioned about festivals;

P1: “We did not have the opportunity to organize it due to the earthquake, but we normally have festivals and events, such festivals can give local tourists the opportunity to get to know the local culture and traditions more closely.”

Improving of plateau tourism and accommodation facilities: It has been mentioned many times that the potential for plateau tourism is quite high, and in order to develop this tourism, accommodation facilities should be increased and different accommodation options should be offered to tourists.

P1: “Building new accommodation facilities or improving existing ones, offering tourists a variety of accommodation options.”

P3: “In my opinion, highland tourism can be emphasized. In this way, the cool clean air of Belen can attract thousands of tourists. Domestic tourists can be directed to picnic areas and forest facilities in the Soğukoluk region.”

Protection of natural places and revitalization of nature tourism: Considering the natural structure of Belen district, including active tourism activities to revitalize this tourism potential and conducting studies for the protection of nature will enable the development of tourism in this region.

P1: “Belen's natural beauties include areas suitable for trekking trails, nature walks and nature activities. Nature tourism focusing on these natural beauties can be attractive for nature lovers and adventure enthusiasts..... Active tourism activities such as mountaineering, camping, cycling tours and water sports. Promote sports and outdoor activities using Belen's geographical features.”

P4: “More tourism investments can be made in campsites.”

Restoration and protection of historical sites: Protecting and renovating the existing historical buildings in Belen and keeping the areas where excavations can be carried out alive are thought to increase the potential of attracting tourists to the district.

P1: “Adopting sustainable tourism practices, prioritizing environmental and cultural protection.”

P2: “If our historical sites such as ‘Bakras Castle’ are restored, we can bring more tourists to the district. The current situation can be improved by cooperating with the District Governorship and Municipality.”

Solving transportation problems: Considering the location of Belen district, it can be considered as a difficult region to access due to its narrow roads. Carrying out studies to solve transportation difficulties will facilitate the transition to existing or newly established facilities and tourism areas. Facilitating transportation is likely to make the use of tourism areas more widespread.

P1: “To improve road networks to overcome transportation difficulties. Taking measures such as activating Hatay airport, improving highway routes or increasing public transportation alternatives."

Solving infrastructure deficiencies: Inadequate infrastructure has been mentioned, and there are opinions that an effort to overcome these infrastructure deficiencies and the cooperation of several sectors can lead to positive results.

P1: “Cooperation between local authorities, public institutions and the private sector to improve infrastructure.”

Forming a Tourism Development Team: It was stated that the lack of a tourism development team or council in Belen district caused delays in identifying and eliminating deficiencies, and it was mentioned that the existence of such a council or organization would be faster in many aspects of tourism development in this region.

P1: “By focusing on these issues, it is possible to develop Belen's tourism potential in cooperation with private sectors, local government and non-governmental organizations. These efforts can contribute to the creation of a sustainable and developed tourism sector.”

Education and awareness of local people: The views that educating the local people about tourism will make it easier to support tourism in that region can also be considered as a factor to revitalize tourism.

P1: “Providing local people with job opportunities in the tourism sector, organizing training programs and raising awareness about tourism.”

When we have asked about festivals, they stated that;

P1: “Festival and event tourism based on festivals, cultural events and special events throughout the year. Such events can be used to introduce local culture and traditions to tourists."

P2: “...We are also weak in handicraft and shopping tourism, which focuses on bazaars selling traditional handicrafts and souvenirs.”

There were some opinions that creating tour routes and providing tourist guide services in the district would be effective in terms of promoting tourism opportunities and attracting tourists.

P1: “Cultural tourism focusing on Belen's rich historical and cultural heritage, ancient ruins and historical buildings. Organizing historical and cultural tours for tourists, providing guidance services....Kanuni Sultan Süleyman Mosque in our district is a historical mosque of religious importance. Providing religious tours, worship opportunities and guidance services to visitors to our district can develop tourism."

IV. DISCUSSION

These interviews show that Belen's tourism potential is rich in terms of culinary culture and gastronomy, natural beauties and highland tourism. Cultural, historical and local tourism opportunities

specific to Belen were mentioned, and when all these opportunities and elements are brought together, it can be thought that tourism in Belen district can create a potential that can be called good.

The main problems affecting tourism in Belen district are lack of promotion and advertising, transportation problems, lack of accommodation and infrastructure deficiencies. The fact that not much is being done to protect cultural sites in the district is also an important part of these problems. In addition to these, some of the problems that are less noticeable because they are mentioned by fewer people, but which can be effective in revitalizing tourism are; the lack of parking spaces, the lack of education of the people to contribute to tourism, the lack of incentive efforts within the local government to revitalize touristic places, the lack of geographical indication of some of the dishes in Belen cuisine, the lack of a tour route that would attract tourists, the lack of a tour route that would attract tourists, the lack of a team that would recognize the deficiencies within the district and make tourism development plans, and the scarcity or absence of festivals promoting local culture. It is understood that the existence of these deficiencies pulls the tourism potential of Belen district backwards.

We can say that plateau tourism has an economically effective contribution to the district in terms of providing job opportunities. It is also understood that there is income from accommodation in this type of tourism, but this contribution is also low in terms of insufficient accommodation.

In addition to plateau tourism, another important area that offers economic contribution and promotion opportunities to the district is the cuisine of the district. It is understood from the statements of the participants that the local dishes of Belen district offer different flavours to tourists and generate income and increase the potential to attract tourists to the district.

When we have looked at festivals, which are effective in promoting Belen culture and traditions, have the potential to attract tourists, it is understood that festivals have been interrupted due to some recent problems.

It is understood from the interviews that the inclusion of cultural activities, traditional motifs and local food and beverages in activities such as festivals. These festivals will increase the vitality of tourism.

When the problems that need to be overcome in Belen are evaluated based on the interviews conducted, the most important of these is the adequate implementation of promotional and advertising activities. Secondly, it is noteworthy that accommodation facilities should be increased and different options should be included in order to make highland tourism, which has a strong potential, more vibrant. The existence of a beautiful nature in Belen draws attention to the many active tourism activities that can be carried out in this area. Taking measures to protect nature and revitalizing nature tourism is another tourism area that needs to be developed. Restoration and protection of historical sites, elimination of infrastructure inadequacy and transportation problems, establishment of a tourism development team in the district, training and raising awareness of the public in terms of tourism, including cultural activities and providing tour and guidance services in the district will not only improve the existing tourism but also enable the formation of new tourism areas.

V. CONCLUSION

Tourism has taken on a new face by moving away from traditional mass tourism patterns. It is seen that new types of tourism emerging with the change in the tourist profile increase the interest in natural and cultural areas. Türkiye is a place with rich geographical and cultural potential, and Belen district of Hatay province is a valuable part of these riches. This region, where plateau tourism is prominent, has revealed its tourism potential with the discovery of its natural and cultural heritage in recent years. Although Belen district is less known in terms of tourism compared to other districts of Hatay, it is understood that it will make a name for itself in the field of tourism when its potential is revealed.

Based on the information obtained from the interviews, it is seen that tours for tourism are not organized in Belen district for touristic purposes. The historical and cultural values of many natural areas in the district have the potential to be used for tourism activities. However, while there are many opportunities for rural tourism, these opportunities cannot be fully utilized due to the lack of knowledge and experience of local people and local administrations in this field. This situation reveals the importance of raising awareness of local people and local administrations on tourism. Increasing interest and demand, together with the interest in rural tourism, local cultures and undiscovered destinations, will increase if various rural tourism activities are realized in the region.

The fact that Arsuz district, which is only 40 km. away from Belen district, is known for sea-sand-sun tourism may create an opportunity for Belen district in terms of tourism. For this reason, in addition to the strengths and potential of the district, a new impetus can be given to tourism revenues by organizing daily sightseeing-shopping tours.

Although highland tourism has become a prominent feature of Belen, it is important for the district to explore and promote other potential tourism areas. For example, it may be possible to evaluate historical and cultural richness in terms of tourism or to support alternative types of tourism such as gastronomy tourism.

Belen's potential can be publicized more effectively in the national and international arena by giving more importance to tourism promotion. Activities such as digital marketing, social media use and tourism fairs can be useful in this regard.

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Proposal and Evaluation of Biogas-Fired Power Plant Integrated with Helium Gas Cycle and Power-Ejector Refrigeration Cycle

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Abstract – This study proposes and evaluates an innovative biogas-fired power plant integrated with a Helium Gas Cycle (HGC) and a Power-Ejector Refrigeration Cycle (PERC) to enhance overall energy efficiency and sustainability. The integration aims to leverage the high thermal efficiency of the helium gas cycle and the effective refrigeration capabilities of the ejector cycle, utilizing the biogas combustion's high-temperature output. The performance of the integrated system is analyzed under varying biogas turbine inlet and environmental temperatures. According to the results of the analysis, the net power obtained from the integrated system is 5690 kW. The net power obtained from the biogas cycle is 5158 kW, and the capacity of the ejector cooling system is 154.5 kW. Also, results indicate that increasing the biogas turbine inlet temperature significantly enhances net power production and energy efficiency due to improved thermodynamic efficiency and greater energy conversion rates. However, it also increases total exergy destruction due to higher irreversibilities associated with higher thermal gradients.

Keywords – Biogas, Helium Gas Cycle, Power-Ejector Refrigeration Cycle, Energy, Exergy.

I. INTRODUCTION

The increasing global emphasis on sustainable energy solutions necessitates innovative approaches to power generation that maximize efficiency while minimizing environmental impact. One such promising development is the integration of biogas-fired power plants with advanced thermodynamic cycles, specifically the helium gas cycle and the power-ejector refrigeration cycle. This integrated system is designed to optimize energy conversion, enhance operational efficiency, and utilize waste heat effectively, thus representing a significant step forward in renewable energy technology. Biogas, produced through the anaerobic digestion of organic waste materials such as agricultural residues, food waste, and sewage sludge, presents a viable renewable energy source. It offers the dual benefits of waste management and energy production, contributing to a circular economy. The carbon-neutral nature of biogas, as the carbon dioxide released during its combustion is offset by the carbon dioxide absorbed during the growth of the organic matter, makes it an environmentally friendly alternative to fossil fuels [1]. The integration of a helium gas cycle into the biogas power plant capitalizes on the unique thermodynamic properties of helium. Helium, with its high specific heat ratio and excellent thermal conductivity, allows the cycle to operate at elevated temperatures and pressures. These properties result in higher thermal efficiency and greater power output compared to traditional gas cycles. The helium gas cycle, often used in advanced nuclear reactors, is particularly suited for integration with biogas combustion processes, where it can efficiently convert high-temperature thermal energy into mechanical and electrical energy [2]. In addition to the helium gas cycle, the power-ejector refrigeration cycle plays a critical role in enhancing the overall efficiency of the power plant. The power-ejector refrigeration cycle uses waste heat from the power generation process to drive an ejector-based refrigeration cycle. This approach not only provides the necessary cooling for the plant

operations but also utilizes energy that would otherwise be wasted. The ejector-based system is advantageous due to its simplicity, reliability, and ability to operate without moving parts, reducing maintenance requirements and increasing the system's robustness [3]. By effectively managing the thermal energy, the power-ejector refrigeration cycle significantly improves the overall energy efficiency and sustainability of the power plant. The combined integration of these technologies in a biogas-fired power plant offers multiple benefits. The enhanced efficiency and reduced greenhouse gas emissions contribute to a more sustainable and environmentally friendly energy production process. Moreover, this integrated approach aligns with global efforts to reduce reliance on fossil fuels and mitigate climate change by promoting the use of renewable energy sources [4]. In summary, the proposal and evaluation of a biogas-fired power plant integrated with a helium gas cycle and power-ejector refrigeration cycle represent a novel and promising advancement in renewable energy technology. This integrated system maximizes energy conversion efficiency, effectively utilizes waste heat, and significantly reduces environmental impact. By harnessing the synergies between these advanced thermodynamic cycles, this innovative approach sets new benchmarks in sustainable power generation and supports global efforts to achieve a low-carbon future. There are many studies in the literature about biogas-based integrated systems.

de Faria et al. [5] conducted an experimental study on an engine-generator unit powered by biogas, examining various operating modes and engine conditions. They developed a comprehensive mathematical model to describe the internal cylinder pressure in relation to the crank angle, comparing the theoretical results with experimental data. Mudasar et al. [6] integrated an Organic Rankine Cycle (ORC) with a sewage treatment plant to provide heat and electricity for residential areas by burning biogas under different operating conditions. They highlighted the significant role of biogas in reducing greenhouse gas emissions from an environmental perspective and argued that biogas-based power plants are an effective solution for supplying energy to rural areas. Hosseini et al. [7] integrated a gas turbine cycle with an organic Rankine cycle to enhance power extraction from the waste heat of the gas turbine cycle. Using biogas instead of methane as fuel, they conducted a comprehensive thermal design and parametric study, achieving 1.4 MW net power output. Barzegaravval et al. [8] performed an exergoeconomic evaluation of a biogas-based GTC, examining the impact of fuel composition and system size on critical exergy and economic parameters. They calculated a net electricity cost of $0.05–0.18 per kWh and observed a 1% increase in total system cost as methane content decreased from 0.95 to 0.6. Leonzio [9] proposed an innovative combined cooling, heating, and power system, which produced 473 kW of cooling energy, 2523 kW of thermal energy, and 925 kW of electrical energy from 3280 kW of biogas combustion. Khaljani et al. [10] conducted energy, exergy, and exergoeconomic assessments of a combined heating and power cycle, identifying the combustion chamber as the primary source of exergy destruction. Their research indicated that increasing the air preheater outlet temperature could improve the system's thermodynamic and thermoeconomic performance.

The study aims to propose and assess a novel power plant design that combines a biogas-fired system with a helium gas cycle and a power-ejector refrigeration cycle. The primary goal includes evaluating the thermal and electrical efficiency of this integrated system under various operational conditions. It is also aimed to conduct parametric studies to examine the effects of basic parameters on system performance. This integrated system offers a novel approach to enhancing energy efficiency and sustainability in power generation and refrigeration by combining biogas utilization, helium gas cycle efficiency, and advanced refrigeration technology.

II. SYSTEM DESCRIPTION

Fig. 1 shows the combination of a biogas-fired power plant with a helium gas cycle and a power ejector cooling cycle to increase energy efficiency and sustainability. The proposed configuration aims to leverage the renewable nature of biogas and the high efficiency of helium as a working fluid, along with the advanced refrigeration technology, to create a synergistic energy production and utilization system. Biogas is produced from organic waste materials through anaerobic digestion. The biogas primarily consists of

methane (CH_4) and carbon dioxide (CO_2). The biogas is combusted in a combustion chamber to produce high-temperature flue gases. The combustion process converts the chemical energy of the biogas into thermal energy. The thermal energy from the flue gases is transferred to a steam cycle via a heat recovery steam generator, producing high-pressure steam. Helium gas is compressed, increasing its pressure and temperature. The heated, high-pressure helium expands in a gas turbine, converting thermal energy into mechanical energy to drive an electric generator. The expanded helium is cooled and recompressed, completing the cycle. The cooling process can be integrated with the power-ejector refrigeration cycle for enhanced efficiency. The cycle utilizes an ejector to compress the refrigerant vapor. The primary flow of high-pressure refrigerant entrains the secondary flow, resulting in compression without mechanical work. The compressed refrigerant vapor is condensed, releasing heat that can be utilized for district heating or other processes. The liquid refrigerant evaporates by absorbing heat from the environment or a cooling load, providing the refrigeration effect. The refrigerant is pumped back to the ejector, completing the cycle.

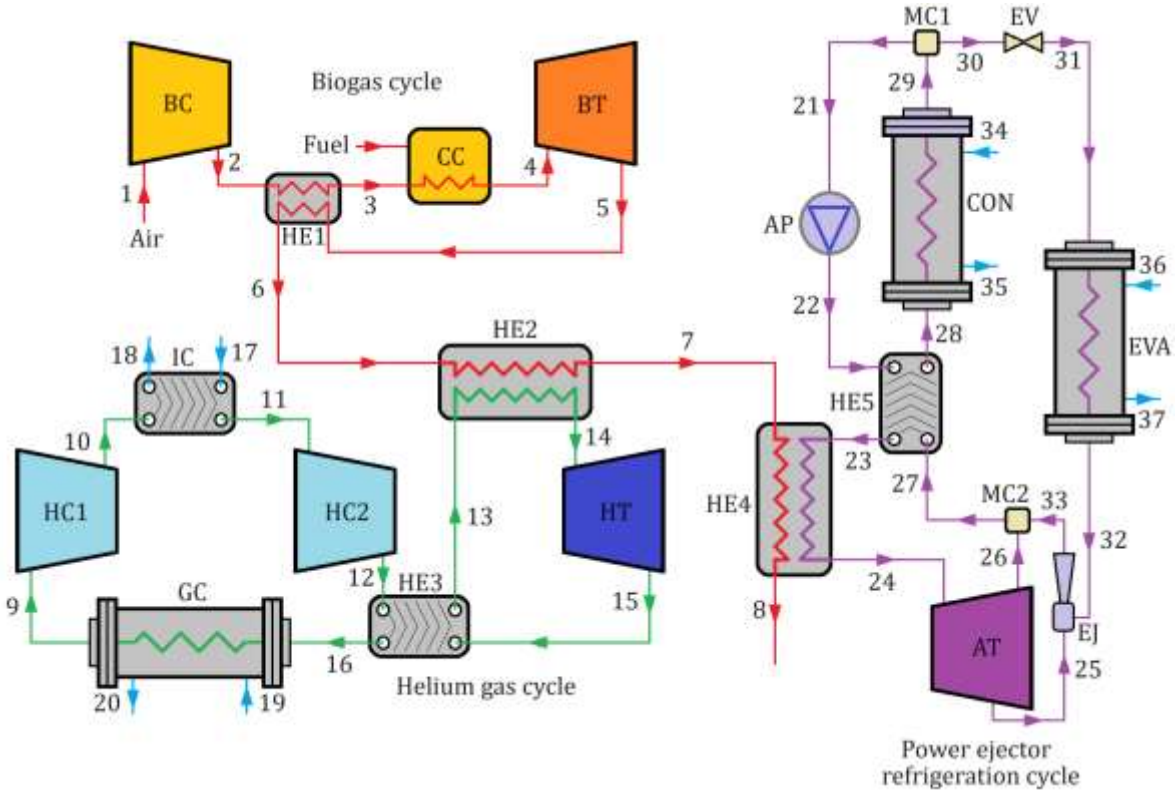

Fig. 1. System description of the biogas-fired power plant integrated with Helium Gas Cycle and Power-Ejector Refrigeration Cycle

III. METHODOLOGY

For the performance assessment of the solar-driven system, the first and second laws of thermodynamics and the principles of mass conservation are applied to each system element. The mass and energy balance equations for steady-state and steady-flow processes are written as [11]:

$$\sum \dot{m}_{in} = \sum \dot{m}_{out} \tag{1}$$

Here, $\dot{m}$ is the mass flow rate, subscripts "in" and "out" are the input and output states. Energy balance equality in a general method is written as [12]:

$$\sum \dot{m}_{in}\left(h + \frac{v^2}{2} + gz\right)_{in} + \sum \dot{Q}_{in} + \sum \dot{W}_{in} = \sum \dot{m}_{out}\left(h + \frac{v^2}{2} + gz\right)_{out} + \sum \dot{Q}_{out} + \sum \dot{W}_{out} \tag{2}$$

Here, $\dot{Q}$ is the heat energy transfer rate, $\dot{W}$ is the power transfer rate, h is the specific enthalpy, v is the velocity, z is the elevation, and g is the gravitational acceleration. Entropy balance equality is given as:

$$\sum \dot{m}_{in} s_{in} + \sum \frac{\dot{Q}}{T} + \dot{S}_{gen} = \sum \dot{m}_{out} s_{out} \quad (3)$$

Here, s is the specific entropy, and $\dot{S}_{gen}$ stands for entropy generation rate. An exergy balance equality of any system can be described as [13]:

$$\sum \dot{m}_{in} \dot{ex}_{flow} + \sum \dot{Ex}_{in}^{Q} + \sum \dot{Ex}_{in}^{W} = \sum \dot{m}_{out} \dot{ex}_{flow} + \sum \dot{Ex}_{out}^{Q} + \sum \dot{Ex}_{out}^{W} + \dot{Ex}_{dest} \quad (4)$$

Where $\dot{ex}_{flow}$ is the flow exergy, $\dot{Ex}_{in}^{Q}$ is the exergy associated with heat flow across the control volume of the process, $\dot{Ex}_{in}^{W}$ is the exergy associated with work and $\dot{Ex}_{dest}$ is the exergy destruction. In the above equation, each term is defined as follows:

$$\dot{ex}_{flow} = (h - h_0) - T_0(s - s_0) \quad (5)$$

$$\dot{Ex}^{Q} = \dot{Q}\left(\frac{T - T_0}{T}\right) \quad (6)$$

$$\dot{Ex}^{W} = \dot{W} \quad (7)$$

$$\dot{Ex}_{dest} = T_0 \dot{S}_{gen} \quad (8)$$

The energy and exergy efficiency equations for the partial cooling sCO_2 Brayton cycle can be written as follows:

$$\eta_{en} = \frac{\dot{W}_{net}}{\dot{Q}_{in}} \quad (9)$$

$$\eta_{ex} = \frac{\dot{W}_{net}}{\dot{Ex}_{\dot{Q}_{in}}} \quad (10)$$

IV. RESULTS

This paper aims to evaluate the performance of the biogas-fueled power plant integrated with the helium gas cycle and power ejector cooling cycle. It is also aimed to conduct parametric studies to examine the effects of turbine inlet temperature and environmental temperature in the biogas cycle on system performance. For this purpose, thermodynamic analyses were carried out using EES software. The default initial parameters of the integrated system are arranged in Table 1.

Fig. 2 shows the useful outputs of the integrated system. As seen in the figure, the highest power production is in the biogas compressor, followed by the helium compressor and the power ejector refrigeration cycle. Fig. 3 demonstrates the exergy destruction in the system components. As seen in the figure, the highest exergy destruction is in the combustion chamber, with 45%. This is followed by biogas compressor with 22% and biogas turbine with 14%. The least exergy destruction is in heat exchangers.

Table 1. The default initial parameters

Parameter	Value
Biogas turbine temperature	1050 °C
Combustion chamber efficiency	0.95
Turbine efficiency	0.9
Pressure ratio	8
Biogas efficiency	0.85
Compressor efficiency	0.80
Helium compressor temperature	30 °C
High pressure	8000 kPa
Low pressure	3500 kPa
Evaporator temperature	8 °C
Condenser temperature	35°C
Entrainment ratio	0.2
Expansion ratio of turbine	2.5
Ejector pump efficiency	0.80
Extraction ratio of the turbine	0.4

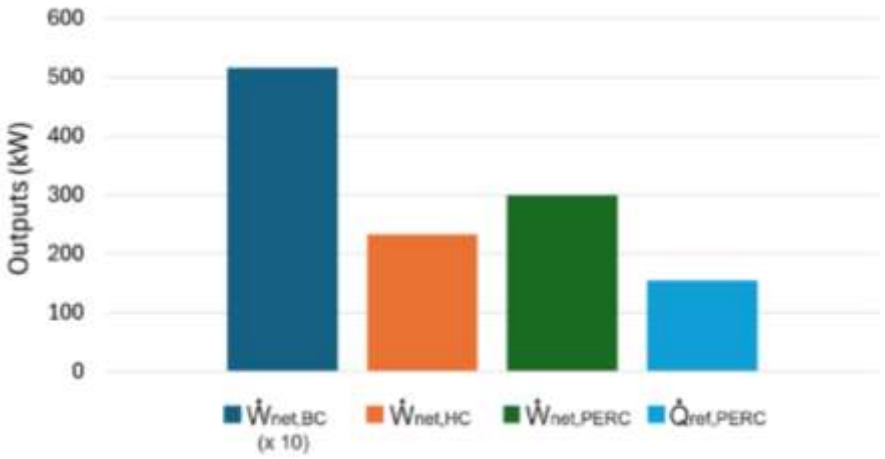

Fig. 2. Useful outputs of the integrated system

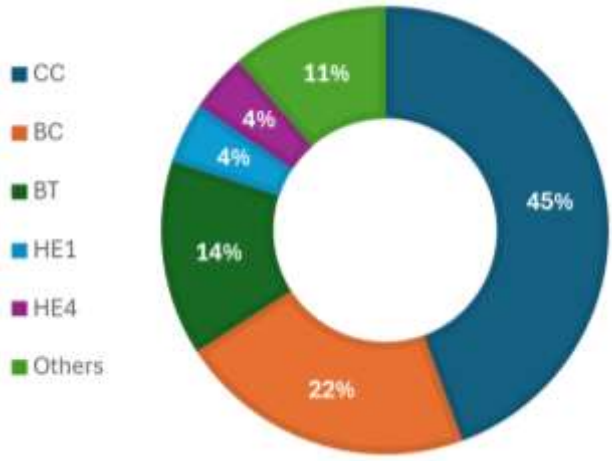

Fig. 3. Exergy destruction rates of the system components

In the second stage of the study, parametric studies were conducted to examine the effects of some basic parameters on system performance. Fig. 4 shows the effect of biogas turbine inlet temperature on net power production and energy efficiency. As seen in the figure, net power production and energy efficiency increase when the biogas turbine inlet temperature is increased from 800℃ to 1300℃. A higher turbine inlet temperature allows for more complete combustion of the biogas, leading to a higher rate of energy conversion from fuel to mechanical work. This results in greater net power output from the turbine. Moreover, increasing the turbine inlet temperature enhances the thermal efficiency of the cycle. According to the Carnot efficiency principle, higher temperatures at the turbine inlet result in a greater temperature difference between the heat source and sink, leading to improved efficiency of the thermodynamic cycle.

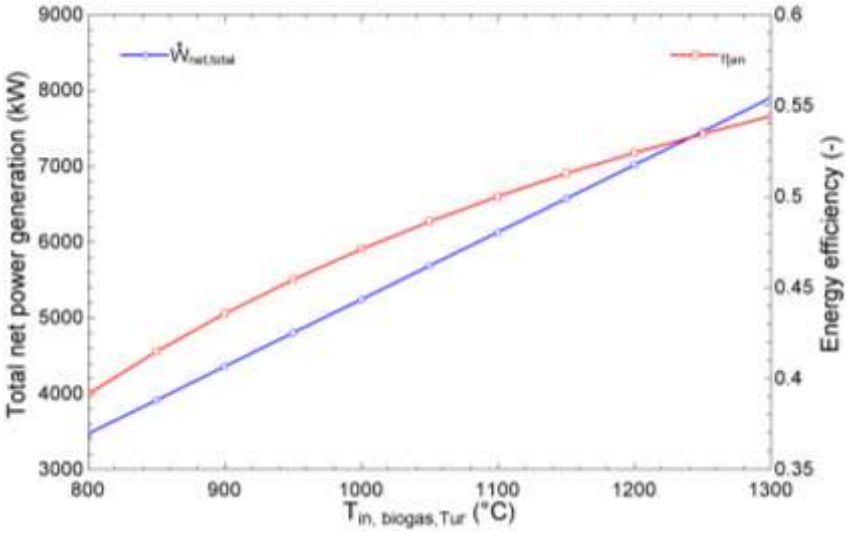

Fig. 4. Variation of net power generation and energy efficiency with the biogas turbine inlet temperature

Fig. 5 represents the effect of biogas turbine inlet temperature on BC net power generation and energy efficiency. As seen in the illustration, as the biogas turbine inlet temperature increases, BC's net power production and energy efficiency increase. With a higher turbine inlet temperature, the energy content of the working fluid entering the turbine is higher. This means more energy can be converted to mechanical work during the expansion process in the turbine. The increase in work output from the turbine outweighs the increase in the compressor work, leading to a higher net power output. Moreover, higher temperatures at the turbine inlet allow for better utilization of the thermal energy available from the combustion of biogas. This leads to a more efficient conversion of fuel energy into mechanical energy. This efficient conversion translates to a higher overall plant efficiency because less energy is wasted as heat to the surroundings.

The effect of biogas turbine inlet temperature on helium compressor net power production and fuel mass flow rate is seen in Fig. 6. As seen in the figure, as the biogas turbine inlet temperature increases, the helium compressor net power production and fuel mass flow rate increase. As the biogas turbine inlet temperature increases, the efficiency of the Brayton cycle improves. This means that the turbine generates more power for the same amount of fuel input. The increased power output from the turbine translates into a higher available energy for the helium compressor. Furthermore, to achieve higher turbine inlet temperatures, more thermal energy must be provided by burning additional biogas. This increases the fuel mass flow rate because more fuel needs to be combusted to reach the desired higher temperatures. The relationship between fuel flow rate and power output is directly proportional; as the desired power output increases, so does the fuel consumption to provide the necessary thermal energy.

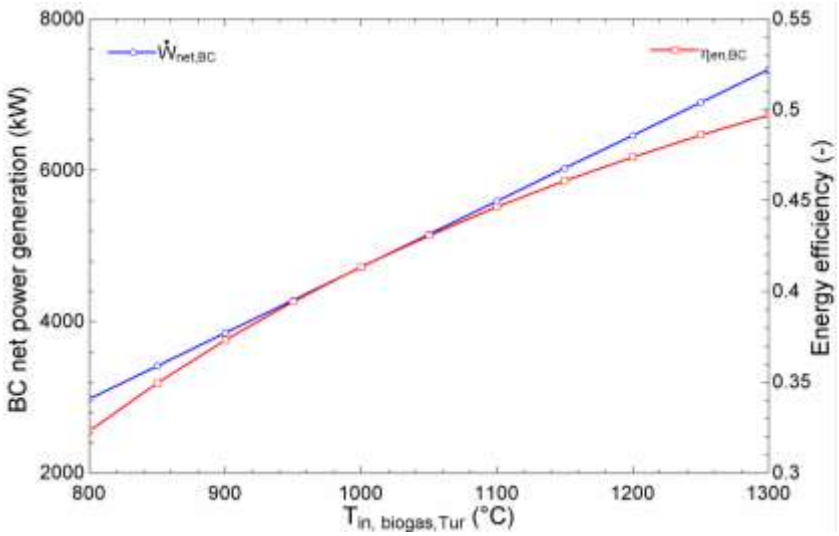

Fig. 5. Variation of BC net power generation and energy efficiency with the biogas turbine inlet temperature

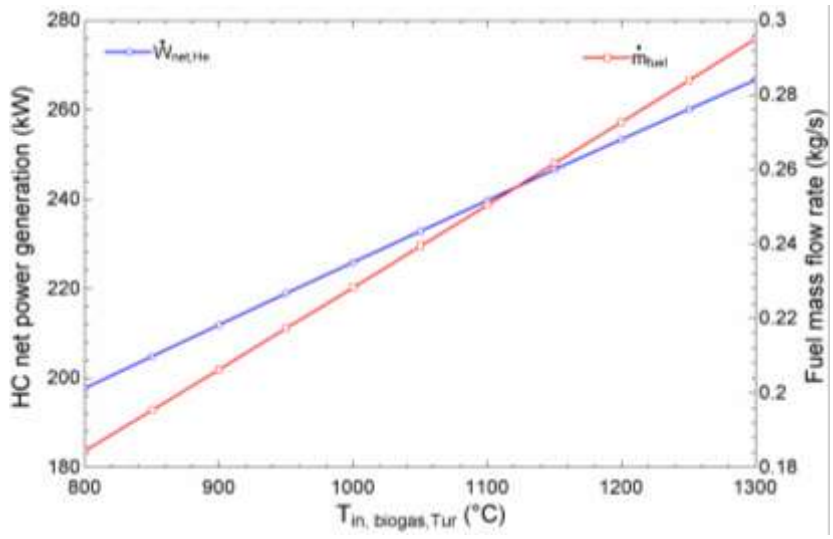

Fig. 6. Variation of HC net power generation and fuel mass flow rate with the biogas turbine inlet temperature

Fig. 7 demonstrates the effect of biogas turbine inlet temperature on PERC net power generation and PERC refrigeration capacity. As seen in the figure, as the biogas turbine inlet temperature increases, PERC net power production increases, and PERC refrigeration capacity decreases. Higher temperatures can improve the efficiency of the ejector and other components within the PERC. The ejector works on the principle of utilizing high-pressure motive fluid (steam or another working fluid) to entrain a low-pressure suction fluid, thereby creating a refrigeration effect. Increased thermal energy results in higher pressure and temperature of the motive fluid, improving the entrainment ratio and overall efficiency of the ejector, leading to enhanced power production capabilities. As the biogas turbine inlet temperature increases, more of the available thermal energy is diverted towards power production due to the higher efficiency and output of the turbine and the helium cycle. This leaves less thermal energy specifically for cooling purposes within the PERC. The increased focus on power production at higher temperatures means that less energy is available to drive the refrigeration cycle, thus reducing its cooling capacity.

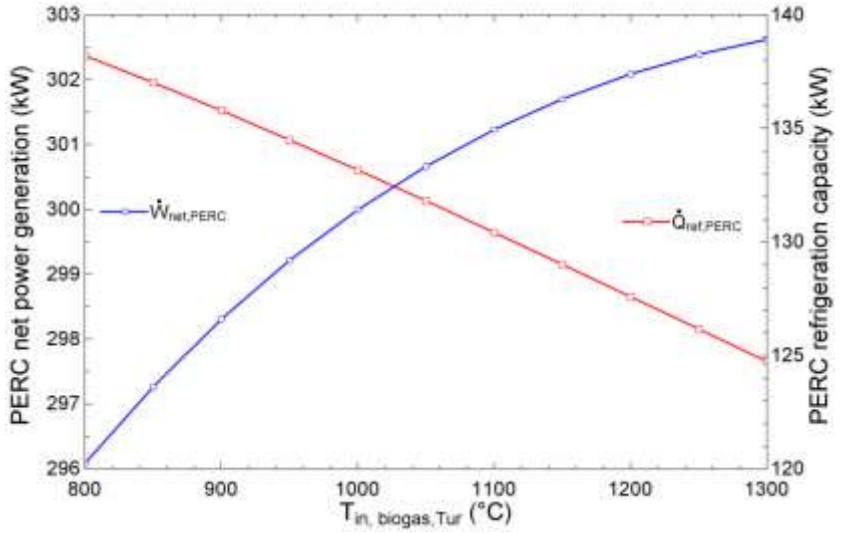

Fig. 7. Variation of PERC net power generation and PERC refrigeration capacity with change of biogas turbine inlet temperature

The impact of biogas turbine inlet temperature on total exergy destruction and exergy efficiency is seen in Fig. 8. As seen in the figure, as the biogas turbine inlet temperature increases, total exergy destruction and exergy efficiency increase. As the biogas turbine inlet temperature increases, the Brayton cycle becomes more thermodynamically efficient. The higher temperature leads to a greater temperature differential between the heat source (combustion gases) and the heat sink, improving the overall cycle efficiency. This means more of the input energy is converted to useful work, increasing the exergy efficiency. As the biogas turbine inlet temperature increases, the system operates at higher energy inputs. This increased energy input can lead to higher absolute values of exergy destruction because more energy is being processed by the system. Even though the efficiency improves, the total amount of exergy being handled by the system increases, leading to a higher total exergy destruction in absolute terms.

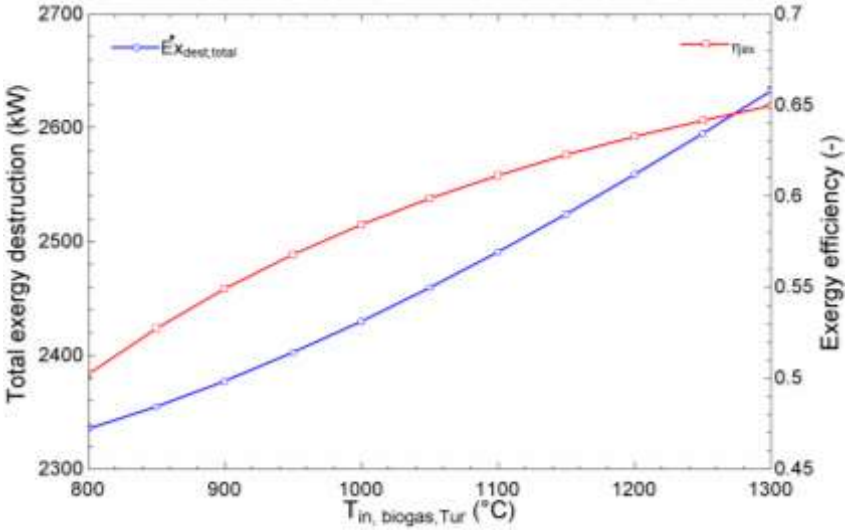

Fig. 8. Variation of total exergy destruction and exergy efficiency with change of biogas turbine inlet temperature

Fig. 9 indicates the effect of environmental temperature on total exergy destruction and exergy efficiency. As seen in the figure, as the ambient temperature increases, total exergy destruction increases, and exergy efficiency decreases. Exergy destruction is closely related to the irreversibilities in the system, which are influenced by the temperature gradients between different components and the environment. When the environment temperature increases, the temperature gradient between the high-temperature components (like the biogas turbine and heat exchangers) and the environment decreases. A smaller temperature

gradient reduces the driving force for heat transfer, leading to less efficient heat exchange processes and increased irreversibilities, thereby increasing total exergy destruction. Additionally, exergy efficiency is defined as the ratio of useful exergy output to the total exergy input. It measures how well the system converts available energy into useful work while accounting for the irreversibilities. As the environment temperature increases, the exergy input to the system decreases because the exergy content of the fuel is partially a function of the reference environment temperature. Higher environmental temperatures reduce the exergy efficiency of the fuel.

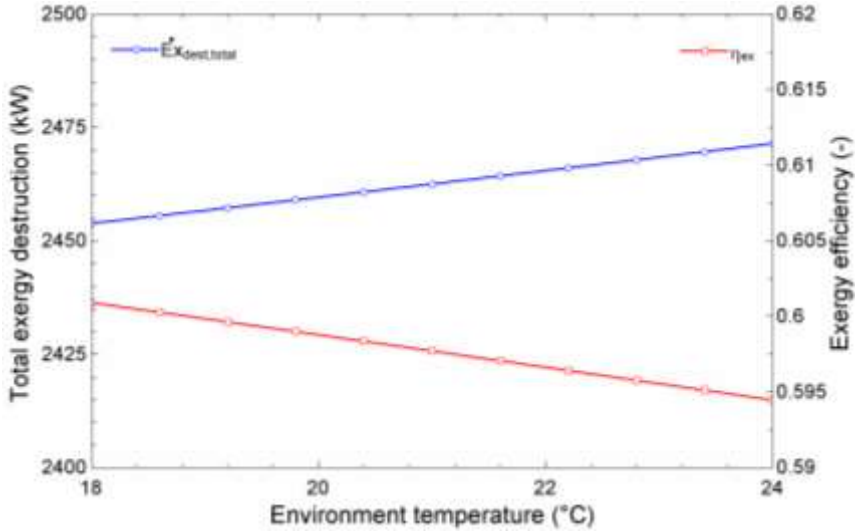

Fig. 9. Variation of total exergy destruction and exergy efficiency with the environment temperature

V. CONCLUSION

The goal of the research is to develop and assess an innovative hybrid energy system that combines a biogas-fired power plant with a Helium Gas Cycle and a Power-Ejector Refrigeration Cycle. The primary objectives are to enhance the overall efficiency of power generation, maximize the utilization of renewable biogas, and effectively recover and utilize waste heat. For this purpose, thermodynamic analyses were carried out using the EES software program. According to the results of the analysis, the system's overall energy efficiency is 48.82%, and the exergy efficiency is 59.86%. The net power produced in the system is 5690 kW, and the net power produced in the biogas cycle is 5185 kW. The net power produced in the helium cycle is 232.9 kW, and the net power produced in the ejector cooling cycle is 299 kW. In addition, the capacity of the ejector cooling cycle is calculated as 154.5 kW. The total exergy destruction in the system is 2459.652 kW, and the exergy destruction in the combustion chamber is 1092.5 kW. The combustion chamber is followed by the biogas compressor with 529.2 kW and the biogas turbine with 345.8 kW. The least exergy destruction is in heat exchanger 4 with 104.9 and heat exchanger 1 with 108 kW. According to the parametric analyses performed in the second stage of the study, as the biogas turbine inlet temperature increases, total net power production, energy efficiency, biogas compressor, and helium compressor net power production increase. Additionally, as the environmental temperature increases, total exergy destruction increases, and exergy efficiency decreases.

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Thermodynamic Assessments of a Novel Hybrid System Based on a Solid Oxide Fuel Cell

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Abstract – This study conducts a thorough thermodynamic assessment of a new integrated energy system comprising a Solid Oxide Fuel Cell (SOFC), a Helium Brayton cycle, and thermoelectric generators (TEGs). The innovative system harnesses the high-efficiency potential of SOFCs, which operate at elevated temperatures to produce electrical power and significant waste heat. This waste heat is subsequently utilized in the Helium Brayton cycle, leveraging helium's favorable thermal properties to generate additional power. Furthermore, residual heat from the Brayton cycle is captured by the TEG, which directly converts thermal energy into electrical energy, thereby maximizing the overall energy output. The integrated system is evaluated through detailed thermodynamic analyses, examining the performance metrics of each component and the hybrid system as a whole. The results show that the net power from the hybrid system is 601 kW, the net power from the Helium Brayton cycle is 178.4 kW, and the net power from the SOFC is 395.5 kW. Additionally, this study conducted parametric studies to understand the impact of various operating conditions on system performance, providing valuable information for optimizing design and operational strategies.

Keywords – Biogas, Helium Gas Cycle, Power-Ejector Refrigeration Cycle, Energy, Exergy.

I. INTRODUCTION

Access to energy resources and the issue of global warming are significant long-term challenges. Despite the finite nature of nonrenewable fossil fuels, global energy demand has consistently increased. As a result, there is a growing pursuit of more efficient and cleaner energy systems. Traditional power plants, which typically use a single prime mover, often have energy efficiencies below 40%, with a large portion of energy lost as waste heat. However, incorporating heating and cooling subsystems into these plants can greatly enhance their efficiency. Trigeneration—producing cooling, heating, and electricity simultaneously from a single energy resource—can boost energy efficiencies by up to 80% [1,2]. Innovative hybrid systems integrating multiple energy conversion technologies are emerging as promising solutions to enhance overall efficiency and sustainability. The primary driver plays a crucial role in an innovative hybrid system, making its selection critical. Primary drivers include steam turbines, gas turbines, internal combustion engines, external combustion engines, fuel cells and micro-turbines. Among these alternatives, hybrid systems that use fuel cells generally attain higher energetic efficiency. This is partly due to the fact that fuel cells are not subject to Carnot efficiency limitations.

SOFC is regarded as a major emerging technology that can directly produce electricity from fuels like methane and oxidants like air. Operating at high temperatures, it produces substantial waste heat, often recovered to enhance overall efficiency by pairing the SOFC with a gas turbine (GT) or a Brayton cycle as a bottoming cycle. One such innovative approach is the integration of SOFC with the Helium Brayton cycle and TEG. The SOFC, an advanced electrochemical device, directly converts chemical energy from fuels

such as methane into electrical energy with high efficiency and minimal environmental impact. Operating at high temperatures, the SOFC generates significant waste heat, which can be effectively utilized to drive additional power cycles. In this novel hybrid system, the waste heat from the SOFC is employed in a Helium Brayton cycle. Helium, with its excellent thermal properties and chemical inertness, serves as an ideal working fluid for the Brayton cycle, enhancing the overall efficiency of the power generation process. Additionally, the residual heat from the Brayton cycle is harnessed by a thermoelectric generator, which directly converts thermal energy into electrical energy, further improving the system's energy conversion efficiency. The combination of these three technologies—SOFC, Helium Brayton cycle, and TEG—offers a synergistic effect, resulting in a highly efficient and environmentally friendly hybrid power generation system. Many studies have explored the performance of SOFC-GT integrated power systems [3-16], integrated SOFC-ORC power systems [17,18], and combined SOFC-Stirling hybrid systems [19]. However, there is a limited availability of analyses focusing on trigeneration power plants that utilize SOFC technology.

In this study, exergetic and energetic analyses of a SOFC-based hybrid system consisting of the Helium Brayton cycle and TEG in a proposed new trigeneration facility were performed using a zero-dimensional approach and assuming steady-state operation. In this new intergrated system, waste heat from the SOFC is used in the Helium Brayton cycle. Helium, with its excellent thermal properties and chemical inertness, serves as a working fluid for the Brayton cycle, improving the efficiency of the energy production process. Additionally, the residual heat from the Brayton cycle is utilized by a thermoelectric generator, which directly converts thermal energy into electrical energy, thereby enhancing the system’s overall energy conversion efficiency. In summary, This study aims to make comprehensive thermodynamic evaluations of this new system and analyze its energy and exergy performance under various operating conditions. Through detailed parametric studies, the research aims to identify optimal design and operational strategies and ultimately contribute to the development of more sustainable and efficient hybrid energy systems for future applications.

II. SYSTEM DESCRIPTION

The new hybrid energy system seen in Fig. 1 combines three advanced technologies: SOFC, Helium Brayton cycle, and TEGs. This hybrid configuration is designed to maximize energy conversion efficiency and minimize environmental impact by effectively utilizing the waste heat generated during the process. At the heart of the system is the SOFC, an electrochemical device that operates at high temperatures. The SOFC directly converts chemical energy from fuels, such as methane, into electrical energy through an electrochemical reaction with an oxidant, usually air. The SOFC’s high operating temperature enables internal fuel reforming and results in high electrical efficiency. Additionally, the SOFC generates substantial waste heat, which can be utilized for further power generation processes. The waste heat generated by the SOFC is harnessed by a Helium Brayton cycle, which serves as the secondary power generation unit. Helium is chosen as the working fluid due to its excellent thermal properties, including high thermal conductivity and low viscosity, as well as its chemical inertness, which ensures safe and efficient operation. In the Brayton cycle, helium is compressed and then heated by the waste heat from the SOFC. The high-temperature, high-pressure helium then expands through a turbine, generating additional electrical power. The use of helium enhances the overall efficiency of the Brayton cycle, making it a suitable choice for high-temperature waste heat recovery. The residual heat from the exhaust of the Helium Brayton cycle is subsequently utilized by a TEG. The TEG directly converts thermal energy into electrical energy based on the Seebeck effect, which occurs when a temperature difference is maintained across thermoelectric materials. The TEG is particularly effective in converting low-grade waste heat into useful electrical power, thus maximizing the total energy output of the system. By capturing and utilizing this residual heat, the TEG further improves the efficiency of the hybrid system. The integration of the SOFC, Helium Brayton cycle and TEG creates a synergistic effect, where each component enhances the performance of the others. The high operating temperature of the SOFC provides a valuable heat source for the Brayton cycle, while the Brayton cycle's exhaust heat is effectively converted into additional electrical

power by the TEG. This cascade utilization of energy not only boosts the overall efficiency but also ensures a more sustainable and environmentally friendly energy production process.

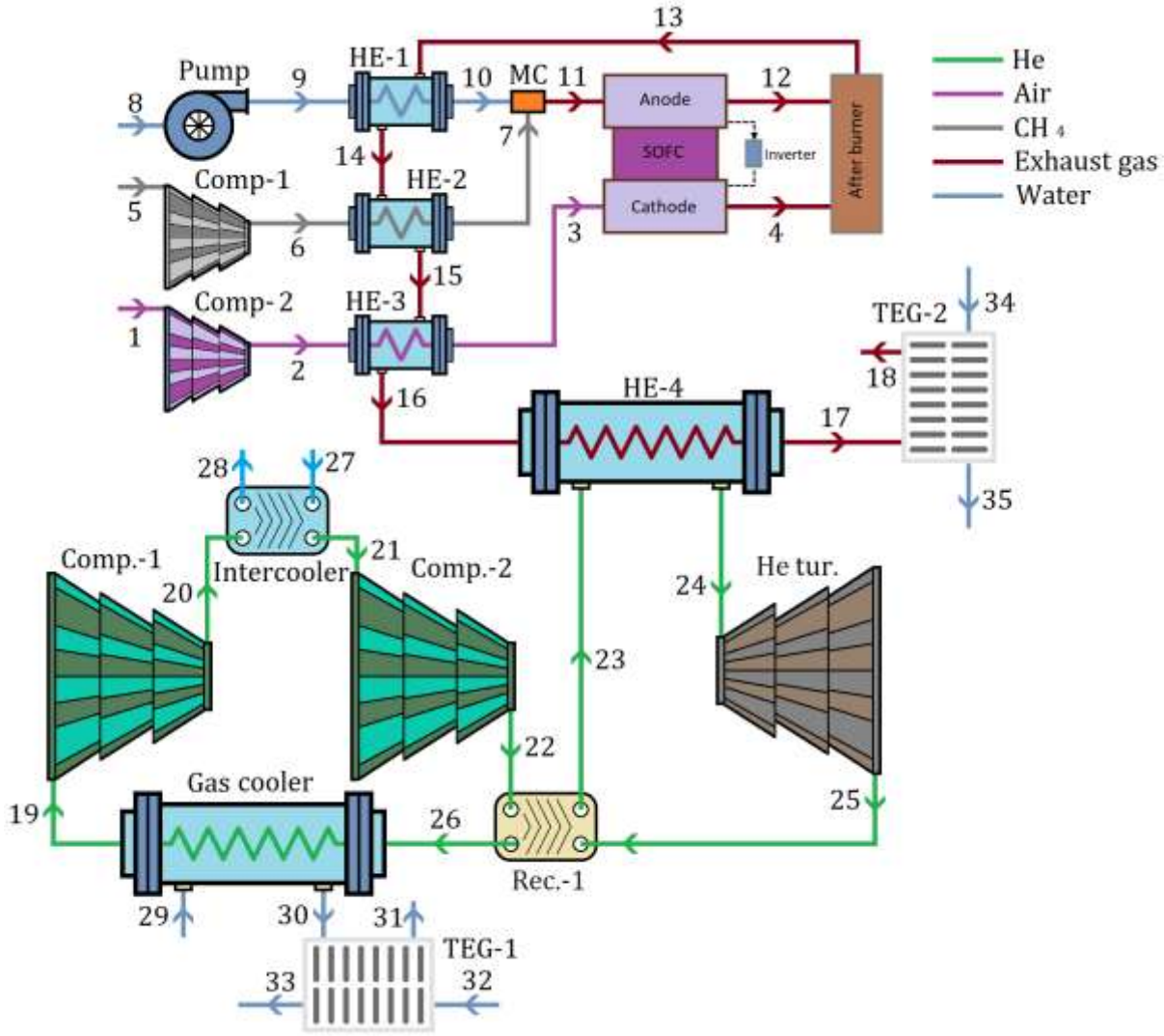

Fig. 1. Schematic representation of hybrid energy system based on SOFC

III. RESULTS

In this study, energetic and exergetic analyses were used to evaluate the hybrid energy system's performance, which consisted of SOFC, Helium Brayton cycle, and TEGs under steady-state conditions. While energy analysis focuses on overall energy conversion efficiency, exergy analysis provides information on the quality and use of energy at various stages of the process. The study aims to determine the optimum design and operational strategies that increase the efficiency and sustainability of the system by examining these parameters. Table 1 shows the initial parameters used in the hybrid system analysis.

Fig. 2 shows the net powers produced in the hybrid system. According to the results of the analysis, the net power obtained from the system is 601 kW. Additionally, as seen in the figure, the net power obtained from the He Brayton cycle is 178.4 kW, the net power obtained from SOFC is 395.8 kW, and the net power obtained from TEG is 26.75 kW. Fig. 3 shows the exergy destruction occurring in the hybrid energy system. According to the analysis results, the total exergy destruction in the system is 403.9 kW. The highest exergy destruction is in heat exchanger 1, with 29% (114.8 kW). The exergy loss in SOFC was determined as 13% (53.68).

Table 1. Design parameters of the hybrid energy system

Reference temperature	22 ℃
Reference pressure	101.325
Baseline inlet temperature for SOFC	850 ℃
Temperature differential between SOFC inlet and outlet	100
Baseline current density	8000 A/m^2
Faraday constant	96485 C/ [g mol])
Gas constant	8.314 kJ/kmolK
Steam-to-carbon ratio	2.5
Fuel utilization factor	0.85
Number of cells	11000
DC-AC inverter efficiency	0.97
Active surface area	0.01 m^2
Afterburner combustion efficiency	0.99
Air compressor isentropic efficiency	0.85
Fuel compressor isentropic efficiency	0.85
Pump isentropic efficiency	0.85
Pressure ratio air compressor	8
Pressure ratio CH_4 compressor	8
Pressure ratio water pump	1.19
Helium Brayton cycle compressor temperature	30 ℃
Helium Brayton cycle high pressure	8000
Helium Brayton cycle high pressure	3500

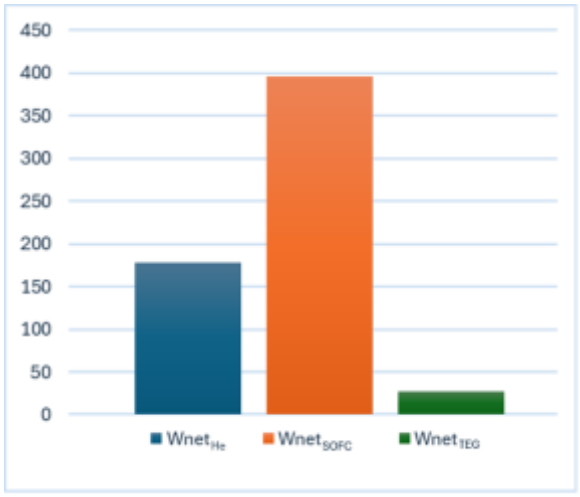

Fig. 2. Net power production from the sub-cycles of the hybrid system

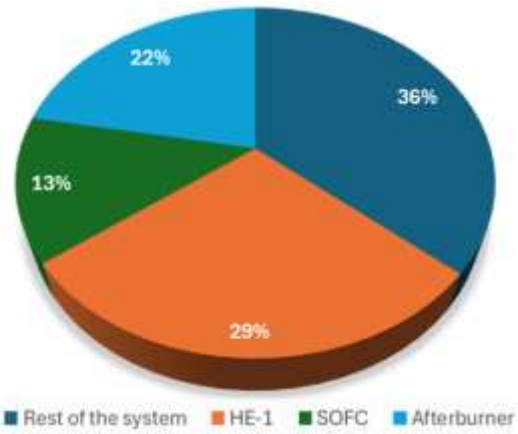

Fig. 3. Exergy destruction rates in the hybrid energy system

Fig. 4 shows the change in total energetic and exergetic efficiency according to the change in current density. As seen in the figure, exergy and energy efficiency decrease when the current density is increased. As current density increases, the rate at which fuel is consumed in the SOFC increases, leading to more efficient fuel utilization. Higher current densities mean more electrochemical reactions are occurring per unit area of the SOFC, producing more electrical power from the same amount of fuel. This efficient use of fuel enhances the overall energy output and reduces fuel wastage, contributing to higher energy efficiency. Exergy efficiency benefits similarly because higher current densities mean a greater portion of the input exergy (fuel exergy) is converted into useful exergy forms (electricity and high-grade heat), minimizing the exergy destroyed in irreversibilities.

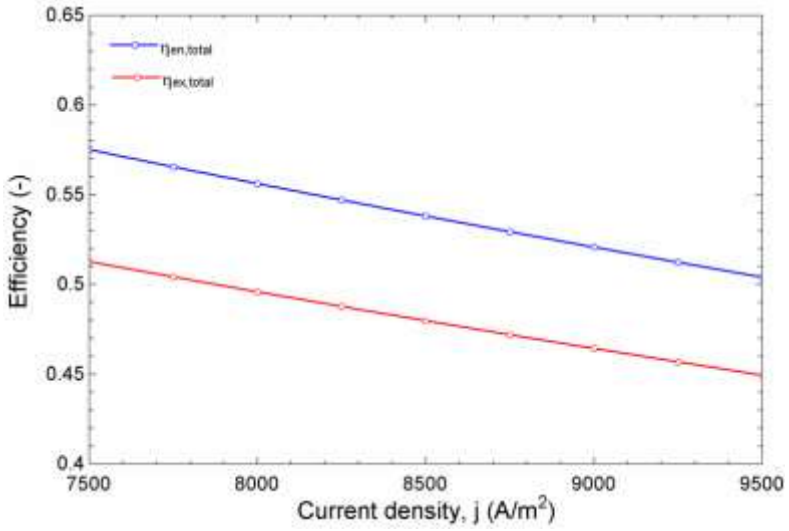

Fig. 4. Variation of energy efficiency with change of current density

Fig. 5 represents the impact of the SOFC inlet temperature on net power generation. As seen in the illustration, as the SOFC inlet temperature increases, the net power and energetic efficiency obtained from the system decreases. At higher inlet temperatures, the fuel utilization efficiency can decrease due to less effective fuel reforming and incomplete electrochemical reactions. This can result in more fuel passing through the cell unreacted, reducing the amount of electrical power generated per unit of fuel. The less efficient fuel usage at higher temperatures means that more input energy is wasted rather than converted into useful electrical power.

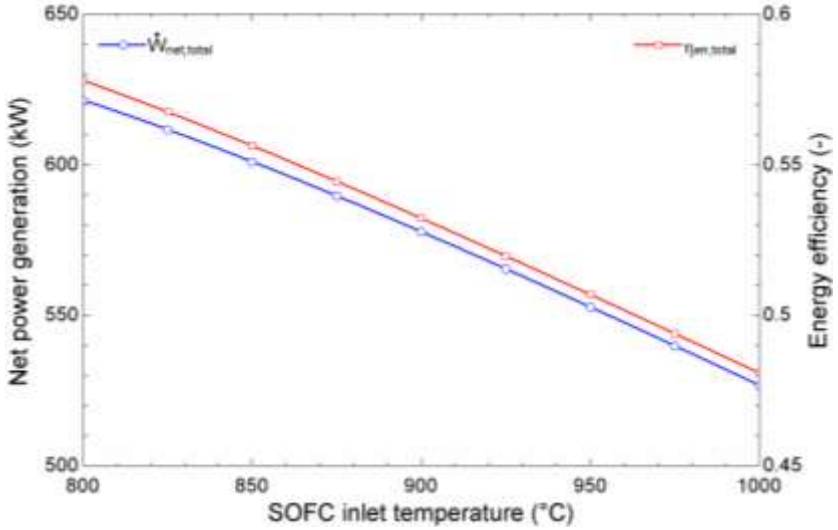

Fig. 5. Variation of net power generation and energy efficiency with the SOFC inlet temperature

Fig. 6 depicts the influence of SOFC inlet temperature on total exergy destruction and exergy efficiency. As shown in the figure, increasing the SOFC inlet temperature leads to a rise in total exergy destruction and a decrease in exergy efficiency. Elevated temperatures exacerbate activation and ohmic losses within the SOFC, increase material degradation, and create inefficiencies in downstream components like the Brayton cycle and TEG due to mismatched temperature profiles. These conditions lead to greater irreversibilities and entropy generation, resulting in higher exergy destruction. Consequently, a larger portion of the input exergy is lost as waste heat rather than being converted into useful work, thereby reducing the overall exergetic efficiency of the integrated energy system.

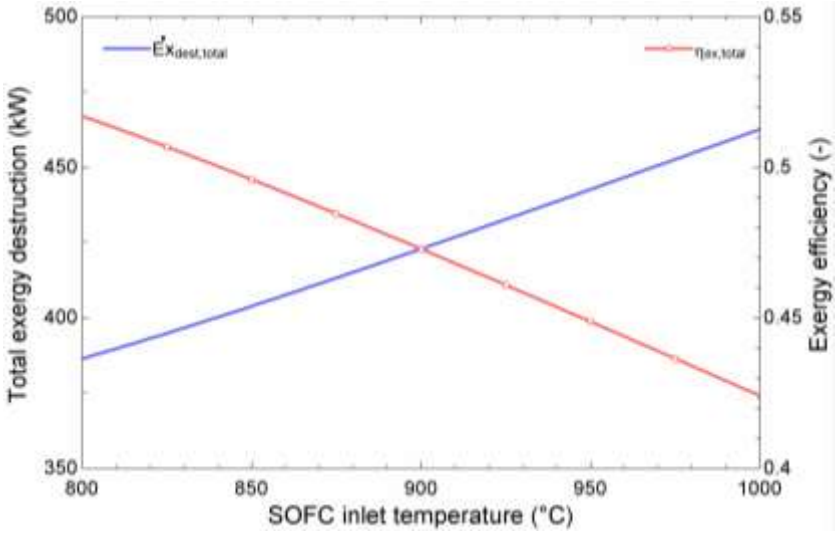

Fig. 6. Variation of total exergy destruction and exergetic efficiency with the SOFC inlet temperature

Fig. 7 shows the impact of SOFC inlet temperature on SOFC net power, Helium Brayton cycle net power and TEG net power. As seen in the figure, as the SOFC inlet temperature increases, the net power of the Helium Brayton cycle and TEG net power increases, and the SOFC net power decreases. An increase in fuel cell inlet temperature leads to higher net power outputs from the Helium Brayton cycle and TEG due to the greater availability of high-quality waste heat, which enhances their operational efficiency. However, the SOFC itself experiences a decrease in net power output as elevated temperatures exacerbate irreversibilities, such as increased activation and ohmic losses, and reduce electrochemical efficiency. Thus, while downstream components benefit from the increased thermal energy, the SOFC's performance declines, highlighting the importance of optimizing the inlet temperature for overall system efficiency.

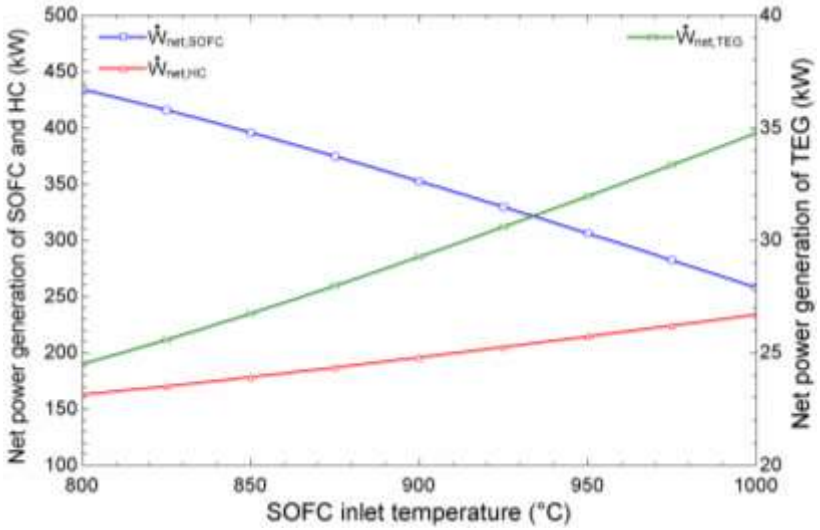

Fig. 7. Variation of net power production of subcycles with the SOFC inlet temperature

Fig. 8 illustrates the impact of the fuel usage factor on net power production and energy efficiency. As seen in the figure, as the fuel usage factor increases, net power production decreases, and energy efficiency increases. As the fuel utilization factor increases, the net power production of the hybrid system decreases due to less available fuel and heat for the Helium Brayton cycle and TEG, as well as increased internal losses within the SOFC. However, the energy efficiency increases because the SOFC more effectively converts the chemical energy of the fuel into electrical energy, resulting in less waste heat and improved overall fuel utilization. This trade-off highlights the balance between maximizing power output and optimizing energy efficiency in hybrid energy systems.

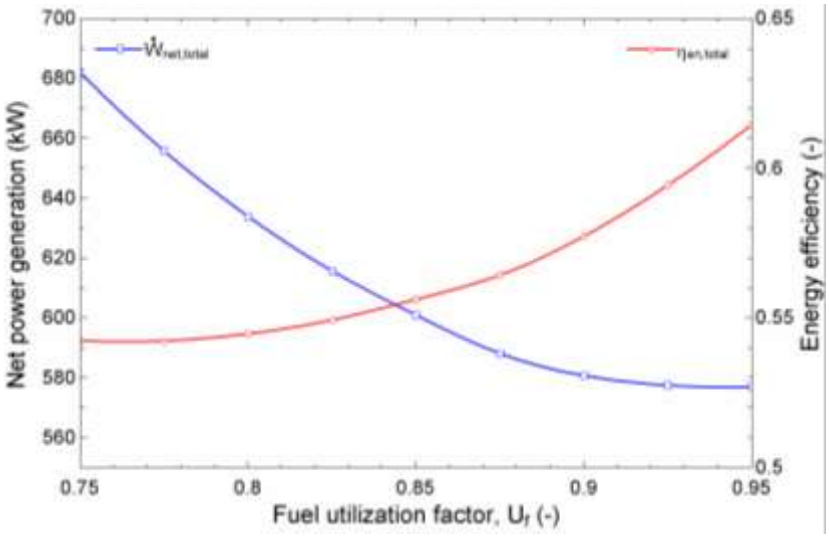

Fig. 8. Variation of net power generation and energy efficiency with the fuel utilization factor

Fig. 9 demonstrates the impact of the fuel usage factor on total exergy destruction and exergy efficiency. As seen in the figure, as the fuel usage factor increases, total exergy destruction decreases, and exergy efficiency increases. As the fuel utilization factor increases, the SOFC becomes more efficient in converting the chemical energy of the fuel into electrical energy, thereby reducing the amount of unreacted fuel and waste heat. This leads to lower exergy destruction within the SOFC and downstream components like the Helium Brayton cycle and TEG, as they handle less waste heat and operate under more optimal conditions. As a result, the exergetic efficiency of the hybrid energy system increases since more of the input exergy is converted into useful work with fewer losses.

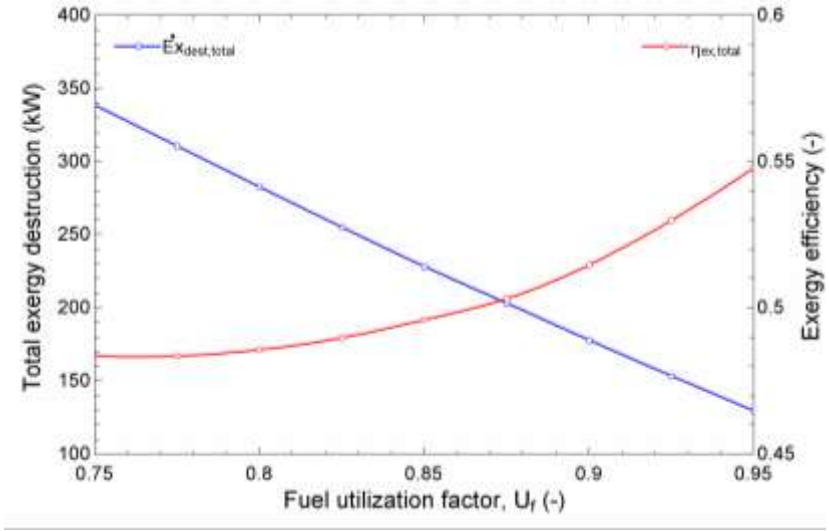

Fig. 9. Variation of total exergy destruction and exergy efficiency with the fuel utilization factor

The effects of the fuel usage factor on SOFC, Helium Brayton cycle, and TEG net power production are seen in Fig. 10. As seen in the figure, as the fuel usage factor increases, SOFC net power production and Helium Brayton cycle net power production decrease. TEG net power production starts to decrease when the value of the fuel usage factor is approximately 0.85. As the fuel usage factor increases in the hybrid system, both the SOFC and Helium Brayton cycle experience a decrease in net power generation. In the SOFC, higher fuel utilization leads to reduced fuel flow rates and increased internal losses, which lower the electrical power output. In the Helium Brayton cycle, less waste heat and lower exhaust temperatures from the SOFC result in reduced thermal energy available for power generation, leading to decreased turbine efficiency and net power output. These factors collectively cause a decline in the net power production of both the fuel cell and the Helium Brayton cycle as the fuel usage factor increases.

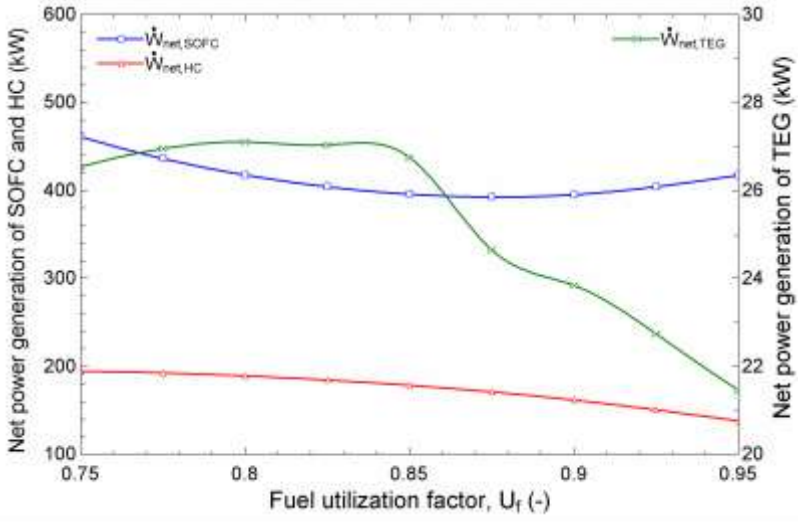

Fig. 10. Variation of net power generation of subcycles with the fuel utilization factor

IV. CONCLUSION

This study presents a comprehensive thermodynamic evaluation of an innovative hybrid energy system integrating a Solid Oxide Fuel Cell (SOFC), a Helium Brayton cycle, and thermoelectric generators (TEG). By harnessing the high-efficiency potential of SOFCs, which operate at elevated temperatures, the system effectively generates electrical power and significant waste heat. This waste heat is then utilized by the Helium Brayton cycle, capitalizing on helium's excellent thermal properties to produce additional power. Subsequently, residual heat from the Brayton cycle is captured by the TEG, converting thermal energy directly into electrical energy, thus maximizing the overall energy output.

Detailed thermodynamic analyses reveal that the integrated energy system achieves a net power output of 601 kW, with the Helium Brayton cycle contributing 178.4 kW and the SOFC contributing 395.5 kW. In addition, the overall energetic efficiency of the system is 55.62%, and the overall exergy efficiency is 49.59%. The parametric studies conducted provide insights into the effect of various operating conditions on system performance, highlighting opportunities for optimizing design and operational strategies. These findings underscore the potential of such hybrid systems in enhancing energy efficiency and power generation. By effectively utilizing waste heat through integrated cycles, the system demonstrates a promising approach for achieving higher overall energy conversion efficiencies, contributing to the development of more sustainable and efficient energy solutions.

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Fuzzification of Hesitant Fuzzy Bézier Surface Approximation Model in Visualizing Uncertain Data by Hesitancy

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Abstract **–** Till now, geometric modeling is still applied widely in various fields including computer graphics, engineering and industries. The application of fuzzy set theory in geometric modelling leads to an advancement in handling uncertain data, in which the concept of membership degree provides a representation for the uncertainty occurred in data collection. On top of that, hesitant fuzzy set was introduced to handle the complex data with uncertainty due to hesitancy in data collection. The application of hesitant fuzzy set in geometric modelling remains a research gap, which will be discussed in this paper. The paper defines a new construction model, namely hesitant fuzzy Bézier surface (HFBS) approximation model with its properties. With a comprehensive literature review on the history and background of study, the study defines definition such as hesitant fuzzy point relation (HFPR) and hesitant fuzzy control net relation (HFCNR), which are the foundation to construct the HFBS approximation model. An example visualization of the model was presented based on a dataset, while a fuzzification method is proposed to manipulate the data. Through this exploration, the paper aims to contribute to the development of fuzzy geometric modelling, which specifically handling hesitancy in data collection.

Keywords – hesitant fuzzy set, Bézier surface, uncertainty, fuzzification, geometric

I. INTRODUCTION

The concept of geometric modeling was introduced by Pierre Bézier in the 1960s, which proposes to represent complex shapes or surfaces through parametrization [1]. Till now, geometric modeling finds applications in engineering, computer graphics, and data visualization [2]. Beyond the introduction of curve modelling, geometric modeling is extended to represent 3D objects with surfaces. Models such as B-spline surfaces and NURBS, which applied the fundamental concepts of Bézier are popularly applied in engineering and computer graphics. These methods enable the creation and analysis of complex structures in fields like CAD, computer graphics, and data visualization [3].

The concept of fuzzy set theory was proposed by Lotfi A. Zadeh in 1965 to provide a framework for handling imprecise information, which is common in real-world situations [4]. He proposed the concept of membership degrees to address the uncertainty flexibly, which are widely applied in various fields such as control systems, pattern recognition and optimization. Afterwards, type-2 fuzzy sets was introduced, which is an extended version of ordinary fuzzy set, which provides a way to determine more uncertainty rather than just a single number. Apart from that, Krassimir Atanassov has introduced the notion of non-membership degree which rely on the membership degree and uncertainty [5]. The extensions such as interval-valued fuzzy sets, linguistic fuzzy sets, and picture fuzzy sets, offer different concepts for modeling and reasoning with uncertainty [6][7][8]. On top of that, hesitant fuzzy sets was proposed by Torra and Narukawa in early 2000s, which introduced the concept of multiple membership degree assigned to an element [9]. With this representation, hesitant fuzzy sets become a solution to represent and solve uncertainty due to hesitancy while making decision.

In geometric modeling, particularly Bézier and B-spline model, the most important consideration is the data of control net vertices, which plays the role to control the shape of curve or surface generated. In fact, any slight change in position of any control net vertices will affect the shape of output. Nevertheless, the difficulty in data collection will be increased if uncertainty occurs. The integration of fuzzy set theory with geometric modelling has been done to overcome the uncertain data. In 1995, Anile et al. implemented fuzzy arithmetic to handle imprecise data, which showcase an application in environmental impact analysis to demonstrate practical scenarios of fuzzy arithmetic [10]. Afterwards, numerous studies were conducted to apply different fuzzy set theory in geometric modeling. In 2014, Zakaria and Wahab introduced Fuzzy B-spline surface modelling for visualizing uncertain data [11]. With the inspirations, numerous fuzzy Bézier and fuzzy B-spline surface were introduced, which includes type-2 fuzzy surface modeling, intuitionistic fuzzy surface modeling, neutrosophic surface modeling and so on [12][13][14]. Despite these constructed models, a research gap has remained to address the hesitancy in data collection. Suppose two experts are collecting data for a surface visualization, and they have different opinions on certain data points. Since they cannot persuade each other, hesitancy occurs. The application of hesitant fuzzy set in geometric modeling provides a methodology to address that hesitancy through multiple membership degree assigned to those particular points.

This study aims to develop a novel model, namely hesitant fuzzy Bézier surface (HFBS) approximation model. By exploring the background and history of geometric modeling and hesitant fuzzy sets, the study will define necessary definitions including hesitant fuzzy point relation (HFPR) and hesitant fuzzy control net relation (HFCNR). After that, the HFBS approximation model along with its properties will be constructed and introduced based on the definition proposed. A fuzzification method is introduced to modify the data collected based on multiple membership degrees assigned and the output of an example HFBS approximation model is visualized as well. The final section will summarize the key insights presented in the paper.

II. PRELIMINARIES

This section will present fundamental definitions such as hesitant fuzzy set (HFS), hesitant fuzzy point (HFP), and hesitant fuzzy relation (HFR). Additionally, both HFPR and HFCPR will be defined. HFS was introduced by Torra in 2010 to address hesitancy or ambiguity by different membership degrees, which is common occurred in real-life application [9]. Rather than assigning a solitary membership degree to each element, HFS facilitates the representation of multiple membership degrees by different entities for each specific element.

Definition 1. [9, 15, 16] Let X be a fixed set. A hesitant fuzzy set (HFS) on X is in terms of a function applying to "X" and returns a subset of [0,1]. Mathematically, a HFS can be described as follows:

$$A = \{\langle x, h_A(x)\rangle | x \in X\}$$

where $h_A(x)$ is a set of some values in [0,1], denotes the possible membership degrees of the element $x \in X$ to the set A. In that the case, $h = h_A(x)$ is called as a hesitant fuzzy element (HFE), while Θ represents the set of all HFEs.

As the HFEs can consist of more than one membership degrees, some special HFEs for $x \in X$ are given as follows [9]:

1. Empty set: $h = \{0\}$, denoted as O^* as simplification.
2. Full set: $h = \{1\}$, denoted as I^*.
3. Complete ignorance (all are possible), $h = [0,1] \triangleq U^*$.
4. Nonsense set: $h = \emptyset^*$.

Definition 2. [17] Let $Y \subseteq X$ and $A = \{\langle x, h_A(x)\rangle | x \in X\}$ such that $h_A(x) \subseteq [0,1]$.Then, $A_Y \in HF(X)$ is defined as follows:

$$A_Y(x) = \begin{cases} A, & for\ x \in Y \\ \{0\}, & for\ x \in X \backslash Y \end{cases}$$

If Y is a singleton, namely $\{y\}$, then $A_{\{y\}}$ is called as a hesitant fuzzy point (HFP) or hesitant fuzzy singleton, which denoted by y_A.

Definition 3. [18, 19] Suppose X and Y are universal sets. A hesitant fuzzy subset $\mathcal{R}$ of $X \times Y$ is defined as a hesitant fuzzy relation (HFR) from X to Y, that is,

$$\mathcal{R} = \{\langle (x, y), h_{\mathcal{R}}(x, y)\rangle | (x, y) \in X \times Y\}$$

For all $(x, y) \in X \times Y$, $h_{\mathcal{R}}(x, y)$ is a set of values in [0,1], which are the possible membership degrees or the relations for respective x and y.

A. Hesitant Fuzzy Point Relation

Definition 3 defined the HFR from X to Y, where X and Y are universal sets, while *Definition 2* describes the HFP. With these inspirations, the hesitant fuzzy point relation (HFPR) is defined to describe the relation between two HFPs.

Definition 4. Suppose X and Y are universal sets. Let $P \subseteq X$, $Q \subseteq Y$, $A = \{\langle x, h_A(x)\rangle | x \in X\}$ and $B = \{\langle y, h_B(x)\rangle | y \in Y\}$. Then by Definition 1, $h_A(x)$ and $h_B(x)$ are two sets of some possible values in [0,1]. Let P and Q are two HFPs, then by Definition 2, $A_{P=\{p\}} = \{\langle x, h_A(x)\rangle | x \in P\}$ and $B_{Q=\{q\}} = \{\langle y, h_B(x)\rangle | y \in Q\}$, where $\{p\}$ and $\{q\}$ are two singletons for sets P and Q respectively. A hesitant fuzzy subset $\mathcal{R}^*$ of $P \times Q$ is defined as a hesitant fuzzy point relation (HFPR) from X to Y, as follows:

$$\mathcal{R}^* = \{\langle (x_i, y_j), h_{R^*}(x_i, y_j)\rangle | x_i \in P_i, y_j \in Q_j, (x_i, y_j) \in P_i \times Q_j\}$$

For all $(x_i, y_j) \in P \times Q$, $h_{\mathcal{R}^*}(x_i, y_j) \in h_A(x_i) \times h_B(y_j)$ are the set of values in [0,1], which denotes the possible membership degrees of the HFPR for x_i and y_j.

B. Hesitant Fuzzy Control Net Relation

Control net (CN) plays an important role in the surface approximation model. CN are a set of points, which can affect the shape of a surface. Any slight change in the position of the CN will cause different approximation of geometry. It is necessary to define hesitant fuzzy control net (HFCN) and hesitant fuzzy control net relation (HFCNR) as well, which will be applied in the model construction.

Definition 6. Suppose P represents the control net vertices of a Bézier surface such that

$$P = \{P_{i,j}\}_{i \in I, j \in J}$$

where $I = \{0,1,2, \dots, n\}$, $J = \{0,1,2, \dots, m\}$ and P is a set of $(n+1)(m+1)$ points denoting the coordinates of each control net vertices. Let $\mathcal{R}^*$ be a HFPR, then the hesitant fuzzy control net relation (HFCNR) is defined as a relation of $(n+1)(m+1)$ points with different number of choices as follows:

$$\mathcal{R}^*_{cp} = \left\{\langle \left(\mathcal{P}^{\mathcal{H}}_{i,j,q_{ij}}\right), h_{R^*}\left(\mathcal{P}^{\mathcal{H}}_{i,j,q_{ij}}\right)\rangle | \mathcal{P}^{\mathcal{H}}_{i,j,q_{ij}} \in \mathcal{P}^{\mathcal{H}}_{i,j,S_{ij}}, \left(\mathcal{P}^{\mathcal{H}}_{0,0,q_{00}}, \dots, \mathcal{P}^{\mathcal{H}}_{0,m,q_{0m}}, \dots, \mathcal{P}^{\mathcal{H}}_{n,m,q_{nm}}\right) \in \mathcal{P}^{\mathcal{H}}_{0,0,S_{00}} \times \dots \times \mathcal{P}^{\mathcal{H}}_{0,m,S_{0m}} \times \dots \mathcal{P}^{\mathcal{H}}_{n,m,S_{nm}}\right\}$$

where $q_{ij} \in S_{ij}$, $S_{ij} = \{0,1,2, \dots, s_{ij}\}$ and $\mathcal{P}^{\mathcal{H}}_{i,j,M_i}$ are the hesitant fuzzy control net vertices (HFCNVs) at (i, j)-th term. Noted that $q_{ij} = q_{kl}$ for $(i, j) \neq (k, l)$ is possible but not compulsory. For each $\mathcal{P}^{\mathcal{H}}_{i,j,S_{ij}}$, there are q_i number of possible memberships, therefore, the relation returns in a set of possible HFCNVs. The HFCNV at (i, j)-th term are defined as follows:

$$\begin{aligned}
&\mathcal{P}^{\mathcal{H}}_{0,0,q_{00} \in S_{00}} = \{\mathcal{P}^{\mathcal{H}}_{0,0,0}, \mathcal{P}^{\mathcal{H}}_{0,0,1}, \dots, \mathcal{P}^{\mathcal{H}}_{0,0,s_{00}}\} \\
&\vdots \\
&\mathcal{P}^{\mathcal{H}}_{0,m,q_{0m} \in S_{0m}} = \{\mathcal{P}^{\mathcal{H}}_{0,m,0}, \mathcal{P}^{\mathcal{H}}_{0,m,1}, \dots, \mathcal{P}^{\mathcal{H}}_{0,m,s_{0m}}\} \\
&\vdots \\
&\mathcal{P}^{\mathcal{H}}_{n,m,q_{nm} \in S_{nm}} = \{\mathcal{P}^{\mathcal{H}}_{n,m,0}, \mathcal{P}^{\mathcal{H}}_{n,m,1}, \dots, \mathcal{P}^{\mathcal{H}}_{n,m,s_{nm}}\}
\end{aligned}$$

In this case, HFCNVs is a set of $(n+1)(m+1)$ control net vertices, where each control points has s_i possibilities based on different hesitant fuzzy membership degrees assigned. Therefore, there are a variety number of possible HFCNRs, that is, a variety number of possible HFCNVs produced. The total number of HFCNRs, namely $N_{\mathcal{R}^*_{cnv}}$ is denoted by equation below:

$$N_{\mathcal{R}^*_{cnv}} = \prod_{i=0,j=0}^{n,m} s_{i,j}$$

The HFCP can be redefined as

$$\mathcal{P}_k^{\mathcal{H}} = \left\{ \{\mathcal{P}^{\mathcal{H}}_{0,0,q_{00}}, \dots, \mathcal{P}^{\mathcal{H}}_{0,m,q_{0m}}, \dots, \mathcal{P}^{\mathcal{H}}_{n,m,q_{nm}}\} | q_{ij} \in S_{ij}, S_{ij} = \{0,1,2, \dots, s_{ij}\}, \mathcal{P}^{\mathcal{H}}_{i,j,q_{ij}} \in \mathcal{P}^{\mathcal{H}}_{i,j,S_{ij}} \right\}$$

for $N_{\mathcal{R}^*_{cnv}}$ possibilities, where $k = 1,2,, \dots N_{\mathcal{R}^*_{nv}}$. Therefore, the set of all HFCNs is described as follows:

$$\boldsymbol{\mathcal{P}^{\mathcal{H}}} = \{\mathcal{P}_k^{\mathcal{H}} | k = 1,2, \dots, N_{\mathcal{R}^*_{cnv}}\}$$

III. Hesitant Fuzzy Bézier Surface Approximation Model

A Bézier surface approximation model constructs its output with Bernstein basis [3]. As the HFCNR successfully defined, a hesitant fuzzy Bézier Surface (HFBS) approximation model is proposed and constructed, which applies the Bézier surface approximation model with the HFS from *Definition 2*.

Definition 6: Let $\boldsymbol{\mathcal{P}^{\mathcal{H}}} = \{\mathcal{P}_k^{\mathcal{H}} | k = 1,2, \dots, N_{\mathcal{R}^*_{cnv}}\}$ be the set of all HFCNs such that $\mathcal{P}_k^{\mathcal{H}} = \left\{ \{\mathcal{P}^{\mathcal{H}}_{0,0,q_{00}}, \dots, \mathcal{P}^{\mathcal{H}}_{0,m,q_{0m}}, \dots, \mathcal{P}^{\mathcal{H}}_{n,m,q_{nm}}\} | q_{ij} \in S_{ij}, S_{ij} = \{0,1, \dots, s_{ij}\}, \mathcal{P}^{\mathcal{H}}_{i,j,q_{ij}} \in \mathcal{P}^{\mathcal{H}}_{i,j,S_{ij}} \right\}$ is the possible HFCNs. Let $BS(u,w)$ as the surface position vector of a Bézier surface. A HFBS approximation model, namely $\boldsymbol{BS^{\mathcal{H}}}(u,v)$ is defined as follows:

$$\boldsymbol{BS^{\mathcal{H}}}(u,w) = \sum_{i=0}^{n} \sum_{j=0}^{m} N_{n,i}(u) \cdot \boldsymbol{\mathcal{P}^{\mathcal{H}}} \cdot M_{m,j}(w), 0 \le u \le 1, o \le w \le 1$$

where u and v are the parameters and the Bernstein basis, $N_{n,i}(u)$ and $M_{m,j}(w)$ are

$$N_{n,i}(u) = \binom{n}{i} u^i (1-u)^{n-i} \; with \; \binom{n}{i} = \frac{n!}{i!\,(n-i)!}$$

$$M_{m,j}(w) = \binom{m}{j} w^j (1-w)^{m-j} \; with \; \binom{m}{j} = \frac{m!}{j!\,(m-j)!}$$

Restrictions such as $(0)^0 \equiv 1$ and $0! \equiv 1$ are considered in this model. Since there are $N_{\mathcal{R}^*_{cn}}$ number of possible HFCNs, therefore, there are the same number of possible HFBSs equation as well. In other words, a $\boldsymbol{BS^{\mathcal{H}}}(u,v)$ is the set of all possible HFBSs, $BC_k^{\mathcal{H}}(t)$ such that

$$\boldsymbol{BS^{\mathcal{H}}}(u,w) = \left\{ BS_k^{\mathcal{H}}(u,w) = \sum_{i=0}^{n} \sum_{j=0}^{m} N_{n,i}(u) \cdot \mathcal{P}_k^{\mathcal{H}} \cdot M_{m,j}(w) \, | k = 1,2,3, \dots, N_{\mathcal{R}^*_{cn}} \right\}$$

A. *Properties of Hesitant Fuzzy Bézier Surface*

A Bézier surface is generated based on its control net, which is formed by control net vertices. As the Bézier basis follows the Bernstein basis, Bézier surfaces will have the same properties [35]. That is, HFBS has the properties as follows:

- The basis functions of HFBS are real.
- The degree of the HFBS in both parametric directions is one less than the number of HFCNVs in that particular direction.
- The continuity of the HFBS in both parametric directions is two less than he number of HFCNVs in that particular direction.
- The shape of HFBS will always follow the shape of HFCN.
- The corner points of HFCNs are the only points which coincide with the resulting HFBS.
- HFBS generated will always be bounded by its respective HFCN.
- HFBS does not exhibit variation-diminishing property, which is both undefined and unknown for bivariant surfaces.
- Under an affine transformation, HFBS is invariant.

IV. Data Fuzzification and Surface Visualization

Bézier surface approximation model is widely used in generating complex surface. One of the applications is visualizing the surface of lakebed using bathymetric data. In this chapter, one numerical example will be discussed and visualized using the HFBS approximation model. Suppose the (x, y)-coordinates represents the position of control net vertices in x and y directions respectively and remain crisp. Using *Microsoft Excel*, the z-coordinates of each control net vertex are generated using random number function. Two experts provide their opinions on each point based on membership degrees. Suppose h represents the membership degree, the fuzzification of data is described as Table 1 below.

Table 1. Fuzzification of Data

Membership Degree, h	**If $h < 0.5$**	**If $h = 0.5$**	**If $h > 0.5$**
z-coordinate, z	$z = z - [z \times (0.5 - h)]$	$z = z$	$z = z + [z \times (h - 0.5)]$

For certain vertices, both experts provide different opinions and cannot persuade each other. Hesitancy occurred. In this case, HFBS approximation model is used to visualize the hesitancy of the data. Table 2 shows the data along with the membership degrees assigned respectively, while Table 3 shows the fuzzified data for visualization.

Table 2. Coordinate of control net vertices with membership degrees.

(x, y)	z	h_1	h_2	(x, y)	z	h_1	h_2
(0,0)	402.907	0.5	-	(2,0)	802.601	0.38	0.78
(0,1)	246.038	0.5	-	(2,1)	483.830	0.74	-
(0,2)	586.092	0.5	-	(2,2)	500.617	0.55	-
(0,3)	318.279	0.5	-	(2,3)	303.885	0.75	-
(1,0)	832.274	0.97	0.19	(3,0)	574.288	0.5	-
(1,1)	343.809	0.43	-	(3,1)	416.010	0.5	-
(1,2)	337.307	0.31	-	(3,2)	581.577	0.5	-
(1,3)	219.833	0.67	-	(3,3)	340.757	0.5	-

Table 3. Fuzzified control net vertices.

(x, y)	z_{h_1}	z_{h_2}	(x, y)	z_{h_1}	z_{h_2}
(0,0)	402.9073	-	(2,0)	706.2888	1027.329
(0,1)	246.0382	-	(2,1)	599.9482	-
(0,2)	586.0921	-	(2,2)	525.6479	-
(0,3)	318.2793	-	(2,3)	379.8561	-
(1,0)	1223.442	404.4036	(3,0)	574.2879	-
(1,1)	319.742	-	(3,1)	416.0096	-
(1,2)	273.2187	-	(3,2)	581.5774	-
(1,3)	257.2045	-	(3,3)	340.7569	-

Using HFBS approximation model, there are 4 different HFBSs visualized based on the fuzzified control net vertices.

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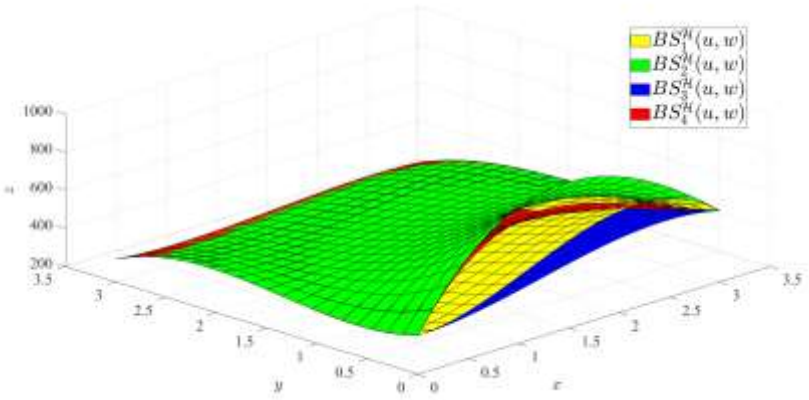

Fig. 1 HFBSs, $BS_k^{\mathcal{H}}(u,w)$, $k = 1,2,3,4$.

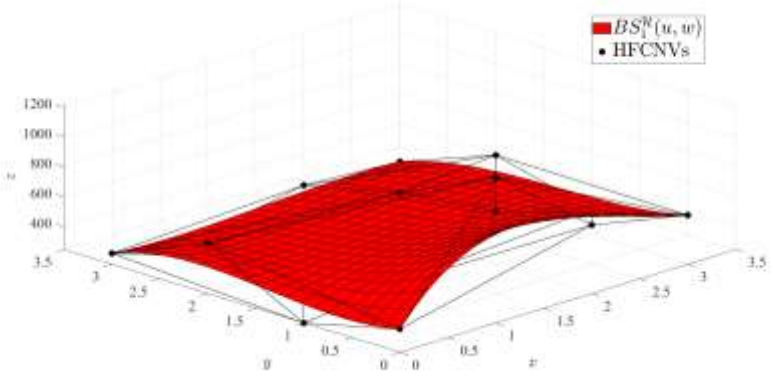

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Fig. 2 HFBS, $BS_1^{\mathcal{H}}(u,w)$.

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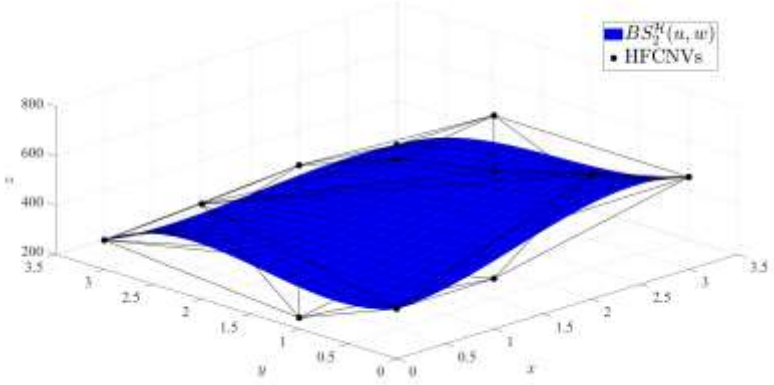

Fig. 3 HFBS, $BS_2^{\mathcal{H}}(u,w)$.

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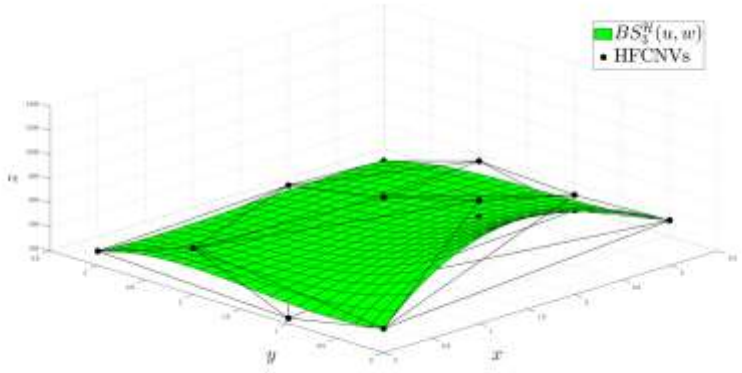

Fig. 4 HFBS, $BS_3^{\mathcal{H}}(u,w)$.

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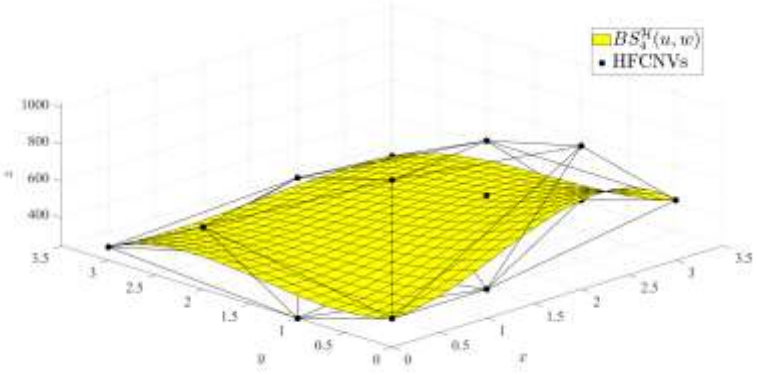

Fig. 5 HFBS, $BS_4^{\mathcal{H}}(u,w)$.

V. DISCUSSION

Through Section IV, the visualization of uncertain data due to hesitancy has been successfully done through HFBS approximation model. Figure 1 shows all the HFBSs on a same space, which visualize the uncertainty of data due to hesitancy. Figure 2 to Figure 5 shows separates HFBSs, which clearly presents the surfaces with respective HFCNVs and HFCNs. Via observation, it is obvious that every HFBSs visualized from the fuzzified data performs the properties as a hesitant fuzzy Bézier surface. It can be noticed that every HFBS generated are bounded by its respective HFCN. The degree of every HFBS in both parametric directions (3) is one less than the number of HFCNVs (4) in that particular direction. Apart from that, the shape of each HFBS follows the shape of its respective HFCN. The corner points of HFBNs are the only points which coincide with the HFBS. On top of that, the HFBSs visualized are bounded by the respective largest convex hull of HFCNs.

VI. CONCLUSION

To conclude, the study proposes a novel model, namely hesitant fuzzy Bézier surface (HFBS) approximation model in addressing uncertainty due to hesitancy. Some fundamental concepts are introduced, and new definitions are defined. A simple fuzzification method and numerical visualization example are shown in the paper to present the behaviour of the output by HFBS approximation model. Nevertheless, the HFBS model can only provide multiple output, which cannot lead to a final solution. Regarding this, a justification method is exactly necessary, which to justify the suitable membership degree in producing crisp result or conclusion. From the aspect real-life scenarios, the information of control net vertices, particularly HFCNVs in this paper are difficult to be obtained through data collection. Therefore, an interpolation model is necessary, which applied the data points rather than control net vertices as input.

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B2 Yapılı BaCd İntermetalik Bileşiğinin Yapısal, Elastik, Elektronik, Titreşimsel ve Optiksel Özellikleri

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Özet – BaCd intermetalik bileşiği, B2 yapısında (CsCl tipi) incelendiğinde birçok ilginç fiziksel ve kimyasal özellik sergiler. Bu yapıdaki BaCd bileşiğinin örgü sabiti hesaplanmış ve litertürdeki verilerle uyumlu olduğu görülmüştür. BaCd bileşiğinin elastik sabitleri (C_{11}, C_{12}, C_{44}) hesaplanmıştır. Bu sabitler, malzemenin mekanik stabilitesi ve rijitliği hakkında bilgi verir. Elde edilen sonuçlara göre BaCd bileşiği mekaniksel olarak kararlıdır. B2 yapısında BaCd intermetalik bileşiği, yapısal, elastik, elektronik, titreşimsel ve optiksel özellikleri açısından Yoğunluk Fonksiyoneli Teorisi kullanılarak kapsamlı bir şekilde incelenmiştir. Elde edilen sonuçlara göre BaCd bileşiği dinamiksel olarak kararlıdır. Bu özellikler, malzemenin potansiyel uygulamaları ve performansı hakkında önemli bilgiler sunar. Özellikle optoelektronik ve mekanik uygulamalar için uygunluk değerlendirmelerinde bu tür kapsamlı analizler kritiktir.

Anahtar Kelimeler – BaCd, DFT, elastic, optic, electronic

I. GİRİŞ

B2 yapılı intermetalik bileşikler, genellikle yüksek sıcaklıklarda kararlı yapıları ve üstün mekanik özellikleri nedeniyle araştırılmaktadır. B2 yapısı, basit kübik bir kristal yapısına sahip olup, iki farklı metal atomunun birbirine periyodik olarak dizilmesiyle oluşur. Bu yapı, mekanik özellikler açısından önemli avantajlar sunar[1]. B2 yapılı bileşiklerin mekanik özellikleri, atomların düzenli bir şekilde dizilmesi ve bu yapının yüksek bağ enerjilerine sahip olması nedeniyle dikkate değerdir. Özellikle, yüksek sıcaklıklarda mükemmel bir stabilite sergilerler ve bu nedenle genellikle yüksek sıcaklık uygulamaları için tercih edilirler. Ayrıca, bu yapıların difüzyon özellikleri de önemlidir. B2 yapılı bileşiklerde difüzyon, genellikle boşluk mekanizmasıyla gerçekleşir ve bu mekanizma, yapının yüksek sıcaklıklarda bile düzenli kalmasını sağlar [2].

B2 yapısındaki bileşiklerin bir diğer önemli özelliği ise elektronik yapı ve optik özellikleridir. Bu bileşikler, genellikle yarı iletken özellikler gösterir ve elektronik geçişler için uygun enerji seviyelerine sahiptirler. Optik özellikler açısından ise, bu bileşikler yüksek kırılma indisi değerlerine sahip olabilir ve bu da onları optoelektronik uygulamalar için uygun hale getirir[3]

BaCd intermetalik bileşikleri, yüksek sıcaklıklarda kararlı yapıları ve üstün mekanik özellikleri nedeniyle araştırmalarda önemli bir yer tutmaktadır. BaCd bileşikleri, genellikle CsCl tipi B2 yapısında kristalleşirler. Bu yapı, yüksek sıcaklık stabilitesi ve mekanik dayanıklılık sunar.

Bu bağlamda, bu çalışmada B2 yapılı BaCd intermetalik bileşiğinin yapısal, elastik, elektronik, titreşimsel ve optik özellikleri detaylı bir şekilde incelenmektedir.

II. MATERYAL VE YÖNTEM

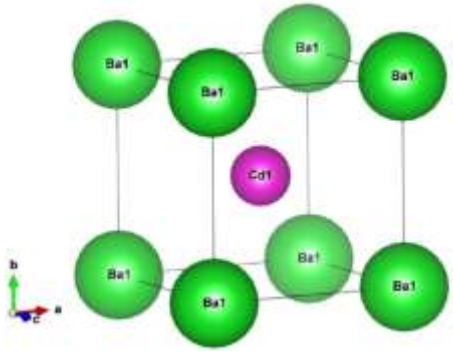
Tüm hesaplamalar, Vienna Ab-initio Simulation Package (VASP)[4] kullanılarak gerçekleştirilmiştir. Düzlem dalga pseudopotansiyel yöntemi ile, BaCd 'nin B2 kristal yapısında yapısal, elektronik, elastik,

optik ve titreşimsel özellikleri Yoğunluk Fonksiyonel Teorisi (DFT) kullanılarak incelenmiştir. Elektron-elektron etkileşimleri, Generalized Gradient Approximation (GGA) içindeki PBE fonksiyonu[5] ile değerlendirilmiştir. İyon-elektron etkileşimi Projector-Augmented-Wave (PAW) yöntemiyle analiz edilmiştir. Düzlem dalga tabanı için 700 eV kinetik enerji kesme değeri kullanılmıştır. BaCd'nin B2 yapısındaki Brillouin bölgesi, 18x18x18 Monkhorst-Pack k-noktası örnekleme yöntemi ile sayısal olarak entegre edilmiştir. Lattice yapısı, atom başına 10^{-8} eV'un altında toplam enerji yakınsaması göstermiştir, bu da olağanüstü bir kararlılığı göstermektedir. Elastik sabitler, zor-zorlanma yöntemi ile belirlenmiştir. Titreşimsel özellikleri analiz etmek için fonon dispersiyon eğrileri ve frekansları PHONOPY kodu[6] kullanılarak hesaplanmıştır.

III. BULGULAR VE TARTIŞMA

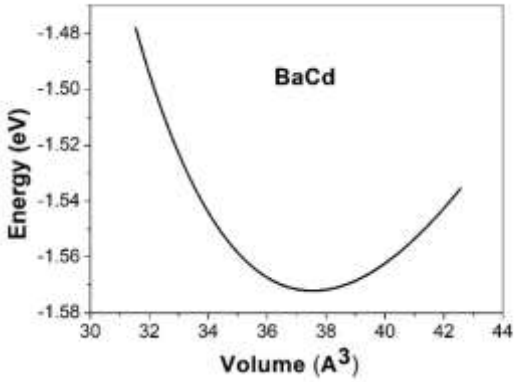
A. *Yapısal ve Elastik Özellikler*

Şekil 1, BaCd'nin birim hücresinin kristal yapısının, uzay grubu (221) (Pm3m) olarak tanımlanan B2 fazı CsCl yapısına uyduğunu göstermektedir. Atom pozisyonları, Ba atomları için (0, 0, 0) ve Cd atomları için (0.5, 0.5, 0.5) olarak şeklindedir.



Şekil.1 BaCd' nin birim hücresi

BaCd nin örgü sabitlerinin yapısal optimizasyonu, birim hücre geometrisi optimizasyonu ile tam gevşemeler kullanılarak gerçekleştirilmiştir. Murnaghan'ın durum denklemi [7]kullanılarak teorik temel durum enerjisi E(V) (bkz. Şekil 2), bulk modülü ve birinci türevini ve termodinamik özellikleri belirlemek için kullanılmıştır. Toplam enerji, tüm fiziksel özelliklerle bağlantılıdır. Elde edilen örgü sabiti, bulk modülü, bulk modülün basınç türevi ve toplam enerji değerleri Tablo 1. de verilmiştir.



Şekil.2 Enerji-hacim grafiği

Tablo 1. Yapısal parametreler

	$a_{0)}$ (Å)	V_0 (Å^3)	B (GPa)	B'	E_{tot}(eV/atom)
BaCdBu çalışma	4.269	75.095	22.14	4.75	-1.57
BaCd	4.215				

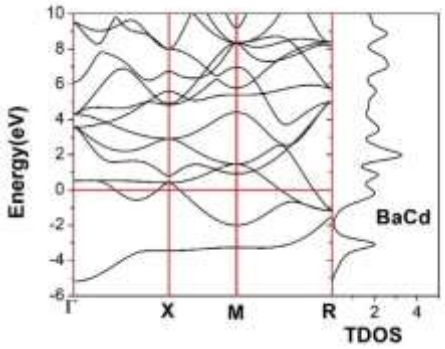
Kristalin dış kuvvetlere tepkisi, malzemelerin mekanik özelliklerini belirlemek için kritik olan elastik sabitler tarafından kontrol edilir. Elastik sabitler, komşu atomik düzlemler arasındaki bağ karakteri, bağ anizotropisi ve yapısal kararlılık hakkında önemli detaylar sunar. BaCd 'nin hesaplanan ikinci dereceden elastik sabitler seti, Tablo 2'de verilmiştir. Bu sabitler, malzemenin mekanik kararlılık kriterini karşıladığı için BaCd'nin mekanik olarak kararlı olduğunu göstermektedir.

Tablo 2. Mekaniksel özellikler

Materials	C_{11}	C_{12}	C_{44}	B	G	E
BaCd	33.4	13.5	16.4	20.1	13.4	32.8

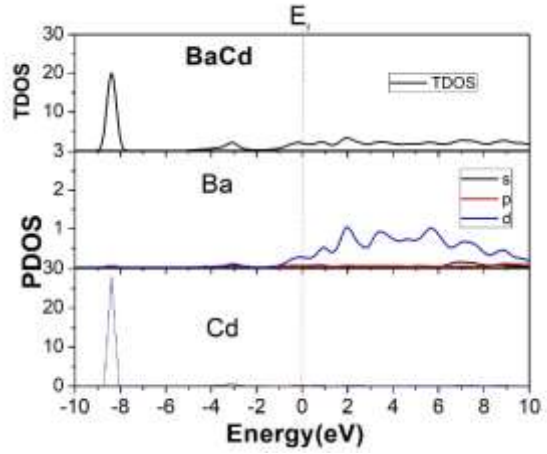
B. *Elektronik Özellikler*

Herhangi bir malzemenin elektronik özellikleri malzemenin doğası hahhında bilgi verir. Elektronik özelliklerin kesinliği fiziksel özelliklerin hassas elde edilmesine sebep olur. Brillouin bölgesinin yüksek simetri doğrultuları boyunca enerji band yapısı Şekil 3 de verilmiştir. Fermi seviyesi 0' sabitlenmiştir. Bu grafikten valans band bölgesi ve iletkenlik band bölgesi içi içe giridiği için BaCd bileşiği metalik özellik göstermektedir.



Şekil. 3 BaCd bileşiği için elektronik band yapısı ve toplam durumlar yoğunluğu

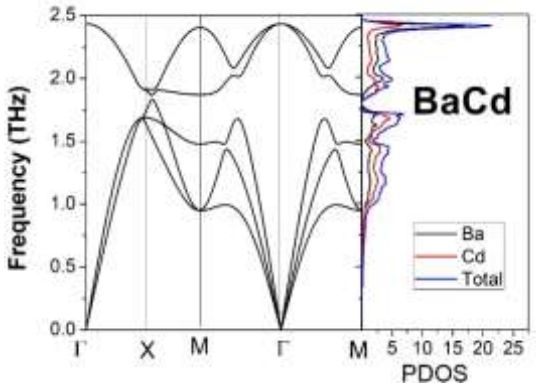
Şekil 4 de görüldüğü gibi BaCd için elde edilen toplam ve kısmi durumlar yoğunluğu grafiğinin Şekil 3 ile uyumlu olarak metalik özelliğini doğrulamaktadır. -10 ile -8 eV arasında düşük enerji aralığında valans band bölgesinde katkı Cd atomunun d bandından gelmektedir. İletkenlik bandında ise katkı Ba-d bandından gelmektedir.



Şekil 4. BaCd bileşiği için toplam ve kısmı durumlar yoğunluğu

C. *Titreşimsel Özellikler*

Phonopy programı aracılığı ile BaCd bileşiğinin B2 yapıda fonon frekans dağılım eğrisi temel simetri doğrultuları boyunca Şekil -5 de verilmiştir. Elde edilen grafiğe göre herhangi bir negatif frekans görülmediği için BaCd bileşiği dinamiksel olarak kararlıdır. Birim hücrede 2 atom olduğu için 6 tane titreşim modu söz konusudur. Bunların düşük frekanslı 3 tanesi akustik moda, yüksek frekanslı geri kalan 3 tanesi de optik kola aittir. Optik ve akustik kollar arasında çok az yasak frekans bölgesi mevcuttur. Bu bölge Ba ve Cd atomlarının kütle farkından kaynaklanmaktadır. Şekil 5'in sağ tarafında fonon durumalar yoğunluğu eğrisinden görüldüğü gibi her iki bölgedede hem Ba atomları hemde Cd atomlarının titreşimlerinin katkısı mevcuttur.



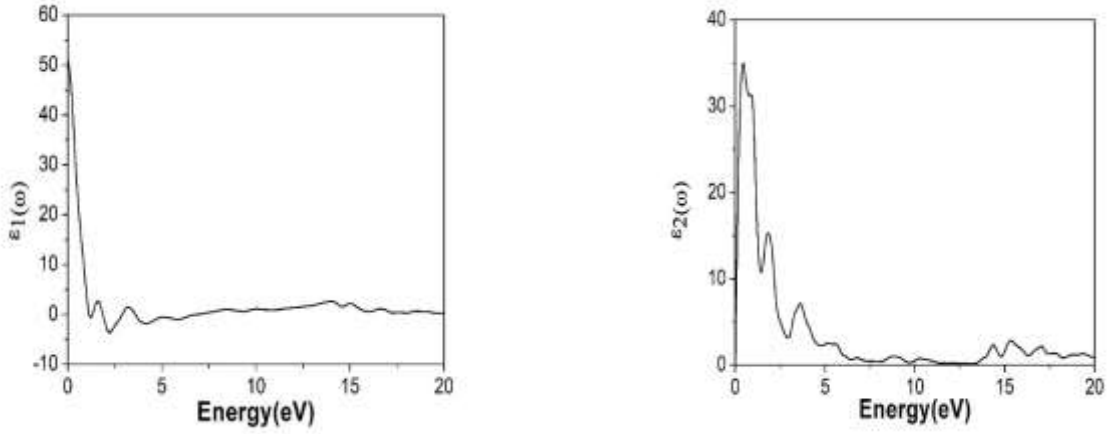
Şekil 5. BaCd için Fonon dağılım eğrisi

D. Optik Özellikler

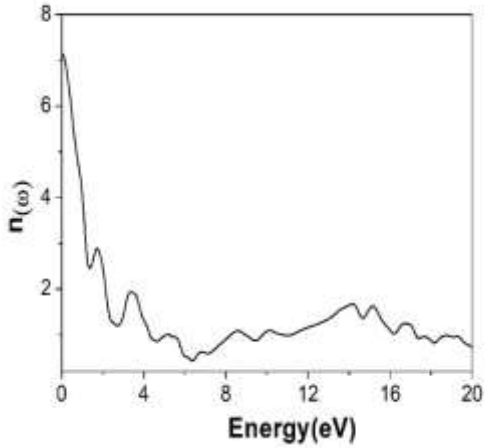
Katı hal fiziğinde malzemelerin optik özelliklerini anlamak, elektromanyetik dalgalarla malzeme arasındaki etkileşim hakkında önemli bilgiler sunar. Bu bilgi, özellikle kırılma indisi ve absorpsiyon özellikleri gibi parametreler, fotovoltaik cihazların geliştirilmesi için önemlidir. Bu çalışmada, BaCd'nin nin optik özellikleri 0-20 eV enerji aralığında incelenmiştir. BaCd'nin optik özellikleri, dielektrik fonksiyonundan türetilerek analiz edilmiştir ve bu analiz, yapının teknolojide bir optoelektronik cihaz olarak kullanılıp kullanılamayacağını belirlemek amacıyla yapılmıştır.

Dielektrik fonksiyonu, bir malzemenin elektrik alanına nasıl tepki verdiğine dair fikir veren çok önemli bir optik sabit görevi görür. Dielektrik fonksiyonunun reel bileşeni, uygulanan elektrik alanı tarafından indüklenen malzemenin polarizasyonunu tanımlarken, sanal kısmı malzemenin soğurma özellikleriyle

ilişkilidir [8]. Şekil 6(a), çeşitli basınçlarda 0-20eV aralığında dielektrik fonksiyonunun gerçek kısmındaki değişikliklerin grafiksel bir temsilini sunmaktadır. Özellikle gerçek kısım sıfır enerjiye yakın bir başlangıç tepe noktası sergiliyor ve foton enerjisi arttıkça azalıyor. Statik gerçek dielektrik fonksiyon değerleri ($\varepsilon_1(0)$) 50 dir. Daha yüksek dielektrik sabitine sahip malzemeler, yüksek değerli kapasitörlerin üretiminde pratik uygulamalar bulur [8]. 0-3 eV aralığında zirveye ulaşan sanal dielektrik fonksiyonu, artan foton enerjisiyle birlikte azalma eğilimi izlemektedir (Şekil 6(b)). Özellikle, ε_2 değerleri BaCd için yaklaşık 7.5 eV'de sıfır olur. Bu spesifik enerji seviyeleri, malzemenin bu noktaların ötesinde şeffaflığını belirtir ve emilim, $\varepsilon_2(\omega)$ sıfırdan farklı olduğunda başlar.

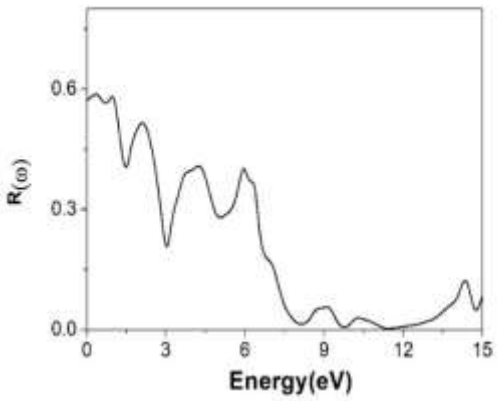


Şekil 6. (a)Reel ve (b) Sanal dielektrik sabitlerinin enerji ile değişimi



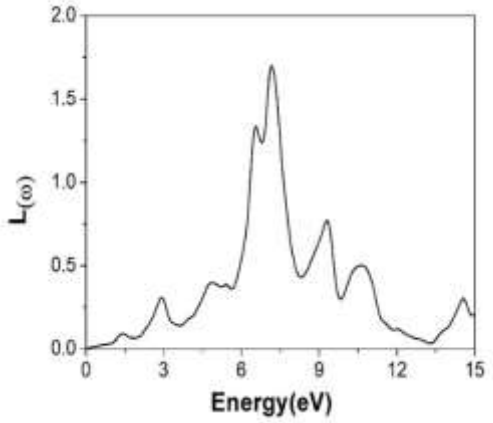
Şekil 7. Kırılma indisinin enerji ile değişimi

Temel bir optik özellik olan kırılma indisi, bir malzemeye girdiğinde ışığın ne kadar bükülecceğini veya kırılacağını belirler. n(ω) olarak temsil edilen bu sabit, bir malzeme içindeki elektromanyetik dalgaların yayılması hakkında değerli bilgiler sağlayan kritik bir sabittir [60]. Kırılma indisindeki değişiklikler, Şekil 7'de verildiği gibi 7.1 olarak belirlenen statik değerler n(0) ile gösterilmektedir. Sıfır frekansta, $\varepsilon_1(0) \approx n^2(0)$[9] ilişkisine bağlı kalarak, ortamın oldukça yüksek bir soğurma katsayısına sahip olduğu durumlar dışında hesaplamaların kesinliğini doğrular [10].



Şekil 8. Yansıma katsayısının enerji ile değişimi

Bir malzemenin yüzeyinden geri dönen radyasyon olgusu olan yansıma, çeşitli malzemelerin yüzey özelliklerini analiz etmek için değerli bir araçtır [10]. Şekil 8 de BaCd için yansıtıcılık faktörünün enerki ile değişimi verilmiştir. 0 elektron voltta (eV), yansıtma maksimumu 0 ev de 0,58 değerine sahiptir. Enerjide 1.5 eV'ye kadar yaklaşık sabit , 8 eV'ye kadar keskin bir şekilde düşmeden önce dalgalanmalar yaşar. Metaller genellikle ışığı yansıtmada oldukça etkilidir. Bu, ışığın bir metalin yüzeyine çarptığında büyük bir kısmının yansıdığı anlamına gelir. Bu özellik ayna ve optik cihazların üretiminde kullanılmaktadır.



Şekil 9. Kayıp fonksiyonunun enerji ile değişimi

Önemli bir optik parametre olan kayıp fonksiyonu, bir materyalden geçen hızlı bir elektronun enerji kaybını aydınlatır. Katı içindeki Coulomb etkileşimleri hakkında fikir verir ve malzemenin optik spektrumunu karakterize eder [10]. Şekil 9 de kayıp fonksiyonunun UV bölgedeki maksimum değer göstermektedir. Buna karşılık, Şekil 10(b)'de gösterildiği gibi, hayali dielektrik fonksiyonu bu bölgelerde baskındır. Kayıp fonksiyonundaki maksimumlar yansımadaki hızlı düşüşlere karşılık gelir ve 7.4 ölçülen plazmon frekansı olarak tanımlanır. Daha da önemlisi, plazmon frekansının ötesindeki frekanslar, ışık geldiğinde metalik davranıştan dielektrik davranışa geçişe yol açabilir.

IV. SONUÇLAR

B2 yapısında kristalleşen BaCd intermetalik bileşiğinin çeşitli fiziksel özelliklerini incelemek için DFT yönteminden yararlanıldı. Bu kapsamlı teorik çalışma, malzemenin yapısal, elastik, elektronik, fonon ve optik özelliklerini araştırdı. Çalışmanın ilk aşamasında yapısal parametrelerin belirlenmesi amacıyla geometrik optimizasyon için teorik hesaplamalar yapılmıştır. Örgü sabiti 4.269 Å olarak belirlenmiş olup, literatürde bulunan teorik hesaplamalar ile bu sonuç tutarlıdır. Mekanik özelliklerin değerlendirilmesi, bileşiğin mekaniksel olarak kararlı olduğu belirlendi. Elektronik bant yapılarının analizi, oldukça simetrik

Brillouin bölgesi içindeki metalik özellikleri ortaya çıkardı. Fonon dağılım eğrisi ise bu bileşiğin dinamiksel kararlılığını göstermektedir. Optik özellikler ayrıca 0-20 eV enerji aralığında incelendi. Özellikle BaCd bileşiğinin kırılma indeksi 3-7 aralığına düştü ve bu da onu optoelektronik uygulamalar için potansiyele sahip bir malzeme olarak sonuçlandırabiliriz. Enerjiye bağlı optik sabitler güçlü metalik özellikleri ortaya çıkarır. Bütün bunlar elektronik bant yapısı hesaplamalarıyla tutarlıdır

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BaHg İntermetalik Bileşiğinin Yapısal, Elektronik ve Titreşim Özelliklerinin Teorik Analizi

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Özet – MÖ 2500 civarına kadar uzanan bir geçmişe sahip olan intermetalik bileşikleri, metalurjinin ilk dönemlerinden itibaren kullanılmaktadır. Bu bileşikler, üstün mekanik özelliklere sahip olmaları nedeniyle özellikle yüksek sertlik ve aşınma direnci gerektiren uygulamalarda tercih edilmektedir. Bunun yanı sıra, dekoratif amaçlarla da yaygın olarak kullanılmaktadırlar. İntermetalik bileşikleri, mükemmel oksidasyon direnci, yüksek mukavemet, yüksek rijitlik ve yüksek sıcaklıklara karşı dayanıklılık gibi dikkat çekici özellikler sergilemektedir. Bu özellikler, intermetalik bileşiklerini elektrikli motorlar ve kimyasal süreç endüstrisi gibi alanlarda ideal bir malzeme haline getirmektedir. Çalışmamızda, BaHg'nin yapısal, elektronik ve titreşim özellikleri yoğunluk fonksiyoneli teorisi (DFT) çerçevesinde ve Vienna ab-initio simülasyon paketi (VASP) kullanılarak analiz edildi. Çalışmamız tamamen teorik bir çalışma olup, hesaplamalarımızda hiçbir deneysel veri kullanılmamaktadır. İlk olarak yapısal parametreler, geometrik optimizasyonla belirlendi. BaHg intermetalik bileşiğinin deneysel olarak da sentezlenebileceği belirlendi.Yapısal parametreler literatürde mevcut teorik ve deneysel verilerle karşılaştırıldı. BaHg bileşiğinin elektronik bant yapısı özellikleri analiz edildi. Kristal yapıların fiziksel özelliklerinin daha iyi anlaşılması için elektronik bant yapısının hesaplanması önemlidir. Bu özellikler, bant aralığının doğası ve taşıyıcıların hareketliliği dahil olmak üzere çeşitli hususların belirlenmesinde doğrudan rol oynar. Ayrıca, son olarak BaHg intermetalik bileşiğinin titreşim özellikleri belirlendi. Titreşim özelliklerinin analizi ile elementlerin negatif fonon frekansının bulunmadığı görüldü. Titreşim analiziyle bileşiğin dinamik olarak karalı olduğu anlaşıldı.

Anahtar Kelimeler – İntermetalik, DFT, metal, fonon, BaHg

I. GİRİŞ

BaHg intermetalik bileşiği, baryum (Ba) ve cıva (Hg) elementlerinin belirli bir oranda birleşerek oluşturduğu bir bileşiktir. Intermetalik bileşikler, metalik elementlerin belirli oranlarda bir araya gelerek oluşturduğu ve genellikle kristal yapıya sahip olan maddelerdir [1]. Bu bileşikler, metalik ve iyonik bağların kombinasyonu ile karakterizedir ve çoğu zaman benzersiz fiziksel ve kimyasal özelliklere sahiptirler [2], [3]. BaHg intermetalik bileşiği de bu bağlamda önemli bir araştırma konusu olarak dikkat çekmektedir.

BaHg intermetalik bileşiği, hem baryumun hem de cıvanın özelliklerini yansıtır. Elektriksel iletkenlik, termal iletkenlik, manyetik özellikler ve mekanik dayanıklılık gibi fiziksel özellikler, bu bileşiğin uygulama alanlarını belirlemede kritik rol oynar. Örneğin, BaHg'nin elektriksel iletkenlik özellikleri, potansiyel olarak elektronik ve yarı iletken endüstrisinde kullanımını mümkün kılabilir

BaHg, kimyasal açıdan inert bir yapı sergileyebilir ancak belirli koşullar altında reaktif hale gelebilir. Baryumun alkali toprak metal olması, cıvanın ise geçiş metali özelliklerine sahip olması, bu bileşiğin kimyasal reaktivitesini etkileyen faktörler arasındadır. BaHg, özellikle oksidasyon ve diğer redoks reaksiyonlarına karşı gösterdiği direnç ile incelenir.

Bu çalışma, literatüre katlı sağlamak amacıyla, B2 yapıda olan BaHg intermetalik bileşiğinin yapısal, elektronik ve titreşim özellikleri ayrıntılı olarak incelendi.

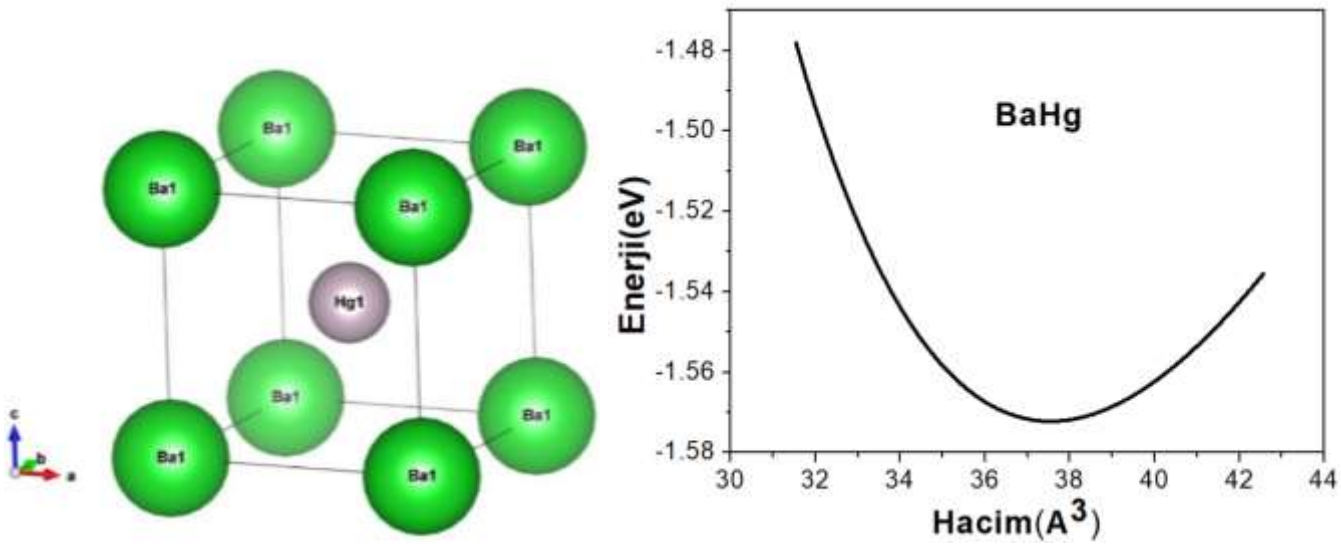
II. MATERYAL VE YÖNTEM

BaHg intermetalik bileşiğinin fiziko-kimyasal özelliklerinin araştırılması, VASP yazılımı [4]–[6] kullanılarak düzlem dalga psödopotansiyel Yoğunluk Fonksiyonel Teorisi (DFT) yöntemi [4], [7] ile gerçekleştirilmiştir. Hesaplama gereksinimlerini karşılamak için değiş-tokuş ve korelasyon fonksiyonu olarak Genelleştirilmiş Gradyan Yaklaşımı (GGA) kullanılmıştır [8]. Kafes parametreleri ve atomik pozisyonların optimizasyon sürecinde, indirgenemez Brillouin bölgesinde entegrasyon için 14x14x14 Monkhorst ve Pack k-noktaları ızgarası kullanılmıştır. Düzlem dalga temel seti için 600 eV'lik bir kinetik enerji kesme değeri belirlenmiştir.

III. BULGULAR

A. Yapısal Özellikler

BaHg intermetalik bileşiği, CsCl yapısında (B2 yapısı) kristalleşmektedir ve 221 (pm3m) uzay grubuna sahiptir. CsCl yapısı, iç içe geçmiş iki anyon ve katyon alt kafesinden oluşur. Bu sistemde, bir iyon küpün merkezinde yer alırken, diğer iyonu sekiz iyon çevreler. Bu nedenle, birim hücrede Ba ve Hg atomları sırasıyla Wyckoff 1a(0,0,0) ve 1b(0.5, 0.5, 0.5) pozisyonlarında bulunur (Şekil 1'de gösterilmiştir). Hesaplamalar yapılmadan önce, CsCl kristal yapısının en kararlı konfigürasyonunu belirlemek için geometrik optimizasyon gerçekleştirilmiştir. Yapısal parametreler, birim hücrenin hacminin bir fonksiyonu olarak toplam enerji ile belirlenmiştir. E-V eğrisi, yani durum denklemi eğrisi, bir malzemenin hacmi (V) ve toplam enerjisi (E) arasındaki ilişkiyi sağlar [9]. Bu eğri incelenerek hacim, yığın modülü ve yığın modülünün basınç türevi gibi yapısal parametreler elde edilebilir.



(a) (b)

Şekil 1. BaHg bileşiğinin a) Birim hücresi, b) Enerji hacim grafiği

Tablo 1. Hesaplanan örgü sabiti a (Å), hacim V (Å^3), Hacim modülü B(GPa), Hacim modülünün birinci türevi B'

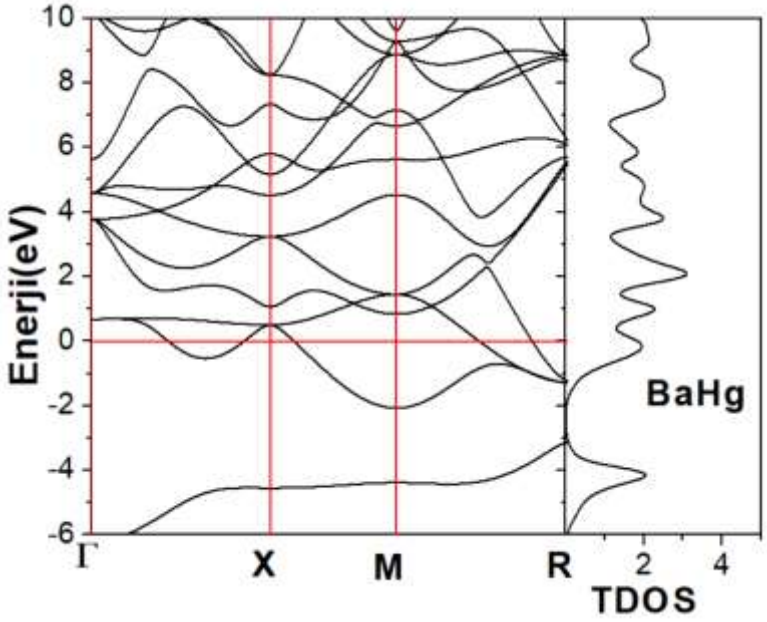
Bileşik	a(Å)	E(eV)	V(Å^3)	B(GPa)	B'
BaHg	---	-3.144	75.088	22.371	4.831

Yapısal hesaplamalar ile örgü sabiti değeri …. Å olarak belirlendi. Örgü sabiti değerinin literatürle oldukça uyumlu olduğu belirlendi.Hacim modülü bileşiğin hangi oranda sıkıştırılabileceğini gösterir.

Hacim modülü değeri oldukça küçüktür, bileşiğin kolay sıkıştırılabilir, bileşiğin sünek bir malzeme olduğu hakkında bilgi verir.

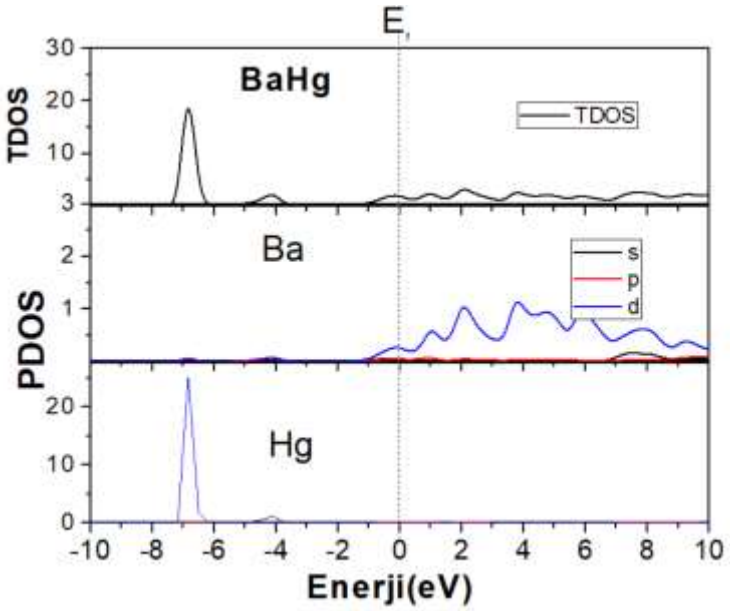
B. Elektronik Özellikler

Elektronik bant yapısının bilinmesi, kristal yapıların fiziksel, optik ve taşıma özellikleri hakkında bilgi edinmek için gereklidir. Elektronik özellikler, bant aralığının türü ve taşıyıcıların hareketliliği gibi birçok özelliği doğrudan belirleyebilir [10]–[12]. BaHg'nin Brillouin bölgesinin ΓXMR yüksek simetri yönü boyunca elektronik enerji bant yapısı Şekil 2'da verilmiştir. Fermi enerji seviyesi 0 eV olarak ayarlanmıştır. Bant yapısında, değerlik bandı maksimumları ve iletkenlik bandı minimumları birbirleriyle öyle bir şekilde örtüşmüştür ki, aralarında bir boşluk yoktur. Bu nedenle, BaHg metalik bir doğaya sahiptir.



Şekil 2. BaHg bileşiğinin bant yapısı grafiği

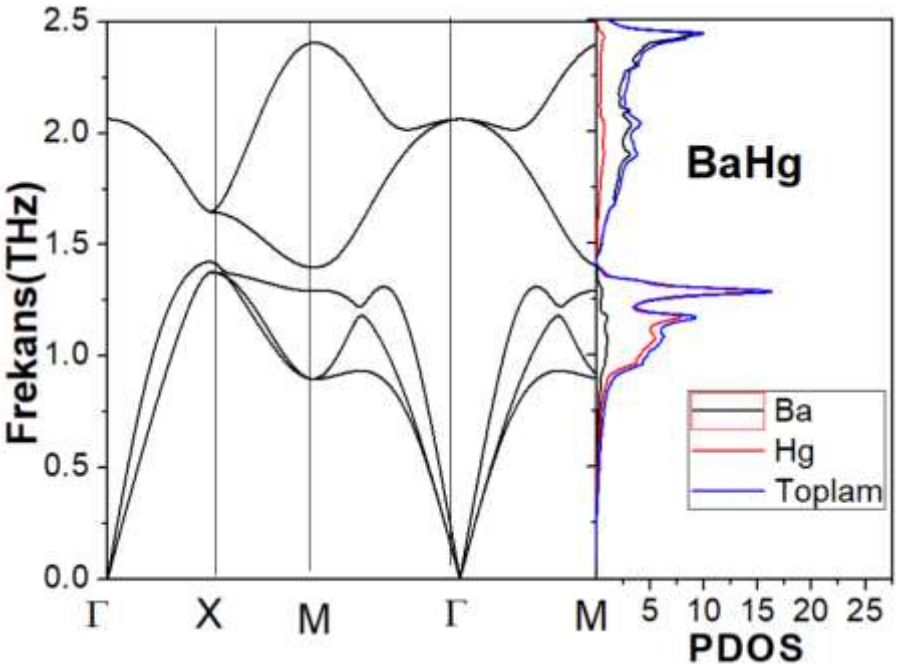
BaHg bileşiğinin kısmi yoğunluk (DOS) grafiği Şekil 3'te gösterilmiştir. Grafiğimizi Fermi seviyesi, değerlik bandı ve iletkenlik bandı olarak değerlendirebiliriz. Sıfır noktasındaki Fermi seviyesine en büyük katkı Ba-d durumlarından gelmektedir. Değerlik bandına en büyük katkı Hg-d durumlarından gelirken, iletkenlik bandına en büyük katkı Ba-d durumlarından gelmektedir.



Şekil 3. BaHg bileşiğinin kısmi ve durum yoğunluğu

C. Titreşim Özellikleri

BaHg bileşiğinin fonon frekansları PHONOPY kodu ile hesaplanmıştır [13]. Phonopy [14], fonon tabanlı hesaplamalar için açık kaynaklı bir koddur. Bu kodda, malzemelerin sonlu sıcaklıktaki dinamik özellikleri tanımlanmıştır. BaHg bileşiğinin fonon dağılım eğrileri Şekil 4'de gösterilmiştir. Yüksek simetri yönelimli fonon dağılım eğrileri 2 x 2 x 2 süper hücreler kullanılarak hesaplanmıştır. Fonon dağılım eğrisi için B2 (CsCl) yapısında ΓX, XM, MΓ ve ΓM yüksek simetri noktaları kullanılmıştır. Brillouin bölgesinde hayali fonon frekansı bulunmaması, BaHg bileşiğinin dinamik kararlılığını doğrulamaktadır. BHg bileşiği iki atoma sahip olduğundan, üçü akustik dallar ve diğer üçü optik fonon dalları olmak üzere altı fonon dalı gösterir. Şekil 4'te fonon eğrilerinin sağ tarafında, bu bileşik için toplam fonon durum yoğunluğu gösterilmiştir. Akustik modlara en büyük katkı Hg atomlarından, Optik modlara en büyük katkı ise Ba atomlarından gelmektedir.



Şekil 4. BaHg bileşiğinin fonon dispersiyon eğrileri

IV. SONUÇLAR

BaHg intermetalik bileşiğinin yapısal, elektronik ve titreşim özellikleri DFT ile analiz edildi. Bileşiğin yapısal özelliklerinde bileşiğin kolayca sıkıştırılabileceği ve yumuşak karakterli olduğu belirlendi. Elektronik özellikleriyle metalik bir bileşik olduğu ve PDOS ve TDOS katkılarının d orbitallerinden kaynaklandığı belirlendi. Titreşim özellikleri bileşiğin dinamik olarak kararlı olduğunu gösterdi. Yapılan bu çalışmayla intermetalik bir bileşik olan BaHg'nin yapısal ve elektronik özellikleri belirlenerek literatüre katkı sağlanmış oldu.

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BaHg İntermetalik Bileşiğinin Mekanik ve Termodinamik Özelliklerinin Teorik Analizi

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Özet – İntermetalik bileşikler, yapısını oluşturan malzemelerden farklı özelliklere sahip iki veya daha fazla atom içeren bileşiklerdir. Bu bileşikler, yüksek erime sıcaklıkları, oksidasyon direnci, sertlik ve mukavemetleriyle sıradan alaşımlardan ayrılırlar. Ek olarak, süneklik, tokluk ve yorulma direnci gibi özellikler de optimize edilebilir. Çalışmamız tamamen teorik bir çalışma olup, hesaplamalarımızda hiçbir deneysel veri kullanılmamaktadır. CsCl yapıda olan BaHg intermetalik bileşiğinin mekanik ve termodinamik özellikleri ayrıntılı olarak analiz edildi. BaHg bileşiğinin teorik analizi VASP yazılımı kullanılarak düzlem dalga psödopotansiyel Yoğunluk Fonksiyonel Teorisi (DFT) yöntemi ile belirlendi. Mühendislik uygulamalarında kullanılacak malzemelerin gerilme ve şekil değiştirme etkisi altındaki tepkisi çok önemlidir. Malzemelerin elastik sabitleri, mekanik özellikler için anahtardır. Bu nedenle, sertlik, süneklik, kimyasal bağ yapısı, plastiklik, anizotropi, ses hızları, Debye sıcaklığı, erime sıcaklığı gibi birçok bilgiye bu elastik sabitlerle ulaşılır. Elastik özellikler zor-zorlanma yöntemi ile belirlendi. Ayrıca, elastik özellikler, Young modülü, lineer sıkıştırılabilirlik, kayma modülü ve Poisson oranının detaylı analizi üç boyutlu (3B) olarak belirlendi ve analiz için açık bir kod olan ELAM kodu kullanıldı. Son olarak, BaHg intermetalik bileşiğinin yüksek sıcaklık ve yüksek basınca maruz kaldığında termodinamik özellikler üzerindeki etkileri araştırıldı. Termal özellikler, Gibbs kodu quasi-harmonik Debye modeli ile hesaplandı. Termodinamik özellikler, 0–800 K sıcaklık aralığında ve 0–0.5 GPa basınç aralığında analiz edildi.

Anahtar Kelimeler – intermetalik, DFT, sünek, anizotropi, BaHg

I. GİRİŞ

İntermetalik bileşikler, fiziksel metalurjinin ilerlemesiyle birlikte son yüzyılda bilimsel araştırmaların konusu olmuş ve 1939 yılında Karsten tarafından incelenmiştir. Ancak, bu bileşiklerin iç yapısı ve mekanik özellikleri 1960'lı yıllarda araştırılmaya başlanmıştır.

İntermetalik bileşikler, metal ve seramik malzemeler arasında yer alan, genellikle kimyasal olarak birbirine benzemeyen iki veya daha fazla saf metalin belirli oranlarda oluşturduğu kristal yapılı bileşikler veya katı çözeltilerdir. Bu bileşikler, hem yüksek sıcaklık uygulamaları hem de mekanik özellikler açısından metalik ve seramik malzemeler arasındaki boşluğu doldurabilecek potansiyele sahiptir.

Süper alaşımlar, mukavemet ve tokluğun iyi bir kombinasyonunu sunmalarına rağmen, sadece 1100°C'nin altındaki sıcaklıklarda kullanılabilirler. Modern mühendislik seramikleri ise daha yüksek sıcaklıklarda kullanılabilmelerine rağmen, kovalent bağlanma nedeniyle kırılgan olup, bu durum kullanım alanlarını sınırlandırır. İntermetalikler ise atomlararası kuvvetli bağlar sayesinde süperalaşımlardan daha yüksek mukavemet gösterirken, metalik karakterdeki bağlanmaları nedeniyle seramiklere göre daha az kırılgandır.

Mekanik özelliklerin bilinmesi özellikle mühendislik uygulamaları için oldukça gereklidir. Çalışmamızda CsCl yapıdaki BaHg nin mekanik özellikleri ve termodinamik özelliklerle ilgili gerekli bilgiler sunulacak, literatüre katkı sağlanmış olacaktır.

II. MATERYAL VE YÖNTEM

BaHg intermetalik bileşiğinin fiziko-kimyasal özelliklerinin araştırılması, VASP yazılımı [1]–[3] kullanılarak düzlem dalga psödopotansiyel Yoğunluk Fonksiyonel Teorisi (DFT) yöntemi [1], [4] ile gerçekleştirilmiştir. Hesaplama gereksinimlerini karşılamak için değiş-tokuş ve korelasyon fonksiyonu olarak Genelleştirilmiş Gradyan Yaklaşımı (GGA) kullanılmıştır [5]. Kafes parametreleri ve atomik pozisyonların optimizasyon sürecinde, indirgenemez Brillouin bölgesinde entegrasyon için 14x14x14 Monkhorst ve Pack k-noktaları ızgarası kullanılmıştır. Düzlem dalga temel seti için 600 eV'lik bir kinetik enerji kesme değeri belirlenmiştir. Mekanik özelliklerin belirlenmesinde kullanılan elastik sabitler zor-zorlanma yöntemi ile bulundu. Termodinamik özellikler ise Gibbs kodu, quasi-harmonik Debye modeli ile hesaplandı.

III. BULGULAR

A. Mekanik Özellikler

Elastik sabitler, kristalin temel katı hal ve termodinamik özellikleri ile ilgili makroskopik mekanik özellikleri anlamak için temel araçlardır. BaHg kübik yapıda olduğu için birbirinden bağımsız, C_{11}, C_{12} ve C_{44} üç elastik sabit vardır. Bu elastik sabitler, Born kararlılık ilkelerini sağladığı için mekanik olarak kararlıdır. Mekanik özellikler, Eşitlik (1-5)'ten [6]–[12] hesaplanmış olup, değerleri Tablo 1'de sunulmuştur.

$$B = \frac{1}{3}(C_{11} + 2C_{12}) \quad (1)$$

$$G = \frac{1}{5}(C_{11} - C_{12} + 3C_{44}) \quad (2)$$

$$E = \frac{9BG}{3B+G} \quad (3)$$

$$\upsilon = \frac{3B-2G}{2(3B+G)} \quad (4)$$

$$A = \frac{2C_{44}}{C_{11}-C_{12}} \quad (5)$$

Tablo 1. Elastik sabitler (C_{11}(GPa), C_{12}(GPa), C_{44}(GPa)), Hacim modülü (B(GPa)), Kayma modülü (G(GPa)), Young modülü (E(GPa)).

Bileşik	C_{11}	C_{12}	C_{44}	B	G	E
BaHg	40.4	16.6	16.5	24.5	14.4	36.1

Kristalin sertliği, Tablo 1 de sunulan Young modülü ve Kayma modülünden tahmin edilebilir. BaHg'nin düşük Young ve Kayma modülüne sahip olması, bu bileşiğin yumuşak bir malzeme olduğunu gösterir.

Bulk modülünün kayma modülüne oranı olarak bilinen Paugh oranı, malzemenin kovalent/iyonik durumu hakkında bilgi verir. G/B değerleri Tablo 2'te verildi. Genellikle, kovalent bir malzeme için G/B yaklaşık 1.1 iken, iyonik bir malzeme için G/B 0.6'dır. Bu G/B değerleri göz önüne alındığında, BaHg bileşiği iyonik karaktere sahip bir malzemedir. Diğer yandan, G/B değeri, malzemenin sünek/kırılgan özelliğini

değerlendirmede belirleyicilerden biridir . Eğer bu oran ≤0.6 ise sünek davranış, aksi takdirde kırılgan davranış sergiler[13]. Tablo 2'den, BaHg bileşiğinin sünek davranış sergilediği görüldü.

Poisson oranı (ν), malzemenin sünek/kırılgan olup olmadığını belirleyen ikinci bir parametredir. Bu Poisson oranında, malzemenin sünek olabilmesi için kritik değer ≥ 0.26'dır[14]. Tablo 2'de sunulduğu gibi, BaHg nin poisson değeri yaklaşık 0.26'dır. Poisson oranına göre de malzeme sünek özellik göstermektedir.

Cauchy basıncı ($C' = C_{12} - C_{44}$), metalik yapılar ve bileşiklerde atom bağlarının açısal özelliklerini tanımlayan ve elastik sabitlerden belirlenen bir parametredir. Cauchy basıncında, eğer değer pozitif ise, bileşik metalik özellikler gösterir ve yapısı sünektir. BaHg bileşiğinde bu değer pozitif olup sünektir.

Hv değeri bileşiğin sertlik değerini gösterir. Tablo 2 de görüldüğü gibi BaHg bileşiğinin sertlik değeri oldukça düşüktür. BaHg bileşiği oldukça yumuşak bir bileşiktir. Malzemenin sert olabilmesi için Hv değerinin 10 olması gerekmektedir. Hv değeri 40 olduğunda ise malzeme süper sert olarak değerlendirilir[15].

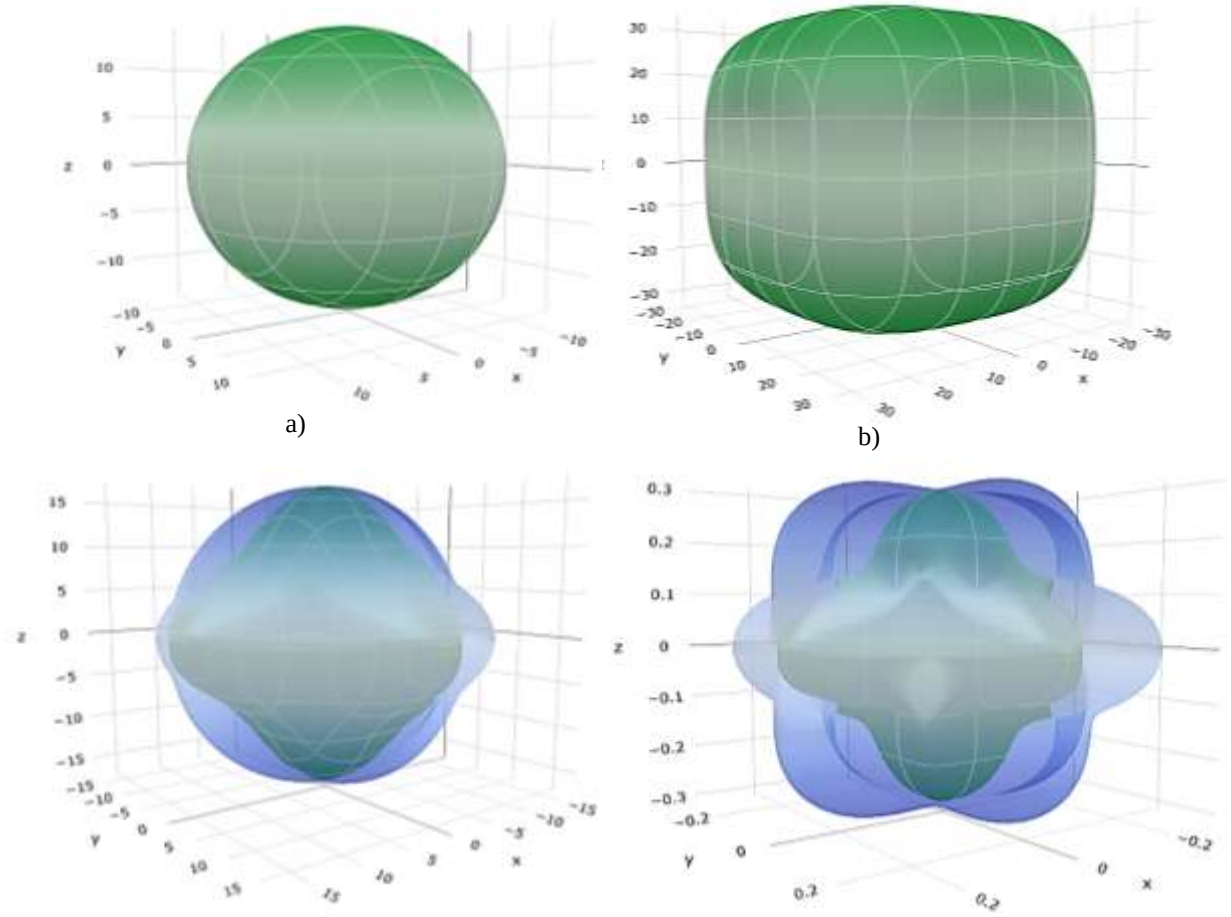
Malzeme biliminde plastiklik (B/C44), bir katı malzemenin uygulanan bir kuvvete karşı geri dönüşümsüz deformasyonu olarak tanımlanır [16]. Tablo 2'te görüldüğü gibi, BaHg bileşiği düşük plastiklik göstermektedir.

Tablo 2. G/B oranı, Poisson oranı (v), Cauchy basıncı (C' (GPa)), Sertlik (Hv), Plastiklik (B/C_{44})

Bileşik	G/B	v	C'	Hv	B/C_{44}	A
BaHg	0.587	0.254	0.1	1.6	1.48	1.387

Mikro çatlakların analizinde kullanılan elastik anizotropi derecesi (A), teknolojik uygulamalarda oldukça önemlidir. A değeri 1 e eşit olunca bileşik izotropik, 1 den büyükse veya küçükse anizotropiktir. BaHg nin değeri 1 den büyüktür ve anizotropiktir. BaHg intermetalik bileşiğinin anizotropi özellikleri ayrıntılı olarak analiz edildi.

Anizotropi hesaplamalarında ELAM kodu kullanıldı. Küreselliğin yokluğu, üç boyutlu fiziksel özelliklerde anizotropinin derecesini gösterir. Şekil 1 ve Tablo 3'te Doğrusal sıkıştırılabilirlik dışındaki tüm formlarda anizotropinin varlığı görülmektedir.



Şekil 1. 3D Elastik Modüller: a) Doğrusal sıkıştırılabilirlik (β (TPa-1)), b) Young Modülü E(GPa), c) Kayma Modülü G(GPa), d) Poisson oranı (υ))

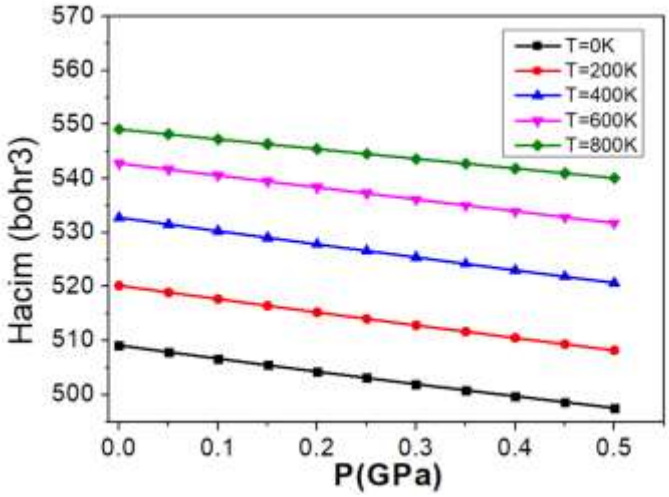
Tablo 3. Mekanik özelliklerin minimum ve maksimum değerleri

Bileşik	β (TPa^{-1})		G(GPa)		E(GPa)		υ	
	β_{min}	β_{max}	G_{min}	G_{max}	E_{min}	E_{max}	υ_{min}	υ_{max}
BaHg	13.587	13.587	11.9	16.5	30.731	40.435	0.13566	0.35515
Anizotropi	1.000		1.387		1.316		2.618	

B. Termodinamik Özellikler

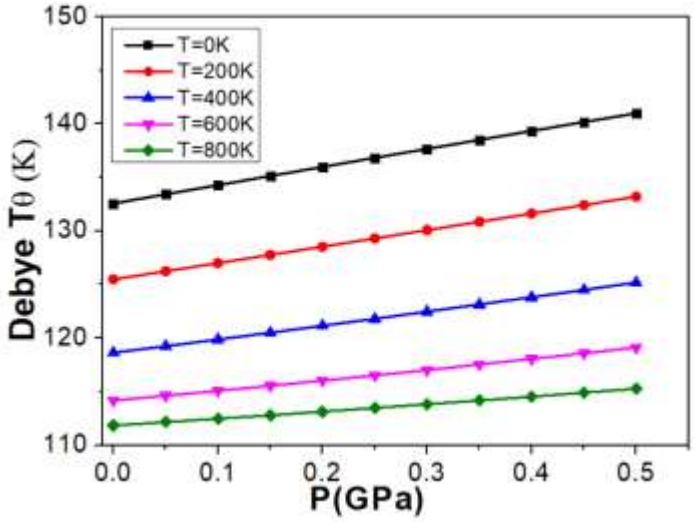
Termal özellikler, Gibbs kodu quasi-harmonik Debye modeli kullanılarak 0–800 K sıcaklık aralığında ve 0–0.5 GPa basınç aralığında analiz edildi [17]. Hacim değişimi ve Debye sıcaklığı değişimi analiz edildi.

Şekil 2'de, BaHg bileşiğinin farklı sıcaklıklarda basınca göre hacim değişimi gösterilmiştir. Görülebileceği gibi, belirli bir sıcaklıkta basınç arttıkça hacim azalır. Diğer yandan, belirli bir basınçta hacim, sıcaklıkla çok yavaş bir oranda artar. Belirli bir sıcaklıkta, basınç arttıkça hacim azalırken, belirli bir basınçta sıcaklık arttıkça hacim artıyor. Bu bileşik için bileşik üzerinde sıcaklığın etkisi daha fazladır.



Şekil 2. Farklı sıcaklıklarba Hacim Basınç değişimi

Şekil 3'de, BaHg bileşiğinin farklı sıcaklıklarda basınca göre Debye sıcaklığı değişimi gösterilmiştir. Debye sıcaklığı, θ_D, katıların elastik sabitler, özgül ısı ve erime sıcaklığı gibi farklı fiziksel özellikleri hakkında değerli bilgiler sağlar[18]. Debye sıcaklık değerleri, belirli bir basınç değerinde sıcaklık arttıkça azalır, diğer yandan belirli bir sıcaklıkta basınç arttıkça yükselir. BaHg bileşiğinin 0 K de de 0 GPa Debye sıcaklığı 132.57 K dir.



Şekil 3. Farklı sıcaklıklarda Debye sıcaklığı Basınç değişimi

SONUÇLAR

BaHg intermetalik bileşiğinin mekanik ve termodinamik özellikleri analiz edildi. Bileşiğin mekanik özellikleriyle Born kararlılık şartlarını sağladığı, mekanik olarak kararlı olduğu bulundu. Elastik sabitlerin belinlenmesiyle mekanik özellikler ayrıntılı olarak değerlendirildi. Bileşik sünek ve yumuşak karakterlidir. Anizotropi özellikleri üç boyutlu olarak değerlendirildi. Doğrusal sıkışabilirlikleri hariç diğer özellikleri anizotropik özellik gösterdi. Termodinamik özelliklerinden Hacim ve Debye sıcaklığı analiz edildi. Yapılan bu çalışmayla intermetalik bir bileşik olan BaHg'nin mühendislikte oldukça önemli olan mekanik özellikleri ve termodinamik özellikleri belirlenerek literatüre katkı sağlanmış oldu.

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Investigation of Temperature and Inlet Relative Humidity Effects on the Performance of a Three-Cell PEM Fuel Cell Stack

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Abstract – This study investigates the effects of temperature and hydrogen inlet pressure on the performance of a three-cell Proton Exchange Membrane (PEM) fuel cell stack. The experiments were conducted at three different temperatures (30°C, 50°C, and 70°C) and three different levels of inlet relative humidity on the anode side (50%, 75%, and 100%) to understand their influence on the stack's performance metrics, including voltage, current density, and power output. The results demonstrate that both temperature and hydrogen inlet pressure significantly impact the performance of the PEM fuel cell stack. At higher temperatures, the stack exhibited improved performance due to enhanced proton conductivity and faster electrochemical reaction rates. Specifically, at 70°C, the cell showed the highest power output across all pressure settings. Conversely, lower temperatures such as 30°C resulted in reduced performance, emphasizing the importance of thermal management in PEM fuel cell operations. Inlet relative humidity variations also played a crucial role. Higher humidity levels led to better membrane hydration, which is essential for maintaining high proton conductivity. The highest performance was observed at 100% relative humidity, indicating that optimal humidification can significantly enhance cell output. However, excessive humidity may cause water flooding, leading to reduced performance and operational challenges. In conclusion, the study provides valuable insights into the thermal and humidity optimization of PEM fuel cells, suggesting that a combination of higher temperatures (70°C) and high inlet relative humidity (100%) can maximize performance.

Keywords – PEM Fuel Cell, Temperature Effects, Inlet Relative Humidity, Fuel Cell Performance, Electrochemical Reaction.

I. INTRODUCTION

Proton Exchange Membrane (PEM) fuel cells are gaining significant attention as a clean and efficient energy conversion technology, particularly for applications in transportation, stationary power generation, and portable power devices. The performance of PEM fuel cells is highly sensitive to operating conditions such as temperature and inlet relative humidity, which directly influence the electrochemical reactions and proton conductivity within the membrane. Understanding the optimal operating conditions is crucial for maximizing the efficiency and durability of PEM fuel cells. This study aims to investigate the combined effects of temperature and inlet relative humidity on the performance of a three-cell PEM fuel cell stack, providing insights that can guide the design and operation of more efficient fuel cell systems [1]- [5].

Y. Shan and S.Y. Choe [6] proposed a dynamic PEM fuel cell stack model that accounts for temperature's significant impact on performance and dynamics. Simulations were performed to analyze start-up behaviors and stack performance. Jang et al. [7] investigated the effects of key operating conditions on the performance of individual cells and the stack in a PEM fuel cell. The four key operating conditions examined were gas humidification temperature, cell temperature, assembled torsion, and gas flow rate. Results revealed that the center cells had lower performance compared to the cells on the edges of the stack.

Additionally, stack performance improved with increasing anode humidification temperature and cell temperature. While the anode gas stoichiometric ratio had no significant impact, performance increased with higher cathode gas stoichiometric ratios. Furthermore, the study showed that the overall stack performance was enhanced with increased assembling torsion. Park and Caton [8] experimentally investigated various cooling methods using a PEM fuel cell stack with 8 cells in series.

This study stands out by systematically investigating the combined effects of temperature and inlet relative humidity on a three-cell PEM fuel cell stack, offering a comprehensive understanding of how these factors influence performance metrics. Unlike previous models that either oversimplify or overly complicate the representation of fuel cell behavior, our research adopts a balanced approach to capture the dynamic interactions within the stack. By numerically analyzing different operating temperatures and humidity levels, we provide novel insights into optimizing thermal and moisture management strategies. This approach not only enhances the stack's efficiency and stability but also addresses practical challenges in real-world fuel cell applications, paving the way for more robust and reliable PEM fuel cell systems.

II. MATERIALS AND METHOD

In this study, a 3D numerical model has been created with COMSOL Multiphysics, Batteries & Fuel Cells Module [9]. Fig. 1 shows that the numerical model of PEM fuel cell.

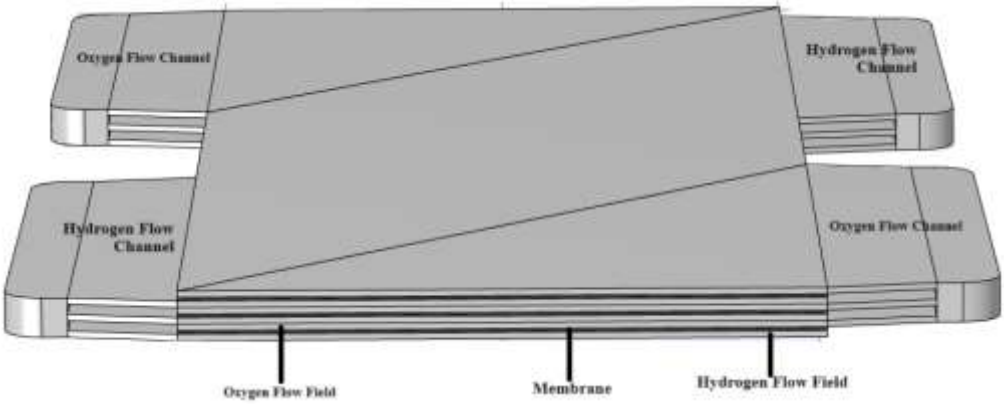

Fig. 1. PEM fuel cell model

The cell sizes employed in models are given in Table 1.

Table 1. The cell sizes used in the PEM fuel cell model

Parameter	Unit	Dimensions
Plate width	cm	10
Plate length	cm	25
Plate height	μm	250
Membrane height	μm	100
Number of stack cells		3

Electrochemical reactions occurring in the anode and cathode layers are represented in Equations 1-3. At the anode, hydrogen gas (H_2) is electrochemically split into its ions:

$$H_2 \rightarrow 2H^+ + 2e^- \quad (1)$$

At the cathode, oxygen gas (O_2) combines with the protons and electrons to form water:

$$\frac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow H_2O \quad (2)$$

The overall reaction occurring in the cell is as follows:

$$H_2 + \frac{1}{2}O_2 \rightarrow H_2O \quad (3)$$

These equations illustrate the basic operation and energy production of a PEM fuel cell. Hydrogen fuel and oxygen are converted into water through electrochemical reactions, generating electrical energy in the process.

III. RESULTS

In this numerical study, a model of three-cell PEM fuel cell stack based on computational fluid dynamics has been developed. In the developed model, the performance of the fuel cell stack was investigated for temperature, and inlet relative humidity effects.

Fig. 2 shows that H_2 concentration distribution at different temperatures.

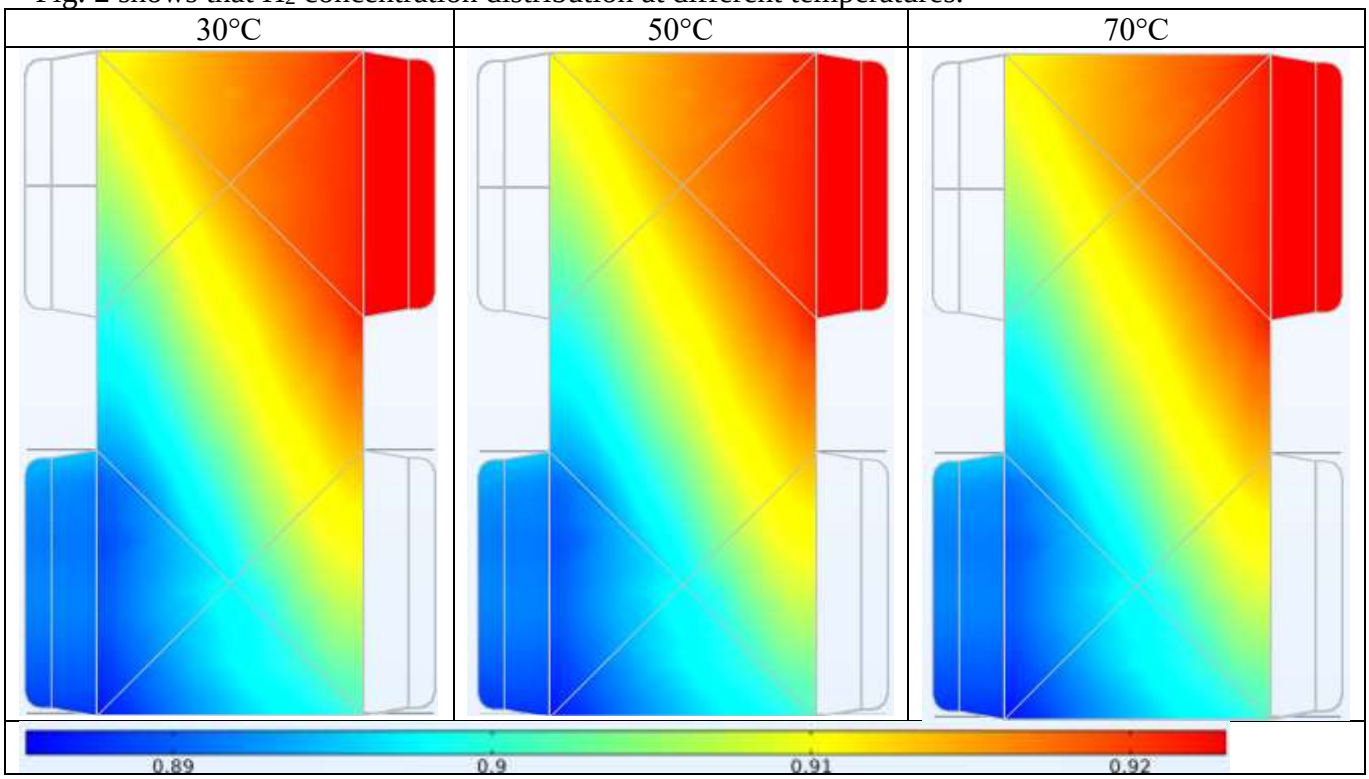

Fig. 2. H_2 concentration distribution at different temperatures

Fig. 3 shows that O_2 concentration distribution at different temperatures.

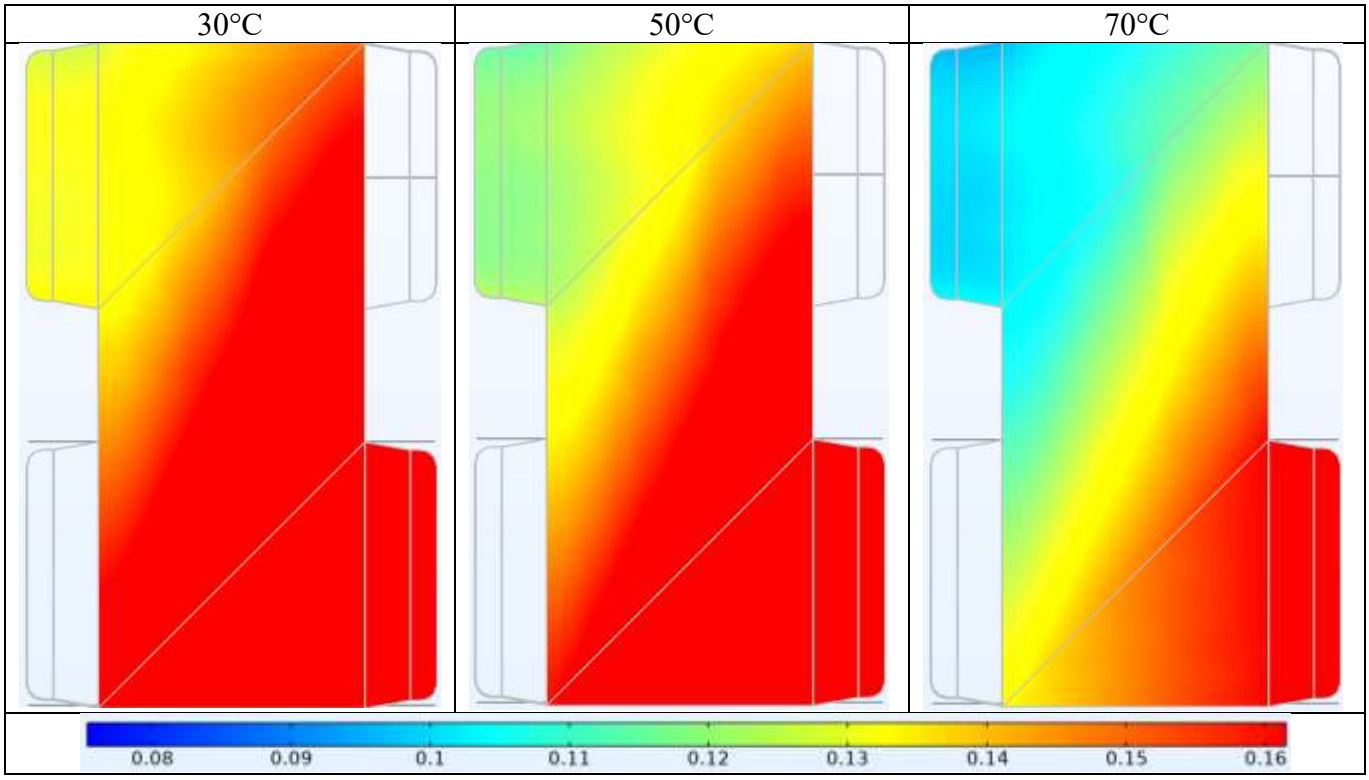

Fig. 3. O_2 concentration distribution at different temperatures

Fig. 4 shows that H_2O concentration distribution at different temperatures.

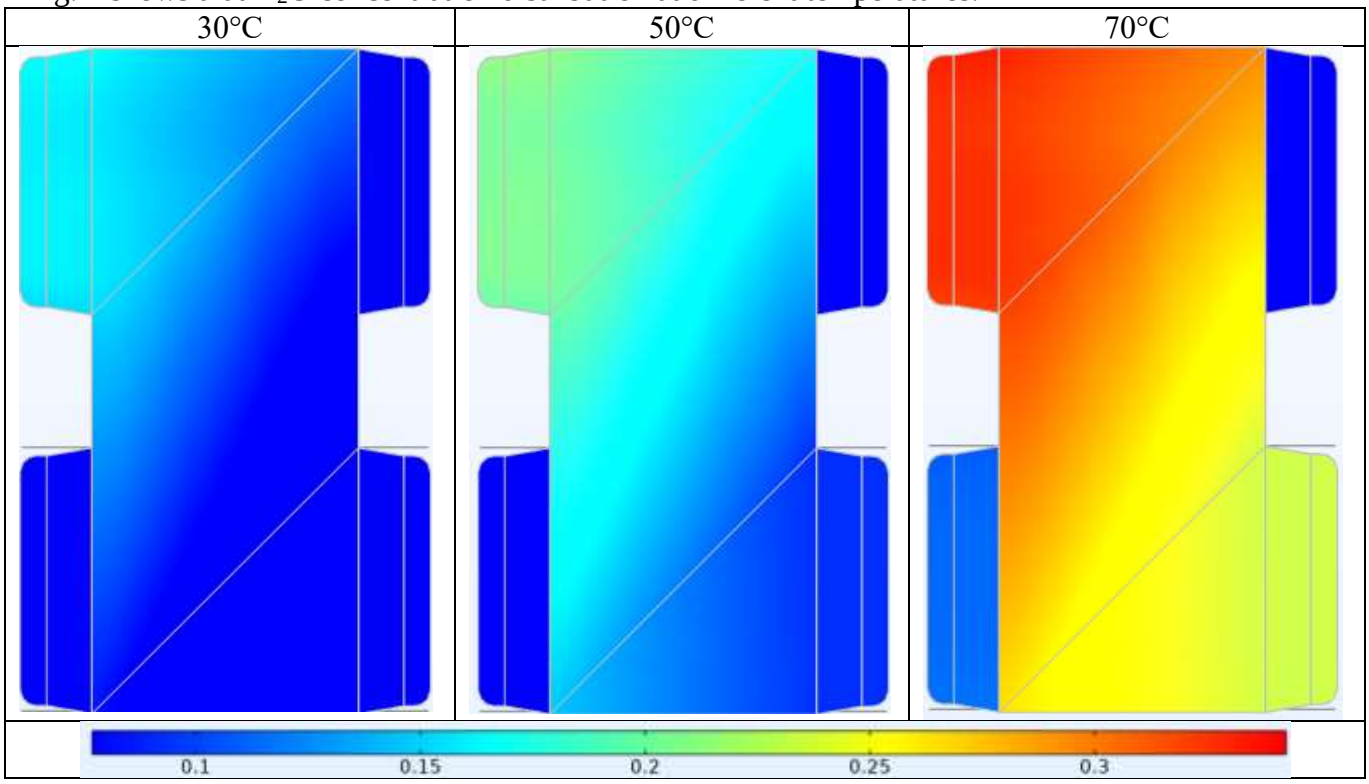

Fig. 4. H_2O concentration distribution at different temperatures

Fig. 5 shows that polarization curve at different temperatures.

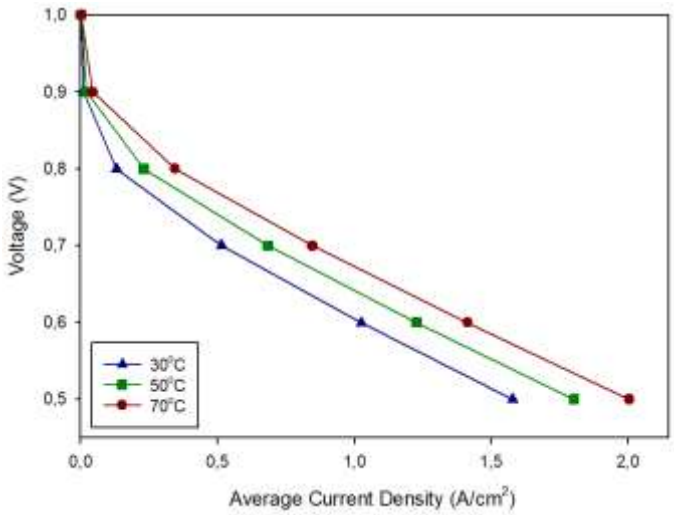

Fig. 5. Polarization curve at different temperatures

Fig. 6 shows that H_2 concentration distribution at different inlet relative humidities.

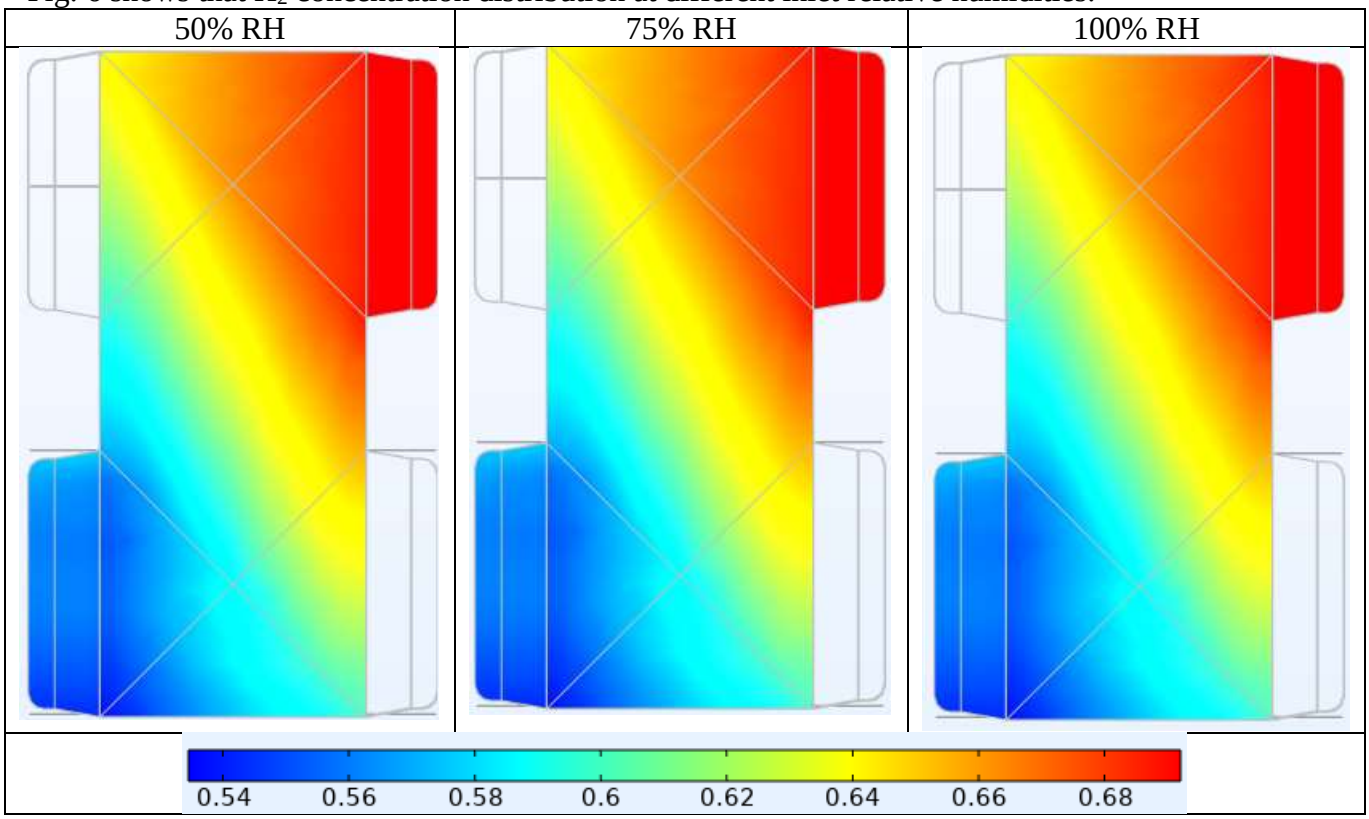

Fig. 6. H_2 concentration distribution at different inlet relative humidities

Fig. 7 shows that O_2 concentration distribution at different inlet relative humidities.

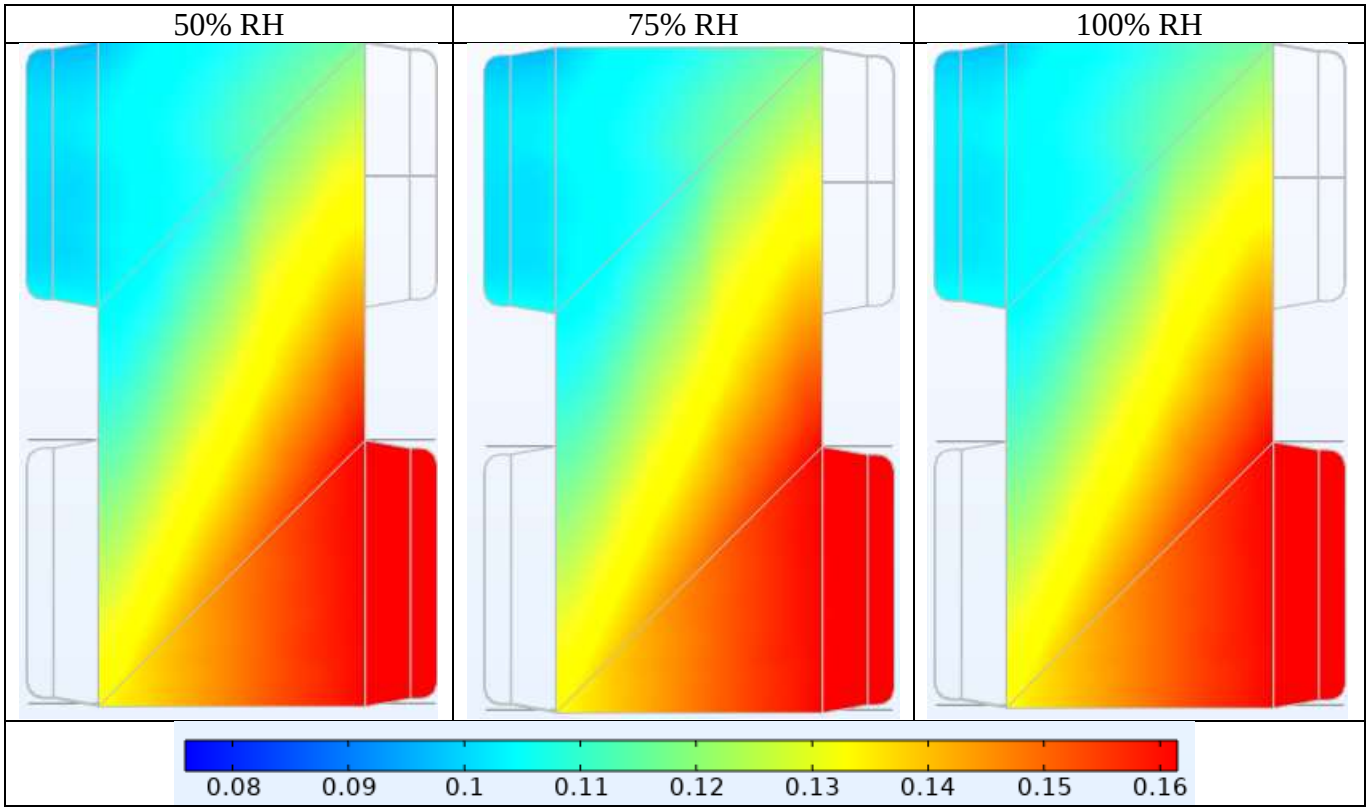

Fig. 7. O_2 concentration distribution at different inlet relative humidities

Fig. 8 shows that H_2O concentration distribution at different inlet relative humidities.

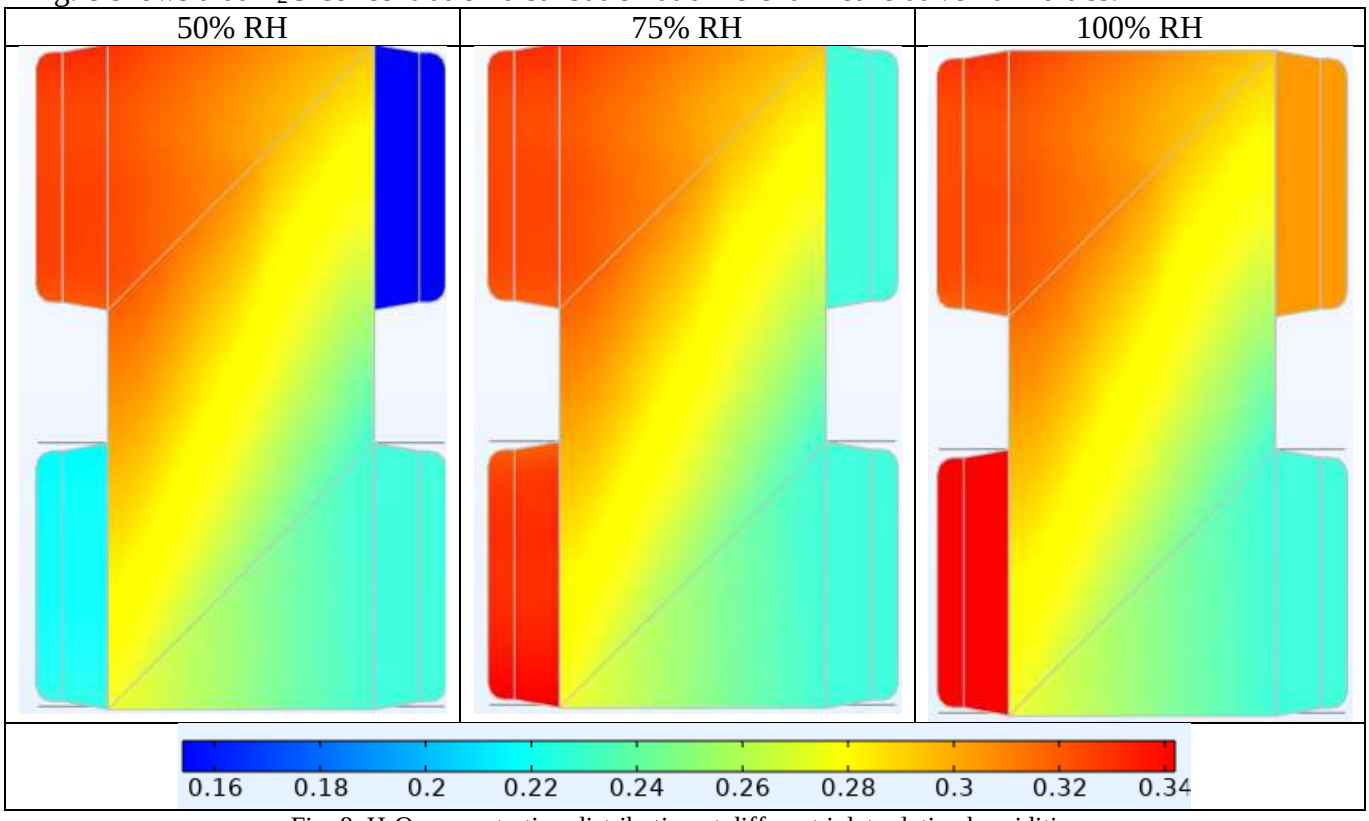

Fig. 8. H_2O concentration distribution at different inlet relative humidities

Fig. 9 shows that polarization curve at different inlet relative humidities

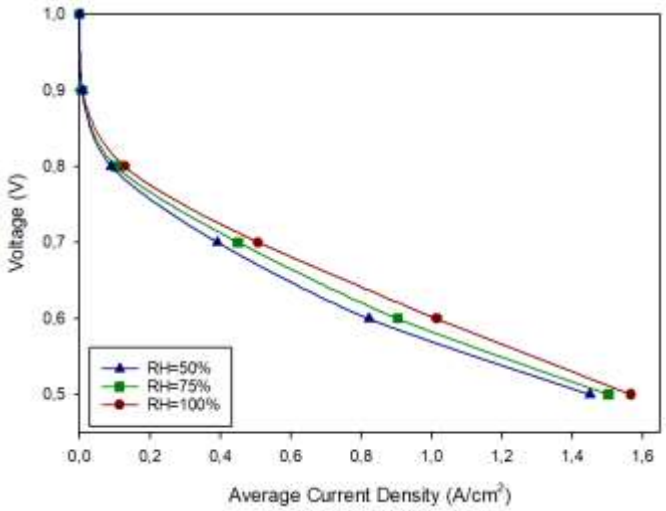

Fig. 9. shows that polarization curve at different inlet relative humidities.

IV. DISCUSSION

In a PEM fuel cell stack, at 30°C, the hydrogen molecules are less active, leading to lower reaction rates and power output. At 50°C, the hydrogen activity increases, improving reaction efficiency and performance. At 70°C, hydrogen molecules are highly active, optimizing reaction rates but requiring effective heat management to maintain stability. At 30°C, oxygen diffusion is relatively slow, resulting in lower reaction rates and efficiency. At 50°C, oxygen diffusion improves, enhancing the overall reaction kinetics and cell performance. At 70°C, oxygen diffusion is optimal, significantly boosting reaction rates, but it necessitates effective thermal management to prevent overheating and ensure stability. As temperature increases in a PEM fuel cell stack, water molecule distribution shifts. Lower temperatures result in moderate water production with a risk of cell flooding. With rising temperatures, water production increases, enhancing proton conductivity but requiring efficient management to balance membrane hydration and avoid flooding. At higher temperatures, water production peaks, optimizing proton transport but necessitating advanced water and thermal management to ensure stable performance and prevent degradation.

As relative humidity increases from 50% to 100%, hydrogen and oxygen diffusion improve, enhancing reaction rates and overall performance. However, the risk of water flooding also rises, requiring effective water management to maintain optimal cell function.

Increasing temperature improves the polarization curve by reducing activation and ohmic losses, but optimal temperature management is essential to prevent overheating. Similarly, increasing relative humidity enhances the curve by improving proton conductivity and reducing activation and ohmic losses; however, effective water management is necessary to avoid flooding and maintain optimal performance.

The combined increase in temperature and relative humidity can significantly improve PEM fuel cell performance, but it requires careful balancing to avoid negative effects on the polarization curve, especially at high current densities.

V. CONCLUSION

In a PEM fuel cell stack, as temperature increases, hydrogen and oxygen activity rises, improving reaction rates and efficiency. Effective heat management is crucial for stability, especially at higher temperatures. Similarly, increasing relative humidity enhances performance by improving proton conductivity, but careful water management is necessary to prevent flooding. Optimizing both temperature and humidity can significantly boost fuel cell performance, but it requires careful balancing to avoid negative impacts on the polarization curve, particularly at high current densities.

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The Line of Yoghurt Production of Türkiye: Forecasting with Box-Jenkins Model

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Abstract – Yoghurt is a fermented milk product that stands out among dairy products with its nutritional value and health benefits. In this study, the trend of Yoghurt production in Türkiye is analyzed by time series analysis. Time series data on Yoghurt production are obtained from the Turkish Statistical Institute (TurkStat). The data include annual and monthly Yoghurt production quantities and are made available for analysis. The data are between January 2010 and March 2024. All analyses were performed in R programme.

Keywords – Production of Yoghurt, TurkStat , Time Series.

I. INTRODUCTION

Yoghurt, a dairy product cherished and consumed globally, has its roots deeply embedded in Türkiye, which is hailed as the birthplace of this beloved traditional food item, boasting a rich historical and cultural heritage. The production of yoghurt not only holds a significant position in the Turkish economy but also shines as a nutritional powerhouse, offering a plethora of health benefits. This comprehensive research delves into the intricate details of the historical evolution, intricate production processes, substantial economic contributions, and the prevailing challenges encountered in the realm of yoghurt production within the Turkish borders. Through the lens of time series analysis, a meticulous evaluation of the yoghurt production landscape in Türkiye will be meticulously conducted.

Delving into the historical aspects and the cultural significance of Yoghurt, it is imperative to acknowledge the origins of this revered dairy product. Tracing back its beginnings to the ancient Turkish communities of Central Asia, the ingenious fermentation techniques devised by the nomadic Turkish tribes aimed at the preservation and storage of milk laid the foundation for the creation of yoghurt. Through a natural fermentation process, milk metamorphosed into the creamy goodness of yoghurt, gradually gaining popularity and traversing vast geographical regions over time.

The profound intertwining of yoghurt with the tapestry of Turkish culture is a testament to its indispensable role in the daily dietary practices of the populace. Embedded in the fabric of Turkish cuisine, yoghurt serves as a versatile ingredient, seamlessly incorporated in an array of culinary delights ranging from hearty breakfast spreads to tantalizing main courses, delectable appetizers, and luscious desserts. Moreover, the myriad health benefits attributed to yoghurt, including its probiotic properties and its prowess in aiding digestion, further accentuate its significance within the rich tapestry of Turkish culinary traditions.

II. YOGHURT PRODUCTION PROCESS IN TURKIYE

Raw Materials and Preparation Stages: The process of yoghurt production in Türkiye commences with the sourcing of raw materials, primarily milk. Although cow's milk is the preferred choice for yoghurt production in this region, there is also utilization of sheep, goat, and buffalo milk in certain areas. The procurement of milk is a critical step emphasizing the significance of hygiene and quality control measures. Upon arrival at the production facilities, the milk undergoes the initial stage of pasteurization.

Pasteurization: The pasteurization stage is implemented to eliminate any harmful microorganisms present in the milk. This vital process involves heating the milk to a specific temperature followed by rapid cooling. Through this method, the milk becomes safe for consumption while creating an optimal environment conducive to the fermentation process.

Fermentation Process: Yoghurt Cultures Central to the fermentation process are the essential yoghurt cultures, comprising Lactobacillus bulgaricus and Streptococcus thermophilus bacteria. These particular bacteria play a crucial role in converting milk lactose into lactic acid, thereby reducing the pH level of the milk and imparting the distinctive texture and flavor associated with yoghurt.

Fermentation Conditions: The pasteurized milk is then inoculated with the yoghurt cultures within a specific temperature range, typically maintained between 40-45°C. Subsequently, the milk is placed in incubation chambers for a duration of 4-6 hours. Throughout this incubation period, the bacteria proliferate within the milk, facilitating the fermentation process. Upon completion of fermentation, the yoghurt is cooled and left to rest.

Packaging and Storage: Upon the conclusion of the fermentation stage, the yoghurt undergoes packaging in readiness for the end consumer. Plastic containers are the conventional choice for packaging yoghurt in Türkiye, although occasionally glass or clay containers are also utilized. The packaging procedures are meticulously conducted under hygienic conditions to ensure the preservation of freshness and extend the shelf life of the yoghurt.

III. ECONOMIC IMPORTANCE

Yoghurt Consumption in Domestic Market

The consumption of yoghurt in Turkey is significantly high, surpassing the world average with an annual per capita consumption of around 30 kg. Yoghurt, being a food item favored across all age demographics, is predominantly chosen for its nutritional richness and the associated health advantages it offers to consumers.

Export and International Markets

Within the global landscape, Turkey holds a prominent position in the production of yoghurt, boasting a substantial potential for exports. Yoghurt from Turkey finds its way to numerous nations, particularly those in the Middle East, Europe, and Central Asia. The exportation of Turkish yoghurt plays a dual role in bolstering the economy and showcasing the cultural heritage of Turkey on an international platform.

Economic Contributions

The production of yoghurt emerges as a significant economic contributor to the agricultural and livestock sectors within Turkey. The presence of milk producers, yoghurt manufacturing units, and packaging facilities plays a pivotal role in stimulating local economies through employment generation. Moreover, the production and exportation of yoghurt further enhance the national economy by bolstering foreign exchange reserves.

IV. Challenges Faced

Milk Supply Chain Problems

Issues along the milk supply chain exert adverse impacts on the production of yoghurt. Challenges faced by milk producers in adhering to stringent hygiene and quality norms often lead to disruptions in the production cycle. Furthermore, fluctuations in milk output due to seasonal variations may result in shortages of raw materials for yoghurt manufacturing.

Hygiene and Quality Control Problems

The realm of yoghurt production underscores the utmost significance of hygiene and quality control measures. Any lapses in upholding hygiene standards during production processes can culminate in diminished product quality and undermined consumer trust. Therefore, the meticulous implementation of hygiene and quality control protocols stands as essential in the realm of yoghurt production.

Unregistered Production and Non-Standard Products

The unregistered production of yoghurt within Turkey emerges as a substantial menace to the sector. Unregistered yoghurt manufacturers jeopardize consumer well-being by flouting hygiene and quality standards. Furthermore, the proliferation of non-standard yoghurt products in the market adversely impacts the competitiveness of duly registered producer.

V. Time Series models

A. The Data

The data set utilized in the study encompasses detailed information pertaining to the production of yoghurt in tons, which has been systematically collected on a monthly basis spanning from the period of January 2010 to March 2024. This valuable data was meticulously compiled and reported by the esteemed Turkish Statistical Institute, known as TurkStat, in the year 2024. The methodologies employed in this research endeavor entailed the development of various models through the utilization of well-established and widely acknowledged approaches within the field.

B. Time Series Analysis

These methodological approaches encompass a thorough assessment of the stationarity of the data set, the meticulous selection of models based on the analysis of the Automatic Correlation Function (ACF) and Partial Automatic Correlation Function (PACF), as well as the execution of diagnostic tests on the models through the implementation of comprehensive residual analyses. The resultant models derived from the application of these sophisticated techniques exhibited commendable predictive capabilities, effectively aligning with the inherent characteristics and patterns encapsulated within the data set.

The depiction of a time series serves as a visual tool that presents a graphical manifestation of the various data points gathered at specified time intervals, oftentimes in a consistent manner, with the primary aim of illustrating the fluctuations in a particular variable over a period of time. This method enables researchers to discern trends, detect patterns, and analyze behaviors encapsulated within the dataset. Initially, the investigation commenced with the acquisition of the time series plot portraying the production of yoghurt in the nation of Turkey. To facilitate this task, the functionality of the '*autoplot*' package within the R programming software was harnessed for the creation of the aforementioned visualization [1]

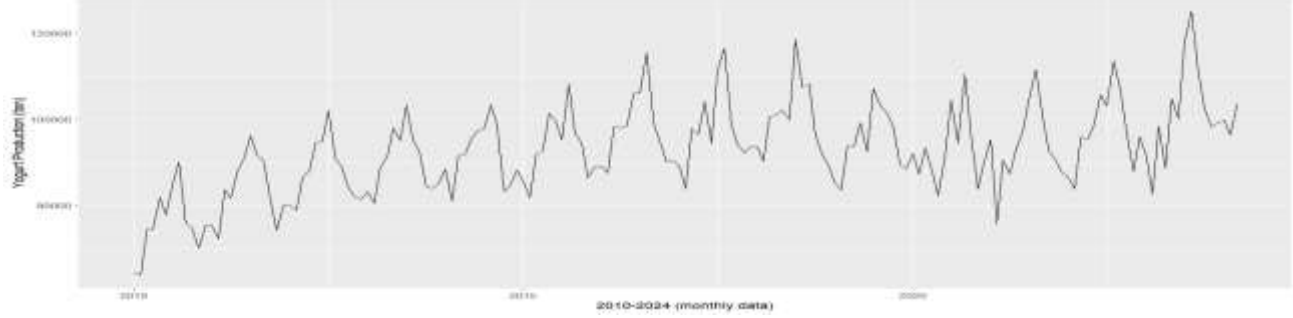

Figure 1. Time Series production of Turkiye's Yoghurt Production

B.1. Components of Time Series

Upon closer examination of the graph presented in Figure 1, it becomes apparent that the data illustrating the production of yoghurt in Turkey does not display characteristics of stationarity. Moreover, the graph suggests the presence of a noticeable trend in the production levels of yoghurt in the Turkish market.

Time series analysis is a comprehensive methodology that encompasses various crucial components which play a significant role in understanding and interpreting the dynamics of time-dependent data patterns. One of these fundamental components is Trent, which delineates the intricate movement exhibited by a series as it undergoes alterations in its values over a specified duration, either by escalating or diminishing over time. This aspect provides valuable insights into the directional trends and tendencies within the series, offering a deeper comprehension of its underlying behavior and fluctuations.

Another pivotal element within time series analysis is Seasonality, a concept that holds paramount importance due to its influence on the fluctuations observed within a series based on recurring factors such as annual, monthly, or weekly occurrences. These periodic influences can significantly impact the overall trajectory of the series, leading to distinctive patterns and variations that need to be meticulously analyzed and accounted for in order to derive accurate and reliable interpretations.

Furthermore, Heteroscedasticity emerges as a critical component within time series analysis, highlighting the variability in the error term's variance in correlation with changes transpiring in the independent variable. This phenomenon signifies the presence of fluctuating variances, indicating a dynamic relationship between the error term and the independent variable. Conversely, when the variance remains constant despite changes in the independent variable, it signifies a scenario characterized by consistent variance, which entails a different set of implications and considerations in the analysis of the time series data.

Trend: $T_t = \beta_1 + \beta_2 t$

Seasonality: $S_t = \beta_1 \sin(\frac{t\pi}{2})$

Heteroscedasticity: $I_t = \beta_1 I_{t-1} + e_t$

B.2. Autocorrelation Function

The Autocorrelation Function is a statistical tool used to quantify the presence and strength of correlations within a time series data. Autocorrelation, on the other hand, delves into the linear relationship that exists between lagged values within the same time series. This means that autocorrelation examines how past values of a variable are related to its current value, providing insights into patterns and trends that may persist over time. To illustrate, an autocorrelation coefficient such as r1 elucidates the connection between the current observation (yt) and the immediately preceding observation (yt-1), capturing the extent to which they move in tandem. Similarly, r2 extends this analysis to encompass the relationships among yt-1, yt-2, and potentially further lagged values, unveiling deeper insights into the underlying mechanisms governing the time series data.

$$r_k = \frac{\sum_{t=k+1}^{T} (y_t - \bar{y})(y_{t-k} - \bar{y})}{\sum_{t=1}^{T} (y_t - \bar{y})^2}$$

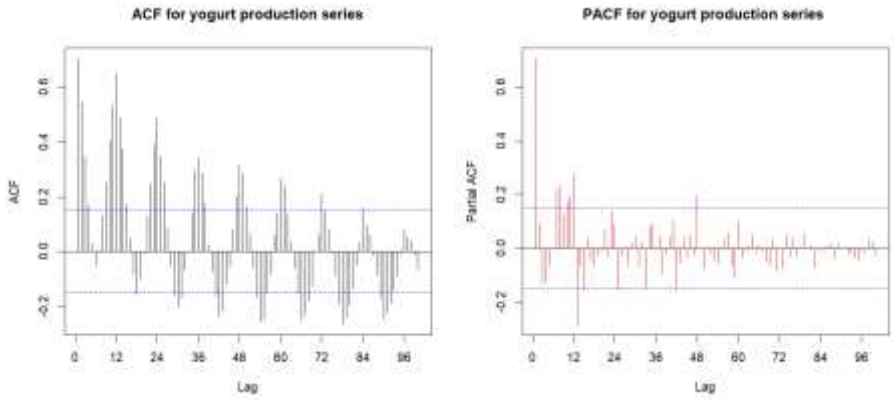

Figure 2. ACF and PACF graphs

In Figure 2, the confidence limits are visually represented by the blue lines in order to provide a clear indication of the statistical significance of the data points. Upon close examination of the ACF graph presented above, it becomes evident that the ACF graph pertains to a dataset that exhibits a discernible trend in its values over time. Specifically, when focusing on the initial 4 lags of the autocorrelation function, it is observed that these lags fall outside the established confidence limits.

B.2. Seasonal-subseries graph

One effective approach for visualizing the temporal patterns within a dataset is through the construction of a seasonality graph. This graphical representation facilitates a clearer observation of the recurring seasonal trends present in the data. To generate such visualizations, the *ggseasonplot()* function from *forecast* package is commonly employed for this specific purpose [2].

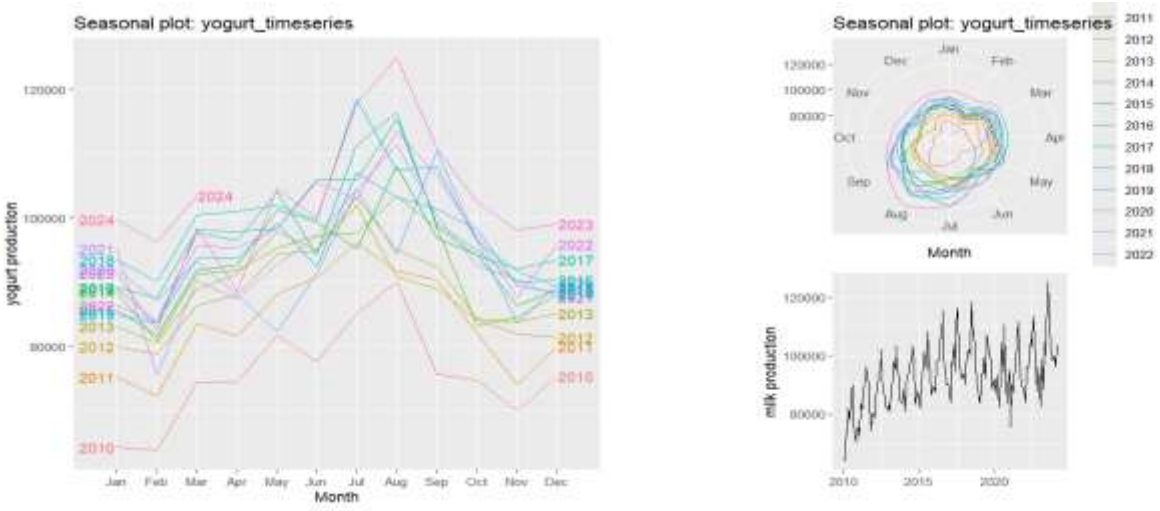

Figure 3. Seasonal-subseries plot

The series will be decomposed into its basic components before being evaluated objectively using the Friedman rank test. Initially, the stl() function was used to break down the series into its constituent pieces. Figure 5 shows the decomposition of the time series graph using the *autoplot()* function.

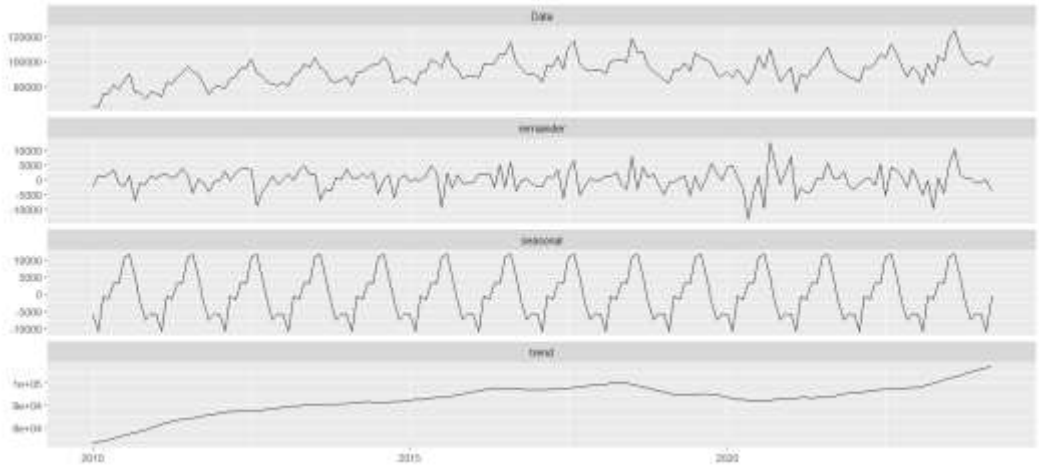

Figure 5. Decomposition of time series

Friedman test was used to determine whether the series contains seasonality. According to the test result, it was decided that the series contains a seasonality component ($p<0.05$). Due to the presence of seasonality in time series data, the study used the *seasadj()* function, which is part of the '*forecast*' package in R, to efficiently lessen the effect of seasonality on the series.

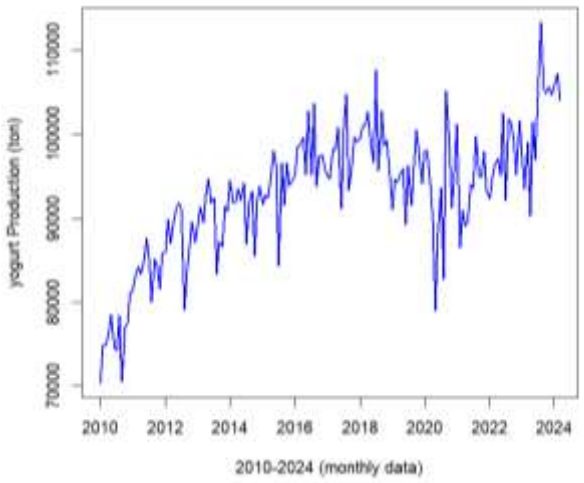

Figure 6. Time series plot of seasonally adjusted series

B.3. Stationary

In the realm of time series analysis, the term 'stationarity' pertains to the notion that the statistical characteristics of a time series exhibit consistency across various time instances. Working with stationary series in time series analysis enhances the reliability of outcomes. When dealing with non-stationary series, they can be converted into stationary series through methods like data manipulation (e.g. log or Box-Cox transformation) or differencing, ultimately facilitating the commencement of forecasting analysis. Various techniques have been devised for evaluating stationarity, known as Unit Root Tests. Among the commonly utilized unit root tests are the Augmented Dickey-Fuller (ADF) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests [3,4]. The primary objective of the ADF unit root test is to verify the absence of autocorrelation in errors, thereby permitting the incorporation of lagged values of the dependent variable into the model.

The KPSS test was initially proposed in 1992 by Kwiatkowski, Phillips, Schmidt, and Shin. Three categories—deterministic trend, random walk, and stationary error—may be distinguished from the time series according to the test's underlying assumptions. In this study, according to the ADF test, no stationarity was observed in the series ($p>0.05$), but according to the KPSS test, stationarity was obtained ($p<0.05$).

B.3. Trend Analysis

The p value being less than the significance level of alpha=0.05 indicates the presence of a statistically significant trend component in the series. Subsequently, Sen's slope estimator [5] was utilized to estimate the magnitude of this trend following the aforementioned observation. The series under investigation in this research exhibits characteristics of being seasonally adjusted, trending upwards, and non-stationary. To assess stationarity, the variable underwent a first difference transformation. ADF testing utilizing the "diff_samp" object was conducted for this purpose. The application of this test on the first difference data indicated the presence of stationarity within the dataset. The output of the Sen's slope indicates that there is a statistically significant annual increase of about 1% over the preceding year.

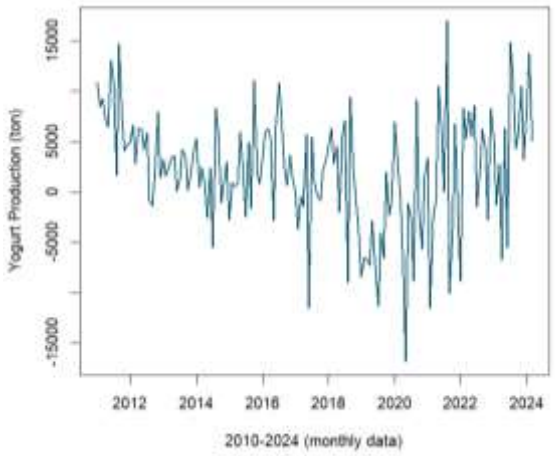

Figure 8. Plots of de-trending and stationarised series

C. Forecast with Box and Jenkins

The ARIMA/SARIMA, which stands for Autoregressive Integrated Moving Average/Average Seasonal model, developed by Box and Jenkins, provides a sophisticated framework for predicting future values by considering various components such as trend and seasonality within time series datasets. The ARIMA(p,d,q) model consists of three key elements: autoregressive (p) component capturing the relationship between an observation and a number of lagged observations, differencing (d) component to address non-stationarity by removing trends, and moving average (q) component which models the error term as a linear combination of the error terms observed at previous time points. The *auto . arima()* function in the *forecast* package was used in the study to obtain results more quickly and easily. The estimated values obtained with the *auto.arima()* function are as follows:

Table 1. Forecast for *autoarima* model

	PointForecast	Lo80	Hi80	Lo95	Hi95
Apr2024	11910.178	6042.561	17777.794	2936.433	20883.92
May2024	4381.386	-1625.779	10388.550	-4805.780	13568.55
Jun2024	8079.159	1935.615	14222.702	-1316.581	17474.90
Jul2024	1840.237	-4436.723	8117.198	-7759.546	11440.02
Aug2024	-1597.730	-8005.330	4809.871	-11397.309	8201.85
Sep2024	3953.870	-2581.759	10489.499	-6041.512	13949.25
Oct2024	4137.895	-2523.303	10799.093	-6049.528	14325.32
Nov2024	3163.670	-3620.772	9948.112	-7212.239	13539.58
Dec2024	4025.079	-2880.409	10930.567	-6535.953	14586.11
Jan2025	3348.603	-3675.688	10372.894	-7394.122	14091.33
Feb2025	1823.667	-5317.549	8964.884	-9097.881	12745.22
Mar2025	4512.292	-2743.967	11768.550	-6585.198	15609.78
Apr2025	4792.074	-2796.850	12380.999	-6814.185	16398.33
May2025	3017.893	-4588.565	10624.352	-8615.181	14650.97
Jun2025	3889.284	-3734.668	11513.236	-7770.544	15549.11

Jul2025	2419.065	-5222.340	10060.470	-9267.456	14105.59
Aug2025	1608.898	-6049.920	9267.717	-10104.254	13322.05
Sep2025	2917.148	-4759.045	10593.341	-8822.576	14656.87
Oct2025	2960.514	-4733.013	10654.042	-8805.721	14726.75
Nov2025	2730.935	-4979.888	10441.759	-9061.751	14523.62
Dec2025	2933.929	-4794.152	10662.009	-8885.151	14753.01

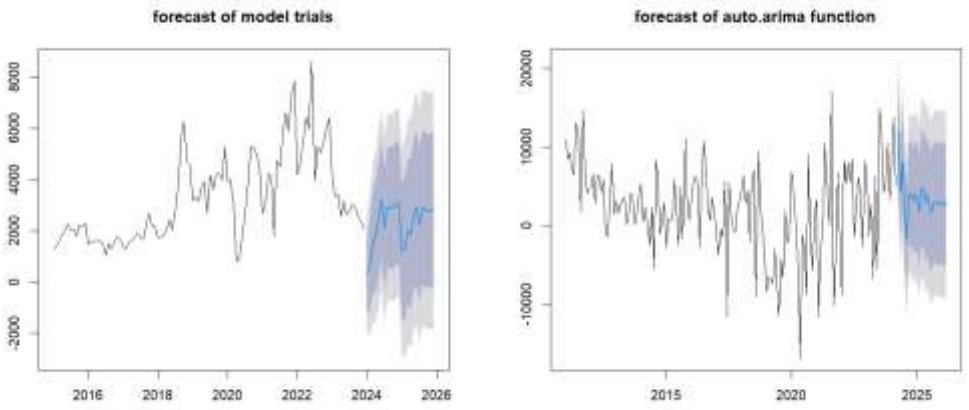

Figure 9. Graph for production of yoghurt in Türkiye from April 2024 to December 2025.

VI. CONCLUSION

Yoghurt production in Turkey is culturally and economically significant. Time series analysis helps understand production changes and make future forecasts. This study uses time series analysis to reveal trends, fluctuations, and provide future forecasts for yoghurt production. The findings can assist producers and policy makers in strategic decision-making.

Recommendations for improving yoghurt production: 1. Enhance Milk Supply Chain to ensure sustainability and quality. 2. Implement strict hygiene and quality controls to maintain product quality and consumer trust. 3. Boost Export Potential by enhancing competitiveness in international markets. 4. Invest in Research and Development for efficiency and innovation in yoghurt production. 5. Conduct Training and Awareness Campaigns for milk and yoghurt producers to enhance hygiene and quality awareness. These recommendations aim to promote sustainable development and increase economic value in the yoghurt production sector in Turkey.

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Contribution of Machine Learning Technologies to Genomic Prediction in Animal Breeding

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Abstract **–** The introduction of modern genotyping technologies has brought about a significant transformation in the field of genomic selection within the realm of animal breeding. In recent times, there has been a notable surge in interest towards the utilization of machine learning models in the domain of animal breeding, primarily owing to their remarkable adaptability and their adeptness in discerning intricate patterns within extensive and noisy datasets. In this discourse, we aim to present a comprehensive and overarching delineation of a select few machine learning algorithms, elucidating their roles and applications in the sphere of genomic prediction. This exposition seeks to furnish a holistic perspective on the efficacy and utility of these algorithms in the context of genomic estimated breeding values estimation, genotype imputation, and feature selection.

Keywords – Machine learning, Genomic prediction, Animal.

I. INTRODUCTION

Since the advent of agriculture, a decade of millennia in the past, various techniques including selective breeding, originating from the initial stages of animal domestication and gradually evolving and being utilized throughout the ages, as well as genomic selection, a concept that has garnered increasing attention in contemporary times, have brought about a significantly crucial and efficient transformation in the realm of livestock.

For ages, the process of choosing the most high-performing animals for breeding purposes has traditionally relied on observable characteristics. In the 20th century, a range of statistical approaches has emerged to forecast the reproductive worth of animals. These methods include the selection index and the Mixed Model Equations (MME). The evolution of computational capabilities has notably contributed to the establishment of the Best Linear Unbiased Prediction (BLUP) by Henderson in 1984. Consequently, this has facilitated precise decision-making in selection processes as highlighted by [1] in 2016.

With the development of molecular genetics, studies on molecular methods in selection have increased. Several studies have been conducted aiming to identify specific regions within the genome that are crucial in explaining variations in genetic traits referred to as Quantitative Trait Loci (QTL). Subsequently, between the 1980s and 2000s, various approaches were suggested for marker-assisted selection (MAS) research, which integrate details on QTL in the MME as constant factors. Consequently, the estimation of breeding value involves the summation of the predicted impacts of each QTL.

However, the scattered distribution of genetic markers in linkage disequilibrium with Quantitative Trait Loci throughout the population has constrained the efficacy of incorporating QTL in the assessment of breeding values. Additionally, it has been noted that quantitative characteristics are impacted by numerous QTL with minimal individual effects. [2] Meuwissen et al. (2001) introduced a multi-QTL strategy, termed genomic selection, which computes breeding values utilizing a dense array of genetic markers. Genomic

selection proposes that forecasting the impacts of a substantial number of single nucleotide polymorphisms (SNPs) across the genome will streamline breeding value estimation without prior knowledge of gene positions on the genome [3].

Various statistical methodologies, such as Genomic Best Linear Unbiased Prediction (GBLUP) or Bayesian approaches incorporating different prior assumptions, have been devised for the estimation of markers' effects and, by extension, the genomic breeding values of individuals. Nonetheless, these traditional methodologies have not been equipped to account for non-additive effects such as epistasis and genotype interactions [4], factors that can exert significant influence on phenotypic outcomes in animal populations. Moreover, the escalating volume of marker data resulting from genotyping efforts exacerbates the challenge known as the "curse of dimensionality" or the "large P, small N" scenario [5]. As a result, conventional linear models have become increasingly insufficient in capturing underlying patterns and elucidating the intricate relationships embedded within this vast pool of noisy data.

In recent times, the advancement of machine learning (ML) algorithms alongside the simultaneous increase in computational processing capabilities has caused a stir within the academic community. The flexibility of ML models is widely recognized, as well as their capacity to uncover concealed patterns within extensive and noisy datasets. Consequently, the utilization of machine learning models in genomics has been scrutinized in numerous research endeavors.

II. MACHINE LEARNINGS (ML)

Machine learning is divided into four categories: supervised learning, unsupervised learning, semi-supervised learning, and reinforcement learning. Supervised learning is made up of a data set with independent variables and an objective variable, also known as the dependent variable. In contrast, unsupervised learning does not have a specified objective variable to concentrate on during the learning process. Semi-supervised learning, as the name implies, uses only a subset of the training data that contains target labels. Finally, unlike unsupervised learning, reinforcement learning involves data with fewer labels.

A. Popular machine learning models for genomic prediction

A.1. Linear Regression

In linear regression, which explains the mathematical expression of the relationship between two variables, if there is more than one independent variable, these relationships are defined as multivariate linear regression (MLR). Linear regression is classified as a supervised learning algorithm. For linear regression, the least squared error (LSE) loss function is most frequently used. Basic function of MLV is [6]:

$$y = \beta_0 + \beta_0 x_1 + ... + \beta_m x_m + \varepsilon$$

A.2. Logistic Regression

In logistic regression where the dependent variable is categorical or binary, unlike linear regression, there is no linear relationship between dependent and independent variables. The loss function in logistic regression is Maximum likelihood estimation (MLE). g is a sigmoid function and the logistic regression hypothesis is defined as :

$$g(z) = \frac{1}{1+\varepsilon^{-z}} \quad \text{and} \quad h_\theta(x) = g(\theta^T x)$$

A.3. Decision Trees

Decision Trees, referred to as Classification and Regression Trees (CART), are recognized as a widely utilized supervised learning algorithm that relies on iterative partitioning [7]. The fundamental principle of this methodology involves dividing a sizable heterogeneous dataset into numerous smaller homogeneous subsets, resulting in a tree-like structure.

A.4. Ensemble learning

A.4.1. Bootstrap aggregating: Bootstrap aggregating, known as bagging in the literature, represents a machine learning ensemble meta-algorithm crafted with the objective of enhancing the stability and precision of machine learning algorithms employed in statistical classification and regression tasks. Furthermore, it serves the purpose of diminishing variance and mitigating the risk of overfitting.

A.4.2. Random forest: Random forests, also known as random decision forests, represent an ensemble learning technique utilized for classification, regression, and various other tasks. This method functions by creating numerous decision trees during the training phase.

A.4.3. Boosting: A type of ensemble meta-algorithm used mainly in machine learning to lower variance and bias is called boosting. A family of machine learning algorithms that turns weak learners into strong learners and supervised learning both use it [8]

A.5. Kernel-based algorithms

A.5.1. Reproducing kernel Hilbert spaces (RKHS): In plant and animal breeding, one of the first statistical machine learning techniques proposed for use was Reproducing Kernel Hilbert Spaces (RKHS) regression [9] for the complex trait prediction. When all of the evaluation functionals in a Hilbert space of functions are bounded linear functionals, the space is called an RKHS. Projecting the original input data, which is contained in a finite-dimensional vector space, onto an infinite-dimensional Hilbert space is the basic idea behind RKHS methods. With the kernel method, the data is first transformed using a kernel function, and then traditional statistical machine learning techniques are applied to the transformed data in the hopes of achieving better outcomes. For the analysis of nonlinear patterns in data sets from a variety of academic disciplines, techniques based on implicit transformations (RKHS methods) have grown in popularity. In addition, the utilization of kernel functions has emerged as a proficient substitute for acquiring similarity indices among objects lacking a vector representation. The Reproduced Kernel Hilbert (RKHS) was first applied on marker genotypes by [10].

A.5.2. Support vector machines: One powerful machine learning algorithm that is used for both linear and nonlinear classification, regression, and even outlier detection is the Support Vector Machine (SVM). The SVM algorithm's main goal is to locate the best hyperplane in an N-dimensional space that can be used to efficiently divide data points into various feature space classes. The hyperplane aims at maximizing the difference between the closest points that belong to different classes. The hyperplane's dimension depends on how many features are there. When using the SVM algorithm for regression tasks, a distance metric must be included in the loss function. The Huber, Laplacian, quadratic, and insensitive loss functions are potential loss functions [11].

A.6. Nearest neighbors

One non-parametric supervised learning technique is the k-nearest neighbors algorithm (k-NN). It is applied to regression and classification. This method's concept is to predict, using the distance between xi and other data points, the value of a target variable (y_i) associated with an input variable (x_i). Although the Euclidean distance is typically utilized, there are alternative ways to compute this distance, including the Manhattan distance [12].

A.6. Deep neural networks

Deep neural networks (DNNs) perform exceptionally well in a wide range of machine learning applications. DNNs outperform standard machine learning techniques like support vector machines, perceptrons, decision trees, and k-nearest neighbors in terms of extracting features at multiple levels of abstraction and learning more complicated patterns. The DNN model consists of a fixed number of layers, each with many neurons. Each neuron is linked to neurons in adjacent layers using weights that reflect the strength and direction of the connection (excitatory or inhibitory) [13]. Deep learning consists of the following three structures: multilayer perceptron (MLP), recurrent neural networks (RNN)

andconvolutional neural networks (CNN). A multilayer perceptron (MLP) is a feed-forward network with completely interconnected layers. The information flows in one direction. In Recurrent Neural Networks (RNN), information flows in both directions. Convolutional Neural Networks (CNN) were developed for handling conditions when data is represented in the form of numerous arrays [14].

III. CURRENT MACHINE LEARNING RESEARCH IN GENOMIC PREDICTION

Machine learning models play a crucial role in genomics due to their various significant applications. By leveraging advanced algorithms and computational models, ML can undergo training utilizing extensive datasets containing genotypes and phenotypes to forecast the breeding values of animals for specific traits. Consequently, this capability facilitates the precise selection of animals exhibiting the highest genetic merit, thereby empowering breeders to make more informed decisions regarding breeding strategies. The utilization of ML models has proven to be successful in the realm of predicting genomic breeding values across a diversity of animal species such as dairy cattle [15], beef cattle [16], pigs [17], and broilers [18]. The calculated Genomic Estimated Breeding Values (GEBVs) serve as a reliable means to predict the genetic potential of animals, aiding in the identification of individuals with exceptional genetic capabilities surpassing the average of the population. As a result, the integration of ML models proves to be instrumental in enabling breeders to make more accurate breeding decisions, ultimately accelerating genetic advancements.

[18] employed the F-metric model, kernel regression, reproducing kernel Hilbert spaces (RKHS) regression, and Bayesian regression methods to predict mortality in broilers and assess their performance in comparison to the conventional genetic assessment (E-BLUP), which relies solely on pedigree data. The dataset encompassed information on mortality rates for 12167 offspring from 200 sires, with a total of 5523 SNPs. The researchers deduced that kernel regression and RKHS regression exhibited a diminished residual sum of squares and enhanced accuracy by a margin of 25% to 150% in relation to alternative approaches. Consequently, the researchers advocated for their applicability in the genomic prognosis of premature mortality in broilers.

[19] introduced a novel kernel-based algorithm called Cosine Kernel-based Ridge Regression (KcRR) for the purpose of conducting genomic prediction utilizing both simulated and actual datasets. The findings revealed that KcRR exhibited the highest level of prediction accuracy compared to other methodologies. Furthermore, it demonstrated consistent performance across all traits and genetic structures, thus validating its dependability and resilience.

A boosting algorithm known as L2-Boosting was proposed by [20] as a method to predict the transmitting abilities for the length of productive life (PL) in a dataset of dairy cattle, along with the records of average food conversion rate in a dataset of broilers. The authors conducted a comparison between the performance of ordinary least squares (OLS)-Boosting and nonparametric (NP) regression-Boosting against Bayesian LASSO (BL) and Bayes A regression. The ultimate conclusion drawn by the authors was that L2-Boosting, when paired with an appropriate learner, emerges as a viable alternative for genomic prediction, exhibiting high accuracy and minimal bias within a concise computational timeframe.

[21] undertook a study where they evaluated the effectiveness of Adaboost RT, SVR, KRR, and RF in comparison to the traditional GBLUP in predicting breeding values related to growth traits in Chinese Simmental cattle, such as carcass weight, live weight, and eye muscle area. This investigation involved a dataset comprising 1,217 young bulls with a total of 671990 SNPs. In contrast to prior research, the authors advocated for the utilization of machine learning methods as opposed to GBLUP. Overall, Liang et al. (2021) observed a significant benefit in employing ML algorithms for Genetic Prediction (GP) in Simmental beef cattle, particularly highlighting the reliability of Adaboost.RT. Nonetheless, they also highlighted the sensitivity of ML models to variations in data, which implies that predictive accuracy can significantly differ between two distinct datasets.

In a separate research endeavor, [22] crafted a multi-layer perceptron tailored for the prediction of yield and fertility traits within a cohort of 92 genotyped Holstein heifers, leveraging a set of pivotal input variables termed as "Key traits". These encompass Milk Yield, Fat Yield, Protein Yield, Somatic Cell Score (SCS), Productive Life (PL), Daughter Pregnancy Rate (DPR), Daughter Calving Ease (DCE), Final Type

(PTA Type), and Genomic Future Inbreeding (GFI). The outcomes of the study by Beskorovajni et al. (2022) revealed that the Artificial Neural Network (ANN) structured as network MLP 9-11-11, optimized using the Broyden-Fletcher-Goldfarb-Shanno algorithm, adeptly conformed to the data patterns and exhibited proficiency in predicting yield and fertility traits.

IV. CONCLUSION

Machine learning algorithms have shown considerable adaptability and proficiency in identifying patterns in extensive and dispersed datasets in various fields. The field of genomic prediction has a notable challenge with an ever-expanding marker dataset, management of this dataset, identification of interactions between genotypes and non-additive effects. There is a growing interest in the animal breeding community to explore the applicability of machine learning algorithms in genomic prediction. While machine learning models offer flexibility and robustness, they are not without limitations. Overfitting is a common problem in machine learning, along with the complexity of optimising hyperparameters and the requirement of large training datasets, especially for training deep learning models. Combining machine learning algorithms with biological expertise undeniably yields valuable results. Essentially, machine learning algorithms show significant promise in effectively capturing and discerning patterns from extensive and noisy datasets. However, the integration of these algorithms in animal breeding is still in its infancy and requires further research to reveal new insights in genomic prediction. The underutilisation of machine learning in animal breeding has prevented researchers from fully realising the significant potential these models have in improving genomic prediction of important traits. Therefore, iterative approaches should be applied on a continuous basis.

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Equivalent circuit model analysis of symmetrical rGO/MnO_2 nanocomposite electrodes for supercapacitors

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Abstract – In this study, rGO/MnO_2 nanocomposite was presented for 4 different equivalent circuit model evaluations. It was set up with a 2-electrode system on stainless steel electrode for rGO/MnO_2 nanocomposite. The simulation programme of ZSimpWin 3,22 was used for equivalent circuit model of R(QR), RQ, R(CR), LR(QR). In addition, the circuit parameters of (L, R, C, Q, etc.) in each circuit parameters were explained specifically for each circuit.

Keywords – Equivalent circuit model, supercapacitor, reduced graphene oxide, MnO_2, constant phase element

I. INTRODUCTION

As the rapid decreasing of fossil fuels is causing severe concerns on both sustainable civilization and environmental pollution, so it is the most promising solutions is to develop new energy storage devices, such as photovoltaics [1], photoelectrochemical cells [2] and supercapacitors [3].

Supercapacitors are devices that store high energy density because they have greater charge/discharge stability than dielectric capacitors and batteries [4]. Electrode active materials play an important role to determine the electrochemical performance of supercapacitors [5]. In this study, reduced graphene oxide was used in electroactive materials. Advantageous of carbon materials are their stable structure, high conductivity, large surface area, usability in mass production and low cost [6]. Manganese oxide (MnO_2) was used with metal oxide in Faradaic reactions to enhance electrochemical performance due to their low stability and low power density [7]. MnO_2 has been widely used in many applications in the field of supercapacitors [8]. MnO_2 is a transition metal oxide, and its low cost, high energy surface area, environmental safety, good ion diffusion and natural abundance provide many advantageous to it [9]. In addition, MnO_2 has industrial applications in battery materials, supercapacitors and catalysts [10, 11].

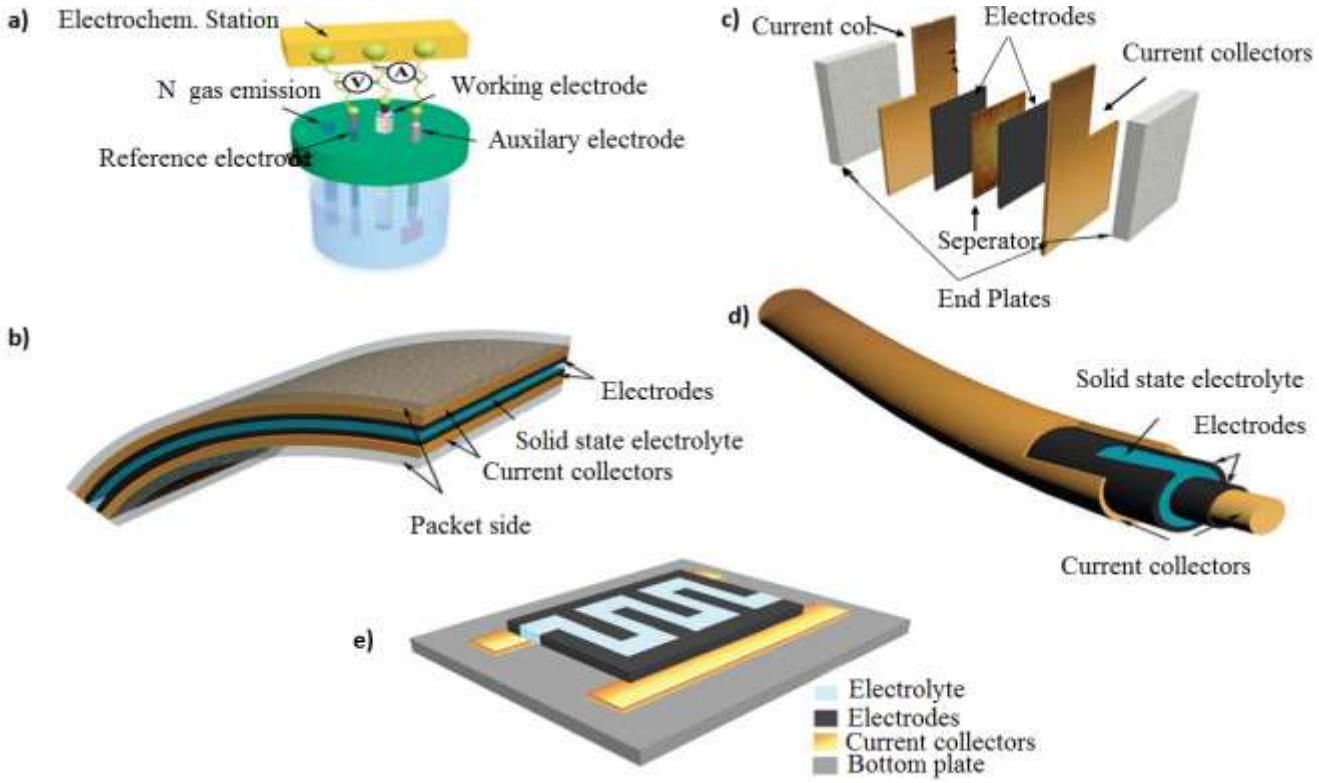

Fig. 1 a) Three electrode (half cell) system supercapacitor, b) two-electrode cell supercapacitor, c) Flexible solid state supercapacitor, d) Fiber supercapacitor, e) planar (micro) supercapacitor [12].

II. MATERIALS AND METHOD

In this study, 1-Butyl-3-methylimidazolium tetrafluoroborate ionic liquid, stainless steel electrode, kapton tape and *N*-Methyl-2-pyrrolidone material were used in the fabrication of supercapacitor devices.

Used Devices

In this study, rGO/MnO_2 nanocomposite was synthesized as binary nanocomposite. Electrochemical performance measurements were carried out using EIS method using IVIUMSTAT device and equivalent circuit model analysis, programme ZSimpWin 3,22.

III. RESULTS & DISCUSSION

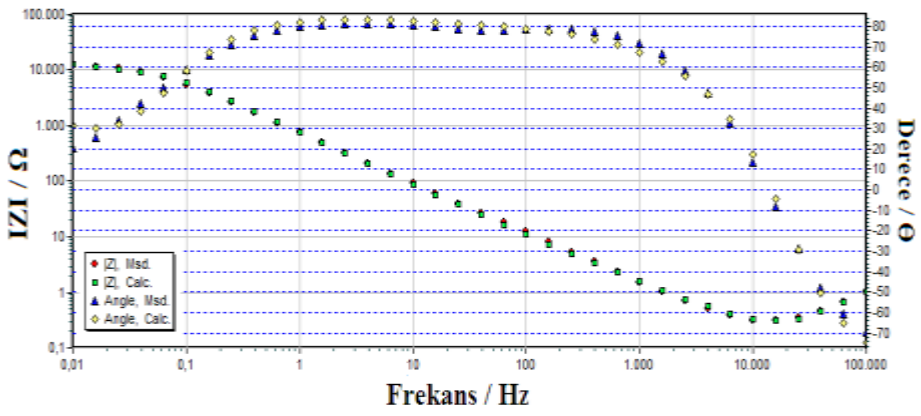

Fig. 1 Equivalent circuit model analysis LR(QR) of rGO nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 1. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2 nanocomposite.

Circuit parameters	**L/Henri**	**R_1 / Ω**	**CPE,Yo [S.Sec^n]**	**Fred power n [0<n<1]**	**R_2 / Ω**
rGO	1.7×10^{-6}	0.2805	5.9×10^{-4}	0.7745	2407

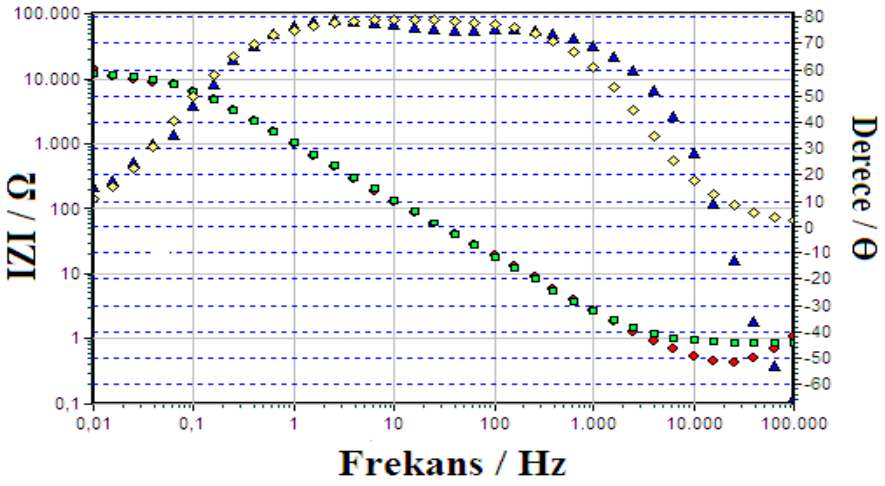

Fig. 2 Equivalent circuit model analysis R(QR) of rGO/MnO_2 nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 2. Results of R(QR) equivalent circuit model analysis of rGO/MnO_2 nanocomposite.

Circuit parameters	**R_1/Ω**	**R_2/Ω**	**CPE,Yo [S.Sec^n]**	**Fredpower,n [0<n<1]**	**C/F**
rGO/MnO_2=1:1	0.91	1.12×10^{-4}	1.83×10^{-4}	0.89	9.2×10^{-5}

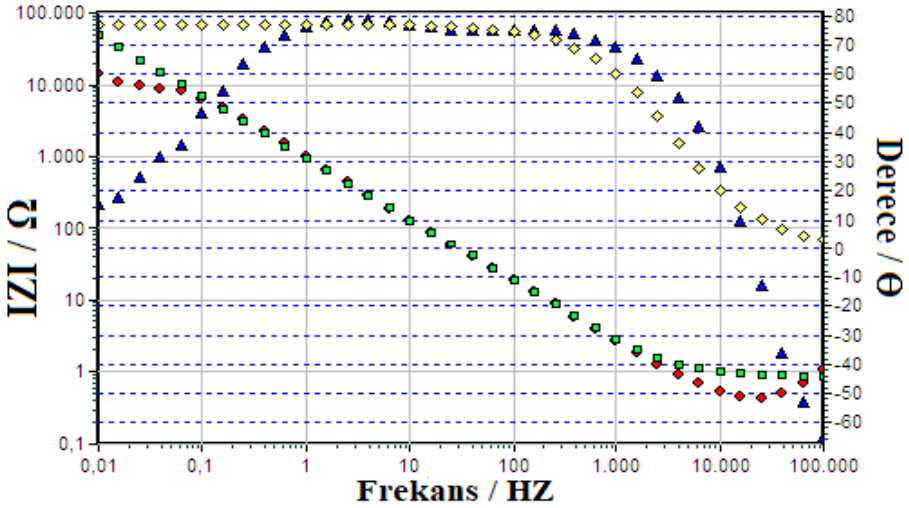

Fig. 3 Equivalent circuit model analysis RQ of rGO/MnO_2 nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 3. Results of RQ equivalent circuit model analysis of rGO/MnO_2 nanocomposite.

Circuit parameters	**R/Ω**	**CPE,Yo [S.Sec^n]**	**Fred power, n [0<n<1]**
rGO/MnO_2=1:1	0.86	2.2×10^{-4}	0.86

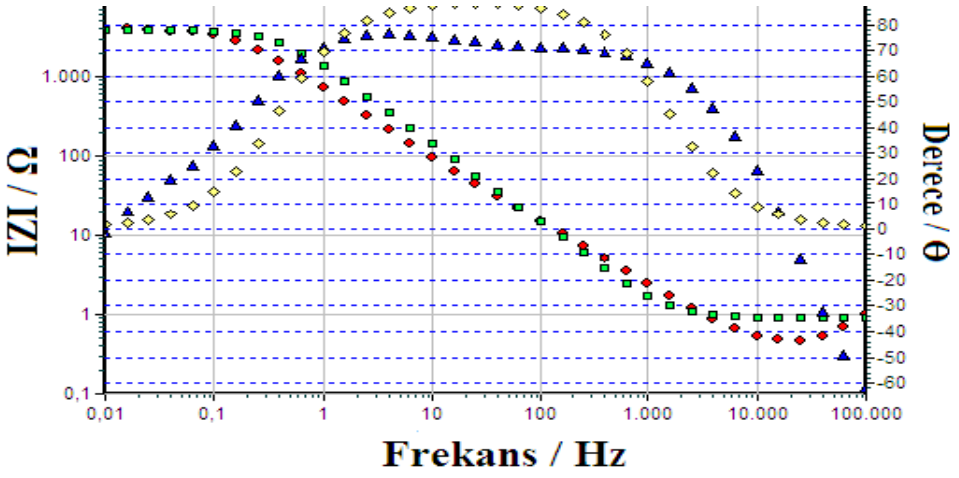

Fig. 4 Equivalent circuit model analysis R(CR) of rGO/MnO_2 nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 4. Results of R(CR) equivalent circuit model analysis of rGO/MnO_2 nanocomposite.

Circuit parameters	**R_1/Ω**	**R_2/Ω**	**C/F**
rGO/MnO_2=1:1	0.92	1.12×10^{-4}	9.12×10^{-5}

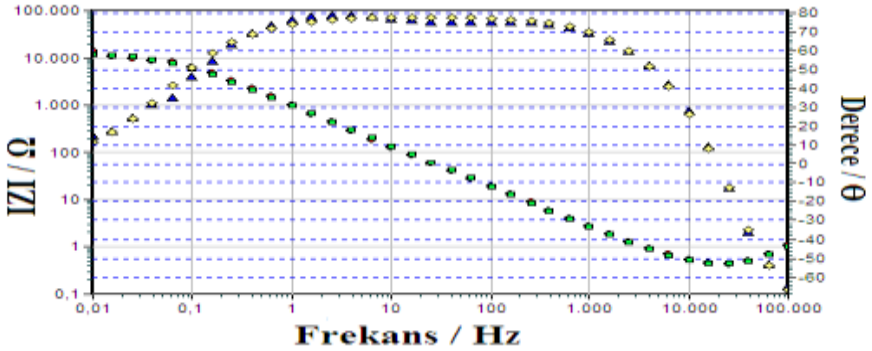

Fig. 5 Equivalent circuit model analysis LR(QR) of rGO/MnO_2 nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 5. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2 nanocomposite.

Circuit parameters	**L/Henri**	**R_1/Ω**	**CPE,Yo [S.Sec^n]**	**Fred power, n [0<n<1]**	**R_2/Ω**
rGO/MnO_2=1:1	1.58×10^{-6}	0.40	1.9×10^{-4}	0.87	1310

IV. CONCLUSION

The results obtained after applying the equivalent circuit model are given in Table 1 to Table 5. As a result, equivalent circuit model studies of rGO/MnO_2 was given using the EIS data of the nanocomposites using ZSimpWin 3.22. It was carried out in the circuit programme. The lowest charge

transfer resistance (R_{ct}) was obtained for equivalent circuit models of R(QR) and R(CR). If the R_{ct} is low, the capacitance of the supercapacitor should be higher value.

It is thought that ionic liquid synthesis should be carried out in future studies. Because ionic liquid has enabled a high potential window study for supercapacitor. Therefore, it supplies higher energy and power densities than inorganic solutions.

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USING CROPWAT MODEL FOR ESTIMATING THE OPTIMAL CROP WATER NEEDS IN GRAPE CULTIVATION IN ADANA PROVINCE

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Abstract - The Mediterranean climate of Adana, Turkey, characterized by hot, dry summers and mild, wet winters necessitates efficient water management for sustainable agriculture. This study aimed to determine the optimal irrigation scheduling in grape cultivation in Adana using FAO Cropwat software over a period from 1990 to 2020. The study utilized local weather (maximum and minimum temperature, precipitation, wind speed, humidity and sun hour), soil, and crop data to optimize irrigation practices, thereby ensuring sustainable water use without compromising crop yield. The research indicated the following average results: the net irrigation requirement at critical depletion was determined to be 581,5 mm, while the net irrigation at a user-defined interval was 475,4 mm. The reference evapotranspiration (ETo) was found to be 968,7 mm, with a crop evapotranspiration (ETc) of 668,4 mm. The average of effective rainfall was 37,7 mm. Grape yield under full irrigation conditions was estimated to be 533,9 kg/daa, whereas yield under rainfed conditions was approximately 361,2 kg/daa. The study also identified optimal irrigation scheduling as four periods and corresponding net irrigation amounts as 154, 155, 147, 26 mm respectively, resulting in 20% water savings compared to traditional practices.

Keywords: Irrigation scheduling, Net irrigation, Reference evapotranspiration, Crop evapotranspiration, Crop yield, Deficit irrigation.

I. INTRODUCTION

Grape cultivation is an important agricultural activity in the world, with vineyards covering around 7.4 million hectares and producing 77.8 million metric tons of grapes annually [1]. Turkey is part of the important grape producers, ranking among the top ten globally with an annual production of around 4.2 million metric tons [2]. The Adana province, situated in the Mediterranean climate zone of Turkey, is one of the major regions for grape cultivation. The Adana province benefits from favorable environmental and climatic conditions, with hot, dry summers and mild, wet winters, contributing to its agricultural productivity.

However, grape cultivation presents unique water management challenges due to the high water demand of grapevines, especially in arid and semi-arid regions. The water demands for grapevines can be substantial, necessitating good irrigation practices to ensure sustainable grape production. In Turkey, the agricultural sector represents for approximately 67% of groundwater withdrawals, primarily for irrigation

purposes [3]. The unsustainable extraction of groundwater, often from unauthorized wells, exacerbates the pressure on water resources, posing considerable challenges to sustainable water management [4]. Adana province, with its Mediterranean climate, faces these challenges keenly. Efficient water management is crucial to maintain agricultural productivity and prevent the depletion of groundwater resources. Effective water management strategies are essential to prevent surface water bodies from drying up, which could lead to a decline in water quality and ecological health [5]. Therefore, a modernizing and efficiently managing irrigation system by accurately assessing crop water requirements (CWR) and irrigation schedules becomes a priority [6].

To achieve this, the CROPWAT 8.0 software, a model developed by the Food and Agriculture Organization (FAO), is a vital tool. It assists the experts of water management and farmers in performing standard computations for irrigation water requirements and in designing and managing irrigation systems [7], [8]. The Penman-Monteith equation, implemented in CROPWAT 8.0, is commonly used to determine reference evapotranspiration (ETo), from which crop evapotranspiration (ETc) is derived using crop coefficients (Kc) [9]. The proper estimation of ETc and CWR values varies depending on climate, planting area, planting time, and soil type [10]. These parameters can be calculated using direct or indirect measurement methods such as the Penman-Monteith equation and meteorological data. Additionally, estimating irrigation water requirements and potential yield decreases due to critical reductions in irrigation water allows for the improvement of irrigation schedules [9].

In Adana province, efficient irrigation is important due to its Mediterranean climate, characterized by high summer temperatures and substantial evapotranspiration rates. By accurately estimating ETc and irrigation water demands, proper irrigation schedules can be developed, preventing irrigation-induced yield reductions and ensuring sufficient moisture in the crop root zones. The CROPWAT 8.0 model has been used in many studies due to its reliable results, especially in semi-arid regions without compromising the crop yield.

This study aimed to determine the optimal irrigation scheduling and amount for grape cultivation in Adana province over a period from 1990 to 2020. This research by highlighting the irrigation water requirements and programs for grape cultivation would contribute to the sustainable management of water resources in Adana province.

II. Materials and Method

2.1. Study Area

The study was carried out in Adana Province in the Mediterranean region. The Adana province is located in the southern part of Turkey, at 36.99◦ N latitude, 35.20◦ E longitude, and an elevation of 67 m.

The study area, Adana province, is characterized by temperate and rainy winters, as well as scorching and arid summers.

2.2. Description of CROPWAT Model and Input Data

The tool CROPWAT was created by The Food and Agriculture Organization (FAO) Land and Water Development Division. It assists to estimate irrigation water requirements and irrigation planning under different management and meteorological situations, simulate crop evapotranspiration(ETc), and calculate reference evapotranspiration(ETo).

By CROPWAT, the crop's coefficient (Kc), reference crop evapotranspiration (ETo) and finally crop evapotranspiration (Etc) can be considered for selected crop and irrigation water requirements can be calculated entering the input data as climate, crop, and soil variables, and it then presents the findings in tables or graphs. The model needs soil variable as soil type, maximum rooting depth, total available soil moisture, and soil moisture depletion in order to schedule irrigation. In addition to the calculation of crop water requirement, the model can be used to prepare irrigation programs under different irrigation conditions, to develop more efficient irrigation methods, and to evaluate crop yield under rainfed conditions or adequate irrigation conditions [11]. The model is also useful to evaluate drought impacts, and measuring the irrigation efficiency. It is widely identified and recognized as an important tool for contributing to sustainable agriculture and water management practices.

2.3. Cropwat input data

The CROPWAT 8.0 software requires four categories of data to run. These input data include climate parameters (maximum, minimum and average temperatures, relative humidity, sunshine, wind speed), rainfall or precipitaion, soil (heavy, medium, light), and the characteristics of the crop that is studied.

2.3.1. Climate Data

In this study, climate data are taken from the central meteorological station of Adana province, Turkey, for the period of 1990–2021. The CROPWAT 8.0 model requires climate parameters including daily total precipitation (mm), maximum and minimum temperatures (◦C), precipitation, relative humidity (%), sunshine, and wind speed(m/s) to function well and make a good simulation.

Table 1: Climate parameters and rainfall obtained from the central meteorological station of Adana province (CROPWAT Climate file 2020)

Month	**Min T**	**Max T**	**R Hum**	**Wind**	**Sun**	**Rain**
	°C	**°C**	**%**	**km/day**	**Hours**	**Mm**
January	8.4	15.0	62	104	5.7	15.0
February	7.2	18.4	67	112	4.4	8.2
March	8.4	19.7	69	104	7.3	4.8
April	11.7	22.3	63	121	7.7	2.7
May	16.1	29.5	69	95	9.2	12.2
June	23.0	33.4	69	112	9.0	14.5
July	11.6	32.4	67	121	10.7	0.0
August	23.0	34.0	68	104	10.0	2.0
September	20.2	32.1	64	104	8.9	0.0
October	14.9	29.0	61	95	8.0	0.0
November	7.9	18.6	68	104	5.7	7.5
December	8.5	15.8	69	95	5.3	3.1
Average	13.4	25.0	66	106	7.7	70.0

2.3.2. Crop Data

In this study the crop material was determined as Vitris vinifera (grape). The crop growing stage can be categorized into four different growing periods: initial, crop development, mid-season and late-

season[12], [13]. For the grape cultivated in the selected location, the emergence, development, mid-season, and late-season values were determined to be 24, 55, 85, and 66 days, respectively. And 05 March was designated as the planting date and 20 October as the harvest date. The crop parameters like crop grow stages, the planting date, crop coefficient (Kc) and critical depletion fraction (P) values provided in the Fig. 1 were compiled from the book of the Ministry of Food, Agriculture and Livestock of Turkey [14]. In addition to aforementioned properties, other crop data like yield response factor (Ky), rooting depth and cropheight were manually compiled from FAO56 and (FAO, 2002) [15].

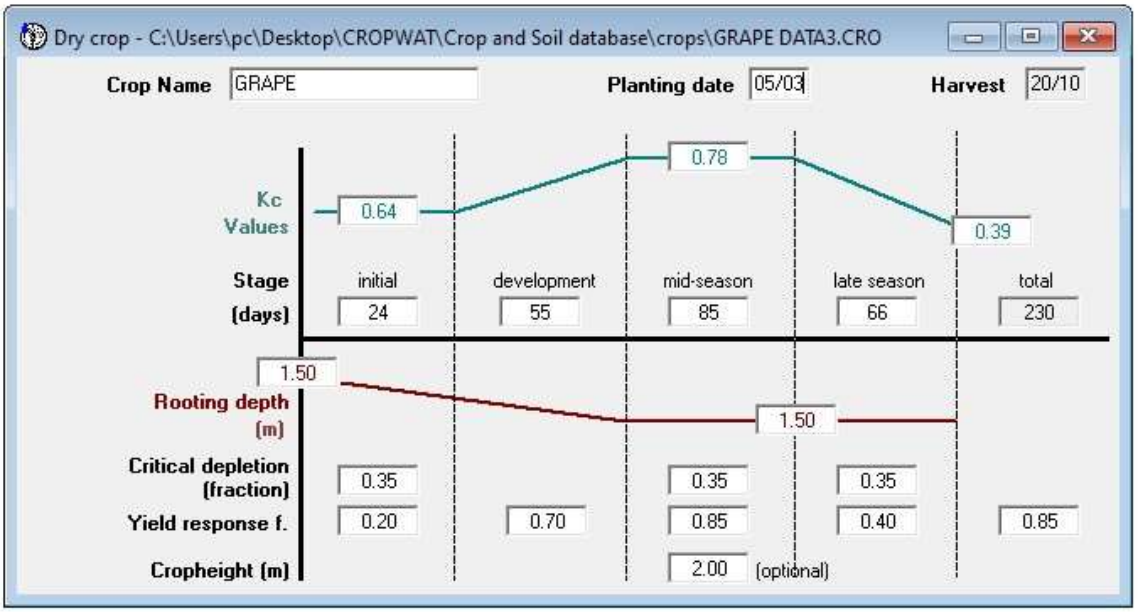

Fig. 1: Grape crop parameters for cropwat input data

2.3.2. Soil data

The agricultural soils of Adana Province are predominantly loamy, characterized by a balanced mixture of sand, silt, and clay. Thus, soil texture for the agricultural soils in this study were considered as medium(loam) textured in the solution of the CROPWAT software

The soil parameters in this study like initial soil moisture depletion (0%), total and initial available soil moisture (290 mm day−1), maximum rooting depth (150 cm), maximum rain infiltration rate (40 mm day−1) utilized as input data provided in the Fig. 2 were taken from FAO Cropwat internal database.

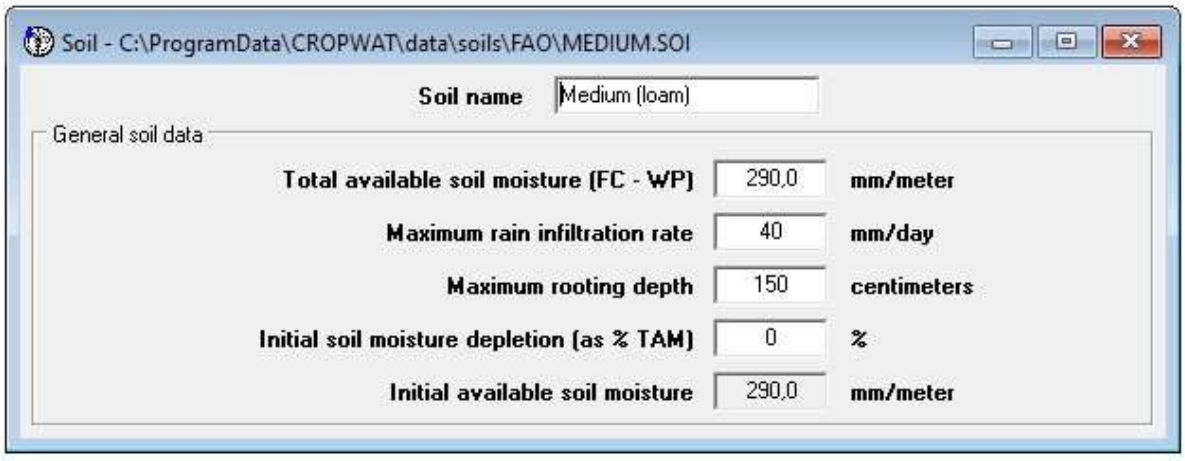

Fig. 2: Soil parameters for cropwat input data

2.4. Cropwat output data

Reference Evapotranspiration (ETo)

The reference evapotranspiration (Eto) is the quantity of evapotranspiration from a proposed reference crop with a supposed crop height of 12 cm, a fixed canopy resistance of 70 sm-1, and an albedo of 0.23, which closely resembles the ET from a comprehensive surface of grass cover that is of suitable height, growing, totally shading the field, and receiving acceptable water [16], [12]. The potential evapotranspiration influences the quantity of irrigation water requirements(IWR) of grape. The FAO Penman–Monteith formula was used to calculate evapotranspiration [16], [12]. Inputs like solar radiation , minimum and maximum temperatures (◦C), wind speed (m/s), and relative humidity (%) a needed for The FAO PenmanMonteith method to calculate Eto [17].

Crop evapotranspiration (ETc)

The crop evapotranspiration(Etc) is defined as the total amount of water lost from a crop field due to the combined processes of evaporation and transpiration. ETc is an important parameter for determining the crops water requirements and for scheduling irrigation effectively.

The actual ETc values of the crops studied are calculated by using the reference evapotranspiration (ETo) with a crop coefficient (Kc) as given:

$$ETc = ETo \times Kc$$

where ETc is mm/d; Kc is coefficient, and ETo is mm/d.

The crop coefficient (Kc) is determined by climatic conditions and crop growth stages. Kc is defined as the ratio of the ETc to the Eto [15]. As changes occur in evapotranspiration during crop growth stages, the value of Kc for the given crop alters over the growing period. These different growing periods of crops are taken into account in the calculations of Kc based on ETc. The FAO-56 model is based on the concepts of ETo and crop coefficient [18].

Irrigation water requirement (IWR)

The Irrigation Water Requirement (IWR) is the volume of water that needs to be supplied to the crop through irrigation to meet its evapotranspiration needs and ensure optimal growth and yield. It accounts for the crop's water need that is not met by rainfall or soil moisture. The IWR was determined by using

the calculated evapotranspiration figures along with the effective rainfall (Peff) values. The CROPWAT model's USDA Soil Conservation Service approach was employed to calculate Peff,. This following SCS approach is used by the United States Department of Agriculture (USDA) for determining Peff.

$$Peff = P\times(125-(0.2\times P))/125 \quad \text{for} \quad P\leq 250\text{mm}$$

$$Peff = 125+(0.1\times P) \text{ for } P>250 \quad \text{for} \quad P>250\text{mm}$$

Where; Peff is the Effective rainfall (mm) and P the Total rainfall (mm)

When irrigation is the sole water source for the plant, IWR should surpass ETc. However, if the plant derives water from alternate sources such as rainfall, deep seepage, or runoff, IWR can be less than Etc [19]. In this study, the drip irrigation method was employed with 70% of irigation efficiency, focusing on replenishing insufficient moisture to reach field capacity, hence disregarding all sources except rainfall. The folloxing equation was employed to calculate IWR.

$$IWR=ETc-Peff$$

Irrigation scheduling and net irrigation requirement

For any expected benefit from irrigation, it's crucial to define in advance the amount of water needed by the crops and proper irrigation timing. The net irrigation water requirement (NIR) of crops is the amount of water required for crops to fully and properly develop or to bring the decreased available soil water content in the plant root zone back to the field capacity. The NIR varies with the crop pattern and climate characteristics of the local condition. Net irrigation water requirements are calculated using the following equation;

$$NIWR=ETc-Peff$$

where; ETc is the crop evapotranspiration, and Peff is the effective rainfall.

2.5. Adjustments in Cropwat

To obtain accurate and reliable results, several key adjustments were made in the FAO Cropwat software. These adjustments included setting the sprinkler irrigation efficiency to 70%, which reflects typical field conditions and ensures realistic water use calculations. Additionally, two different irrigation scheduling scenarios were analyzed: critical depletion and user-defined intervals. These scenarios allow for a comparison of the irrigation requirements and efficiency under different management strategies.

While the critical depletion approach ensures that the crop does not experience water stress, the user-defined interval method offers significant water savings and improved efficiency. This flexibility allows for better adaptation to varying climatic conditions and crop stages, ultimately leading to more sustainable water use in grape cultivation in Adana province.

III. RESULTS

The parameters such as net irrigation water requirement (NIR), reference evapotranspiration (ETo), crop evapotranspiration (ETc), the effective rainfall, the percentage of the crop yield reduction under irrigation and rainfed condition, the irrigation scheduling and amount as well as the corresponding irrigation amount for the grape crop studied in Adana Province were simulated by using the FAO CROPWAT model.

Net Irrigation Requirements (NIWR) and Effective Rainfall

Using the FAO Cropwat software, the net irrigation requirements (NIWR) were calculated for both critical depletion and user-defined intervals. The NIWR for the critical depletion scenario was found to be 581.5 mm. In contrast, the user-defined interval scenario, which allows for more flexibility in irrigation scheduling, resulted in a lower NIWR of 475.4 mm.

The contribution of effective rainfall to the overall water needs of the grapevines was evaluated. On average, effective rainfall contributed 37.7 mm. Although this contribution is relatively modest, it underscores the importance of accounting for all water sources in irrigation planning to maximize efficiency and reduce the reliance on supplemental irrigation.

Table 2: NIWR under critical depletion and user defined and effective rainfall

Parameters	Eff Rainfall	Net Irr_Ud	Net Irr_Cd
Average amount (mm)	37.7	475	581,5

The following **fig. 3** showed the net irrigation amount under critical depletion and user defined compared with the effective over a 31-year period.

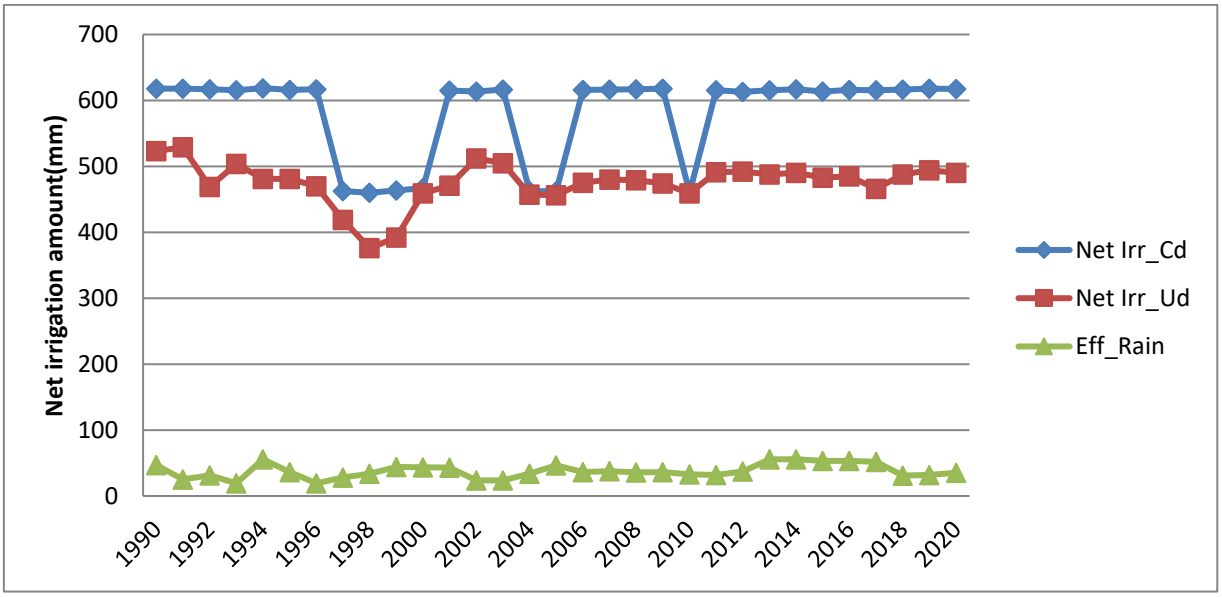

Fig. 3: Variation of net irrigation amount under critical depletion and user defined and rainfall over a 31-year period

*Net Irr_Cd : net irrigation amount under critical depletion
*Net Irr_Ud : net irrigation amount under user defined
*Eff_Rain : effective rainfall

Estimates evapotranspiration

The reference evapotranspiration (ETo) and crop evapotranspiration (ETc) were also calculated. The ETo, which represents the evaporative demand of the atmosphere, was determined to be 968.7 mm.

Table 3: Simulation of ETo from Cropwat from the input data of year 2020

Month	Min T	Max T	Humidity	Wind	Sun	Rad	Eto
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	8.4	15.0	62	104	5.7	9.3	1.32
February	7.2	18.4	67	112	4.4	10.1	1.73
March	8.4	19.7	69	104	7.3	16.1	2.46
April	11.7	22.3	63	121	7.7	19.4	3.39
May	16.1	29.5	69	95	9.2	23.1	4.42
June	23.0	33.4	69	112	9.0	23.3	5.38
July	11.6	32.4	67	121	10.7	25.4	5.35
August	23.0	34.0	68	104	10.0	23.0	5.08

September	20.2	32.1	64	104	8.9	19.0	4.23
October	14.9	29.0	61	95	8.0	14.6	3.08
November	7.9	18.6	68	104	5.7	9.7	1.61
December	8.5	15.8	69	95	5.3	8.2	1.11
Average	13.4	25.0	66	106	7.7	16.8	3.26

The ETc, which accounts for the specific water needs of the grape crop, was measured at 668.4 mm. ETc values were calculated considering the growth stages of plants in Cropwat, below is an example of ETc value simulated in Cropwat from our input data of the year 2020.

Table 4: Simulation of ETc from Cropwat

Month	**Decade**	**Stage**	**Kc**	**ETc**	**ETc**	**Eff rain**	**Irr. Req.**
			Coeff	**mm/day**	**mm/dec**	**mm/dec**	**mm/dec**
Mar	1	Init	0.64	1.42	8.5	1.2	7.5
Mar	2	Init	0.64	1.57	15.7	1.6	14.1
Mar	3	Deve	0.64	1.77	19.5	1.4	18.2
Apr	1	Deve	0.66	2.03	20.3	0.8	19.5
Apr	2	Deve	0.68	2.31	23.1	0.4	22.7
Apr	3	Deve	0.70	2.62	26.2	1.6	24.6
May	1	Deve	0.72	2.95	29.5	3.2	26.4
May	2	Deve	0.75	3.30	33.0	4.3	28.7
May	3	Mid	0.76	3.60	39.6	4.4	35.2
Jun	1	Mid	0.76	3.90	39.0	5.0	34.0
Jun	2	Mid	0.76	4.16	41.6	5.5	36.2
Jun	3	Mid	0.76	4.13	41.3	3.6	37.7
Jul	1	Mid	0.76	4.08	40.8	0.1	40.6
Jul	2	Mid	0.76	4.07	40.7	0.0	40.7
Jul	3	Mid	0.76	4.00	44.0	0.0	44.0
Aug	1	Mid	0.76	3.93	39.3	0.5	38.8
Aug	2	Late	0.75	3.82	38.2	0.8	37.4
Aug	3	Late	0.70	3.35	36.9	0.5	36.3
Sep	1	Late	0.64	2.89	28.9	0.1	28.8
Sep	2	Late	0.58	2.47	24.7	0.0	24.7
Sep	3	Late	0.53	2.03	20.3	0.0	20.3
Oct	1	Late	0.47	1.63	16.3	0.0	16.3
Oct	2	Late	0.42	1.28	12.8	0.0	12.8
					680.2	35.0	645.3

These values highlight the substantial water demand for optimal grape growth in the Mediterranean climate of Adana.

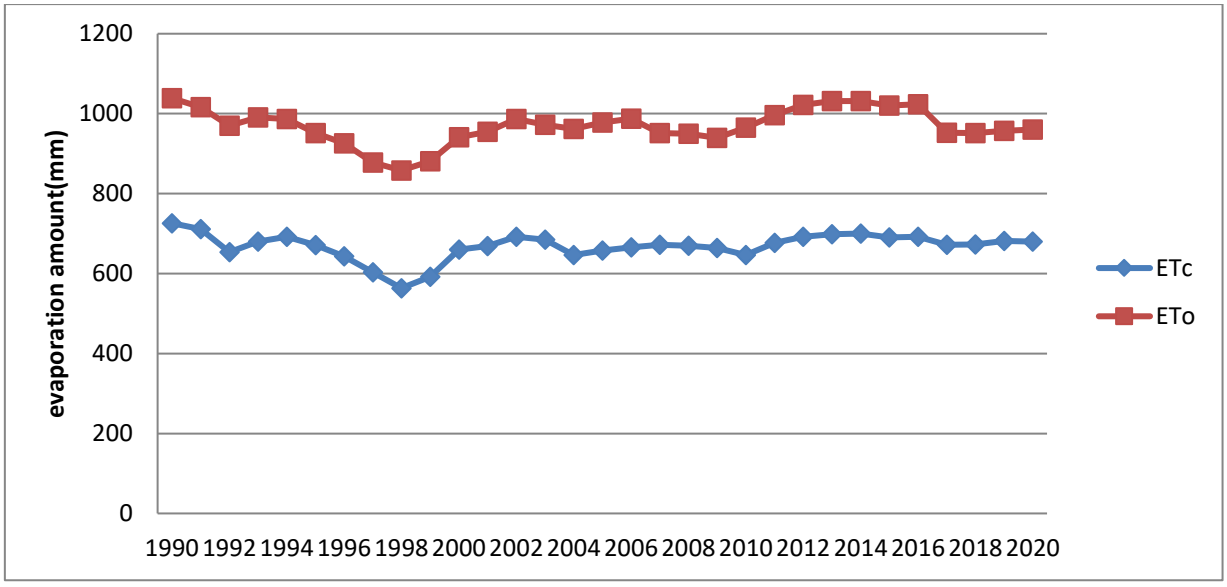

Fig. 4: Variation of ETo and ETc over a 31 year period

Impact on Grape Yield

The impact of optimized irrigation scheduling on grape yield was significant. Under full irrigation conditions, the grape yield was 533.9 kg/daa, compared to 361.2 kg/daa under rainfed conditions and the result indicated 32% in grape yield over 17 years from 2004 to 2020 in the figure 5 below.

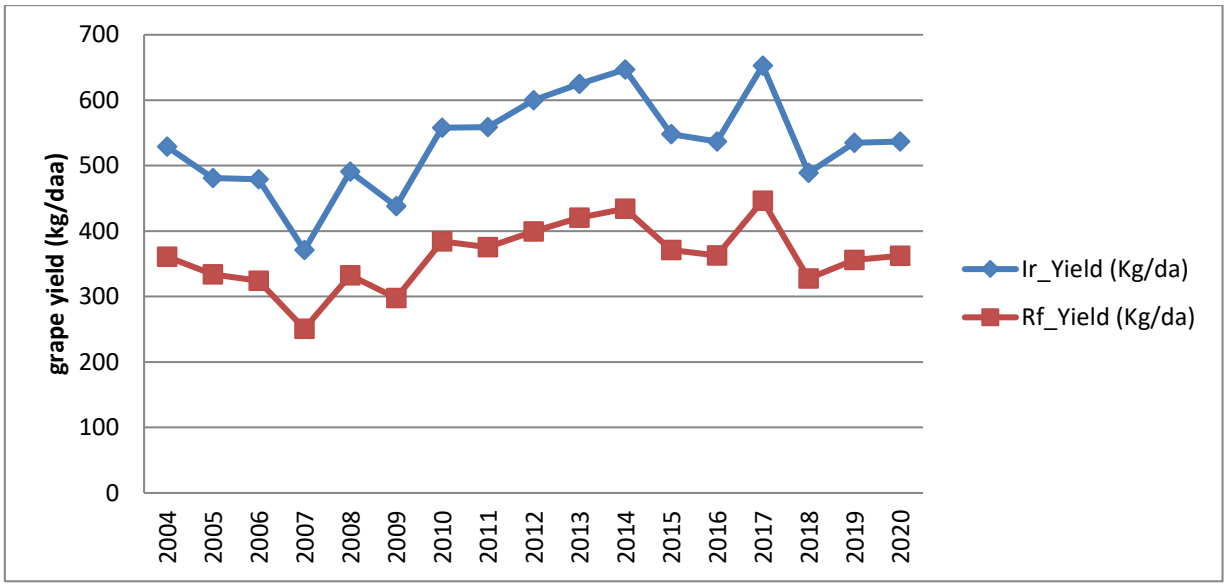

Fig. 5: Grape yield under full irrigation and rainfed conditions for the period 2004-2020

*Ir_Yield: yield under full irrigation conditions
*Rf_Yield: yield under rainfed conditions

This substantial increase in yield demonstrates the importance of adequate irrigation in achieving high productivity.

Optimal Irrigation Scheduling

The optimal irrigation scheduling identified in this study comprised four irrigation periods with net irrigation amounts of 154 mm, 155 mm, 147 mm, and 26 mm, respectively (Table 5). This schedule achieved a 20% water savings compared to traditional irrigation practices, highlighting the efficiency of the optimized approach.

Table 5: Optimal Irrigation Scheduling and Net Irrigation Amounts

Months	D A P	Net Irr_Ud (mm)	Net Irr_Cd (mm)
20 MAY	76	154	154
03 JULY	120	155	155
12 AUGUST	160	147	147
01 OCTOBER	210	26	148
TOTAL		482	604

*DAP: Date after planting
* Net Irr_Ud: Net irrigation amount under user defined
* Net Irr_Ud: Net irrigation amount under critical depletion

By carefully timing the irrigation events and adjusting the amounts based on crop needs and local conditions, it is possible to conserve water while maintaining or even enhancing crop yield. In Cropwat, adjusting user-defined value with the average irrigation value determined as input data (Fig. 6) did show no reduction in crop yield. However, this scheduling resulted in a 20% water savings compared to traditional practices.

IV. DISCUSSION

The results of this study indicate that optimized irrigation scheduling can significantly enhance water use efficiency in grape cultivation in Adana province. The optimal number of irrigation was found to be 5 periods with the starting date on May 20th , as shown in Fig. 6.

Fig. 6: One of the examples of simulation of irrigation scheduling from Cropwat (the year 2020) at user defined condition

Similar result was found by Aydin (2022) [20] in the cultivation of grape in Gaziantep Province. It found that the number of irrigation of the grape crop was 5 and the starting date of irrigation was in the first 10 days of June. But in Tarsus-Adana conditions, the number of irrigation for grape was determined to be 10–11, and the irrigation was recommended between second half of May and second half of July [21]. These results in Tarsus-Adana are different from ours and the results observed in grape cultivation in Gaziantep Province. These differences in the number of irrigation and the irrigation period can be attributed to the differences in the climate, altitude and geographic locations this specific area unlike the general climate conditions of Adana Province. The net irrigation requirement at critical depletion (581.5

mm) and at a user-defined interval (475.4 mm) provides crucial benchmarks for irrigation management. These findings are consistent with the literature emphasizing the importance of precise irrigation scheduling in arid and semi-arid regions [22], [23]. Specifically, Fereres and Soriano (2007) [22] highlighted that precise irrigation scheduling can enhance water-use efficiency and sustain crop yields under water-scarce conditions. Similarly, Pereira et al. (2002) [23] underscored the necessity of tailored irrigation practices to optimize water use and maintain agricultural productivity in such climates. The reference evapotranspiration (ETo) of 968.7 mm and crop evapotranspiration (ETc) of 668.4 mm highlight the substantial water need for grapevines in the Mediterranean climate of Adana. The lower ETc compared to ETo suggests that employing crop-specific coefficients can significantly reduce water usage without compromising crop health. Allen et al. (1998) [16]supported this by demonstrating that crop-specific coefficients can lead to more accurate irrigation requirements, thereby reducing water consumption while ensuring optimal crop conditions. Effective rainfall, averaging 37.7 mm, although a relatively small contribution, underscores the importance of considering all water sources in irrigation planning. Smith (2000) [24] also observed that effective rainfall, though often minimal, can play a critical role in reducing the overall irrigation needs by contributing to the total water available to crops. This highlights the necessity of incorporating effective rainfall in comprehensive irrigation management strategies to optimize water use efficiency. The grape yield of 533.9 kg/daa under irrigation conditions demonstrates the benefits of full irrigation compared to 361.2 kg/daa under rainfed conditions. Chaves et al. (2010) [25] found similar results, indicating that water stress can significantly compromise grape yield and quality. Their research showed that well-irrigated vines produced higher yields and better quality grapes, reinforcing the value of adequate irrigation for maintaining grapevine productivity and quality. The cumulative total irrigation amounts under the user-defined strategy showed 482 mm compared to 604 mm for the critical depletion strategy. The net irrigation amounts under user-defined conditions and critical depletion are identical for the first three irrigation dates (20 May, 3 July, and 12 August). However, a significant difference is observed on 1 October (210 DAP), where the user-defined irrigation amount (26 mm) is much lower than the critical depletion amount (148 mm). Both of them meet the crop water requirements effectively but the user-defined irrigation conserves water, achieving a reduction in total water use by 122 mm over the growing season (Fig. 7).

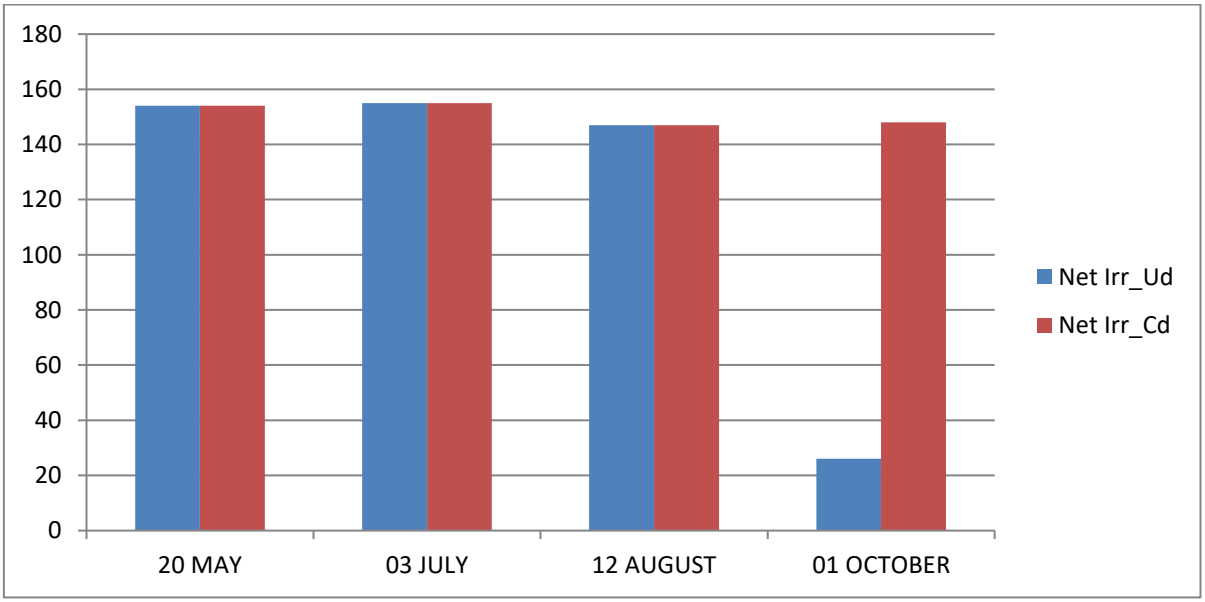

Fig. 7: irrigation Scheduling and net irrigation amounts under critical depletion and user defined

Sadler et al. (2005) [26] documented the benefits of precision agriculture techniques in crop water management, noting that such techniques can significantly enhance water use efficiency. The observed water savings in this study corroborate Sadler et al.'s findings, highlighting the potential of optimized irrigation scheduling to conserve water while maintaining or improving crop yields.

V. CONCLUSION

This study demonstrated the critical importance of optimized irrigation scheduling for grape cultivation in Adana, Turkey, a region with a Mediterranean climate characterized by hot, dry summers and mild, wet winters. Utilizing FAO Cropwat software and integrating local weather, soil, and crop data over a 30-year period, the research provides a robust framework for efficient water management.

Key findings include the determination of net irrigation requirements at critical depletion (581.5 mm) and user-defined intervals (475.4 mm), highlighting the significant water needs of grapevines in this climate. The study also measured reference evapotranspiration (ETo) at 968.7 mm and crop evapotranspiration (ETc) at 668.4 mm, emphasizing the high evapotranspiration rates in Adana's climate. Additionally, the average effective rainfall was found to be 37.7 mm, underscoring the limited contribution of rainfall to the water needs of grape cultivation.

The research estimated grape yields under full irrigation conditions to be 533.9 kg/daa, compared to 361.2 kg/daa under rainfed conditions, illustrating the substantial impact of irrigation on crop productivity.

Optimal irrigation scheduling was identified as four periods with corresponding net irrigation amounts of 154 mm, 155 mm, 147 mm, and 26 mm, respectively. This optimized scheduling approach resulted in a 20% water savings compared to traditional practices, demonstrating the potential for significant water conservation without compromising yield.

By implementing the optimized irrigation schedule derived from this study, farmers of Adana Province can achieve sustainable water use, enhance grape yield, and contribute to the overall sustainability of agricultural practices in the Mediterranean region.

ACKNOWLEDGMENT

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Tekstil Atıkları Depolarının Konumlandırılması Problemleri için Çok Kriterli Karar Verme (ÇKKV) Uygulamalarının Nicel Analizi

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Özet – Bu çalışma, tekstil atıkları depolarının konumlandırılması ile ilgili problemlerin çözümünde Çok Kriterli Karar Verme (ÇKKV) yöntemlerinin uygulanmasını ele almaktadır. Hızlı kentleşme ve artan nüfusla birlikte atık yönetimine olan ihtiyaç da aynı paralellikte artmaktadır. Bu nedenle atık depolarının konumunun optimal olarak belirlenmesi son derece önemlidir. Araştırma, ilgili çalışmaları belirlemek ve değerlendirmek için Scopus veri tabanını kullanarak sistematik bir yaklaşım kullanmakta ve atık deposu konumlandırması problemlerinin çözümünde kullanılan ÇKKV yöntemlerinin etkinliğine dair içgörüler elde etmektedir. Scopus veri tabanı, zengin bir akademik makale havuzuna erişim sağlayarak bu konudaki literatürün kapsamlı bir şekilde incelenmesini sağlamaktadır. Toplanan veriler istatistiksel olarak analiz edilmiştir. Bu çalışma, atık deposu konumlandırması bağlamında ÇKKV' nin güçlü yönlerine ve sınırlamalarına ışık tutmakta ve ÇKKV ile Atık depoları konumlandırması sorunlarının çözümünün kesiştiği noktalarla ilgilenen politika yapıcılara, uygulayıcılara ve araştırmacılara değerli bir rehberlik sunmaktadır. Scopus veri tabanının kullanılması, araştırmanın derinliğini ve güvenilirliğini artırarak akademik topluluk için önemli bir kaynak haline getirmektedir. Bu çalışma, tekstil atıkları yönetiminde entegre bir yaklaşım sunarak, çevresel ve kentsel planlama bağlamında önemli bulgular ortaya koymakta ve sürdürülebilir bir geleceğe katkıda bulunmayı amaçlamaktadır. Ayrıca, ÇKKV yöntemlerinin farklı bağlamlarda nasıl uygulanabileceğine dair geniş bir perspektif sunmakta ve bu yöntemlerin atık yönetimi süreçlerindeki potansiyel faydalarını vurgulamaktadır. Çalışma, özellikle hızlı kentleşen bölgelerde atık yönetimi politikalarının geliştirilmesi ve uygulanması sürecinde karar vericilere somut önerilerde bulunmayı hedeflemektedir. Bu bağlamda, araştırma bulguları, tekstil atıkları depolama alanlarının daha etkili ve verimli bir şekilde yönetilmesi için önemli bilgiler sağlamaktadır. Bu çalışma, sadece akademik topluluk için değil, aynı zamanda pratik uygulamalar için de değerli bir kaynak oluşturmayı amaçlamaktadır.

Anahtar Kelimeler – ÇKKV, atık depoları konumlandırması, literatür taraması, bibliyometrik analiz

I. GİRİŞ

Tekstil atıkları depolama alanlarının seçilmesi ya da depolar için en iyi lokasyona karar verilmesi, bölgenin ekonomik, ekolojik ve çevre sağlığı üzerinde güçlü etkileri olması nedeniyle kentsel planlama sürecinde çok önemli bir konudur [1].

Depolama sahası için olası alternatif lokasyonlar arasından en uygun lokasyonun belirlenmesi hem niceliksel hem de niteliksel kriterleri içeren çok kriterli karar verme problemi olarak sınıflandırılmaktadır [1]. Literatürde çözüm önerisi olarak çok çeşitli yöntemler önerilmiştir. Bu tür problemlerde hem niceliksel hem de niteliksel kriterleri dikkate alan Çok Kriterli Karar Verme (ÇKKV) yöntemlerinin yaygın olarak kullanılmış olduğu görülmüştür. Yine bu tür problemlerin çözümünde Analitik Hiyerarşi Süreci (AHP), TOPSIS, CODAS ve PROMETHEE yöntemleri öne çıkmıştır. Bu yöntemler, karar vericilere kriter ağırlıklandırma, alternatiflerin değerlendirilmesi ve en uygun seçeneğin belirlenmesi

konusunda yardımcı olmaktadır. Ayrıca belirsizliklerin bulunduğu durumda bulanık mantıktan faydalanılmış ve NP-Hard problemlerde sezgisel yöntemler ya da genetik algoritmalar kullanılmıştır. Bu yöntemlerin yanı sıra doğrusal programlama ve çok amaçlı optimizasyon gibi matematiksel modeller de karar verme sürecinde önemli rol oynar.

Bu çalışma, tekstil atıkları depolarının konumlandırılması sorununu ele alarak, bu alanda kullanılan çeşitli çözüm yöntemlerinin güçlü yönlerini ve sınırlamalarını ortaya çıkarmayı amaçlamaktadır. ÇKKV yöntemlerinin gücünü Scopus veri tabanındaki bilgi zenginliği ile birleştirerek, farklı yöntemlerin etkinliğini değerlendirmektedir. İstatistiksel analiz ve grafiksel gösterimler aracılığıyla eğilimler, en iyi uygulamalar ve iyileştirme alanları belirlenmiştir. Bu araştırmanın bulgularının yalnızca ÇKKV yöntemlerinin tekstil atıkları depolarının konumlandırılmasındaki uygulanabilirliğine ilişkin akademik anlayışa katkıda bulunması değil, aynı zamanda sürdürülebilir atık yönetimi ve çevre koruma hedefleri doğrultusunda çalışan politika yapıcılar, kentsel planlamacılar ve araştırmacılar için pratik bilgiler sunması beklenmektedir.

II. MATERYAL VE YÖNTEM

Farklı ÇKKV yaklaşımlarını kullanan depo yeri seçimi çalışmalarının incelenmesinin yanı sıra, farklılıkları vurgulamak ve bu çalışmanın temelini oluşturmak için kullanılan çalışmaların sistematik olarak belirlenmesi gerekmektedir. David Moher tarafından literatür taraması için önerilen Sistematik İncelemeler ve Meta-Analizler için Tercih Edilen Raporlama Öğeleri (Preferred Reporting Items for Systematic Reviews and Meta-Analyses/PRISMA) metodolojisi [2], detaylı bir literatür taraması gerçekleştirmek için kullanılmıştır. Metodoloji beş ana adımdan oluşmaktadır: kriterlerin tanımlanması, kaynakların belirlenmesi, literatürün seçilmesi, verilerin toplanması ve veri öğelerinin seçilmesi [3]. Bu metodoloji, literatür araştırmasındaki yanlılığı azaltmak ve daha sistematik yöntemler geliştirmek için benimsenmiştir [4]. Tekstil atıkları depolarının konumlandırılması ile ilgili karar verme problemleri incelenmiştir. Bu nedenle, bu çalışmalarda ÇKKV yaklaşımlarının kullanımı analiz edilmiş, Literatür taraması 1 Mayıs 2024 – 20 Mayıs 2024 tarihleri arasında Tablo 1'de gösterilen anahtar kelimeler ile gerçekleştirilmiştir.

Tablo 1. Literatür taramasında kullanılan anahtar kelimeler

Data Base	**Sorgu**	**Sayı**
Scopus	(“site selection" AND "waste disposal" AND multi-criteria)	136
	(“site selection" AND "waste disposal" AND ahp)	101
	(“site selection" AND "waste disposal" AND fuzzy)	86
	("location selection" AND "waste disposal" AND fuzzy)	13
	(“site selection" AND "waste collection" AND multi-criteria)	8
	(“location selection" AND "waste disposal" AND multi-criteria)	7
	(“location selection" AND "waste disposal" AND ahp)	3
	(“site selection" AND "waste recycling" AND multi-criteria)	3
	(“location selection" AND "waste recycling" AND ahp)	3
	(“location selection" AND "waste collection" AND fuzzy)	3

	(“location selection" AND "waste recycling" AND fuzzy)	3
	(“site selection" AND "waste recycling" AND fuzzy)	2
	(“location selection" AND "waste recycling" AND multi-criteria)	2
	(“location selection" AND "waste collection" AND multi-criteria)	2
	(“site selection" AND "waste collection" AND ahp)	3
	(“site selection" AND "waste collection" AND fuzzy)	2
	(“site selection" AND "waste recycling" AND ahp)	2

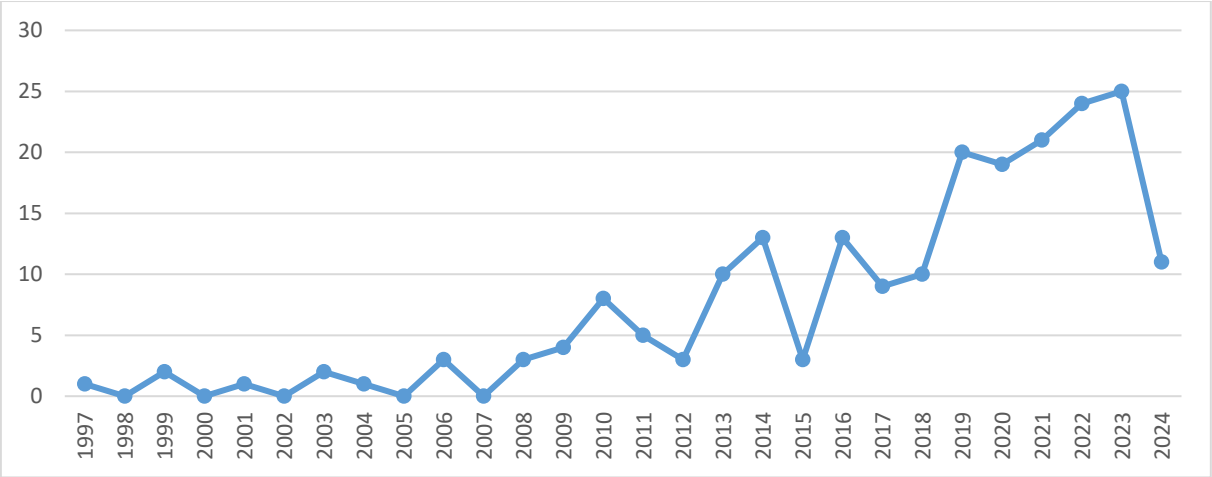
Tablo 1’de gösterilmiş olan anahtar kelimeler SCOPUS veri tabanında aratılmış ve toplam 379 çalışma elde edilmiştir. Bazı makaleler iki ya da üç aramada tekrarlı olarak çıktığı için listeden çıkarılmıştır. Nihai olarak elde edilen çalışma sayısı 212 olmuştur. 212 adet çalışma incelenmişir.

III. BULGULAR

Detaylı ve sistematik bir literatür taramasının ardından çalışmaların bazı karakteristik özelliklerine göre özet diyagramlar oluşturulmuştur. Bu diyagramlar sayesinde çalışma kapsamında yürütülen araştırmalara yönelik özet bir yapı ortaya çıkarılmıştır. Çalışmaların yayın yılı, kullanılan yöntem ve türü gibi temel ayrımları gösteren bu şekiller değerlendirilerek bu çalışmanın tartışma bölümü oluşturulmuştur. Bu ayrımların detaylı yorumlarına ilerleyen alt bölümlerde yer verilmiştir.

A. Yıllara Göre Çalışmalar

Literatür taraması sonucu çalışmaların yıllara göre dağılımı, atık depolarının konumlandırılması konusundaki çalışmalardaki ilginç eğilimleri ortaya koymaktadır. Şekil 1, bu alandaki araştırma faaliyetlerindeki eğilimleri göstermektedir.



Şekil 1. Yıllara göre çalışmalar

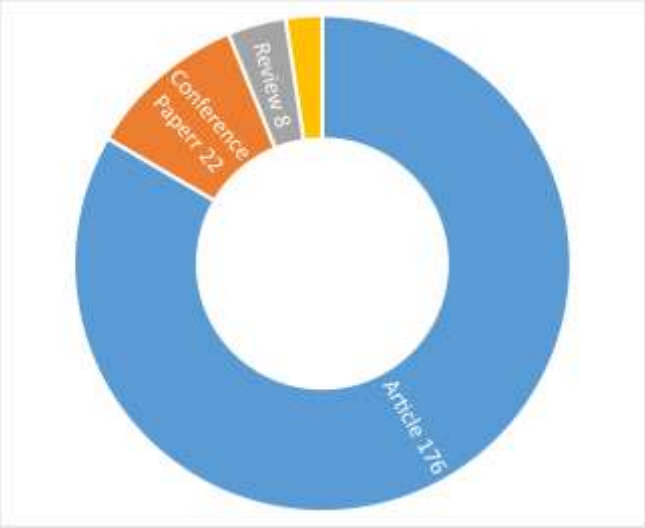
Yıllar içinde atık deposu konumlandırması problemleri konusunda yayınlanan çalışmaların sayısının analizi, ilginç eğilimleri ve dalgalanmaları ortaya koymaktadır. Atık deposu konumlandırması konusunda yayınlanan çalışmaların sayısının analizi, özellikle COVID-19 salgını bağlamında, ilgi çekici eğilimleri

ve dalgalanmaları ortaya koymaktadır. Özellikle son yıllarda, muhtemelen pandeminin ortaya çıkardığı zorluklardan etkilenerek, atık deposu konumlandırmasına yönelik akademik ilgide belirgin bir artışla birlikte önemli bir yükseliş eğilimi söz konusudur. 2015 yılından itibaren her yıl yayınlanan çalışma sayısında istikrarlı bir artış olmuş ve 2021 yılında konu ile ilgili toplam 13 yayınla zirveye ulaşmıştır. Bu durum, bir akademik araştırma konusu olarak atık depolama konumlandırmasının öneminin giderek arttığını göstermektedir.

Eğilim genel olarak yukarı doğru olsa da atık deposu konumlandırması konusundaki yayın sayılarında yıldan yıla dalgalanmalar görülmektedir. Örneğin, 2022 yılı, önceki yıllara kıyasla yayınların sayısında hafif bir düşüşe tanık olmuş ve bu da araştırma çıktılarında bir miktar değişkenlik olduğunu göstermiştir. Benzer şekilde 2018, 2016 ve 2013 gibi yıllar atık deposu konumlandırması araştırmalarında genel olarak artan bir yörüngeyle birlikte dalgalanmalar göstermektedir. İlk yıllarda, özellikle 2001-2004 yılları arasında, konuyla ilgili yayınların çok düşük olduğu veya hiç olmadığı görülmüştür; bu da o dönemde akademik ilginin olası bir eksikliğine işaret etmektedir. Ancak 2004'ten itibaren az da olsa yayın yapılması sebebiyle ilginin yeniden canlanması, atık deposu konumlandırılması ile ilgili sorunlara yeniden odaklanıldığının bir göstergesi olabilir. 2010- 1012 yılları arasında yayın olmaması, bu yıllarda potansiyel araştırma boşlukları veya akademik önceliklerdeki değişimler hakkında sorunlar ortaya çıkarmaktadır. Atık deposu konumlandırması literatüründeki bu boşluklar, gelecekteki araştırmalar için fırsat teşkil edebilir.

B. Türlere Göre Çalışmalar

Bu bölümde, atık deposu konumlandırması çalışmalarının türlerinin kapsamlı analizi gerçekleştirilmiştir. Şekil 2'de incelenen makalelerin çalışma türlerine göre ayrımı gösterilmektedir. Çalışmalar dört ana türe ayrılmıştır: Araştırma makaleleri, Konferans Bildirileri, Literatür İncelemeleri ve Kitap Bölümleri.



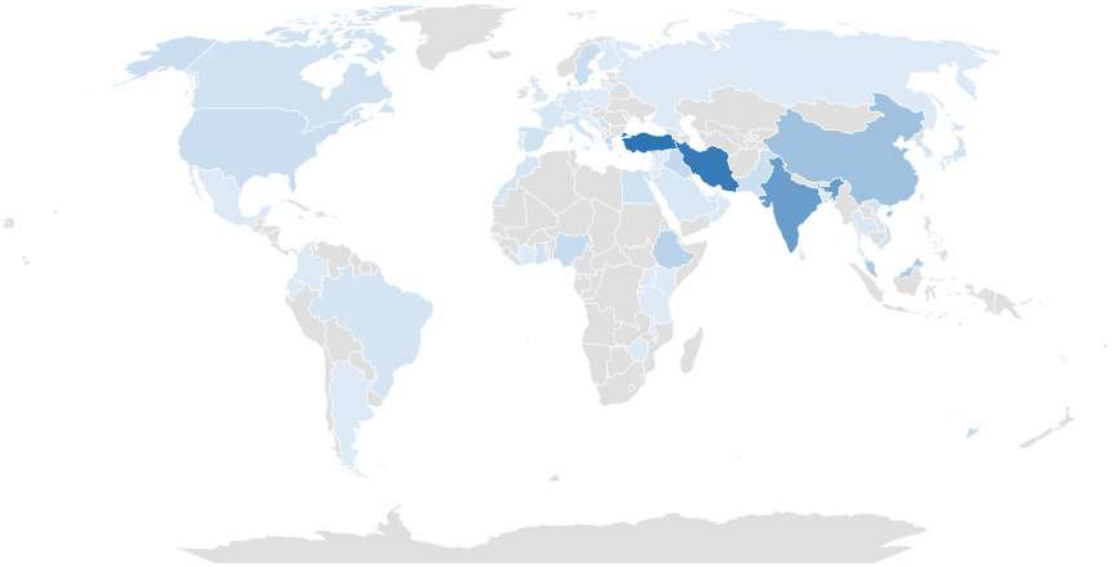
Şekil 2. Türlerine göre çalışma sayıları

Şekil 2' de gösterildiği üzere, çalışmaların çoğunu 176 adet ile Araştırma Makaleleri oluşturmuştur. Bu, ampirik çalışmalar yapmanın, derinlemesine analizler gerçekleştirmenin ve atık depoları konumlandırmaları alanındaki bilgi birikimini önemli ölçüde artırmanın önemini göstermektedir. Şekil 2' ye göre çalışmaların bir diğer önemli boyutunu oluşturan tür Konferans Bildirileri olmuştur ve sayıları 22'dir. Bu çalışmalar, atık depoları konumlandırması araştırmalarının dinamik yapısını ve konferanslar aracılığıyla akademik toplulukla olan aktif etkileşimini yansıtarak, araştırma bulgularını yaymak için daha kısa ve zamanında bir platform sunma yetenekleriyle öne çıkmaktadır. Literatür incelemelerinin sayısı az olmasına rağmen bahsedilen konu alanındaki önemi göz ardı edilemez. Bu incelemeler, konu ile alakalı

mevcut bilgileri özetleyip sentezleyerek, araştırma boşluklarının belirlenmesine yardımcı olur. Ayrıca daha sonra gerçekleştirilecek çalışmalar için bir ön ayak oluşturur. Çalışma türlerinin sonuncusu ise en az sayıdaki Kitap Bölümleridir. Atık depolarının konumlandırılması alanında 5 adet Kitap Bölümü bulunmaktadır. Bu çalışmalar, konuyu derinlemesine ele alarak geniş bir perspektif sunmakta ve okuyuculara kapsamlı bir bilgi birikimi sağlamaktadır. Kitap bölümleri, akademik yazında önemli bir kaynak olup, araştırmacılara ve öğrencilere değerli referanslar sunmaktadır.

C. Bölgelere Göre Çalışmalar

Atık depolama tesislerinin konumlandırılması çalışmaları, farklı ülkelerde gerçekleştirilen araştırmalarla küresel çapta önem arz eden bir konudur. Atık depolama tesislerinin doğru konumlandırılması, çevresel, ekonomik ve sosyal faktörlerin dengelenmesi açısından kritik bir rol oynamaktadır. Şekil 3'te gösterilen görsel, atık depolama tesislerinin ülkeler bazında dağılımını göstermektedir, bu da atık yönetimi stratejilerinin çeşitliliğini ve buna bağlı olarak metodolojilerin farklı bağlamlarda nasıl uygulandığını ortaya koymaktadır.



Şekil 3. Çalışmaların Bölgelere Göre Coğrafi Isı Haritası

Şekil 3'te verilmiş olan coğrafi ısı haritasına dayanarak atık depoları konumlandırması çalışmalarının dünya genelinde geniş bir ilgi gördüğünü söylemek mümkündür. Türkiye 41 adet çalışma ile ilk sırada yer alırken İran 39 adet ile hemen Türkiye'nin arkasından gelmektedir. Bu durum, bu iki ülkede atık yönetimi ve depolama konusunun çevresel ve toplumsal açıdan ne kadar kritik olduğunu ortaya koyuyor. Özellikle Türkiye'deki 41 çalışma, bu ülkenin atık yönetimi konusunda ciddi adımlar attığını ve bu alanda bilimsel araştırmaları teşvik ettiğini gösteriyor. Hindistan, 27; Çin, 15 ve Malezya, 11 çalışma sayılarıyla listenin başlarında yer almıştır. Asya ülkelerinden bazıları olan bu ülkeler, büyük nüfusları ve hızlı sanayileşmeleri ile ön plana çıkmaktadır. Bu durum da atık yönetimi ve depolama konusundaki araştırmaların artmasına ön ayak olmaktadır. Asya ülkelerindeki bu ilgi, sürdürülebilir kalkınma ve çevre yönetimi açısından olumlu bir adım olarak değerlendirilebilir. Ayrıca, Etiyopya ve Nijerya gibi Afrika ülkelerinin de bu listede üst sıralarda yer alması, Afrika kıtasında da atık yönetimi konusunun önemli bir araştırma alanı olduğunu gösteriyor. Etiyopya'daki çalışma sayısı 9 iken Nijerya'da bu sayı 6 olmuştur. Gelişmekte olan ülkelerde atık yönetimi, halk sağlığı ve çevre koruma açısından büyük bir öneme sahip. Bu nedenle, Etiyopya ve Nijerya gibi ülkelerde yapılan araştırmalar, bölgesel çözümler ve politika

geliştirme açısından kritik bir rol oynayabilir. Gelişmiş ülkelerden Amerika Birleşik Devletleri 5, Kanada 4 ve Avustralya 6 adet çalışmaya listeye girmiştir. Bu ülkelerde çevresel sürdürülebilirlik konusundaki farkındalık ve yasal düzenlemeler, atık yönetimi konusundaki araştırmaları teşvik etmektedir. Gelişmiş ülkelerde atık yönetimi konusundaki araştırmalar genellikle ileri teknoloji ve yenilikçi çözümler üzerine odaklanır, bu da küresel ölçekte atık yönetimi stratejilerinin geliştirilmesine katkı sağlamaktadır. Genel olarak, listede yer alan ülkelerin büyük çoğunluğu 1 ile 5 arasında çalışma yapmış durumdadır. Bu, atık depoları konumlandırma konusunun global ölçekte birçok ülkede araştırma konusu olduğunu, ancak bazı ülkelerde daha yoğun çalışıldığını göstermektedir. Düşük çalışma sayılarına sahip bazı ülkelerin ise bu konuda daha fazla araştırmaya ihtiyaç duyduğu söylenebilir. Bu farklı coğrafi temsil, atık depoları konumlandırması sorunlarının ele alınmasında uluslararası iş birliğine duyulan ihtiyacın altını çizmekte ve hem politika yapıcıları hem de araştırmacıları atık yönetimi araştırmalarının küresel durumu hakkında bilgilendirmektedir.

D. En Çok Yayın Yapılan Dergiler

Bu alt bölümde, atık depoları konumlandırması araştırmaları alanındaki en çok yayın yapan dergiler değerlendirilmiştir. Bu dergiler, akademisyenlerin bulgularını paylaşmaları ve bu önemli alandaki literatüre katkıda bulunmaları için kilit platformlar olarak işlev görmektedir. Tablo 2, en fazla yayına sahip ilk 5 dergiyi göstermektedir.

Tablo 2. En çok yayın yapılan dergiler

Dergi	**Sayı**
Environmental Science And Pollution Research	21
Waste Management And Research	17
Environmental Monitoring And Assessment	15
Waste Management	9
Environmental Earth Sciences	8

Bu dergiler, atık deposu konumlandırması alanındaki araştırma ve bilgi yayılımının teşvik edilmesinde önemli rol oynamaktadır. “Environmental Science And Pollution Research” [5]- [25], 21 yayınla Tablo 2’ de en başta yer almıştır ve bu durum atık depolarınının konumlandırılması konusunun çevre bilimi ve kirlilik üzerine ne derece önemli olduğuna işaret etmektedir. 17 adet çalışmayla ilk sıralarda yer alan “Waste Management And Research” [26]- [42] dergisi atık yönetimi ile ilgili çalışmaların yoğunlukla yer aldığı bir dergidir. “Environmental Monitoring And Assessment” [43]- [57] dergisi 15 adet çalışmaya yer vermiştir ve atık depolarının çevresel etkilere göre konumlanması amaçlandığı gözlemlenmiştir. “Waste Management” [58]- [66] dergisi 9 çalışma ile tabloda yer alırken “Environmental Earth Sciences” [67]- [74] dergisi 8 çalışmaya yayıncı olmuştur. Genel olarak dergilerin çevresel konularda olduğu göz önüne alındığında atık depolarının konumlandırılması konulu problemlerin çevresel açıdan son derece önemli olduğu ve problemlerin çözümünde kullanılan kriterlerin buna göre belirlendiği sonucuna varılabilir.

E. En Çok Alıntı Yapılan Çalışmalar

Bu alt bölümde, atık depoları konumlandırması araştırmaları alanında en çok atıf alan yayınlar incelenmiştir. Bu makaleler, akademik camiada büyük ilgi ve tanınırlık kazanmış olup, alana yaptıkları etkili katkıları gözler önüne sermektedir. Tablo 3, en çok atıf alan yayınları vurgulayarak, bu araştırmaların etkisini ve önemini ortaya koymaktadır.

Tablo 3. En çok atıf yapılan beş çalışma

Makale	Atıf
GIS-based approach for optimized siting of municipal solid waste landfill [75]	338
Combining AHP with GIS for landfill site selection: A case study in the Lake Beyşehir catchment area (Konya, Turkey) [76]	323
Siting MSW landfill using weighted linear combination and analytical hierarchy process (AHP) methodology in GIS environment (case study: Karaj) [77]	249
Solid waste disposal site selection with GIS and AHP methodology: A case study in Senirkent-Uluborlu (Isparta) Basin, Turkey [78]	245
Fuzzy multicriteria disposal method and site selection for municipal solid waste [79]	235

Tablo 3'te verilmiş olan makaleler atık depoları konumlandırması konusundaki araştırmaları büyük ölçüde etkilemiştir. "GIS-based approach for optimized siting of municipal solid waste landfill" 338 atıfla listenin ilk sırasında yer almıştır ve bu makalede çok kriterli karar analizi (MCDA) ve coğrafi bilgi sistemi (GIS) kullanılarak kaplama analizi kullanılarak yeni bir atık depolama sahasının konumlandırılması ele alınmıştır. "Combining AHP with GIS for landfill site selection: A case study in the Lake Beyşehir catchment area (Konya, Turkey)" 323 atıfla listenin ikinci sırasında yer almıştır. Çalışmada Beyşehir Gölü Havzasında optimal bir depolama alanı yer seçimi hedeflenmiş ve Gölün atık deposundan etkilenmesi durumu göz önünde bulundurularak kriterler belirlenmiştir. Bahsi geçen makalenin atık depolarının çevresel etkileri konusunda önemli bir bilgi sağladığı sonucuna varılabilir. Listenin üçüncü sırasında yer alan "Siting MSW landfill using weighted linear combination and analytical hierarchy process (AHP) methodology in GIS environment (case study: Karaj)" çalışması 249 atıf almıştır ve bu çalışmada belirli bir alanın katı atık depolama sahası olarak uygunluğu üzerinde durulmuştur. Depo yeri seçimi konusunda kullanılan kriterler açısından önemli bilgiler sunmaktadır. "Solid waste disposal site selection with GIS and AHP methodology: A case study in Senirkent-Uluborlu (Isparta) Basin, Turkey" çalışması 245 atıf ile listenin dördüncü sırasındadır. Depolama alanı yer seçimine ilişkin kriterlerin belirlenmesi konusuna yeni bakış açıları getirerek yol gösterici bir çalışma olmuştur. Listenin sonunda yer alan çalışma 235 atıf ile "Fuzzy multicriteria disposal method and site selection for municipal solid waste" olmuştur. Çalışmada belirsizlik ortamında başvurulan bir yöntem olan Fuzzy yöntemi kullanılmıştır ve belirsizlik ortamında yapılan çalışmalar için önemli bilgiler sunmaktadır.

IV. TARTIŞMA

Atık depoları konumlandırması konulu çalışmalar yıllara göre analiz edildiğinde yıllar ilerledikçe çalışma sayısında artış olduğu gözlemlenmiştir. Atık deposu konumlandırması çalışmalarının muhtemelen kentleşme ve çevre düzeni eksiklerine duyulan ihtiyaçtan etkilenerek son yıllarda ivme kazandığını göstermektedir. Önceki yıllardaki dalgalanmalar ve boşluklar, bu dinamik ve kritik atık deposu konumlandırması araştırma alanında keşfedilecek ve ortaya çıkarılacak daha çok şey olduğunu göstermektedir. Depo yeri seçimi alanındaki araştırmacılar ve politika yapıcılar, bu eğilimlerin arkasındaki nedenleri daha derinlemesine incelemeyi ve atık deposu yer seçimi problemleri içinde daha fazla araştırılması gereken belirli alanları belirlemeyi değerli bulabilirler. Genel olarak, bu analiz atık deposu konumlandırması çalışmalarının son yıllarda ivme kazandığını, bunun da muhtemelen kentleşme ve çevre düzenlemesi konularında artan ihtiyaçlara yanıt olarak gerçekleştiğini göstermektedir. Daha önceki yıllardaki dalgalanmalar ve boşluklar, bu konudaki araştırmaların bu dinamik ve kritik alanda hala keşfedilecek ve ortaya çıkarılacak çok şey olduğunu göstermektedir. Atık deposu konumlandırılması alanındaki araştırmacılar ve politika yapıcılar, bu eğilimlerin arkasındaki nedenleri daha derinlemesine incelemeyi ve bunun içinde daha fazla araştırma ve dikkat gerektiren belirli alanları belirlemeyi değerli bulabilirler.

Konu hakkında üretilmiş çalışmalar türlerine göre incelendiğinde dört çalışma türü olduğu ve bunların arasından en fazla sayıyı Araştırma Makaleleri' nin aldığı görülmüştür. Konferans Bildirileri ve Literatür İncelemeleri çalışmalarının nicelik olarak az olduğu gözlemlenmiş olmasına rağmen ilerleyen zamanlardaki çalışmalara öncü olması açısından son derece önemli olduğu yorumu yapılabilir.

Çalışmaların bölgelere göre incelenmesiyle atık depolarının konumlandırılması problemlerinin ülkelerin kentleşme ve çevre düzeni konularına verdiği önem anlaşılmaktadır. Gelişmekte olan ülkelerin ekonomik, ekolojik ve çevre planlamasındaki çalışmalara daha fazla teşvikte bulunduğu, gelişmiş ülkelerin ise bu alanda çalışma yapılmasına ön ayak olduğu görülmektedir. Daha sonra en fazla yayın yapılmış dergiler incelenmiş ve bu dergilerin çevresel konular ve atık yönetimi ile ilgili olduğu gözlemlenmiştir.

V. SONUÇLAR

Atık depoları konumlandırması üzerine yapılan bu çalışma, bu önemli alanın dinamik ve çok boyutlu manzarasına ilişkin değerli bilgiler sağlamıştır. Sistematik tarama ve analiz yoluyla, atık depoları konumlandırması araştırmalarını şekillendiren temel eğilimler ve kalıplar ortaya çıkarılmıştır. Çalışmaların yıllara göre analizi, atık depoları konumlandırması yayınlarında kayda değer bir artış eğilimi göstererek bu alanın giderek artan önemini vurgulamıştır. Bu eğilim, özellikle gelişen küresel dinamikler bağlamında, bölgenin ekonomik, ekolojik ve çevre sağlığı üzerindeki güçlü etkileri nedeniyle kentsel planlama sürecinde çok kritik bir konudur. Çalışmaların türlerine göre sınıflandırılması, atık depoları konumlandırması araştırmalarına yapılan çeşitli katkıları göstermektedir. Araştırma makaleleri, konferans bildirileri, literatür incelemeleri ve kitap bölümleri, bilginin ilerletilmesinde ve atık yönetimi konusundaki çok yönlü zorlukların ele alınmasında farklı roller oynamaktadır. Çalışmalar bölgelere göre incelendiğinde, dünya çapındaki ülke ve bölgelerden gelen katkılar, çalışmaların küresel alaka düzeyini ortaya koymaktadır. Bu küresel perspektif, kentleşme ve çevresel düzenlerin evrensel öneminin altını çizmektedir. En çok yayın yapan dergilerin ve en çok atıf alan çalışmaların belirlenmesi, atık depoları konumlandırması araştırmaları içindeki etkili platformları ve önemli araştırmaları öne çıkarmaktadır. Bu yayınlar, literatüre yön vermeye ve bu kritik alandaki gelecekteki araştırma yönelimlerine rehberlik etmeye devam etmektedir. Bu çalışmayı sonuçlandırırken, atık depoları yer seçimi konusunun karmaşıklıklarının ele alınmasında önemli bir rol oynamaya devam ettiği açıktır. Bulgularımız, araştırmacılar, politika yapıcılar ve paydaşlar için değerli bir kaynak sunmakta ve toplum yararına çevre düzenlemesi ile doğru kentleşme için sağlam bir temel oluşturmaktadır.

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Örnek Bir İnşaat Projesinde Karşılaşılan Sorunların Kök Neden Analizi Yöntemi ile İncelenmesi

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Özet – İnşaat gibi dinamik bir sektörde yaşanan problemlerin genelde asıl sebepleri görünmemektedir. Asıl sebepleri gizleyen görünürde farklı problemler vardır. Görünen problemlere odaklanıp onları ortadan kaldırmak her zaman kalıcı bir çözüm değildir. Kalıcı çözüm olabilmesi için gerçek problemlerin çözülmesi gereklidir. Bu sebeple problemlerin gerçek sebeplerini belirleyip ortadan kaldırmak önemlidir. Bu çalışmada Sakarya ilindeki bir inşaat projesinde karşılaşılan problemler yetkililerle görüşülerek belirlenmiştir. Problemlerin kök nedeninin belirlenmesi için 5 Neden Analiz yöntemi uygulanmıştır. Bu amaçla yaşanan ve görünür olan her problem için ortalama 5 defa neden sorusu sorulup kök nedene inilmiştir. Ayrıca görünen nedenler ve kök nedenler PMI (Project Management Institute) tarafından ifade edilmiş 12 bilgi birikim alanlarına (zaman yönetimi, tedarik yönetimi, risk yönetimi, paydaş yönetimi, maliyet yönetimi, kapsam yönetimi, kalite yönetimi, sağlık/emniyet/güvenlik yönetimi, iletişim yönetimi, finans yönetimi, entegrasyon yönetimi, insan kaynakları yönetimi) göre kategorilere ayrılmıştır. Yapılan çalışmada 5 farklı problem tespit edilip detaylı bir şekilde incelenmiştir. Bu problemlerden 3'ü zaman yönetimi, diğerleri maliyet yönetimi ve tedarikçi yönetimi problemi olarak görünmektedir. Ancak kök nedenlerine inildiğinde 2'sinin risk yönetimi diğerlerinin kalite yönetimi, finans yönetimi ve iş sağlığı yönetimi problemleri olduğu görülmüştür. Ayrıca çalışma sonucunda elde edilen bir diğer veri ise problemlerin %60'ına 3 defa, %40'ına ise 2 defa neden sorusu sorulmasıyla kök nedene inildiğidir. İnşaat projelerinde karşılaşılan sorunların görünür ve kök nedenlerinin birbirinden farklı alanlarda olması sorunlara ve çözümlerine bakış açısını değiştirmekte önemli bir konudur.

Anahtar Kelimeler – 5 Neden Analizi, Kök Neden Analizi, İnşaat Sektörü, Proje Yönetimi, Proje Yönetim Enstitüsü

I. GİRİŞ

Bir inşaat projesi, planlanan zamanda, bütçe dahilinde, tüm gereksinimlere uygun olarak ve ilgili tüm tarafları memnun edecek şekilde tamamlandığında başarılı sayılır [1]. Çok sayıda proje beklentileri karşılamada yetersiz kalmakta ve ne yazık ki gecikmeler ve maliyet aşımlarıyla karşılaşmaktadır [2]. Geciken ödemeler, maliyet aşımları, proje gecikmeleri, inşaat sırasındaki tasarım değişiklikleri, zaman kısıtlamaları veya hızlandırılmış programlar, düşük üretkenlik, etkisiz yönetim ve denetim, aşırı fazla mesai ve ortalamanın altındaki kalite gibi sorunlar, inşaat sektöründeki başarısızlıklara sebep olan yaygın faktörlerdir [3].

İnşaat sektörü gibi uzun vadeli ve dinamik yapılarla karakterize edilen sektörlerde, sorunların veya olayların çoğu önceki olaylardan kaynaklanmaktadır [4]. Bu sebeple problemlerin ardındaki gerçek nedenleri anlamak büyük önem taşımaktadır. Sadece görünen problemleri ortadan kaldırmak kalıcı bir çözüm olmayabilir. Asıl problem çözülmeyip sadece çözülmüş görünebilir. Birinci veya daha üst düzeydeki nedenleri ortadan kaldırmak sorunu geçici olarak hafifletebilir, ancak temel neden eninde sonunda başka bir sorun biçiminde kendini göstermenin bir yolunu bulmaktadır [5].

Kök neden analizi (RCA), bir sorunun altında yatan nedeni ortaya çıkarmak ve sorunu hafifletmek için gereken düzeltici eylemleri belirlemek için tasarlanmış sistematik bir araştırma sürecidir. Kök neden analizi, başarısızlık noktasından kaynağına kadar olan nedensel yolun izlenmesini gerektirir. Sorunun yeniden ortaya çıkmasını önlemek amacı ile istenen durumdan istenmeyen duruma geçişi hızlandıran nedensel mekanizmayı anlamayı amaçlayan metodik bir araştırma sürecidir [6]. Basitçe ifade etmek gerekirse RCA, bir olayın yalnızca ne olduğunu ve nasıl meydana geldiğini değil, aynı zamanda neden olduğunu da tanımlamaya yardımcı olmak için tasarlanmış bir süreçtir. Ancak araştırmacılar bir olayın veya başarısızlığın neden oluştuğunu belirleyebildiklerinde, gelecekte gözlemlenen türden olayları önleyecek uygun düzeltici önlemleri belirleyebilirler [7].

Kök neden analizi yapılırken kullanılan birçok yöntem vardır. Kepner Tregoe, Nedensel Ağaç Analizi (Apollo), Hata Ağacı Analizi, Mantık Ağacı Analizi, Bariyer Analizi ve İnsan Performans Değerlendirmesi bunlardan bazılarıdır [8]. Kök neden analizi yapmanın en basit yolu, neden sorusunu 5 kez sormaktır. 5 Neden, belirli bir sorunun altında yatan neden-sonuç ilişkilerini araştırmak için kullanılan yinelemeli bir sorgulama tekniğidir [9]. 5-Neden yöntemi, bir problem veya başarısızlık olayındaki neden-sonuç ilişkilerinin belirlenmesine yardımcı olur. Bu yöntem, bir problemin veya durumun kesin nedeninin belirsiz olduğu durumlarda uygulanabilir. En basit kök neden analizi tekniklerinden biridir ve aynı zamanda doğru kullanıldığında oldukça etkilidir [10].

Literatürdeki çalışmalar çok çeşitli alanlarda kök neden analizi ve sonuç modellemeyi ele almaktadır. Kök neden analizi sanayi, sağlık ve mühendislik gibi pek çok farklı alanda sorunların temel nedenini bulmak için kullanılmaktadır. Sanayi sektöründe kazaların tekrarını önlemek amacıyla kazaların kök neden analizine yönelik birçok çalışma yapılmıştır. [11,12,13,14]

Ayrıca sağlık alanındaki hatalar ve hastanelerdeki kazaların kök neden analizleri yapılmaktadır. Kök Neden Analizi (RCA), hastaneler tarafından kalite iyileştirme ve hasta güvenliği çabalarında kullanılan analitik bir araçtır [15]. Hastanelerdeki kazaların (özellikle düşmelerin) ve ölümlerin gerçek nedeninin anlaşılmasına yönelik birçok çalışma yapılmıştır [16].

Dünyanın çeşitli yerlerinde trafik kazalarının nedenlerini ortaya çıkarmak için kök neden analizi kullanılarak yapılan çalışmalar da bulunmaktadır. Gelecekteki hava, demiryolu ve karayolu kazalarını önlemek için mevcut kazaların analizleri yapılmıştır [17,18]. Kök neden analizini gerçekleştirmek için farklı teknikler kullanılmıştır. Kum ve Şahin (2015), Arctic Marine'de 1993-2011 yılları arasında meydana gelen kazaların kök neden analizini hata ağacı yöntemini kullanarak araştırmışlardır [19]. Aderibigbe (2017), havaalanı yolu üzerinde akaryakıt depolama alanı yakınında meydana gelen kazanın balık kılçığı diyagramını kullanarak kök neden analizine odaklanmıştır [20].

İnşaat sektöründeki maliyet artışlarının nedenlerini bulmaya yönelik çalışmalar da yapılmıştır. Rosenfeld (2014) inşaat projelerinde maliyet artışlarının nedenlerinin kök neden analizini yapmıştır. Sonuçlara göre bir numaralı neden erken ihale dokümanları, 2 numaralı neden ise müşterilerin gereksinimlerinde veya tanımlarında çok fazla değişiklik yapılması ve 3 numaralı sebep, ihaleyi kazanan fiyatların gerçekçi olmayacak kadar düşük olmasıdır [21].

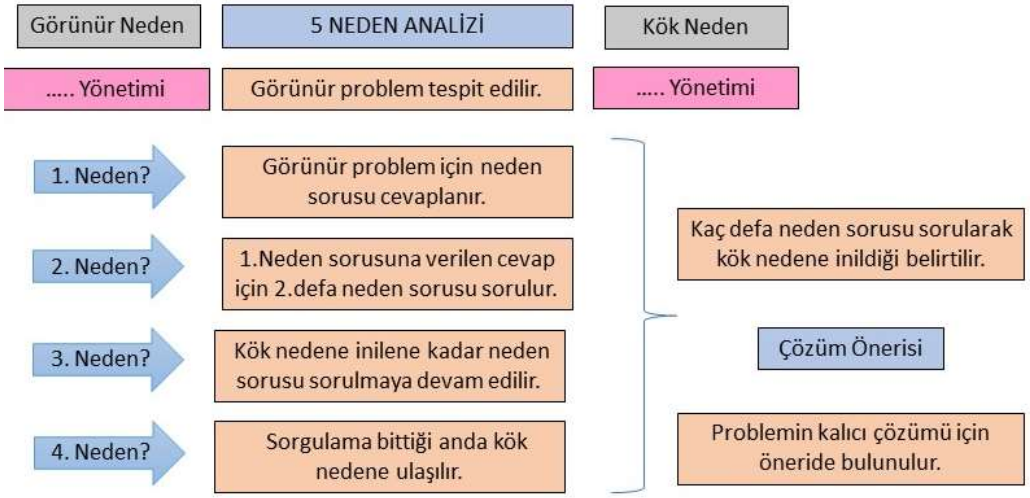
Bazı araştırmacılar inşaat sektöründeki başarısızlıkların kök neden analizini yapmıştır. Yeganeh vd., (2019), sorunların temel nedenlerini araştırmak için İran'daki dört inşaat projesini incelemiştir. 26 sorundan en önemlisini, işverenin tasarıma çok fazla dahil olması ve zayıf planlama ve karar verme olarak tanımlamışlardır [22]. Hata ağacı analizi yöntemini kullanarak yaptıkları çalışmada Shahhossein vd., (2018) inşaat sektöründeki başarısızlığın ana nedenlerini araştırmışlardır. Sonuçlara göre, mali sorunlar ve ihale sürecindeki yetersizlikler başarısızlığın temel nedenleridir [23]. Faiq vd., (2018) farklı proje yönetimi süreçlerini (başlatma süreç grubu, planlama süreç grubu, tasarım süreç grubu, sözleşme süreç grubu, yürütme ve izleme süreç grubu ve yakın süreç grubu) kullanarak Irak inşaat sektöründeki başarısızlıkların nedenlerini araştırmıştır. Ishikawa diyagramlarını, Pareto diyagramlarını ve 5-neden tekniklerini kullanarak başarısızlığın 35 ana nedenini belirlemişlerdir [24].

Yapılan literatür taramasında görüldüğü üzere kök neden analizi sağlık, sanayi, üretim ve mühendislik gibi pek çok farklı alanda kullanılmıştır. Kök neden analiziyle birlikte problemlerin görünen sebeplerinden çok asıl sebepleri araştırılmıştır. Özellikle inşaat sektörü gibi dinamik alanlarda problemlerin çoğu genelde kendinden önce gelen farklı sebeplere bağlıdır. Literatürde inşaat sektöründeki

gecikmeler ve farklı konulardaki problemlerin kök neden analizi yapılmıştır. Ancak daha çok tek bir problemin ya da belirli alandaki problemlerin kök neden analizi yapılmıştır. İnşaat sektöründe karşılaşılan her alandaki problemlerin eş zamanlı kök neden analizini yapan çalışmalar yetersizdir. Bu çalışmada farklı inşaat projelerinde söz konusu olan problemlerin genel bir kök neden analizi yapılmış ayrıca literatürden farklı olarak görünen problemin ve asıl nedenin PMI (Project Management Institute) tarafından belirlenen 12 adet bilgi birikim alanlarından hangi başlık altında değerlendirildiği de belirtilmiştir.

II. YÖNTEM

Bu çalışmada Sakarya ilindeki bir inşaat projesinde karşılaşılan problemlerin kök neden analizi yapılmıştır. Bu amaçla projedeki yetkili kişilerle görüşülmüştür. Belirlenen 5 farklı problemin kök nedenlerinin bulunması için 5 Neden analiz yöntemi kullanılmıştır. Görünürdeki her bir sorun için ortalama 5 defa neden sorusu sorularak kök nedene ulaşılana kadar sorgulama devam etmiştir. Kök nedenleri belirlenen her problemin görünür hali ve kök nedeninin PMI tarafından ifade edilen hangi bilgi birikim alanına dahil olduğu gösterilmiştir. Ayrıca bu problemlerin tamamen ortadan kaldırılması için çözüm önerisi sunulmuştur. Şekil 1.'de 5 Neden analizinin yapım aşaması gösterilmiştir.

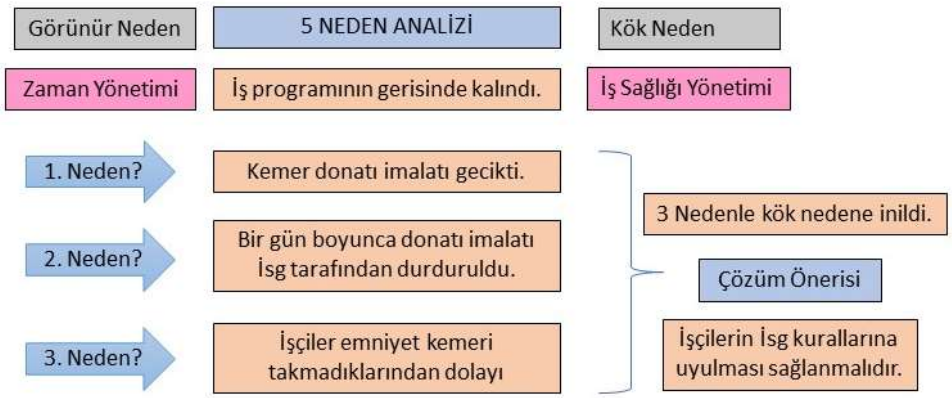


Şekil 1. 5 Neden Analizi

III. BULGULAR

Tespit edilen 5 farklı problem için kök neden analizleri yapılmıştır. Şekil 2.'de Problem 1'in 5 Neden analizi yapılmıştır. Yetkilinin belirttiği görünür olan problem iş programının gerisinde olmalarıdır. Zaman yönetimi problemi gibi görünen sorunun kökenine inilmesi için peş peşe neden sorusu sorulmuştur. İlk nedenin cevabı kemer donatı imalatının gecikmesidir. Kemer donatı imalatının neden geciktiği sorulduğunda ise İş Sağlığı Güvenliği (İSG) uzmanı tarafından donatı imalatının 1 gün boyunca durdurulduğu anlaşılmıştır. Donatı imalatının neden durdurulduğu sorgulanınca işçilerin güvenlik amacıyla kullanılan emniyet kemerini takmadıkları sonucuna varılmıştır. Başlangıçta zaman yönetimi problemi sanılan sorunun kök nedeninin, işçilerin İSG kurallarına uymaması olduğu anlaşılmıştır. Yani görünür neden zaman yönetimi problemi iken kök neden iş sağlığı güvenliği yönetimi problemidir. Bu ve

bunun gibi problemlerin ortaya çıkmasını engellemek için zaman yönetimi değil iş sağlığı güvenliği yönetimi konusunda tedbir alınması gereklidir.



Şekil 2. Problem 1 için 5 Neden Analizi

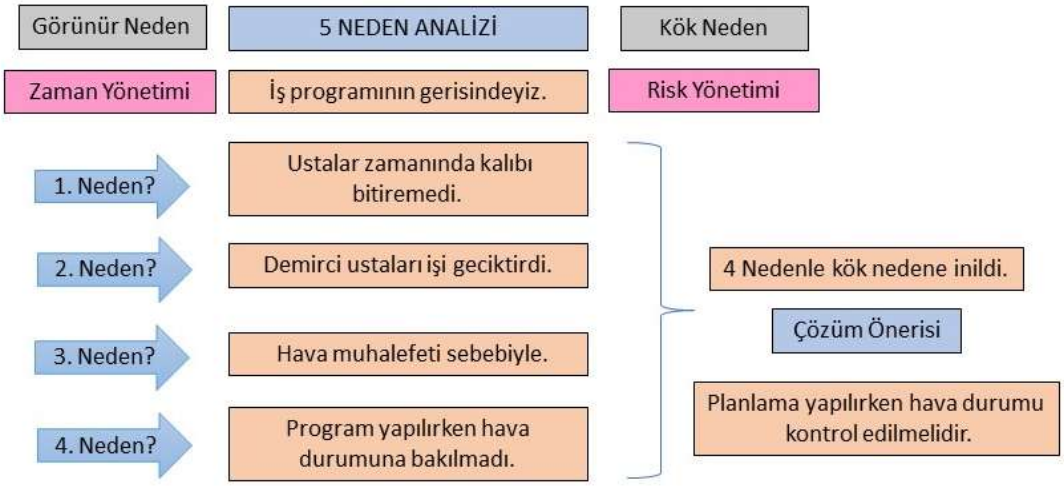
Şekil 3.'te Problem 2'nin 5 Neden analizi yapılmıştır. Sorun kendisini maliyet yönetimi problemi olarak dışa vurmuştur. Beton için planlanandan daha fazla ödeme yapılmıştır. Bunun sebebi araştırıldığında ise hesaplanandan daha fazla beton harcandığı görülmüştür. Beton miktarının neden hesaplanan değerin dışına çıkıldığı sorgulandığında ise kazı payına kadar beton döküldüğü anlaşılmıştır. Bu işlemin sebebi sorulmuştur ve kalıpçıların ampatmanın bittiği yere kalıp koymadığı bu sebeple de fazladan beton kullanıldığı anlaşılmıştır. Yani görünürde maliyet yönetimi problemi olarak görünen bu sorun aslında kalite yönetimi sorunudur. Yapılması gereken işler doğru bir şekilde yapılmadığı zaman bir sonraki adımı olumsuz etkileyebilir. Yapılan işlerin adım adım kontrol edilmesi bu gibi problemlerin önüne geçilmesine yardımcı olabilir.

Şekil 3. Problem 2 için 5 Neden Analizi

Şekil 4.'te Problem 3 için 5 Neden analizi yapılmıştır. Çalışma sahasında vinçlerin yetersiz kalması bir tedarikçi yönetimi problemi olarak görülmektedir. Görünen sorun irdelenerek kök nedenine inilmiştir. Vincin istenen mesafeye malzeme aktaramadığı görülmüş ve bunun sebebi sorgulandığında ise vinç operatörünün vince gerekli olan yükü alamadığı görülmüştür. Tekrar neden diye sorulduğunda vinç özelliklerinin işin niteliğini karşılamadığı ve bunun sebebinin de istenen vincin maliyeti yüksek bulunduğu için alınmayıp daha niteliksiz vinç alınması olduğu anlaşılmıştır. İşin niteliğine göre bütçe düzenlemesi yapılması bu gibi problemlerin yaşanmasını engelleyebilir.

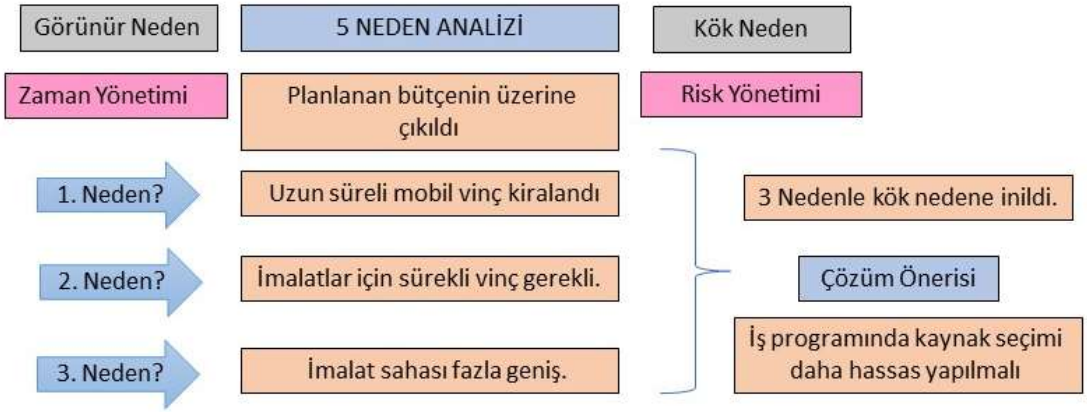
Şekil 4. Problem 3 için 5 Neden Analizi

Şekil 5.'te Problem 4 için 5 Neden analizi yapılmıştır. İş programının gerisinde olmak görünür bir problemdir. Bu problemin gerçek sebebinin anlaşılması için neden sorusu sorularak irdelenmiştir. Kalıp ustaları kalıbı zamanında bitiremediği görülmüştür. Bunun sebebi ise demir ustalarının işi geciktirmesidir. Demir ustalarının işi neden geciktirdiği sorgulanınca hava muhalefeti sebebiyle olduğu görülmüştür. İş programı yapılırken hava durumu göz ardı edildiği için bu problemle karşılaşılmıştır.



Şekil 5. Problem 4 için 5 Neden Analizi

Şekil 6.'da Problem 5 için 5 Neden analizi yapılmıştır. Planlanan bütçenin üzerine çıkılmıştır. Bu problemin kök nedeni sorgulandığında uzun süreli vinç kiralanması olduğu görülmüştür. Uzun süreli vinç kullanılmasının sebebi imalat sahasının fazla geniş olmasıdır. İş programı yapılırken kaynak ihtiyaçları detaylı incelenip belirlenmelidir. Aksi takdirde iş programı yapılırken belirlenemeyen ihtiyaçlar daha sonra planlanan bütçenin açılmasına sebep olabilir.



Şekil 6. Problem 5 için 5 Neden Analizi

5 Neden Analizi yönteminde problemlere her zaman 5 defa neden sorusu sorulmaz. Daha az ya da fazla olabilir. Çalışmada analiz edilen problemlerden 3'üne 3 defa, 2'sine 4 defa neden sorusu sorularak kök neden bulunmuştur. Problem 1.'de görünen sorun zaman yönetimi iken kök neden İSG yönetimi, Problem 2.'de görünür sorun maliyet yönetimi iken kök neden kalite yönetimi, problem 3.'te görünen sorun tedarikçi yönetimi iken kök neden finans yönetimi, Problem 4.'te görünen sorun zaman yönetimi iken kök neden risk yönetimi, Problem 5.'te görünen sorun zaman yönetimi iken kök neden risk yönetimi problemidir.

IV. TARTIŞMA

İnşaat sektöründe yaşanan problemleri minimize etmek için görünen sebeplerden daha çok kök nedenler belirlenmeli ve ortadan kaldırılmalıdır. Yapılan çalışma sonucunda yaşanan problemlerinin nerdeyse hepsinin görünen nedenleri ve kök nedenlerinin farklı bilgi birikim alanlarına dahil olduğu görülmüştür. Yani zaman problemi gibi görünen gecikmelerin altında iş sağlığı yönetimi, kalite yönetimi gibi görünen problemlerin altında yeterince vakit olmadığı için zaman yönetimi problemleri olabilir. Bu sorunları belirlemek ve gerçek sebeplerini irdelemek çözümünde kolaylık sağlayacaktır.

V. SONUÇLAR

Yapılan çalışmada elde edilen sonuçlara göre sorunlar daha çok zaman yönetimi problemi gibi görünse de kök nedenleri farklıdır. Zaman yönetimi probleminin altında iş sağlığı yönetimi ve risk yönetimi olabilir. Maliyet yönetimi problemi gibi görünen sorunların altında kalite yönetimi olabilir. Tedarikçi yönetimi problemi sanılırken asıl sorun finans yönetimi olabilir. Bir problemin kök nedeninin sorgulanarak belirlenmesi o problemi tamamen çözmek için önemlidir. Kök nedeni belirlenmeden sadece görünür sorunun ortadan kaldırılması her zaman kalıcı çözüm olmayabilir. Bu çalışma inşaat projelerinde karşılaşılan sorunların görünür ve kök nedenlerinin farklı bilgi birikim alanlarına dahil olabileceğini göstermede önemlidir.

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RTV 2 Kalıp Silikonu ile Poliüretan Malzemenin Dekoratif Ürünlerde Kullanımı

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Özet **–** Tarihsel süreçte; model, kalıp ve seri üretim örneklerine rastlanması, bu üretim yönteminin oldukça eski zamanlara tarihlendiğini göstermektedir. Dekoratif ürünlerin çeşitli alanlarda yaygın olarak kullanıldığı günümüz süsleme anlayışında da, hızlı ve kolay elde edilebilecek malzeme ve yöntemlerin kullanımının oldukça yaygın olduğu görülmektedir. Bu üretim yöntemlerinde özellikle tercih edilebilir oluşu ve işlevselliği öncelikli aranan özellikler arasında yer almaktadır. Bu ürünlerin üretilmesinde kalıp olarak çoğunlukla silikon ve ürün oluşumunda ise plastik türevi malzemeler kullanılmaktadır. Her iki malzeme içinde belirli oranlarda karışımların dikkatli bir şekilde hesaplanması gereklilik arz etmektedir. Bu çalışmada, öncelikle uygun ana model üretimi ve RTV 2 kalıp silikonu ile kalıbının alınması ve sonrasında da poliüretan denilen sıvı plastik reçine olarak da bilinen malzemenin dekoratif ürünlerdeki kullanımı ve üretim aşamalarının incelenmesi amaçlanmıştır. Çalışmanın uygulama aşamasında modelleme ve kalıp alma, izlenen yollar ve kullanılan yöntemler olarak belirtilmiştir. Çalışmada ele alınan konu kapsamında dekoratif elemanların üretiminde izlenen yöntemler ve malzeme kullanımı detaylı şekilde incelenmiştir. Seri üretim açısından değerlendirildiğinde modelleme ve kalıp alma yöntemleri incelenmiştir. Bu çalışmada, pek çok farklı kalıplama seçeneğinden silikon ile kalıplama yöntemi çeşitli avantajlarından ötürü tercih edilmiştir. Bu çerçevede, ulusal ve uluslararası düzeyde yapılan araştırmalar, uygulamalar ve mevcut dekoratif ürünler incelenen materyaller arasında yer almaktadır. Sonuç olarak dayanıklılığı, sağlamlığı ve çok kısa sürede elde edilebilmesi nedeniyle ürünlerde tercih edilirliğinin arttığı görülmektedir.

Anahtar Kelimeler – RTV 2 Silikon, kalıp, poliüretan, dekor, üretim

I. GİRİŞ

Sanat tarihinin önemli bir parçası olan dekoratif ürünler, insanoğlunun devinimsel şekilde keşfetme ve üretme çabası neticesinde gerçekleşmiştir. Geçmişte ve günümüzde kullanılan pek çok ürün, bu keşiflerin ve kültürün sürekliliği anlamına gelmektedir (Erkaplan ve Güldür, 2022). Dekor her alanda, farklı kültürlerde, farklı işlevlerle ve temalarla mevcudiyet göstermiştir. Temalar ve biçimsel özellikler, her kültürde, her dönemde farklılık göstermiştir.

Tarih boyunca başta günlük kullanım ihtiyacını karşılamak amacıyla yapılan dekoratif ürünler, kullanılan malzeme, teknik, kullanım alanları ve yapıldıkları coğrafi konum açısından değerlendirildiğinde geniş bir ürün çeşitliliği sunmaktadır (Şekil 1).

Şekil 1. Tanrıça İştar model ve pişmiş toprak kalıbı, Babil Dönemi, MÖ 2000-1750, Güney Mezopotamya, British Museum, Londra.
https://www.worldhistory.org/image/8095/ishtar-clay-mould

Farklı ihtiyaçlar doğrultusunda şekillenen dekoratif ürünler, aynı zamanda dönemin özelliklerini yansıtan kültür öğelerdir. Bu öğeler süreç içerisinde estetik değerleri de içerisinde barındıran bir dönüşüme uğramıştır. Her dönemin kendine özgü sosyolojik özellikleri, beğeni anlayışı ve tercihleri, dekoratif ürünlerin birçok özelliğini ortaya koymaktadır. Nesiller arası bağ kuran dekoratif sanat ürünleri, kültürel ve tarihsel değer taşımaktadır.
Dekoratif unsurları destekleyen sanat, insanların günlük yaşam alanlarını güzelleştirilmeyi ve dönüştürülmeyi amaçlamaktadır. Dekoratif olarak nitelendirilen her şey sanat olmasa da sanat, dekoratif anlam taşıyabilmektedir (Aslan, 2018, 1372).

II. MATERYAL VE YÖNTEM

Çalışmada ele alınan konu kapsamında dekoratif elemanların üretiminde izlenen yöntemler ve malzeme kullanımı detaylı şekilde incelenmiştir. Seri üretim açısından değerlendirildiğinde modelleme ve kalıp alma yöntemleri incelenmiştir. Bu çalışmada, pek çok farklı kalıplama seçeneğinden silikon ile kalıplama yöntemi çeşitli avantajlarından ötürü tercih edilmiştir. Bu çerçevede, ulusal ve uluslararası düzeyde yapılan araştırmalar, uygulamalar ve mevcut dekoratif ürünler incelenen materyaller arasında yer almaktadır. Şahin 2015'e göre, özellikle endüstriyel üretim malzemelerine yönelerek seri üretim yaklaşımlarına dayanan ürünlerin artışı kendilerine has bir sanat dili oluşturarak kullanmaktadır (Şahin, 2015). Aslan 2018 ise, Dekoratif unsurları destekleyen sanat, insanların günlük yaşam alanlarını güzelleştirilmeyi ve dönüştürülmeyi amaçladığını ifade etmektedir. (Aslan, 2018, 1372).

Seri Üretim

Yeryüzünde hızlı nüfus artışı nedeniyle artan talepler seri üretim gerekliliğini de beraberinde getirmiş, teknolojik gelişmelerin de olumlu etkileriyle endüstriyel ürünlerin tasarlanması ve üretilmesi hız kazanmıştır (Dilmaç, 2015: 12). Seri üretim, özellikle sıklıkla tercih edilen ürünlerin, düzenli ve sürekli olarak büyük miktarlarda, standart ve teknolojik üretim yöntemleri ile üretilmesi anlamına gelmektedir. Genellikle önceden belirlenmiş bir üretim bandı, iş akışı programı üzerinde gerçekleştirilen bu tür bir üretim süreci yoğun taleplere cevap verebilmektedir. Seri üretim, süreci kısaltmak ve düzenli bir arz yaratmak amacıyla üretim yapabilen bir sistem geliştirmekle mümkün olabilmektedir (Oğuz, 2022, 1784).

Seri üretim yöntemleri, alternatif üretim süreçleri sunmak, maliyetleri en aza indirmek ve kaliteyi artırmak için kullanılan yöntemlerdendir. Bu tür üretim genellikle endüstriyel ürünleri ve tüketim ürünlerinin yanı sıra, dekoratif eşyalar, mobilya, tekstil otomotiv ve elektronik gibi çeşitli sektörlerde de kullanılabilir. Günümüzde seri üretim yöntemlerinin çeşitli faydaları görülmektedir (Tablo 1).

Tablo 1. Seri Üretim Faydaları (Yazar tarafından hazırlanmıştır)

Sürekli ve fazla talep
Az türde çeşidin fazla sayıda üretimi
Sermayenin yüksek oluşu
Ürünlerin aynı makineler üzerinde tek tip işlenmesi
Özel üretim makinelerinin kullanımı
Kalifiye olmayan çalışanların mevcudiyeti

Tasarım ürünleri geliştirirken mümkün oldukça gerçek malzemeye uygun görünüme sahip, yüksek kalitesi oldukça yüksek seviyede ve son derece hassas bir üretim gerekmektedir. Ancak aslına en uygun malzeme üretmek için gereken ahşap, plastik, seramik gibi dayanıklı, katı, dirençli ve içi dolu malzemenin elle şekillendirilmesi oldukça güçtür. Özellikle de endüstriyel anlamda üretilecek malzemelere yönelerek seri üretimlere dayanan ürünlerdeki artışı, kendilerine has bir sanat dili oluşturarak kullanmaktadır (Şahin, 2015).

Endüstri-sanat etkileşiminin en güçlü olduğu sanat dallarından biri de geleneksel bir geçmişe sahip olan seramik sanatıdır. Ülkemizde 1950' lerden sonra diğer gelişmelere paralel olarak gelişen seramik endüstrisi; kaplama seramikleri, sofra takımları, sağlık gereçlerinin yanı sıra, süs eşyaları ve dekoratif ürünler gibi endüstriyel üretim alanına girmiştir. Günümüzde dekoratif ürünlerin yapımında çeşitli yöntemler kullanılmaktadır. Bunlar, alçı kalıp ve seramik malzeme ile yapılabileceği gibi silikon kalıp ve plastik türevi malzemelerle de yapılabilmektedir.

Plastik Türevi Malzemeler

Gelişen teknolojinin yeni arayışları da beraberinde getirmesi, plastik türevi sentez yöntemlerini de etkilemektedir. Bu yöntemlerle elde edilmiş binlerce poliüretan türevi malzemelere her gün yenileri eklenmektedir. Günümüzde neredeyse her alanda rastlanan plastik türevleri, hayatın vazgeçilmez malzemeleri olmuşlardır (Tablo 2). Bu tür malzemelerin bu denli büyük kullanım alanlarına sahip oluşlarının asıl sebebi, strüktürel niteliklerinin kullanıma uygun şekilde ayarlanabilir ve ekonomik olarak elde edilebilmeleridir. Hem kimyasal yapı özelliklerinin hem de fiziksel esnekliklerinin istenildiği gibi ayarlanabilir olması, tercih edilirliğini arttırmaktadır. Ayrıca istenilen fonksiyonlara sahip plastik türevleri, uygun fonksiyonel gruplara göre kolaylıkla hazırlanabilmektedir.

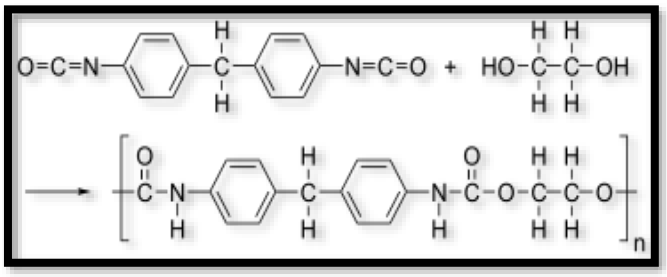
Tablo 2. Plastik türevleri (Yazar tarafından hazırlanmıştır)

Epoksi
Sentetik kauçuklar
Polyester reçine
Poliresin
Poliüretan

Epoksi reçineler, çok yüksek sıcaklıklara ve kimyasal etkilere de dirençli ve sert olmalarıdır. Sentetik kauçuklar, esnek ve elastik olmaları da ayrıca önemlidir.. Polyester reçinesinin ise, kullanım şekli özellikle cam takviyeli ve yarı saydam bir plastik (CTP) türevi malzemedir. Boyanabilme özelliğine sahip olup, polyester reçine ve içeriğinin kimyasal katkısına kalsit ilave edilerek oluşan ve sertleştiğinde ağırlaşır bir maddedir Hacimsel ürünleri üretmek için kullanılan Poliresin de, kullanım alanları son derece geniş bir hammaddedir. Genellikle sanatçıların istediği ürünleri şekillendirebilmesine uygun, elmas etkisi sağlayan, düzgün yüzeyli ve saydam bir doku sağlamaktadır. Bu nedenle işlenmesi de son derece basittir. Üç boyutlu şekillendirme sürecinde yaygın olarak kullanılır. Dekoratif süs eşyaları, hediyelik eşyalar, heykeller ve çeşitli tasarım ürünlerinde kullanışlı bir malzeme olması nedeniyle, bu tür ürünlerin üretilmesinde tercih edilir. Ayrıca Poliresin, banyo ve dekoratif ev ürünleri gibi ürünlerin üretiminde sıra dışı bir gerçeklik etkisine sahiptir. Replika taş, taklit porselen ve türevi ürünler, bitkisel ve hayvansal

figürler gibi ayrıntıların üretilmesinde endüstri, dekorasyon gibi alanlarda kullanılan bir hammaddedir. Sağlık açısından riski bulunmayan, hafif ve oldukça iyi sonuçlar elde edilebilen el sanatları üretimi sağlayan poliresin malzeme çeşitli kullanım alanlarına sahiptir. Poliüretanlar, hem sıvı hem de köpük halinde olup, çok sayıda özel kullanım alanına da sahiptir. Dayanıklılık ya da esneklik sağlayabilen bu malzeme, inşaat sektöründe çatı yalıtımında ve dekorasyon işlerinde yararlanılmaktadır. Poliüretanlar da tıpkı polyester hammaddeler gibi sıvı reçinedir. Bu nedenle birçok kullanıcı tarafından karıştırılır. Poliüretan, polyestere benzer bir maddedir. Ancak aradaki fark, poliüretan reçinesi daha hafiftir. Poliüretan reçine olarak bilinen bu malzemenin, Poliüretan (A) ve Sertleştirici (B) olacak şekilde iki kompenantı bulunmaktadır. A kompenantından 1 birim, B kompenantından 1 birim ile karıştırılarak ürün elde edilir. Yani 100 gram Poliüeratan Reçine'ye 100 gram Sertleştirici eklenerek 3-4 dakika aralığında karıştırılır. Poliüretan reçine dökülecek bölgenin veya kalıbın derinliğine göre 15-30 dakika aralığında sertleşmektedir. Tam donma için 1 saat beklemek gerekebilir. Poliüretan reçineler sıvı plastik olarak da adlandırılmaktadır. Poliüretan reçine; Poliüretan dekoratif ve hediyelik eşya üretiminde kullanımının yanı sıra, kaplamalarda, poliüretan mastik yapımında, poliüretan deri alanında, poliüretan ayakkabı, poliüretan astar, poliüretan ahşap, poliüretan araç kaplama, poliüretan ambalaj, poliüretan ayna gibi alanlarda kullanıma sahiptir. Özellikle dekoratif ürün ve süsleme objelerinde kullanımı tercih edilen Poliüretan reçinenin dökümünde dikkat edilmesi gereken bir takım ilkeler bulunmaktadır. Örneğin; karışımı tartmadan önce (A) kompenantına dibinden iyice karıştırıp homojen hale getirilmelidir. Ayrıca, dökülecek silikon kalıpların iyi kalitede olmasına dikkat edilmelidir. Çünkü karışımın ısınmasından dolayı kalıplara zarar verebilir. Bunun yanı sıra, döküm yapılacak alanın havadar olmasına da özen gösterilmelidir. Üretan grupların moleküler birimlere bağlandığı poliüretan sentezi Tablo 3.'de verilmiştir.

Tablo 3 Poliüretan sentezi (Yazar tarafından hazırlanmıştır)



Silikon kalıplar

Çeşitli sektörlerde ve evde kullanım için son derece pratik araçlardır. Bu esnek ve dayanıklı malzeme, çeşitli ürünlerin üretiminde ve şekillendirilmesinde yardımcı olur. 20. Yüzyılın başlarından itibaren endüstriyel üretimlerde, model yapımında ve kalıp alma aşamalarında kolay olması amacıyla kullanılmaktadır. Oldukça kısa sürede kalıp üretimi gerçekleştiği için, deneme amaçlı örnek imalat yöntemi olarak da kullanılmaktadır. Bu tür silikon malzemeyle yapılan kalıplara çift komponantlı plastik malzemeler dökülerek obje üretimi yapılmaktadır. Geçmişte yaygın olarak kullanılan Polyester malzemeler, 80'li yılların sonlarına doğru malzeme teknolojisindeki gelişmeler sonucunda yerini yüksek teknik özellikteki başka poliüretan döküm malzemelere bırakmaya başlamıştır.

Günümüzde dayanıklılık ve hızlı donma özelliğinden dolayı poliüretanlar daha çok tercih edilmektedir. Silikon kalıpların küçülme oranının düşük olası ve detayları yüksek yansıtabilmesi gibi nedenlerle genellikle heykel ve seramik gibi ürünlerin kopyalandığı ve modellediği eserlerin çoğaltabilmek için kullanılmaktadır. Sivri, keskin ve ters açılı parçaların alçı ve polyester kalıplarla üretilemediği ürünlerde esnek ve elastik yapıya sahip silikon, tercih sebebidir. Böylece silikon kalıplama yöntemi diğer endüstriyel ürünlerin de üretiminde yer edinme imkânı bulmuştur. Silikon kalıplama diğer döküm kalıpçılığı yöntemleri gibi öncelikle bir ana modelleme üretimi ile başlamaktadır. Ana modeller; el işçiliği, Cnc türü üretim tezgâhları veya hızlı prototipleme yöntemleriyle üretilmektedir. Eğer kopyalama yapmak için kalıp alınacak ise örnek parça master model olarak kullanılabilir (Şekil 2, 3).

Şekil 2. Rtv silikon kalıplar
https://www.silikonkalip.com.tr/index.php?route=product/product&product_id=4729

Şekil 3. Sıvı plastik dekoratif ürünler
https://www.silikonkalip.com.tr/index.php?route=product/product&product_id=4729

RTV silikon kalıp ve poliüretan türevi olan sıvı plastik malzemeler ile sanat ve el işi ürünlerinin üretimi kolaylıkla yapılabilmektedir. Dekoratif eşya üretimi, günümüzde oldukça tercih edilen bir yöntemdir. Bu tür bir üretim sürecinde önemli olan bazı unsurlar bulunmaktadır (Tablo 4).

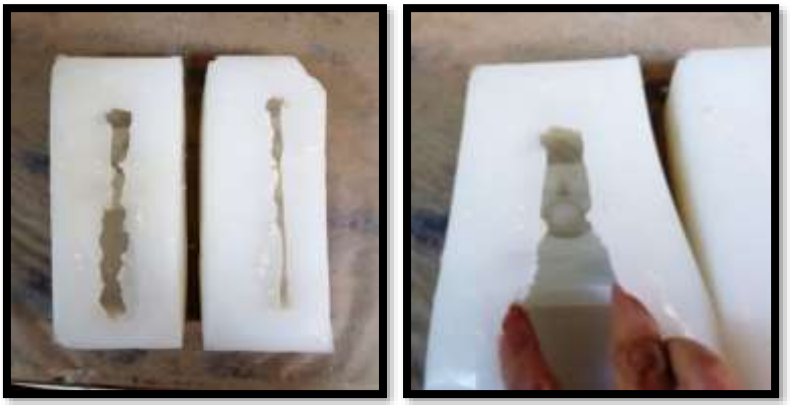
Tablo 4. Üretim Sürecinde (Yazar tarafından hazırlanmıştır)

Malzeme Seçimi	Sıvı plastikle dekoratif eşyalar üretmek için özel sıvı plastik malzemeleri gereklidir. Bu malzemeler genellikle reçine veya epoksi tabanlıdır. Bu malzemelerin çeşitli türleri ve özellikleri bulunmaktadır, bu nedenle üretim amacına ve gereksinimlere göre doğru malzemenin seçilmesi önemlidir.
Kalıp Seçimi	Üretilecek dekoratif eşyanın şekline ve boyutuna göre uygun bir kalıp seçilmelidir. Silikon kalıplar genellikle bu amaç için kullanılır, çünkü esneklikleri sayesinde kalıptan çıkarma işlemi kolaydır.
Karıştırma ve Döküm	Sıvı plastik malzemesi, üretim için uygun oranlarda karıştırılmalıdır. Karışım işlemi genellikle bir karıştırıcı kullanılarak yapılır. Ardından, hazırlanan karışım dökme işlemine geçilir ve kalıba dökülür.
Sertleşme	Sıvı plastik malzeme, belirli bir süre boyunca sertleşme işlemine tabi tutulur. Bu süreç, malzemenin tamamen sertleşmesi ve istenen şekli alması için gereklidir. Sertleşme süresi malzeme türüne ve kalınlığına bağlı olarak değişir.
Düzeltme ve Rötuş	Eşyanın tamamen sertleşmesinin ardından, gerekiyorsa yüzey düzeltilir ve rötuşlanır ve parlatılır. Bu adım, eşyanın görünümünü iyileştirmek ve istenen parlaklık düzeyini sağlamak için yapılır.
Renklendirme ve Dekorasyon	Sıvı plastik malzemesi genellikle renklendirilebilir ve çeşitli dekoratif unsurlar eklemek için kullanılabilir. Pigmentler, boya ve diğer dekoratif malzemelerle sıvı plastik renklendirilebilir veya özel desenler oluşturulabilir.

III. SİLİKON KALIP VE POLİÜRETAN MALZEME İLE KİŞİSEL TASARIMLAR

Sıvı plastikle dekoratif eşya üretimi, sanat ve el işi alanında büyük bir yaratıcılık ve esneklik sağlamaktadır. Bu süreç, kişisel zevklere ve taleplere göre özelleştirilebilir ve geniş bir ürün yelpazesi sunar. Bu durum, ev dekorasyonundan takıya kadar birçok farklı alanda kullanılabilir ürünlerin üretilmesini sağlamaktadır. Dolayısıyla ürünlerin seri ve hızlı bir şekilde üretilebilmesi amacıyla

kalıplamada silikon malzeme tercih edilmektedir. Silikon malzeme, donma sonrası esnekliği sahip olduğu için üretimde avantajlıdır. Çalışma kapsamında özgün olarak tasarlanan master model, seramik çamuru ile şekillendirilmiştir. Modelin, RTV silikon malzeme ile kalıbı alınmıştır. Hem master modelin hem de kalıptan elde edilecek ürünlerin rahat çıkabilmesi için arka kısımda boşluk bırakılmıştır. (Şekil 4).



Şekil 4. RTV Silikon kalıp (Kişisel arşivden)

Silikon kalıp içine ürün elde edebilmek için çeşitli malzemeler ile döküm yapılabilmektedir. Bunlar, genellikle poliüretan türevi malzemeler olabilmektedir. Şeklini kolay alan, kısa sürede donabilen, kalıptan rahatlıkla çıkabilen ve renklendirilme kolaylığı sağlayan özelliklere sahiptir (Şekil 5).

Şekil 5. Sıvı Plastik dekoratif ürünler (Kişisel arşivden)

III. BULGULAR

Çalışma kapsamında yapılan araştırmalar neticesinde, RTV Silikon kalıplar; esnek, dayanıklı ve yapışmaz özelliklere sahip olduğu gibi olumlu bulgulara ulaşılmıştır. Bu özellikleri sayesinde kalıptan çıkarmak kolaydır ve şekilleri bozulmadan çıkarılabilirler ve uzun süre kullanılabilirler. Ayrıca, yapışmaz bir yüzeye sahiptir, bu da kalıptan çıkarmayı kolaylaştırmakta ve kalıba yapışma sorununu azaltmaktadır. Silikon kalıplarla birçok farklı şekil, boyut ve tasarımda ürün çalışması yapılabilmektedir. Bu, kullanıcıların farklı ihtiyaçlarına ve tercihlerine uygun seçenekler sunmaktadır. Sağlık ve güvenlik açısından güvenli olması nedeniyle el sanatları, dekoratif ürünler ve diğer pek çok alanda da kullanılabilmektedir.

Günümüz sürdürülebilir üretim yöntemlerine uygunluğu nedeniyle RTV silikon kalıplarla çeşitli poliüretan malzemeler ile dekoratif ürünler elde edilebilmektedir. Bu malzemelerin pek çok avantajları sebebiyle özellikle tercih edildiği görülmektedir.

IV. SONUÇLAR

Seri üretim yöntemleriyle ilgili yapılan çalışmalarda, endüstriyel süreçlerin optimize edilmesi, verimliliğin artırılması ve üretim maliyetlerinin düşürülmesi gibi yararlı sonuçların olduğu sonucuna varılmaktadır. Buna dayanarak, genellikle seri dekoratif üretim yönetimlerinden olan silikon kalıplama ile seri üretim yöntemlerinin endüstriyel uygulamalardaki önemi ve potansiyeli vurgulanmaktadır. Ayrıca, bu alandaki araştırmaların kesintisiz olarak devam ediyor olması bu yöntemin önemini kanıtlar niteliktedir.

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THE ROLE OF EPIGENETIC MODIFICATIONS ON CARDIOVASCULAR DISEASE

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Abstract – Globally, cardiovascular diseases (CVD) are now among the main causes of death. The incidence of CVD disorders is predicted to rise in both industrialized and emerging nations as risk factors for the disease, such as obesity, dyslipidemia, and hypertension, rise. Currently, the pathophysiology of CVD is still poorly understood, which increases the need for a comprehensive investigation of the developmental processes of the disease and to find alternative research areas. Epigenetic mechanisms have a significant function in modifying inherited traits along with regulating gene expression. Under the effect of alterations in genetic structure and environmental stimuli, epigenetic mechanisms such as miRNA, DNA methylation, lincRNA, and histone modifications cause variations in the expression of genomic information. These processes control how genes are activated or inhibited and affect how well cells respond to cues from their surroundings. It is believed that epigenetic pathways have a role in the development and progression of CVD. Gaining knowledge on how epigenetic changes affect cardiovascular disease (CVD) could help to improve diagnostic and therapy approaches by shedding light on the pathophysiology of the condition.

Keywords – Epigenetics, Cardiovascular diseases, Histone modification, DNA methylation, miRNA

I. INTRODUCTION

Cardiovascular diseases (CVD) are conditions affecting the cardiovascular system that begin with the onset of cardiovascular risk factors and can result in organ failure and death by damaging target organs through progressive vascular disease [1]. CVD causes approximately 16.7 million deaths each year and is one of the most common causes of death globally [2]. In 2004, cerebrovascular disease and ischemic heart disease accounted for nearly 5.5 million and 7.2 million deaths, respectively, accounting for 22% of all deaths [3]. However, these deaths reflect only a fraction of cardiovascular disease. Many individuals develop target organ damage due to asymptomatic risk factors. Modifiable risk factors such as stress, irregular diet, hypertension, smoking, abnormal lipid levels, diabetes and epigenetic mechanisms are some of the major causes of cardiovascular mortality [4], [5]. Cardiovascular risk factors have a direct relationship with cardiovascular health, and there is no specific threshold for disease [6]. These risk factors usually occur in combination rather than in isolation. Almost 70 percent of individuals at risk have more than one risk factor and interact with each other to increase the individual's total CVD risk; a single risk factor increases the risk 4-fold, whereas multiple risk factors can increase the risk up to 60-fold [7].

Gene transcription alterations that result in inherited variations in gene expression are referred to as epigenetic modifications [8]. Interactions between the environment and the genome lead to changes in gene expression. While epigenetic alteration of genetic information plays a role in differentiation and development, it is also influenced by environmental stimuli. Major epigenetic modifications include microRNAs (miRNAs), DNA methylation, long interval non-genetic RNAs (lncRNAs), and histone

modification [9]. These changes may cause variation in gene expression, causing the expression of the same hereditary information to change depending on environmental conditions. The study of these changes offers an exciting area of research to fully understand the underlying causes of CVD.

A. Epigenetic Impact on Cardiovascular Disease

Recent research suggests that epigenetic changes may explain the missing part of the genetic predisposition for complicated cardiovascular diseases like atherosclerosis and hypertension [10]. Epigenetic modifications such as DNA methylation, miRNA, histone modifications and lncRNA affect gene expression mechanisms. Environmental and/or nutritional factors, especially early in life, may increase future disease risk through epigenetic modifications [11]. Folate, vitamin B12, and choline deficiencies play an important role in this process [12]. Homocysteine has been reported to have a critical effect on the methylation cycle, causing high levels of DNA hypomethylation and alterations of gene expression. Mathiyalagan et al. examined epigenetic changes affecting the expression of certain genes during physiological cardiovascular development and found that histone acetyltransferase p300 plays an active role in the expression of natriuretic peptide A (ANP) and natriuretic peptide B (BNP) genes in the left ventricle of the heart [13]. Furthermore, histone deacetylase 7 has been reported to affect vascular development and histone acetylation plays an important role in regulating gene expression in smooth muscle cells (SMC) and endothelial cells. Histone acetyltransferase (HAT) p300 significantly affects vascular smooth muscle cell differentiation, highlighting that chromatin remodeling is crucial for the phenotypic differentiation of SMC [14].

B. DNA Methylation on Cardiovascular Disease

DNA methylation, a common epigenetic modification in the genome, is a mechanism by which a methyl group is attached to the C5 location of cytosine residues [15]. CpG islands are rich in cytosine and guanosine and, unlike other genomic regions, are mostly unmethylated [16]. CpG islands are about 200-300 base pairs long, with a G/C content of about 50% and an observed CpG ratio above 0.6. In addition, recent analyses have revealed that DNA regions longer than 500 base pairs with at least 55% G+C content and a CpG ratio of 0.6 are more likely to be associated with 5' regions [17].

DNA methylation has an important function in various epigenetic events such as retro element silencing, genomic imprinting and X chromosome inactivation [18]. CpG dinucleotides are not homogenously spread along the human genome, but instead are condensed in sites known as CpG islands, which contain approximately 70% of gene promoter regions [19]. Cytosine methylation occurs by the transfer of methyl from S-adenosylmethionine to the C5 residue of the cytosine base, a process catalyzed by the enzymes DNMT1, DNMT3b and DNMT3a [20], [21]. DNMT1 ensures that hemi-methylated DNA regions are fully methylated and methylation is maintained, while DNMT3b and DNMT3a are involved in the de novo methylation process [22]. Methylation of the cytosine nucleotide on CpG islands causes transcriptional suppression by preventing transcription factors from binding to cis-DNA binding sites in the promoter region of the gene [23]. In addition, methyl-CpG binding proteins activate histone regulatory proteins, causing transcriptional repression.

DNA methylation is associated with cardiovascular diseases. For instance, This methylation reduces the expression of atherosclerosis-associated genes such as ESR1 and ESR2, which are atheroprotective estrogen receptor genes [24]. Decreased expression of these genes has been found to increase the risk of vascular damage. Folic acid deficiency affects the function of endothelial cells. Low serum folic acid in the blood is related to high homocysteine levels, and folic acid deficiency is linked to various

cardiovascular diseases [25]. Decreased production of nitric oxide (NO), Akt, VEGF, and extracellular signal-regulated kinase 1/2 is associated with hyperhomocysteinaemia (HHcy) [26]. Inhibition of angiogenesis is associated with dyslipidemia, VSMC development, injured endothelial function, and regeneration. Specific genes may be differentially expressed in response to changes in gene-specific methylation and decreases in HHcy global CpG methylation levels [27]. Dysregulation of DNA methylation can also occur during embryonic development and can result in increased risk of cardiovascular disease and congenital heart disease [28]. The intrauterine environment is thought to play an essential role in this process.

C. Histone Modifications on Cardiovascular Disease

In eukaryotic cells, DNA is condensed into a chromatin structure consisting of nuclear units called nucleosomes [29]. Nucleosomes are structures consisting of four different histone types (H4, H3, H2B, and H2A) that surround the DNA. Histones are modified by various modifications. Several types of modifications are known, including ubiquitination, sumoylation, acetylation, phosphorylation, and methylation [30]. These modifications affect gene expression and modify chromatin structure. The 'histone code' theory proposes that different types of modifications and their combinations change chromatin structure and gene expression in different ways [31]. In particular, lysine acetylation at the aminoterminals of histones H3 and H4 is known to promote transcription. Histone acetylation is catalyzed by histone acetyl transferases and regulated by transcriptional mechanisms [32]. Histone methylation is also an important modification affecting gene expression, and its effect is not yet fully understood.

Histone acetylation is interceded by histone acetyltransferase enzymes (HATs), while deacetylation occurs via histone deacetylase enzymes (HDACs) [33]. HDAC activity is critical in determining the extent of myocardial ischemia and reperfusion injury. Trichostatin A (TSA) is a histone deacetylase (HDAC) inhibitor and is used in the regulation of epigenetic modifications [34]. HDAC inhibitors regulate gene expression by increasing the acetylation levels of histones within the cell. Studies on cultured embryonic stem cells have shown that TSA administration stimulates angiogenesis and myogenesis by inhibiting HDACs [35]. In vivo studies in mice have shown that TSA treatment improves recovery after myocardial infarction (MI) by preventing myocardial remodeling and reducing tumor necrosis factor alpha levels. Furthermore, HDAC inhibition was found to increase myocyte and microvessel formation in the heart [35]. These data suggest that HDAC inhibition may minimize loss of myocardial function after MI by promoting angiogenesis.

Histone coding has been associated with endothelial cell responses to hypoxia, angiogenesis, and endogenous myocardial infarct recovery in CVD [36]. The endothelial gene nitric oxide synthase (NOS3), whose cardiovascular effects have been described, is regulated by histone coding and encodes endothelial nitric oxide synthase (eNOS), which enables the production of nitric oxide (NO) in blood vessels [37]. NO has an important role in the regulation of vascular tone and in the fight against atherosclerosis. eNOS, which is abundant in endothelial cells, is responsible for NO synthesis. However, VSMCs in arteries do not produce eNOS. Epigenetic regulation is involved in the control of gene expression in these cell types.

D. microRNAs (miRNAs) on Cardiovascular Disease

Non-coding RNA molecules known as miRNAs, which range in length from 21 to 23 nucleotides, are involved in the control of gene expression [38]. which range in length from 21 to 23 nucleotides, are involved in the control of gene expression [38]. Numerous processes, including apoptosis, metastasis, tumor growth, and cell proliferation and survival, are regulated by miRNAs. In 1993, Lee et al. discovered Lin-4 miRNA in Caenorhabditis elegans. Through translational regulation of protein

production or mRNA degradation following transcription, miRNAs suppress target genes [39]. DGCR8 and the Drosha complex transform the pri-miRNAs into precursor miRNAs following transcription by RNA polymerase II. After being carried to the cytoplasm by exportin 5 and Ran-GTP, the precursor miRNA is cleaved into mature miRNA by Dicer. The mature miRNA is then incorporated into the RNA-mediated silencing complex (RISC) and represses protein synthesis by specifically targeting mRNAs [40].

miRNAs have a significant and crucial role in CVD and have an impact on the pathophysiological mechanisms underlying these illnesses. The advancement and development of CVD are significantly influenced by miRNAs' specific capacity to control gene expression and cellular signaling pathways [41]. The degrees of miRNA expression vary throughout tissues. Research indicates that myocardial infarction is significantly influenced by tissue-specific miRNAs [42]. Acute MI did not significantly alter the levels of miRNA-1, miRNA-133b, or miRNA-133a, despite the fact that these miRNAs are highly expressed in the heart and skeletal muscle [43]. Following ischemic preconditioning, there was a considerable rise in the expression of miRNA-24, miRNA-1, and miRNA-21 in the heart. These miRNAs play a key role in cardioprotection by regulating factors such as eNOS, Heat Shock Protein 70 (HSP70), and Heat Shock Factor 1 (HSF1) [44]. In conclusion, miRNAs can be shown as a potential biomarker in the diagnosis and treatment of CVD due to their stable structure and unchanging stability in circulation.

E. Long non-coding RNAs (lncRNAs) on Cardiovascular Disease

Non-coding transcripts with a length of 200 nucleotides are defined as lncRNAs. These lncRNAs can be classified as antisense, sense, bidirectional, intronic or intergenic depending on the location of protein-coding genes [45]. These RNAs, which are usually found in the nuclear domain and expressed at low levels, can be modified by adenylation. Recently, lncRNAs have been found to play an active role in the development of human pathologies [46]. lncRNAs regulate gene expression through histone-modifying enzymes, forming chromatin domains that control dosage stabilization, repression, and developmental gene expression. lncRNAs are more highly conserved than most other lncRNAs, and they are distinguished by the trimethylation of histone H3 at their promoters (H3K4me3) and during transcription (H3K36me3) [47]. lncRNAs Air and Xist regulate X-chromosome inactivation by contributing to epigenetic changes. Xist interacts with the polycomb complex to initiate X-chromosome inactivation, while Air silences transcription by binding to specific chromatin regions [48].

RNA-based mechanisms, among the major mechanisms of epigenetic control, have only recently been discovered and have not yet been studied in the most comprehensive way. Recent research specifically examines the role of long non-coding RNAs (lncRNAs) in epigenetic regulation [49]. Research on epigenetics has led to the exploration of many lncRNAs. lncRNAs were first identified in 2008 and 2009, and more than 8000 lncRNAs have been identified thanks to the studies carried out today [50]. lncRNAs are more tissue-specific than other protein-coding genes, and some lncRNA groups are often co-expressed with the genes they are associated with.

Many lncRNAs regulate transcription by modulating chromatin structure. lncRNAs can interact with activating/repressive chromatin remodeling structures that affect chromatin structure at target sites [51]. An example of chromatin structure-dependent lncRNA-mediated transcription regulation is Xist. Xist is a lncRNA functioning in X chromosome inactivation and controls the process of systematic silencing of one of the two X chromosomes in each female somatic cell [52].

In recent studies with lncRNAs, Tie-1AS, an antisense long non-coding transcript for epidermal growth factor homology domain-1 tyrosine kinase and immunoglobulin, was discovered. Tie-1AS lncRNA regulates Tie-1 transcript levels by targeting Tie-1 mRNA in vivo [53]. This has been found to lead to

abnormalities in endothelial cell connections and plays a key role in maintaining vascular homeostasis. In conclusion, defining the altered expression profiles and functions of lncRNAs is an important area of research that may arise in different scenarios of cardiovascular diseases.

II. CONCLUSION

Epigenetic regulation helps us to understand disease mechanisms in more depth and provides new perspectives for future therapeutic and diagnostic opportunities. Abnormal epigenetic mechanisms caused by various environmental or genetic factors may be involved in disease development and may contribute to the identification of new therapeutic targets. This approach offers a new perspective on epigenetic modulation of cardiovascular improvement and differentiation processes in the study of cardiovascular diseases. The growing interest in this field illuminates the future potential of epigenetic research and its impact on cardiovascular health. Additional studies are indispensabled to comprehend the importance of epigenetic events in the improvement of cardiovascular disease.

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ALZHEIMER'S DISEASE AND NEUROTOXIC EFFECTS OF CHEMOTHERAPY

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Abstract – Dementia is a general term used to describe a significant decline in cognitive abilities that interferes with thinking, social skills, and activities of daily living. Alzheimer's disease (AD), recognised by the World Health Organisation (WHO) as a global public health problem, is the most common form of dementia. AD is a progressive neurological disorder characterised by progressive cognitive and behavioural changes, a decline in daily vital functions, and various psychiatric symptoms. It is the most common disease in the elderly population worldwide, and the incidence of the disease is increasing with the increase in the elderly population. The course of AD can vary greatly depending on many factors, such as when the disease is diagnosed, age, gender, environmental factors, educational status, dietary habits, and other health problems experienced by the patient. In particular, it has been suggested that some chemotherapeutic agents may affect brain functions and play a role in the pathogenesis of AD. The effects of chemotherapy on AD-related cognitive impairments and the underlying biological mechanisms should be examined, and more studies should be conducted to elucidate the genetic and molecular interactions of the apolipoprotein E (APOE) genotype, the most critical gene in this regard, with chemotherapy. A better understanding of the interactions between chemotherapy and AD is of great importance for optimising treatment strategies for both cancer patients and individuals at risk of AD.

Keywords – Alzheimer disease, Neurotoxicity, Chemotherapy, Cancer, CRCI,

I. INTRODUCTION

Described in 1906 by Alois Alzheimer, Alzheimer's disease (AD) is the most common form of dementia [1], with individuals over the age of 65 accounting for two-thirds of cases [2]. The disease is characterised by progressive memory loss, a decline in cognitive abilities, a loss of language functions, and the ability to perform daily functions [3]. AD constitutes a major public health crisis worldwide with an increasing number of cases [4], leading to devastating consequences that deeply affect not only the patients but also their carers [5].

A. Epidemiology of Alzheimer's Disease

The number of patients with AD worldwide is quite high, and this number continues to increase day by day [6]. According to the 2019 data from Alzheimer's Disease International (ADI), 50 million AD cases have been identified in the world, and this number is estimated to increase four times by 2050 [7]. Pathological findings associated with AD in brain tissue begin in middle age, but clinical findings manifest themselves after the age of 65 [8]. The increase in the average age in the world every year brings with it an increase in the number of people over 65 years of age, and therefore the prevalence of the disease is increasing rapidly [9], [10]. In addition to advanced age, other factors such as income level, educational status, and nutrition also affect the prevalence of the disease [11], [12]. Healthy nutrition, a high income level, and a high a high education level reduce the risk of developing AD [11]- [13].

B. Stages of Alzheimer's Disease

AD basically consists of three stages. These are the initial stage (early stage), the intermediate stage, and the dementia stage (advanced stage) [14]. AD varies between individuals, and therefore, the stage progression also varies from person to person [15], [16].

The mild cognitive impairment (MCI) stage of the disease is characterised by mild memory problems, attention deficits, and cognitive impairments [17]. In this stage, patients have problems learning new information, but no significant changes occur in the patient's social life or behaviour [18]. Therefore, it is possible for patients to manage their lives on their own. Since the symptoms of the disease are not yet fully evident, a diagnosis cannot be made at this stage. This period is the most important stage for early diagnosis because overlooking the symptoms in this period leads the disease to advanced stages [19].

In the middle stage, symptoms are more pronounced than in the initial stage, and the person's life becomes more restrictive [20]. Difficulty in performing daily activities such as eating, dressing, walking alone, and going to the toilet; increased forgetfulness; decreased language skills; and changes in personality traits are among the most important symptoms of this stage [21].

In the dementia stage, patients have advanced memory impairment and are completely dependent on care [22]. In this stage, people are often unable to recognise even their closest relatives and have severe difficulties with language use and motor functions [23]. As a result of the deterioration in the visual-spatial abilities of patients in the dementia stage, 20–40% of patients hallucinate. At this stage, patients are unable to take care of themselves and need a carer for all vital activities. The most common causes of death at this stage are bed-sore infections and malnutrition [24], [25].

C. Symptoms and Diagnosis of Alzheimer's Disease

In the early stages of AD, symptoms such as loss of cognitive function and character changes are observed, but as the disease progresses, difficulties in motor skills, impairment in executive functions, language disorders, psychosis, neuropsychiatric symptoms, and even in the last stage, severe complications such as inability to speak, urinary incontinence, and bedriddenness develop to the extent that the person cannot continue his or her life without assistance [26], [27]. These complications cause the death of patients with AD [28], [29].

AD is very difficult to diagnose at an early stage because there are no specific tests to identify the initial complications at this stage [29]. The majority of people with HBB show signs of advanced AD within 5 to 7 years [30]. Biochemical tests, imaging techniques, and neurological tests are used to diagnose advanced AD [31]. Among these, computed tomography (CT) and magnetic resonance imaging (MRI) techniques are used to assess structural changes and atrophy in the brain, while positron emission tomography (PET) is used to identify biochemical changes in the brain [29]. Amyloid PET scanning is used to identify amyloid deposits in the brain, while techniques such as single photon emission computed tomography (SPECT) and functional magnetic resonance imaging (fMRI) are used to identify functional disorders in the medial, temporal and perietal lobes. [32],[33] . In addition to these techniques, for the diagnosis of AD, the patient's medical history should be evaluated, and other tests such as physical examination, blood tests, liver and thyroid function measurement, cognitive, neuropsychological, and genetic tests should be subjected to. Although these tests show the presence of the disease with a high probability, they are not sufficient for a definitive diagnosis. It is known that the definitive diagnosis of AD is only possible by examining brain tissue after an autopsy [34], [35].

D. Risk Factors for Alzheimer's Disease

Although it is known that AD is caused by a number of age-related deteriorations in nerve cells, the causes of these deteriorations other than advanced age have not yet been determined [36]. It is known that there are many genetic or environmental risk factors that increase the likelihood of AD [37]. Family history, genetic predisposition due to APOE e4, chronic diseases, cardiovascular and cerebrovascular diseases, diabetes, obesity, increased homocysteine levels, hypertension, and hypercholesterolemia increase the risk of AD [38]. In addition, environmental factors such as traumatic brain injury, low education level, sleep disorders, depression and stress, smoking or alcohol consumption, excessive coffee

or tea consumption, diet, low education level, insufficient cognitive activity, occupational failures, high parental age, gender hormonal factors, social factors, and low education level increase the susceptibility to the disease by causing a decrease in cognitive reserve [39].

E. Pathology of Alzheimer's Disease

The fact that there are many factors affecting the onset and progression of AD makes it difficult to understand the pathology of the disease and, therefore, its diagnosis and treatment [40]. Although many pathological findings have been identified for AD, the most prominent and important ones are the formation of amyloid plaques and the accumulation of neurofibrillary tangles (NFTs) [41].

Amyloid plaques are formed by the abnormal accumulation of beta-amyloid (Aβ) protein in the brain as a result of defective cleavage of amyloid precursor protein (APP) by γ, β, or α-secretases [38],[42]. These deposits form dense, small structures in the brain called amyloid plaques, which interfere with communication between nerve cells and cause neuronal damage [38], [43], [44].

NFTs, another pathological finding for the disease, are formed by the abnormal accumulation and folding of tau proteins in neurons. These tangles disrupt neuronal function or lead to the death of neurons, paving the way for the occurrence of many cognitive diseases, including AD [45].

The accumulation of amyloid plaques and the formation of neurofibrillary tangles, which are the two main problems in AD pathology, are mainly associated with mutations occurring in four genes [46]. These genes are APP on chromosome 21, Presenilin 1 (Psen1) on chromosome 14, Presenilin 2 (Psen2) on chromosome 1, and Apolipoprotein E (ApoE) on chromosome 19 [47], [48]. It is known that mutations in the APP, Psen1, and Psen2 genes are responsible for early-onset AD seen before the age of 65, while mutations in ApoE are responsible for 50–80% of late-onset AD cases seen after the age of 65 [49] - [51].

The ApoE gene has three main variants: ApoE2, ApoE3, and ApoE4 [52], [53]. It is known that ApoE2 and ApoE3 variants have a protective effect on Alzheimer's disease, while the ApoE4 variant is one of the most important genetic risk factors for AD [52], [54], [55]. It is also thought that ApoE e4 may be associated with cognitive impairments occurring after chemotherapy [56], [57].

F. Chemotherapy and Side Neurotoxicity

Chemotherapy is a medical treatment often used in the treatment of cancer to destroy or control malignant cells [58]. The scientific basis of chemotherapy is based on the biological characteristics of cancer cells and the effects of drugs on these cells [59]. The course of treatment varies depending on the type and stage of cancer and the general health status of the patient [60]. Chemotherapy mainly targets rapidly dividing cells [61], [62]. Therefore, while chemotherapy targets cancer cells that have spread to different parts of the body, it can also affect healthy cells that are capable of dividing rapidly [63]. As a result, many unwanted side effects such as hair loss, nausea, vomiting, fatigue, loss of appetite, and weakening of the immune system may occur. These harmful side effects reduce the quality of life of cancer patients and cause disruptions in the treatment of the disease [62], [64].

Chemotherapy, which destroys cancer cells, can also cause damage to the central or peripheral nervous system [65]. Neurotoxic effects due to chemotherapy may vary from person to person depending on the drugs used, the dose, and the duration of treatment [66]. Examples of these damages include numbness in the hands and feet (peripheral neuropathy), acute, subacute, and chronic encephalopathies, symptoms of cerebrospinal damage such as concentration impairment, memory and balance problems, neuropsychological damage, and disorders in motor abilities [67].

G. Chemotherapy-Induced Alzheimer's Disease

It has been observed for many years that cancer chemotherapy causes negative consequences in the central nervous system (CNS), such as decreased cognitive abilities and neurotoxic effects [68]. Cancer-related cognitive impairment (CRCI) affects memory, verbal ability, and executive functions. [69]. In studies, brain damage, permanent cognitive impairments, and changes in brain physiology have been observed after chemotherapy treatment, especially in individuals with breast cancer [70]. Genetic studies have revealed that the APOE gene is one of the factors predisposing to CRCI [71]. The APOE gene is

known as a strong genetic risk factor for AD and affects processes such as inflammation, neuronal health, oxidative stress and the removal of Aβ [72].

Mandelblatt et al. In their study, to better understand the effects of APOE alleles and to define the CRCI effect, they examined the differences depending on APOE genotype between cancerous mice that did not receive chemotherapy and cancerous mice exposed to doxorubicin. They showed that there is a link between the presence of the E4 allele of the APOE gene and chemotherapy in relation to cognitive decline, and that the E4 allele is a risk factor in this context. The APOE4 allele also affects plasticity, brain inflammation, and repair mechanisms, which play an important role in ageing processes [73].

A study by Speidell and colleagues examined the effects of chemotherapy on cognitive function in female mice with different genetic backgrounds. The researchers aimed to elucidate how brain structure and function are affected in mice with APOE3 or APOE4 genes treated with doxorubicin (DOX), which is widely used in cancer treatment.

In the study, APOE4 mice treated with doxorubicin showed significant structural damage and cognitive decline, especially in the hippocampus and frontal cortex, compared to both APOE3 mice and untreated APOE4 mice. This suggests that individuals with the APOE4 gene may be at higher risk of cognitive problems after chemotherapy.

Furthermore, since the hippocampus naturally shrinks as we age, the results of this study suggest that the differences between the APOE3 and APOE4 genes may be more pronounced in older individuals. The researchers also note that chemotherapy may accelerate the aging process by affecting brain plasticity and leading to inflammation [74].

In another study conducted in 2020, the same team aimed to understand how APOE genotype affects cognitive and non-cognitive behaviours and how it affects pathological changes associated with AD in old female mice with a history of breast cancer. According to the findings, it was determined that doxorubicin was tolerated in old mice without the APOE genotype after chemotherapy. Short-term cognitive behavioural impairment and CRCI susceptibility were observed in old mice with the APOE4 genotype, whereas such findings were not observed in APOE3 mice. It was also reported that no change in AD-related markers was observed in APOE4 mice after chemotherapy. As a result of the study, it was shown that elderly APOE4 carriers exposed to chemotherapy are more sensitive to cognitive disorders [75].

II. CONCLUSION

AD is an increasing problem in the elderly population and is expected to become more common in the coming years. When the potential effects on AD and the role of the APOE gene in this process are analysed, it is seen that there is a complex relationship between the neurotoxic effects of chemotherapy on the CNS and AD pathogenesis. Chemotherapy negatively affects neuronal health and cognitive functions and may cause oxidative stress and inflammation, leading to the progression of AD. It has been determined that individuals with the ApoE4 gene, which plays a critical role in the development and progression of AD, have more chemotherapy-related adverse effects on brain function. Therefore, it is very important to develop personalised approaches when planning chemotherapy treatment and especially to consider the potential neurological effects of APOE4 carriers after chemotherapy. As a result, future research should aim to determine personalised treatment methods based on APOE genotype and to develop strategies to reduce the neurotoxic effects of chemotherapy. This will help to reduce chemotherapy-induced cognitive problems and prevent the risk of developing AD.

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Wood Composites for Furniture Industry in term of Ergonomics, Design, and Durability

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Abstract – This study explores the role of wood composites in the furniture industry within the context of the circular economy in Europe. Predominantly derived from wood chips or sawdust, wood composites offer an efficient use of raw materials, generating higher value-added products and supporting closed-loop supply chains. Solid wood, while ecologically favorable, faces challenges such as high-water sensitivity and mechanical limitations, prompting the adoption of wood-based materials like particleboards, MDF, and laminated veneer lumber. These composites, though not ideal for load-bearing applications, provide valuable benefits in terms of design flexibility, surface quality, and cost-effectiveness. Ergonomic furniture design, emphasizing user comfort and efficiency, is achieved through anthropometric measurements and adaptable production techniques. The study also addresses the durability concerns of wood composites, affected by environmental and biological factors. Innovations in biobased materials and fire-retardant treatments are highlighted as essential for enhancing resistance properties. Ultimately, this research underscores the need for sustainable practices, continuous material improvements, and adherence to ergonomic principles in furniture production to meet modern consumer demands and environmental standards.

Keywords – Composites, innovation, furniture, lightweight board, particleboard

I. INTRODUCTION

Implementing lean manufacturing and 6R (reduce, reuse, recycle, recover, redesign, and remanufacture) strategies can significantly reduce wood waste in the furniture industry. This approach supports the circular economy by utilizing production waste as raw material for new products, thereby reducing the need for cutting down trees [1]. Sustainable design practices in furniture manufacturing can influence competitiveness by meeting consumer demand for eco-friendly products. Practices such as biomimicry, green supply chain management, and eco-labeling are gaining traction and can enhance firm competitiveness by promoting sustainable material utilization and extending product lifespan [2]. Developing circular economy business models for the furniture sector aligns with EU Sustainable Development Goals. Such models focus on sustainable manufacturing and eco-design, providing practical pathways for businesses to transition towards sustainability. These models offer a framework for companies to adopt more sustainable practices and enhance resource efficiency [3].

The integration of wood composites into the furniture industry, coupled with circular economy principles, can significantly enhance sustainability and economic efficiency. By utilizing wood residues and promoting recycling, the industry can reduce waste and meet consumer demands for eco-friendly

products. This approach not only aligns with EU waste management policies but also supports the development of sustainable business models that enhance competitiveness and resource efficiency.

In contrast to solid wood, which is seen on the one hand as the most ecological, renewable, and most suitable material for furniture, on the other hand, it has several weaknesses. These weaknesses include relatively high water sensitivity [4], difficulties during forming, machining, and assembly due to large moisture movements [5], homogeneity and symmetry of its structure, and highly anisotropic mechanical properties [6]. To eliminate these problems, wood-based materials, including wood composites, can be used. Currently, particleboards, MDF, various laminated veneer lumber (LVL), laminated strand lumber (LSL), oriented strand lumber (OSL) composites, and other advanced wood materials are used for furniture. Some wood composite board examples were given n in Fig. 1.

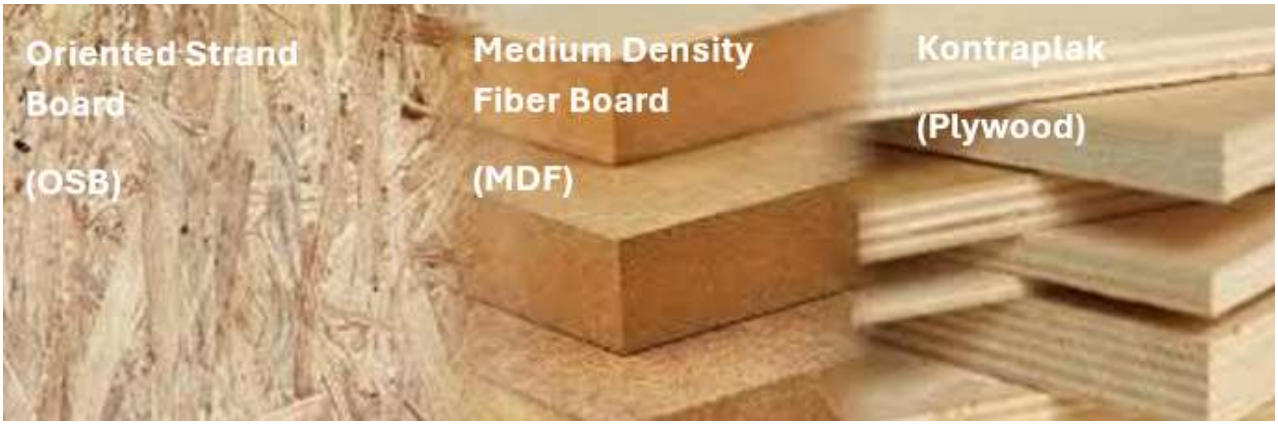

Fig. 1 Wood composite samples and density range

It is worth mentioning that the most significant part of MDF and particleboard production is used in the furniture industry [7]. Various types of wood composites are also used in design. However, due to relatively low mechanical properties, especially bending durability, the mentioned wood composites have not widely spread for load-bearing constructions of furniture. High water sensitivity and limited humidity range are the limitations of wood composites' application for furniture with sealed surfaces, for example, kitchen furniture [8].

II. Definition and Types of Wood Composites

It can be defined in general as materials produced with various techniques (compression, layering, or perforation) by combining wood, which is an environmentally friendly, renewable, biodegradable, high-strength, and natural product, with several adhesives, screws, nails, metal, cement, or plastics, in order to produce products having different features and behaviors than solid wood itself [9]. Some wood composites and their density ranges were given in Fig. 2.

In the furniture and construction sectors, various wood composite materials are widely used due to such reasons as the limitedness of the number of different tree species, deforestation, the production of panel boards in desired thickness sizes, observance of the desired mechanical features, performance, quality, pattern, light weight, thermal and acoustic features, easy use & processing, high surface quality, and decorative surface applications [10]. High, medium, and low-density fiberboards, OSB (oriented strand board), wood cement board, WPC (Wood Polymer Composite) are some of the popular ones [11].

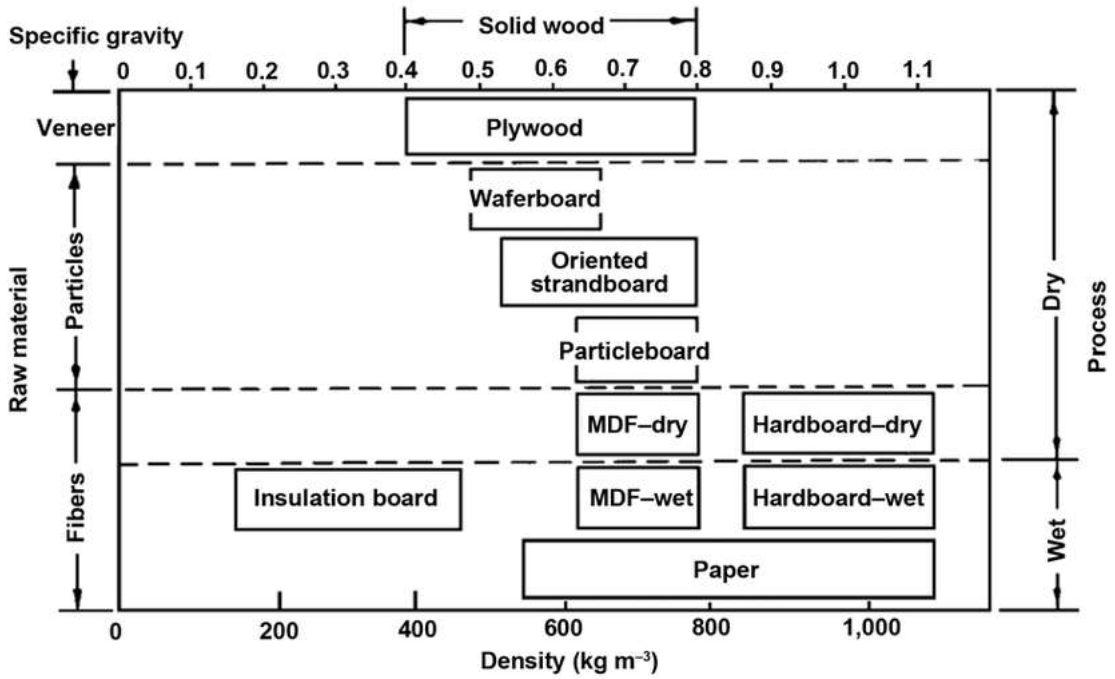

Fig. 2 Some wood composites and their density ranges

Wood composites are available as decorative and furniture-grade products, generally within a labor-intensive manufacturing process, with no waste, and are offered in flexible dimensions [12]. MDF and Particleboard, common resilient composites, are the lowest priced, most common wood-based materials as the core intermediates for furniture and other interior applications [13]. Composite products with high bending or surface strength values, fire resistance, similar joining properties to those of solid wood, and light transmittance are also available for value-added applications [14]. The basic definitions of the composite materials, the manufacturing principles, and the types of the available wood composites are described.

III. Ergonomics in Furniture Design

Individual body variations are considered by a few proponents of "form follows anthropometry," actually proposing either the creation of a 'personal mold' or the creation of a 'personal mold' in producing such one-off furniture as the best solution [15]. Ergonomics also implies that control is necessary in the traditional procedures of finishing wood. However, the same processes can be used in maintaining heirloom furniture [16]. With wood characteristic changes with age, certain furniture at a certain stage of time needs to have the same properties of the replaced structure so that the old furniture can then function as required. Small series production, a typical characteristic of wood composites, can also be an alternative in providing the ergonomic design of furniture [17]. With ABS plastic, PU foam, Re-foil PVC, and lesser demand for the more durable wood composites, cost-effective furniture resulting in added human comfort and advanced aesthetic characteristics, which also include acceptable healthy manufacturing characteristics, also need to be provided by furniture [18]. Characteristics of furniture that determine the level of physical and psychological comfort, namely the physical suitability, the intellectual suitability, and the emotional compatibility of the users with the furniture composition, also design satisfaction, need to be allowed by furniture ergonomics. Lightweight wood furniture is important issue in term of moving they from somewhere to anywhere (Fig. 3).

Fig. 3 Lightweight furniture samples

In designing furniture, particularly with intended prolonged human use, furniture needs to be designed ergonomically [19]. Ergonomics in furniture is the match between the biophysical, functional, aesthetic, and preference, and the properties of the furniture (structural judgments) [20]. It further is the composition of furniture resulting in furniture that will not cause discomfort or injuries [21]. Body dimensions of particular populations, who are actually going to use the furniture, need to be used as a basis in designing furniture. Deriving from anthropometric measurements, BXI as suggested by Chaffin and Olkolahti is a helpful tool for ergonomic assessment [15].

A. Principles of Ergonomics

Demand for new products should come from the industry to help set the goals [22]. The industry will have to be more concerned with technological priorities for innovation or with identifying the personnel to provide research institutes with the necessary information for accomplishment [23]. It is important to match product development, market research, design, and materials [24]. Given the functional object definition – use, form, and user – design research delves into ergonomic aspects that have been previously studied [19]. Design improvement is performed through shape and dimension adaptation, graphics and chromatic choices, integration into leftover space, adoption of construction materials, finishes, and coatings, and focusing on concerns with adjoining operations, elements, and materials such as hardware [25].

B. Comfort and work efficiency

The importance of ergonomics in design is evaluated in terms of comfort and work efficiency [26]. The human factor is the basis for ergonomic product design [27]. By utilizing knowledge of human limitations, typical user profiles, and behavior patterns, it is possible to reach portions of the market that have not been explored so far [28]. High-performance tooling and machines are being developed to facilitate the use of wood and wood-based materials, taking into account the trend of reducing workers' strength requirements through intelligent design processes [29]. Customers have recently shown more concern for products with low prices, thus paying less attention to other advantages. However, when these advantages are added, selling success will be brought by design and quality [30].

IV. Design Considerations for Wood Composites

With regard to the regressive economy in terms of space and resources, the idea of material efficiency is analogous to economic efficiency because ideally, modular or adjustable furniture can make material savings by adaptation for temporary or permanent changes in the layout [31]. Usage, replacements, and upgrades provide personalization for the ergonomic characteristics, style, identity, comfort, reservation, and restoration of objects [32]. Sustainability in producing additional parts or excess material-containing elements, in organizing manufacturing waste for simple but profitable reuse, is also critical [33]. The main directions follow the natural modularity and explanation of sliced and walking core isotypes, the

development of a fragmented or partitioned wood base, individual segments of desktops, chairs, cabinets, and their assemblies in particular [34].

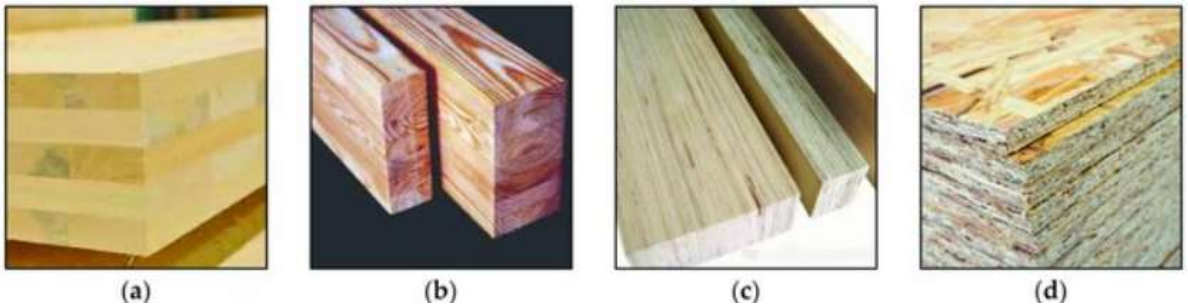

Fig. 4 (a) cross laminated timber (CLT), (b) glulam, (c) laminated veneer lumber (LVL), (d) plywood

All the innovative applications of wood composites for furniture production will be possible only when the resulting material solutions are in demand among broad communities of potential end-users, and this question of aesthetic performance of wood-based materials is crucial for the furniture industry because of a highly competitive market in terms of furniture design [35]. The use of natural wood grains in composite materials has been recognized as the most successful solution, and the appearance of traditional laminated veneer lumber strengthens this position of the natural wood "look" [12]. Main directions of its future developments are the following: natural relief, feature strokes, and simple designs from a single thin layer of cross-bands; visualization of textbooks on anatomy, dendrobiology, etc.; multi-layered microrelief from different species; non-trivial additional processing, e.g., diffusion-based images and holograms [35].

V. DURABILITY OF WOOD COMPOZITES

Nevertheless, it is considered that the main benefits of such new engineered composites may be entirely ecological and ethical [36]. Alternative technology or bioinspired fire-retardant approaches like pita cloth, anthophyllite, or hunting pink make the story intensive and exciting [37]. To answer the question of how raw wood and modified relative materials will perform relatively in different regions of the country, various sources provide benchmarks for strength, moisture, heat, and light [38]. Uncertainty and the sometimes discontinuity of current legal solutions have created a need for a definitive and consistent approach to improve and broaden wood use [39]. Knowing the potential impact on the environment and local economy caused mostly by failing to keep the wood preserved, more economical and automatically adaptable materials are being advertised. When ground contact is the main reason for product failure and a lifetime three times longer is achieved, the case is proven. Repeated scenarios encourage people to minimize elements under these conditions. Materials may not be assessed by what standard tests have disclosed for their performance properties or by public perception of historic product failure. They must be assessed by sound biological and abiotic reasoning and the continuous verification by appropriate reliability tests [40].

Any wood product is not entirely natural in terms of creation and use. It needs some maintenance in order to ensure its durability. Now, thousands of man-made materials have been introduced to replace traditional materials whose demand exceeded what nature could supply. Wood products are having to be reconsidered in terms of ideas, concerns, and possible changes that will lead to the introduction of new wood products. It is obvious that wood and wood composites lose their stability and strength due to various decay systems (i.e., fungi, termites, marine borers, and general wood-eating insects). A lot of scientific effort has been expended to study the synergy between these systems and the nature of treated wood. Modifications with biocides, thermal modifications, or chemical impregnation are very effective for improving resistance properties [41]. Besides, common methods are not acceptable in the wide public

because of the nature of the chemicals and certain reduction in mechanical properties [39]. These facts stimulated the quest for new biobased materials not subject to manipulation [38].

VI. CONCLUSION

In conclusion, the durability of wood composites in the furniture industry is influenced by various factors that must be carefully considered in the design and manufacturing process. Some potential factors include the type of adhesive used, the level of moisture resistance, and the quality of the wood fibers. Additionally, proper maintenance and care by the end user can also impact the durability of wood composites in furniture. Some possible next words or sentence predictions could be: 1. "Regular inspections and cleaning routines" 2. "Furthermore, the use of protective coatings and sealants" 3. "Moreover, following manufacturer's guidelines for usage and storage" 4. "This can include avoiding exposure to extreme temperatures and moisture" 5. "Ultimately, the longevity of wood composites relies on proper handling and upkeep" 6. "Regular maintenance and preventive measures are also essential for preserving the durability of wood composites."

Regular maintenance and preventive measures are also essential for preserving the durability of wood composites. This includes sealing any exposed surfaces and protecting them from moisture and weathering. Additionally, proper storage and handling can also contribute to the long-term durability of wood composites. Predicted next words: "Regular maintenance and treatment" Predicted next sentence: "For example, protecting wood composites from moisture and extreme temperatures can prevent deterioration over time." Predicted next words: "can significantly increase the lifespan of furniture made from these materials." The incorporation of moisture-resistant resins and treatments can significantly increase the lifespan of furniture made from these materials. Additionally, proper sealing and finishing techniques are crucial for enhancing the durability of wood composites in furniture manufacturing. These measures help prevent moisture penetration and protect the material from environmental factors. such as decay and rot. Additionally, proper sealing and finishing can also contribute to the overall durability of the wood composite. Some methods that can increase the durability of wood composites include the use of preservatives and proper maintenance. - "such as pressure treatment and sealants."

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BLOW UP AT FINITE TIME FOR SIXTH-ORDER EVOLUTION EQUATIONS WITH POSITIVE INITIAL ENERGY

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Abstract **–** In this study, we explore the variable coefficients wave equation, which belongs to the class of evolution equations. Evolution equations are characterized by having time t as one of the independent variables, typically manifesting as partial differential equations. This particular type of problem finds extensive application in diverse fields of applied sciences, including the modeling of electrorheological fluid flows, thin liquid films, and more. We establish the blow-up phenomenon of positive initial energy solutions under specific conditions.

Keywords –Blow up, Positive initial energy, Evolution equations, Energy identity, Variable coefficients

I. INTRODUCTION

In this work, we are concerned with the following problem:

$$m(x,t)u_t + \Delta^3 u - \Delta^2_{p(.)}u = f_{q(.)}u \quad (1)$$

with the initial conditions

$$u(x,0) = u_0(x), u_t(x,0) = u_1(x), x \in \Omega, \quad (2)$$

and boundary condition

$$u(x,t) = 0, \Delta u = 0 x \in \partial\Omega, \quad (3)$$

whereΩ is a bounded domain in $R^n (n \in N)$ with smooth boundary$\partial\Omega$. The term

$\Delta^2_{p(x)}u = \Delta(|\Delta u|^{p(x)-2}\Delta u)$ is called *p(.)* – biharmonic operator. The coefficients $m(x,.)$ is a nonnegative function, $f_{q(.)}(u)$ is a general source term depends on *q(.)*.

The variable exponents $p(.)$ and $q(.)$ are given as measurable functions on Ω satisfying

$$2 < p_1 \leq p(x) \leq p_2 < q_1 \leq q(x) \leq q_2 \leq p_*(x) \quad (4)$$

Recently, some authors studied the variable coeffientsequatons (see [1, 3, 4, 5, 7, 8])

In this work, we considered the blow up of positive initial energy solutions. To our best knowledge, the blow up of solutions of the *p(.)* – biharmonic equation with variable coefficients have not yet studied.

This work is organized as follows: In the next section, we present some lemmas, notations and local existence theorem. In section 3, the blow up of positive initial energy solutions is given.

II. MATERIALS AND METHOD

A. In this part, some well-known results and facts from the theory of Sobolev Spaces with variable exponents are recalled and listed [2, 6].

Lemma 1. Let Ω be a bounded domain of R^n, $q(.)$ and $p(.)$ satisfy (4) then $B_0\|\Delta u\|_{p(.)} \geq \|u\|_{q(.)}, for all u \in W_0^{2,p(.)}(\Omega)$, (5) where the optimal constant of Sobolev embedding B_0 is depend on $q_{1,2} and |\Omega|$.

Lemma 2 (Poincare's Inequality). Let Ω be a bounded domain of R^n, $q(.)$ and $p(.)$ satisfy (4) then $D_0\|\Delta u\|_{p(.)} \geq \|u\|_{p(.)}, for\ all\ u \in W_0^{2,p(.)}(\Omega)$, (6) where the optimal constant of Sobolev embedding D_0 is depend on $p_{1,2} and\ |\Omega|$.

B. **Mathematical assumptions:**

Let the function $f_{q(.)}(u) \in C_0(R,R^+)$, with the primitive

$$F(u) = \int_0^u f_{q(.)}(\eta)\, d\eta, \qquad (7)$$

satisfies

$$f_{q(.)}(s) \leq C_0|s|^{q(.)-1}, q(x)F(s) \leq sf_{q(.)}(s), s \in R, C_0 > 0. \qquad (8)$$

A simple typical example of these functions is

$$f_{q(.)}(s) \leq |s|^{q(.)-2}s.$$

Suppose that $m(x,t)$ is a positive function which belongs to the space $W^{2,\infty}(0,\infty;L^\infty(\Omega))$ and that $m_t(x,t) \leq 0$ a.e. for $t \geq 0$. Let

$$B_1 = max\left(1, B_0, \left(\frac{1}{C_0}\right)^{\frac{1}{q_1}}\right),\ \alpha_1 = \left(\frac{1}{B_1^{q_1} C_0}\right)^{\frac{p_2}{q_1 - p_2}}, \alpha_0 = \|\nabla u^0\|_{p(.)}^{p_2}, \qquad (9)$$

and

$$E_0 = \left(\frac{1}{B_1^{q_1} C_0}\right)^{\frac{p_2}{q_1 - p_2}} \left(\frac{1}{p_2} - \frac{1}{q_1}\right) = \left(\frac{1}{p_2} - \frac{1}{q_1}\right) \alpha_1. \quad (10)$$

C. **Blow up for positive initial energy**

In this part, we present our main blow-up result with positive initial energy.

Theorem 1. For all $u_0 \in W_0^{2,p(.)}(\Omega)$, there exists a number $T_0 \in (0,T]$ such that the problem (1) has a strong solution u on $[0,T_0]$ satisfying

$$u \in C([0,T_0]:W_0^{2,p(.)}(\Omega) \cap C([0,T_0];L^{q(.)}(\Omega)) \cap W^{1,2}([0,T_0];L^2(\Omega)).$$

Lemma 2. The corresponding energy to problem (1) is given by

$$\left(\frac{d}{dt}\left(\frac{1}{p(x)}\|\Delta u\|_{p(x)}^{p(x)} + \frac{1}{2}\|\Delta u\|^3 - \int_\Omega F(u(x,t))dx\right) = -\int_\Omega m(x)u_t^2 dx \right. \quad (11)$$

By the equality (5), we have

$$E'(t) = -\int_\Omega m(x)u_t^2 dx \leq 0, \quad (12)$$

and $E(t) \leq E(0)$. Where

$$E(t) = \frac{1}{p(x)}\|\Delta u\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u\|^3 - \int_\Omega F\big(u(x,t)\big)dx$$

and

$$E(0) = \frac{1}{p(x)}\|\Delta u_0\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u\|^3 - \int_\Omega F(u_0(x,t))dx \leq E_0$$

The inequality $E(t) \leq E(0)$ is obtained.

Theorem 2. If the initial data $u_0 \in W^{2,p(.)}(\Omega)$ are such that $u_0 \neq 0$,

$$E(0) = \frac{1}{p(x)}\|\Delta u_0\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u\|^3 - \int_\Omega F(u_0(x,t))dx < E_0 . \quad (13)$$

Then there exists T^* such that $\lim_{t \to T^*} sup\|u(.,t)\|_2 = +\infty$. Morever, if $E(0) < E_0$, then the T^* can be bounded above as:

$$T^* \leq \frac{8\|\sqrt{a_0}u_0\|_{L^2(\Omega)}^2}{(q_1-2)^2(E_0 - E(0))}, \quad (14)$$

where $a(x,0) = a_0$ and $u(x,0) = u_0$.

In order to prove the main theorem, we recall the following lemmas.

Lemma 2 [7]. Assume that $\phi \in C^2([0,T])$ satisfying:

$$\phi''\phi - (1+\alpha)(\phi')^2 \geq 0, \alpha > 0$$

and

$$\phi(0) > 0, \phi'(0) > 0,$$

then

$\phi \to \infty ast \to t_1 \leq t_2 = ((\phi(0))/(\alpha\phi'(0)))$.

Lemma 3 [1]. Suppose $E(0)<E_0$ and $\alpha_1<\alpha_0\leq B_1^{-p_2}$. Then it exists a constant $\alpha_2>\alpha_1$ such that:

$$\|\Delta u\|_{p_2}^{p(.)} \geq \alpha^2 > \alpha^1 \ \ for\ all\ \ t \geq 0.$$

Proof of Theorem 2. $E(0)<E_0$. The goal is to construct a suitable function which satisfies the conditions in Lemma 2. Following the arguments of for our purpose, we define the following suitable function

$\phi(t) = \int_0^t \int_\Omega m(x,s)u^2(x,s)dxds + \int_0^t \int_\Omega m_t\,(x,s)u^2(x,s)dxds + (T_0 -$

$t) \int_\Omega m_t\, m_0(x)u_0^2(x)dx + \beta(t+t_0)^2,$ (15)

where t_0, T_0 and β are positive constants to be determined later. Then using equation (1) and integration by parts, we have

$$\phi'(t) = \int_\Omega m(x,s)u^2(x,s)dxds - \int_0^t \int_\Omega m_t\,(x,s)u^2(x,s)dxds - \int_\Omega m_0(x){u_0}^2(x)dx + 2\beta(t+t_0)$$

$= 2\int_0^t \int_\Omega m(x,s)u^{\square}(x,s)u_t(x,s)dxds$ (16)

and

$\phi''(t) = \int_\Omega m(x,s)u^{\square}(x,s)u_t(x,s)dxds + 2\beta.$ (17)

Then, due to (8) and Lemma 3, the following is obtained

$$\phi''(t) \geq -2\int_\Omega |\Delta u(x,s)|^{p(x)}dx + 2\int_\Omega q(x)F(u)dx + \int_\Omega \|\Delta u\|^3 dx + 2\beta$$

$$\geq -2\int_\Omega |\Delta u(x,s)|^{p(x)}dx + 2q_1\left(\frac{1}{p(x)}\int_\Omega |\Delta u(x,s)|^{p(x)}dx + \frac{1}{3}\|\Delta u\|^3 - E(t) + 2\beta\right.$$

$$\geq \left(\frac{2q_1}{p_2} - 2\right)\int_\Omega |\Delta u(x,s)|^{p(x)}dx + q_1\|\Delta u\|^3 - 2q_1E(t) + 2\beta$$

$$\geq \left(\frac{2q_1}{p_2} - 2\right) \int_{\Omega} |\Delta u(x,s)|^{p(x)} dx + 2q_1 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds - 2q_1 E(0) + q_1 \|\Delta u\|^3 + 2\beta$$

$$\geq \left(\frac{2q_1}{p_2} - 2\right) min(\alpha_2^{\frac{p_1}{p_2}}, \alpha_2) + 2q_1 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds$$
$$-2q_1 E(0) + q_1 \|\Delta u\|^3 + 2\beta$$

$$\geq \left(\frac{2q_1}{p_2} - 2\right) min(\alpha_1^{\frac{p_1}{p_2}}, \alpha_1) + 2q_1 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds$$
$$-2q_1 E(0) + q_1 \|\Delta u\|^2 + 2\beta$$
$$= 2q_1 \left(\frac{1}{p_2} - \frac{1}{q_1}\right) min(\alpha_1^{\frac{p_1}{p_2}}, \alpha_1)\alpha_1 + 2q_1 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds$$
$$-2q_1 E(0) + q_1 \|\Delta u\|^3 + 2\beta$$
$$= 2q_1 \big(E_0 - E(0)\big) + 2q_1 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds + 2\beta$$

Now, let $\beta = 2(E_0 - E(0)) > 0$, and note that $q_1 > 2$, then

$$\phi''(t) \geq (p_1 + 2)\beta + (p_1 + 2) \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds \qquad (18)$$

From (15), (16), (17) and (18), we obtain

$$\begin{cases} \phi(0) = T_0 \int_{\Omega} m_0(x) u_0{}^2(x) dx + \beta t_0{}^2 > 0; \\ \phi'(0) = 2\beta t_0 > 0; \\ \phi''(t) = (q_1 + 2)\beta > 0 \forall t \geq 0. \end{cases}$$

Therefore ϕ and ϕ' are both positive. Since $m_t(x,s) \leq 0$, for all $x \in \Omega$ and $t \geq 0$, we obtain

$$\phi(t) = \int_0^t \int_{\Omega} m(x,s) u^2(x,s) dx ds + \beta(t + t_0)^2 \qquad (19)$$

Thus, from (15)-(18) and (19), the following inferred for all $(\zeta, \eta) \in R^2$

$$\phi(t)\zeta^2 + \phi(t)\zeta\eta + \left(\frac{\eta^2}{q^1 + 2}\right)\phi''(t)$$
$$\geq \left(\int_0^t \int_{\Omega} m(x,s) u^2(x,s) dx ds + \beta(t + t_0)^2\right)\zeta^2$$
$$+2\zeta\eta \int_0^t \int_{\Omega} m(x,s) u^{\square}(x,s) u_t(x,s) dx ds + 2\zeta\eta\beta(t + t_0)$$
$$+\beta\eta^2 + \eta^2 \int_0^t \int_{\Omega} m(x,s) u_t{}^2(x,s) dx ds \geq 0,$$

which implies that

$$\phi(t)((\phi''(t))/(q_1+2)) - (((\phi'(t))/2))^2 \geq 0.$$

Subsequently

$$\phi(t)\phi''(t) - ((q_1+2)/4)(\phi'(t))^2 \geq 0.$$

Then using Lemma 2, to infer $\phi(t)\to\infty$ as $t\to T^*$, where,

$$T^* \leq \frac{\phi(0)}{(\frac{q_1-2}{4})\phi'(0)} = \frac{2(T_0\|\sqrt{(m_0)}u_0\|_{L^2(\Omega)}+\beta t_0^2)}{(q_1-2)\beta t_0}.$$

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Nonexistence of global solutions for variable coefficients wave equation with negative initial energy

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Abstract **–** This work, we consider the variable coefficients wave equation. The variable coefficients wave equation is a kind of evolution equation. The evolution equations, namely partial differential equations with time *t* as one of the independent variables. This type problem has been widely used in many mathematical models of various applied sciences such as flows of electrorheological fluids, thin liquid films, etc. We prove the blow up of negative initial energy solution sunder suitable conditions.

Keywords – Nonexistence, Negative initial energy, Wave equation, Energy identity, Variable coefficients

I. INTRODUCTION

In this work, we are concerned with the following problem:

$m(x,t)u_t + \Delta^3 u - \Delta^2_{p(.)}u = f_{q(.)}u(1)$

with the initial conditions

$u(x,0) = u_0(x), u_t(x,0) = u_1(x), x \in \Omega, \quad (2)$

and boundary condition

$u(x,t) = 0, \Delta u = 0 x \in \partial\Omega, (3)$

whereΩ is a bounded domain in $R^n (n \in N)$ with smooth boundary$\partial\Omega$. The term $\Delta^2_{p(x)}u = \Delta(|\Delta u|^{p(x)-2}\Delta u)$ is called *p(.)* – biharmonic operator. The coefficients $m(x,.)$ is a nonnegative function, $f_{q(.)}(u)$ is a general source term depends on *q(.).*

The variable exponents $p(.)$ and $q(.)$ are given as measurable functions on Ω satisfying$2 < p_1 \leq p(x) \leq p_2 < q_1 \leq q(x) \leq q_2 \leq p_*(x) \quad (4)$

Recently, some authors studied the variable coeffients equatons (see [1, 3, 4, 5, 7, 8])

In this work, we considered the blow up of positive initial energy solutions. To our best knowledge, the blow up of solutions of the *p(.)* – biharmonic equation with variable coefficients have not yet studied. This work is organized as follows: In the next section, we present some lemmas, notations and local existence theorem. In section 3, the blow up of negative initial energy solutions is given.

II. MATERIALS AND METHOD

A. In this part, some well-known results and facts from the theory of Sobolev Spaces with variable exponents are recalled and listed [2, 6].

Lemma 1. Let Ω be a bounded domain of R^n, $q(.)$ and $p(.)$ satisfy (4) then$B_0\|\Delta u\|_{p(.)} \geq \|u\|_{q(.)}, forallu \in W_0^{2,p(.)}(\Omega)$, (5) where the optimal constant of Sobolev embedding B_0 is depend on $q_{1,2}and|\Omega|$.

Lemma 2 (Poincare's Inequality). Let Ω be a bounded domain of R^n, $q(.)$ and $p(.)$ satisfy (4) then$D_0\|\Delta u\|_{p(.)} \geq \|u\|_{p(.)}, forallu \in W_0^{2,p(.)}(\Omega)$, (6) where the optimal constant of Sobolev embedding D_0 is depend on $p_{1,2}and|\Omega|$.

B. Mathematical assumptions**:**

Let the function $f_{q(.)}(u) \in C^0(R,R^+)$, with the primitive

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A simple typical example of these functions is

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and

$$E_0 = \left(\frac{1}{B_1^{q_1}C_0}\right)^{\frac{p_2}{q_1-p_2}}\left(\frac{1}{p_2}-\frac{1}{q_1}\right) = \left(\frac{1}{p_2}-\frac{1}{q_1}\right)\alpha_1. \quad (10)$$

C. **Blow up for negative initial energy**

In this part, we present our main blow-up result with negative initial energy.

Theorem 1. For all $u_0 \in W_0^{2,p(.)}(\Omega)$, there exists a number $T_0 \in (0,T]$ such that the problem (1) has a strong solution u on $[0,T_0]$ satisfying

$$u \in C([0,T_0]:W_0^{2,p(.)}(\Omega) \cap C([0,T_0];L^{q(.)}(\Omega)) \cap W^{2,2}([0,T_0];L^2(\Omega)).$$

Lemma 2. The corresponding energy to problem (1) is given by

$$\left(\frac{d}{dt}\left(\frac{1}{p(x)}\|\Delta u\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u\|^3 - \int_\Omega F(u(x,t))dx\right) = -\int_\Omega m(x)u_t{}^2 dx \qquad (11)$$

By the equality (5), we have

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and $E(t)\leq E(0)$. Where

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and

$$E(0) = \frac{1}{p(x)}\|\Delta u_0\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u\|^3 - \int_\Omega F(u_0(x,t))dx) \leq E_0$$

The inequality $E(t) \leq E(0)$ is obtained.

Theorem 2. If the initial data $u_0 \in W^{2,p(.)}(\Omega)$ are such that $u_0 \neq 0$,

$E(0) = \frac{1}{p(x)}\|\Delta u_0\|_{p(x)}^{p(x)} + \frac{1}{3}\|\Delta u_0\|^3 - \int_\Omega F(u_0(x,t))dx) < E_0$. (13)

Then there exists T^* such that $\lim_{t \to T^*} sup\|u(.,t)\|_2 = +\infty$. Moreover, if $E(0) < E_0$, then the T^* can be bounded above as:

$$T^* \leq \frac{8\|\sqrt{a_0}u_0\|_{L^2(\Omega)}^2}{(q_1-2)^2(E_0-E(0))}, \quad (14)$$

where $a(x,0)=a_0$ and $u(x,0)=u_0$.

In order to prove the main theorem, we recall the following lemmas.

Lemma 2 [7]. Assume that $\phi \in C^2([0,T])$ satisfying:

$$\phi''\phi - (1+\alpha)(\phi')^2 \geq 0, \alpha > 0$$

and

$$\phi(0) > 0, \phi'(0) > 0,$$

then

$\phi \to \infty ast \to t_1 \leq t_2 = ((\phi(0))/(\alpha\phi'(0)))$.

Lemma 3 [1]. Suppose $E(0) < E_0$ and $\alpha_1 < \alpha_0 \leq B_1^{-p_2}$. Then it exists a constant $\alpha_2 > \alpha_1$ such that:

$$\|\Delta u\|_{p_2}^{p(.)} \geq \alpha^2 > \alpha^1 \quad for \quad all \quad t \geq 0.$$

Lemma 4. Let $u_0 \in W_0^{2,p(.)}(\Omega)$ such that

$\int_\Omega u_0^2 dx > 0$, $f_{q(.)}$ satisfies (8) and $E(0) \leq 0$.

$$\int_\Omega |u(t)|^2 dx \to \infty \, if \, t \to T_{max}.$$

Proof of Lemma 4. We then define

$$\varphi(t) = \int_\Omega m(x,t)|u(t)|^2 dx$$

$\varphi'(t) = \int_\Omega m(x,t)uu_t dx + \frac{1}{2}\int_\Omega m_t(x,t)|u(t)|^2 dx$

$\geq -\int_\Omega (|\Delta u|^{p(x)} - uf_{q(.)}u)dx + +\|\Delta u\|^2$

$$\geq -\int_{\Omega}^{\square}(|\Delta u|^{p(x)} - q(x)F(u)dx$$

$$\geq -\int_{\Omega}^{\square}(|\Delta u|^{p(x)} - q_1 F(u)dx$$

$$= -\int_{\Omega}^{\square}(|\Delta u|^{p(x)}dx - q_1\int_{\Omega}^{\square}\frac{1}{p(x)}|\Delta u(x,t)|^{p(x)}dx - p_1 E(t)$$

$$\geq \left(\frac{q_1}{p_2} - 1\right)\int_{\Omega}^{\square}|\Delta u(x,t)|^{p(x)}dx - p_1 E(0)$$

$$\geq \left(\frac{q_1}{p_2} - 1\right)\int_{\Omega}^{\square}|\Delta u(x,t)|^{p(x)}dx = c_0\int_{\Omega}^{\square}|\Delta u(x,t)|^{p(x)}dx\,,(c_0 > 0)$$

We define the sets

$$\Omega_2 = \{x \in \Omega \,||\Delta u| \geq 1\} and \Omega_1 = \{x \in \Omega \,||\Delta u| < 1\}$$

so

$$\varphi'(t) = c_0\int_{\Omega_2}^{\square}|\Delta u(x,t)|^{p(x)}dx + c_0\int_{\Omega_1}^{\square}|\Delta u(x,t)|^{p(x)}dx$$

$$\geq C_1\left(\left(\int_{\Omega_2}^{\square}|\Delta u(x,t)|^{p(x)}dx\right)^{\frac{p_1}{2}} + \left(\int_{\Omega_2}^{\square}|\Delta u(x,t)|^{p(x)}dx\right)^{\frac{p_2}{2}}\right)$$

Using the fact that $\|\Delta u\| \leq C\|\Delta u\|_S$ for all $s \geq 2$, to obtain

$$\begin{cases}\left(\varphi'(t)\right)^{\frac{2}{p_2}} \geq C_2\int_{\Omega_1}^{\square}|\Delta u|^2 dx \\ \left(\varphi'(t)\right)^{\frac{2}{p_1}} \geq C_3\int_{\Omega_2}^{\square}|\Delta u|^2 dx\end{cases}$$

By addition, leads to

$$\left(\varphi'(t)\right)^{\frac{2}{p_2}} + \left(\varphi'(t)\right)^{\frac{2}{p_1}} \geq C_4\int_{\Omega_2}^{\square}|\Delta u|^3 dx$$

$$\geq C_5\int_{\Omega_2}^{\square}|u|^2 dx \geq \frac{C_5}{supm(x,t)}\varphi(t), \forall t \geq 0 \quad (15)$$

or

$$\left(\varphi'(t)\right)^{\frac{2}{p_1}}\left(1 + \left(\varphi'(t)\right)^{\frac{2}{p_2}-\frac{2}{p_1}}\right) \geq C_6\varphi(t), \forall t \geq 0.$$

By (15) and the fact that $\varphi(t) \geq \varphi(0) > 0$ ($\varphi'(t) \geq 0$), we have for each $t > 0$, either

$$\begin{cases}\left(\varphi'(t)\right)^{\frac{2}{p_1}} \geq \frac{C_6}{2}\varphi(t) \geq \frac{C_6}{2}\varphi(0) \\ or \\ \left(\varphi'(t)\right)^{\frac{2}{p_2}} \geq \frac{C_6}{2}\varphi(t) \geq \frac{C_6}{2}\varphi(0)\end{cases}$$

which gives, in turn

$$\begin{cases}\varphi'(t) \geq C_7\left(\varphi(0)\right)^{\frac{p_2}{2}}; \\ or \\ \varphi'(t) \geq C_8\left(\varphi(0)\right)^{\frac{p_1}{2}}\end{cases}$$

hence

$$\varphi'(t) \geq \alpha = min\left(C_7\left(\varphi(0)\right)^{\frac{p_2}{2}}, C_8\left(\varphi(0)\right)^{\frac{p_1}{2}}\right),$$

Since $(1/(q_2))-(1/(q_1)) \leq 0$ (15) yields

$$\left(\varphi'(t)\right)^{\frac{2}{p_1}}\left(1+\left(\varphi'(t)\right)^{\frac{2}{p_2}-\frac{2}{p_1}}\right)\geq C_4\varphi(t),\forall t\geq 0.$$

Therefore

$$\varphi'(t)\geq \beta\varphi^{\frac{p_1}{2}}(t),\forall t\geq 0.$$

simple integrating then leads to

$$\left(\varphi(t)\right)^{1-\frac{p_1}{2}}\leq\left(\varphi(0)\right)^{1-\frac{p_1}{2}}-\frac{p_1-2}{2}\beta t,\forall t\geq 0.$$

which implies that

$$\varphi(t)\geq\frac{1}{\left(\left(\varphi(0)\right)^{1-\frac{p_1}{2}}-\frac{p_1-2}{2}\beta t\right)^{\frac{2}{p_1-2}}}$$

This show that φ blows up in finite time T_{max} given by the estimate

$$T_{max}\leq\frac{2\left(\varphi(0)\right)^{1-\frac{p_1}{2}}}{(p_1-2)\beta}.$$

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Stability and convergence analysis of a new algorithm for contraction mappings

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Abstract – Let C be a nonempty subset of a metric space X, and $T: C \to C$ be a mapping. The fixed point set of T is denoted by $F(T)$, that is, $F(T) = \{x \in C: Tx = x\}$. A mapping $T: C \to C$ is called contraction if there exists a constant $a \in [0,1)$ such that

$$d(Tx, Ty) \leq ad(x, y)$$

for all $x, y \in C$. According to Banach fixed point theorem, every contracting mapping defined on the metric space has a unique fixed point. And the Picard iteration converges to the fixed point of this mapping. In the literature, studies have been carried out by different authors considering the generalizations of this theorem in many different aspects such as spaces, contraction mappings and iteration methods. It is also known that this theory is very important for the solutions of differential and integral equations.

In this study, we define a new iteration process and prove its stability and convergence analysis for weak contraction mappings in a Banach space. Moreover, we compare the rate of convergence between our iteration and other iterations. Finally, we give stability result for our algorithm.

Keywords – Contraction mapping, convergence rate, stability, Banach space

1 Introduction and preliminaries

Let D be a nonempty subset of a Banach space X, and $T: D \to D$ be a mapping. A point $q \in D$ is a fixed point of T if $Tq = q$. Let $F(T)$ denote the set of fixed points of T. Fixed point theory is one of the important theories with widespread use in mathematics, engineering, medicine and many other fields. Many problems in these fields can be represented by solving a nonlinear equation. Finding a fixed point of nonlinear mappings is an important problem and various algorithms have been used by many researchers. Picard iteration [1] is one of the most common methods used to find the fixed point of contraction mappings. Some of the other iteration methods are mentioned below:

i) Mann iteration method [2]: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$x_{n+1} = (1 - \alpha_n)x_n + \alpha_n T x_n$$

where $\{\alpha_n\}$ is a sequence in $[0,1]$.

ii) Ishikawa iteration method [3]: $x_1 \in D$ and for all $n \in \mathbb{N}$,

$$x_{n+1} = (1-\alpha_n)x_n + \alpha_n T y_n$$
$$y_n = (1-\beta_n)x_n + \beta_n T x_n$$

where $\{\alpha_n\}$ and $\{\beta_n\}$ are sequences in [0,1].

iii) Noor iteration method [4]: $h_1 \in D$ and for all $n \in \mathbb{N}$,

$$l_n = (1-\gamma_n)h_n + \gamma_n T h_n$$
$$k_n = (1-\beta_n)h_n + \beta_n T l_n$$
$$h_{n+1} = (1-\alpha_n)h_n + \alpha_n T k_n$$

where $\{\alpha_n\}, \{\beta_n\}$, and $\{\gamma_n\}$ are sequences in [0,1].

iv) SP-iteration method [5]: $a_1 \in D$ and for all $n \in \mathbb{N}$,

$$c_n = (1-\gamma_n)a_n + \gamma_n T a_n \tag{1.1}$$
$$b_n = (1-\beta_n)c_n + \beta_n T c_n$$
$$a_{n+1} = (1-\alpha_n-\lambda_n)b_n + \alpha_n T b_n + \lambda_n T c_n$$

where $\{\alpha_n\}, \{\beta_n\}, \{\gamma_n\}, \{\lambda_n\}$, and $\{\alpha_n + \lambda_n\}$ are sequences in [0,1].

v) SR-iteration method [10]: $w_1 \in D$ and for all $n \in \mathbb{N}$,

$$u_n = (1-\gamma_n)w_n + \gamma_n T w_n \tag{1.2}$$
$$v_n = (1-\beta_n)Tu_n + \beta_n T^2 u_n$$
$$w_{n+1} = (1-\alpha_n)Tv_n + \alpha_n T^2 v_n$$

where $x_1 \in C, \{\alpha_n\}, \{\beta_n\}$, and $\{\gamma_n\}$ are sequences in [0,1].

Definition 1 *[10] A mapping $T: D \to D$ is said to satisfy condition $(*)$ if there exist $\delta \in (0,1)$ and some $L_1 \geq 0$ such that*

$$\| Tx - Ty \| \leq \delta \| x - y \| + L_1 \| x - Tx \| \tag{1.3}$$

for each $x, y \in D$.

In 1995, Osilike [7] proved several stability results of some iteration methods for a class of mappings satisfying the condition $(*)$. Those results are generalizations and extensions of those of Rhoades [8].

In 2002, Berinde [9] gave the following definiton for comparing the rate of convergence between the two iterative methods as follows:

Definition 2 *[9] Let $\{a_n\}$ and $\{b_n\}$ be two sequences of positive numbers that converge to a, b, respectively. Assume there exists*

$$\lim_{n\to\infty} \frac{|a_n - a|}{|b_n - b|} = l$$

(i) If $l = 0$, then it is said that the sequence $\{a_n\}$ converges to a faster than the sequence $\{b_n\}$ to b.

(ii) If $0 < l < \infty$, then we say that the sequence $\{a_n\}$ and $\{b_n\}$ have the same rate of convergence.

Definition 3 *([9], [6]) Let D be a nonempty closed convex subset of a Banach space X and $T: D \to D$ be a mapping. Suppose $\{x_n\}$ and $\{w_n\}$ are two iterations which converge to a fixed point q of T. We say that $\{x_n\}$ converges faster than $\{w_n\}$ to p if*

$$\lim_{n\to\infty} \frac{\|x_n - q\|}{\|w_n - q\|} = 0$$

He also introduced class of weak contraction mapping as follows:

Definition 4 *[9] Let D be a nonempty closed convex subset of a Banach space X. A mapping $T: D \to D$ is said to be weak contraction if there exist a constant $\delta \in (0,1)$ and some $L \geq 0$ such that*

$$\| Tx - Ty \| \leq \delta \| x - y \| + L \| y - Tx \|$$

for all $x, y \in D$.

Proposition 1 *[9] Let D be a nonempty closed convex subset of a Banach space X and $T: D \to D$ be a weak contraction with condition (*). Then T has a unique fixed point. Further, the Picard iteration converges to a unique fixed point of T.*

Remark 1 *It is known that only weak contraction does not guarantee the uniqueness of fixed point of T. But if T also satisfies the condition (*), its fixed point must be unique.*

Motivated by the above, we introduce a new algorithm and prove strong convergence theorems of the our iteration for approximating fixed points of weak contractions in a Banach space, and also compare the rate of convergence of this iteration with SR-iteration, SP-iteration and Noor iteration. Moreover, we prove the stability result of the our iteration for a weak contraction.

Our algortihm is as follows:

$$\begin{cases} x_{n+1} = (1-\alpha_n)T^k y_n + \alpha_n T^{k+1} y_n \\ y_n = (1-\beta_n)T^k z_n + \beta_n T^{k+1} z_n \\ z_n = (1-\gamma_n)T^{k-1} x_n + \gamma_n T^k x_n \end{cases} \qquad (1.4)$$

where $x_1 \in D, \{\alpha_n\}, \{\beta_n\}$, and $\{\gamma_n\}$ are sequences in $[0,1]$ and k is a fixed natural number.

Remark 2 *The our iteration reduces to the SR-iteration method when we take* $k = 1$.

2 Convergence Theorems

Theorem 1 *Let D be a nonempty closed convex subset of a Banach space X and $T: D \to D$ be a weak contraction with condition (*). Suppose that the sequence $\{x_n\}$ is defined by the 1.4, where $\{\alpha_n\}$, $\{\beta_n\}$, and $\{\gamma_n\}$ are sequences in $[0,1]$ which satisfy one of the following conditions:*

$$(C1)\sum_{n=1}^{\infty}\alpha_n = \infty; (C2)\sum_{n=1}^{\infty}\beta_n = \infty; (C3)\sum_{n=1}^{\infty}\gamma_n = \infty$$

Then $\{x_n\}$ converges strongly to a unique fixed point of T.

Proof. Let $q \in F(T)$. From Proposition 1, we obtain

$$\begin{aligned} \|x_{n+1} - q\| &= \|(1-\alpha_n)T^k y_n + \alpha_n T^{k+1} y_n - q\| \\ &\le (1-\alpha_n)\|T^k y_n - q\| + \alpha_n \|T^{k+1} y_n - q\| \\ &\le (1-\alpha_n)\delta^k \|y_n - q\| + \alpha_n \delta^{k+1} \|y_n - q\| \\ &= [1-\alpha_n(1-\delta)]\delta^k \|y_n - q\| \end{aligned}$$

$$\begin{aligned} \|y_n - q\| &= \|(1-\beta_n)T^k z_n + \beta_n T^{k+1} z_n - q\| \\ &\le (1-\beta_n)\|T^k z_n - q\| + \beta_n \|T^{k+1} z_n - q\| \\ &\le (1-\beta_n)\delta^k \|z_n - q\| + \beta_n \delta^{k+1} \|z_n - q\| \\ &= [1-\beta_n(1-\delta)]\delta^k \|z_n - q\| \end{aligned}$$

and

$$\|z_n - q\| = \|(1-\gamma_n)T^{k-1}x_n + \gamma_n T^k x_n - q\|$$
$$\leq (1-\gamma_n)\|T^{k-1}x_n - q\| + \gamma_n\|T^k x_n - q\|$$
$$\leq (1-\gamma_n)\delta^{k-1}\|x_n - q\| + \gamma_n\delta^k\|x_n - q\|$$
$$= [1-\gamma_n(1-\delta)]\delta^{k-1}\|z_n - q\|.$$

If we combine the above inequalities, we have

$$\|x_{n+1} - q\| \leq \delta^{3k-1}[1-\alpha_n(1-\delta)][1-\beta_n(1-\delta)][1-\gamma_n(1-\delta)]\|x_n - q\| \quad (2.1)$$
$$\vdots$$
$$\leq (\delta^{3k-1})^n \prod_{j=1}^{n} \big(1-\alpha_j(1-\theta)\big)\big(1-\beta_j(1-\theta)\big)\big(1-\gamma_j(1-\theta)\big)\|x_1 - q\|.$$

Thus, we can conclude that $\{x_n\}$ converges to q.

If we take $k = 1$ in our algortihm 1.4, we obtain the following results.

Theorem 2 *[10] Assume X, D, T are as in Theorem 1. Suppose that the sequence $\{w_n\}$ is defined by the 1.2 and the sequences $\{\alpha_n\}, \{\beta_n\}$ and $\{\gamma_n\}$ are in $[0,1]$ which satisfy one of the conditions $(C1), (C2), (C3)$ in Theorem 1. Then $\{w_n\}$ converges strongly to a unique fixed point of T.*

Theorem 3 *[6] Assume X, D, T are as in Theorem 1. Suppose that the sequence $\{a_n\}$ is defined by the 1.1 and the sequences $\{\alpha_n\}, \{\beta_n\}, \{\gamma_n\}, \{\lambda_n\}$, and $\{\alpha_n + \lambda_n\}$ are in $[0,1]$ which satisfy one of the conditions $(C1), (C2), (C3)$ in Theorem 1. Then $\{a_n\}$ converges strongly to a unique fixed point of T.*

Theorem 4 *[6] Assume X, D, T are as in Theorem 1. Suppose that the sequence $\{h_n\}$ is defined by the Noor iteration and the sequences $\{\alpha_n\}, \{\beta_n\}$ and $\{\gamma_n\}$ are in $[0,1]$ such that $\sum_{n=1}^{\infty} \alpha_n = \infty$. Then $\{h_n\}$ converges strongly to a unique fixed point of T.*

3 Rate of Convergence

Now, we compare the rate of convergence between the other iterations and our iteration.

Theorem 5 *Assume X, D, T are as in Theorem 1. Suppose $\{x_n\}$ and $\{w_n\}$ are sequences generated by our iteration and SR-iteration, respectively, where $x_1 = w_1 \in D$, and the sequences $\{\alpha_n\}, \{\beta_n\}$ and $\{\gamma_n\}$ are in $[0,1]$ and the sequences $\{\alpha_n\}, \{\beta_n\}, \{\gamma_n\}$ satisfy one of the conditions $(C1), (C2), (C3)$ in Theorem 1.*

Then if $lim_{n\to\infty}\alpha_n = lim_{n\to\infty}\beta_n = lim_{n\to\infty}\gamma_n = 0$ *then* $\{x_n\}$ *converges faster than* $\{w_n\}$ *to a unique fixed point of* T.

Proof. From Theorems 1, and 2, the sequences $\{x_n\}$ and $\{w_n\}$ converge to a unique fixed point of T, say p.

(i) From SR-iteration, we have

$$\begin{aligned}
\|w_{n+1} - q\| &= \|(1-\alpha_n)Tv_n + \alpha_n T^2 v_n - q\| \\
&\geq (1-\alpha_n)\|Tv_n - q\| - \alpha_n\|T^2 v_n - q\| \\
&\geq (1-\alpha_n)\delta\|v_n - q\| - \alpha_n\delta^2\|v_n - q\| \\
&= [1-\alpha_n(1+\delta)]\delta\|v_n - q\| \\
&= [1-\alpha_n(1+\delta)]\delta\|(1-\beta_n)Tu_n + \beta_n T^2 u_n - q\| \\
&\geq [1-\alpha_n(1+\delta)]\delta[(1-\beta_n)\|Tu_n - q\| - \beta_n\|T^2 u_n - q\|] \\
&\geq [1-\alpha_n(1+\delta)]\delta[(1-\beta_n)\delta\|u_n - q\| - \beta_n\delta^2\|u_n - q\|] \\
&= [1-\alpha_n(1+\delta)]\delta[1-\beta_n(1+\delta)]\delta\|u_n - q\| \\
&= [1-\alpha_n(1+\delta)][1-\beta_n(1+\delta)]\delta^2\|(1-\gamma_n)w_n + \gamma_n Tw_n - q\| \\
&\geq [1-\alpha_n(1+\delta)][1-\beta_n(1+\delta)]\delta^2[1-\gamma_n(1+\delta)]\|w_n - q\| \\
&\vdots \\
&\geq \delta^{2n}\prod_{j=1}^{n}\big[1-\alpha_j(1+\delta)\big]\big[1-\beta_j(1+\delta)\big]\big[1-\gamma_j(1+\delta)\big]\|w_1 - q\|.
\end{aligned}$$

Thus

$$\frac{1}{\|w_{n+1}-p\|} \leq \frac{1}{\delta^{2n}\prod_{j=1}^{n}[1-\alpha_j(1+\delta)][1-\beta_j(1+\delta)][1-\gamma_j(1+\delta)]\|w_1-q\|} \tag{3.1}$$

Using 2.1, 3.1 and the assumption, we write

$$\frac{\|x_{n+1}-p\|}{\|w_{n+1}-p\|} \leq \frac{(\delta^{3k-1})^n\prod_{j=1}^{n}\Big(1-\alpha_j(1-\delta)\Big)}{\delta^{2n}\prod_{j=1}^{n}\big[1-\alpha_j(1+\delta)\big]\big[1-\beta_j(1+\delta)\big]} \cdot \frac{\big(1-\beta_j(1-\delta)\big)\big(1-\gamma_j(1-\delta)\big)\|x_1-q\|}{\big[1-\gamma_j(1+\delta)\big]\|w_1-q\|}.$$

Taking

$$\theta_n = \frac{\begin{matrix}(\delta^{3k-1})^n \prod_{j=1}^{n} \Big(1-\alpha_j(1-\delta)\Big)\Big(1-\beta_j(1-\delta)\Big) \\ \big(1-\gamma_j(1-\delta)\big)\|x_1-q\|\end{matrix}}{\begin{matrix}\delta^{2n} \prod_{j=1}^{n} \big[1-\alpha_j(1+\delta)\big]\big[1-\beta_j(1+\delta)\big] \\ \big[1-\gamma_j(1+\delta)\big]\|w_1-q\|\end{matrix}},$$

we obtain

$$\frac{\theta_{n+1}}{\theta_n} = \frac{\left(\delta^{3k-1}\right)^{n+1} \prod_{j=1}^{n+1} (1-\alpha_j(1-\delta))(1-\beta_j(1-\delta))(1-\gamma_j(1-\delta))}{\delta^{2n+2} \prod_{j=1}^{n+1} [1-\alpha_j(1+\delta)][1-\beta_j(1+\delta)][1-\gamma_j(1+\delta)]}$$

$$\times \frac{\delta^{2n} \prod_{j=1}^{n} [1-\alpha_j(1+\delta)][1-\beta_j(1+\delta)][1-\gamma_j(1+\delta)]}{\left(\delta^{3k-1}\right)^{n} \prod_{j=1}^{n} (1-\alpha_j(1-\delta))(1-\beta_j(1-\delta))(1-\gamma_j(1-\delta))}$$

$$= \frac{\delta^{3k-1}(1-\alpha_{n+1}(1-\delta))(1-\beta_{n+1}(1-\delta))(1-\gamma_{n+1}(1-\delta))}{\delta^2(1-\alpha_{n+1}(1+\delta))(1-\beta_{n+1}(1+\delta))(1-\gamma_{n+1}(1+\delta))}.$$

Since $k \in \mathbb{N}$ and $\delta \in (0,1)$, we have $\frac{\delta^{3k-1}}{\delta^2} < 1$ and so

$$\lim_{n\to\infty} \frac{\theta_{n+1}}{\theta_n} = \frac{\delta^{3k-1}}{\delta^2} < 1.$$

By the ratio test, it implies that $\sum_{n=1}^{\infty} \theta_n < \infty$. So, $\lim_{n\to\infty}\theta_n = 0$, we conclude that $\{x_n\}$ converges faster than $\{w_n\}$.

If we take $k = 1$ in our algortihm 1.4, we obtain the following results.

Theorem 6 *[6] Assume X, D, T are as in Theorem 1. Suppose $\{w_n\}, \{a_n\}$ and $\{h_n\}$ are sequences generated by SR-iteration, SP-iteration, and Noor iteration, respectively, where $w_1 = a_1 = h_1 \in C$, and the sequences $\{\alpha_n\}, \{\beta_n\}, \{\gamma_n\}, \{\lambda_n\}$, and $\{\alpha_n + \lambda_n\}$ are in $[0,1]$ and the sequences $\{\alpha_n\}, \{\beta_n\}, \{\gamma_n\}$ satisfy one of the conditions $(C1), (C2), (C3)$ in Theorem 1. Then*

(i) If $\lim_{n\to\infty}(\alpha_n + \beta_n + \lambda_n) = 0 = \lim_{n\to\infty}\gamma_n$ then $\{x_n\}$ converges faster than $\{w_n\}$ to a unique fixed point of T.

(ii) If $\lim_{n\to\infty}\alpha_n = \lim_{n\to\infty}\beta_n = \lim_{n\to\infty}\gamma_n = 0$ and $\sum_{n=1}^{\infty} \alpha_n = \infty$ then $\{x_n\}$ converges faster than $\{h_n\}$ to a unique fixed point of T.

Stability

In this section, we will give the stability result for the our iteration defined by 1.4 for a weak contraction with condition $(*)$. Firstly, we recall the definition of stability.

Definition 5 *Let X be a Banach space and $T: D \to D$ be a mapping. Suppose a point $x_1 \in X$ and define a fixed point iteration procedure by a general relation of the form*

$$x_{n+1} = f(T, x_n)$$

for all $n \in \mathbb{N}$, and $\{x_n\}$ converge to a fixed point p of T. Let $\{y_n\}$ be an arbitrary sequence in X and set

$$\varepsilon_n = \|y_{n+1} - f(T, y_n)\|$$

The sequence $\{x_n\}$ is T-stable (or stable with respect to T) if

$$\lim_{n\to\infty} \varepsilon_n = 0 \text{ if and only if } \lim_{n\to\infty} y_n = p$$

We now prove the stability result of the our iteration.

Theorem 7 *Let D be a nonempty closed convex subset of a Banach space X and $T: D \to D$ be a weak contraction with condition $(*)$. Suppose that the sequences $\{x_n\}$ is defined by the 1.4 and the sequence $\{\alpha_n\}, \{\beta_n\}$, and $\{\gamma_n\}$ are in $[0,1]$ which satisfy one of the conditions $(C1), (C2), (C3)$ in Theorem 1. Then the sequence $\{x_n\}$ is T-stable.*

Proof. From Theorem 1, we know that the sequence $\{x_n\}$ converge to a unique fixed point of T, say p. Let $\{p_n\}$ be an arbitrary sequence in D and define

$$\varepsilon_n = \|p_{n+1} - [(1-\alpha_n)T^k r + \alpha_n T^{k+1} r_n]\|$$
$$r_n = (1-\beta_n)T^k q_n + \beta_n T^{k+1} q_n$$
$$q_n = (1-\gamma_n)T^{k-1} p_n + \gamma_n T^k p_n$$

for all $n \in \mathbb{N}$. Using the same proof of Theorem 1, we get

$$\|(1-\alpha_n)T^k r + \alpha_n T^{k+1} r_n - q\| \le \delta^{3k-1}[1-\alpha_n(1-\delta)][1-\beta_n(1-\delta)][1-\gamma_n(1-\delta)]\|p_n - q\|$$

$$\vdots$$

$$\le (\delta^{3k-1})^n \prod_{j=1}^{n} \big(1-\alpha_j(1-\theta)\big)\big(1-\beta_j(1-\theta)\big)\big(1-\gamma_j(1-\theta)\big)\|p_1 - q\|.$$

Next, assume that $\lim_{n\to\infty} \varepsilon_n = 0$. From above inequality, we obtain

$$\|p_{n+1} - p\| \le \|p_{n+1} - [(1-\alpha_n)T^k r + \alpha_n T^{k+1} r_n]\| + \|[(1-\alpha_n)T^k r + \alpha_n T^{k+1} r_n] - p\|$$

$$\le \varepsilon_n + (\delta^{3k-1})^n \prod_{j=1}^{n} \big(1-\alpha_j(1-\theta)\big)\big(1-\beta_j(1-\theta)\big)\big(1-\gamma_j(1-\theta)\big)\|p_1 - q\|.$$

It follows from above inequality and our assumptions on the sequences $\{\alpha_n\}, \{\beta_n\}$ and $\{\gamma_n\}$ that $\lim_{n\to\infty} p_n = p$.

Conversely, suppose that $\lim_{n\to\infty} p_n = p$, then

$$\begin{aligned}\varepsilon_n &\leq \|p_{n+1} - p\| + \|p - [(1-\alpha_n)T^k r + \alpha_n T^{k+1} r_n]\| \\ &\leq \|p_{n+1} - p\| + \delta^{3k-1}[1-\alpha_n(1-\delta)][1-\beta_n(1-\delta)][1-\gamma_n(1-\delta)]\|p_n - q\| \\ &\leq \|p_{n+1} - p\| + \|p_n - q\|\end{aligned}$$

By above inequality and $p_n \to p$ as $n \to \infty$, we obtain that $\lim_{n\to\infty} \varepsilon_n = 0$. Therefore, the sequence $\{x_n\}$ is T-stable.

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Hokey A Milli Takım Kadın Sporcularında Müziğin Etkisi

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Özet – Bu çalışmada Hokey A Milli takım sporcularının müsabaka döneminde dinlenilen müziğin hokey sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amaçlanmıştır. Araştırma grubunu; Türkiye Hokey A Milli Kadın Takımda bulunan toplam 16 hokey kadın sporcusu oluşturmaktadır. Araştırmada veri toplama amacıyla araştırmacılar tarafından hazırlanan kişisel bilgi formu ve Sportif Uygulamalarda Müziğin Etkisi Ölçeği kullanılmıştır. Veriler analiz edilirken Cronbach's Alpha güvenilirlik testi, Mann Whitney U testi ve Kruskal-Wallis H testi yapılarak çalışmanın sonuçları $p<0,05$ önem düzeyine göre değerlendirilmiştir. Yapılan analizler sonucunda Hokey A milli kadın sporcuların ölçek güvenirlik sonuçları ve al boyut güvenirlikleri yüksek düzeyde çıkmıştır. Çalışmada kullanılan değişken sonuçlarında ise doğum yılı, mevki, spor yaşı, Millilik yaşı, Hokey A Milli takımında kaç maç oynadınız? ve aileniz hokey sporunu yapmanızı destekliyor mu? değişkenlerinde anlamlı bir farklılık olmadığı bulunmuştur. ($p<,05$). Hokey sporcularının müsabaka döneminde dinledikleri müziğin sporlarına etkisi konusu, sporcuların performansını ve spor hayatlarını etkileyebilecek önemli bir faktördür. Hokey A milli kadın sporcularının müsabaka döneminde dinlenilen müziğin hokey sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi adlı çalışmamızda sonuç bulgularının önemi araştırılmalı ve çıkan sonuçlar ile önceki yapılan çalışmalar karşılaştırılarak bilime katkısı yorumlanmalıdır.

Anahtar Kelimeler –Müzik, Hokey, Spor, Kadın, Milli Takım,

I. GİRİŞ

Hokey sporu, olimpiyat oyunlarında 1908 yılından bu yana yer almış ve en çok seyirci kitlesine sahip sporlar arasında yer alan 28 olimpik spordan biridir. Salon Hokeyi ve Açık alan kategorilerinde oynanan bu sporda; açık alan hokeyine hazırlık evresi olarak yapılan salon hokeyi kategorisi, sporcuları kış dönemi içerisinde performanslarını korumak amaçlı olarak oynanmaya başlanan saha içerisinde 6, toplamda ise 12 kişilik oyuncularla oynanan kategorisidir. Açık alan hokeyi kategorisi ise, olimpiyat oyunlarında yer alan ve saha içerisinde 11, toplamda ise 16 kişilik oyuncularla oynanan kategorisidir. Hokeyin, erkekler ve kadınlar için Dünya Şampiyonası, Milli Takım Olimpiyatları, Dünya Hokey Ligi ve Avrupa Şampiyonaları gibi uluslararası müsabakaları olduğu gibi, kulüpler bazında da Avrupa Hokey Ligi gibi önemli müsabakaları bulunmaktadır. Dünyada popüler olan bu spor, ülkemizde de azımsanmayacak seviyededir ve ne yazık ki ülkemizde Hokey alanında çok sayıda çalışma bulunmamaktadır [1].

Hokey sporunda son zamanlarda kalıplaşmış ve geleneksel metotların yerine daha sistemli ve planlı antrenmanlar yapılmaktadır ve başarılı olabilmek için birçok metot denenmektedir [2], [3]. Antrenmanlar ve müsabakalar sırasındaki egzersiz tarzı, fizik kondisyon düzeyi ve genel ruh hali, futbolcuların performanslarını etkileyen bazı faktörler olarak dikkat çekmektedir [4]. Müziğin; müsabaka anında sporcuların performanslarını üst noktaya çıkartma ve müsabakalara daha iyi hazırlanmadaki en iyi metotlarından biri olduğu bilinmektedir. [5].

Müzik; belli bir amaç ve metodla, belirli bir güzellik algısına göre özümsenerek bütünleştirilen seslerin oluşturduğu estetik bir bütündür [6]. Müzik yaşamımızın her periyodunda eğlence amaçlı, terapi nedeniyle ya da sporcularda egzersiz öncesi ısınma, egzersiz sırasında veya egzersiz sonrası soğuma sırasında dinlenilerek [7], sporcuların algılarını, duygu ve düşüncelerini sözlü olmadan etkileyen bir sanat çeşitidir [8]. Müzik ve spor yaşamın her alanında karşımıza çıkmaktadır. Hem rekreatif etkinlik olarak spor yapanların hem de sporcuların vazgeçilmezi olan müzik müsabaka başlangıçları ve bitişleri gibi önemli spor olaylarında da kritik bir önem taşımaktadır. Ancak müziğin, kişileri fiziksel aktivite esnasında eğlendirmek dışında egzersiz performansını yükseltmek, güç ve dayanıklılığı arttırmak, yorgunluğu geciktirmek, gibi destekleyici etkileri olduğu da bilinmektedir [9]. Müziğin ergojenik etkisi, yorgunluğu geciktirerek veya çalışma kapasitesini artırarak egzersiz performansını iyileştirdiği için belirgindir. Bu etki, beklenenden daha yüksek dayanıklılık, güç, üretkenlik veya güç seviyeleri ile sonuçlanır [10]. Egzersiz yaparken müzik dinlemek iş performansını artırır ve devam eden egzersizin neden olduğu algılanan eforu ve yorgunluğu azaltır [11], [12]. Son zamanlarda müzik, egzersiz ve sporun içerisinde daha çok yer almaya başlamıştır. Sporcular fiziksel destek aracı olarak müziği, duygusal ve zihinsel yorgunluklarından 82 kurtulmakta kullanmanın yanında [13], performanslarını arttırmak ve motive olmak amacı ile de kullanmaktadırlar.

[14], çalışmalarında hızlı tempolu müzik dinlemenin maksimal egzersiz anında aktivite zamanının uzamasına ve kalp atım hızının da artmasına neden olduğunu ve egzersiz sonrası düşük tempoda müzik dinlemenin egzersiz sonrası toparlanmaya katkı sağladığını tespit etmişlerdir. Çeşitli müzikler ile yapılan güce dayalı yürüyüşler ve motor beceri üzerindeki etkiler psikolojik bir etkileşim içermektedir [15]. Yapılan çalışmalarda göstermektedir ki müsabaka dönemi sporcular için fiziksel olarak önemli bir etken iken psikolojik olarakta önemli bir süreçtir ve bu süreci birçok değişken etkilemektedir.

Bu çalışmada; müsabaka döneminde dinlenilen müziğin hokey sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amaçlanmıştır. Çalışmamızla hokey sporcularının müsabaka dönemindeki dinledikleri müziğin fiziksel güç ve performansın yanında motivasyon ve psikolojik sağlamlık bakımından da etkileri hokey branşında ele alınmıştır.

II. MATERYAL VE YÖNTEM

A. *Araştırma Grubu*

Araştırma grubunu; Türkiye Hokey A Milli takımda bulunan toplam 16 kadın sporcu oluşturmaktadır. Sporcular çalışmada gönüllü olarak yer almaktadır. Araştırmada kolayda örnekleme yöntemi tercih edilmiştir. Kolayda örnekleme yöntemi; araştırmacıların ulaşabileceği sporcuların tümünün çalışmaya gönüllü olarak katılması olarak bilinmektedir [16].

B. *Veri Toplama Aracı*

Çalışma; 6 soruluk demografik değişkenlerden ve [17] tarafından hazırlanan 18 sorudan oluşan "Sportif Uygulamalarda Müziğin Etkisi Ölçeği" kullanılmıştır. Ölçek, toplamda 18 sorudan ve 3 alt boyuttan oluşan 5 kategorili likert türünde yapılandırılmıştır. Ölçeğin alt boyutları Motivasyon (5 soru), Fiziksel Güç ve Performans (6 soru) ve Psikolojik Sağlamlık (7 soru) durumlarını ölçmektedir. Ölçeğin Cronbach Alpha güvenirliği "Motivasyon", "Fiziksel Güç ve Performans", "Psikolojik Sağlamlık" alt boyutları ve ölçeğin tamamı için sırasıyla 0,71, 0,78, 0,80 ve 0,88 olarak hesaplanmıştır.

C. *Verilerin Toplanması*

Veriler elde edilirken; internet ortamında, anket sisteminden yararlanılarak sorular Hokey takımında bulunan tüm sporculara ulaştırılıp sonuçlar elde edilmiştir. Çalışmamıza katılan sporcuların tümüne yaptığımız çalışmanın amacı, yöntemi ve önemi hakkında bilgilendirme yapılarak, isimlerinin kesinlikle hiçbir yerde paylaşılmayacağı ve sadece araştırma amaçlı kullanılacağı bilgisi verilmiştir.

D. Verilerin Analizi

Araştırmamıza katılan sporculardan elde edilen verilerin analizleri SPSS 26.0 analiz programında yapılmıştır. Cronbach's Alpha güvenilirlik testi, Mann Whitney U Testi ve Kruskal-Wallis H Testi yapılarak çalışma sonuçları p<0,05 önem düzeyine göre istatistiksel olarak değerlendirilmiştir.

III. BULGULAR

Tablo 1. Sportif Uygulamalarda Müziğin Etkisi Ölçeği Güvenirlilik Dağılımları (Genel)

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0, 963	18

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,963 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin yüksek güvenilirlik düzeyinde olduğu tespit edilmiştir (Tablo 1).

Tablo 2. Motivasyon Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0,920	5

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği motivasyon alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,920 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin yüksek güvenilirlik düzeyinde olduğu tespit edilmiştir (Tablo 2).

Tablo 3. Fiziksel Güç ve Performans Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0,939	6

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği fiziksel güç ve performans alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,939 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin yüksek güvenilirlik düzeyinde olduğu tespit edilmiştir (Tablo 3).

Tablo 4. Psikolojik Sağlamlık Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0,891	7

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği psikolojik sağlamlık alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,891 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin yüksek güvenilirlik düzeyinde olduğu tespit edilmiştir (Tablo 4).

Tablo 5. Sporcuların, Kişisel Değişkenlerine İlişkin Dağılımları

Değişkenler		n	%
Doğum Yılı	1993-1998 Doğumlu	8	50,0
	1999-2004 Doğumlu	8	50,0
Mevki	Kaleci	3	18,8
	Defans	5	31,2
	Orta Saha	5	31,2
	Forvet	3	18,8
Spor Yaşı	6-10 Yıl	7	43,8
	11 Yıl ve üstü	9	56,2
Millilik Yaşı	1-5 Yıl	6	37,5
	6-10 Yıl	4	25,0
	11 Yıl ve Üstü	6	37,5
Hokey A Milli Takımında Kaç Maç Oynadınız?	1-10 Maç	5	31,3
	11-20 Maç	2	12,5
	31-40 Maç	3	18,8
	41 Maç ve Üstü	6	37,4
Aile Destek Durumu	Evet	15	93,7
	Hayır	1	6,3

Tablo 6. Sporcuların, Doğum Yılı Değişkenine Göre Mann Whitney U Testi Sonuçları

Ölçek ve Alt Boyutları	Doğum Yılı	n	Sıra Toplamı	Sıra Ortalaması	M.W. U	z	p
Genel	1993-1998 Doğumlu	8	78,500	9,812	21,500	-1,108	0,268
	1999-2004 Doğumlu	8	57,500	7,187			
Motivasyon	1993-1998 Doğumlu	8	81,500	10,187	18,500	-1,528	0,126
	1999-2004 Doğumlu	8	54,500	6,812			
Fiziksel Güç ve Performans	1993-1998 Doğumlu	8	76,000	9,500	24,000	-0,856	0,392
	1999-2004 Doğumlu	8	60,000	7,500			
Psikolojik Sağlamlık	1993-1998 Doğumlu	8	78,500	9,812	21,500	-1,134	0,257
	1999-2004 Doğumlu	8	57,500	7,187			

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takımı sporcularının, doğum yılı değişkeni incelendiğinde, Mann Whitney U testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 6).

Tablo 7. Sporcuların, spor yaşı değişkenine göre Mann Whitney U Testi sonuçları

Ölçek ve Alt Boyutları	Spor yaşı	n	Sıra T.	Sıra O.	M. W. U	z	p
Genel	6-10 Yıl	7	63,000	9,000	28,000	-0,372	0,709
	11 Yıl ve Üstü	9	73,000	8,111			
Motivasyon	6-10 Yıl	7	60,000	8,571	31,000	-0,057	0,954
	11 Yıl ve Üstü	9	76,000	8,444			
Fiziksel Güç ve Performans	6-10 Yıl	7	62,500	8,928	28,500	-0,324	0,746
	11 Yıl ve Üstü	9	73,500	8,167			
Psikolojik Sağlamlık	6-10 Yıl	7	62,500	8,928	28,500	-0,326	0,743
	11 Yıl ve Üstü	9	73,500	8,167			

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takımı sporcularının, spor yaşı değişkeni incelendiğinde, Mann Whitney U testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 7).

Tablo 8. Sporcuların, aile destek durumu değişkenine göre Mann Whitney U Testi sonuçları

Ölçek ve Alt Boyutları	Aile Destek	n	Sıra T.	Sıra O.	M.W.U	z	p
Genel	Evet	15	123,000	8,200	3,000	-0,981	0,327
	Hayır	1	13,000	13,000			
Motivasyon	Evet	15	124,500	8,300	4,500	-0,702	0,483
	Hayır	1	11,500	11,500			
Fiziksel Güç ve Performans	Evet	15	123,000	8,200	3,000	-0,995	0,320
	Hayır	1	13,000	13,000			
Psikolojik Sağlamlık	Evet	15	122,500	8,167	2,500	-1,115	0,265
	Hayır	1	13,500	13,500			

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takımı sporcularının, aile destek durumu değişkeni incelendiğinde, Man Whitney U testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 8).

Tablo 9. Sporcuların, mevki değişkenine göre Kruskal-Wallis H Testi sonuçları

	Mevki	n	Mean Rank	Test Statistics	
Genel	Kaleci	3	7,666	Kruskal-Wallis H	5,923
	Defans	5	6,200	df	3
	Orta Saha	5	7,800		
	Forvet	3	14,333	p	0,115
Motivasyon	Kaleci	3	7,833	Kruskal-Wallis H	7,432
	Defans	5	5,900	df	3
	Orta Saha	5	7,900		
	Forvet	3	14,500	p	0,059
Fiziksel Güç ve Performans	Kaleci	3	8,666	Kruskal-Wallis H	5,497
	Defans	5	6,700	df	3
	Orta Saha	5	6,900		
	Forvet	3	14,000	p	0,138
Psikolojik Sağlamlık	Kaleci	3	8,333	Kruskal-Wallis H	6,232
	Defans	5	6,300	df	3
	Orta Saha	5	7,300		
	Forvet	3	14,333	p	0,101

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takımı sporcularının mevki değişkeni incelendiğinde, Kruskal-Wallis H testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 9).

Tablo 10. Sporcuların, Millilik yaşı değişkenine göre Kruskal-Wallis H Testi sonuçları

	Millilik Yaşı	n	Mean Rank	Test Statistics	
Genel	1-5 Yıl	6	9,083	Kruskal-Wallis H	0,591
	6-10 Yıl	4	9,375	df	2
	11 Yıl ve Üstü	6	7,333	p	0,744
Motivasyon	1-5 Yıl	6	9,250	Kruskal-Wallis H	0,996
	6-10 Yıl	4	9,500	df	2
	11 Yıl ve Üstü	6	7,083	p	0,608
Fiziksel Güç ve Performans	1-5 Yıl	6	9,000	Kruskal-Wallis H	0,845
	6-10 Yıl	4	9,750	df	2
	11 Yıl ve Üstü	6	7,170	p	0,655
Psikolojik Sağlamlık	1-5 Yıl	6	8,420	Kruskal-Wallis H	0,549
	6-10 Yıl	4	9,875	df	2

11 Yıl ve Üstü	6	7,670	p		0,760

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takımı sporcularının, Millilik yaşı değişkeni incelendiğinde, Kruskal-Wallis H testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 10).

Tablo 11. Sporcuların, Hokey A Milli Takımında kaç maç oynadınız? değişkenine göre Kruskal-Wallis H Testi sonuçları

	Hokey A Milli Takımında Kaç Maç Oynadınız?	**n**	**Mean Rank**	**Test Statistics**	
Genel	1-10 Maç	5	8,300	Kruskal-Wallis H	3,497
	11-20 Maç	2	14,250	df	3
	31-40 Maç	3	7,333		
	41 Maç ve Üstü	6	7,333	p	0,321
Motivasyon	1-10 Maç	5	8,800	Kruskal-Wallis H	2,786
	11-20 Maç	2	13,000	df	3
	31-40 Maç	3	7,833		
	41 Maç ve Üstü	6	7,083	p	0,426
Fiziksel Güç ve Performans	1-10 Maç	5	8,200	Kruskal-Wallis H	3,320
	11-20 Maç	2	14,000	df	3
	31-40 Maç	3	8,000		
	41 Maç ve Üstü	6	7,170	p	0,345
Psikolojik Sağlamlık	1-10 Maç	5	7,400	Kruskal-Wallis H	3,871
	11-20 Maç	2	14,500		3
	31-40 Maç	3	8,000		
	41 Maç ve Üstü	6	7,670	p	0,276

*p<0,05 düzeyinde anlamlı

Türkiye Hokey A Milli takım sporcularının, Hokey A Milli Takımında kaç maç oynadınız? değişkeni incelendiğinde, Kruskal-Wallis H testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılıkların olmadığı görülmüştür (p<0,05) (Tablo 11).

IV. TARTIŞMA

Araştırma; Türkiye Hokey A Milli Kadın takımında bulunan tüm sporcuların, müsabaka döneminde dinlenilen müziğin hokey sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amacı ile yapılarak, Türkiye Hokey A Milli Kadın takımında bulunan 16 sporcuya da uygulanmıştır.

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,963 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin yüksek güvenilirlik düzeyinde olduğu tespit edilmiştir (Tablo 1).

Türkiye Hokey A Milli Kadın takım sporcularının, doğum yılları değişkeni incelendiğinde, Mann Whitney U analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 6). Çalışmamıza farklı olarak; [18] yaptıkları çalışmalarında yaş değişkeni ile sportif uygulamalarda müziğin etkisi arasında anlamlı farklılık olduğunu tespit etmişlerdir. Çalışmamıza paralel olarak; [19] ise, Beden Eğitimi ve Spor Yüksekokulu Öğrencileri Üzerine yapmış oldukları çalışmalarında yaş değişkeni ile sportif uygulamalarda müziğin etkisi arasında anlamlı farklılık tespit etmemişlerdir.

Türkiye Hokey A Milli Kadın takım sporcularının, spor yaşı değişkeni incelendiğinde, Mann Whitney U analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 7). Çalışmamızdan farklı olarak; [18] yaptıkları çalışmalarında spor yılı değişkeni ile sportif uygulamalarda müziğin etkisi arasında anlamlı farklılık olduğunu tespit etmişlerdir. Aynı çalışmada futbolcuların oynadığı lig seviyesi değişkeni ile sportif uygulamalarda müziğin etkisi ölçeği arasında bizim çalışmamızdan farklı olarak profesyoneller lehine sonuçlanmıştır. [20] futbolcular üzerinde yaptığı çalışmasında futbolcuların oynadığı lig ve spor yaşı değişkeni ile ölçek alt boyutları için yapılan analiz testi sonrasında $p<0,05$ düzeyinde fiziksel güç ve performans, psikolojik sağlamlık ve motivasyon alt boyutlarında anlamlı farklılık bulunmuştur.

Türkiye Hokey A Milli Kadın takım sporcularının, aileniz hokey sporunu yapmanızı destekliyor mu? değişkeni incelendiğinde, Mann Whitney U analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 8). Spor ile ilgilenen ebeveynlerin çocuklarının spora daha ilgili oldukları bilinmektedir [21]. Çalışmamıza benzer olarak [22] çalışmalarında aile destek değişkeninde anlamlı farklılık olmadığını tespit etmişlerdir. [23] çalışmasında sporcuların aile destek değişkenleri arasında anlamlılık olmadığını bulmuştur. Çalışmamızdan farklı olarak; [24] çalışmalarında sporcuların ailelerinde destek görmeleri değişkeninde anlamlı farklılıkların bulunduğunu belirlemişlerdir. [25] öğrenciler ile yaptıkları çalışmalarında, spor etkinliklerinde aile desteğinin pozitif etkilerinin olduğunu tespit etmişlerdir.

Türkiye Hokey A Milli Kadın takım sporcularının, mevki değişkeni incelendiğinde, Kruskal-Wallis H analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 9). Çalışmamıza paralel olarak; [26] çalışmalarında, anlamlı farklılıkların olmadığını tespit etmişlerdir. [27] araştırmalarında anlamlı farklılıkların olmadığını belirlemişlerdir. Çalışmamızdan farklı olarak; [28] çalışmalarında, anlamlı farklılıkların olduğunu belirlemişlerdir. [29] yapmış oldukları araştırmalarında, mevki değişkeninde anlamlı farklılıkların olduğunu bildirmişlerdir.

Türkiye Hokey A Milli Kadın takım sporcularının, Millilik yaşı değişkeni incelendiğinde, Kruskal-Wallis H analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 10). Benzer çalışmalarda; [29] çalışmalarında anlamlı farklılıkların bulunduğunu bildirmişlerdir. [30] futsal sporcuları ile yapmış oldukları çalışmalarında, spor yaşı değişkeninde anlamlı farklılıkların olmadığını belirlemişlerdir. [31] yaptıkları araştırmalarında anlamlı farklılıkların olduğunu belirlemişlerdir.

Türkiye Hokey A Milli Kadın takım sporcularının, Hokey A Milli Takımında kaç maç oynadınız? değişkeni incelendiğinde, Kruskal-Wallis H analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir (Tablo 11). Çalışmamamıza paralel olarak; [29] çalışmalarında, anlamlı farklılıkların olmadığını tespit etmişlerdir. Çalışmamızdan farklı olarak; [32] çalışmalarında, anlamlı farklılıkların olduğunu belirlemişlerdir.

V. SONUÇLAR

Çalışma; Türkiye Hokey A Milli Kadın takımında bulunan tüm sporcuların, müsabaka döneminde dinlenilen müziğin hokey sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amacı ile yapılmıştır. Çalışmadan elde ettiğimiz sonuçlarda "doğum yılı", "mevki", "spor

yaşı", "Millilik yaşı", "Hokey A Milli takımında kaç maç oynadınız?" ve "aileniz hokey sporunu yapmanızı destekliyor mu?" değişkenlerinde anlamlı farklılıkların olmadığı tespit edilmiştir. Hokey A milli kadın sporcularında müziğin etkisi adlı çalışmamızda sonuç bulgularının önemi araştırılmalı ve çıkan sonuçlar ile önceki yapılan çalışmalar karşılaştırılarak bilime katkısı yorumlanmalıdır.

TEŞEKKÜR

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The role of age and gender as moderators of customer loyalty programs in Albanian telecommunication sector

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Abstract – Loyalty programs have been used for decades as an important element of customer relationship management for companies in different industries, in order to retain their customers and attract new ones. Numerous studies have provided insight on the effectiveness, design and outcomes of loyalty programs, but most of them did not consider moderating variables. Understanding the factors that influence customer engagement with loyalty programs is crucial for optimizing their effectiveness. In this context, this study examines the effect of demographic factors such as age and gender on the knowledge and usage of the loyalty programs in the telecommunication sector in Albania. Utilizing a quantitative approach, data were collected through a questionnaire distributed via convenience sampling among 750 telecommunication customers. The data was analyzed using SPSS.

Keywords – customer loyalty, loyalty programs, demographics, telecommunication, marketing.

I. INTRODUCTION

Almost all economies globally have undergone crucial economic transformations and the recent crisis have put many organizations in front of severe tests and difficulties. Consequently, competition became the most important running engine of businesses in recent years.

Studies have shown that the cost of acquiring a new customer is six to eight times more than the that of retaining an already existing customer [1], making it imperative for companies to focus on customer loyalty. Brand loyalty and loyal customers are very important for the future of the business and should be studied carefully [2]. To enhance consumer loyalty, companies adopt many strategies, and the most popular among them is the loyalty program [3]. The implementation of the loyalty programs helps the companies to keep their existing customers by encouraging repeated purchases and also attracts the new ones by programs offering various incentives, such as discounts, points, and exclusive benefits. Loyalty programs are widely used in different industries as strategic tools to enhance customer retention. It is common to find that also mobile network operators around the globe have adopted measures to influence positive customer behavior by the implementation of loyalty programs.

Albania entered the process of liberalization of economy which certainly included the telecommunication sector. This process came as e result of market economic deliberations, a common feature to other Balkan countries. Initially, there were four operating companies but nowadays there are only two, as a result of merger and acquisition processes. This has increased the competition in the offered services between the operating companies, making the customer loyalty an important area of research in the telecommunication sector.

In an increasingly competitive market between the actual operating companies, telecom companies in Albania are turning to loyalty programs to retain customers and enhance brand loyalty. However, the

effectiveness of these programs may vary across different demographic segments. As stated by [4], loyalty programs offer benefits for consumers who can receive rewards and/or reach a higher tier as well as for firms that can potentially gain more repeat businesses and, at the same time, gather detailed consumer insights that allow them to deliver targeted marketing activities.
Though, loyalty programs can help companies to monitor and influence the consumer behavior. Understanding the factors that influence customer engagement with loyalty programs is crucial for optimizing their effectiveness.
Although numerous studies have provided insight on the effectiveness, design and outcomes of loyalty programs, most of the studies did not consider moderating variables. In this context, the objective of this study is to explore how age and gender effect the knowledge and the usage of loyalty programs in telecommunication sector in Albania.

Customer Loyalty

Loyalty as a concept has gained a lot of attention in customer research even though it is nothing new for the world economy. Customer loyalty is a complex and difficult construct to define [5]. Many different definitions have been given in the literature, depending on the focus of the studies. One of the most accepted is the definition given by [6], who suggests that customer loyalty is a deeply held commitment to rebuy or repatronizes a preferred product or service consistently in the future, despite situational influences and marketing efforts having the potential to cause switching behaviour.
One of the most important key drivers of long-term business success is certainly customer loyalty. According to [7] loyal customers tend to repeat purchases, are less prone to price changes and recommend the brand to their social circle.
As mentioned before, it costs less to keep the existing customers than to attract new ones. In this context, companies are using different strategies and tools in order to enhance customer loyalty, especially the loyalty programs.

Loyalty Programs

Over the past decades, loyalty programs have been in the centre of attention of customer research and in practical use as well. Although they have been in existence since the 18th century and since then they have evolved and continue to evolve as many areas remain unexplored [8].
Loyalty programs are intended to increase incentives among the loyal customers for their continued clientele and to inspire repeat purchases. Loyalty programs are well known and used in various sectors of business such as; hospitality, retail and telecommunications. There are many studies and analysis performed on the relationship between loyalty programs and customer loyalty. Some of the findings including those of [9] suggest that a well-made loyalty program can improve customer loyalty thus providing concrete and psychological benefits. According to [10], effective loyalty programs can improve and increase customer satisfaction, higher retention rates, and better financial performance for the companies. Characteristically, loyalty programs offer various rewards such as: points, discounts, exclusive offers and other bonuses. The value and composition of these rewards impact considerably customer satisfaction and participation. Reference [11] states that membership in loyalty programs have a positive effect on customer retention and value, stressing also the importance of program design and execution.

Demographic Factors and Loyalty Programs
In order to increase the impact and the engagement with the loyalty programs of the customers, the companies should consider the factors that affect the consumer behaviour and the responsiveness to the different marketing strategies. Age and gender are two of these factors that can impact the way customers perceive and participate in loyalty programs.
Age

A significant factor that greatly influence the engagement of the customer with the loyalty programs is the age. Reference [12] states that young customers including millennials and Generation Z, have a tendency to participate in loyalty programs due to their acquaintance with the digital platforms and have a greater disposition towards value-added benefits.
On the other hand, [11] underlines that older customers appreciate tangible rewards and clear benefits. That is the reason why this category of customers shows different engagement patterns towards loyalty programs. According to [13], digital loyalty programs usually remain a challenge for the older customers and limit their participation due to lack of interest and familiarity with the digital platforms and technological barriers.

Gender

Various studies examining the differences of genders in participation in loyalty programs can be found in literature. Some researches specify that there are no substantial gender differences in loyalty program engagement, whereas some others stress big differences between them. For example, [14] found that both men and women show similar levels of participation in loyalty programs that suit to their individual needs and preferences.
On the other hand, [15] revealed that women tend to be more involved in loyalty programs compared to men, likely because of their increased participation in shopping and a stronger desire for rewards. Other studies show that men may support loyalty programs that provide tangible benefits and fit to their shopping preferences.
Based on the literature review, we propose the following hypotheses:

Hypothesis 1: There is a significant difference in the knowledge of loyalty programs based on gender among the consumers of mobile operators in Albania.
Hypothesis 2: There is a significant difference in the knowledge of loyalty programs based on age among consumers of mobile operators in Albania.
Hypothesis 3: There is a significant difference in the usage of loyalty programs based on gender among consumers of mobile operators in Albania.
Hypothesis 4: There is a significant difference in the usege of loyalty programs based on age among consumers of mobile operators in Albania.

II. METHODOLOGY

This study employs a quantitative research methodology to explore the role of demographic factors on the knowledge and usage of loyalty programs by the customers in the telecommunication sector in Albania. A questionnaire distributed online was used to collect data from 750 customers and the collected data was analysed by using SPSS. The target population for this study includes all telecommunication customers in Albania who are potential participants in loyalty programs, therefore convenience sampling technique was employed.

III. RESULTS

To test hypothesis 1, a Chi-Square test was performed to examine the relationship between gender and knowledge of loyalty programs among consumers of mobile operators in Albania. The results broken down by gender are presented in Table 1 below:

Table 1. Gender and knowledge of loyalty programs

Gender	Knowledge of Loyalty Programs	Count	% within Gender	% within Knowledge	% of Total
Male	Yes	81	39.5%	24.8%	10.8%
	No	124	60.5%	29.3%	16.5%
Female	Yes	246	45.1%	75.2%	32.8%
	No	299	54.9%	70.7%	39.9%
Total		750	100.0%	100.0%	100.0%

The Chi-Square test result was $\chi 2(1, C=750)=1.917$, p=.166 – presented in Table 2 below. This result suggests that there is no statistically significant difference in the knowledge of loyalty programs based on gender among consumers of mobile operators in Albania. The test did not provide sufficient evidence to accept the hypothesis, which suggests that there are no differences in the level of information that men and women have about loyalty programs offered by mobile operators.

Table 2: Pearson Chi Square results of gender and knowledge of loyalty programs

Test	Value	df	Asymptotic Significance (2-tailed)
Pearson Chi-Square	**1.917**	**1**	**.166**
Continuity Correction	1.695	1	.193
Likelihood Ratio	1.927	1	.165
Fisher's Exact Test			.186
Linear-by-Linear Association	1.914	1	.166
N of valid cases	750		

The Chi-Square test was also performed to examine the relationship between age group and knowledge of loyalty programs among consumers of mobile operators in Albania. The results divided by age group are presented in Table 3.

Table 3: Age and knowledge of loyalty programs

Age Groups	Knowledge of Loyalty Programs	Count	% within Age	% within Knowledge	% of Total
18-24	Yes	189	48.8%	57.8%	25.2%
	No	198	51.2%	46.8%	26.4%
25-34	Yes	98	38.7%	30.0%	13.1%
	No	155	61.3%	36.6%	20.7%
35-44	Yes	30	38.5%	9.2%	4.0%
	No	48	61.5%	11.3%	6.4%
45-54	Yes	9	36.0%	2.8%	1.2%
	No	16	64.0%	3.8%	2.1%
Over 55	Yes	1	14.3%	0.3%	0.1%
	No	6	85.7%	1.4%	0.8%
Total		750	100.0%	100.0%	100.0%

The value generated by the Chi-Square test was $\chi 2(4, C=750) =10.623$, $p=.031$ – shown in Table 4. Based on these results, there is a significant difference in awareness of loyalty programs based on age group between customers of mobile operators in Albania. The analysis provided sufficient evidence to support the hypothesis which suggests that there is a difference in the knowledge of loyalty programs depending on the age group, among consumers of mobile operators in Albania.

Table 4: Pearson Chi Square results of age and knowledge of loyalty programs

Test	Value	df	Asymptotic Significance (2-tailed)
Pearson Chi-Square	**10.623**	**4**	**.031**
Likelihood Ratio	10.981	4	.027
Linear-by-Linear Association	8.614	1	.003
N of Valid Cases	750		

The Chi-Square test was performed to examine the relationship between gender and the use of loyalty programs among consumers of mobile operators in Albania. The results broken down by gender are presented in Table 5.

Table 5: Gender and usage of loyalty programs

Gender	Usage of Loyalty Programs	Count	% within Gender	% within Usage	% of Total
Male	Yes	87	42.4%	25.1%	11.6%
	No	118	57.6%	29.2%	15.7%
Female	Yes	259	47.5%	74.9%	34.5%
	No	286	52.5%	70.8%	38.1%
Total	Yes	346	46.1%	100.0%	46.1%
	No	404	53.9%	100.0%	53.9%

The value generated by the Chi-Square test was $\chi 2(1, C=750) =1.549$, $p = .213$ – presented in Table 6. This result shows that there is no significant difference in the use of loyalty programs based on gender between customers of mobile operators in Albania. The analysis did not provide sufficient evidence to accept the hypothesis, suggesting that the use of loyalty programs does not differ significantly between males and females in this sample. Consequently, this result suggests that there is no difference in the use of loyalty programs depending on gender among consumers of mobile operators in Albania.

Table 6: Pearson Chi Square results of gender and usage of loyalty programs

Test	Value	df	Asymptotic Significance (2-tailed)
Pearson Chi-Square	**1.549**	**1**	**.213**
Likelihood Ratio	1.352	1	.245
Linear-by-Linear Association	1.547	1	.214
N of Valid Cases	750		

The Chi-Square test was performed to examine the relationship between age group and the use of loyalty programs among consumers of mobile operators in Albania. Descriptive results are presented in Table 7.

Table 7: Age and usage of loyalty programs

Age Groups	Usage of Loyalty Programs	Count	% within Age	% within Usage	% of Total
18-24	Yes	196	50.6%	56.6%	26.1%
	No	191	49.4%	47.3%	25.5%
25-34	Yes	106	41.9%	30.6%	14.1%
	No	147	58.1%	36.4%	19.6%
35-44	Yes	40	51.3%	11.6%	5.3%
	No	38	48.7%	9.4%	5.1%
45-54	Yes	4	16.0%	1.2%	0.5%
	No	21	84.0%	5.2%	2.8%
Over 55	Yes	0	0.0%	0.0%	0.0%
	No	7	100.0%	1.7%	0.9%
Total		750	100.0%	100.0%	100.0%

As shown in Table 8 below, the value obtained from the Chi-Square test shows a statistically significant relationship between age group and the use of loyalty programs, $\chi 2(4, C=750) = 20.960$, $p=.000$. As a result, the hypothesis will be supported which suggests that there is a statistically significant difference in the use of loyalty programs based on age groups among consumers of mobile operators in Albania. This implies that different age groups report different levels of usage related to loyalty programs.

Table 8: Pearson Chi Square results of age and knowledge of loyalty programs

Test	Value	df	Asymptotic Significance (2-tailed)
Pearson Chi-Square	**20.960**	**4**	**.000**
Likelihood Ratio	24.678	4	.000
Linear-by-Linear Association	10.616	1	.001
N of Valid Cases	750		

IV. DISCUSSIONS AND CONCLUSIONS

The study discussed the effect of demographic factors on understanding the usage of loyalty programs as a crucial factor to design effective customer retention policies and strategies in the telecommunication sector. It also intends to provide understandings into these relations thus making a contribution to the designation of more focused and comprehensive loyalty programs.

The main aim of the study was to analyse the role of demographic factors, particularly gender and age, in understanding and usage of loyalty programs in telecommunication sector in Albanian market. The findings provide important information and valuable insights on how the above-mentioned factors effect customer engagements with loyalty programs.

The findings highlight that both genders have equal information about the loyalty programs provided by the Albanian mobile operators. As a result of that, the companies can concentrate their efforts, in implementing loyalty program awareness, without tailoring them specifically to either gender.

Young generation, especially those aged 18-24 and 25-34, showed that their information about loyalty programs is higher compared to the older age targeted groups. This shows that young customers have more information about loyalty programs most probably because of their engagement with the cutting-edge technology and digital platforms where loyalty programs are often promoted. Telecommunication companies must take into consideration to target younger generation in a more effective way and improve awareness approaches to the older generation.

Both genders showed almost the same levels of participation in loyalty programs, suggesting that gender does not make any difference in influencing the use of these programs. The findings highlight the need to design loyalty programs that attract all customers regardless gender division.

Nevertheless, it should be mentioned that noteworthy differences were found in the usage of loyalty programs by age groups. The young customers, especially those aged between 18-24, were more frequent users of loyalty programs than the old aged customers. The findings show a higher trend of the young generation in actively engaging in loyalty initiatives most probably due to their convenience with the digital platforms and digital rewards. Telecommunication companies must concentrate on the ways to improve user experience and accessibility of loyalty programs in order to keep high level of participation and engagements of young generation and find out new strategies to increase the participation of the old generation customers.

In conclusion, the findings suggest that gender does not affect considerably the use and information about the loyalty programs in the Albanian telecommunication sector but age plays a significant role. Young customers show higher levels of attention and awareness in participating in loyalty programs compared to the old generation of customers. The telecommunication companies should use and implement those findings to re-arrange their loyalty programs and marketing strategies in order to make them appealing to different age groups and to maximize customer retention and engagement.

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BALANCING URBAN GROWTH AND CULTURAL HERITAGE: PRESERVING RAMALLAH'S HISTORIC CENTER AMIDST DEVELOPMENT

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Abstract – The article investigates the urban development and preservation efforts of Ramallah's historic center. The primary research question explores the strategies and challenges involved in preserving Ramallah's historic center amidst ongoing urban growth and urbanization. The article started by analyzing the historical evolution of Ramallah, identifying key factors influencing its urbanization, and evaluating the effectiveness of preservation initiatives. Methodologically, the study employs a mixed-methods approach, combining historical analysis, qualitative interviews with key stakeholders, and a review of urban planning documents. Historical records and maps were analyzed to trace the development phases. In-depth interviews with representatives from the Ramallah Municipality, the Ministry of Tourism and Antiquities, and heritage conservation organizations provided insights into the preservation strategies and challenges. The results highlight significant urban growth phases and challenges posed as a result of them. Key findings also indicate several challenges that impeded preservation efforts and innovative solutions. The study highlights the significance of balancing between development and preservation and the importance of integrating cultural heritage conservation into urban planning regimes.

Keywords – Historic Center, Urban Development, Urbanization, Preservation, Cultural Heritage

I. INTRODUCTION

Ramallah, located in the Ramallah and Al-Bireh Governorate in the Central West Bank of Palestine, is 16 kilometers north of Jerusalem and strategically situated between the Mediterranean Sea and the Dead Sea. With a population of approximately 44,762, Ramallah forms a single geographical unit with Al-Bireh. The city, surrounded by villages like Surda, Al-Bireh, Rawabi, Beitunia, Ein Qiniya, and AL-Mazra'a Al-Qibliya, is known for its rich history, natural beauty, and cool climate, making it a favored summer resort. The historic center of Ramallah, spanning about 165 dunams with significant historical and archaeological sites like Khirbet Al-Tireh and Khirbet Ein Treifia, has remained a central and strategic location since its establishment in the mountains around Jerusalem, part of the central Palestine Mountain range [1], [2], [3], [4], [5], [6]

The Historical Center of Ramallah serves as the nucleus around which the modern city developed. The center contains a significant portion of historical buildings dating back to the late Ottoman period and the British Mandate, forming a local historical fabric characterized by clusters of connected historical buildings, squares, and alleys. The Historic Center includes important landmarks such as the Frangieh Tower, Maqam Ibrahim Al-Khalil, the Ottoman Court, and the Cannon Station. The Ramallah Municipality has focused on preserving this urban cultural heritage, working with partners to prepare a comprehensive

plan for the cultural heritage of the Historic Center. This includes the designation of historic buildings, courtyards, alleys, and other elements, aiming to integrate cultural heritage into the city's development interest [1], [5], [6], [7], [8], [9].

II. Materials and Method

A triangulation of methods was employed to ensure comprehensive and robust insights. These methods include observations, document analysis, and in-depth interviews with stakeholders.

A. Observations

Field Observations were conducted through regular visits to the historic center, these observations focused on the physical and social environment. This method provided real-time data on the current state of the historic center.

B. Document Analysis

Historical and archival research analysis was conducted by analysis of historical documents, preservation reports, municipal archives, and media content was performed to trace the development and impact of the preservation plan. Also, a review of policy and planning documents provided insights into the strategies and measures implemented by the municipality.

C. In-Depth interviews

In-depth interviews were conducted over several days by the author with key stakeholders, providing valuable insights into the preservation efforts of Ramallah's Historic Center [Personal communication, April 28-May 2, 2024].

III. THE DEVELOPMENT AND URBANIZATION OF RAMALLAH'S HISTORIC CENTER

The urban development of Ramallah evolved through several key phases, beginning as an agricultural village in the mid-16th century and growing into a historical center by the 19th century. The village formed around a central area of social, religious, and economic activities, maintaining its layout centered around Maqam El-Khalil. Significant changes occurred from the mid-17th century to the end of WWI, including administrative reforms and increased commercial activity, transforming Ramallah into a regional commercial hub. The British Mandate period (1920-1948) further accelerated urban growth with administrative reforms, infrastructure development, and modern building materials, shifting the city's center to Al-Manara by the 1950s. The Jordanian rule period saw rapid growth and neighborhood expansion due to post-1948 Nakba forced displacement, while the Israeli occupation period (1967-1994) experienced economic and urban stagnation [1], [7], [8], [9].

Post-1994, following the establishment of the Palestinian National Authority, Ramallah witnessed significant economic and urban revival. Continuous urban development included new neighborhoods, public and cultural buildings, and infrastructure projects, transforming the city into an administrative and cultural center. Observed by the Author, recent developments from 2014 to 2024 saw substantial urban expansion towards the west and northwest, with the establishment of major institutions, malls, and cultural centers, solidifying Ramallah's status as a vibrant and economically robust city. This period highlighted the strategic urban planning and cultural enrichment that reinforced Ramallah's role as a central hub in the Palestinian territories [1], [5], [6], [7], [8], [9].

IV. THE PRESERVATION OF THE HISTORIC CENTER OF RAMALLAH IN THE FACE OF RAPID URBANIZATION AND DEVELOPMENT

The preservation of Ramallah's Historic Center represents a multifaceted endeavor that balances urban development with the conservation of cultural and architectural heritage. This section delves into the initiatives, challenges, and strategies employed to maintain the identity and integrity of Ramallah amidst rapid urbanization. The effort involves collaboration between various stakeholders, including the Ramallah Municipality, the Ministry of Tourism and Antiquities, and heritage conservation organizations.

A. Challenges and Shortcomings in Historical Preservation Efforts

As Ramallah began its expansion towards Al-Bireh, it followed a trade route connecting the north to the south of Palestine. The establishment of the Palestinian National Authority led to economic growth and an influx of population, significantly increasing land prices in Ramallah. The surge, along with the impacts of the Second Intifada and the Security Chaos period, prompted residents in the historic center to demolish old houses for highland sale profits or to build commercial mixed-use buildings. As illustrated in **Figure 1**, on the right, we can see the historic building of Ramallah during the 1930s. On the left, however, as Riwaq lastly surveyed the area in 2013, a large number of historic buildings were demolished and replaced by commercial mixed-use buildings, driven by the forces of urbanization and profit [1], [5]

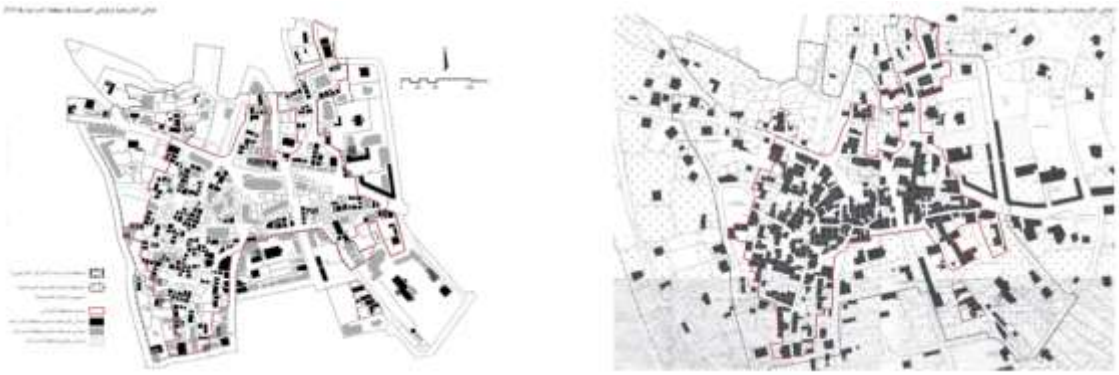

Fig. 1 On the right a map illustrating historic buildings in the 1930s, and on the left a map illustrating new buildings built and their uses. Source: Riwaq-Center for Architectural Conservation.

Master Plans developed by the municipality aimed to manage urban growth, designating future development areas. However, these plans, including the 2012 Master Plan, lacked specific provisions for protecting the historic center's historical buildings. The historic center was still governed by outdated planning tools that did not suit its historical character, resulting in decisions that often-favored modern criteria over heritage preservation. Consequently, Ramallah's historic buildings and unique character faced significant risk due to the absence of tailored preservation guidelines. An example of this strategic planning is Master Plans presented in **Figure 2**. These Master Plans encompass land use plans, building regulations, land classifications, special provisions for buildings, and most importantly, future development guidelines. For instance, the 2012 Master Plan designated 23.371% of Ramallah's area, equivalent to 4,349 dunums, for future development.

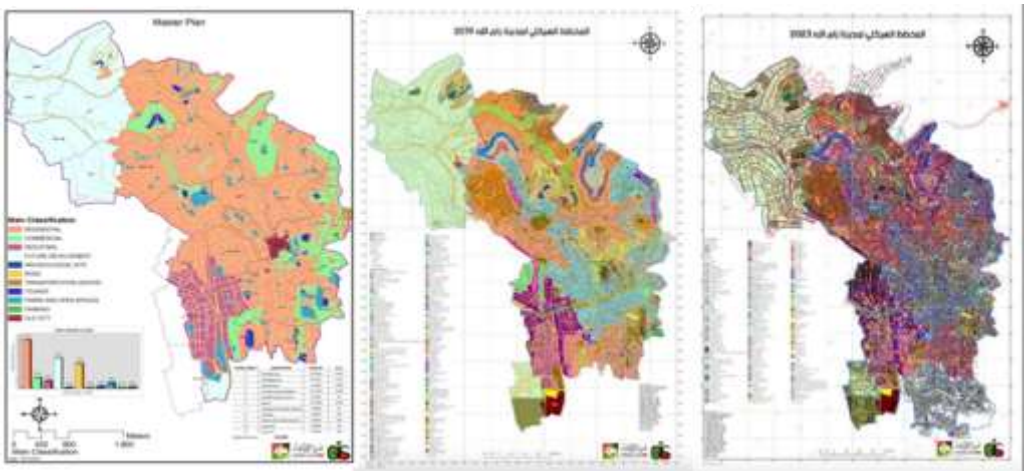

Fig. 2 Master Plans of Ramallah City (2012), (2019), (2023). Source: The Municipality of Ramallah.

B. The Birth of Ramallah's Historic Center's Preservation Plan

Recognizing the importance and the need to preserve and safeguard the architectural heritage of Ramallah in the face of rapid urbanization, the Municipality of Ramallah has undertaken comprehensive preservation initiatives.

In an interview conducted by the author with Eng. Deema Erssan, the head of the Buildings and Cultural Heritage Department at the Municipality of Ramallah (personal communication, May 02, 2024) who had a huge role in the preservation plan, she argued that "Ramallah *is unlike rich historic centers of Palestine such as Jerusalem, Nablus, Bethlehem, and Hebron. Ramallah is more like a newly developed historic center. It started as a small village or community and started growing naturally. However, the rapid urban development it has undergone is concerning. This development could potentially erase the city's cultural and historical identity. Therefore, it is imperative for the city to maintain its identity from its origins to its current state. This way, in the future, when discussing our history, we will have tangible evidence of our existence and evolution."*

Outlining long-term goals and visions of the strategic development plan's vision, 'A city that is optimistic, sustainable, inclusive, proud of its culture, and controls its own destiny.' One of the central goals of these plans was to enhance and empower both the tangible and intangible cultural heritage of the city, ensuring these assets are preserved and celebrated. In a 2019 television interview with Palestine TV, then-President of the Ramallah Municipality, Moussa Hadid, highlighted the dual commitment of the city. He stated, "*Ramallah is widely recognized for its attractiveness and ongoing efforts toward development and progress. Yet, the municipality also upholds a clear vision of preserving its cultural heritage. This preservation is crucial for passing on to the future generations, ensuring that it narrates the city's historical journey and development."*

C. Documentation Efforts and Strategies

Over the years, the Municipality of Ramallah has implemented extensive measures to preserve and rehabilitate the historic center amidst the risks of rapid urbanization. Starting in 1999, the municipality conducted comprehensive surveys of heritage buildings, but these efforts were postponed due to the First Intifada and subsequent Security Chaos. The project resumed in 2006 with a renewed focus, involving partnerships with local government, the Ministry of Tourism and Antiquities, Riwaq-Center for Architectural Conservation, and the Centre of Cultural Heritage Preservation (CCHP). The preservation plan, based on UNESCO criteria, included detailed evaluations of architectural, historical, and social values.

The historic center was divided into two cores: Core A with dense, contiguous buildings, and Core B with a different urban character. Buildings were categorized into three levels:

- **Category A** involved maximum protection, prohibiting demolition or alterations.
- **Category B** involved protection with service additions that do not affect the building's architectural or aesthetic value.
- **Category C** provided protection with allowable interventions.

Detailed profiles of each historic building were documented, including aspects like location, ownership, architectural features, and condition. A project with the European Union in 2012 in collaboration with Ramallah Municipality, Al-Salt Municipality, and CCHP led to the creation of a preservation manual published by Riwaq in 2014. Collaborating with CCHP in 2016, the municipality adopted a more flexible approach, balancing preservation with investment and dividing the buildings into two categories only, unlike Riwaq. Those categories were: **H1** for maximum protection and **H2** for protection with interventions. Interventions were studied so that in some cases additions were allowed without affecting the surroundings or the building's aesthetic and value. By 2018, CCHP had enhanced detailed profiles with comprehensive documentation of internal and external details.

On December 22, 2022, the preservation plan was officially approved, protecting 333 buildings within the historic center and 163 individual historic buildings outside its borders. This plan not only documents and protects the buildings but also provides guidelines for interventions and rebuilding in case of demolition, ensuring the preservation of the area's character.

Fig. 3 The approved Preservation Plan. Source: The Municipality of Ramallah.

D. Results-Navigating Challenges and Innovative Solutions

Preserving Ramallah's historic center amidst rapid urbanization involves numerous challenges, including limited historical resources, high commercial property values, legal hurdles, and conflicting opinions. The scarcity of historical documentation and the expatriation of many original residents complicated efforts to preserve oral and social histories. High commercial property values further motivate the demolition of historic buildings for commercial gain. To address these issues, the municipality focused on the implementation of the preservation plan in parallel with an adaptive reuse strategy which allowed historical buildings, even those in residential areas where master plan legislations typically prohibit cafes or restaurants, to be repurposed for these resources, provided these uses do not compromise the building's architectural, aesthetic, cultural, or environmental integrity and authenticity. Locanda Farah exemplifies successful adaptive reuse, however, detailed and professional plans of revitalization and regeneration leading the adaptive-reuse plans are yet not performed but are definitely needed.

During preparations of the plan and especially the evaluation periods, the professional team adhered to UNESCO criteria to assess the level of significance and determine the appropriate preservation measures. However, the application of UNESCO's standards did not fully align with the local realities and challenges faced by a developing city such as Ramallah which in turn led to disagreements and conflicts in opinions. Integrating diverse viewpoints from various stakeholders posed a significant challenge making it difficult to formulate a cohesive preservation strategy and creating friction among involved parties.

Another significant challenge was the regulatory and legal hurdles, despite the alignment of the prepared preservation plan with municipal objectives, the initial study by Riwaq, faced resistance from local government authorities. Regulatory amendment projects submitted in 2009 and 2011 were returned, as they were perceived to infringe on property rights. Eng. Deema (personal communication, May 02, 2024) notes, *"People accused us of punishing them for having an old, useless house."* To support its perspective, the municipality solicited proposals from four heritage institutions in the country: Al-Taawon, Riwaq, CCHP, and the Hebron Rehabilitation Committee. By providing basic terms of reference, the project was eventually awarded to CCHP, which supported the municipality's vision of balancing preservation with investment. However, a turning point came with the enactment of Law No.11 for the Protection of Tangible Cultural

Heritage in 2018, which only protects historical buildings constructed before 1917. This posed a challenge for Ramallah, as many significant buildings were built after this date. Consequently, the municipality conducted legal consultations and submitted a revised preservation plan in 2019, a year after the enactment of the law according to Article 35, including buildings up to the 1948 Nakba Date for preservation. Despite some initial rejections and several consultations with the Ministry of Tourism and Antiquities, the plan was approved on December 22, 2022, marking a significant milestone in preserving Ramallah's historical center.

Since 2008, the Municipality of Ramallah has proactively protected over 160 buildings of historical value and distinctive architectural character, despite not having legal justification. This proactive stance led to objections and legal cases in the Supreme Court. The municipality distinguished itself nationally by not only issuing legislation to protect historical buildings but also by allocating budgets from its financial resources to purchase, own, or rent many historical structures. Eng. Deema Erssan (personal communication, May 02, 2024) emphasizes, *"We are the first municipality to allocate funds from its budgets to acquire and restore our historic houses believing in their significance in presenting our identity."* For instance, Dar Al-Jaghab, a 100-year-old historic building, was at risk of demolition. The municipality prevented this by declaring the house a historical site per the Ministry of Tourism and Antiquities, though it required purchasing the house for 2.5 million shekels, a significant financial burden on the services-oriented municipality's budget.

To ensure full legal compliance and avoid future legal challenges, the Buildings and Cultural Heritage Department is collaborating with the Geographic Information System (GIS) Department to create a detailed master plan for the historic center. This plan will be presented for objections to secure approval and ensure no legal action against the municipality based on its provisions. The municipality has successfully preserved many historic buildings for the public good, even though some property owners seeking profit find it unfair. A notable application of Law No.79 Article 31 occurred when a property owner with a historic house on a large plot suggested that the municipality take the house instead of cutting off 30% of his plot for services. The municipality agreed and registered the house in its name, transforming the perception of this law from a threat to an opportunity for the community. These efforts demonstrate the municipality's commitment to navigating complex challenges through innovative solutions and strategic collaboration, ensuring that Ramallah's historic center can be preserved for future generations while accommodating modern development needs.

E. Conclusion

The preservation of Ramallah's Historic Center amidst rapid urbanization and development has been a multifaceted endeavor, highlighting the delicate balance between maintaining cultural heritage and fostering urban growth. The article reveals that while significant urban growth has transformed Ramallah into a vibrant economic hub, it has also placed considerable pressure on its historical and cultural assets. The article emphasizes the effectiveness of Ramallah in managing to balance urban development and urban conservation. Despite challenges such as high commercial property values, regulatory hurdles, and financial constraints, the municipality has found innovative solutions. Strategies like adaptive reuse, leveraging legal tools, and developing a comprehensive preservation plan have been key in protecting historic legacy. Engaging stakeholders has also ensured a cohesive approach to overcoming these challenges. Their involvement and partnerships have been vital and led to the creation and implementation of effective preservation strategies. In conclusion, even though Ramallah is not as rich as significant Palestinian Historic Centers such as Jerusalem, Nablus, etc. Ramallah's case stands as a model for balancing urban development and heritage conservation on the applicable level and apart from theories. The municipality's efforts show that sustainable urban growth and cultural preservation are achievable, providing valuable lessons for other historic cities facing similar challenges.

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İçten Yanmalı Dizel Motorlarda Hidrojen Yanmasının İncelemesi

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Özet **–**Fosil yakıtların teknolojinin ilerlemesi ve aşırı kullanımı sonucu hızla tükenmesi, araştırmacıları alternatif yakıt arayışına yöneltmiştir. Hidrojenin çevre dostu olması ve geleneksel yakıtlara göre avantajlarının bulunması, yakın gelecekte en popüler enerji kaynağı olmasını sağlamaktadır. Bir takım işletme sorunları bulunsa da yapılacak çalışmalarla bu sorunlar giderilebilir. Hidrojenin önemli bir özelliği, yapısında karbon bulunmaması nedeniyle hidrojenin yanması sırasında karbon kaynaklı emisyonların oluşmamasıdır. Günümüzde içten yanmalı motorların emisyon değerlerinin düşürülmesi işlemi önemli bir konudur. Yanma ve depolama ile ilgili sorunların çözülmesi durumunda, hidrojen önümüzdeki yıllarda rakipsiz bir içten yanmalı motor yakıtı olacaktır. Bu çalışmada, dizel bir motorda farklı oranlarda hidrojen kullanımı incelenmiştir. Hidrojenin dizel yakıtla karıştırılması sonucu motor performansı ve yanma karakteristiklerinde meydana gelen değişiklikler analiz edilmiştir. Elde edilen sonuçlara göre, hidrojen miktarına bağlı olarak motor performansında belirgin iyileşmeler gözlemlenmiştir. Araştırmada, dizel yakıtına eklenen hidrojenin, motorun yanma verimliliğini artırdığı ve daha temiz bir yanma sağladığı tespit edilmiştir.

Anahtar Kelimeler –Yakıtlar, Hidrojen, İçten yanmalı Dizel Motor, Silindir içi basınç, ısı yayılım ve sıkıştırma oranı

I. GİRİŞ

Tükenmekte olan fosil yakıtlarına, alternatif enerji kaynakları son zamanlarda önemli araştırma konusu olmuştur. İnsanoğlu birçok farklı yöntem ile alternatif enerji kaynakları sağlanmaya çalışmıştır [1]. Fosil yakıtların çevreye, insanlara ve diğer canlılara verdiği zararlar nedeniyle, günümüzde karayolu, denizyolu ve tarım makinelerinde kullanılan LPG, motorin, doğalgaz ve benzine alternatif olarak hidrojen, biyogaz ve alkol kökenli yakıtlar önerilmektedir [2]. Hidrojen yakıtının otobüs, kamyon, traktör ve tarım makineleri gibi içten yanmalı motorlara sahip tüm taşıtlarda kullanılabilmesi, sınırlı rezervlere sahip petrol ürünlerinin yerini alması ve çevre dostu bir enerji kaynağı olması, son yıllarda araç üreten şirketlerin büyük ilgisini çekmiştir. Hidrojen, geleceği karşılamak için önemli bir yenilenebilir yakıttır [3]. Motorlu araçlar ve fosil yakıtların yanması üzerine yapılan birçok araştırmaya göre, fosil yakıtların yanmasıyla açığa çıkan karbon monoksit, hidrokarbon ve azot bileşiklerinin yarısı benzin ve dizel motorlarından kaynaklanmaktadır [4]. Benzinli ve dizel motorlarda, hidrojen, doğalgaz, likid petrol gazı, biyodizel, alkol kökenli yakıtlardan etil ve metil alkol gibi alternatif yakıtların üzerindeki araştırmalar artmıştır. Yapılan araştırmalarda dizel yakıtı yerine bitkisel yağ ve metil esterlerinden elde edilen yakıtların doğrudan, diğer yakıtların ise genellikle ikinci yakıt olarak kullanılabileceğini göstermiştir [2]. Enerji arzı ve talebi arasındaki dengesizliği çözmek ve çevre kirliliğini azaltmak amacıyla, hidrojen yakıtının dizel ile karıştırılarak kullanılması etkili bir yöntemdir[5].

Bu çalışmada, dizel motorlarda hidrojenin ek yakıt olarak kullanılmasıyla çevrimsel yanma değişimlerini incelenmiştir. Böylelikle, hidrojenin motor performansına, yanma sürecine ve emisyonlara etkisini belirlemeyi amaçlar. İçten yanmalı dizel motorlarda hidrojen yanmasının incelemesi için, Wang ve diğer

arkadaşlarının[6] emme manifoldundan fumigasyon yöntemiyle yanma odasına yollanılan hidrojen-dizel çift yakıt karışımlarıyla çalıştırılan sıkıştırma ateşlemeli bir motorda silindir içi basınç, ısı salınım oranı, NOx emisyonu çalışmaları irdelenmiştir.

II. YAKITLARDA ARANAN ÖZELLİKLER

Çevreye fazla zarar vermemesi, depolanabilir olması, kolay bulunabilmesi, ısının mekanik ve elektrik enerjisine kolay ve hızlı dönüştürülebilmesi, güvenli bir şekilde istenilen yere nakledilebilmesi, yüksek verimle enerji üretebilmesi ve ekonomik olması gibi özellikler aranmaktadır [2]. Tablo 1'de yakıtların karşılaştırmalı özellikleri gösterilmiştir.

Tablo 1. Bazı Yakıtların Karşılaştırmalı -Özellikleri [7].

	Benzin	Dizel	Biodizel	Doğal gaz	Ethanol	Methanol
Kimyasal Yapı	C_4H_{12}	C_8C_{25}	Metil ester $C_{12}C_{22}$ yağ asitleri	CH_4	CH_3CH_2OH	CH_3OH
Ham madde	Ham Petrol	Ham Petrol	Katı, sıvı, bitkisel yağlar	Yer altı rezervleri ve yenilenebilir biyogaz	Mısır, tahıl, selüloz	Doğal gaz, kömür, biyokütle
Benzin eşdeğerliği	1	1,12	1,05	0,19	0,67	0,5
Alt ısıl değeri (MJ/kg)	43,4	42,6	37,5	47,1	26,7	19,9
Fiziksel faz	Sıvı	Sıvı	Sıvı	Gaz - Sıvı	Sıvı	Sıvı
Parlama noktası (ºC)	-43	73	132	-185	13	11
Kendi kendine tutuşabilme sıcaklığı (ºC)	258	315	149	540	423	480

A. Hidrojen Yakıtının Özellikleri

Hidrojen atomunun yapısı basit olmasına rağmen, tüm gezegenlerin ve yıldızların temel bileşenini oluşturur. Kimyasal sembolü H olan hidrojen, 1 atomlu, periyodik tablonun en başında yer alan birinci elementtir ve ametal olarak sınıflandırılır. Hidrojenin (H_2) çekirdeğinde 1 proton ve çevresinde 1 elektron bulunur. Hidrojen renksiz, kokusuz, yanıcı ve atmosferde diatomik (H_2) halde bulunan bir gazdır. Oksijen ile tepkimeye girdiğinde su meydana gelir. Normal sıcaklık ve basınçta gaz olan hidrojenin yoğunluğu, havanın yoğunluğunun 1/14'üne eşittir. Atmosfer basıncında hidrojen, -252,77°C'ye kadar soğutulduğunda sıvı duruma geçer. Hidrojenin gaz haldeki yoğunluğu 0,09 kg/m³, sıvı halde ise yoğunluğu 2.267 g/cm³'tür [8]. Tablo 2'de hidrojen gazının diğer özellikleri belirtilmiştir.

Tablo 2. Hidrojenin gazının özellikleri[9]

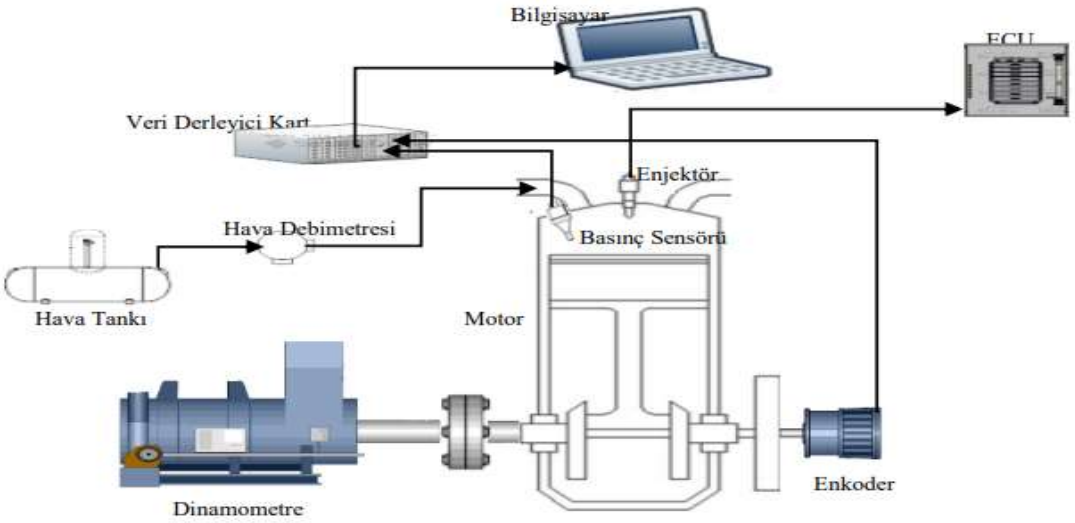
Özellikler	H_2
Alt Isıl Değer 1 atm'de ve 15 °C'de (MJ/kg)	120
Yoğunluk 1 atm'de ve 15 °C'de (kg/m3)	0.0838
Alev hızı (cm/s)	275
Stokiyometrik Hava/Yakıt oranı (kg/kg)	34.2
Alevlenebilme sınırı (hava içinde %'de hacim)	75-4
Araştırma Oktan sayısı	130
Kendi kendine tutuşma sıcaklığı (°C)	585

III. İÇTEN YANMALI MOTORLARDA HİDROJEN KULLANIMI

Taşıtlarda hidrojenin kullanımı, doğrudan gaz halinde ya da yakıt hücreleri aracılığıyla olabilir. Bu konuda BMW, Dodge, Buick, Daimler-Benz ve Suzuki gibi firmaların deneme araçları, Macchi Ansoldo ve MAN firmasının SL202 otobüsleri, Kanada Demiryolları'nın lokomotifi ile Almanya, Avustralya ve Kanada donanmaları için üretilen denizaltılar örnek olarak verilebilir. Bunların yanı sıra, %15-20 hidrojen ve %80-85 doğal gaz karışımından oluşan hytane adlı yakıt ile çalışan yeni bir otobüs, 1993 yılından beri Montreal'de (Kanada) test edilmektedir [2]. Hidrojenin yakıt olarak kullanılmasında, fiziksel ve kimyasal özelliklerine bağlı olarak büyük avantajlar sağlanmaktadır. Özellikle karbon temelli olmayan hidrojen, yanma sonucunda su oluşturan ve çevre dostu olan yenilenebilir bir enerji kaynağıdır. Hidrojen-hava karışımının geniş tutuşma aralığına sahip olması, motorun fakir karışım oranlarında, yüksek termal verimde ve düşük emisyon değerlerinde bir gaz kelebeği olmadan çalışmasını mümkün kılmaktadır. Bu durum, pompalama kayıplarının azalmasına ve motorun kısmi yüklerde çalışması durumunda, termal verimin artmasına yol açmaktadır. Hidrojenin yüksek yanma hızı, yanmanın neredeyse sabit hacimde tamamlanmasına neden olur ki bu durum termodinamik açıdan iyi bir yanmayı temsil eder. Hidrojenin kendiliğinden tutuşma sıcaklığının oldukça yüksek olması, son gaz bölgesinde kendiliğinden tutuşma olmaksızın motorun kısmen yüksek sıkıştırma oranında çalışmasına imkan tanır. Kısmen artırılabilen sıkıştırma oranı, motorun termal verimi ve gücünde bir artışa yol açacaktır. Ayrıca, yakıt olarak hidrojeni kullanan motorlarda hidrokarbon ve karbon monoksit gibi egzoz emisyonları yok denecek kadar az seviyededir. Diğer yandan, hidrojen motorlarında CO, CO_2, HC ve is emisyonu bulunmamaktadır. Dizel motorlarda hidrojen, emme manifoldundan fumigasyon yöntemiyle veya enjektörler vasıtasıyla doğrudan silindirlere gönderilmektedir. Ancak, bu yöntem motorda önemli değişiklikler gerektirdiğinden ve artan maliyetlerden ötürü nadiren tercih edilmektedir. Dizel motorlarda hidrojenin ana yakıt olarak kullanımında ateşleyici olarak, setan sayısı yüksek bir pilot yakıt (dizel veya biyodizel gibi) kullanılmaktadır. Pilot yakıt, sıkıştırma işleminin sonuna yakın bir zamanda yanma odasına püskürtülerek hidrojen ve hava karışımını tutuşturmaktadır. Emme manifoldundan hidrojen gönderilen yöntemlerde emilen hava miktarı azalmakta ve karışım zenginleşmektedir. Aynı zamanda, emme havasında yanıcı gaz bulunmasından dolayı geri tepme problemiyle karşılaşmamak için yüksek sıcaklığa maruz kalan kısımların iyi soğutulması gerekmektedir. NOx emisyon artışına neden olan yüksek alev hızı, aynı zamanda kullanılan hidrojen oranıyla da artmaktadır. Düşük motor torkunda genellikle NOx emisyonları daha azdır. Bu durum silindir sıcaklıklarının düşük olmasından kaynaklanmaktadır. Çevrimsel yanma farklılıkları, motor performansı ve emisyonları üzerinde önemli ölçüde etkili olmaktadır. Aynı zamanda, motor titreşimlerinin başlıca nedenlerinden biri olduğu düşünülmektedir. Çevrimsel değişiklikler, silindirlerde gerçekleşen fiziksel ve kimyasal olaylardan kaynaklanır. Çevrimden çevrime değişen hava-yakıt oranı, önceki çevrimden kalan atık gaz miktarı, yanma odasında oluşan hava hareketleri, yakıt püskürtme basıncı ve miktarı, tutuşma gecikmesi gibi faktörler çevrimsel farklılıkların ana sebepleridir. Ortalama indike basınçtaki küçük çevrimsel değişiklikler, çıkış gücünde önemli değişimlere yol açmaktadır [10].

IV. MATERYAL VE YÖNTEM

Dizel motorda hidrojenin çift yakıt olarak kullanımı için dizel motor yakıt sisteminde bazı değişiklikler yapılması gerekmektedir. Wang ve diğer arkadaşlarının yaptığı çalışmada Dört silindirli bir dizel motor, hidrojen-dizel karışımı yakıt kullanacak şekilde modifiye edilmiştir[6]. Genel olarak Dizel-hidrojen çift yakıtlı motorlarda, dizel, karışımı ateşlemek için pilot yakıt olarak görev yapmaktadır. Hidrojen gazı, yanma odasına girmeden önce homojen bir karışım elde etmek için emme manifolduna bir karıştırıcı aracılığıyla verilmektedir. Hidrojen yanmasının motor performansının irdelendiği bir çalışmada Motor kararlı durum koşullarına ulaştığında, silindir içi basınç, silindir içi sıcaklık, ısı salınım oranı, HC emisyonları, CO emisyonları ve benzeri parametreler ölçülüp kaydedilmiştir.
Deneysel düzenek Şekil 1'de gösterilmiştir.

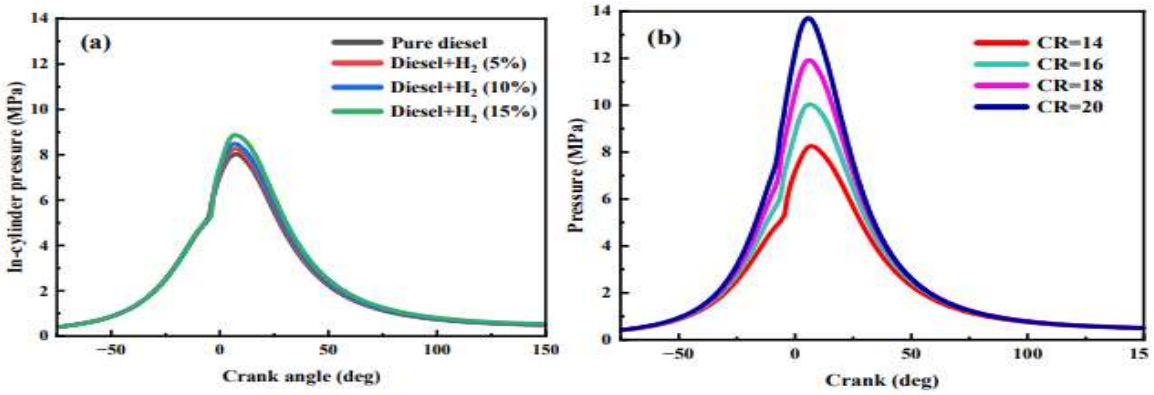


Şekil 1 Deneyin şematik diyagramı.[4].

Wang ve diğer arkadaşlarının dizel motorlarda hidrojen ilavesinin yanma ve emisyon üzerinde yaptığı çalışmada[6], hidrojen enerji payı ve sıkıştırma oranlarının artırılmasıyla silindir içi basınç, ısı salınım oranı, NOx emisyonu çalışmaları irdelenmiştir.
Hidrojen enerji oranlarının yanma özellikleri ve emisyon özellikleri üzerindeki etkisini araştırmak için %0, %5, %10 ve %15 enerji yüzdelerinde hidrojen enjekte edilmiştir. Daha sonra sıkıştırma oranı, yanma özellikleri ve emisyon özellikleri üzerindeki etkisini simüle etmek için CON VERGE yazılımı kullanılarak %5 hidrojen enerji verimliliğinde 14, 16, 18 ve 20 sıkıştırma oranlarında test edilmiştir.

A. *Silindir İçi Basınç*

Dizel-hidrojen birlikte yanmalı bir motorun silindirindeki basınç yörüngeleri hidrojen yanma oranları sırasıyla %0, %5, %10 ve %15 olduğunda verilmiştir. Şekil 2a'da hidrojen yanma oranlar arttıkça maksimum yanma basıncının daha yüksek olduğu görülebilir. %15'lik hidrojen enerji payına sahip çalışma koşulu için maksimum Pmax 8,87 MPa'dır. Bu eğilim Cernat ve diğerlerinin bulgularıyla tutarlıdır. Silindir içi basınç değişim eğrisi ve ısı yayılma oranı değişim eğrisi, çift yakıtlı motorun silindir içi yanma sürecinin doğasını yansıtmaktadır. Hidrojen, daha yüksek alev hızı nedeniyle hızla yanarak basınç artış hızını ve basınç tepe noktasını artırır. Buna ek olarak, hidrojen yakıtının kullanımından sonra basınç pikinin daha erken ortaya çıktığı fark edilebilir. Hidrojen enerji payı arttıkça, basınç zirvesi daha erken meydana gelmiştir. Hidrojen enerji payı artırılmasının silindir içi basınç üzerinde olumlu bir etkisi olduğu sonucuna varılabilir. Aynı şekilde, meydana gelecek yüksek basınç artış oranları nedeniyle vuruntunun ortaya çıkması kaçınılmazdır. Bu durum, motor çalışmasını ve dolayısıyla araç sürüş konforunu olumsuz etkiler[11].



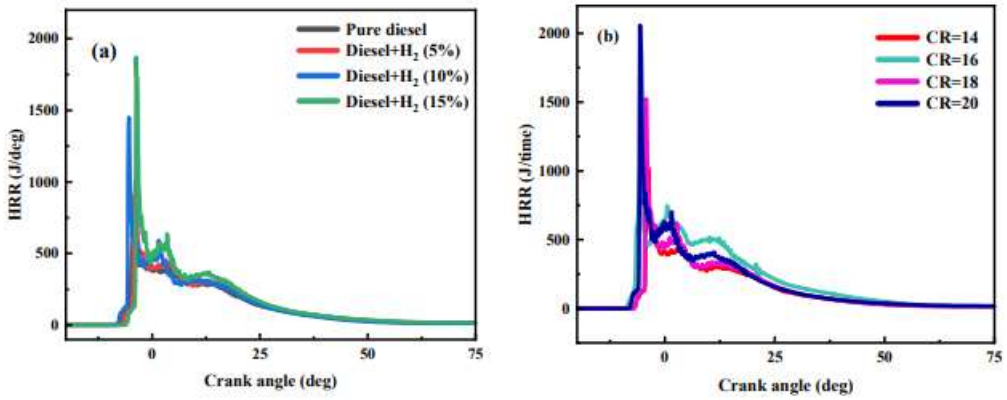
Şekil 2 . Hidrojen enerji payının silindir basıncına etkisi. (a) Sıkıştırma oranının silindir basıncına etkisi. (b)

Hidrojen enerji payı %5 olarak sabit tutulurken sıkıştırma oranı 14-20 aralığında değiştirilmesiyle elde edilen sonuçlar Şekil 2b'de gösterilmiştir. Sıkıştırma oranı artırıldıktan sonra silindir içi basıncın çok daha büyük hale geldiği görülebilir, bu da sıkıştırma oranı sabitken hidrojen enerji payı değiştirildiğinde silindir içi basınç değişimi eğilimiyle tutarlıdır. Ancak sıkıştırma oranı değiştirilmesinin silindir içi basınç üzerinde daha büyük bir etkiye sahip olduğu daha açıktır. Sıkıştırma oranı 14'ten 20'ye yükseltildiğinde, silindir içi basınç 8,26 MPa'dan 13,72 MPa'ya yükselmiştir. Hidrojen yakıtının yanması esas olarak ön karıştırma aşamasında gerçekleşir. Bunun nedeni, sıkıştırma oranındaki artışın yakıtın daha iyi karışmasına ve sıkıştırma sırasında sıcaklığın yükselmesine neden olmasıdır. Bu işlem sırasında yakıt daha hızlı reaksiyona girerek silindirdeki sıcaklığın hızla artmasına neden olur.

B. *Isı Salınım Oranı*

Isı salınım oranı üç farklı aşamadan oluşur. İlk aşamada, basınç keskin bir şekilde yükseldiğinde Isı salınım oranı ilk zirveye ulaşır ve hızlı yanma meydana gelir. Bu aşamada, dizel yakıtın çoğu ve hidrojen yakıtının küçük bir kısmı önceden karıştırılır ve ısı yaymak için yakılır. İkinci aşamada, sıcaklık ve basınç arttıkça, yakıt silindirde hızlı bir şekilde alev oluşması için yeterli oksijene ulaştığında Isı salınım oranı ikinci tepe noktası meydana gelir. Son aşamada, yeterli oksijen mevcut olduğunda, yanmamış yakıt veya önceki aşamalarda yanma odasında kısmen yanmış bileşenler yanmaya devam eder. Son bir ısı salınım gerçekleşir.

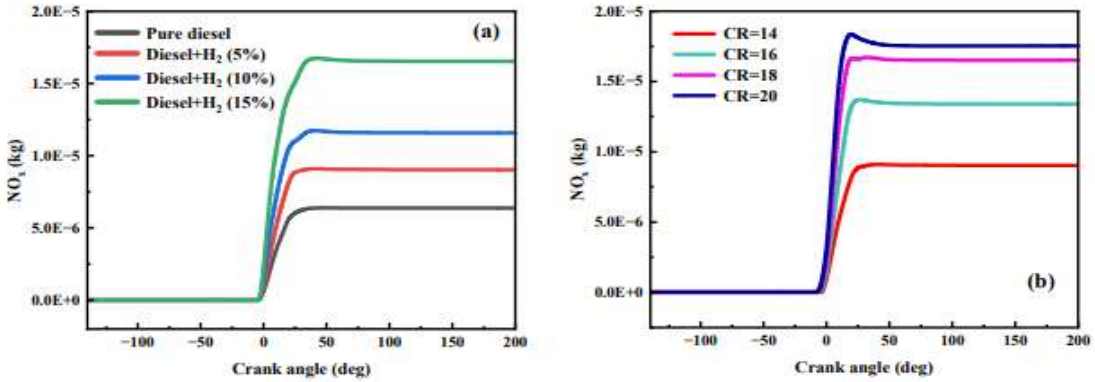
Isı salınım oranı pik değerleri hidrojen yakıtının kullanım koşulları altında saf dizele kıyasla artmıştır. Buna ek olarak, ısı salınım oranı tepe noktası artan hidrojen enerji payı ile artmıştır[6]. Bunun nedeni hidrojenin daha hızlı yayılması ve hidrojen ile havanın daha fazla karışabilmesidir. Bu, Khandal ve diğerleri tarafından ulaşılan sonuçla tutarlıdır[12]. Hidrojenin hızlı yanma hızı nedeniyle ısı salınım oranı ve tepe basıncının geleneksel modelden daha yüksek olduğu sonucuna varmışlardır.



Şekil 3 Hidrojen enerji payının ısı salınım oranına etkisi. (a) Sıkıştırma oranının ısı salınım oranına etkisi. (b)

C. *NOx Emisyonu*

Hidrojen yakıt kullanımı HC, CO ve CO_2 emisyonlarını azaltır, ancak hidrojen yakıt kullanımı en büyük dezavantajlarından biri olan NOx miktarını emisyonunu artırır. Şekil 3a'da gösterildiği gibi, NOx emisyonu hidrojen yakıt kullanımından sonra keskin bir şekilde artmıştır. Hidrojen miktarı artırıldıkça NOx emisyonu da o kadar yüksek olur. Saf dizel çalışmasıyla karşılaştırıldığında, NOx emisyonu %5, %10 ve %15 hidrojen enerji payı için sırasıyla %41,9, %82,1 ve %166,9 oranında artmıştır. Bunun nedeni, hidrojen ilavesinin daha hızlı yanması ve silindirde daha yüksek sıcaklık ve basınçlara yol açmasıdır. NOx emisyonu temel olarak oksijen konsantrasyonu, yerel sıcaklık ve reaksiyon süresi tarafından belirlenir. Yanma sıcaklığı arttıkça, nitrojen ve oksijen atomları arasındaki reaktivite artar. Yanma odasına H_2 eklendiğinde, NOx emisyonu önemli ölçüde artar. Bu durumun arkasındaki neden, H_2 gazının kalorifik değerinin dizel yakıttan önemli ölçüde daha yüksek olmasıyla açıklanabilir. Bu durumda hidrojen, yüksek basınç oranları ve yüksek silindir içi sıcaklıklar sağlar. Yanma sıcaklığı arttıkça, nitrojen ve oksijen atomları arasındaki reaktivite artar ve NOx emisyonlarında artışa neden olur[6].



Şekil 4 Şekil Hidrojen enerji payının NOx oranına etkisi. (a) Sıkıştırma oranının NOx oranına etkisi. (b)

V. SONUÇLAR VE TARTIŞMA

Artan nüfus yoğunluğu ve enerji ihtiyacı nedeniyle, yaygın olarak kullanılan fosil yakıtlarına alternatif olabilecek enerji kaynaklarının kullanımı, son dönemde tüm ülkeler tarafından benimsenmiştir. Bu yeni alternatifler, üzerinde yoğun şekilde çalışılan iklim değişikliği ve karbon salınımının ortaya çıkardığı sorunların çözümünde en hızlı uygulanabilecek yöntemler arasındadır. Hidrojen, bu seçenekler arasında öne çıkmaktadır. Hidrojen, geleceğin temiz yakıtı olarak kabul edilmekte olup, fizikokimyasal ve mühendislik özellikleri açısından bu amaca hizmet eden en önemli elementlerden biridir.

Bilindiği gibi içten yanmalı motorlarda alternatif yakıt kullanımı, yıllardır üzerinde çalışılan ve hala önemini koruyan bir konudur. En önemli enerji kaynaklarından biri olarak kabul edilen hidrojenin, farklı oranlarda dizel yakıtına eklenerek kullanımı da bu çalışma kapsamında araştırılıp sunulmuştur.

Araştırma sonucunda, motorun daha yüksek verimlilikle çalışmasına ve emisyonların azaltılmasına katkıda bulunduğu tespit edilmiştir. Ayrıca, hidrojenin oranı arttıkça, bu olumlu etkilerin daha da belirgin hale geldiği sayısal verilerle desteklenmiştir. Bu bulgular, hidrojenin dizel motorlarda alternatif bir yakıt olarak kullanımının potansiyel faydalarını net bir şekilde ortaya koymaktadır.

Gözden geçirilen literatür ve elde edilen bulgularla bu çalışmadan sıralanan elde edilen belirgin sonuçlar şu şekilde yapılabilir;

- Hidrojen, farklı oranlarda dizel yakıta karıştırılarak kullanılabilir.
- Hidrojenin yüksek yanma ve buharlaşma hızı sayesinde, içten yanmalı motorlarda yanma süresi kısalmaktadır.

- Hidrojen dizel yakıtı içinde oranı yükseldikçe, silindir içi basınç, sıcaklık, ısı salınım oranı artmıştır
- NOx emisyonları başta olmak üzere motor performansı ve çeşitli emisyon türlerin de de artış olmuştur.
- Hidrojen oranın artışı yanmayı iyileştirdiği görülmektedir.
- Doğrudan silindir içine hidrojenin enjeksiyonun motorda önemli değişiklikler gerektirdiği, maliyetlerin yüksek olması ve hidrojenin hızlı yanmasının kontrolünün zor olması nedeniyle içten yanmalı motorlarda araştırılıp geliştirilmesi gerekmektedir.

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Akıllı Kaynak Sistemlerine Yönelik Araştırma

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Özet – Son zamanlardaki artan rekabet nedeniyle özellikle yüksek teknoloji kullanılan havacılık sektöründe çalışan tasarım, Ar-Ge ve üretim firmalarını daha kaliteli, düşük maliyetli ve hızlı ürün geliştirme ve üretime zorlamaktadır. Özellikle farklı kaynak proseslerinin kullanıldığı durumlarda karar verme oldukça önemlidir. Bu nedenle firmalar, birbirinden farklı kriterlere ve deneyimlere göre çalışma yapmaktadır. Bu çalışmada Akıllı Kaynak Sistemleri teknolojileri ile ilgili çalışmaların kapsamlı bir incelemesi yapılmaktadır. Bu kapsamda geçmişten günümüze gelen akıllı sistemler, uzman sistemler ve karar destek sistemleri araştırılmıştır Yapılan çalışmalar değerlendirilerek ileriki aşamalarda kullanıcıya seçim serbestliği tanıyarak parça, sistem tasarım aşamasında farklı malzemelerin de kullanım olasılığının önünü açmasını sağlayacaktır. Aynı zamanda ileride geliştirilecek tasarımlar, Ar-Ge personeli ile imalat, üretim personeli arasında görüş birliğinin oluşmasını sağlayacaktır.

Anahtar Kelimeler – uzman sistem, karar destek sistemi, seçim metotları, kaynak, imalat, kaynak dolgu malzemesi

I. GİRİŞ

Endüstride teknolojik gelişmeler arttıkça farklı kaynak tekniklerinde çeşitli ilerlemeler kaydedilmiştir. Özellikle kaynak prosesinde robotik ve otomatize çözümlerin artması, prosesin kalite, kararlılık ve verimliliğine pozitif etkiler sağlamıştır. Uzman sistemlerin farklı sektörlerde kullanılmaya başlanması bu alandaki metotların da gelişmesi ve iyileşmesine katkı sağlamıştır [1].

Yüksek dikiş kalitesi ve çok yönlülüğe sahip olan tungsten ark kaynağında dolgu malzemesinin kullanımı bazı durumlarda (paso miktarı, istenilen nüfuziyet vb.) gerekli olmaktadır. Havacılık, otomotiv gibi kalın ana malzemelerin sıklıkla kullanıldığı durumlarda dolgu malzemesi seçimi oldukça önemlidir. 2 aynı cins veya farklı ana malzeme kullanımı sırasında birden çok dolgu malzemesi seçimi imkânı olabilmektedir. Bu seçimin sonucunda oluşan kaynak dikişinin de mekanik, kimyasal özellikleri birbirinden ayrışabilmektedir. Bu sebeple kaynaktan beklenilen isterlere göre proses tasarımı yapmak oldukça mühimdir.

Bu çalışmada Akıllı Kaynak Sistemleri teknolojileri ile ilgili çalışmaların kapsamlı bir incelemesi yapılmaktadır. Bu kapsamda araştırma ve derleme makaleleri kronolojik olarak incelenmiştir. 2.bölümde literatür araştırmasına yer verilmiştir. 3. bölümde literatür çalışmaları yorumlanmıştır. 4. bölümde literatür çalışmaları ışığında ileride yapılabilecek çalışmalardan bahsedilmiştir. Son bölümde sonuç ve öneriler verilmiştir.

II. LİTERATÜR ARAŞTIRMASI

Lovegrove vd. [1] yaptıkları çalışmada kaynak mühendisliği alanında uzman sistemlerin entegrasyonuna giriş yapmaktadır. Yazarlar, mühendislerin belirli bir uygulama için en uygun ve uygun maliyetli kaynak işlemini seçmelerine yardımcı olmak için hazırlanmış bir sistemin geliştirilmesini anlatmaktadır. Sistemin önemli bir gücü, teknolojiyi bilgisayar sistemlerini kullanma konusunda kabiliyeti düşük mühendisler için

erişilebilir kılmak için tasarlanmış kullanıcı dostu arayüzüdür. Sistem esneklik için modüler bir bilgi tabanı içermekte ve yeni kaynak bilgilerinin dahil edilmesini sağlamaktadır. Wu vd. [2] yaptıkları çalışmada, alüminyum alaşımlarının ark kaynağında robotik operatörlere yardımcı olmak için tasarlanmış bir uzman sistemin geliştirilmesini incelemektedir. Karar destek sistemlerinin gelişmesinde uzman sistemlerin önemi büyüktür. Sistemlerdeki ana amaç yetkin personel ile robot sistemlerinin arasında olan yetkinlik farkını en aza indirgemektir. Bu uzman sistem, bir kaynak programı bölümü ve bir kusur teşhisi bölümü sağlayarak yetenekli kaynakçılar ve robot operatörleri arasındaki boşluğu kapatmayı amaçlamaktadır. Kaynak programı, kaynak görevini kolaylaştırmak için operatöre gerekli kaynak verilerini sunarken, kusur teşhisi, kaynak kusurlarını önlemek ve düzeltmek için öneriler sunar. Chen ve Lv [3] tarafından hazırlanan çalışmada ark kaynağının manuel bir işlemden ileri bir teknik bilime ilerlemesine ve modern kaynak üretim sistemlerinde akıllı teknolojinin önemli rolüne odaklanmaktadır. Yazarlar, bir kaynakçının eylemlerini simüle edebilen akıllı makinelerin uygulanmasıyla kaynak sürecini otomatikleştirmenin gerekliliğini tartışmaktadır. Makale, insan operasyonlarına benzer şekilde kaynakta otomasyona ulaşmak için üç temel teknik adımı vurgulamaktadır:

1) Dinamik kaynak işlemi sırasında bilgi algılama ve edinme.
2) Kaynak işleminin tanımlanması ve modellenmesi.
3) Kontrol stratejileri tasarlamak için insan beyni benzeri bir denetleyicinin geliştirilmesi.

Kim vd. [4] yaptıkları çalışmada farklı senaryolar için en uygun kaynak yöntemini belirlemek için Analitik Ağ Sürecine dayalı bir karar verme sistemi sunmaktadır. Bu sistem, farklı kaynak yöntemleri arasında önceliğin hesaplanmasına izin verir ve özellikle yeni başlayanlar veya daha az deneyimli yöneticiler için yararlı olabilecek daha doğru ve güvenilir bir karar verme aracı sağlar. Karar güvenini artıran ve daha iyi süreç verimliliği sağlayan güvenilir verilerden oluşan köklü bir veri tabanı sağlayarak yanlış karar olasılığını azaltmak için tasarlanmıştır. Sistemin, tıraş bıçakları için lazer ve plazma kaynağı ve daha kalın borular için toz altı ark kaynağı ve plazma kaynağı gibi belirli görevler için en uygun kaynak tekniklerini etkili bir şekilde seçtiği gösterilmiştir. Sudhagar vd. [5] yaptıkları çalışmada alüminyum alaşımında yapılan kaynakları iyileştirmek için sürtünme karıştırma kaynağı işlem parametrelerini optimize etmeye yönelik bir yaklaşımı açıklamaktadır. Çalışma, sürtünme karıştırma kaynağı proses parametresi seçimi bağlamında TOPSIS metodolojisini kullanmaktadır. Ana hedefleri, her bir parametrenin çekme mukavemetini, sertliği ve darbe tokluğunu nasıl etkilediğini araştırmak ve bu üç hedefi Gri İlişkisel Analiz ve TOPSIS kullanarak tek bir hedefte birleştirmektir. Miller vd. [6] yaptıkları çalışmada kaynak projelerinin kavramsal tasarım aşamasında karar vermeye yardımcı olmak için tasarlanmış bir destek aracının (WeldANA) geliştirilmesini ve uygulanmasını tartışmaktadır. SOLIDWORKS platformuna bir eklenti olarak entegre olan araç, tasarımcıların bölünebilirlik, erişilebilirlik, kurulum/yönlendirme, hazırlık ve kaynaklanabilirlik puanı gibi çeşitli metriklere dayalı olarak farklı tasarım yinelemelerini değerlendirmesine olanak tanır. Yazarlar, WeldANA'nın kaynak için doğal olarak uygun tasarımları geliştirmek, başlangıçta döküm işlemlerine yönelik tasarımları değiştirmek ve sonuçları gerçek dünya testlerinde doğrulamak için nasıl kullanılabileceğini göstermektedir. Wang vd. [7] yaptıkları çalışmada Akıllı Kaynak Sisteminin gelişimi ve mevcut durumu hakkında kapsamlı bir genel bakış sağlar. Temel kavramları, sistem mimarilerini ve Akıllı Kaynak Sistemi için çok önemli olan çeşitli teknolojilerin entegrasyonunu tartışır. Bunlar, algılama ve sinyal işleme, özellik çıkarma ve seçimi, modelleme, karar verme ve öğrenmenin yanı sıra ortaya çıkan platformları ve bunların Akıllı Kaynak Sistemi içindeki potansiyel uygulamalarını içerir. Bu çalışma, Akıllı Kaynak Sistemi karmaşıklığını ve devam eden gelişimini vurguluyor ve sektördeki pratik uygulamalarına atıfta bulunmaktadır. Kuklik vd. [8] yaptıkları çalışmada eklemeli olarak üretilen termoplastik parçaların birleştirilmesi için lazer iletim kaynak işlemlerinin kullanılmasını kapsamlı bir biçimde araştırmaktadır. Araştırma, sinir ağı tabanlı bir uzman sistemin desteğiyle kaynak dikişlerinin kalitesini artırmak için bir yöntem geliştirmeye odaklanmıştır. Yazarlar, üretim sürecinden kaynaklanan parça bileşimindeki sorunlar nedeniyle, eklemeli üretim yoluyla üretilen parçalarla lazer iletim kaynağının zorluklarını ele almaktadır. Ahmed ve Kim [9] yaptıkları çalışmada direnç punta kaynağı süreçleri bağlamında uzman alan bilgisinin veriye dayalı modellerle entegrasyonunu tartışmaktadır. Yazarlar, veri analitiğinin direnç nokta kaynağı kaynaklanabilirlik sertifikasyonu için değerli bilgiler sağlayabileceğini öne sürmektedirler. Bu yöntem, önceki modellerde

eksik olabilecek önemli özelliklerin iyileştirilmesini ve dahil edilmesini sağlar, böylece Direnç nokta kaynağında kullanılan makine öğrenimi modellerini geliştirir. Makale, veriye dayalı yaklaşımların gerçek dünyadaki kaynak kavramları ve standartlarıyla uyumlu olmasını sağlayarak, analitiği yönlendirmek ve doğrulamak için kaynak uzmanlarının derin bilgisinin önemini vurgulamaktadır

III. BULGULAR

Literatür çalışmalarında, Akıllı Kaynak Sistemleri teknolojileri ile ilgili çalışmaların kapsamlı bir incelemesi yapılmaktadır. Kaynak mühendisliğindeki uzman sistemlerin tarihsel gelişimine, kullanılabilirliklerine ve karar verme geliştirme yeteneklerine özel bir vurgu yapılmaktadır. Ayrıca bazı inceleme ve araştırma makalelerinde, mühendisler için süreç seçimlerini kolaylaştıran proses seçimi için kaynak öneri sistemi gibi önemli katkılar vurgulanmaktadır. Bunun dışında, uzman sistemlerin robotik kaynakta entegrasyonuna dikkat çekilerek, kaynakçılar ve robotik operatörler arasındaki beceri farkının azaltılması konusunun üstünde durulmuştur. Genel olarak, kaynak teknolojilerinin mevcut durumu hakkında net bir çerçeve oluşturulmakta ve gelecekteki gelişmeler için zemin hazırlanmaktadır.

IV. TARTIŞMA

Literatür çalışmaları incelenirse tungsten ark kaynağı için önemli bir yer tutan dolgu malzemesi seçimi, bu seçimin hızlı ve doğru şekilde yapılabilmesine yönelik çalışmaların kısıtlı olduğu görülmektedir. Bu sebeple endüstride süregelen bilgi birikiminin kullanılabilmesi için bir veri tabanından yararlanılması gerekir. Geliştirilebilecek yeni sistem ile insan odaklı kararlarının tekrarlanabilmesi, tasarım mühendisinin teknik resim oluştururken yardımcı bir araç olması, kaynak dolgu malzemesinin seçimi konusunda farklılıkların ortadan kalkması, yeni ürün devreye alma aşamasında yapılan tahribatlı/tahribatsız muayene testlerinin başarı oranının artmasına yardımcı olması, deneme yanılma yöntemiyle yapılacak çalışmaların azaltılması ve kullanılan kupon sayısı azalması öngörüldüğünden yeni ürün tanıtımı süreçlerinin maliyetlerinin (sarf malzeme, işçilik saatleri vb.) düşürülmesi sağlanacaktır. Bu noktada literatür ve endüstriden gelen bilgi birikimi ve deneyimden yararlanılarak kullanıcı dostu bir bilgisayar programı geliştirilebilir. Seçilen ana malzemelere göre kullanıcı bir veya birden çok dolgu malzemesi önerisinde bulunulacaktır. Eğer veri tabanında uygun bir sonuç yoksa kullanıcının ana malzeme seçimlerini gözden geçirmesi istenebilecektir.

V. SONUÇLAR

Bu araştırma, özellikle kaynak mühendisliğindeki uzman sistemlere odaklanarak, Akıllı Kaynak Sistemlerinin evrimini ve uygulamasını araştırmaktadır. Literatür taraması, özellikle süreç seçimi için kaynak önerisi ve robotik kaynakta uzman sistemlerin entegrasyonu gibi alanlarda Akıllı Kaynak Sistemleri teknolojilerine önemli bir araştırma ilgisi olduğunu ortaya koymaktadır. Bununla birlikte, özellikle tungsten ark kaynağı için çok önemli olan kaynak dolgu malzemelerinin verimli ve doğru seçimine ilişkin araştırmalarda gözle görülür bir boşluk vardır. Bu araştırma, bu boşluğu doldurmak için kullanıcı dostu bir bilgisayar programının geliştirilmesini önermektedir. Önerilen bu sistem, seçilen temel malzemelere dayalı olarak en uygun dolgu malzemelerini önermek, deneme yanılmaya olan bağımlılığı en aza indirmek ve ilgili maliyetleri azaltmak için mevcut endüstri bilgi ve deneyiminden yararlanacaktır. Bu sayede bu işlemin standardize edilmesinin kolaylaşması hedeflenmektedir. Ayrıca uzman sistemlerin firma çalışanları (mühendis, operatör, kaynakçı, teknik destek uzman vb.) arasında yaygınlaşmasına katkıda bulunacaktır. Önerilen sistem, kaynak tasarımının bu önemli yönünü otomatikleştirerek, kaynak sürecini kolaylaştırmayı, karar vermeyi geliştirmeyi ve nihayetinde akıllı kaynak teknolojilerinin ilerlemesine katkıda bulunmayı amaçlamaktadır.

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Investigation of late-Miocene Unit Distributions in the Inner Cilicia Basin

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Abstract – The Cilicia basin is a Neogene depocenter located between the Turkey and Cyprus in the eastern Mediterranean. Due to its natural structure, Cilicia basin has been subject of several investigations from past to present. In this study, late-Miocene (Messinian) unit distributions in the inner Cilicia basin were interpreted from the seismic reflection data that obtained with permission from the Turkish Petroleum Corporation. This unit correlated with the Messinan evaporates which underlies M-reflector. The base of this unit is marked by N-reflector which indicates the beginning of the Messinian Salinity Crisis in the Mediterranean Sea. Thickness map was prepared with the average velocity of 4000 m/s based on previous studies. According to the interpretation results, the thickness of the Messinian succession observed in the Cilicia Basin varies between 200 and 1600 meters, and the depth of these successions ranges between 500 and 3300 meters. The succession reaches its maximum thickness in the southern part of the continental shelf. This thickening is thought to be due to the downslope flow of evaporitic deposits or tectonism.

Keywords – Cilicia Basin, seismic reflection profiles, evoaporite, Messinian salinity crisis, sediment distribution.

I. INTRODUCTION

The Cilicia basin is an arcuate and elongate Neogene depocenter located between the Turkey and Cyprus in the eastern Mediterranean. It has been formed since the mid to late Miocene by the effect of subduction of the African plate beneath the Anatolian plate along the Cyprus arc ([1]). The Cilicia basin can be divided into E-W trending deeper Outer Cilicia basin in the west and a NE-SW trending shallower Inner Cilicia basin in the northeast ([2]). The study area lies between about 34º-35º.2 E longitudes and 36º-37º N latitudes in Inner Cilicia basin (Figure 1).

In this study we aimed to investigate late-Miocene (Messinian) unit distributions from seismic reflection profiles in the Inner Cilicia Basin. In seismic reflection sections, this unit is delineated by a strong reflector, known as the M reflector, at the ceiling portion extending beneath the Plio-Quaternary sediment accumulations, while at the base, it is bounded by a weaker and intermittently indistinct reflector, referred to as the N reflector. This unit, associated with Messinian-aged evaporite deposits, should be interbedded with minor amounts of anhydrite and limestone, predominantly containing halite ([3],[4],[5],[6]).

II. MATERIALS AND METHOD

Within the study area, 7 analog migrated and processed seismic reflection profiles, obtained legally from TPAO (Turkish Petroleum Corporation) and interpreted. Due to confidentiality agreements with TPAO, the location information of the profiles cannot be provided. Therefore, the coverage area of the profiles is depicted in Figure 1.

The seismic data were interpreted using seismic stratigraphic methods ([7]) to determine the lower and upper boundaries, as well as the thicknesses and depths, of the Late Miocene-aged unit. In preparing the

thickness map, the average speed value was taken as 4000 m/s based on previous studies. The bathymetric data were obtained from the Earth Data Explorer USGS [8].

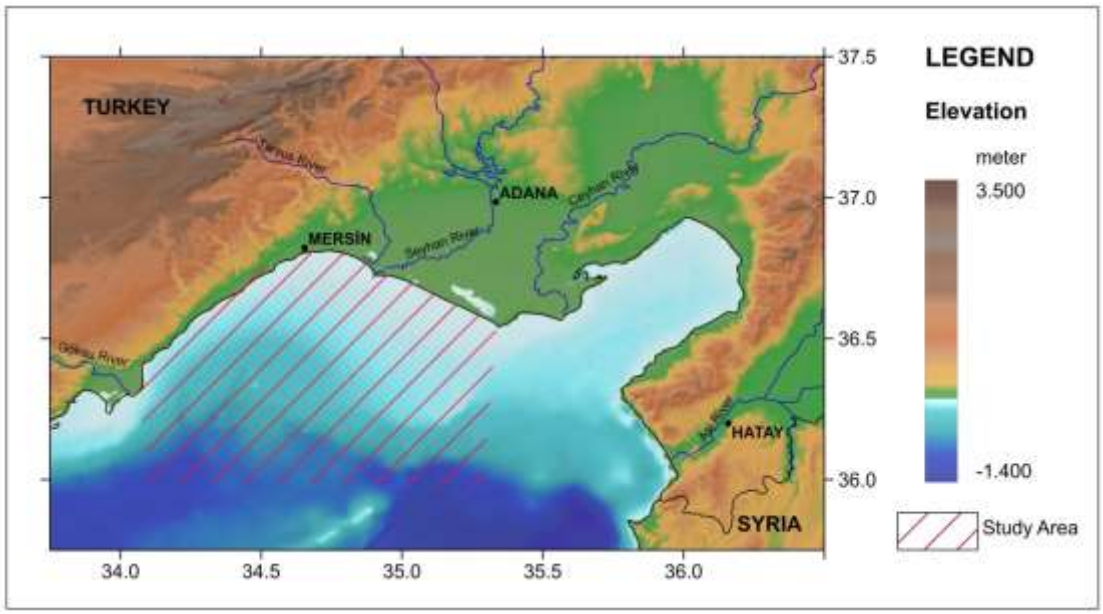

Fig. 1 Topographic and bathymetric map of the study area and its surroundings

III. RESULTS

The bathymetry of the study area reaches a maximum depth of -1100 meters (Figure 1). The thickness of the Messinian succession observed in the Cilicia Basin varies between 200 and 1600 meters (Figure 2), and the depth of these successions ranges between 500 and 3300 meters (Figure 3).

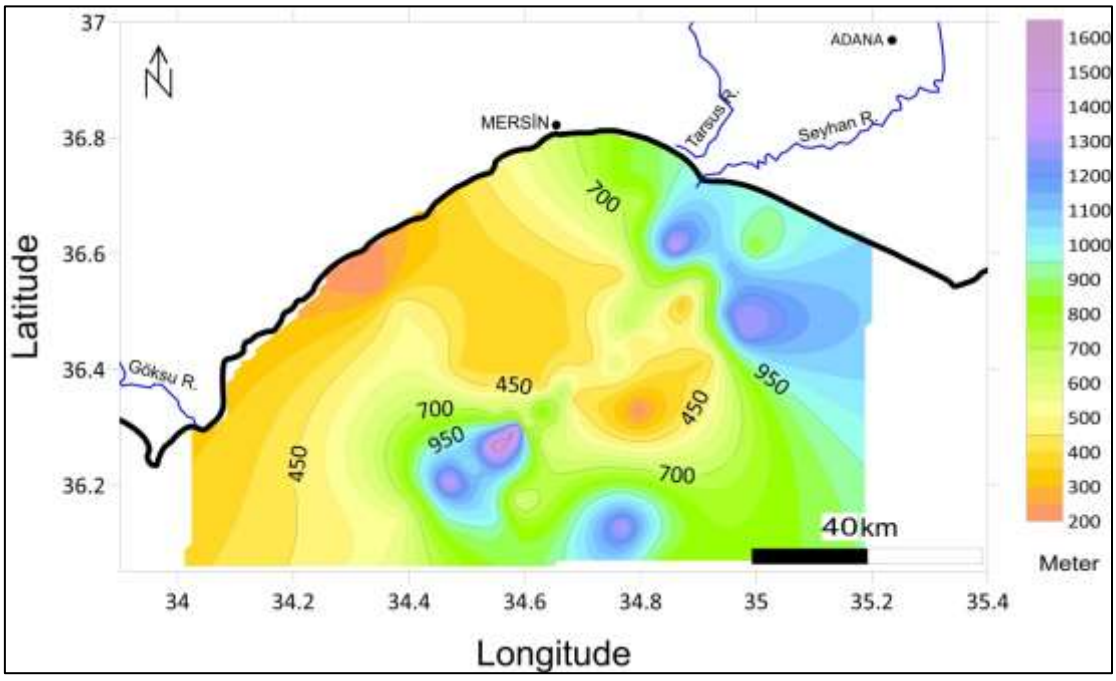

Fig. 2 The thickness map of the Messinian succession in the Cilicia Basin

The succession reaches its maximum thickness in the southern part of the continental shelf. This thickening is thought to be due to the downslope flow of evaporitic deposits or tectonism. The Messinian deposits have a thickness of approximately 1100 meters south and southeast of the points where the Tarsus and Seyhan rivers discharge into the sea. This suggests that the Tarsus and Seyhan rivers might

have discharged into the sea at different locations during the Messinian period compared to their current positions.

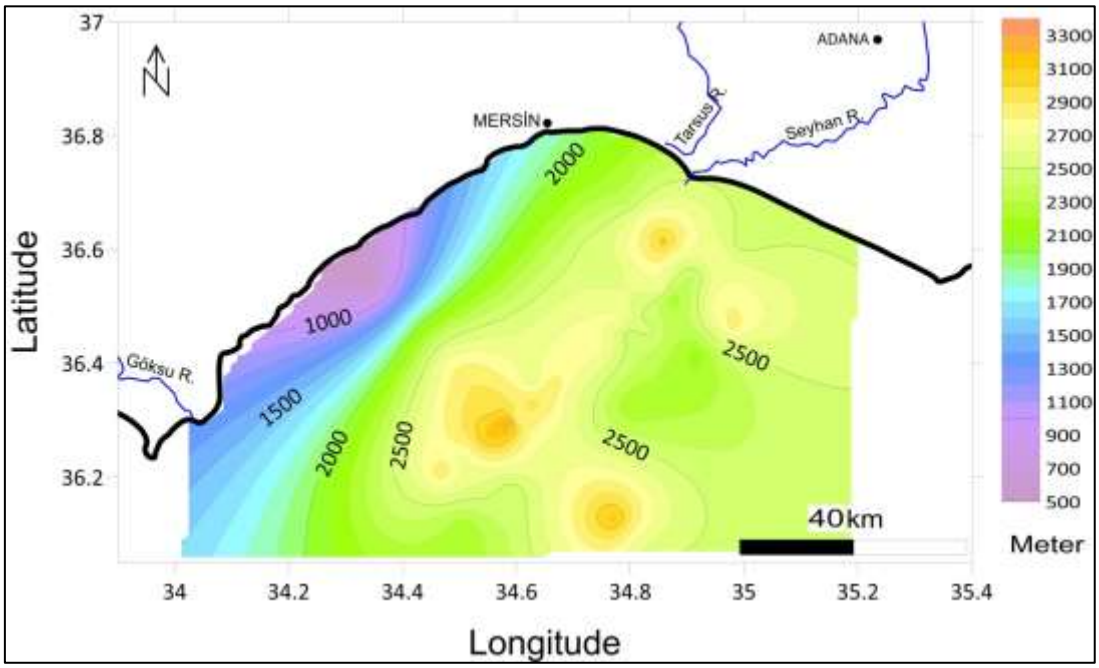

Fig. 3 The depth map of the Messinian succession in the Cilicia Basin

IV. DISCUSSION

The unit containing Messinian evaporites is bounded by the M reflector at the top and the N reflector at the bottom. The thickness of the evaporites has been determined to vary between 200 and 1600 meters. It is hypothesized that evaporite slumping and tectonic activities may have contributed to the maximum thickness of the succession observed towards the southern part of the basin's continental shelf. The Messinian deposits reach a thickness of approximately 1100 meters south and southeast of the discharge points of the Tarsus and Seyhan rivers into the sea. This observation supports the hypothesis that the Tarsus and Seyhan rivers might have discharged into the sea at different locations during the Messinian period compared to their current positions.

ACKNOWLEDGMENT

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Kriket Gençler Türkiye Birinciliğine Katılan Sporcularda Müziğin Etkisi

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Özet – Bu çalışmada Kriket Gençler Türkiye Birinciliğine katılan sporcularda müsabaka döneminde dinlenilen müziğin kriket sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amaçlanmıştır. Araştırma grubunu; Kriket Gençler Türkiye Birinciliği müsabakasına katılan 245 erkek ve 175 kadın toplam 420 kriket sporcusu oluşturmaktadır. Araştırmada veri toplama amacıyla araştırmacılar tarafından hazırlanan kişisel bilgi formu ve Sportif Uygulamalarda Müziğin Etkisi Ölçeği kullanılmıştır. Veriler analiz edilirken Cronbach's Alpha güvenilirlik testi, T testi ve Anova testi yapılarak çalışmanın sonuçları p<0,05 önem düzeyine göre değerlendirilmiştir. Yapılan analizler sonucunda Kriket sporcularında sportif uygulamalarda müziğin etkisine ait ölçek güvenirlik sonuçları ve al boyut güvenirlikleri yüksek düzeyde çıkmıştır. Çalışmada kullanılan değişken sonuçlarında ise yaş, mevki, sınıf düzeyi, baba ve anne meslek değişkenlerinde anlamlı farklılık görülürken cinsiyet, spor yaşı ve aile desteği değişkenlerinde anlamlı bir farklılık olmadığı bulunmuştur. (p<,05). Kriket sporcularının müsabaka döneminde dinledikleri müziğin sporlarına etkisi konusu, sporcuların performansını ve spor hayatlarını etkileyebilecek önemli bir faktördür. Kriket Gençler Türkiye Birinciliğine katılan sporcularda müsabaka döneminde dinlenilen müziğin kriket sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi adlı çalışmamızda sonuç bulgularının önemi araştırılmalı ve çıkan sonuçlar ile önceki yapılan çalışmalar karşılaştırılarak bilime katkısı yorumlanmalıdır.

Anahtar Kelimeler –Kriket, Müzik, Spor, Türkiye Birinciliği, Gençler

I. GİRİŞ

Kriket sporu ilk defa 16. yüzyılda İngiltere'nin güneyinde oynanmış ve 18. yüzyıl sonunda İngiltere'nin millî sporu olmuştur. Britanya İmparatorluğu ülke sınırlarını genişleterek sömürgelerinde yaygınlık göstermeye başlanmış ve ilk olarak 19. yüzyılda uluslararası boyutta maçlar oynanmıştır. Günümüzde Uluslararası Kriket Konseyinin 10 üyesi vardır ve bu spor branşı Avustralya, Hindistan, İngiltere, Karayipler ve Güney Afrika'da popüler bir spor branşı olarak oynanmaktadır [1].

Kriket, iki takım arasında, 11'er kişiden oluşan sopa ve topla oynanan bir spor branşıdır. Oyun alanının merkezi üzerinde 20 metre uzunluğunda dikdörtgen bir saha birde dairemsi bir alan bulunur. Dikdörtgen sahanın bir ucunda yer alan atıcı olarak bilinen oyuncu topu, vurucu olarak bilinen oyuncunun bulunduğu diğer uca doğru fırlatarak vurucu oyuncusunun arkasında bulunan kale benzeri düzeneğe (wicket) değdirmeye çalışır, vurucu oyuncusu ise topun wicketa değmesini engellemek için sopa yardımıyla topa vurmaya çalışır. Başarılı bir vuruş gerçekleştirildikten sonra atıcı oyuncuları topu yakalamaya çalışırken, sahada yer alan vurucu oyuncusu da karşısındaki wicketa doğru koşar. Oyunda Run, top oyun alanı dışına çıkmadan yakalanmasına verilen addır. Top oyun alanı içerisinde yakalanırsa bir sayı, oyun alanı dışına çıkarsa dört sayı, yere hiç değmeden oyun alanı dışına çıkarsa altı sayı kazanılır ve oyuncular vurucu oyuncusu iken ise en fazla sayıyı kazanmaya çalışır. Atıcı oyuncusu, topu wicketlardan herhangi birine değdirmeye ve karşılanan topu yere değmeden yakalamaya çalışır. Oyunda over adı verilen her 6 atışta bir oyuncunun değiştirilmesi zorunlu olan ve oyun dışında kalan oyuncu yerine başka bir oyuncu

zorunludur. Kriket müsabakalarının uluslararası boyutunda kullanılan üç ana format vardır. Bunlardan ilk Twenty20 formatıdır. Bu formatta her iki takım 20'şer over yapmalıdır ve ilk 20 overın yapılmasından sonra takımların görevleri değişir. Eğer ki takım oyuncularından 10 vurucu oyun dışında kalır ise takımlar 20 overa ulaşmasa bile takımların görevleri değiştirilir. Bu iki devreden oluşan her bir bölüme innings adı verilmektedir. Yapılan bir günlük maç içerisinde iki takım 50'şer over gerçekleştirmektedir. Beş gün süren deneme uygulamasındaki bir maçta ise her iki takımın 2'şer innings hakkı bulunmaktadır ve bu inningsler için over sınırlaması bulunmamaktadır. Son inningste vurucu görevindeki takım, rakip takımın toplam run sayısına ulaşamamışsa aradaki run sayı farkına bakılır ve daha çok runı olan takım, aradaki sayı farkı kadar runla kazanmış olur. Maçın sonunda vurucu görevindeki takımın sayısı, rakip takımın run sayısını geçmişse, 10 sayısından maç toplamında elde ettiği wicket sayısı çıkarılır ve kalan sayı kadar wicketla maçı kazanmış olur. Takımların elde ettiği skor sayıları run/wicket şeklinde ele alınmaktadır [2].

Kriket sporcuları çalışma hayatlarında farklı engellerle karşılaşabilmektedirler. Zorluklara karşı direnç gösteren, stres ve baskı altında pozitif düşünebilen ve basit güdülenen sporcular motivasyon seviyeleri yüksek olan bireylerdir. Sporcuların motivasyonu bireysel kazanım ya da kaybetmelerle ilgili doğrudan tecrübelerinden, diğer kişileri izleyerek edindikleri dolaylı tecrübelerden, fizyolojik ve duygusal durumlardan etkilenmektedir. Sporcuların başarılı tecrübeleri, bir işin üstesinden gelebilme ve başarabilme inancını artırmaktadır. Bunun yanında sporcuların bir işlevde yetkin olduklarına dair teşvik edilmeleri, etrafında ki kişilerin başarılı tecrübelerini modellemeleri de motivasyon düzeylerini de artırmaktadır.

Müzik; belli bir amaç ve metodla, belirli bir güzellik algısına göre özümsenerek bütünleştirilen seslerin oluşturduğu estetik bir bütündür [3]. Müzik yaşamımızın her periyodunda eğlence amaçlı, terapi nedeniyle ya da sporcularda egzersiz öncesi ısınma, egzersiz sırasında veya egzersiz sonrası soğuma sırasında dinlenilerek [4], sporcuların algılarını, duygu ve düşüncelerini sözlü olmadan etkileyen bir sanat çeşitidir [5]. Müzik ve spor yaşamın her alanında karşımıza çıkmaktadır. Hem rekreatif etkinlik olarak spor yapanların hem de sporcuların vazgeçilmezi olan müzik müsabaka başlangıçları ve bitişleri gibi önemli spor olaylarında da kritik bir önem taşımaktadır. Ancak müziğin, kişileri fiziksel aktivite esnasında eğlendirmek dışında egzersiz performansını yükseltmek, güç ve dayanıklılığı arttırmak, yorgunluğu geciktirmek, gibi destekleyici etkileri olduğu da bilinmektedir [6]. Müziğin ergojenik etkisi, yorgunluğu geciktirerek veya çalışma kapasitesini artırarak egzersiz performansını iyileştirdiği için belirgindir. Bu etki, beklenenden daha yüksek dayanıklılık, güç, üretkenlik veya güç seviyeleri ile sonuçlanır [7]. Egzersiz yaparken müzik dinlemek iş performansını artırır ve devam eden egzersizin neden olduğu algılanan eforu ve yorgunluğu azaltır [8], [9]. Son zamanlarda müzik, egzersiz ve sporun içerisinde daha çok yer almaya başlamıştır. Sporcular fiziksel destek aracı olarak müziği, duygusal ve zihinsel yorgunluklarından 82 kurtulmakta kullanmanın yanında [10], performanslarını arttırmak ve motive olmak amacı ile de kullanmaktadırlar. [11], çalışmalarında hızlı tempolu müzik dinlemenin maksimal egzersiz anında aktivite zamanının uzamasına ve kalp atım hızının da artmasına neden olduğunu ve egzersiz sonrası düşük tempoda müzik dinlemenin egzersiz sonrası toparlanmaya katkı sağladığını tespit etmişlerdir. Çeşitli müzikler ile yapılan güce dayalı yürüyüşler ve motor beceri üzerindeki etkiler psikolojik bir etkileşim içermektedir [12]. Yapılan çalışmalarda göstermektedir ki müsabaka dönemi sporcular için fiziksel olarak önemli bir etken iken psikolojik olarakta önemli bir süreçtir ve bu süreci birçok değişken etkilemektedir.

Bu çalışmada; Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularda müsabaka döneminde dinlenilen müziğin kriket sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amaçlanmıştır. Çalışmamızla kriket sporcularının müsabaka dönemindeki dinledikleri müziğin fiziksel güç ve performansın yanında motivasyon ve psikolojik sağlamlık bakımından da etkileri kriket branşında ele alınmıştır.

II. MATERYAL VE YÖNTEM

A. Araştırma Grubu

Araştırma grubunu; Okul Sporları Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan 175 Kız ve 245 Erkek toplam 420 kriket sporcusu oluşturmaktadır. Sporcular çalışmada gönüllü olarak yer almaktadır. Araştırmada kolayda örnekleme yöntemi tercih edilmiştir. Kolayda örnekleme yöntemi; araştırmacıların ulaşabileceği sporcuların tümünün çalışmaya gönüllü olarak katılması olarak bilinmektedir [13].

B. Veri Toplama Aracı

Çalışma; 8 soruluk demografik değişkenlerden ve [14] tarafından hazırlanan 18 sorudan oluşan "Sportif Uygulamalarda Müziğin Etkisi Ölçeği" kullanılmıştır. Ölçek, toplamda 18 sorudan ve 3 alt boyuttan oluşan 5 kategorili likert türünde yapılandırılmıştır. Ölçeğin alt boyutları Motivasyon (5 soru), Fiziksel Güç ve Performans (6 soru) ve Psikolojik Sağlamlık (7 soru) durumlarını ölçmektedir. Ölçeğin Cronbach Alpha güvenirliği "Motivasyon", "Fiziksel Güç ve Performans", "Psikolojik Sağlamlık" alt boyutları ve ölçeğin tamamı için sırasıyla 0,71, 0,78, 0,80 ve 0,88 olarak hesaplanmıştır.

C. Verilerin Toplanması

Veriler elde edilirken; internet ortamında, anket sisteminden yararlanılarak sorular Kriket Şampiyonasına katılan tüm sporculara ulaştırılıp sonuçlar elde edilmiştir. Çalışmamıza katılan sporcuların tümüne yaptığımız çalışmanın amacı, yöntemi ve önemi hakkında bilgilendirme yapılarak, isimlerinin kesinlikle hiçbir yerde paylaşılmayacağı ve sadece araştırma amaçlı kullanılacağı bilgisi verilmiştir.

D. Verilerin Analizi

Araştırmamıza katılan sporculardan elde edilen verilerin analizleri SPSS 26.0 analiz programında yapılmıştır. Cronbach's Alpha güvenilirlik testi, T testi ve Anova testi yapılarak çalışma sonuçları $p<0,05$ önem düzeyine göre istatistiksel olarak değerlendirilmiştir.

III. BULGULAR

Tablo 1. Sportif Uygulamalarda Müziğin Etkisi Ölçeği Güvenirlilik Dağılımları (Genel)

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0, 952	18

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,952 olarak bulunmuştur. Bu değer $0,80<R2<1,00$ değerleri arasında olduğundan yapılan ölçeğin güvenirlik seviyesinin yüksek olduğu bulunmuştur (Tablo 1).

Tablo 2. Motivasyon Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	**Soru Sayısı**
0,863	5

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği motivasyon alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,863 olarak bulunmuştur. Bu değer $0,80<R2<1,00$ değerleri arasında olduğundan yapılan ölçeğin güvenirlik seviyesinin yüksek olduğu bulunmuştur (Tablo 2).

Tablo 3. Fiziksel Güç ve Performans Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	Soru Sayısı
0,869	6

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği fiziksel güç ve performans alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,939 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin güvenirlik seviyesinin yüksek olduğu bulunmuştur (Tablo 3).

Tablo 4. Psikolojik Sağlamlık Alt Boyutu Güvenirliği

Cronbach's Alpha Katsayısı	Soru Sayısı
0,899	7

Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği psikolojik sağlamlık alt boyutu güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,891 olarak bulunmuştur. Bu değer 0,80<R2<1,00 değerleri arasında olduğundan yapılan ölçeğin güvenirlik seviyesinin yüksek olduğu bulunmuştur (Tablo 4).

Tablo 5. Sporcuların, Kişisel Değişkenlerine İlişkin Dağılımları

Değişkenler		N	%
Cinsiyet	Erkek	245	58,3
	Kız	175	41,7
Doğum Yılı	2005 Doğumlu	158	37,6
	2006 Doğumlu	129	30,7
	2007 Doğumlu	133	31,7
Kaçıncı Sınıfta Okuyorsunuz?	9. Sınıf	68	16,2
	10. Sınıf	124	29,5
	11. Sınıf	117	27,9
	12. Sınıf	111	26,4
Oynadığınız Mevki	Kaleci	29	6,9
	Atıcı	189	45,0
	Vurucu	202	48,1
Kaç Yıldır Kriket Sporunu Yapıyorsunuz?	1-2 Yıl	166	39,5
	3-4 Yıl	135	32,1
	5 Yıl ve Üstü	119	28,3
Aileniz Kriket Sporunu Yapmanızı Destekliyor Mu?	Evet	283	67,4

	Hayır	137	32,6
Babanızın Mesleği	Çalışmıyor	35	8,3
	Çiftçi	88	21,0
	Memur	115	27,4
	İşçi	103	24,5
	Serbest Meslek	79	18,8
Annenizin Mesleği	Ev Hanımı	204	48,6
	Çiftçi	53	12,6
	Memur	97	23,1
	İşçi	66	15,7

Tablo 6. Sporcuların, Cinsiyet Değişkenine Göre T Testi Sonuçları

Ölçek ve Alt Boyutları	**Cinsiyet**	**n**	**x**	**ss**	**sd**	**t**	**p**
Genel	Erkek	245	3,908	0,846	417,925	-0,315	0,753
	Kız	175	3,930	0,596			
Motivasyon	Erkek	245	3,797	0,961	412,713	0,742	0,459
	Kız	175	3,734	0,768			
Fiziksel Güç ve Performans	Erkek	245	3,959	0,865	412,813	0,089	0,929
	Kız	175	3,952	0,691			
Psikolojik Sağlamlık	Erkek	245	3,944	0,876	415,791	-1,513	0,131
	Kız	175	4,052	0,580			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların cinsiyet değişkeni incelendiğinde, T testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılık olmadığı bulunmuştur (p<0,05) (Tablo 6).

Tablo 7. Sporcuların, Doğum Yılı Değişkenine Göre Anova Testi Sonuçları

Ölçek ve Alt Boyutları	Doğum Yılı	n	x	ss	f	p	Tukey
Genel	2005 Doğumlu	158	3,841	0,849	1,795	0,167	-
	2006 Doğumlu	129	3,918	0,704			
	2007 Doğumlu	133	4,008	0,662			
Motivasyon	2005 Doğumlu	158	3,672	0,992	3,786	**0,023***	**2005 Doğumlu>2007 Doğumlu**
	2006 Doğumlu	129	3,716	0,847			
	2007 Doğumlu	133	3,942	0,759			
Fiziksel Güç ve Performans	2005 Doğumlu	158	3,881	0,878	1,228	0,294	-
	2006 Doğumlu	129	3,976	0,747			
	2007 Doğumlu	133	4,025	0,738			
Psikolojik Sağlamlık	2005 Doğumlu	158	3,926	0,866	0,884	0,414	-
	2006 Doğumlu	129	4,013	0,726			
	2007 Doğumlu	133	4,040	0,679			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, doğum yılı değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde sadece motivasyon alt boyutunun anlamlı farklılığı olduğu bulunmuştur (p<0,05) (Tablo 7).

Tablo 8. Sporcuların, spor yaşı değişkenine göre Anova Testi sonuçları

Ölçek ve Alt Boyutları	Kaç Yıldır Kriket Sporunu Yapıyorsunuz?	n	x	ss	f	p	Tukey
Genel	1-2 Yıl	166	3,880	0,796	0,336	0,715	-
	3-4 Yıl	135	3,946	0,724			
	5 Yıl ve Üstü	119	3,937	0,720			
Motivasyon	1-2 Yıl	166	3,738	0,977	0,192	0,825	-
	3-4 Yıl	135	3,788	0,847			
	5 Yıl ve Üstü	119	3,798	0,793			
Fiziksel Güç ve Performans	1-2 Yıl	166	3,907	0,797	0,585	0,558	-
	3-4 Yıl	135	4,006	0,790			
	5 Yıl ve Üstü	119	3,967	0,806			
Psikolojik Sağlamlık	1-2 Yıl	166	3,959	0,797	0,208	0,812	-
	3-4 Yıl	135	4,007	0,747			
	5 Yıl ve Üstü	119	4,010	0,755			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, spor yaşı değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılık olmadığı bulunmuştur (p<0,05) (Tablo 8).

Tablo 9. Sporcuların, aile destek durumu değişkenine göre T Testi sonuçları

Ölçek ve Alt Boyutları	Aileniz Kriket Sporunu Yapmanızı Destekliyor Mu?	n	x	ss	sd	t	p
Genel	Evet	283	3,930	0,714	237,364	0,486	0,628
	Hayır	137	3,890	0,825			
Motivasyon	Evet	283	3,787	0,829	230,541	0,495	0,621
	Hayır	137	3,738	0,993			
Fiziksel Güç ve Performans	Evet	283	3,944	0,782	418,000	-0,454	0,650
	Hayır	137	3,981	0,829			
Psikolojik Sağlamlık	Evet	283	4,022	0,727	418,000	1,257	0,210
	Hayır	137	3,921	0,846			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların, aile destek durumu değişkeni incelendiğinde, T testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde anlamlı farklılık olmadığı bulunmuştur (p<0,05) (Tablo 9).

Tablo 10. Sporcuların, mevki değişkenine göre Anova Testi sonuçları

Ölçek ve Alt Boyutları	Oynadığınız Mevki	n	x	ss	f	p	Tukey
Genel	Kaleci	29	4,187	0,477	2,026	0,133	-
	Atıcı	189	3,892	0,792			
	Vurucu	202	3,902	0,739			
Motivasyon	Kaleci	29	4,034	0,678	1,466	0,232	-
	Atıcı	189	3,771	0,893			
	Vurucu	202	3,733	0,900			
Fiziksel Güç ve Performans	Kaleci	29	4,155	0,501	1,096	0,335	-
	Atıcı	189	3,920	0,841			
	Vurucu	202	3,961	0,786			
Psikolojik Sağlamlık	Kaleci	29	4,325	0,543	3,028	**0,049***	**Kaleci>Atıcı**
	Atıcı	189	3,955	0,812			
	Vurucu	202	3,973	0,744			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların mevki değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde psikolojik sağlamlık alt boyutunda anlamlı farklılık olduğu bulunmuştur (p<0,05) (Tablo 10).

Tablo 11. Sporcuların, sınıf düzeyi değişkenine göre Anova Testi sonuçları

Ölçek ve Alt Boyutları	Kaçıncı Sınıfta Okuyorsunuz?	n	x	ss	f	p	Tukey
Genel	9. Sınıf	68	3,626	0,986	4,831	**0,003***	**9. Sınıf>11. Sınıf, 12. Sınıf**
	10. Sınıf	124	3,898	0,767			
	11. Sınıf	117	4,014	0,635			
	12. Sınıf	111	4,016	0,633			
Motivasyon	9. Sınıf	68	3,394	1,112	5,822	**0,001***	**9. Sınıf>10. Sınıf, 11. Sınıf, 12. Sınıf**
	10. Sınıf	124	3,751	0,895			
	11. Sınıf	117	3,882	0,830			
	12. Sınıf	111	3,908	0,697			
Fiziksel Güç ve Performans	9. Sınıf	68	3,696	0,987	3,359	**0,019***	**9. Sınıf>11. Sınıf, 12. Sınıf**
	10. Sınıf	124	3,942	0,827			
	11. Sınıf	117	4,045	0,718			
	12. Sınıf	111	4,037	0,676			
Psikolojik Sağlamlık	9. Sınıf	68	3,733	1,014	3,644	**0,013***	**9. Sınıf>11. Sınıf, 12. Sınıf**
	10. Sınıf	124	3,966	0,790			
	11. Sınıf	117	4,081	0,602			
	12. Sınıf	111	4,074	0,694			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların, sınıf düzeyi değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde genel ölçekte ve alt boyutlarının hepsinde anlamlı farklılıkların olduğu görülmüştür (p<0,05) (Tablo 11).

Tablo 12. Sporcuların, baba meslek değişkenine göre Anova Testi sonuçları

Ölçek ve Alt Boyutları	Babanızın Mesleği	n	x	ss	f	p	Tukey
Genel	Çalışmıyor	35	3,539	1,031	3,138	**0,015***	**Çalışmıyor>Memur, İşçi, Serbest Meslek**
	Çiftçi	88	3,838	0,759			
	Memur	115	3,980	0,665			
	İşçi	103	3,984	0,675			
	Serbest Meslek	79	3,995	0,771			
Motivasyon	Çalışmıyor	35	3,280	1,093	4,533	**0,001***	**Çalışmıyor>Memur, İşçi, Serbest Meslek**
	Çiftçi	88	3,640	0,891			
	Memur	115	3,794	0,863			
	İşçi	103	3,904	0,804			
	Serbest Meslek	79	3,926	0,831			

Fiziksel Güç ve Performans	Çalışmıyor	35	3,557	1,063	2,906	**0,022***	**Çalışmıyor>Memur, İşçi, Serbest Meslek**
	Çiftçi	88	3,895	0,756			
	Memur	115	4,037	0,719			
	İşçi	103	3,996	0,719			
	Serbest Meslek	79	4,029	0,868			
Psikolojik Sağlamlık	Çalışmıyor	35	3,710	1,101	1,672	0,156	-
	Çiftçi	88	3,930	0,825			
	Memur	115	4,064	0,664			
	İşçi	103	4,031	0,664			
	Serbest Meslek	79	4,014	0,780			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların, baba meslek değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde genel ölçek ve 2 alt boyutunda anlamlı farklılıkların olduğu görülmüştür (p<0,05) (Tablo 12).

Tablo 13. Sporcuların, anne meslek değişkenine göre Anova Testi sonuçları

Ölçek ve Alt Boyutları	**Annenizin Mesleği**	**n**	**x**	**ss**	**f**	**p**	**Tukey**
Genel	Ev Hanımı	204	3,942	0,783	3,438	**0,017***	**Ev Hanımı>Çiftçi**
	Çiftçi	53	3,625	0,809			
	Memur	97	3,940	0,739			**Çiftçi>İşçi**
	İşçi	66	4,042	0,553			
Motivasyon	Ev Hanımı	204	3,794	0,875	5,188	**0,002***	**Ev Hanımı>Çiftçi**
	Çiftçi	53	3,392	0,911			
	Memur	97	3,760	0,954			**Çiftçi>İşçi**
	İşçi	66	4,021	0,683			
Fiziksel Güç ve Performans	Ev Hanımı	204	3,969	0,815	4,176	**0,006***	**Ev Hanımı>Çiftçi**
	Çiftçi	53	3,616	0,883			
	Memur	97	4,022	0,767			**Çiftçi>Memur, İşçi**
	İşçi	66	4,090	0,633			
Psikolojik Sağlamlık	Ev Hanımı	204	4,025	0,808	1,251	0,291	-
	Çiftçi	53	3,800	0,851			
	Memur	97	3,998	0,738			
	İşçi	66	4,017	0,584			

*p<0,05 düzeyinde anlamlı

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcuların, anne meslek değişkeni incelendiğinde, Anova testi sonuçlarına göre, sportif uygulamalarda müziğin etkisi ölçeğinde genel ölçek ve 2 alt boyutunda anlamlı farklılıkların olduğu görülmüştür ($p<0,05$) (Tablo 13).

IV. TARTIŞMA

Araştırma; Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularda müsabaka döneminde dinlenilen müziğin kriket sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amacı ile yapılarak, Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan 420sporcuya uygulanmıştır. Çalışmamızda kullandığımız sportif uygulamalarda müziğin etkisi ölçeği güvenirlilik dağılımı sonuçlarına göre; Cronbach's Alpha katsayı değeri 0,952 olarak bulunmuştur. Bu değer $0,80<R2<1,00$ değerleri arasında olduğundan yapılan ölçeğin güvenirlik seviyesinin yüksek olduğu bulunmuştur.

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, doğum yılları değişkeni incelendiğinde, Anova analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olduğu belirlenmiştir. Çalışmamıza paralel olarak; [15] yaptıkları çalışmalarında yaş değişkeni ile ölçek arasında anlamlı farklılık olduğu görülmüştür. Çalışmamızdan farklı olarak; [16] ise, BESYO öğrencileri üzerinde yaptıkları çalışmalarında yaş değişkeni ile ölçek arasında anlamlı farklılık tespit etmemişlerdir.

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, spor yaşı değişkeni incelendiğinde, Anova analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir. Çalışmamızdan farklı olarak; [15] yaptıkları çalışmalarında yapılan spor yılı değişkeni ile ölçek arasında anlamlı farklılık olduğunu tespit etmişlerdir. Aynı çalışmada futbolcuların oynadığı lig seviyesi ile ölçek arasında bizim çalışmamızdan farklı olarak profesyoneller lehine sonuçlanmıştır. [17] futbolcular üzerinde yaptığı çalışmasında futbolcuların oynadığı lig ve spor yaşı değişkeni ile ölçek alt boyutları için yapılan analiz testi sonrasında $p<0,05$ düzeyinde ölçek alt boyutlarında anlamlı farklılık olduğu bulunmuştur.

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, aileniz kriket sporunu yapmanızı destekliyor mu? değişkeni incelendiğinde, T testi analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olmadığı belirlenmiştir. Spor ile ilgilenen ebeveynlerin çocuklarının spora daha ilgili oldukları bilinmektedir [18]. Çalışmamıza benzer olarak [19] çalışmalarında aile destek değişkeninde anlamlı farklılık olmadığını tespit etmişlerdir. [20] çalışmasında sporcuların aile destek değişkenleri arasında anlamlılık olmadığını bulmuştur. Çalışmamızdan farklı olarak; [21] çalışmalarında sporcuların ailelerinde destek görmeleri değişkeninde anlamlı farklılıkların bulunduğunu belirlemişlerdir. [22] öğrenciler ile yaptıkları çalışmalarında, spor etkinliklerinde aile desteğinin pozitif etkilerinin olduğunu tespit etmişlerdir.

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, mevki değişkeni incelendiğinde, Anova analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olduğu belirlenmiştir. Çalışmamızdan farklı olarak; [23] çalışmalarında, anlamlı farklılıkların olmadığını tespit etmişlerdir. [24] araştırmalarında anlamlı farklılıkların olmadığını belirlemişlerdir. Çalışmamıza paralel olarak; [25] çalışmalarında, anlamlı farklılıkların olduğunu belirlemişlerdir. [26] yapmış oldukları araştırmalarında, mevki değişkeninde anlamlı farklılıkların olduğunu bildirmişlerdir.

Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, sınıf düzeyi değişkeni incelendiğinde, Anova analizlerinden elde ettiğimiz sonuçlarda, $p<0,05$ düzeylerinde anlamlı farklılıkların olduğu belirlenmiştir. Çalışma sonucunda 9. Sınıf düzeyinde olan sporcularda genel ölçek ve tüm alt boyutlarında sportif uygulamalarda müziğin etkisi daha yüksek görülmüştür. Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularının, anne ve baba mesleği değişkeni incelendiğinde,

Anova analizlerinden elde ettiğimiz sonuçlarda, p<0,05 düzeylerinde anlamlı farklılıkların olduğu belirlenmiştir. Çalışma sonucunda çalışmayan anne ve babaya sahip sporcuların genel ölçek ve alt boyutlarında sportif uygulamalarda müziğin etkisi daha yüksek görülmüştür.

V. SONUÇLAR

Çalışma; Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularda müsabaka döneminde dinlenilen müziğin kriket sporcuları üzerindeki etkisinin bazı demografik değişkenler bakımından incelenmesi amacı ile yapılmıştır. Çalışmadan elde ettiğimiz sonuçlarda "doğum yılı", "mevki", "sınıf düzeyi", "anne ve baba mesleği", değişkenlerinde anlamlı farklılık tespit edilirken "cinsiyet", "spor yaşı" ve "aile desteği" değişkenlerinde anlamlı farklılıkların olmadığı tespit edilmiştir. Kriket Gençler Türkiye Birinciliği Şampiyonasına katılan sporcularda müziğin etkisi adlı çalışmamızda sonuç bulgularının önemi araştırılmalı ve çıkan sonuçlar ile önceki yapılan çalışmalar karşılaştırılarak bilime katkısı yorumlanmalıdır.

TEŞEKKÜR

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An Overview and Evaluation of Management Processes Depending on Business Processes and Strategy Management

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Abstract – A common definition of management is sometimes said to as a method of getting things accomplished. However, because businesses constitute complicated social entities with widely dispersed responsibilities and assets, solely acting is rarely enough. Management is an interpersonal process. It is an operation because it consists of a sequence of acts that contribute to the achievement of goals. It is an activity of society since the acts are primarily focused with interpersonal relationships. A business process is a full, dynamically coordinated collection of operations or conceptually connected tasks that have to be executed to provide value consumers or to achieve other business objectives. Strategy Management is described as the business process by which a company creates, launches, executes, monitoring, evaluations, and reconstructs its operational plan. The aim of this study is to get a deeper comprehension of the management process elements that support flexible capabilities and impact performance. Additionally, the goal of this study is to analyze the present body of information regarding management processes in order to suggest future directions for research and get a deeper comprehension of the intricate, multifaceted nature of these processes. Furthermore, it aims to initiate a discussion among the operational management community regarding how their expertise and background in the management of business processes could be applied to improve comprehension of managerial procedures.

Keywords –Business Process, Management, Strategy.

I. INTRODUCTION

Management is an interpersonal phenomenon. It is a procedure given that it consists of a sequence of acts that contribute to the achievement of goals. It is part of society since the acts are primarily focused with interpersonal relationships. For several decades, the discipline of managerial studies has been focused alongside improving knowledge of how organizations function. Some businesses appear to be capable to quickly generate and implement creative answers to emerging hazards and possibilities in their surroundings (Childe et al., 1994; Bititci et al., 2010). Managing is sometimes said to as a method of obtaining things accomplished. However, considering organisations constitute complicated social entities containing extensively dispersed responsibilities and assets, solely acting is rarely enough. As a result, executives devote the majority of their spare time working together with others. They confront a variety of obstacles, including how to move the organization in the right direction, how to earn the loyalty and backing of key personnel, and how to align varied organizational objectives and objectives. In the most general sense, they constitute procedure issues: they concern the way things are done as opposed to the material or essence of concepts or legislation. The physical aspects of application therefore serve as the basis of this concept of procedures. The emphasis is on how administrators coordinate operations and occurrences while engaging people in activities to achieve the intended results. Action is essential, and the procedure is inherently associated with good professional conduct. Unexpectedly, this phrase is used in a variety of

occupations that need creativity, individuality, and precise judgement. Architects because for instance, participate in the design procedure; researchers use the scientific procedure; and psychiatrists participate in the process of counselling. Regarding leadership, each action has complicated, variable decisions regarding how to effectively translate objectives into outcomes (Childe et al., 1994; Bititci et al., 2010).

The following piece applies accounting ideas to help executives develop a philosophy of value, competitive edge, and prosperity. The argument is that the resource-centered view of the corporation necessitates a labour concept for value generation (Bowman and Toms, 2010). Management procedures have been regarded an element of management of operations for several decades and have emerged piecemeal, deficient in complexity and border creation. In the matter context, it is only used to clarify what companies do throughout these procedures; nevertheless, how management procedures are carried out is as important.

The success of an organization is influenced by the interconnectedness of management procedures, instead of the actions of individuals. The interconnection of a managing structure influences an organization's adaptive capacities, therewith greater degrees of maturity in processes being related through greater degrees of interconnectivity and competence (Armistead and Machin, 1997; Acur and Bititci, 2003).

II. Materials and Method

The execution of Quality Management (QM) in a business necessitates two kinds of choices: what to accomplish (satisfied: the manner in which at first the various methods of QM ought to be employed) as well as how to accomplish it (procedure: the manner in which to carry out the procedure of change through which the selection of QM adheres to become ingrained in a business). The vast amount literary works studied thus far acknowledges the process-based strategy as an essential and strong method, with a general agreement that company procedures occur for many objectives. Several are dealing with customers operational procedures, some are administrative assistance procedures, that are functioning nonetheless dealing with customers, and some are administrative procedures pertaining to the future achievement of the business underlying dynamic qualifications of organizations, according to research in the strategic leadership written Works (Sousa and Voss, 2002; Cepeda and Vera, 2007).

A. Managing operations from an operational oversight approach for flexible capabilities -Perception of Quality Engineer

The execution of QM in a business necessitates two kinds of choices: what to accomplish (satisfied: the manner in which at first the various methods of QM ought to be employed) as well as how to accomplish it (procedure: the manner in which to carry out the procedure of change through which the selection of QM adheres to become ingrained in a business). The vast amount literary works studied thus far acknowledges the process-based strategy as an essential and strong method, with a general agreement that company procedures occur for many objectives. Several are dealing with customers operational procedures, some are administrative assistance procedures, that are functioning nonetheless dealing with customers, and some are administrative procedures pertaining to the future achievement of the business underlying dynamic qualifications of organizations, according to research in the strategic leadership written Works (Sousa and Voss, 2002; Cepeda and Vera, 2007).

Innovative abilities are significant resource kinds for organizations with constantly changing contexts. Having dynamic skills does not ensure achieving a competitive edge. Controlling capacities is a very crucial component. Knowledge management contributes to the development of realistic capacity control techniques. Knowing how and using previous experiences helps to provide rapid responses to changing surroundings. Innovative ways also support the strategy and help to provide value for customers while improving the systems. Nevertheless, wherever is the standard of excellence, and how does it address these essential scores?

Quality entails purposefully manufacturing a product or providing the required quality of service. If organizations seek a competitive edge, they must achieve the appropriate level of quality. System enhancement requires an understanding of the structures and the way they change. Establishing objectives

and picking the best relevant methods for the organization is critical (Sousa and Voss, 2002; Cepeda and Vera, 2007).

The business operations and assistance procedures provide the competitive edge in the present (by means of superiority in products, interaction with customers, and work efficiency), nevertheless it is the structure and operation of the managerial procedures that reinforce a business's dynamic capabilities and therefore identify whether or not competitive benefit is maintained and enhanced in the long run. Management procedures are the fundamental mechanisms that govern dynamic capacities. These are a collection of managerial procedures that, as an interrelated managerial in nature system, support an organization's flexible capabilities through regulating and reorganizing the organization's substance base, thereby influencing the organization's ability to achieve, sustain, or enhance its competitive edge in the long run. According to the literary works, managerial choices and actions including strategy, transformation, performance, and so on are the outcome of interactions between diverse stakeholders, either officially in executive offices or unofficially in workplaces, or even in hallways (Bititci et al., 2010).

B. Management of Strategy

Strategy execution- Management is described as the procedure through which a company expands, goes missing, executes, analyses, critiques, and renovates its operations according to approach. The operations of a company plan ought to incorporate an amalgamation of its operational and assistance processes techniques, considering into consideration any potential disputes. The framework has the benefit of providing several access opportunities for redesigning and redeveloping the business's approach.

After evaluating the current management of strategies platforms, models, strategies, instruments, and methods the investigation determined that, while all of the strategies assessed cumulatively satisfied all of the specifications, none of them did so independently (Armistead and Machin, 1997; Acur and Bitici, 2003).

A comprehensive search for command-and-control procedure revealed two distinct although overlapped collections of scholarship which mainly dealt with managerial procedures

They are presented as below (Bititci et al., 2010); (i) The company process research focuses on defining, categorizing, modelling, and improving company procedures. This corpus of research was particularly interested in the way various writers sought to characterize business processes, and more in particular, how they characterized management processes.

(ii) The strategic planning research focuses on how organizations manage their strategy to gain and maintain their competitive edge. Particularly interesting were how organizations contend, how they build and maintain their competitive advantage, and how they execute strategy, encompassing resource development, learning, and modifications.

There has been a wealth of scholarship on strategic management, just as there is on business procedures. The strategic planning material is typically focused upon the way organizations execute their strategy in order to gain and maintain an advantage over their competitors. An initial examination of research revealed three distinct fields such as dependent on resources viewpoint, flexible capabilities, and management of strategies. The research on the Resource-Based Theory of the Business has focused on how organizations establish and sustain their competitive edge through exploiting their own assets. Organizations gain and maintain an edge over others by learning compared to each other's and their own circumstances, as well as by establishing communication infrastructure, and collaborating (Bititci et al., 2010).

C. The Business Process

The concept of business procedures is widely accepted in both academic and practical groups. In the field of strategic management information available, process-oriented methods to examining strategy creation, execution, and realization have become popular. The importance of business procedures and processual thinking in company enhancement and transformation management has been thoroughly argued and broadly acknowledged. In a similar way compared to a systems management standpoint, a thorough comprehension of company procedures is seen as a vital precondition for the definition, layout, and execution of successful information systems. Business procedures involve interconnected operations that

span divisions of function and include inputs as well as outcomes. Why are firms implementing company procedure management addresses? Arguments involve the method of view:

-Enhances organizational flexibility to connect altering external requirements; - Improves accelerate to the marketplace for new products and amenities; - Reduces expenses; - Improves delivery dependability; - Improves product and assistance excellence and regularity.

The management of business processes is recognized by many as an effective strategy for promoting innovation, alteration, corporate expansion, managing changes to enterprise design, and auditing conformance. The definition of the concepts due to business processes are described as below (empowering (Armistead and Machin, 1997; Acur and Bititci, 2003; Tang et al., 2013);

Process Description: This often focuses on ways to enhance the actual execution of procedures.

Business procedures pose concerns in the following domains: Organizational Coordination: Their companies begin through inputting at the organization's border and end through outflow coming from the business border.

Organizational Structuring: Seemed that the system unconsciously matched the elements of autonomy/coordination, motivational oversight, and efficiency/learning, resulting in the layout of the matrix.

Enhancement: Encouraging a motivation inside businesses to constantly enhance procedures, as seen in the preceding topics of culture.

Evaluation: An important concept in process management includes the goal to discover patterns, evaluate security, establish whether consumer requirements have been truly satisfied, and promote development.

Cultural Fitting: A significant subject when considering companies given that people and procedures have to collaborate together to generate results. Nevertheless, throughout the companies, procedures were not considered as a limitation, but rather, as previously said, as a foundation.

The concept of business procedures, which has existed subsequently the beginning of the 1980s, was popularized by Hammer and is currently gaining broad adoption within scholarly and practical groups alike. In the field of strategic management literary works, process-oriented strategies to investigating strategy creation, execution, and realization have been widely used.

Throughout the purposes of this article, the management of business processes refers to all activities inside a business to assess and continuously enhance vital processes such as manufacturing, advertising, interactions, and other significant parts of the business's day-to-day operations. A company's procedure is a comprehensive, constantly synchronized series of procedures or conceptually interconnected duties that need to be performed in order to provide benefit consumers or achieve additional strategic objectives (Hammer, 1990; Trkman, 2010).

Even though the scientific community offers an assortment of alternating explanations for company procedures, nearly these different explanations both explicitly and implicitly acknowledge which "a company procedure is a collection of ongoing or infrequent multidisciplinary operations that are inherently linked with the work-flowing by means of these operations for a specific outcome/purpose (Bititci et al., 2010). The contributors (Gane and Sarson, 1979; Porter, 1985; Davenport, 1993; Childe et al., 1994; Armistead and Machin, 1997; Garvin, 1998) give differed levels of understanding of the reasoning for their categorization, as well as the internal functioning of the procedures that they have identified. Childe et al. (1994) offers thorough models for operating procedures, but only lists oversee and assist operations as instances. Garvin (1998), on the opposite hand, defines these procedures and uses instances from scholarship and experience to back up his categorization. On the other hand, Armistead and Machin (1997) use the Computer Integrated Manufacturing System Open Architecture (CIM-OSA) taxonomy to show that Managed Procedures are divided into two different independent component classifications: managerial procedures and Direction establishing procedures. Proponents defend this through claiming that commercial performance designs, including European Foundation for Quality Management (EFQM), distinguish management from strategy and policy development. Davenport (1993) also presents a detailed taxonomy of company procedures in order to provide a higher level of organization to management activity. While he acknowledges the significance of qualities like as management and power establishing, the

individual contends that these characteristics might fall beyond the scope of company procedure perspective.

The majority of the researchers concur on the fundamental subject matter and background of different company procedures. There appears to be an agreement that business procedures exist for several goals. For instance, some are dealing with customers operational procedures, while others constitute supporting administrative operations, that remain similarly operating but do not serve customers. The research team is especially keen on managerial procedures which are associated with ensuring the company's future performance, including establishing novel objectives, developing and carrying out strategies, handling shifts and modifications, and tracking and overseeing progress. Indeed, the research implies that organizations having also-developed, mature procedures which enable for prospect imaging, tracking, oversight, as well as ongoing growth and the theory of evolution, are more inclined to outperform and maintain their results. The research on this topic is largely focused with improving company procedure efficiency, having the terms "re-engineering" and the term "management" referring to massive amounts drastic modifications and gradual enhancement, correspondingly. The strategies that follow have been widely acknowledged to increase the effectiveness of an organizational manipulate, whether revolutionary or incremental budgeting: Define and outline the core operations of the company. Understanding these procedures through researching and analysing them. Define measurements for these procedures: Measure and monitor the following indicators: Benchmarking where relevant and practicable; Taking a course of action, revamp, and reconfigure the procedure in order to increase performance. This method is in line with contemporary approaches to process enhancement including Lean manufacturing Business and Six Sigma (Acur and Bititci, 2003; Bititci et al., 2010).

The improvement of Business Operations is also intended to improve the integration of customers. Customer engagement is a type of organizational-customer contact whereby firms keep frequent relationships with their primary consumers gather consumer demands, respond quickly to those needs, and include consumers in organizational operations and procedures.

This is a vital component of managing business procedures since it allows businesses to discover wherever and the way company procedures may add benefit to consumers. Integration of customers provides firms with knowledge on the customers' current wants, important challenges to tackle, and anticipated demands.

D. Flexible Abilities- Dynamic Capabilities

Dynamic competencies are a collection of distinct and recognizable activities such as developing products, making smart choices, and collaboration. They consist of comprehensive, analytical, and steady procedures that provide established outcomes.

Commodities are central to the resource-based view (RBV). They are the physical (such as specialized technology, geographical position), personal (such as chemical knowledge), and organisational (for instance, outstanding marketing staff) resources which may be employed to achieve producing value initiatives. They encompass regional strengths or 'competencies' which are critical to a company's edge over competitors.

In accordance with RBV literary works, numerous of the assets that generate and maintain a competitive edge may be organizational assets including company procedures. Indeed, in an exclusive issue of the Academy of Business on the RBV, Barney (2001) highlights critical topics for additional research: how organizations acquire and pass on information; how organizations establish and oversee alliances and connections; and how organizations develop. The RBV explains how companies gain and maintain their competitive edge throughout time. This approach emphasizes the inner workings of organizations and serves as a counterpoint to the conventional concentration of strategy upon business structure and positioning strategically throughout the framework as drivers of company competitiveness. Initially claiming that changing skills are the basis for lasting competitive edge in dynamically marketplaces mistakenly recognizes the origin of that benefit. Effective flexible skills share significant characteristics across organizations. As a result, they contradict the RBV premise of continuous variability between enterprises. Although organizations possessing enhanced dynamic capabilities, including greater product development and collaborating procedures, have a higher probability to have a superior edge through

businesses possessing less efficient skills, flexible abilities do not provide a competitive edge over the long term. So, wherever does the opportunity for a long-time advantage in competition deceive myself? It consists of employing dynamic capabilities earlier, more astutely, or accidentally than other companies to develop arrangements for resources with that advantage. As a result, long-term competitive advantage is derived from the resource combinations that executives create utilizing flexible abilities, rather than the skills themselves. Efficient dynamic skills are required, though not adequate, for a competitive edge.

Secondly, RBV reasoning exaggerates the tactical significance of pressure. Although certain resource arrangements do result in a lasting competitive edge, and some settings, including those having considerable scale economics or network consequences, encourage the creation of such benefits a competitive edge that lasts is uncommon in markets that are volatile (Armistead and Machin, 1997; Eisenhardt and Martin, 2000 Barney, 2001; Acur and Bititci, 2003; Bititci et al., 2010; Tang et al., 2013).

In conjunction with the discussion over the consequences of a business's resource supplies, the research on dynamic capacities is particularly interesting from the standpoint of management processes. Dynamic assets are an organization's capacity to swiftly alongside minimal disturbance expand, combine, create, change, and rearrange its arsenal of assets, encompassing intangible, material, and human resources. The strategic leadership research has several discussions about what an approach is as well as how it ought to be formed, defined, and executed. The premise of dynamic capacities as the final source of advantage over rivals has propelled these ideas to the foreground of strategic thinking. Nonetheless, a recent study of the dynamic capabilities area found that various writers have looked at the characteristics of changing abilities, their origins, results, and related activities. Nonetheless, empirical research is sparse, and little attempt has been made to synthesize data into a coherent picture. During the beginning of the twentieth century, intense rivalry has compelled businesses to continually adapt, refresh, reorganize, and recreate their assets and abilities in response to the competitive climate. This is reflected in the concept of dynamic capacities, which has offered a significant impetus in research on reality. Dynamic abilities incorporate insights from previous research on unique competency, organisation regularity, organisational understanding, core competency, core ability and rigour, combinative capacity, and architecture competency. The empirical study depicting the growth of company capacities began throughout the turn of the century and has grown since then. "The dynamic approach capabilities" might be established as a company's behavioural introductions that constantly combine, reorganize, regenerate, and reconstruct its assets and abilities, as well as, most importantly, to improve and reassemble its fundamental abilities in reaction to evolving circumstances in order to achieve and maintain the competitive edge (Hammer, 1990).

A key goal for managerial research is to find correlations underlying organizational characteristics. As an emergent idea, dynamic capacities must be analysed within an integrated framework that takes into account the antecedents and implications. The impact of dynamic abilities on development of skills and company performance are rather complicated: a company reinforces specific capabilities in response to its unique strategic objectives; and when the capacity advancement and company strategy are successfully coordinated, the company's dynamic abilities contribute to improved performance and thus suffered competitive advantages. The lack of consensus on the precise meaning of dynamic abilities, as well as the interaction between both dynamic and operational capabilities is likely the most significant cause of confusion. The initial definitions associated flexible skills with competitive edge, arguing that in dynamic circumstances, a company's capacity to continuously create new capabilities is more important than its resources (tangible and intangible assets) or organizational procedures (schedules). These initial notions of dynamic capacities become tautological in nature when competitive edge is included. Identifying the final source of competitive edge is futile if there is constantly a capacity behind it, resulting in an endless regression dilemma. More recent definitions distinguish involving operating (how someone earn current livelihood) and dynamic (how someone modify current operating procedures) skills and claim that a company's advantage derives from innovative arrangements involving assets and operational competencies (Cepeda and Vera, 2007).

Li and Liu (2014) examined ecological influences on business competitiveness. The dynamic approach - capabilities are assessed using the resource-based perspective (RBV), which looks at how sources respond to evolving environments. China was chosen as a case study due to its large citizenry, complex

organizational structure, and more integration into the economies of other nations. In the technique section, 6 pharmacological executives, thirty-five manufacturing companies, and A total of 650 inquirers were chosen. Firstly, chosen metrics are analysed to see whether they are required or excessive. thirty-five production companies were formed to ensure that the survey's effectiveness. Lastly, the calculated correlations are examined.

The dynamic approach capacities are characterized differently depending on the study field. The following piece defines dynamic skills as an organization's capacity to address challenges by identifying potential and potential hazards, making timely judgments, and successfully implementing strategic adjustments to assure the appropriate path (Cepeda and Vera, 2007; Li and Liu, 2012).

E. From the standpoint of knowledge management, dynamic capabilities and operational capabilities

The study was created to explore the relationship between dynamical skills and expertise in organization. Following that, a questionnaire was created. Initially a review of the literature is conducted to better grasp the ideas and key measurements. Following that, Cepeda and Vera conducted an approach to investigation. The initial theory is that the envisioned arrangements were built and then they attempted to establish resources for knowledge. The second theory is that the most important information areas affect continuing information handling buildings. The evaluation version was built throughout Spain in the year 2002. The approach investigation was carried out with twenty-three businesses and knowledgeable professionals in management. In addition, one hundred and sixty-eight on the list businesses engaged with the investigation, with one hundred seventy responding to the arrangement (Cepeda and Vera, 2007; Li and Liu, 2012).

F. Competencies, innovations, and comparative advantages

Weerawardena and Mavondo (2011) proposed that dynamic competencies do not have an immediate effect on the company's competitive edge, and they urged that innovative abilities be separated from other operational competencies.

In accordance to the study report, flexible capabilities need the management side of a business to be more imaginative in order to respond quickly to external changes. Obtaining a competitive edge over the long term might not be a feasible method of handling modifications to the environment, however if the business has short-term planning and a fast reaction capability, it will have an important competitive advantage.

III. DEVELOPING DYNAMICAL CAPACITIES TO IMPROVE THE VALUE OF CUSTOMERS

A total of four techniques to examining dynamical capacities: opposing forces, strategic disagreement, dependent on resources, and dynamically-capabilities.

Considering client demands and desires enables businesses to develop their consumer orientation. Following that, organizations may obtain an advantage over their competitors by adding value and surpassing consumer demands (Cepeda and Vera, 2007; Martelo Landroguez et al., 2011; Li and Liu, 2014). According to Martelo Landroguez (2011) theoretical frameworks, market approach positively impacts the value of customers.

- Understanding managing improves customer value.
- Effective management of client relationships enhances the value of customers.
- Customer relationship management and learning management have a mutual impact.

As anyone may observe from the connection, several characteristics have been extremely crucial in establishing value for consumers.

IV. MEASURING AND MANAGING OF PERFORMANCE

Assessment of performance results indicate how near we are to the company's objective degrees. Choosing specifications is extremely important. Depending on the importance of travertine in the company's operations, the indicators that might be measured must be properly defined. Whenever it is clear which procedures are bottlenecks, managing the infrastructure becomes easier, and this configuration yields successful and efficient outcomes.

Finally, measuring performance takes into account both the future and the present snapshots of what procedures produce. Performance oversight is supported through performance measurements, and they are

unable to evaluate independently. A correlation between cause-and-effect aids in defining the source of failures and determining their impact on the company. After identifying the roots, teams must analyse the theories, and continual enhancement may be achieved through systems thought (Lebas, 1995; Weerawardena and Mavondo, 2011). Lebas (1995) investigated performance assessment along with management in depth. In accordance with the report, understanding performance assessment is a very complicated and unpleasant topic. There isn't always unanimity on what constitutes performance. The previous notion was closely tied to expenses and money. Financial outcomes were used to assess process or organizational effectiveness. However, this does not constitute the right method of measuring performance.

V. CONCLUSION

Management procedures are a critical concept that is relevant to many academic fields. It is necessary to conduct interdisciplinary empirical investigations to have a better knowledge of these methods of management. Managing procedures overlap several management professions. The business procedure method appears to be so successful because it focuses not only on actions, but also on how these operations are interrelated to achieve effective and efficient outcomes. Recognizing all the factors or elements that influence and determine how managerial actions and procedures are carried out. Companies want to provide an improved understanding of the management process, including its nature, framework, and substance. Management procedures support dynamic capabilities, which indicate an organization's capacity to swiftly and with minimal disturbance extend, integrate, construct, change, and rearrange its supply of resources.

Scientists have long argued for a greater awareness of how organisations endure and thrive. One of the biggest mistakes is viewing the managing process as another-dimensional. Most researches appear to concentrate solely on a particular process, ignoring the multifaceted structure that includes management phases. The investigation reveals that the success of management processes is linked to the execution of interconnection and organisation of managerial systems, as well as the long-term performance.

The research demonstrates that management activities take place in a complicated and unpredictable situation. To avoid this predicament, managerial procedures must strive for an equilibrium of steadiness and rapid change. This situation contributes to an organizational learning architecture that resolves disputes and sentiments in a sequential way. In the research, everyone attempted to address what exactly is governmental procedure, the manner in which managerial procedures impact productivity, what's currently the significance of dynamic abilities for organizations along with what exactly is the relationship involving dynamically abilities and management procedure.

Lastly, the answers of the issues attempt to get a deeper knowledge of the management process aspects that impact effectiveness and support dynamic capacities. To sum up, the study is attempted to provide a better grasp of the complicated and multifaceted framework of management processes.

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Random vs. SMOTE Oversampling: Which Enhances Bankruptcy Prediction More?

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Abstract – To address class imbalance, this article focuses on data resampling techniques, specifically SMOTE and random sampling. Using a neural network model, both financial and nonfinancial variables were included. To identify companies with state obligations and to denote companies with payment orders, binary variables were included. The dataset was categorized by company size, excluding entities exceeding SME thresholds to focus on smaller firms. Four financial ratios—quick liquidity, financial account to total assets ratio, debt burden, and self-financing ratio—were included, and they were standardized and subjected to winsorization. The data were divided into training (2013-2016), validation (2017), and testing (2018) sets. While achieving a high accuracy of 99.90%, the Original Data Model failed to detect any positive cases (sensitivity 0%) due to class imbalance. In contrast, the SMOTE Model significantly improved sensitivity to 77.01% and achieved an AUC of 90.60%, though with a reduced accuracy of 85.42%. The Random Oversampling Model slightly outperformed the SMOTE Model in sensitivity (80.46%) and maintained a high AUC of 90.09%, with an accuracy of 85.10%. Thus, the Random Oversampling Model demonstrated the best overall balance, effectively identifying positive cases and distinguishing between classes, making it the most effective for predicting company insolvency.

Keywords – oversampling, bankruptcy, SMOTE, random oversampling, default, neural network

I. INTRODUCTION

Prediction models for business failure are important in finance, particularly in the risk management domain. They provide crucial insights into the stability and financial health of enterprises. In the face of diverse challenges emanating from both internal and external milieus during their operations, a precise evaluation of the financial status stands capable of aiding stakeholders such as investors, creditors, and concerned entities in alleviating potential financial hazards when formulating investment strategies. Models predicting corporate default leverage statistical methodologies and machine learning approaches to gauge the influence of ratio-based financial metrics on other quantitative or qualitative company performance indices. By examining a diverse set of financial data gathered from income statements, balance sheets, and financial markets, these models prioritize identifying indicators indicating the probability of financial instability. The research delves into the risk determinants of corporate collapse among small and medium-sized enterprises engaged in business activities in Slovakia, focusing on the comparison of random and SMOTE oversampling methods. To effectively anticipate corporate failure, it is essential to evaluate a range of financial indicators from different categories that can provide valuable insights into the company's financial health. Drawing from prior research [1], that identified a set of indicators that demonstrated efficacy in forecasting corporate insolvency based on previous empirical studies. For his research, he selected a list of 22 potentially useful ratios divided into five standard

categories: liquidity, indebtedness, profitability, activity, and market indicators. We assume that an increased level of liquidity reduces the probability of a firm's financial difficulties [2, 4, 6, 14, 22, 25, 31]. Furthermore, studies indicate that a high proportion of own resources leads to the financial stability of the company [7, 16, 29]. Previous studies in the field of company failure prediction have shown that a lower failure rate is linked to higher profitability indicators [1, 9, 12, 20, 23, 25] Nevertheless, it is important to note that while profitability indicators are highly predictive, their effectiveness may vary based on the specific circumstances and when considered alongside other financial indicators [19]. Activity ratios measure the effectiveness of a company in utilizing its assets to generate revenue. Higher activity ratio can notably decrease the likelihood of insolvency, indicating that the proficient utilization of a company's resources can enhance its financial stability [20]. This finding is further supported by various other studies [8, 24], which also affirm that activity indicators have a significant and negative influence on the likelihood of company failure. Keasey and Watson [18] were among the first to conduct a study that integrated non-financial variables into failure prediction models for SMEs. Several subsequent research works have delved into this area, affirming the significant impact of non-financial factors specific to the company on enhancing the overall predictive capability. These insights have proven to be valuable, aiding in decision-making processes that influence the risk of corporate failure [3, 10, 11, 27].

Multiple literature reviews have indicated that neural networks (NNs) have generated significant interest in the examination of corporate failure, as they have consistently displayed superior classification results. Gissel et al. [13] propose in their analysis of corporate bankruptcy research that multivariate discriminant analysis and neural networks exhibit the highest accuracy among all existing models. Furthermore, another systematic review of bankruptcy prediction models from 1968 to 2017, revealed a surge in research on bankruptcy prediction following the 2008 global financial crisis [26]. The findings underscored that logistic regression and neural networks are the most prevalent predictive models utilized. A comparative study of Support Vector Machine (SVM) and ANN models, which employed dimensionality reduction via principal component analysis (PCA) and the SMOTE resampling technique, underscored the efficacy of neural networks in achieving high accuracy in forecasting corporate bankruptcy [15, 19, 28]. The aim of this article is to apply selected financial ratios and other variables in order to predict the bankruptcy of SME companies operating in Slovakia with a focus on addressing the imbalances in the data set using two oversampling methods. The utilization of synthetic minority oversampling techniques (SMOTE) and random oversampling to balance class distribution is expected to enhance the accuracy of the bankruptcy prediction model.

II. Materials and Method

The studied dataset encompasses information from 168,252 enterprises that were operating in Slovakia over the period of 2013 to 2018. Alongside data extracted from profit and loss statements and company financial records, the dataset encompasses various non-financial attributes deemed significant determinants of company insolvency, as highlighted in the existing literature. Utilizing the existing data, a binary variable was formulated during the analysis to identify companies with obligations to state entities throughout the monitoring period, such as debts to health or social insurance institutions, tax liabilities, or other dues to the state. Complementing the identification of payment reliability, a secondary binary variable – payment order was established. A payment order denotes a judicial decision issued without a hearing. It can notably enhance the precision of default prognostication models by shedding light on firms' cash flow and payment behavior [5]. Moreover, companies were categorized based on size following the criteria stipulated by the European Commission, which consider factors including employee count, turnover, and total assets. Entities surpassing the SME thresholds were excluded from the examination. Prioritizing smaller firms can yield numerous benefits, primarily owing to the distinct attributes and financial practices of smaller establishments in contrast to larger ones, with the financial fragility of SMEs differing from that evident in big corporations [17]. Lastly, informed by prior studies and the provided literature, four financial parameters from four categories—liquidity, indebtedness, profitability, and activity—were identified. Namely, quick liquidity, the ratio of financial account to total

assets, debt burden, and the degree of self-financing ratio, derived from the dataset comprising profit and loss statements and financial records of companies; subsequently, variables were subject to winsorization at the 95th and 5th percentiles, and standardization of independent variables. The selected data were segregated into three subsets: training, validation, and test samples. The training dataset spans from 2013 to 2016, the validation set pertains to 2017, and the testing dataset encompasses year 2018. Table 1 provides a detailed overview of the distribution of used data.

Table 1. Overview of used Data

	Year	Defaulted	Non-defaulted	SUM
Training Set	2013	232	90690	90922
	2014	205	102003	102 208
	2015	157	100533	100 690
	2016	153	104021	104 174
	Sum	747	397247	397994
	Sum (SMOTE and Random Sampling)	397247	397247	794494
Validation Set	2017	107	99080	99 187
Test Set	2018	87	90725	90 812

Source: Authors' work

To eliminate the disparity between the quantity of unsuccessful and successful firms (168,252 firms and 941 failed), we employed the data resampling method (SMOTE) and random sampling within the training dataset. SMOTE is a sophisticated technique for oversampling designed to address issues with imbalanced class distributions, where one class is notably more prevalent than other. These disparities can lead to biases against the majority class in the model, diminishing the classification performance for the minority class. Consequently, SMOTE enhances the model's capacity to predict defaults accurately [2; 15, 19, 28, 30]. In contrast to simple oversampling approaches replicating existing samples, the SMOTE algorithm creates new synthetic data patterns by employing linear interpolation between minority class samples and their nearest k-neighbors, thus effectively improving class distribution equilibrium. The process entails the selection of a subset of minority class samples, followed by identifying their nearest neighbors within the same class. Subsequently, a synthetic sample is generated by choosing one of these neighbors and producing a sample at a random position in the feature space [21].

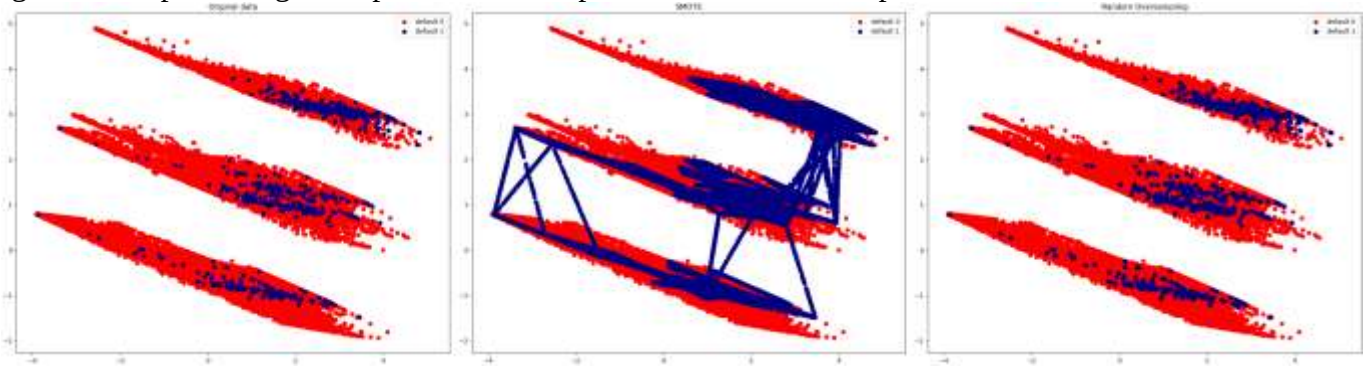

Fig. 1 Class Distribution: Original vs. SMOTE vs. Random Oversampling
Source: Authors' work

This procedure is crucial for tackling class imbalance issues where one category is notably more prevalent than the rest, intending to readjust training data distribution by increasing the number of instances attributed to the minority class.

The input data for the neural network model were standardized and resampled using SMOTE and random sampling, with each epoch presenting cross-sectional data for training. The network comprised fully connected layers using the ReLU activation function. The output layer utilized a sigmoid activation function for binary classification. The training process incorporated an adaptive learning rate via exponential decay. It employed a dropout layer and early stopping to prevent overfitting, with the model's performance evaluated using metrics like accuracy, AUC, and sensitivity.

III. RESULTS

The company employees were categorized into four groups as part of the examination. A visual representation of the firms at risk of insolvency, segmented by labor force data range, is presented in Figure 2.

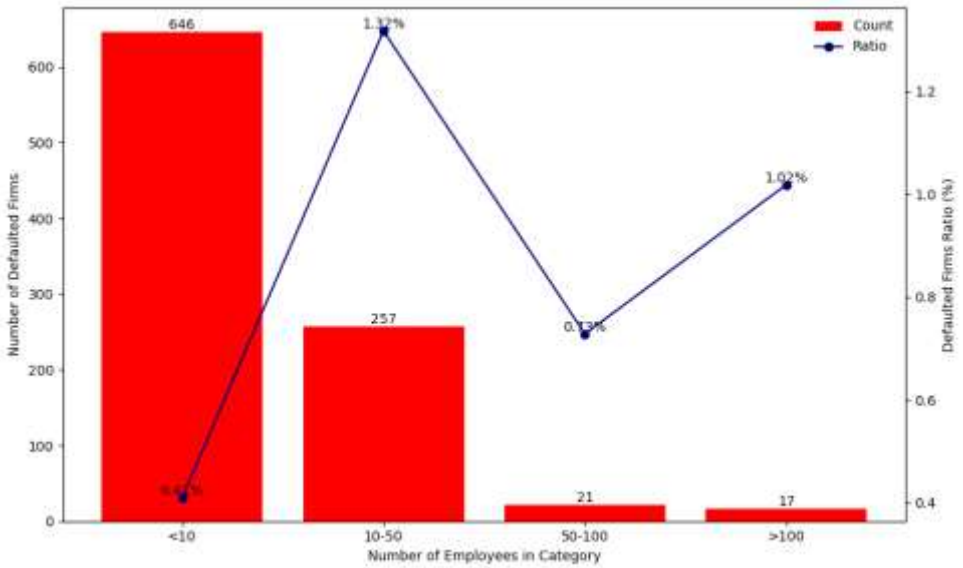

Fig. 2 Defaulted Firms by Employee Count Category
Source: Authors' work

The highest number of failures (646) was documented in companies with fewer than 10 employees. A blue line graph is exhibited on the secondary axis to illustrate the proportion of failed firms in each group relative to their total. Ratio analysis underscores the varying failure rates across different staffing brackets. While the group with less than 10 employees experienced the most failures, it is noteworthy that this group, with the largest number of active firms, has the lowest percentage of failed companies (0.14%). The following category, with a failure rate of 1.32%, emerges as the riskiest. The figure 2 underscores the significance of integrating the count of employees into the insolvency forecasting framework, owing to its ability to mirror the company's operational scope, market competitiveness, and financial robustness. Moreover, as Table 2 shows, a significant number of defaulted companies with payment orders and liabilities to the state institution were recorded.

Table 1. Overview of Number of Observation of Binary Variables

Binary Variable	Value = 1[1]	Value = 0
Micro Company	151 987	16 265
Small Company	13 369	154 883
Medium sized Company	2 896	165 356
Payment Order	13 676	154 576
Liabilities to State Institutions	30 455	137 797

Source: Authors' work

The Original Data Model attains remarkably high precision due to the imbalanced distribution of the dataset but ultimately fails in detecting any positive instances, as illustrated by a sensitivity of 0%. The AUC of 79.14 % implies that the model possesses some capacity to differentiate among categories, primarily driven by the high number of true negatives. The SMOTE Model exhibits a significant enhancement in sensitivity, signifying its superior ability to identify positive instances compared to the Original Data Model. The accuracy is lower than the Original Data Model, reflecting the trade-off with increased false positives. The AUC of 90.60 % signifies a strong capability in distinguishing between positive and negative categories.

[1] Value 1 indicates the presence.

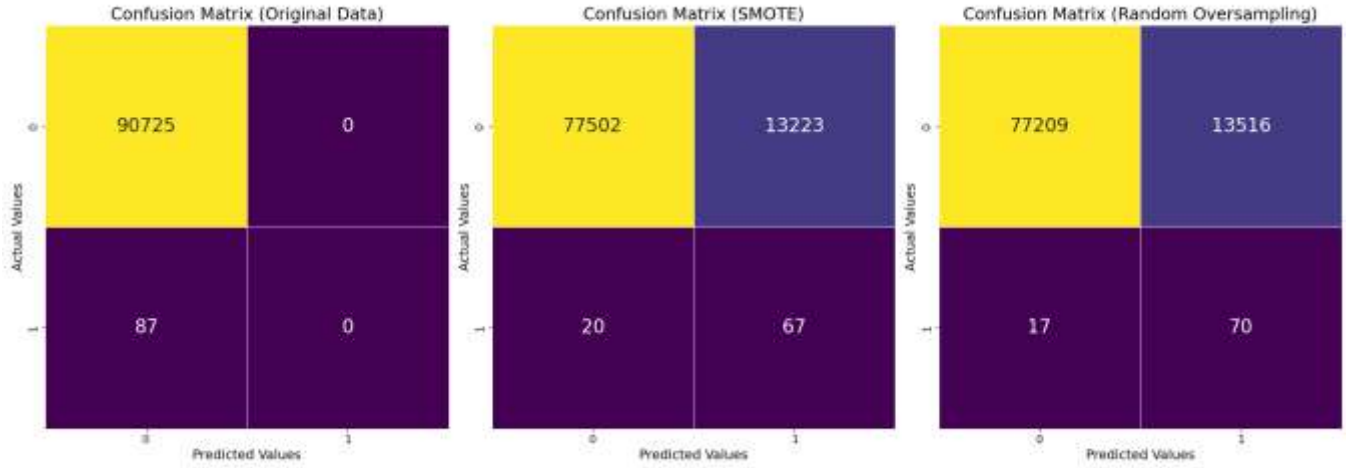

Fig. 3 Confusion Matrices
Source: Authors' work

The Random Oversampling Model has higher sensitivity in comparison to the SMOTE Model, pointing to a heightened detection rate of positive instances when oversampling randomly. The accuracy remains comparable to the SMOTE Model, showing a balanced trade-off. The AUC of 90.09 % suggests a slightly lower but still high performance in distinguishing between the classes.

Table 1. Evaluation of Neural Network Model Default Prediction with Metrics

	Original Data	**SMOTE**	**Random Sampling**
Accuracy	0,9990	0.8542	0.8510
Sensitivity	0.0000	0.7701	0.8046
AUC	0,7914	0.9060	0.9009

Source: Authors' work

IV. DISCUSSION

In data modelling, where the objective is to forecast outcomes accurately, assessing various models uncovers exciting findings. Our investigation commenced with the Original Data Model, renowned for its exceptional accuracy. Evidently, this model attained a remarkable accuracy of 99.90%. Nonetheless, a crucial drawback lay beneath this apparently flawless performance: the model could not identify any positive instances. With a sensitivity of 0%, it is evident that the Original Data Model is inadequate when trying to defect bankrupt companies. The high accuracy merely reflected its proficiency in predicting the dominant class accurately.

Therefore, this article compares the imbalanced data with SMOTE and randomly oversampled data to detect bankruptcy. SMOTE oversampling of our data pledged to improve the model's capacity to detect the minority class SMOTE oversampling of our data pledged to improve the model's capacity to detect the minority class with a sensitivity of 77.01%, a substantial enhancement over the Original Data Model which aligns with our assumption and previous studies [30, 2, 28, 15, 19]. It also exhibited a commendable AUC of 90.60%, indicating a robust ability to differentiate between positive and negative instances. However, the overall accuracy decreased to 85.42%. This trade-off underscored the model's increased false positives but signified noteworthy progress in identifying the crucial minority class.

The Random Oversampling Model, with a sensitivity of 80.46%, displayed an even superior performance in recognizing positive instances. The accuracy remained akin to the SMOTE Model at 85.10%. The AUC of 90.09% suggested that the model preserved a solid ability to differentiate between classes, nearly on par with the SMOTE Model.

V. CONCLUSION

While the Original Data Model excelled in accuracy, it lacked practical utility for imbalanced datasets due to its inability to detect positive instances. The SMOTE Model emerged as a potent alternative, substantially boosting sensitivity and AUC, thereby enhancing the identification of the minority class. Nevertheless, it was the Random Oversampling Model that achieved the best performance while predicting bankrupted companies.

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Deep Learning Approach Towards Satellite Image Classification

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Abstract – With the advancement of technology, satellites and satellite systems have become significant tools for humans. Satellites today have a wide range of applications, including communication systems, navigation systems, meteorological forecasts, remote sensing, and surveillance systems. The diverse and extensive use of satellites has led to increased focus on this field. In particular, advancements in imaging have facilitated the development of spy satellites and various aerial imaging systems. The images obtained by these advanced aerial imaging systems are utilized in numerous fields, such as urban planning and the agricultural industry. With the development of deep learning algorithms, image detection applications have become considerably easier. This study addresses the problem of image classification using deep learning algorithms trained on a dataset consisting of satellite images. The dataset used in the study comprises satellite images and includes 19 different classes. In the study, various deep learning methods were independently trained on the selected dataset, and their performances were compared. When evaluating the results obtained from the models, it was found that the VGG16 method had an accuracy of 0.817, while the DenseNet 201 method demonstrated a more successful performance with an accuracy of 0.875.

Keywords – Artificial Intelligence, Deep Learning, Image Classification, Satellite Images, VGG16, DenseNet201

I. INTRODUCTION

In recent years, advancements and developments in imaging technologies have enabled the acquisition of more detailed and higher quality images. Satellite imaging systems, in particular, are frequently utilized in areas such as urban planning, environmental protection, agriculture, and disaster management. The new image processing methods developed contribute to solving many problems in these fields [1]. In recent literature, advanced deep learning models have been integrated with imaging technology to conduct object and area detection studies [2]. The primary aim of this study is to classify satellite images using deep learning algorithms, compare the performance of these algorithms in classification, and analyze the data obtained from the classified images. The research utilized comprehensive satellite images covering 19 different land type classes. These classes include airports, beaches, bridges, commercial areas, deserts, farmlands, football fields, forests, industrial areas, meadows, mountains, parks, parking lots, ponds, ports, train stations, and many other distinct classes. By training on the diverse class types in the dataset, the ability of the models to distinguish between different land types is tested. For the satellite image classification application, VGG16 and DenseNet201 deep learning models were used. Both VGG16 and DenseNet201 are CNN models. CNNs, with their convolutional layers, extract feature maps, enabling them to detect even the most complex images. Each model was trained separately, and performance results were compared. Metrics such as accuracy, precision, recall, and F1-score were used for performance comparison, and each model was analyzed individually.

II. Materials and Method

A. *Materials*

In this study, WHU-RS19 dataset has been used. WHU-RS19 dataset obtained from Google Earth, which is openly accessible online and contains various terrain images, was used. This dataset consists of 19 classes, including images of airports, beaches, bridges, commercial areas, deserts, agricultural fields, football fields, forests, industrial zones, meadows, mountains, parks, parking lots, ponds, ports, train stations, residential areas, rivers, and viaducts. Each class contains approximately 50 samples, evenly distributed, resulting in a total of 1005 images. The image dimensions are 600 x 600 pixels. The dataset underwent preprocessing with resizing and normalization techniques. The total dataset was divided into 70% training and 30% validation data. The classification performance of deep learning models was examined. Metrics such as Accuracy, Recall, Precision, and F1 score were used to evaluate the model's success.

B. *VGG16*

VGG16 was developed by Simonyan and Zisserman in 2014 and introduced in their paper titled "Very Deep Convolutional Networks for Large-Scale Image Recognition" [3]. It is considered a foundational model for deep learning and is regarded as a milestone in image classification. As implied by its name, VGG16 is a deep neural network consisting of 16 layers. The VGG16 architecture is structured with five blocks containing 13 convolutional layers and 3 fully connected layers. Its layers comprise convolutional and pooling layers. Each convolutional layer utilizes 3x3 filters, while each pooling layer employs 2x2 max pooling operations. This configuration increases the model's complexity, allowing it to extract more effective features. The final layers include fully connected layers and a classification layer with a softmax activation function [4], [5].

Fig. 1 Structure of VGG16 [6]

C. *DenseNet201*

DenseNet201, recognized as innovative and pioneering in the field of deep learning during its time, is a densely connected neural network architecture. As the name suggests, it consists of 201 layers and utilizes intra-block connections more intensively compared to other neural networks. Each layer in its architecture is a convolutional layer that is directly connected to every preceding layer. This allows the output of each layer to be used as the input for the subsequent layer. This design facilitates the training of deep networks by achieving better performance with fewer parameters. To transition between densely connected blocks and reduce the input size, intermediate layers are employed [7-8], [10].

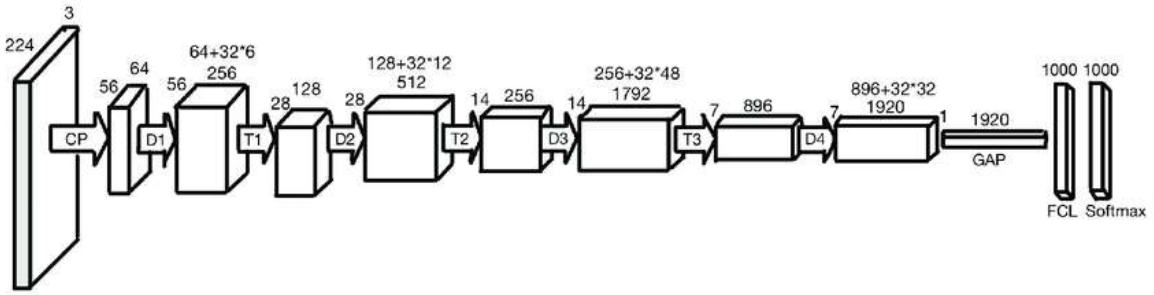

Figure 2. Structure of DenseNet201 [9]

D. Performance Evaluation Metrics

Confusion Matrix

A confusion matrix is used to evaluate the performance of a classification model. This matrix shows how well the model's predictions match the true class labels. Each cell in the table represents the number of instances for a specific predicted and actual class. The rows of the matrix represent the actual classes, while the columns represent the predicted classes, and the size of the matrix corresponds to the number of classes. Correct classifications are found on the diagonal cells of the matrix. Other cells indicate misclassifications. The confusion matrix comprises four key components. True Positives (TP) are instances that the model correctly classified as positive, meaning the model predicted positive and the actual class was positive. False Positives (FP) are instances that the model incorrectly classified as positive, meaning the model predicted positive but the actual class was negative. True Negatives (TN) are instances that the model correctly classified as negative, meaning the model predicted negative and the actual class was negative. False Negatives (FN) are instances that the model incorrectly classified as negative, meaning the model predicted negative but the actual class was positive. A sample confusion matrix is given in Figure 3 [11-12].

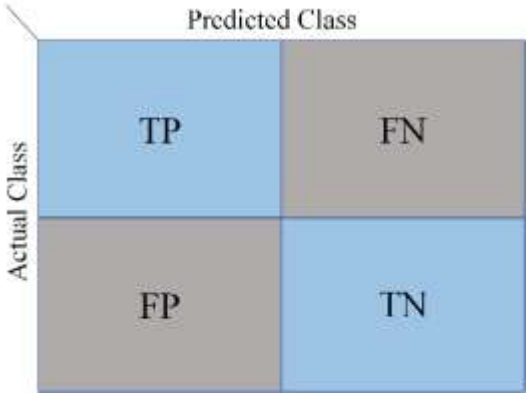

Figure 3. Confusion Matrix example [14]

Accuracy

Accuracy is a metric used to evaluate the performance of a classification model. It is obtained by the ratio of correctly classified instances to the total number of instances, as expressed by Equation 1. A high accuracy value indicates that the model generally performs well. However, accuracy alone is not a sufficient performance measure and should be evaluated in conjunction with other metrics [13].

$$\text{Accuracy} = \frac{\text{TP+TN}}{\text{TP+TN+FP+FN}} \qquad (1)$$

Precision

Precision expresses the ratio of truly positive instances among those predicted as positive by a classification model and is calculated using Equation 2. A high precision value indicates that the model's positive predictions are accurate. It is a critical measure in situations where false positive results are significant [13].

$$\text{Presicion} = \frac{TP}{TP+FP} \qquad (2)$$

Recall

Recall indicates the proportion of actual positive instances that are correctly predicted by the model. It is calculated as the ratio of true positives to the sum of false negatives and true positives. A high recall value shows that the model correctly predicts a large portion of actual positives. It is a crucial measure in scenarios where false negative results are significant and is obtained using Equation 3 [13].

$$\text{Recall} = \frac{TP}{TP+FN} \qquad (3)$$

F1-score

The F1-score is calculated by taking the harmonic mean of recall and precision values. It simultaneously evaluates the model's accuracy in making positive predictions and its ability to capture positive instances. A high F1-score indicates that the model is successful in both predicting true positives and making accurate positive predictions. It is a reliable performance measure for imbalanced datasets compared to the accuracy metric and is obtained using Equation 4 [13].

$$\mathrm{F1-Score} = 2 * \frac{Precision * Recall}{Precision + Recall} \qquad (4)$$

III. Results and Discussion

In this study, the performance of VGG16 and DenseNet201 models was examined using the WHU-RS19 dataset. The WHU-RS19 dataset consists of 1005 satellite images obtained from Google Earth, categorized into 19 different classes. The parameter values for each model are shown in Table 1. The most important features and trends in the results should be described clearly and concisely but should not be interpreted in detail.

Table 1. Parameters of DL Algorithms

	DenseNet201	**VGG16**
Layer Size	5	5
Model Nodes	7, 7, 1920	7, 7, 512
Epoch	150	150
Batch Size	32	32
Optimizer	adam	adam
Learning Rate	4e-7	2e-6
Dense	512, 19	512, 19
# of Neurons	2451	531
Loss Function	Categorical Crossentropy	Categorical Crossentropy
Dropout	0.5	0.5
Activation function	ReLU-Softmax	ReLU-Softmax

The DenseNet201 and VGG16 algorithms were trained separately on the dataset to classify the satellite images. The dataset was split into training and validation sets at ratios of 70% and 30%, respectively. An early stopping function was used to prevent overfitting. Metrics such as Accuracy, Precision, Recall, and F1-Score were employed to evaluate the models' performance. During the training phase, the validation loss and validation accuracy values of the models were recorded and are presented as graphs below.

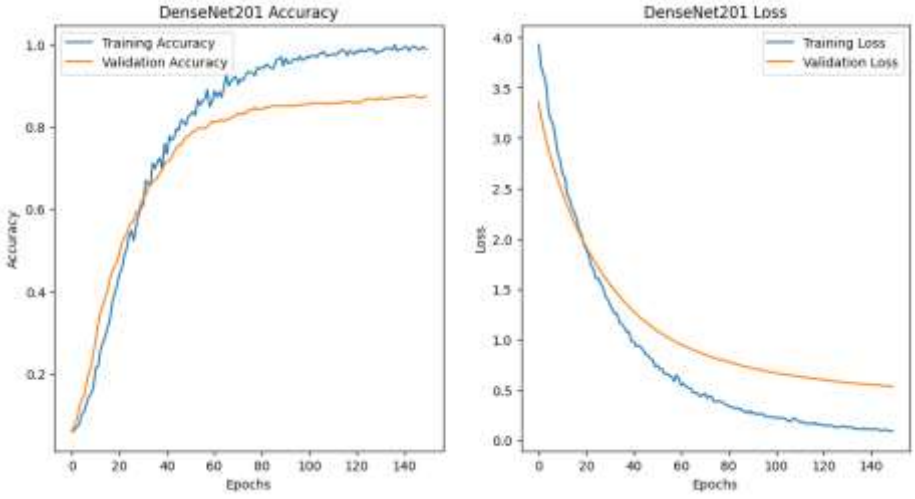

Figure 4. Graph of DenseNet201 Validation – Loss

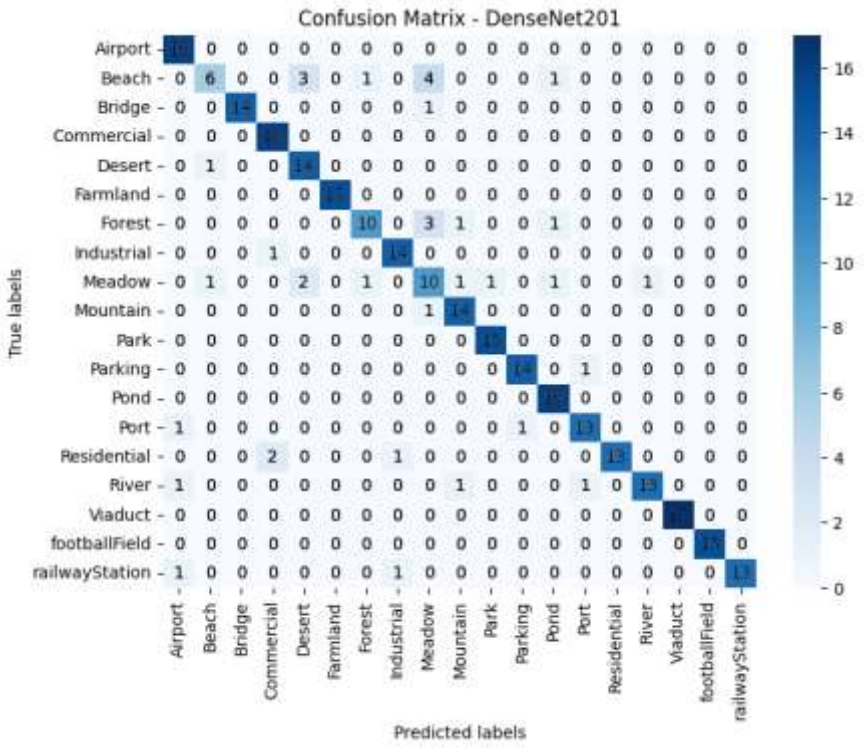

Figure 5. Confusion Matrix of DenseNet201

Figure 4 shows the Validation - Loss graph, and Figure 5 displays the Confusion Matrix for the DenseNet201 model. Upon examining the graph and the Confusion Matrix, it was observed that the DenseNet201 model demonstrated good training performance, while the validation performance was slightly lower than the training performance. This drop in validation performance led to lower performance in certain classes within the Confusion Matrix. It is anticipated that this decrease in validation performance could reduce the model's generalization capability.

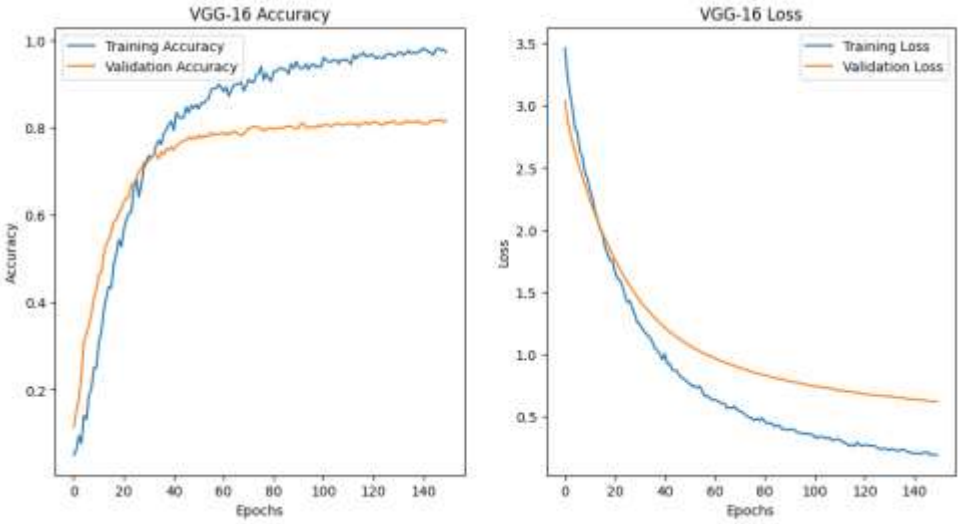

Figure 6. Graph of VGG16 Validation – Loss

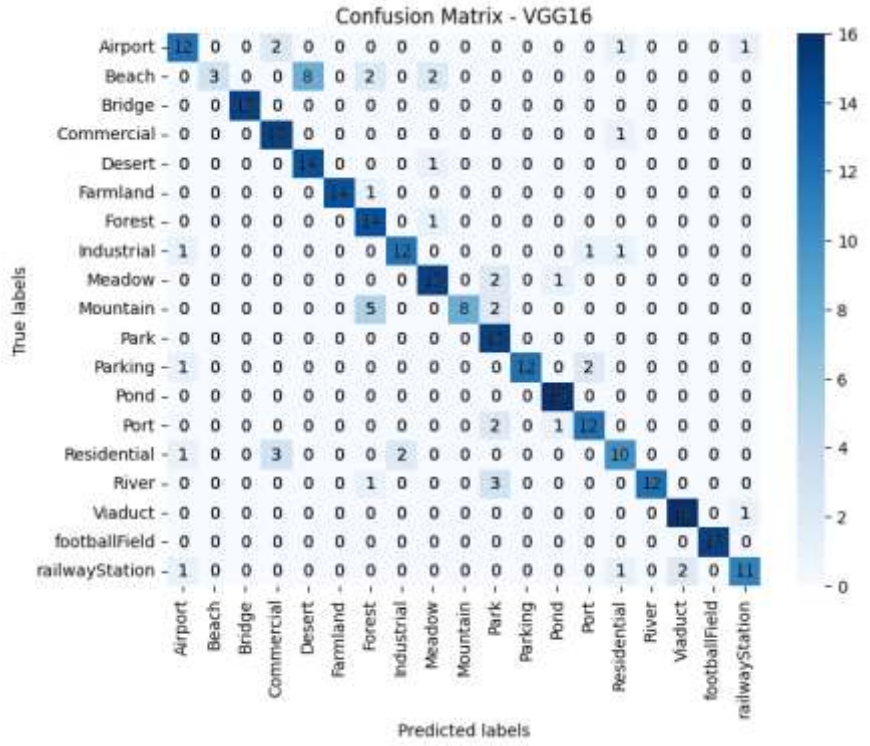

Figure 7. Confusion Matrix of VGG16

Figure 6 shows the Validation - Loss graph, and Figure 7 displays the Confusion Matrix for the VGG16 model,. Upon examining the graph and the Confusion Matrix, it was observed that the VGG16 model demonstrated good training performance, while the validation performance was slightly lower than the training performance. This drop in validation performance led to lower performance in certain classes within the Confusion Matrix. It is anticipated that this decrease in validation performance could reduce the model's generalization capability.

Table 2. Performance Comparisons of Deep Learning Algorithm

Method	Accuracy	Precision	Recall	F1 Score
DenseNet201	0.875	0.881	0.876	0.872
VGG16	0.817	0.850	0.816	0.806

Table 2 shows the performance comparison of the DenseNet201 and VGG16 models. In this context, it was observed that the training performance was higher than the validation performance when examining the Validation - Loss graph and Confusion Matrix for both models. As a result, the Accuracy value for the DenseNet201 model was 0.875, while for the VGG16 model, it was 0.817. It was also observed that the DenseNet201 model achieved higher results in metrics other than accuracy compared to the VGG16 model. These results indicate that the DenseNet201 model, with its deeper layer structure, produced better outcomes than the VGG16 model for the WHU-RS19 dataset, and these findings were shared.

IV. CONCLUSION

In this study, the VGG16 and DenseNet201 deep learning architectures were used for the classification of satellite images. The WHU-RS19 dataset contains 1005 images categorized into 19 different classes. The obtained results showed that the classification of satellite images plays a significant role in areas such as urban planning, disaster management, agriculture, and environmental monitoring. In future studies, different architectures, transfer learning techniques, and optimization algorithms can be explored. Additionally, expanding and diversifying the dataset could further enhance the model's performance. This study is expected to shed light on various fields, including satellite imaging technologies, disaster detection studies, urban planning, and environmental protection.

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ALTERNATİF BESİN KAYNAĞI: YENİLEBİLİR BÖCEKLER

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Özet – Yenilebilir böcekler son yıllarda dikkat çeken protein içeriğiyle geleneksel beslenmeye alternatif ve sürdürülebilir bir besin kaynağı olarak görülmektedir. 2 milyardan fazla insanın beslenmesinde yer almasına rağmen Batı kültüründe hâlâ yeni bir kavramdır. Gıda endüstrisinde farklı şekillerde kullanılan yenilebilir böcekler yapısındaki biyoaktif bileşikler sayesinde olası sağlık yararlarına sahiptir. Bunun yanı sıra alerjik etkisi ve mikrobiyal yükü açısında çok az tür EFSA tarafından yetiştirilebilir kabul edilmiştir. Toplumdaki böcek tüketimine olan ön yargıyı kırmak, tüketilebilirliği arttırmak için daha fazla çalışmaya ihtiyaç vardır. Bu yazıda yenilebilir böceklerin beslenmedeki yeri güncel araştırmalar ile ele alınmıştır.

Anahtar Kelimeler – Yenilebilir böcekler, entomofaji, protein, antioksidan, antiinflamatuar

1. GİRİŞ

Böcekler, 21. yüzyıl toplumları için sürdürülebilir bir besin kaynağı olarak görülmektedir. Çünkü insanların beslenme ihtiyacını karşılayabilirken, üretim sırasında besi hayvanlarından elde edilen et bazlı proteinlerin çoğundan daha az kaynak gerektirmektedir [1]. Yenilebilir böceklerin yetersiz beslenme ve açlığa neden olan geleneksel gıda tedarik zincirine bir alternatif olabileceği düşünülmektedir [2]. Çevresel göstergeler (arazi kullanımı, su ayak izi ve sera gazı emisyonları) yenilebilir böceklerin yem ve beslenme için geleneksel hayvancılığa kıyasla %40-60 daha düşüktür, dolayısıyla karbon ayak izini azaltmaktadır [3]. Özellikle tropikal bölgelerde 2000'den fazla böcek türü tüketilmektedir [4]. Böceklerin dünya çapında 2 milyardan fazla insanın beslenmesinin ayrılmaz bir parçası olmasına rağmen, 'böcek yeme' Batı kültüründe hâlâ yeni bir kavramdır. Ancak böceklerin gıda kaynağı olarak kullanılmasına ilişkin birçok belirsizlik vardır. Bu durum gıda endüstrisinde böcekler hakkında daha fazla bilgi edinmek amacıyla çok sayıda çalışma ve inceleme yapılmasına yol açmıştır [5]. Yenilebilir böcekler besin olarak iki ana biçimde tüketilebilmektedir; bütün böcek olarak veya çeşitli gıda ürünlerine bir bileşen olarak dahil edilerek [6]. Bazı böcekler besin değeri, protein içeriği ve amino asit profili nedeniyle fonksiyonel özellikleri ortaya konmuştur [2]. Böcek proteini üretimindeki son gelişmeler, böcek peptidlerinin antimikrobiyal, antioksidan ve antihipertansif aktivitesi gibi biyoaktif özelliklerinin araştırılması ve kullanılması için umut verici olduğu gösterilmiştir [7]. Hayvan ve insan çalışmalarında yenilebilir böceklerin trigliserit, kolesterol ve kan şekeri seviyelerini düşürdüğü, mikrobiyota çeşitliliğini arttırdığı, iltihabı azalttığı, esansiyel ve dallı zincirli amino asitlerin kan konsantrasyonlarında artışa neden olduğuna ulaşılmıştır [3]. Bazı kanıtlar ise yenilebilir böceklerin, protein eksikliğinin ardından ortaya çıkan yetersiz beslenmeyi tedavi etmek için kullanılabileceğini öne sürmektedir. Bununla birlikte, yenilebilir böceklerin terapötik bir gıda takviyesi olarak potansiyelini ve bunların yetersiz beslenmenin iyileşmesi üzerindeki uzun vadeli etkilerini daha iyi değerlendirmek için ek çalışmalara ihtiyaç vardır [8].

Bu yazıda yenilebilir böceklerin beslenmedeki yeri güncel araştırmalar ışığında ele alınmıştır.

2. DÜNYADAKİ YENİLEBİLİR BÖCEK TÜRLERİ

Böcekleri tüketimi uygulaması olan entomofaji, eski bir beslenme yöntemidir. Çoğunlukla daha düşük ekonomik düzeylerle sınırlı kalmıştır. *Arthropoda filumunun* üyeleri olan böcekler, yaşam döngülerinin kısa olması, devir hızı ve biyokütle dönüşüm oranının yüksek olması nedeniyle oldukça umut verici görünmektedir. Hepsi olmasa da arılar, sinekler, çekirgeler, ağustosböcekleri, termitler, karıncalar, tırtıllar, su böcekleri, böcek larvaları, cırcır böcekleri, yusufçuk gibi bazı böcekler protein, yağ ve mineral bakımından zengindir, toksik değildir [9].

3. YENİLEBİLİR BÖCEKLERİN BESİN BİLEŞİMİ

Dünyanın birçok yerinde geleneksel bir gıda olan böcekler, oldukça besleyici ve özellikle protein açısından zengindir. Bu nedenle potansiyel bir gıda ve protein kaynağı olarak görülmektedir. Veriler arasında büyük farklılıklar gösterse de birçok yenilebilir böceğin yeterli enerji ve protein sağladığı, insanlar için amino asit gereksinimlerini karşıladığı, MUFA ve/veya PUFA bakımından yüksek olduğu, bakır, demir, magnezyum, manganez, fosfor, selenyum ve çinko gibi çeşitli mikro besinlerin yanı sıra riboflavin, pantotenik asit, biyotin ve bazı türlerinde folik asit bakımından zengin olduğu sonucuna varılmaktadır. Alerjenik ve toksik maddelerin yanı sıra antinutrientlerin olası içeriği ve patojenlerin varlığı yer almaktadır. Yenilebilir böceklerin beslenme potansiyelinin kapsamlı bir şekilde değerlendirilmesi için daha fazla veriye ihtiyaç vardır. Gıda güvenliğini sağlamak için uygun işleme ve dekontaminasyon yöntemleri geliştirilmelidir [10]. Yapılan bir çalışmada yenilebilir 107 böcek türü, besin değerleri ve biyoyararlılıkları açısından incelenmiştir. Beş kara ve su böceği türünün analizi yapılmıştır. Çekirge (*Sphenarium purpurascens)*; 71,50 protein, %5,75 yağ, %2,5 mineral, %3,89 lif, %16,36 çözünebilir karbonhidrat içermektedir. Chicatana karıncası (*Atta Mexicana B*); %66,00 protein, %24,02 yağ, %3,00 mineral, %2,06 lif, %4,92 çözünebilir karbonhidratlar içermektedir. Maguey kurdu (*Aegiale hespheriaris K*); %30,88 protein, %58,55 yağ, %2,29 mineral, %0,12 lif, %8,16 çözünebilir karbonhidrat içermektedir. Escamol karınca yumurtası (*Liometopum apiculatum H);* %40,90 protein, %33,96 yağ, %7,58 mineral, %1,3 lif, %16,26 çözünebilir karbonhidrat içermektedir. Ahuahutle sivrisinek yumurtaları (*Krizousacorixia azteca J* ve diğer türlerin karışımı); %53,60 protein, %4,33 yağ, %21,00 kül, %3,00 lif, %18,07 çözünebilir karbonhidrat içermektedir. Böcekler iyi bir besin değerine sahiptir ve tüm temel amino asitleri içeren protein bakımından yüksektir [11].

4. YENİLEBİLİR BÖCEKLERİN OLASI SAĞLIK YARARLARI

Yenilebilir böcekler, besin içerikleri nedeniyle sağlıklı, sürdürülebilir alternatifler olarak hizmet etme potansiyeline sahiptir. Yenilebilir böcekler, yüksek düzeyde B12 vitamini, demir, çinko, lif, esansiyel amino asitler, antioksidanlar, omega-3 ve omega-6 yağ asitleri nedeniyle sağlık yararlarına sahip olabileceği düşünülmektedir [12].

4.1 YENİLEBİLİR BÖCEKLERİN ANTİHİPERTANSİF ÖZELLİKLERİ

Vercruysse ve ark. (2005), çeşitli enzimler (gastrointestinal proteazlar, alkalaz ve termolisin) tarafından hidrolize edilen böcek proteinindeki anjiyotensin dönüştürücü enzim (ACE) inhibitör aktivitesini ilk kez rapor etmiştir. Çalışmada *Spodoptera littoralis* (Lepidoptera), *Bombyx mori* (Lepidoptera), *Schistocerca gregaria* (Orthoptera) ve *Bombus terrestris* (Hymenoptera) olmak üzere 4 farklı böcek türü incelenmiştir. Hidrolize edilen böcek proteininin, ACE inhibitör aktivitesinin artmasına neden olduğu sonucuna varılmıştır. Genel olarak en yüksek ACE inhibitör aktivitesi gastrointestinal sindirimden sonra elde

edilmiştir. Bu sonuçlar, fonksiyonel gıdalar ve nutrasötiklerde antihipertansif bileşen olarak böcek proteininin rolünü ortaya koymaktadır [13]. Yapılan başka bir çalışmada ise böcek proteininden (*Spodoptera littoralis ; Lepidoptera)* saflaştırılan ve *in vitro* ACE inhibitör etkisi gösteren tripeptit Ala-Val-Phe'nin biyoyararlılığını ve *in vivo* antihipertansif aktivitesini değerlendirilmiştir. Çalışma sonucunda böcek proteininden türetilen peptitlerin *in vivo* olarak antihipertansif aktivitesine ilişkin ilk rapor elde edilmiştir [14]. Son yıllarda yapılan çalışmalarda da *Coleoptera, Diptera, Hymenoptera, Lepidoptera* ve *Orthoptera* takımlarına ait böcek türlerinden elde edilen protein hidrolizatlarında ACE inhibitör aktivitesi tespit edilmiştir. Daha ileri araştırmalar ipekböceği *Bombyx mori (Lepidoptera: Bombycidae)*, sarı un kurdu *Tenebrio molitor (Coleoptera: Tenebrionidae)*, pamuk yaprak kurdu *Spodoptera littoralis (Lepidoptera: Noctuidae)* ve ayrıca dokumacı karınca *Oecophylla smaragdina'dan (Hymenoptera: Formicidae)* spesifik ACE inhibitör peptitlerin tanımlanmasına yol açmıştır [15] .

4.2 YENİLEBİLİR BÖCEKLERİN ANTİİNFLAMATUAR ÖZELLİKLERİ

Yenilebilir böcekler, sitokinleri azaltan ve spesifik transkripsiyon faktörlerini modüle eden antiinflamatuar aktivite sergilemektedir [16] . Biyolojik çalışmaların sonuçları, Çin siyah karıncalarının antiinflamatuar, immünosüpresif ve böbrek koruyucu aktiviteler sergileyen bileşikler içerdiğini göstermektedir [17]. Yapılan bir çalışmada kriket proteini hidrolizatlarının *in vitro* gastrointestinal sindirimlerinden elde edilen antihipertansif, antiglisemik ve antiinflamatuar peptitlerin tanımlanması amaçlanmıştır. Çalışma sonucunda katyonik peptit fraksiyonu, *in vitro* alfa-amilaz, alfa-glukosidaz ve anjiyotensin dönüştürücü enzim (ACE) aktivitesini önemli ölçüde azaltmıştır ($p < 0.05$) ve ayrıca RAW 264.7 makrofaj hücrelerinde NF-κB ekspresyonunu inhibe etmiştir [18]. Başka bir çalışmada kriketten *(Gryllus bimaculatus* , Gb) elde edilen glikozaminoglikanın (GAG) antiinflamatuar etkisinin, kronik artrit dahil inflamatuar hastalıkların tedavisinde faydalı olabileceği düşünülmektedir [19].

4.3 YENİLEBİLİR BÖCEKLERİN ANTİOKSİDAN ÖZELLİKLERİ

Yenilebilir böcekler potansiyel bir antioksidan içerik kaynağını temsil etmektedir. Çalışmaların çoğunda böceklerin oksidatif stresi azaltma, antioksidan durumunu modüle etme, antioksidan enzimlerin bozulmuş aktivitesini onarma ve oksidatif hasar belirteçlerini azaltma yeteneğini gösterdiği ortaya konmuştur [16]. Yapılan bir çalışmada ticari olarak temin edilebilen 12 yenilebilir böcek ve iki omurgasızdan elde edilen su ve yağda çözünebilen ekstraktların *in vitro* antioksidan etkisi araştırılmıştır. Sonuçlar, çekirge, ipekböceği ve cırcır böceğinin suda çözünür özlerinin, taze portakal suyundan 5 kat daha yüksek bir antioksidan kapasite (TEAC) değeri sergilediğini gösterirken, akşam ağustos böceği, dev su böcekleri, Tay zebra tarantulası ve kara akreplerin antioksidan kapasitesinin (TEAC) en yüksek değerlerini sergilediğini göstermektedir [20]. Vanqa ve ark. (2022) 3 tane yenilebilir böcek **(***Gonimbrasia belina, Hermetia illucens, Macrotermes subhylanus*) unu üzerine yaptığı bir çalışmada yenilebilir böcek unlarının iyi bir antioksidan kaynağı olduğunu ve tekno-fonksiyonel nitelikleri nedeniyle alternatif bir protein kaynağı ve potansiyel yeni bir gıda katkı maddesi olarak kullanılabileceğini ortaya koymuştur [21].

5. BÖCEK TÜKETİMİNDE RİSKLER

EFSA'nın olumlu risk değerlendirme raporunun ardından, 2015/2283 sayılı Yeni Gıdalar Yönetmeliğinde belirtilen önlemler kapsamında Avrupa Birliği'nde çok az tür yasal olarak yetiştirilebilir kabul edilmiştir [22]. Yapılan bir çalışmada seri üretim sistemleri için umut vadeden yenilebilir böcek türlerinde birçok farklı virüs türü tespit edilmiştir. Bu virüsler, toplu böcek yetiştirme sistemleri için akut yüksek ölüm oranına, gençlik evrelerinde büyümede ve yetişkinlerin üreme performansında ciddi bir düşüşe neden olarak risk oluşturabilmektedir [23]. Bununla birlikte, yapılarında anti-besinlerin baskın olduğu fitokimyasallar da içermektedir. Bu fitokimyasallar yüksek miktarlarda veya uzun süre tüketildiğinde

alerjik reaksiyonlarla veya besin canlılığının azalmasıyla insanları olumsuz yönde etkileyebilir. Ancak oluştukları dozlar gıdalardaki limitlerin çok altındadır. Ayrıca fırında kurutma ve yağdan arındırma yöntemleri gibi işlemlerde anti-besin seviyeleri önemli ölçüde azalır [24]. Isıl işlem, alerjenik riskten sorumlu proteinlerin en azından bazılarının alerjenitesini azaltır, ancak tamamen ortadan kaldırmaz. Mikrobiyolojik tehlikeleri kontrol etmek için böceklerin insan tüketimi için yetiştirilmesi, işlenmesi ve pazarlanması sırasında uygun hijyen önlemleri uygulanmalıdır [25].

6. SONUÇ

Yenilebilir böcekler insanların besinsel ihtiyaçlarını karşılayabildiği ve çeşitli fonksiyonel özellikleri nedeniyle günümüzde sürdürülebilir bir besin kaynağı olarak görülmektedir. Yapılan çalışmalarda özellikle yenilebilir böceklerin yüksek protein içeriğine dikkat çekilmiştir. Böcek peptidlerinin antiinflamatuar, antioksidan ve antihipertansif gibi biyoaktif özellikleri araştırılmıştır. Olumlu sağlık etkilerinin yanı sıra olası riskler göz önünde bulundurulmalıdır. Gıda güvenilirliği açısından daha fazla çalışmaya ihtiyaç duyulmaktadır.

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Mating behavior and a new host of *Rhinusa tenuirostris* (Stierlin, 1888) (Coleoptera, Curculionidae) from field observations

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Abstract – *Rhinusa tenuirostris* (Stierlin, 1888) (Coleoptera, Curculionidae) is a member of *R. tetra* group complex. Members of this group generally feed on *Verbascum* spp. Previous studies reported only "flat-margined mullein" *Verbascum gaillardotii* Boiss. as host of this species. We discovered that *R. tenuirostris* has a new host and can be a potential biocontrol agent of the *Verbascum phrygium* Bornm. (Scrophulariaceae). Additionally its distribution in Türkiye is now expanded to West Anatolia with recording from Isparta province. Interesting mating behavior of female *R. tenuirostris* is provided and related with physiology of spermatheca. This behavior observed in the aforementioned insect reminds us that taxonomically complex groups can be differentiated more clearly by utilizing their behavioral characteristics if any.

Keywords – Rhinusa tenuirostris, Verbascum phrygium, new host, mating behavior, Isparta, Türkiye

I. INTRODUCTION

Weevils (Curculionoidea) represent one of the most diverse groups of beetles in the world. Roughly 62,000 described species comprise about 15.5% of the approximately 400,000 species of beetles currently described worldwide [1, 2].

The genus *Rhinusa* Stephens, 1829 is comprised of approximately 50 named Palearctic species [3, 4]. All known species of *Rhinusa* utilize Plantaginaceae and Scrophulariaceae species as host plants [4, 5].

There is so much behavior studies about Curculionidae [6, 7, 8, 9, 10, 11] but not a record on behaviour of the *R. tenuirostris*, also very little known about the host choices of the species.

Aim of the current work is to find out the mating behaviour characters of *R. tenuirostris* and connect it with physiological traits of spermatheca.

Additional host species found in Isparta province provide a valuable information about diversification of this group and the mating behaviour will be helpful in resolving the taxonomical complication of *R. tetra* complex. Türkiye is very rich for the endemic *Verbascum* species, main host plants of *R. tetra* complex.

Also, these findings may add useful information to enhance behaviour based control strategies.

II. Materials and Method

Insect materials of *R. tenuirostris* were collected from Isparta province on *V. phyrgium* species between June-July 2022, and their videos were recorded for behavioural analysis.

Taxonomic studies were carried out under binocular microscope, and photographs of both the species and female genitalia (Fig. 1) were taken by using a trinocular microscope with a digital camera. The identification of the mullein was done by following the key of Davis (1984) by Prof. Dr. Hasan ÖZÇELİK (Fig. 2); *R. tenuirostris* was identified following redescriptions [12] and female genitalia [13].

Fig. 1 Spermatheca, dorsal and lateral view of *R. tenuirostris*

Fig. 2 New host plant of *R. tenuirostris*, identified as *V. phyrgium* Bornm.

III. Results

Mating behavior is typically viewed as comprising all events from pair formation through courtship to the final breakup of the mating pair [14]. The general context of this behaviour can be analyzed in three phases; before copulation, copulation and after copulation [14]. First phase is about gathering information about gender, possible benefits and readiness, competition, perform movements to have proper position. While coupling, physiological mechanisms such as the shape of genitalia, synchronize the behaviour of the sexes and form characteristic movements. The last phase is about uncoupling and terminate mating.

In insects the potential for paternity competition is high because females typically mate with more than one male and store their long-lived sperm in specialized organs. Female adaptations include fertilization biases caused by moving favored ejaculates [14]. The movement of female *R. tenuirostris* from side to side while copulation phase can be probably one of the fertilization adaptations to store more ejaculates. Because of the female spermatheca of the species is heavily chitinous and merely connected with muscle tissue to help storing ejaculates.

The vast diversity and complexity of insect genitalia may result from these processes: species with multiple-mating females are known to have more complex male genitalia than species in which females mate only once[14]. The male genitalia of *R. tenuirostris* is not complex.

Another interesting finding about the *R. tenuirostris* is hiding inside petals of not fully bloomed flowers of *V. phyrgium* at temperatures higher than 30℃. The species start mating at early morning after sunrise and approximately two hours before sunset (Fig. 3).

Fig. 3 *R. tenuirostris* hiding within the flowers of *V. Phyrgium.*

IV. DISCUSSION

The difficulties encountered in taxonomic studies can be overcome with various laboratory studies. However, an important method for identifying complex taxa under field conditions and studying their relationships with their hosts is the observation of identified behavioural characters such as mating behaviours. R. tenuirostris females represent an important copulation behavior; moving body side to side. This behaviour can be related to mating success by enhancing ejaculate storage. More detailed physiological studies must be done to reveal if this hypothesis is true or false. And also, the strength of male is tested by this behaviour. This can be another selective force for the future of the generations.

Another fact that *R. tenuirostris* adults are hiding in flowers at a temperature of around 30℃ during the day may be an ecological indicator that the origins of the species may be linked to a temperate region. It can also be assumed that the species is undergoing an adaptation process to climate change.

The *R. tetra* complex is utilizing *Verbascum* species and Türkiye is the center for endemism of this host genus [15]. Speciation may not be coincidential for this complex group in Anatolian region.

V. CONCLUSION

After learning more about behavioural traits of insects, it would be easier to identify them on their habitats. This will add to the host preference knowledge. Additionally we can control their host

populations by manipulating insect populations which feed and reproduce on them without chemical applications.

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İstatiksel Proses Kontrolünde U Kontrol Grafiğinin Kullanımı ve Savunma Sanayiinde Bir Uygulama

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Özet **–** İş dünyasında rekabetin artmasıyla birlikte, firmaların sürekli olarak gelişme göstermesi ve ürün kalitelerini iyileştirmesi kaçınılmaz hale gelmiştir. Bu süreçte, istatistiksel kalite kontrol teknikleri önemli bir rol oynamaktadır. Bu teknikler, ürün kalitesini belirlemek, süreçteki değişkenlikleri analiz etmek ve önemli sonuçlar çıkarmak için kullanılmaktadır.

Bu çalışma, Savunma Sanayi sektöründe bulunan bir fabrikada üretilen tabancaların kapak parça kalitesini belirlemek amacıyla yapılmıştır. Belirli bir kapak modeline ait kontrol sonuçlarından elde edilen kusur sayıları, kontrol grafiği oluşturmak için temel alınmıştır. Bu kontrol grafiği, kalite kontrol sürecindeki değişkenlikleri analiz etmek, anormal durumları incelemek ve üretim sürecindeki dalgalanmaları belirleyerek iyileştirici faaliyetlerde bulunmak için kullanılacaktır.

Çalışmada, 2023 Aralık ayından seçilen kontrol verileri kullanılarak U kontrol grafiği ile sürecin kontrol durumu incelenmiştir. Elde edilen sonuçlar, sürecin kontrol altında olduğunu göstermektedir. Bu durum, üretim sürecinde istenmeyen varyasyonların azaltılması ve ürün kalitesinin iyileştirilmesi için önemli bir başlangıç noktasıdır.

Kontrol grafiği, üretim sürecindeki hataları analiz etmek ve sürecin istikrarını sağlamak için değerli bir araçtır. Bu çalışma, fabrikanın kalite kontrol sürecindeki performansını değerlendirmek ve geliştirmek için bir adım olarak önemli bir katkı sağlamaktadır.

Anahtar Kelimeler – İstatistiksel Süreç Kontrol, Kontrol Grafikleri, U kontrol Grafiği, Savunma Sanayi

I. GİRİŞ

İşletmelerde ürün kalitesini korumak ve sürekli olarak iyileştirmek, rekabetçi bir avantaj sağlamanın temel unsurlarından biridir. Bu hedefe ulaşmak için kalite kontrol yöntemleri, süreçlerin izlenmesi ve performansın değerlendirilmesi açısından kritik öneme sahiptir. Bu bağlamda, kontrol grafikleri gibi istatistiksel araçlar, üretim süreçlerinin kontrol altında tutulmasına ve anormal durumların tespit edilmesine yardımcı olur.

Kontrol grafikleri, sürecin kararlılığını ve varyasyonlarını grafiksel olarak görselleştiren ve izleyen araçlardır. Bu grafikler, bir sürecin normal çalışma sınırlarını belirleyerek, süreçte meydana gelen olağandışı değişiklikleri tespit etmeye olanak tanır. Kalite kontrol grafiklerinin amacı, üretimin (hizmetin) kalite yönüyle, üretim/hizmet sırasında zorunlu olarak ortaya çıkması beklenilen değişkenlerin kabul edilebilir sınırlar arasında tutulmasını sağlamaktır **[1].** Böylece, ürün kalitesindeki olası sapmalar erken aşamada belirlenip düzeltilebilir. Kontrol grafikleri, tesislerde üretilen ürünlerin kalitesini izlemek ve norm dışı sapma gösteren, sınır değerlerin üzerindeki kontrolsüz durumları belirlemek amacıyla çeşitli alanlarda kullanılmaktadır. Üretilen bir ürünün satılabilmesi ve kar elde edilebilmesi için uygulanacak

kapsamlı çalışmalarda 'mükemmel yedi' olarak isimlendirilen kalite kontrol yöntemleri kullanılmaktadır. Bunlar, dal-yaprak ya da histogram grafikleri, kontrol tabloları, pareto grafikleri, sebep sonuç grafikleri, kusur yoğunluğu grafikleri, saçılım grafikten ve kontrol grafikleridir.

Kontrol grafiklerinin ve istatistiksel proses kontrol yöntemlerinin farklı sektörlerde uygulanmasıyla, ürün ve hizmetlerin kalite seviyelerinin artırıldığı gözlemlenmiştir. Örneğin, bir üretim işletmesinde kontrol grafiklerinin kullanılmasıyla kalite araçları uygulanmış ve bu sayede ürün kalitesinde önemli iyileşmeler sağlanmıştır.

Benzer şekilde, web ürünlerinin kalite kontrolünde U şemaları kullanılarak istatistiksel proses kontrolü gerçekleştirilmiştir. Bu uygulama, web ürünlerinin kalitesinin izlenmesi ve anormal durumların tespit edilmesinde etkili olmuştur. Biyodizel üretim süreçlerinin izlenmesinde kontrol şemalarının kullanılması, üretim sürecindeki sapmaları belirleyerek kaliteyi koruma yolunda önemli adımlar atılmasını sağlamıştır. Bu gibi örnekler, kontrol yaklaşımlarının farklı sektörlerde ve uygulamalarda nasıl başarılı bir şekilde kullanılabildiğini ve kalite iyileştirme süreçlerine nasıl katkı sağladığını göstermektedir. Kontrol grafiklerinin ve istatistiksel proses kontrol yöntemlerinin, süreç varyasyonlarını izlemek, anormal durumları tespit etmek ve ürün kalitesini artırmak için güçlü araçlar olduğu açıktır. Bu nedenle, bu tür yaklaşımlar, kalite kontrol süreçlerinde kritik bir öneme sahiptir ve farklı endüstrilerde yaygın olarak kullanılmaktadır.

Kontrol grafikleri, üretim süreçlerindeki değişkenlikleri izlemek ve kontrol etmek için önemli bir araçtır. U kontrol kartları, süreç performansını değerlendirmek ve iyileştirmek için vazgeçilmez bir araç haline gelmiştir **[2] .**

Sektörler arasında Savunma Sanayinin önemi çok fazla olması ile birlikte bu sektörde ortaya çıkan ürünlerin kalite kontrolünün riskler göz önünde bulundurularak doğru alt-üst limitler ile çalışma yapılması gerekmektedir. Kontrol ne kadar doğru ve düzenli olursa ürün müşteriye ulaşmadan doğabilecek zararların önüne geçilebilecektir.

Bir kontrol grafiği esas olarak üç çizgiden oluşur. Bunlar; alt kontrol sınır limiti (AKL), üst kontrol sınır limiti (ÜKL) ve orta değer (OÇ) çizgisidir. Kalite özelliğinin ortalama değeri aynı zamanda hedeflenen değer olarak da ifade edilen orta çizgi ile temsil edilir. Eğer ilgilenilen kalite özelliği ölçülebilir özellikte ise, bu durumda merkezi eğilim ölçülerinden aritmetik ortalama, dağılma ölçülerinden ise değişim aralığı ve standart sapma kullanılır. Merkezi eğilim ve dağılma için kontrol grafikleri “Değişkenler İçin Kontrol Grafikleri” olarak adlandırılır. Kalite özelliğinin sürekli ve sayısal olarak ölçülememesi, yani kusur sayısı gibi belli bir olayın gözlem sayısına dayanması durumunda kullanılan kontrol grafiklerine ise “Özellikler İçin Kontrol Grafikleri” adı verilir. Kalite kontrolü ve süreç iyileştirmesi için farklı kontrol grafikleri kullanılmaktadır. Bunlar arasında en yaygın olanları X-Çubuk (X-Bar) ve R Kontrol Grafikleri, P Kontrol Grafikleri, NP Kontrol Grafikleri, C Kontrol Grafikleri ve U Kontrol Grafikleri bulunmaktadır **[3].**

X-Çubuk ve R Kontrol Grafikleri, sürecin ortalama ve varyansını izlemek için kullanılır. X-Çubuk grafikleri, sürecin ortalama değerini, R grafikleri ise varyansını gösterir. P Kontrol Grafikleri ise kategorik verilerin (örneğin, kabul/ret oranları) izlenmesi için kullanılır ve her bir örnekte kabul edilen ürünlerin oranını gösterir.

NP Kontrol Grafikleri, P kontrol grafiklerine benzerdir ancak örnek büyüklüklerine dayanır. Her bir örnekte kabul edilen ürün sayısını gösterir. C Kontrol Grafikleri ise hataların sayısını izlemek için kullanılır ve her bir örnekte meydana gelen hata sayısını gösterir.

Shewhart tarafından geliştirilen kontrol grafikleri, bir sürecin kontrolden çıkmaya başladığı sinyalini vermek üzere tasarlanmıştır. Bu grafikler, U kontrol kartları da dahil olmak üzere, üretim sürecinde değişkenlikleri izlemek ve kontrol etmek için gereklidir **[4].**

U Kontrol Grafikleri süreçteki hataların sayısını izlemek için kullanılır, ancak her örneğin büyüklüğü sabit değildir. Bir üretim işletmesinde uygulanan kontrol grafiklerinden U kontrol kartları, ürün kalitesinde önemli iyileşmeler sağlamakta ve prosesin kontrol altında tutulmasına katkıda bulunmaktadır **[5].** U grafiği, süreçteki varyasyonu kontrol altında tutmak için kullanılır ve örnekleme büyüklüğünün değişebileceği durumlarda tercih edilir. U kontrol kartları, birim başına hata sayısını izlemek için kullanılan önemli bir kalite kontrol aracıdır. Bu kartlar, üretim süreçlerindeki değişkenlikleri tespit etmede ve kontrol altında tutmada etkili bir yöntem sunar **[6]**.Bu grafikler, özellikle değişken örnekleme büyüklüklerine sahip süreçlerde etkin bir şekilde kullanılabilirler.

Yapılan bu çalışma ile üretim sürecinde meydana gelen hataların son kontrolde saptanmasıyla kalitenin iyileştirilmesi ve analizi amacıyla istatistiksel proses kontrol yöntemlerinden u kontrol grafiği ile analiz edilmiştir. 2023 Aralık ayına ait 15 farklı prosesten geçen kapak son kalite kontrolü yapılarak bu kontrolden elde edilen verilere göre tablo 1 çıkarılırmıştır. Bu tablo ile seçilen yönteme ait formüller kullanılarak alt – üst limitler belirlenmiş ve tabloda bulunan verilerin bu limitler arasında olup olmadığı grafik ile incelenmiştir.

II. MATERYAL VE YÖNTEM

Üretim süreçlerinin istatistiksel kontrolü, sürecin performansını değerlendirmek ve sürekli olarak iyileştirmek için kritik bir öneme sahiptir. Bu süreçte kullanılan kontrol grafikleri, verilerin görselleştirilmesini sağlayarak sürecin istatistiksel kontrolünü izlemeyi ve değişiklikleri belirlemeyi kolaylaştırır. Bu makalede, kontrol grafiklerinin genel yapısı ve U kontrol grafiğinin özel kullanımı incelenecektir.

Kontrol grafikleri, sürecin performansını değerlendirmek için kullanılan istatistiksel araçlardır. Bu grafikler, süreçten alınan verilerin görselleştirilmesini sağlar ve sürecin kontrol limitleri içinde veya dışında ne kadar değiştiğini belirler. Kontrol grafikleri, özellikle kalite kontrol süreçlerinde yaygın olarak kullanılır ve sürecin istikrarını ve tutarlılığını izlemek için önemli bir araçtır.

U Kontrol Grafiği

U kontrol grafiği, birim başına düşen hata sayısını izlemek için kullanılan bir kontrol grafik türüdür. Bu grafik, bir üretim sürecindeki hataların birim başına düşen ortalama sayısını görselleştirir ve kontrol limitleri içinde veya dışında ne kadar değiştiğini belirler. U kontrol grafiği genellikle aşağıdaki adımları içerir:

Veri Toplama ve Analiz: Öncelikle, üretim sürecinden alınan örneklerin her birindeki hata sayısı ve örnek büyüklüğü kaydedilir. Bu veriler, birim başına düşen hata sayısının hesaplanması için kullanılır.

Hesaplama ve Grafik Oluşturma: Her bir örnekte birim başına düşen hata sayısı hesaplanır ve bu değerlerin ortalaması alınarak genel bir birim başına düşen ortalama hata sayısı belirlenir. Ardından, kontrol limitleri (UCL ve LCL) hesaplanır ve U kontrol grafiği çizilir.

Grafiğin Yorumlanması: Oluşturulan U kontrol grafiği incelenir ve kontrol limitleri içinde veya dışında kalan noktalar belirlenir. Eğer noktaların çoğu kontrol limitleri içindeyse, süreç istatistiksel olarak kontrol altındadır. Ancak, kontrol limitleri dışında anormal bir nokta varsa, süreçte bir problem olabileceği veya dış faktörlerin etkisi olabileceği düşünülmelidir.

Veri toplama sürecinde, her bir örnekteki kapak sayısı (n) ve tespit edilen toplam hata sayısı (c) kaydedilmiştir. Bu veriler, U kontrol grafiği oluşturmak için temel teşkil etmiştir. Aşağıda, U kontrol grafiği için kullanılan temel formüller ve hesaplama yöntemleri detaylı olarak açıklanmıştır:

Kullanılan Parametreler:

c: n birimde oluşan toplam kusur sayısı

u: Birim başına düşen hata sayısı

$\bar{u}$: Birim başına düşen ortalama hata sayısı

n: Örnek büyüklüğü

Hesaplamalar:

u ve $\bar{u}$ hesaplanırken aşağıdaki formülden yararlanılır.

u= c/n

$\bar{u}$ = Σ u / Σ n

Alt ve üst limitler hesaplanırken aşağıdaki formülden yararlanılır.

UCL=

$$\bar{u} + 3\sqrt{\frac{\bar{u}}{n}}$$

Merkez çizgisi= $\bar{u}$

LCL=

$$\bar{u} - 3\sqrt{\frac{\bar{u}}{n}}$$

Her bir örnek için birim başına düşen hata sayısı (u) yukarıdaki formüle göre hesaplanmıştır. Tüm örnekler için birim başına düşen ortalama hata sayısı $\bar{u}$ hesaplanarak, kontrol grafiği için merkez çizgi belirlenmiştir. Üst kontrol sınırı (UCL) ve alt kontrol sınırı (LCL) hesaplamaları, belirlenen ortalama hata sayısı $\bar{u}$ ve örnek büyüklüğü (n) kullanılarak gerçekleştirilmiştir.

Kontrol limitlerinin belirlenmesi, sürecin istatistiksel kontrol altında olup olmadığının değerlendirilmesi için kritik bir adımdır. Hesaplanan UCL ve LCL değerleri, her bir örnekte gözlemlenen hata adetleri ile karşılaştırılarak, sürecin kontrol altında olup olmadığı değerlendirilmiştir. U kontrol grafiği, her bir örnek için hesaplanan u değerlerini ve belirlenen kontrol limitlerini görselleştirmiştir.

Sonuç olarak, bu çalışmada kullanılan U kontrol grafiği, kapak üretim sürecinin kalite kontrolünü sağlamak ve süreçteki varyasyonları minimize etmek için etkili bir araç olarak kullanılmıştır. U kontrol grafiği, değişken örnek büyüklüklerine sahip veri setlerinde birim başına düşen hata sayısını analiz ederek, sürecin istatistiksel kontrol altında olup olmadığını belirlemeye yardımcı olmuştur. Elde edilen sonuçlar, üretim sürecindeki olası sapmaların ve hata kaynaklarının tespit edilmesine olanak sağlamış ve süreç iyileştirme çalışmaları için önemli bilgiler sunmuştur.

Bu çalışma, Savunma Sanayi'nde kullanılan kapakların kalite kontrol süreçlerinde U kontrol grafiğinin etkinliğini göstermekte ve bu yöntemin, süreç iyileştirme ve kalite güvencesi sağlama konularında önemli katkılar sunabileceğini ortaya koymaktadır. Kontrol grafikleri, sürecin istatistiksel kontrolünü sağlamak ve süreç içindeki değişkenlikleri minimize etmek için güçlü bir araçtır. Bu nedenle, kalite kontrol

süreçlerinde U kontrol grafiği gibi istatistiksel yöntemlerin kullanımı, ürün kalitesini artırmak ve müşteri memnuniyetini sağlamak için kritik bir öneme sahiptir.

III. BULGULAR

Bu çalışmada, belirli bir Savunma Sanayi firmasından alınan kapakların kalite kontrol süreçlerinin analiz edilmesi amaçlanmıştır. Araştırma, Aralık ayı boyunca üretim hattından rastgele zamanlarda toplanan 20 farklı örnek setini kapsamaktadır. Her bir örnek seti, değişken sayıda kapak içermekte ve her örnekte tespit edilen hata adetleri detaylı bir şekilde kaydedilmiştir. Bu süreçte, her bir örnek için farklı sayıda kapak kullanıldığı için, analizlerde U kontrol grafiği tercih edilmiştir. U kontrol grafiği, değişken örnek boyutlarına sahip veri setlerinde birim başına düşen hata sayısını değerlendirmekte etkili bir yöntemdir.
U kontrol kartları, süreçlerdeki varyasyonları izlemek ve kontrol etmek için etkili bir araçtır. Bu kartlar, süreç performansını görsel olarak izlemeyi sağlar ve anormal durumları tespit etmeye yardımcı olur **[7]**
Kalite kontrol araçlarından biri olan U kontrol kartları, üretim süreçlerindeki varyasyonları izlemek ve anormal durumları tespit etmek için kullanılır. Bu kartlar, süreçteki istenmeyen değişiklikleri erken aşamada belirlemeye yardımcı olur **[8].**
Araştırmaya başlamadan önce, kapak üretim süreçleri detaylı bir şekilde incelenmiştir. Üretim hattında gerçekleştirilen bu incelemeler, sürecin her bir aşamasında olası hata kaynaklarını ve bu hataların kaynağını belirlemeyi hedeflemiştir. Bu incelemeler sonucunda, üretim sürecinin belirli aşamalarında kalite kontrol noktaları oluşturulmuş ve bu noktalar üzerinden veri toplama işlemi gerçekleştirilmiştir. Aralık ayı boyunca, üretim hattından 20 farklı zaman diliminde, rastgele seçilen kapak örnekleri alınmış ve bu örnekler son kontrol sürecine tabi tutulmuştur. Çalışma esnasında, veri yapısına uygun olarak U kontrol grafiği kullanılmıştır. U kontrol grafiği, her bir örnek için farklı sayıda kapak içermesi durumunda, birim başına düşen hata sayısını değerlendirmede etkili bir araçtır.

A. *Veri Toplama ve Analiz Süreci*

Veri toplama süreci, Aralık ayı boyunca 20 farklı zaman diliminde gerçekleştirilmiştir. Bu süreçte, her bir örnek seti farklı sayıda kapak içermekte ve her örnek seti son kontrol sürecine tabi tutulmuştur. Kontroller sonucunda tespit edilen hata adetleri detaylı bir şekilde kaydedilmiştir. Her bir örnekteki hata sayısı (c) ve örnek büyüklüğü (n) kaydedilerek, istatistiksel analiz için gerekli veriler toplanmıştır. Bu veriler kullanılarak, birim başına düşen hata sayısı (u) ve ortalama hata sayısı $\bar{u}$ hesaplanmıştır.

B. *Hesaplama ve Grafik Oluşturma*

Toplanan veriler, U kontrol grafiği oluşturmak için kullanılmıştır. U kontrol grafiği, her bir örnek için hesaplanan birim başına düşen hata sayısını $\bar{u}$ ve belirlenen kontrol limitlerini (UCL ve LCL)

görselleştirmektedir. Aşağıda kullanılan parametreler ve hesaplama yöntemleri detaylı olarak açıklanmıştır:

u ve $\bar{u}$ hesaplanırken aşağıdaki formülden yararlanılır.

u= c/n

$\bar{u}$ = Σ u / Σ n

Alt ve üst limitler hesaplanırken aşağıdaki formülden yararlanılır.

UCL=

$$\bar{u} + 3\sqrt{\frac{\bar{u}}{n}}$$

Merkez çizgisi= $\bar{u}$

LCL=

$$\bar{u} - 3\sqrt{\frac{\bar{u}}{n}}$$

Yukarıda verilen formüllere göre hesaplamalar yapıldıktan sonra grafik çizilerek limit değerlerine göre anormal olan verilerin nedenleri araştırılmalıdır.

Tablo 1. Son Kontrol Verileri

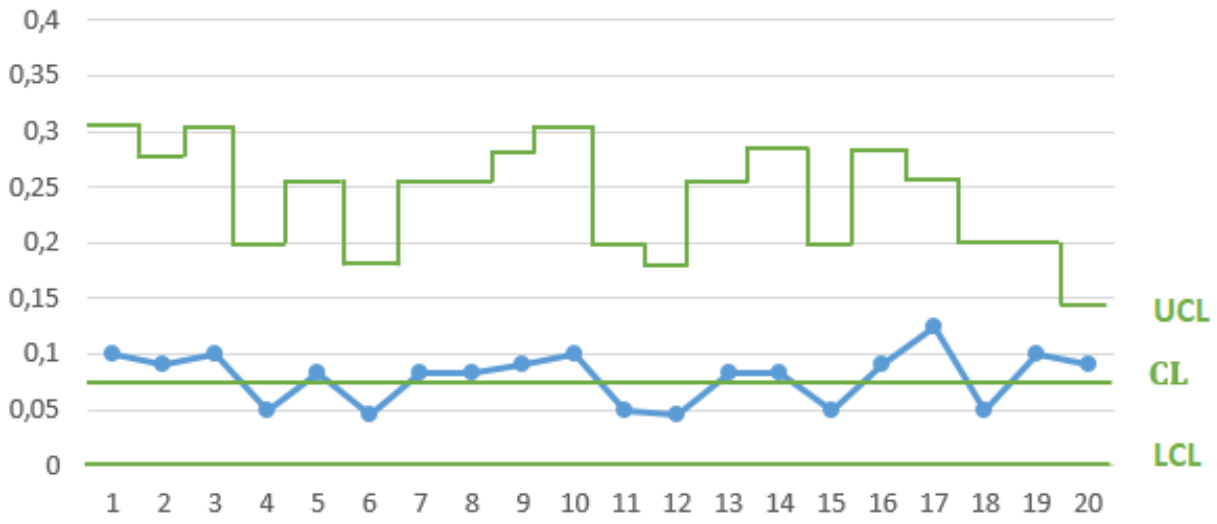
Örnek No	**Örnek Büyüklüğü**	**Kusur Sayısı**	**Örnek No**	**Örnek Büyüklüğü**	**Kusur Sayısı**
1	20	2	11	20	1
2	22	2	12	22	1
3	20	2	13	24	2
4	20	1	14	22	2
5	24	2	15	20	1
6	22	1	16	22	2
7	24	2	17	24	2
8	24	2	18	20	1
9	22	2	19	20	1
10	20	2	20	24	1

Tabloda bulunan verilerle kontrol limitleri aşağıdaki gibi hesaplanmıştır.

Tablo 2. Alt ve Üst Kontrol Limitler

Örnek No	U	UCL	ACL
1	0,1	0,312132034	0
2	0,090909091	0,283756395	0
3	0,1	0,312132034	0
4	0,05	0,2	0
5	0,083333333	0,260110029	0
6	0,045454545	0,181818182	0
7	0,083333333	0,260110029	0
8	0,083333333	0,260110029	0
9	0,090909091	0,283756395	0
10	0,1	0,312132034	0
11	0,05	0,2	0
12	0,045454545	0,181818182	0
13	0,083333333	0,260110029	0
14	0,090909091	0,283756395	0
15	0,05	0,2	0
16	0,090909091	0,283756395	0
17	0,083333333	0,260110029	0
18	0,05	0,2	0
19	0,05	0,2	0
20	0,041666667	0,166666667	0

$\bar{u}$ = Σ u / Σ n = 1,462 / 20 = 0,073



Şekil 1. Kontrol Grafiği

IV. TARTIŞMA

U kontrol grafikleri, diğer kontrol grafiklerinden farklı olarak, özellikle birim başına düşen kusurların izlenmesi gerektiği durumlarda kullanılmaktadır. Örneğin, bir üretim hattında üretilen kapakların her

birinin farklı sayıda kusur içerebileceği durumlarda, U kontrol grafikleri, bu kusurların izlenmesini ve analiz edilmesini sağlamaktadır. Bu grafikler, prosesin istatistiksel olarak kontrol altında olup olmadığını değerlendirmeye olanak tanır ve süreçteki olağandışı değişiklikleri erken aşamada tespit ederek müdahale edilmesini sağlar.

Bu çalışmanın bulguları, U kontrol grafiklerinin kapak üretim hattındaki kalite kontrol süreçlerinde kullanılmasının faydalarını ortaya koymakla birlikte, bu grafikleri kullanarak elde edilen verilerin analizi ve yorumlanması için ek bilgilere ihtiyaç duyulabilir. Örneğin, süreç değişkenliklerinin nedenlerini daha iyi anlamak için ayrıntılı hata analizi ve kök neden analizi yapılabilir. Ayrıca, diğer kontrol grafiklerinin (X-bar, R, p, np grafikler gibi) sonuçlarıyla karşılaştırma yaparak, U kontrol grafiklerinin sağladığı avantajları ve olası dezavantajları daha net bir şekilde ortaya koymak mümkündür.

Bu bağlamda, gelecekteki çalışmaların, farklı üretim süreçlerinde U kontrol grafiklerinin etkinliğini incelemesi ve bu grafikleri kullanarak elde edilen verilerin daha derinlemesine analiz edilmesi önerilmektedir. Böylece, U kontrol grafiklerinin çeşitli endüstrilerdeki uygulamaları ve faydaları daha iyi anlaşılabilir ve kalite kontrol süreçlerinde daha etkin bir şekilde kullanılabilir.

V. SONUÇLAR

Elde edilen U kontrol grafiği, kapak üretim hattının son kontrol ölçüm sonuçlarını ve bu sonuçların alt ve üst kontrol limitleri aralığında olup olmadığını görselleştirmiştir. Grafik incelendiğinde, kapak üretim hattındaki son kontrol ölçüm sonuçlarının belirlenen alt ve üst kontrol limitleri aralığında kaldığı görülmüştür. Bu durum, üretim sürecinin istatistiksel olarak kontrol altında olduğunu ve belirlenen kontrol limitlerinin geçerliliğini kanıtlamaktadır.

Bu sonuçlar, belirlenen alt ve üst limitlerin sonraki son kontrol süreçlerinde de kullanılabilir olduğunu göstermektedir. Böylece, üretim hattındaki varyasyonlar etkin bir şekilde kontrol altında tutulabilmekte ve süreç içindeki olası sapmalar minimize edilebilmektedir. Bu çalışma, Savunma Sanayi'nde kullanılan kapakların kalite kontrol süreçlerinde U kontrol grafiğinin etkinliğini ve uygulanabilirliğini ortaya koymaktadır.

Sonuç olarak, bu çalışma, kapak üretim sürecinde kalite kontrolünün sağlanması ve süreç iyileştirmelerinin yapılması için önemli bilgiler sunmaktadır. U kontrol grafiği, süreç içindeki varyasyonları izlemek ve kontrol etmek için güçlü bir araçtır. Bu nedenle, kalite kontrol süreçlerinde U kontrol grafiği gibi istatistiksel yöntemlerin kullanımı, ürün kalitesini artırmak ve müşteri memnuniyetini sağlamak için kritik bir öneme sahiptir.

TEŞEKKÜR

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Akciğer Kanser Türlerini Otomatik Sınıflandırmak için BT Taraması Görüntülerini Kullanan MobileNet ve DenseNet201 Tabanlı Derin Öğrenme Modeli

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Özet – Günümüzde kanser, dünya genelinde önemli bir sağlık sorunu olarak karşımıza çıkmaktadır. Akciğer kanseri, kanser kaynaklı ölümler arasında en yüksek orana sahip olup, erken teşhis ve tedavi büyük önem taşımaktadır. Akciğer kanseri teşhisinde, doğru ve hızlı bir şekilde kanser türlerinin sınıflandırılması, hastaların tedavi sürecinde hayati bir rol oynamaktadır. Bilgisayarlı tomografi (BT) taramaları, akciğer kanseri teşhisinde en sık kullanılan yöntemlerdendir. Ancak, BT taramalarının manuel olarak incelenmesi zaman alıcı ve hata yapmaya müsaittir. Bu nedenle, otomatik sınıflandırma yöntemlerine ihtiyaç duyulmaktadır. Son yıllarda, tıbbi görüntüleme tekniklerindeki gelişmeler ve yapay zeka, özellikle derin öğrenme alanındaki ilerlemeler, akciğer kanseri türlerinin sınıflandırılmasında başarılı sonuçlar elde etmiştir. Bu çalışmada, BT tarama görüntüleri kullanılarak akciğer kanser türlerinin otomatik sınıflandırılması için derin öğrenme tabanlı yeni bir yöntem önerilmektedir. Önerilen yöntem MobileNet ve DenseNet201 yöntemlerinin birleşiminden oluşmakta ve MobileDenseNet olarak adlandırılmaktadır. MobileNet, mobil ve gömülü cihazlarda kullanım için optimize edilmiş hafif bir yöntem iken, DenseNet201, katmanlar arasındaki yoğun bağlantılar sayesinde daha derin ve karmaşık özelliklerin öğrenilmesine olanak tanımaktadır. Bu iki yöntemin birleşimiyle oluşturulan MobileDenseNet, akciğer kanser türlerinin otomatik sınıflandırılmasında etkili, hızlı ve güvenilir çözümler sunmaktadır. Önerilen MobileDenseNet yöntemi, Kaggle platformundaki akciğer BT görüntüleri üzerinde test edilmiş ve %93.96 doğruluk, %93.61 kesinlik, %95.5 duyarlılık ve %94.2 F1 skoru elde edilmiştir. Elde edilen sonuçlar, MobileDenseNet'in yalnızca MobileNet ve DenseNet201'e göre değil, aynı zamanda literatürdeki diğer derin öğrenme tabanlı yöntemlere kıyasla da daha üstün performans sergilediğini göstermektedir. Bu bulgular, MobileDenseNet'in akciğer kanser türlerinin sınıflandırılmasında etkili bir çözüm sunduğunu doğrulamaktadır.

Anahtar Kelimeler – Akciğer kanseri, BT görüntüleme, Derin öğrenme, MobileNet, DenseNet201

I. GİRİŞ

Kanser, ölümcül sonuçlara yol açma potansiyeli olan tehlikeli bir hastalıktır. Dünya çapında yaygın bir kanser türü olan akciğer kanseri, hem gelişmiş hem de gelişmekte olan ülkelerde kansere bağlı ölümlerin önemli bir nedeni olarak öne çıkmaktadır [1]. Erkeklerde prostat kanseri, kadınlarda ise meme kanseriyle birlikte en sık görülen ikinci kanser türüdür [2]. Dünya Sağlık Örgütü tarafından yapılan son tahminlere göre, akciğer kanseri nedeniyle dünya çapında yılda yaklaşık 7,6 milyon ölüm gerçekleşmektedir [3]. Akciğer kanserini erken evrede teşhis etmek, tedavisi için oldukça önemlidir. Akciğer röntgen grafisi ve Bilgisayarlı Tomografi (BT), farklı akciğer hastalıklarının tanınmasında düzenli olarak kullanılan iki tanıdık anatomik görüntüleme yöntemidir. Bunlar arasından, BT taraması en sık kullanılan patolojik testtir ve tanı için oldukça tercih edilmektedir [4]. Bu görüntüleme tekniği, akciğerlerin farklı

perspektiflerden yüksek çözünürlüklü, yüksek kontrastlı görüntülerini yakalayarak kanserin üç boyutlu bir değerlendirmesini sunmaktadır [1]. Ancak, BT taramalarının manuel olarak incelenmesi zaman alıcı ve hata yapmaya müsait bir süreçtir. Bu nedenle, akciğer kanseri türlerinin otomatik olarak sınıflandırılmasına yönelik güvenilir ve hızlı yöntemlere olan ihtiyaç giderek artmaktadır.

Son yıllarda, derin öğrenme yöntemleri, tıbbi görüntü analizinde başarılı ilerlemeler sağlamış ve özellikle evrişimsel sinir ağları (ESA'lar), tıbbi görüntülerin otomatik olarak sınıflandırılmasında yüksek doğruluk oranlarına ulaşmıştır [5][6]. Bu yöntemler, geleneksel görüntü işleme tekniklerine kıyasla, daha yüksek doğruluk oranları ve güvenilirlik sağlamaktadır. Bu da doktorların hastalıkları tespit ederken ve teşhis koyarken ihtiyaç duyduğu yardım düzeyini arttırmaktadır. Erken evrelerde doğru teşhis konulacak, uygun tedavi planları hazırlanacak ve hastaların yaşam kalitesinin arttırılması sağlanacaktır [7].

Derin öğrenme yöntemlerinin kullanımındaki hızlı ilerlemeler, akciğer kanser türlerinin sınıflandırılması çalışmalarında araştırmacıların ilgisini çekmiş ve giderek daha fazla çalışmalar yapılmasını sağlamıştır. Akciğer BT görüntüleri kullanılarak akciğer kanser türlerini sınıflandırma ile ilgili literatürde yer alan çalışmalardan bazıları şu şekildedir. Mohamed vd. [8] BT görüntülerinde akciğer kanserinin sınıflandırılması için hibrit bir metasezgisel ve CNN algoritması önermektedir. İlk olarak bir CNN mimarisi tasarlanmış ve ardından modelin çözüm vektörü hesaplanmıştır. Elde edilen çözüm vektörü, sınıflandırma problemini ele almak üzere CNN modelini eğitmek için en iyi ağırlık ve bias kombinasyonunu seçmek üzere Ebola optimizasyon arama algoritmasına aktarılmıştır. Kalaivani vd. [9] BT görüntülerinden akciğer kanserini tespit etmek için bir derin sinir ağı geliştirmiştir. Akciğer görüntüsünün normal veya kötü huylu olarak sınıflandırılması için yoğun bağlantılı bir evrişimsel sinir ağı (DenseNet) ve uyarlanabilir güçlendirme algoritması kullanılmıştır. Raza vd. [10] BT tarama görüntülerinden akciğer kanserinin sınıflandırılması için EfficientNetB1 kullanan transfer öğrenme tabanlı bir ince ayar yaklaşımı sunmaktadır. Humayun vd. [11] BT tarama görüntülerinden akciğer kanserinin çok sınıflı (iyi huylu, kötü huylu ve normal) sınıflandırması için VGG16, VGG19 ve Xception'ı içeren önceden eğitilmiş modelleri kullandılar. Lyu vd. [12] dört ayrı derin özellik tabanlı CNN (DCNN) mimarisinden oluşan bir topluluk öğrenme modeli sundular. Önceden eğitilmiş AlexNet, VGG16, DCNN ve DenseNet'ten oluşan önerdikleri topluluk öğrenme modeli, hem voting hem de stacking kullanılarak gerçekleştirilmiştir.

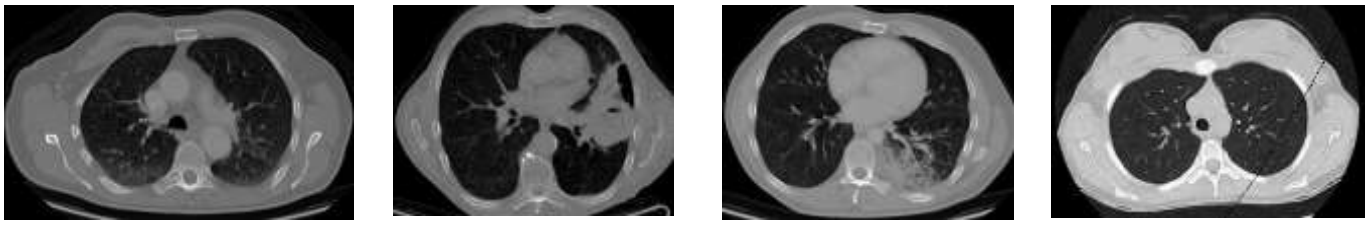
Bu çalışmada, BT tarama görüntülerini kullanarak akciğer kanser türlerini sınıflandırmak amacıyla MobileNet ve DenseNet201 tabanlı derin öğrenme yöntemlerinin birleşiminden oluşan MobileDenseNet yöntemi önerilmiştir. MobileNet, standart evrişim yerine derinlemesine ayrılabilir evrişim katmanları kullanmaktadır. Bundan dolayı daha az parametreye sahiptir ve hafif bir modeldir. Daha az hesaplama gücü ve bellek kullanımı gerektirir, bu da daha hızlı ve verimli çalışmasını sağlar. DenseNet201, derin bir sinir ağı modelidir ve çok katmanlı yapısı sayesinde daha karmaşık ve zengin özellikler öğrenebilmektedir. MobileNet'in hafiflik ve verimlilik avantajları ile DenseNet201'in derin ve karmaşık özellik öğrenme yeteneklerinin birleşimi, dengeli ve güçlü bir yöntem oluşturmaktadır. Bunun yanı sıra, MobileNet'in hızlı ve verimli çalışması ile DenseNet201'in derin öğrenme kapasitesi, sınıflandırma performansını arttırmaktadır. İki modelin güçlü yönlerinin birleşimi, hızlı ve güvenilir teşhis sistemlerinin geliştirilmesine olanak tanımakta, bu da klinik uygulamalarda büyük bir avantaj sağlamaktadır. Önerilen MobileDenseNet yönteminin sınıflandırma performansını analiz etmek için Kaggle platformunda yer alan akciğer BT görüntülerini içeren bir veriseti kullanılmıştır. Veriseti üç tür (adenokarsinom, büyük hücreli karsinom ve skuamöz hücreli karsinom) akciğer kanseri ile kanserli olmayan görüntüleri içermektedir. Bu veriseti üzerinde gerçekleştirilen kapsamlı deneysel çalışmalar sonucunda önerilen MobileDenseNet yöntemi ile %93.96 doğruluk, %93.61 kesinlik, %95.5 duyarlılık ve %94.2 F1 skoru elde edilmiştir.

Çalışmanın geri kalanı şu şekilde organize edilmiştir. Bölüm 2'de BT görüntülerinin yer aldığı veriseti ile önerilen MobileDenseNet yöntemi detaylı açıklanmıştır. Bölüm 3'te deneysel kurulum, değerlendirme ölçütleri ve deneysel çalışmaların sonuçları verilmiştir. Çalışmanın genel bir özeti Bölüm 4 olan sonuçlar bölümünde yer almaktadır.

II. MATERYAL VE YÖNTEM

A. Veriseti

Bu çalışmada Kaggle platformunda halka açık akciğer BT görüntülerinin bulunduğu bir veriseti kullanılmıştır [13]. Bu verisetinde üç akciğer kanser türü ve normal BT görüntülerinden oluşan toplam dört sınıf bulunmaktadır. Bu kanser türleri şu şekildedir: adenokarsinom (adenocarcinoma-ADE), büyük hücreli karsinom (large cell carcinoma-LCC) ve skuamöz hücreli karsinom (squamous cell carcinoma-SCC)'dur. Akciğer adenokarsinomu (ADE), tüm vakaların %30'unu ve tüm küçük hücreli olmayan akciğer kanseri oluşumlarının yaklaşık %40'ını oluşturan en yaygın akciğer kanseri türüdür. ADE'ler, meme, prostat ve kolorektal dahil olmak üzere birçok yaygın kanserde bulunur. Akciğer ADE'leri, akciğerin dış bölgesinde, mukus salgılayan ve nefes almamıza yardımcı olan bezlerde bulunur. Belirtileri arasında öksürük, ses kısıklığı, kilo kaybı ve halsizlik yer alır. Büyük hücreli karsinom (large cell carcinoma-LCC) akciğer kanseri hızla büyür ve yayılır. Bu tür kanserler, akciğerin herhangi bir yerinde bulunabilir ve tüm vakaların %10-15'ini oluşturur. Skuamöz hücreli karsinom (squamous cell carcinoma-SCC) türü akciğer kanseri, merkezi olarak akciğerde, daha büyük bronşların trakea ile akciğere birleştiği yerde veya ana hava yolu dallarından birinde bulunur. SCC hücreli akciğer kanseri, küçük hücreli olmayan akciğer kanserlerinin yaklaşık %30'undan sorumludur ve genellikle sigara içmeyle bağlantılıdır. Verisetinde, 338 ADE, 187 LCC, 260 SCC ve 215 normal olmak üzere toplam 1000 BT görüntüsü bulunmaktadır. Verisetinin kaggle platformunda bulunan orijinal klasörü eğitim (train), test ve doğrulama (validation) olmak üzere üç alt klasöre ayrılmıştır. Eğitim klasöründe 613, test klasöründe 315 ve doğrulama klasöründe 72 BT görüntüsü yer almaktadır. Şekil 1'de dört sınıf ile ilgili örnek BT görüntülerine yer verilmiştir.

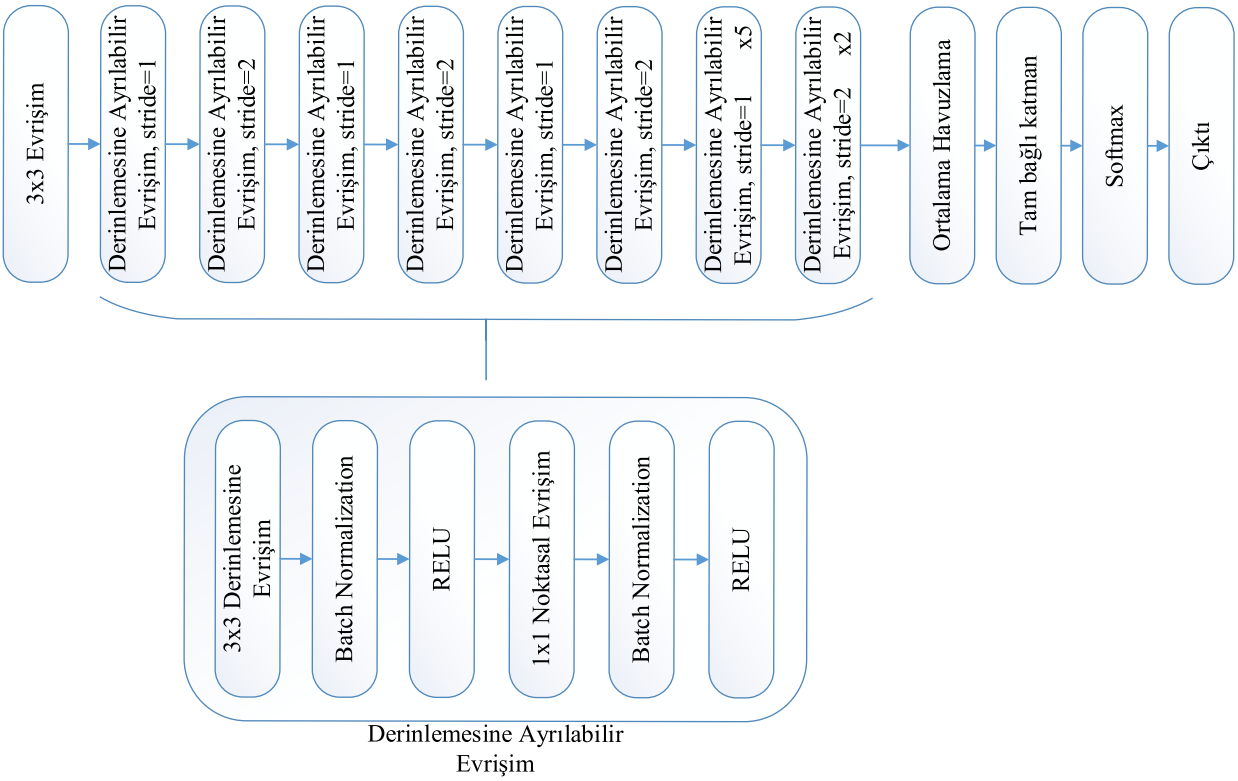


Şekil 1. Akciğer kanser türleri ve normal BT görüntüleri

B. Önerilen Yöntem

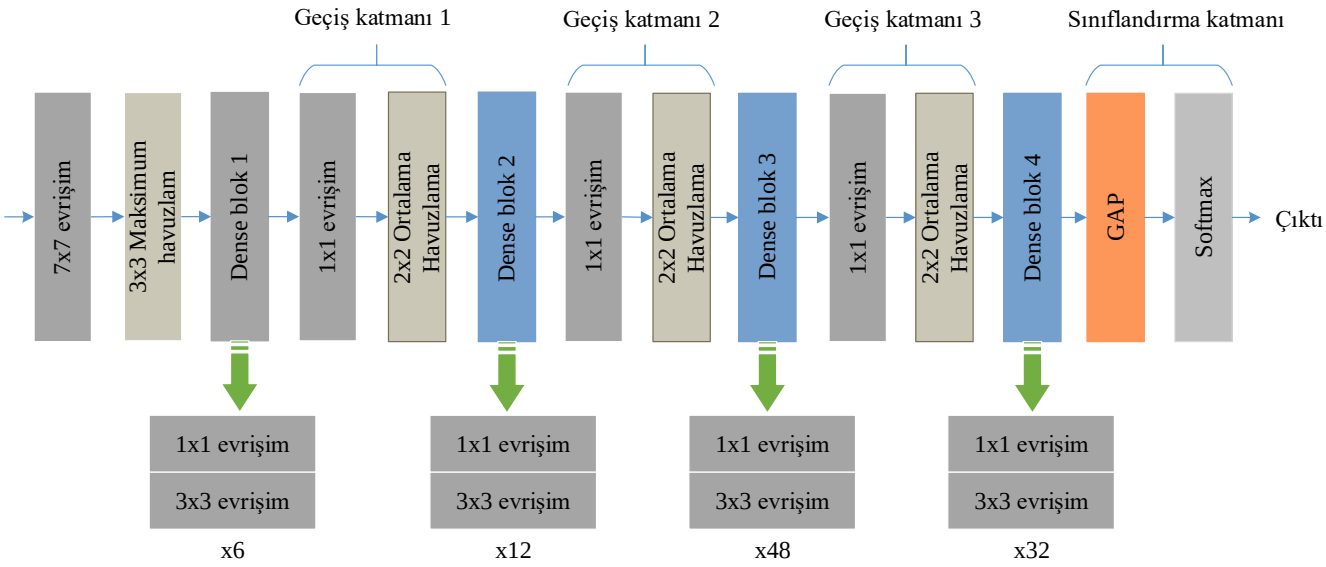
Bu çalışmada, akciğer kanser türlerinin sınıflandırılması için yeni bir hibrit derin öğrenme yöntemi önerilmektedir. Önerilen yöntem, MobileNet ve DenseNet201 yöntemlerinin birleşiminden oluşmaktadır. MobileNet ve DenseNet201, her ikisi de görüntü sınıflandırma ve diğer bilgisayarla görme görevlerinde yaygın olarak kullanılan derin öğrenme yöntemleridir. Bu çalışmada, her iki yöntemin avantajlarını kullanan hibrit bir yöntem kullanılarak deneysel çalışmalar gerçekleştirilmiştir. Önerilen yöntemde, MobileNet'in düşük hesaplama karmaşıklığı ve DenseNet201'in güçlü özellik çıkarımı birleştirilerek, akciğer kanser türlerinin sınıflandırılmasında daha başarılı bir yöntem elde edilmesi hedeflenmektedir.

MobileNet, Google tarafından geliştirilen hafif ve verimli bir derin öğrenme yöntemidir. Özellikle mobil cihazlar ve gömülü sistemler gibi sınırlı kaynaklara sahip ortamlar için tasarlanmıştır. Temel olarak, standart evrişim katmanlarının yerine derinlemesine (depthwise) ve noktasal (pointwise) evrişim katmanlarını kullanılır. Yani, standart evrişim yerine derinlemesine ayrılabilir evrişim kullanılır. Derinlemesine ayrılabilir evrişim, standart evrişim işlemini iki aşamaya ayırır. İlk olarak, derinlemesine evrişim, her bir giriş kanalı üzerinde ayrı ayrı bir evrişim uygular. Ardından, noktasal evrişim (1x1 çekirdek boyutuna sahip evrişim) bu filtrelerin çıktısını birleştirir. Bu, hesaplama yükünü ve parametre sayısını büyük ölçüde azaltır. Böylece mobil cihazlar ve gömülü sistemlerde kullanılabilir hale gelir [14]. MobileNet, giriş katmanı, 13 derinlemesine ayrılabilir evrişim ve tam bağlı katmanlardan oluşur. MobileNet'in genel yapısı Şekil 2'deki gibidir.



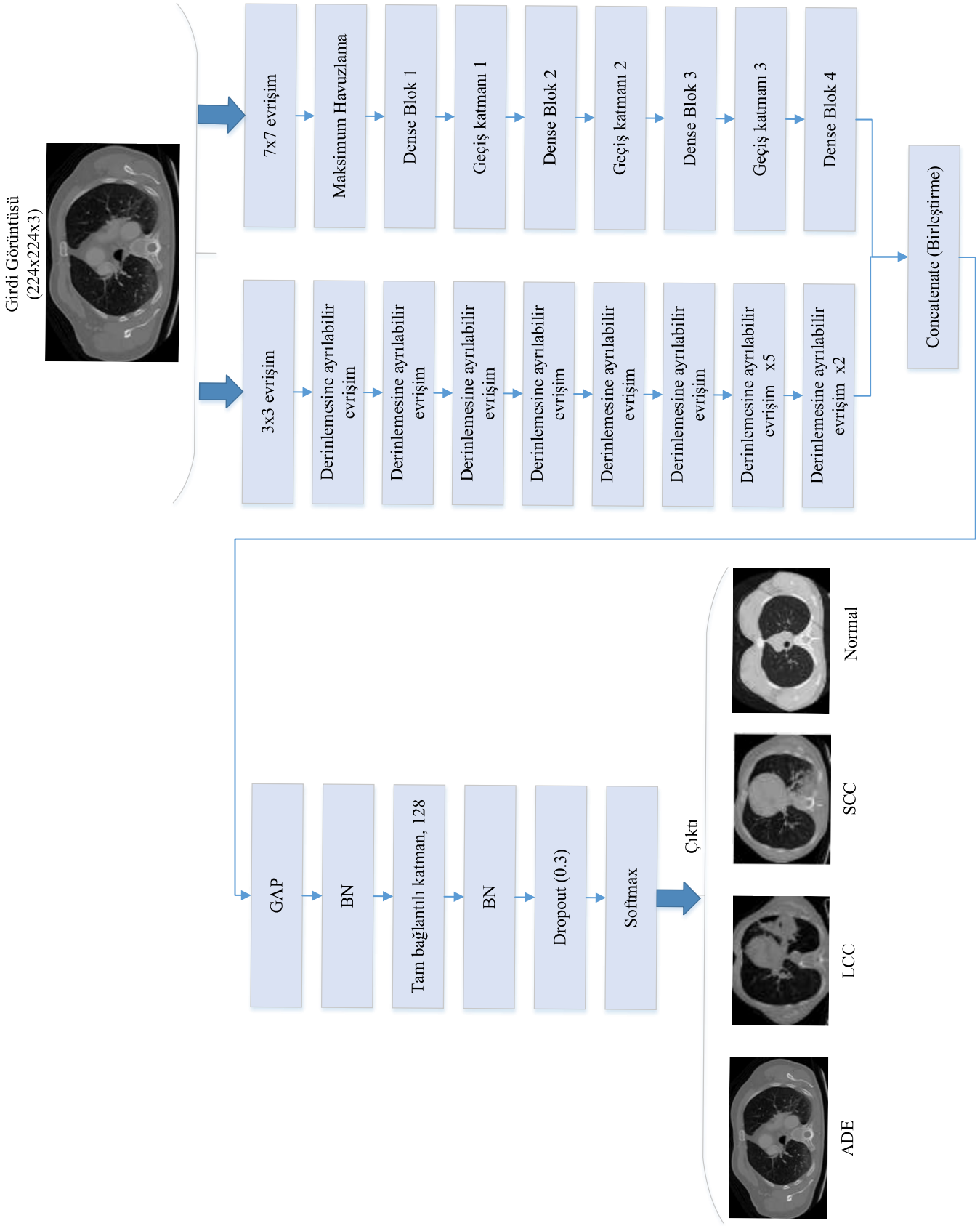
Şekil 2. MobileNet'in yapısı

DenseNet201, 201 katmandan oluşan bir derin öğrenme yöntemidir. DenseNet (Densely Connected Convolutional Networks) mimarisinin bu versiyonu, çok sayıda katmanın yoğun bir şekilde birbirine bağlanmasıyla karakterizedir. Her katmanın önceki tüm katmanların çıktısını girdi olarak alması, yöntemin daha verimli öğrenme ve gradyan yayılımı yapmasını sağlamaktadır. DenseNet, katmanları "dense blok" adı verilen yapılar içinde düzenler. Her katman, önceki tüm katmanların özellik haritalarını girdi olarak alır ve kendi çıktısını bu haritalara ekler. DenseNet201'de, dört dense blok yapısı bulunmaktadır. Bu Dense bloklarında 1x1 ve 3x3 evrişim işlemleri uygulanmaktadır. Bunun yanı sıra, bu Dense blokları arasında, boyutları azaltan geçiş katmanları (transition layers) bulunur. DenseNet201'in yapısında üç adet geçiş katmanı bulunmaktadır. Bu geçiş katmanlarında, 1x1 evrişim ve 2x2 ortalama havuzlama olmak üzere iki katman bulunmaktadır. Son olarak, DenseNet'te yer alan kısayol bağlantıları ile her katman, önceki tüm katmanlardan direkt olarak bağlantı alır, bu da gradyanların daha verimli bir şekilde yayılmasını sağlar ve derin ağlarda görülen gradyan kaybolması problemini azaltır. DenseNet201'in kullanımının avantajları şu şekildedir: (i) DenseNet201 daha derin bir yapıya sahip olup, daha karmaşık özellik çıkarımı gerçekleştirebilmektedir. (ii) Her katmanın önceki tüm katmanlardan bilgi alması, daha verimli özellik öğrenimine olanak tanımaktadır. (iii) Kısayol bağlantıları, gradyanların daha etkin bir şekilde yayılmasını sağlayarak eğitim sürecini kolaylaştırmaktadır. DenseNet201 yönteminin genel yapısı Şekil 3'teki gibidir.



Şekil 3. DenseNet201'in yapısı

Önerilen hibrit yöntem Şekil 4'te gösterilmektedir. Öncelikle, hibrit yöntemin giriş BT görüntü boyutu olarak 224x224x3 alındı. MobileNet ve DenseNet201 modelleri, ImageNet veritabanı üzerinde önceden eğitilmiş ağırlıklarla yüklendi. Bu modellerin sadece özellik çıkarım katmanları kullanıldı. Daha sonra, MobileNet ve DenseNet201 modellerinin çıktı katmanları, Concatenate katmanı kullanılarak birleştirildi. Bu işlem, her iki modelin özelliklerinin bir araya getirilmesini sağlar. Birleştirilen özellik haritası, global ortalama havuzlama (Global Average Pooling-GAP) katmanından geçirilmektedir. Bu katman, her özellik haritasının ortalama değerini alarak, boyutları küçültür ve böylece modelin parametre sayısını azaltır. GAP katmanı, derin öğrenme modellerinde hesaplama verimliliğini artırmak, aşırı öğrenmeyi azaltmak, parametre sayısını düşürmek ve modelin daha iyi genelleme yapabilmesini sağlamak amacıyla kullanılır. Özellikle, özellik haritalarını son sınıflandırma katmanına geçmeden önce özetleyerek, modelin performansını ve verimliliğini artırır. GAP'tan sonra, derin öğrenme modellerinde eğitim sürecinin hızlanmasını, aktivasyon fonksiyonlarının etkin kullanımını, hiperparametre hassasiyetinin azalmasını ve derin ağların eğitilebilirliğinin artırılmasını sağlayan Batch Normalization (BN) kullanılmaktadır. BN'den sonra elde edilen özellik haritasına 128 nörona sahip bir tam bağlantılı katman (Fully connected-FC), tekrar BN ve aşırı öğrenmeyi önlemek için 0.3 bırakma (dropout) oranına sahip dropout katmanı uygulanmaktadır. Son katman, softmax aktivasyon fonksiyonu ile çıktıyı vermektedir. Softmax fonksiyonu, modelin çıktılarını sınıf olasılıklarına dönüştürür. Her bir sınıf için tahmini olasılıkları sağlar ve en yüksek olasılığa sahip sınıf tahmin edilen sınıf olarak seçilir.



Şekil 4. Önerilen MobileDenseNet yöntemi

III. DENEYSEL ÇALIŞMALAR

A. Deneysel Kurulum

Deneysel çalışmalar python programlama dili ve Keras-TensorFlow kütüphaneleri kullanılarak gerçekleştirilmiştir. Python kodları Kaggle platformunda yazılmıştır. Kaggle platformunun kullanılmasının amacı donanım hızlandırıcı olarak Tensör işleme birimi sunmasıdır. Akciğer kanseri türlerini sınıflandırmak için kullanılan veriseti klasörü eğitim-test-doğrulama olmak üzere üç alt klasöre ayrılmıştır. Eğitim klasöründe 613, test klasöründe 315 ve doğrulama klasöründe 72 BT görüntüsü yer almaktadır. Deneysel çalışmalarda, orijinal verisetindeki eğitim-test-doğrulama oranları alınmıştır. Verisetinde herhangi bir veri arttırımı yapılmamıştır. Eğitim işlemi gerçekleştirilirken girdi BT görüntü boyutları 224x224x3 olarak alınmıştır. Tüm deneylerde, batch size değeri 64, adam optimizasyon algoritması kullanılarak 100 epok boyunca eğitim işlemi gerçekleştirilmiştir. Kayıp fonksiyonu olarak sparse_categorical_crossentropy kullanılmıştır.

B. Değerlendirme Ölçütleri

Akciğer BT görüntülerinden kanser türlerini otomatik olarak sınıflandırmak için kullanılan değerlendirme ölçütleri olan karışıklık matrisi, doğruluk (accuracy), kesinlik (precision), duyarlılık (recall) ve F1 skoru, modelin performansını anlamak ve iyileştirmek için kritik öneme sahiptir. Karışıklık matrisi, sınıflandırma problemlerinde modelin tahminlerini ve gerçek sınıflarını karşılaştırmak için kullanılır. Matris, her sınıfın gerçek ve tahmin edilen örneklerini dört kategoride gösterir: True Positive (TP), True Negative (TN), False Positive (FP), False Negative (FN). TP, modelin doğru şekilde pozitif olarak sınıflandırdığı gerçek pozitif örnekler. TN, modelin doğru şekilde negatif olarak sınıflandırdığı gerçek negatif örnekler. FP, modelin yanlış şekilde pozitif olarak sınıflandırdığı gerçek negatif örnekler. FN, modelin yanlış şekilde negatif olarak sınıflandırdığı gerçek pozitif örnekler.

Doğruluk, modelin tüm örnekler içinde doğru sınıflandırdığı örneklerin oranını ifade eder. Kesinlik, modelin pozitif olarak sınıflandırdığı örneklerin ne kadarının gerçekten pozitif olduğunu ifade eder. Duyarlılık, modelin gerçek pozitif örnekleri ne kadar iyi tespit ettiğini ifade eder. F1 skoru, hassasiyet ve duyarlılığın harmonik ortalamasıdır ve dengesiz sınıf dağılımlarında iyi bir performans ölçütüdür. Doğruluk, kesinlik, duyarlılık ve F1 skor değerleri sırasıyla Denklem (1)-(4)'teki gibi hesaplanmaktadır.

$$Doğruluk = \frac{TP + TN}{TP + TN + FP + FN} \tag{1}$$

$$Kesinlik = \frac{TP}{TP + FP} \tag{2}$$

$$Duyarlılık = \frac{TP}{TP + FN} \tag{3}$$

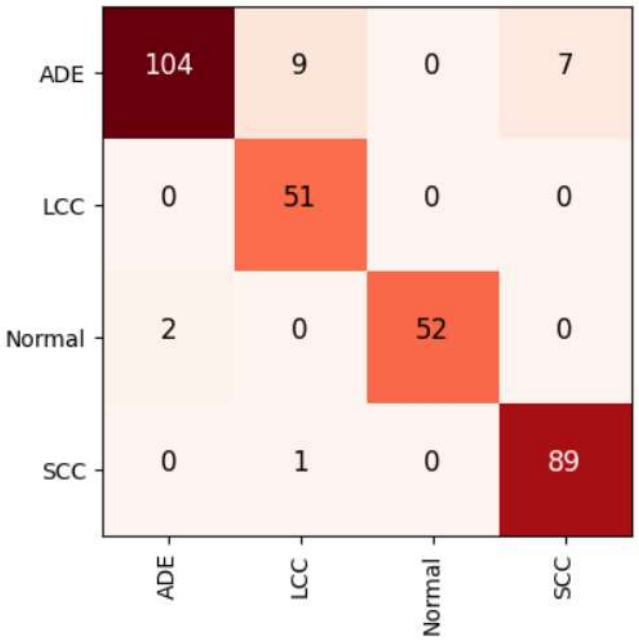
$$F1\ skor = 2\ x\ \frac{Kesinlik\ x\ Duyarlılık}{Kesinlik + Duyarlılık} \tag{4}$$

C. Deneysel Sonuçlar

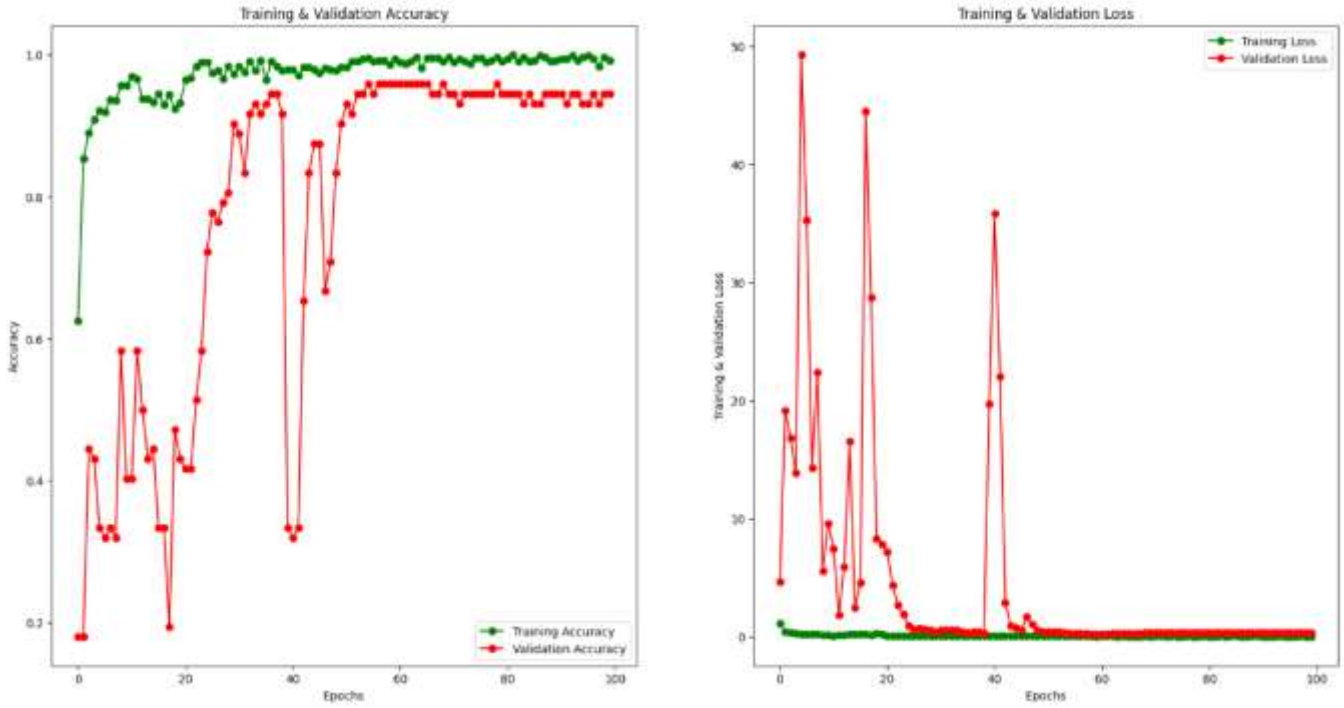
Deneysel çalışmalarda kullanılan akciğer BT görüntülerinin yer aldığı veriseti dört sınıf içermektedir. Bu sınıflardan üçü akciğer kanser türlerini (adenokarsinom (adenocarcinoma-ADE), büyük hücreli karsinom (large cell carcinoma-LCC) ve skuamöz hücreli karsinom (squamous cell carcinoma-SCC)) içermekte ve diğer sınıf ise kanserli olmayan akciğer BT görüntülerinin yer aldığı normal sınıfıdır. Önerilen yöntem kullanılarak gerçekleştirilen deneylerde elde edilen karışıklık matrisi Şekil 5'teki gibidir. Şekil 5'e göre, 120 ADE görüntüsünden 104, 51 LCC görüntüsünün tamamı, 54 normal görüntüden 52 ve 90 SCC görüntüsünden 89'unun doğru bir şekilde sınıflandırıldığı görülmektedir.

Toplamda 315 test görüntüsünden 296 BT görüntüsü doğru bir şekilde sınıflandırılmıştır. Bu durumda, (296/315)*100 = %93.96 oranında bir doğruluk değeri elde edilmektedir.

Şekil 6, önerilen yöntem için 100 epok boyunca eğitim ve doğrulama doğruluğunun (train-validation accuracy) yanı sıra eğitim ve doğrulama kaybını (train-validation loss) göstermektedir. Şekil 6 soldaki eğri, eğitim-doğrulama doğruluk grafiğini göstermektedir. Yeşil çizgi, düşük başlayan ve model eğitim verilerinden öğrendikçe kademeli olarak artan eğitim doğruluğunu (train accuracy) temsil eder. Eğitim doğruluğu epok değeri arttıkça %100 değerine yakınsamaktadır. Kırmızı çizgi, yine düşük başlayıp artan ancak eğitim doğruluğuna kıyasla daha fazla dalgalanma gösteren doğrulama doğruluğunu temsil etmektedir. Yaklaşık 60 epok değerine kadar dalgalanma görülmekte ve 60 epoktan sonra %93-95 arası değerlere ulaşmaktadır. 100 epok sonunda elde edilen doğrulama doğruluk değeri %94.44'tür. Eğitim ve doğrulama doğrulukları 100 epok sonuna doğru yakınsıyor gibi görünmektedir, bu da yöntemin doğrulama verilerine iyi genelleme yaptığını göstermektedir. Şekil 6 sağdaki eğri eğitim-doğrulama kaybını (train-validation loss) göstermektedir. Eğitim kaybının (yeşil çizgi) 100 epok boyunca 0'a yakınsadığı görülmektedir. Bu da modelin öğrendiğini ve geliştiğini göstermektedir. Kırmızı çizgi, eğitim kaybına kıyasla daha fazla dalgalanma gösteren doğrulama kaybını temsil etmektedir. Yaklaşık 50 epok değerine kadar doğrulama kaybı dalgalanmalar göstermekte ve 50 epok değerinden sonra kayıp değeri azalmaktadır. Hem eğitim hem de doğrulama kayıpları epok değeri arttıkça azalır, ancak doğrulama kaybı eğitim kaybından daha yüksektir. Sona doğru, eğitim ve doğrulama kayıpları stabilize olmuş gibi görünmektedir, bu da yöntemin eğitim performansı ve genelleme arasında iyi bir dengeye ulaştığını göstermektedir.



Şekil 5. Önerilen MobileDenseNet201 yöntemi ile elde edilen karışıklık matrisi



Şekil 6. Önerilen yöntemin eğitim-doğrulama doğruluk-kayıp eğrileri

Önerilen yöntemin literatürden farklı derin öğrenme tabanlı yöntemler ile karşılaştırılması Tablo 1'de verilmiştir. Tablo 1 incelendiğinde, önerilen yöntemin %93.96 doğruluk, %93.61 kesinlik, %95.5 duyarlılık ve %94.2 F1 skor değeri ile en başarılı sonuçları elde ettiği görülmektedir. Önerilen yöntem, MobileNet ve DenseNet201 yöntemlerinin birleşiminden oluşmaktadır. Sadece MobileNet ile gerçekleştirilen deneysel çalışmalarda %90.15 doğruluk, %90.63 kesinlik, %91.5 duyarlılık ve %90.5 F1 skor elde edilirken, DenseNet201 yöntemi ile %92.06 doğruluk, %92.24 kesinlik, %94 duyarlılık ve %92.9 F1 skor değeri elde edilmiştir. Önerilen MobileDenseNet yöntemi, MobileNet'ten %3.81 doğruluk, %2.98 kesinlik, %4 duyarlılık ve %3.7 F1 skor daha başarılıdır. Bunun yanı sıra diğer yöntemlerden daha başarılı sonuçlar elde eden DenseNet201 ile önerilen MobileDenseNet yöntemi karşılaştırıldığında, önerilen yöntemin sınıflandırma sonuçlarını %1.9 doğruluk, %1.37 kesinlik, %1.5 duyarlılık ve %1.3 F1 skor oranında arttırdığı görülmektedir. Özetle, hem VGG16 hem de VGG19 en düşük performansı göstererek bu basit yapıya sahip modellerin bu sınıflandırma görevi için daha az etkili olduğunu göstermektedir. ResNet50 ve ResNet101 orta düzeyde performans sağlarken, ResNet50 biraz daha iyi performans göstermektedir. Xception ve InceptionV3 modelleri de yüksek performans gösterirken, Xception InceptionV3'ten biraz daha iyi performans gösterir. EfficientNetB0, başarılı kesinlik ve duyarlılık gösterir, bu da yüksek genel performansla sonuçlanır. DenseNet modellerinden, hem DenseNet121 hem de DenseNet201 son derece iyi performans gösterirken DenseNet201 biraz daha iyi sonuçlar elde etmektedir. MobileNet, DenseNet121 ile karşılaştırılabilir güçlü performans sunmaktadır. Önerilen MobileDenseNet, tüm değerlendirme ölçütlerinde en yüksek ölçümleri elde ederek sınıflandırma görevi için en etkili ve güvenilir model olduğunu göstermektedir. Tablo 1'deki tüm sonuçlar göz önüne alındığında, değerlendirilen tüm modeller arasında en yüksek performansı ve en iyi dengeyi gösteren önerilen MobileDenseNet modelinin üstünlüğü açık bir şekilde görülmektedir.

Tablo 1. Farklı modeller ile elde edilen sınıflandırma sonuçları (%)

Model	Doğruluk	Kesinlik	Duyarlılık	F1 skor
VGG16	60.00	55.73	58.00	56.8
VGG19	58.73	62.97	61.8	61.00
ResNet50	77.14	78.99	83.4	78.6
ResNet101	72.70	77.09	80.3	74.8
Xception	89.20	88.80	92.1	89.6
InceptionV3	88.57	88.19	89.5	88.8
EfficientNetB0	88.25	90.42	91.7	90.1
DenseNet121	90.47	90.71	93.00	91.4
MobileNet	90.15	90.63	91.5	90.5
DenseNet201	92.06	92.24	94.00	92.9
Önerilen yöntem (MobileDenseNet)	**93.96**	**93.61**	**95.5**	**94.2**

IV. SONUÇLAR

Bu çalışmada, BT görüntülerinden akciğer kanser türlerini sınıflandırmak için MobileNet ve DenseNet201 yöntemlerinin birleşiminden oluşan MobileDenseNet yöntemi önerilmiştir. MobileNet, özellikle mobil ve gömülü cihazlar için tasarlanmış hafif bir modeldir. Daha az hesaplama gücü ve bellek kullanımı gerektirir, bu da daha hızlı ve verimli çalışmasını sağlar. Aynı zamanda MobileNet, standart evrişimleri derinlemesine ayrılabilir evrişimlerle değiştirir, bu da modelin hesaplama maliyetini ve parametre sayısını azaltır. DenseNet201, 201 katmandan oluşan çok derin bir sinir ağıdır ve çok katmanlı yapısı sayesinde daha karmaşık özellikleri öğrenebilir. DenseNet yapısında, her katman önceki tüm katmanlardan bilgi alır ve kendi çıktısını tüm sonraki katmanlara iletir. Bu, gradyanların daha etkili bir şekilde akmasını ve daha iyi öğrenme performansı sağlar. Yoğun bağlantılar, parametre verimliliğini arttırır ve daha iyi performans elde edilmesini sağlar. Bu çalışmada, MobileNet ve DenseNet201 yöntemlerinin birleşimi ile, her iki yöntemin avantajlarını bir araya getirerek daha etkili akciğer kanser türü sınıflandırma sistemi oluşturulabilmektedir. MobileNet ve DenseNet201 yönteminin birleşimi, hem hafiflik ve verimlilik hem de yüksek doğruluk ve derin özellik öğrenimi avantajlarını bir araya getirir. Bu birleşim, akciğer kanser türlerinin sınıflandırılmasında daha etkili ve esnek bir sistem oluşturulmasını sağlar. Her iki modelin güçlü yönlerinden faydalanarak, daha kapsamlı, doğru ve uyarlanabilir bir sınıflandırma çözümü elde edilebilir. Önerilen MobileDenseNet yönteminin etkinliğini test etmek için Kaggle platformunda halka açık bir veriseti kullanılarak deneysel çalışmalar gerçekleştirilmiştir. Verisetinde üç akciğer kanser türü (adenokarsinom, büyük hücreli karsinom ve skuamöz hücreli karsinom) ve normal hastalara ait dört sınıf içeren BT görüntüleri bulunmaktadır. Deneysel çalışmalar sonucunda önerilen yöntem %93.96 doğruluk, %93.61 kesinlik, %95.5 duyarlılık ve %94.2 F1 skoru elde etmiştir. Elde edilen sonuçlar, MobileDenseNet'in hem MobileNet ve DenseNet201'e kıyasla hem de literatürdeki diğer derin öğrenme tabanlı yöntemlere kıyasla daha başarılı olduğunu göstermektedir. Sonuç olarak, bu bulgular, MobileDenseNet'in akciğer kanser türlerinin sınıflandırılmasında güçlü bir araç olduğunu göstermektedir. Gelecek çalışmalarda, önerilen MobileDenseNet yönteminin farklı ve daha büyük verisetleri üzerinde test edilmesi planlanmaktadır. Ayrıca, sınıflandırma performansını arttırmak için farklı derin öğrenme teknikleri ve mimari iyileştirmeler araştırılacaktır.

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Ankara ve Eskişehir İllerinin SPEI ve SPI İndisleri ile Kuraklık Değerlendirmesi

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Özet – Kuraklık, belirli coğrafi bölgede uzun bir süre boyunca normal yağış miktarının altında seyrettiği ve genellikle su kaynaklarını olumsuz etkileyen meteorolojik bir durumu ifade eder. Günümüzde etkisi altında olduğumuz ve geleceğimizin en önemli problemlerinden biri haline gelecek olan kuraklık, geniş yüz ölçümlerini etkileyebilen ve uzun yıllar devam eden afet çeşitlerindendir. Kuraklık sınıflandırması için çeşitli standartlaştırılmış meteorolojik, hidrolojik, tarımsal ve çevresel endeksler vardır. Bu çalışma iklim değişimi etkisi sonucu Ankara ve Eskişehir illeri sınırları içerisinde olan meteorolojik gözlem istasyonlarınca ölçülmüş, 1989-2022 yılları arası ölçüm verilerinin kuraklık değerlendirmesi yaygın olarak kullanılan Standartlaştırılmış Yağış-Evapotranspirasyon İndisi (SPEI) ve Standartlaştırılmış Yağış İndisi (SPI) ile bulunmuştur. Bu yöntemlerle yapılan kuraklık analizi, beş senelik dönemlerle değerlendirilerek 7 sınıfta incelenmiştir. Aylık toplam yağış ve aylık ortalama sıcaklık verileri kullanılarak 3, 6, 9 ve 12 aylık zaman aralığında kuraklık parametreleri elde edilmiştir. Elde edilen yıllık değerlendirme sonuçlarına göre; SPEI yöntemi Ankara ilinde 10 yıl hafif nemli (1989-1998), 5 yıl hafif kurak (1999-2003), 5 yıl hafif nemli (2004-2008) ve 14 yıl hafif kurak (2009-2022) kuraklık tespit edilmiştir. Aynı yöntem ile Eskişehir ilinde 10 yıl hafif kurak (1989-1998), 5 yıl orta kurak (1999-2003), 5 yıl hafif kurak (2004-2008), 5 yıl hafif nemli (2009-2013) ve 4 yıl orta nemli (2014-2022) kuraklık görülmüştür. SPI yöntemi Ankara ilinde 10 yıl hafif nemli (1989-1998), 5 yıl hafif kurak (1999-2003), 5 yıl hafif nemli (2004-2008), 10 yıl hafif kurak (2009-2018) ve 4 yıl hafif nemli (2019-2022) kuraklık görülmüştür. Yine aynı yöntem ile Eskişehir ilinde 25 yıl hafif kurak (1989-2013), 5 yıl orta nemli (2014-2018) ve 4 yıl aşırı şiddetli nemli (2019-2022) kuraklık verileri elde edilmiştir.

Standartlaştırılmış Yağış İndisi (SPI), Standartlaştırılmış Yağış-Evapotranspirasyon İndisi (SPEI),), Kuraklık Analizi, Ankara, Eskişehir, Türkiye

I. GİRİŞ

Türkiye'nin iklimi genellikle yarı kurak özellikler taşır. Bu durum, ülkenin denizlerle çevrili olmasının yanı sıra, kıyı şeridi boyunca uzanan sıra dağlarının varlığı ve kısa mesafelerde yükselti farklılıklarının bulunmasından kaynaklanır[1]. Kuraklık indisleri, kuraklık olaylarının zaman ve alandaki seyrini izleyerek, şiddetini değerlendirme ve erken belirleme konusunda önemli bir rol oynar. Bu indisler, kuraklıkla mücadele stratejilerinin geliştirilmesine katkı sağlar. Kuraklık indisleri arasında en yaygın olarak kullanılan Standartlaştırılmış Yağış İndisi (SPI) ve Standartlaştırılmış Yağış Evapotranspirasyon İndisi (SPEI), birbirlerine benzer olup farklı kuraklık çeşitlerini tanımlayabilme ve kuraklık özelliklerindeki değişiklikleri daha hassas bir şekilde yansıtabilme kabiliyetleriyle literatürde yaygın olarak kullanılmaktadır [2]. Bu çalışmada, 1989-2022 yılları arasında aylık toplam yağış ve aylık ortalama sıcaklık verileri kullanılarak 3, 6, 9 ve 12 aylık zaman aralığı kullanılarak SPEI ve SPI indeksleri ile kuraklık değerlendirmesi yapılmaktadır. Çalışma alanı olarak, Kızılırmak havzasında bulunan Ankara ve Sakarya havzasında

bulunan Eskişehir illeri seçilmiştir. Çalışmada bu illere ait olan istasyonların 34 yıllık verileri analize tabi tutulacaktır.

II. MATERYAL VE YÖNTEM

Analiz edilecek bölge seçilen Ankara ili, Kızılırmak havzasında ve Eskişehir ili Sakarya Havzasında bulunmaktadır. Bu bölgelere ait 1989-2022 seneleri arasındaki aylık toplam yağış ve ortalama sıcaklık verileri Meteoroloji Genel Müdürlüğünden (MGM) temin edilerek SPEI ve SPI değerleri incelenecektir.

A. Çalışma Alanı

Çalışmada kullanılan veriler, Ankara ve Eskişehir meteorolojik istasyonlarından temin edilmiştir. Kullanılacak istasyonları için genel veriler Tablo 1'de belirtilmiştir.

Tablo 1. Kullanılan istasyonların genel bilgileri

İstasyon No	İstasyon Adı	Ölçüm Aralığı	Rakım (m)
17130	Ankara	1989-2022	938
17124	Eskişehir	1989-2022	788

Çalışma alanı olarak seçilen Ankara ilinin bir kısmı Kızılırmak Havzası içerisinde bulunmaktadır. Bu havzanın çevresi 3.546 km iken alanı 82.221 km^2' dir[3]. Eskişehir ilinin tamamı Sakarya Havzası içerisinde bulunmaktadır. Türkiye yüzölçümünün yaklaşık %8'ini oluşturmaktadır[4]. Kızılırmak Havzası ve Sakarya Havzası konumları Şekil 1'de belirtilmiştir.

Şekil 1: Kızılırmak Havzası ve Sakarya Havzası Konumları

1989-2022 yılları arasındaki, Ankara-17130 istasyonu ve Eskişehir-17124 istasyonu aylık ortalama sıcaklık verileri yıl geneli dağılım çizgi grafikleri Şekil 2-3'de sunulmuştur.

Şekil 2: Ankara-17130 İstasyonu Aylık Ortalama Sıcaklık Grafiği

Şekil 3: Eskişehir-17124 İstasyonu Aylık Ortalama Sıcaklık Grafiği

1989-2022 yılları arasındaki, Ankara-17130 istasyonu ve Eskişehir-17124 istasyonu aylık toplam yağış verilerinin yıl geneli dağılım çizgi grafikleri Şekil 4-5'te belirtilmiştir.

Şekil 4: Ankara-17130 İstasyonu Aylık Toplam Yağış Grafiği

Şekil 5: Eskişehir-17124 İstasyonu Aylık Toplam Yağış Grafiği

Kullanılan verilere ilave olarak hesaplanan ortalama değerler ve standart sapma değerleri Tablo 2'de belirtilmiştir.

Tablo 2. İstasyonlara Ait istatiksel Veriler

İstasyon Adı/No	**Aylık Ortalama Sıcaklık Verileri Ort.**	**Aylık Toplam Yağış Verileri Ort.**	**Aylık Ortalama Sıcaklık Verileri Std. Sapması**	**Aylık Toplam Yağış Verileri Std. Sapması**
Ankara /17130	12,61	408,50	0,99	84,58
Eskişehir /17124	11,65	770,27	1,88	444,19

B. Standartlaştırılmış Yağış İndisi (SPI)

SPI, McKee ve ekip arkadaşları, farklı iklim bölgelerindeki kuraklık durumlarını tanımlamak ve takip etmek için 1993 yılında bu yöntemi geliştirmişlerdir[5]. Bu yöntemde, tek gereken meteorolojik değişken yağış olduğundan, uygulanması kolaydır. Ayrıca, kuraklık analizlerinin farklı zaman ölçeklerinde tespit edilmesini sağlaması da önemli bir avantajdır. SPI indisi Dünya Meteoroloji Örgütü (WMO) tarafından küresel ölçekte tavsiye edilen bir indistir. SPI, belirli bir zaman dilimindeki yağışın ortalama değerinden çıkarılarak standart sapmasına bölünmesiyle hesaplanır.

$$SPI_{i,j} = \frac{X_{i,j} - X_j^{ort}}{O_j} \qquad (1)$$

(1)`de, i yılının j ayındaki yağışı(mm) $X_{i,j}$ ile , j ayındaki ortalama yağışı (mm) X^{ort}_j ile ve yine j ayındaki yağışın standart sapması Q_j ifadesi ile ifade edilmektedir. SPI yöntemiyle farklı zaman ölçekleri için hesap yapılabilir. Ancak yağış verileri genellikle 12 ay ve daha kısa dönemler için normal dağılıma uygun değildir. Bu sebeple, her veri seti Gamma fonksiyonuyla uyumlu hale getirilir[6].

C. Standartlaştırılmış Yağış Evapotranspirasyon İndisi (SPEI)

SPEI kuraklık koşullarını takip etmek ve analiz etmek için en sık kullanılan ölçütlerden biridir. SPI ile birbirleriyle benzer olup Vicente Serrano ve ekip arkadaşları, bitki evapotranspirasyonu ile meteorolojik kuraklık arasındaki ilişkiyi kullanarak tarımsal kuraklık şiddetini değerlendirmek için 2010 yılında bu yöntemi geliştirmişlerdir[7]. SPEI hesaplama işlemi oldukça basit bir yöntemdir. SPEI, aylık veya haftalık potansiyel evapotranspirasyon (PET) ile yağış (P) arasındaki farkı (D) temel alır[8]. Bu fark (D), incelenen ay (i) için su fazlasını veya eksikliğini ifade eder ve (2) kullanılarak hesaplanır.

$$D_i = P_i - PET_i \qquad (2)$$

Thornthwaite'nin 1948 yılında geliştirdiği bir yöntem olan potansiyel ve gerçek evapotranspirasyon hesaplamaları için adımlar aşağıdaki gibidir.

- Her ay için ortalama sıcaklık değerlerine dayanarak aylık sıcaklık indekslerinin belirlenmesidir.

$$i = \left(\frac{t}{5}\right) 1.514 \qquad (3)$$

(3)`de; aylık sıcaklık indisi i ile ortalama aylık sıcaklık t ile ifade edilir (^oC)'dır.

- Her ayın sıcaklık indisleri toplanarak yıllık bir sıcaklık indeksi elde edilir.

$$I = \sum_{k=1}^{12} i \quad k = 1 - 12 \qquad (4)$$

(4)`de; yıllık sıcaklık indisi 'I', aylık sıcaklık indisi 'i' ve işlem yapılan ay 'k' ile ifade edilir.

- Potansiyel Evapotranspirasyon,

$$PET = \left(16 * \frac{10*t}{I}\right)^a \qquad (5)$$

(5)` de; potansiyel evapotranspirasyon PET(mm/ay); ortalama aylık sıcaklık t (°C), yıllık sıcaklık indeksi I iken; katsayı a ile ifade edilir ve (6) de hesaplama yöntemi gösterilmiştir.

$$a = (0.000000675 * I^3) - (0.000077 * I^2) + (0.01792 * I) + 0.49239 \qquad (6)$$

- Ayın evapotranspirasyon değeri, o ayın enlem düzeltme katsayısıyla çarpılarak Düzeltilmiş Potansiyel Evapotranspirasyon

(DPET, mm/ay) elde edilir. Enlem düzeltme katsayı değerleri Thornthwaite tarafından hazırlanan bir tabloda yer alır.

$$\mathrm{DPET} = (\mathrm{PET} * \mathrm{G}) \qquad (7)$$

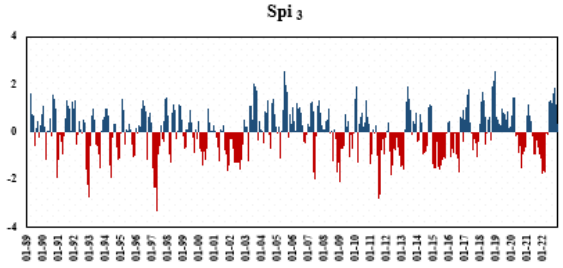
Araştırma havzalarında, SPEI ve SPI İndisleri yöntemleriyle elde edilen sonuçlar, Tablo 3'de belirtilen kuraklık kategorilerine göre sınıflandırılmıştır.

Tablo 3. Kuraklık Kategorileri Sınıflandırması

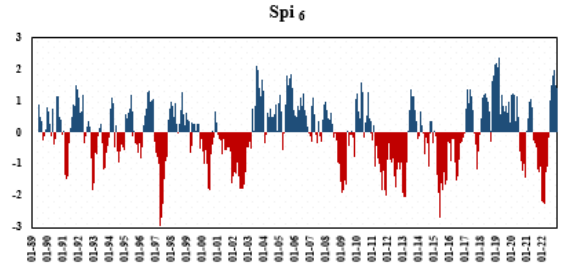
SPEI ve SPI Değer aralıkları	Kategori Sınıflandırması
2.00 ve üzeri	Aşırı Şiddetli Nemli
1.50 ile 1.99 arası	Şiddetli Nemli
1.00 ile 1.49 arası	Orta Nemli
0.00 ile 0.99 arası	Hafif Nemli
-0.99 ile 0.00 arası	Hafif Kurak
-1.49 ile -1.00 arası	Orta Kurak
-1.99 ile -1.50 arası	Şiddetli Kurak
-2.00 ve altı	Aşırı Şiddetli Kurak

III. BULGULAR

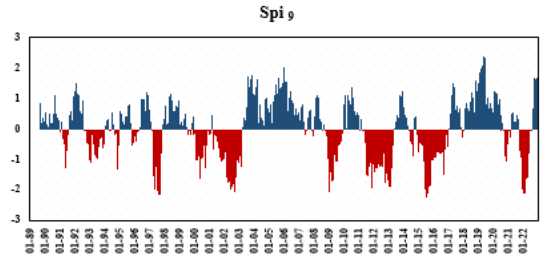
Bu çalışmada; 1989-2022 yılları arasında Kızılırmak havzasında bulunan Ankara ve Sakarya havzasındaki Eskişehir illerindeki istasyonlardan 34 yıllık aylık toplam yağış ve aylık ortalama sıcaklık verileri kullanılarak SPI ve SPEI yöntemleri ile kuraklık değerlendirmesi yapılmıştır. İki indiste de 3,6,9 ve 12 aylık kuraklık incelenmiş ve değerlendirilmiştir. Ankara ili için SPI_3, SPI_6, SPI_9 ve SPI_{12} grafikleri Şekil 6-9'da gösterilmiştir.



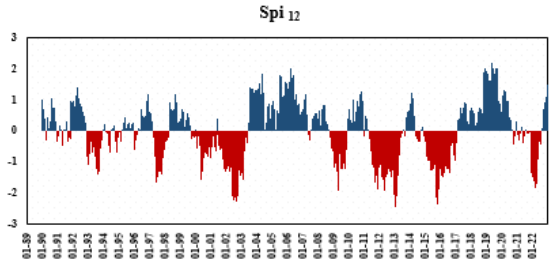
Şekil 6: Ankara ili 3 Aylık Kuraklık Değerleri (SPI_3)



Şekil 7: Ankara ili 6 Aylık Kuraklık Değerleri (SPI_6)

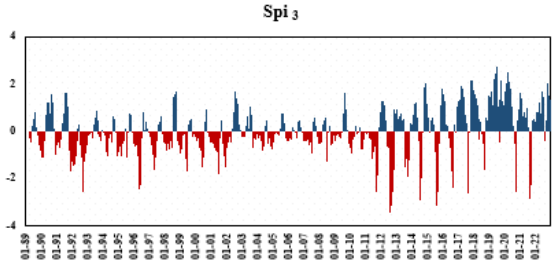


Şekil 8: Ankara ili 9 Aylık Kuraklık Değerleri (SPI_9)

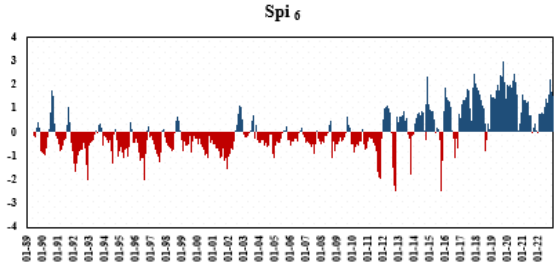


Şekil 9: Ankara ili 12 Aylık Kuraklık Değerleri (SPI_{12})

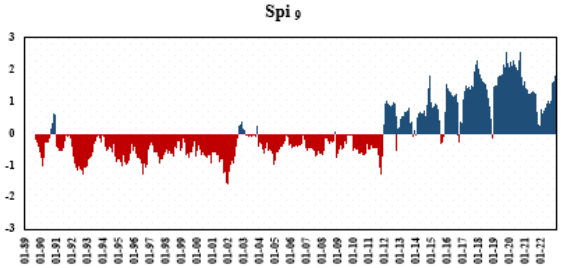
Eskişehir ili için SPI_3, SPI_6, SPI_9 ve SPI_{12} yöntem grafikleri Şekil 10-13'de gösterilmiştir.



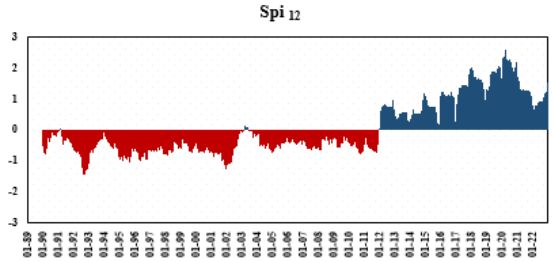
Şekil 10: Eskişehir ili 3 Aylık Kuraklık Değerleri (SPI_3)



Şekil 11: Eskişehir ili 6 Aylık Kuraklık Değerleri (SPI_6)

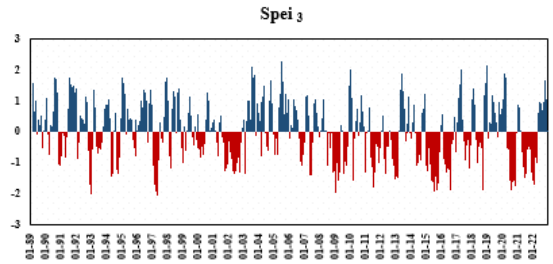


Şekil 12: Eskişehir ili 9 Aylık Kuraklık Değerleri (SPI_9)

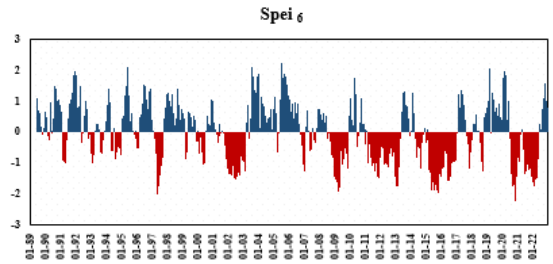


Şekil 13: Eskişehir ili 12 Aylık Kuraklık Değerleri (SPI_{12})

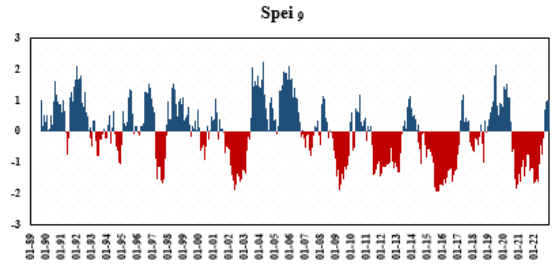
Ankara ili için $SPEI_3$, $SPEI_6$, $SPEI_9$ ve $SPEI_{12}$ yöntem grafikleri Şekil 14-17'de belirtilmiştir .



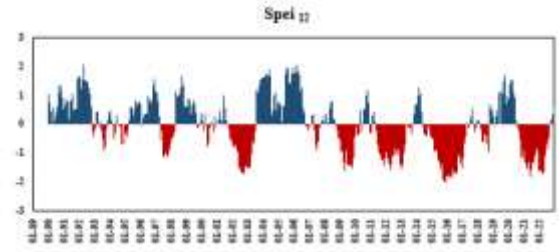
Şekil 14: Ankara ili 3 Aylık Kuraklık Değerleri ($SPEI_3$)



Şekil 15: Ankara ili 6 Aylık Kuraklık Değerleri ($SPEI_6$)

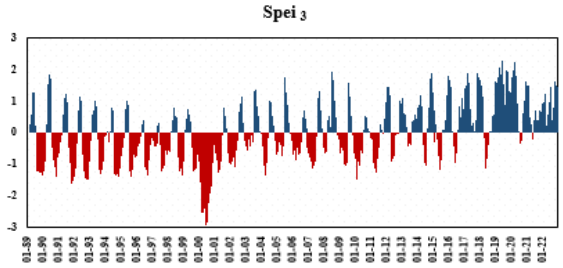


Şekil 16: Ankara ili 9 Aylık Kuraklık Değerleri ($SPEI_9$)

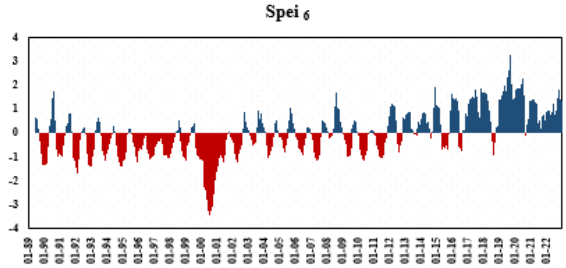


Şekil 17: Ankara ili 12 Aylık Kuraklık Değerleri($SPEI_{12}$)

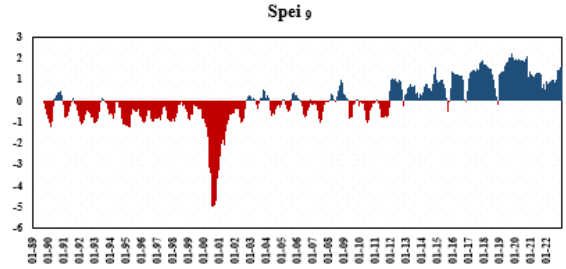
Eskişehir ili için $SPEI_3$, $SPEI_6$, $SPEI_9$ ve $SPEI_{12}$ yöntem grafikleri Şekil 18-21'de belirtilmiştir.



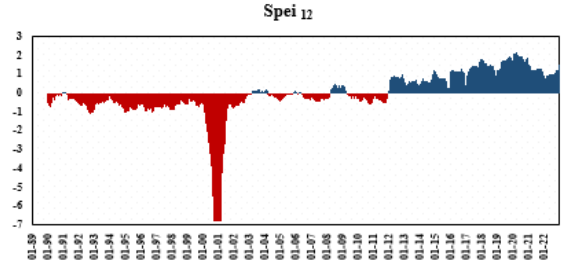
Şekil 18: Eskişehir ili 3 Aylık Kuraklık Değerleri ($SPEI_3$)



Şekil 19: Eskişehir ili 6 Aylık Kuraklık Değerleri ($SPEI_6$)



Şekil 20: Eskişehir ili 9 Aylık Kuraklık Değerleri ($SPEI_9$)



Şekil 21: Eskişehir ili 12 Aylık Kuraklık Değerleri ($SPEI_{12}$)

Ankara ve Eskişehir illerinin kuraklık değerlendirmesi beş senelik periyotlarla ele alınarak 7 sınıfta incelenmiştir. Aylık ortalama sıcaklık ve aylık toplam yağış verileri kullanılarak 3, 6, 9 ve 12 aylık zaman ölçeklerinde değerler elde edilmiştir. 7 sınıfta incelenen SPEI ve SPI yöntemlerinin 5 yıllık periyot değerleri Tablo 4-5'de incelenmiştir.

Tablo 4. Ankara ve Eskişehir illeri SPI değer tablosu

Spi_3	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,038	0,005	-0,204	0,311	-0,232	-0,018	0,172

Spi_6	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,033	0,053	-0,298	0,472	-0,373	-0,093	0,289

Spi_9	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,071	0,029	-0,407	0,660	-0,483	-0,139	0,365

Spi_{12}	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,090	0,011	-0,466	0,797	-0,581	-0,147	0,399

Spi_3	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,136	-0,312	-0,207	-0,157	-0,304	0,287	0,933

Spi_6	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,271	-0,490	-0,381	-0,327	-0,202	0,769	1,363

Spi_9	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,403	-0,641	-0,503	-0,426	-0,069	1,032	1,526

Spi_{12}	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,433	-0,675	-0,542	-0,452	-0,038	1,105	1,554

Tablo 5. Ankara ve Eskişehir illeri SPEI değer tablosu

$Spei_3$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,290	0,192	-0,067	0,263	-0,265	-0,317	-0,103

$Spei_6$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,345	0,298	-0,111	0,401	-0,412	-0,470	-0,086

$Spei_9$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,454	0,287	-0,124	0,589	-0,508	-0,586	-0,172

$Spei_{12}$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	0,525	0,264	-0,123	0,706	-0,592	-0,616	-0,239

$Spei_3$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,258	-0,440	-0,522	-0,016	-0,043	0,508	1,053

$Spei_6$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,301	-0,560	-0,729	-0,072	-0,047	0,725	1,322

$Spei_9$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,356	-0,656	-1,071	-0,106	0,047	0,992	1,448

$Spei_{12}$	1989-1993	1994-1998	1999-2003	2004-2008	2009-2013	2014-2018	2019-2022
	-0,373	-0,713	-1,483	-0,111	0,127	1,102	1,474

Bu değerler doğrultusunda kuraklık eğilimi SPI yönteminde en kurak yılların 2009-2013, en nemli olduğu yılların 2019-2022 olarak görülmüştür. SPEI yönteminde kuraklık eğiliminin en kurak olduğu yılların 1999-2003, en nemli olduğu yılların ise 2019-2022 olduğu görülmüştür.

IV. SONUÇ

Bu çalışmada, Ankara ve Eskişehir illerindeki istasyonlardan alınan 1989-2022 yılları arasındaki 34 yıllık aylık ortalama sıcaklık ve aylık toplam yağış verileri SPEI ve SPI indisleri ile kuraklık incelenip değerlendirilmiştir. SPI indisi sonuçları ile SPEI indisinin sonuçları doğrultusunda bu çalışma incelendiğinde; SPEI yöntemi Ankara ilinde 10 yıl hafif nemli (1989-1998), 5 yıl hafif kurak (1999-2003), 5 yıl hafif nemli (2004-2008) ve 14 yıl hafif kurak (2009-2022) kuraklık tespit edilmiştir. Aynı yöntem ile Eskişehir ilinde 10 yıl hafif kurak (1989-1998), 5 yıl orta kurak (1999-2003), 5 yıl hafif kurak (2004-2008), 5 yıl hafif nemli (2009-2013) ve 4 yıl orta nemli (2014-2022) kuraklık görülmüştür. SPI yöntemi Ankara ilinde 10 yıl hafif nemli (1989-1998), 5 yıl hafif kurak (1999-2003), 5 yıl hafif nemli (2004-2008), 10 yıl hafif kurak (2009-2018) ve 4 yıl hafif nemli (2019-2022) kuraklık görülmüştür. Yine aynı yöntem ile Eskişehir ilinde 25 yıl hafif kurak (1989-2013), 5 yıl orta nemli (2014-2018) ve 4 yıl aşırı şiddetli nemli (2019-2022) kuraklık verileri elde edilmiştir.

TEŞEKKÜR

Veriler için, Meteoroloji Genel Müdürlüğü çalışma ekibine teşekkür ederiz.

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LiCuS'in Yapısal, Mekanik ve Elektronik Özellikleri Üzerindeki Basınç Etkileri: İlk İlkeler Çalışması

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Özet – Bu çalışmada, yoğunluk fonksiyonel teorisi (DFT) kullanılarak Yarı- Heusler alaşımı olan LiCuS bileşiğinin basınç altındaki yapısal, mekanik ve elektronik özellikleri detaylı bir şekilde incelenmiştir. Heusler alaşımları, yüksek termal ve elektriksel iletkenlikleri, manyetik özellikleri ve yapısal stabiliteleri ile bilinir ve bu özellikler LiCuS'in de karakteristiklerini yansıtmaktadır. Farklı basınç seviyelerinde LiCuS'in kristal yapısı optimize edilmiş ve bu yapıdaki değişimler analiz edilmiştir. Basınç altındaki elastik modüller ve Bulk modülü gibi mekanik özellikler hesaplanmış ve bu parametrelerin malzemenin deformasyona karşı direncini nasıl etkilediği araştırılmıştır. Elektronik bant yapısındaki değişimler incelenerek basıncın LiCuS'in yarı iletkenlik ve mekanik özelliklerine olan etkileri değerlendirilmiştir. Elde edilen sonuçlar, LiCuS'in yüksek basınç koşullarında pil, sensör ve optoelektronik cihazlar gibi alanlarda potansiyel uygulamaları için önemli bilgiler sunmaktadır.

Anahtar Kelimeler – Half Heusler, DFT, Elektronik Özellikler, Mekanik Özellikler, Optik Özellikler

1. GİRİŞ

Son zamanlarda, malzeme bilimi alanındaki çalışmaların genişliği, yeni malzemelerin geliştirilmesiyle ilgilenmektedir. Heusler bileşikleri, 1500'den fazla bileşik oluşturabilen bir intermetalik bileşikler ailesi olarak, geniş bileşim aralığı ve ayarlanabilir malzeme özellikleri nedeniyle yeni malzeme tasarımı için uygun bir çalışma alanı sunar. Heusler bileşiklerinin çoğu manyetik intermetalik olup, kristal yapıları yüzey merkezli kübiktir. Heusler bileşikleri, üç elementin farklı stokiyometrileri tarafından oluşturulan 1:1:1 (yarı Heusler) veya 2:1:1 (tam Heusler) olmak üzere iki sınıftan oluşur[1,2].

Yarı Heusler bileşiklerinin farklı uygulama alanları vardır. Yarı Heusler bileşikleri, bant aralıkları nedeniyle termoelektrik uygulamalarda, Fermi seviyesindeki spin polarizasyonu ve yüksek Curie sıcaklıkları ile spintronik uygulamalarda dikkat çekmişlerdir. Ayrıca, optoelektronik uygulamalarda ince film güneş pilleri ve lazer diyotları gibi uygulamalarda kullanılmaktadırlar. Yarı metaller, manyetik tünel bağlantıları ve dev magnetorezistans cihazları için spin polarize akımlarını yarı iletkenlere enjekte etmek üzere ideal elektrot malzemeleri olarak kabul edilir. Bu üçlü Yarı Heusler bileşikleri, termoelektrik, optoelektronik ve elektronik cihaz uygulamalarıyla ilgili birçok teorik ve deneysel çalışmanın konusu olmuştur[3].

DFT (Yoğunluk Fonksiyonel Teorisi) ve basınç etkisi üzerine yapılan araştırmalar, malzemelerin yapısal, elastik ve elektronik özelliklerini anlamada önemli bir rol oynamaktadır[4]. DFT hesaplamaları, malzemelerin kristal yapılarının basınç altındaki değişimlerini incelemek için yaygın olarak kullanılır. Örneğin, yüksek basınç altında yapısal faz geçişleri gözlemlenebilir ve bu geçişler malzemenin fiziksel ve kimyasal özelliklerini önemli ölçüde etkileyebilir. Basınç altında mekanik kararlılığın korunup korunmadığı DFT hesaplamaları ile belirlenebilir.Ayrıca, bant aralıkları basınç altında daralabilir veya genişleyebilir, bu da malzemenin iletkenlik özelliklerini etkiler. DFT ve basınç etkisi üzerine yapılan bu tür çalışmalar, malzemelerin yüksek basınç altındaki davranışlarını anlamada ve yeni malzemelerin

tasarımında kritik öneme sahiptir. Bu çalışmalar, hem teorik modellerin geliştirilmesine katkıda bulunmakta hem de deneysel çalışmalara rehberlik etmektedir.
Günümüzde lityum piller, mobil elektronik uygulamalarda önemli bir rol oynamakta olup, cep telefonları, dizüstü bilgisayarlar ve diğer cihazlar için endüstriyel ölçekte seri üretimi yapılmaktadır. Yakın gelecekte, elektrikli arabaların fosil yakıtlar yerine lityum pillerle çalışması ve büyük kapasiteli lityum-iyon akümülatörlerin güneş panelleri ve rüzgar türbinleri gibi yenilenebilir enerji uygulamaları için geçici depolama sağlaması beklenmektedir. Bu nedenle, tüm pil sistemleri (birincil, ikincil veya şarj edilebilir piller) için yeni elektrot malzemeleri elde etmek amacıyla lityum bazlı bileşikler geniş çapta araştırılmıştır.

Li tabanlı Yarı- Heusler bileşikler ile ilgili literatürde çok çalışma mevcuttur. Aynı gruba ait LiCuS yarı iletken bileşiği ile ilgili henüz bir kaç çalışma mevcuttur. Ancak basınç etkisi çalışılmamıştır. Bu çalışmanın amacı Yoğunluk fonksiyoneli teorisi kullanarak LiCuS bileşiği için yapısal, elastik, elektronik özellikleri üzerine basınç etkisinin teorik olarak incelenmesidir.

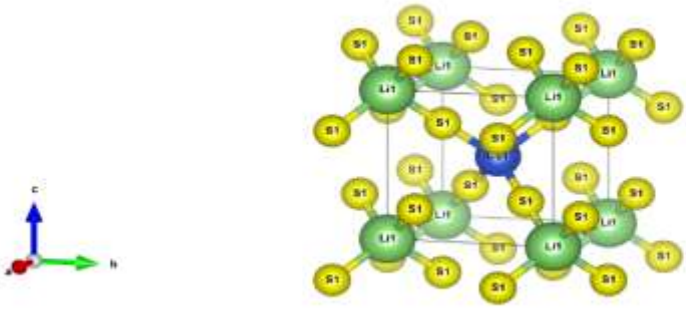
I. MATERYAL VE YÖNTEM

Hesaplamalar, Vienna ab initio simülasyon paketi (VASP) [5] kullanılarak yoğunluk fonksiyon teorisi (DFT) çerçevesinde gerçekleştirilmiştir. Projeksiyon artırılmış dalga (PAW) yöntemi kullanılarak değişim-korelasyon fonksiyoneli, Perdew-Burke-Ernzerhof (PBE) [6] ile genelleştirilmiş gradyan yaklaşımı (GGA) ile ele alınmıştır. 700 eV'lik kinetik kesme enerjisi, toplam enerjilerin ve yapısal parametrelerin mükemmel bir şekilde yakınsadığını göstermiştir. Birim hücrelerin Brillouin bölgeleri, 16×16×16 Monkhorst-Pack ızgara ağları ile temsil edilmiştir. Enerji değişimi 1.0×10^{-5} eV'den daha düşük bir seviyeye yakınsadı ve maksimum kuvvet 0.01 eV/Å'den daha az oldu.

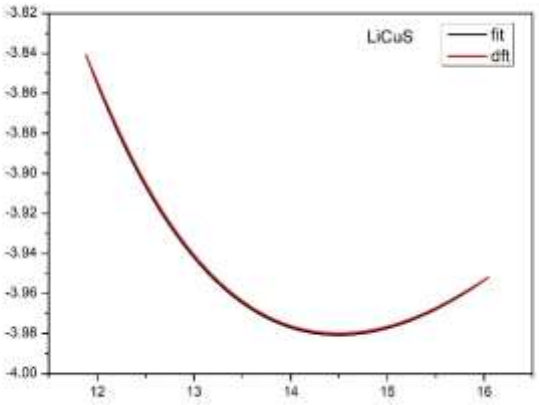
II. BULGULAR

A. *Yapısal Özellikler*

LiCuS, kübik MgAgAs tipi fazda F43m (216) uzay grubuna sahip olarak kristalleşir. Bu yapıda Li atomları (0.0; 0.0; 0.0) konumlarını, Cu atomları (0.25; 0.25; 0.25) konumlarını ve S atomları (0.25; 0.25; 0.25) konumlarını işgal eder, Şekil 2'de gösterildiği gibi denge geometrisini belirlemek için, birim hücrenin hacmini ve tüm atomik konumları rahatlatmak amacıyla VASP'de ISIF = 3 ayarı kullanılmıştır. Rahatlatılmış denge örgü sabiti ile E (V) eğrilerine Murnaghan[7] durum denklemi uygulanarak hacim modülü (B) belirlenmiştir. Araştırılan bileşiğin elde edilen sonuçları Tablo 1'de verilmiştir ve literatür değerleri ile karşılaştırılmıştır [8]. Tablo 1'den görüldüğü üzere, hesaplanan LiCuS için (a = 5.47 Å) örgü sabiti, Belmiloud ve arkadaşlarının sonuçları ile iyi bir uyum içindedir. Optimizasyon sonucu elde edilen örgü sabitine karşılık gelen hacim, denge hacmi olarak adlandırılır. Literatürde hesaplanan denge hacmimiz V_0 (Å^3) ve bulk modülünün basınç türevi için herhangi bir veri bulunmamasına rağmen, bulk modülü (GPa) değeri litaratür ile uyum içindedir. Tablo 1'den, hesaplanan kafes parametrelerinin mevcut verilerle iyi bir tutarlılık gösterdiği ve bu çalışmanın güvenilirliğini desteklediği görülmektedir. Değerlendirilen değerlerin mevcut verilerden küçük sapmalar göstermesi, farklı hesaplama parametrelerinden kaynaklanabilir.



Şekil 1. LiCuS bileşiğinin Birim hücresi,



Şekil. 2 Enerji hacim grafiği

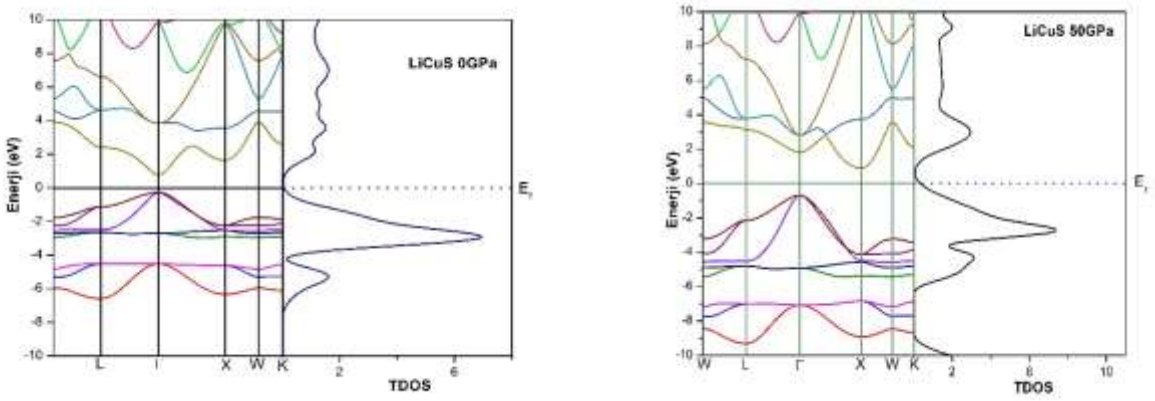
Tablo 1. Hesaplanan örgü sabiti a (Å), hacim V (Å^3), Hacim modülü B(GPa), Hacim modülünün birinci türevi B'

Bileşik	**a(Å)**	**E(eV)**	**V(Å^3)**	**B(GPa)**	**B'**
LiCuS [8]	5.47 5.57	-11.94 eV	43.49	66.38 65.73	4.26

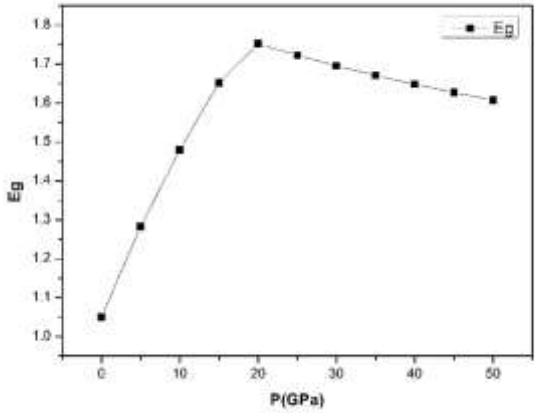
B. Elektronik Özellikler

Kristallerin elektronik yapısının bilinmesi, deneysel modelleme ve çeşitli enerji cihazlarının üretiminde değerli bilgiler sağlaması açısından önemlidir. Şekil 3'da gösterildiği gibi, sonuçlarımız LiCuS'nin bant aralığı 0GPa'da 1.05 eV olan doğrudan bant (Γ- Γ) geçişine karşılık geldiğini ve daha önce bildirilen teorik değerden düşük (1.88 eV [8]) olduğunu göstermektedir. Şekil 3(a)'da görüldüğü üzere, denge örgü sabitinde toplam durum yoğunluğu ile elektronik bant yapısı hesaplanmıştır. Teorik bant aralığı enerji değerlerinin deneysel olanlara kıyasla daha küçük olduğu vurgulanabilir. Bu fark, DFT ile yapılan ab initio hesaplamalarda iletkenlik bandı durumu enerjilerinin iyi bilinen bir şekilde düşük tahmin edilmesinden kaynaklanmaktadır.

LiCuS'nin elektronik özellikleri üzerindeki basınç etkisini görmek için, bant yapısını 50 GPa basınç altında hesapladık (Şekil 3(b)). Sonuçlar, hala doğrudan bant aralıklı bir yarı iletken olduğunu, ancak bant aralığının artan basınçla neredeyse 20 GPa basınca lineer olarak arrttığını göstermektedir, bu da Şekil 4'te gösterilmiştir. 20 GPa basınçtan sonra azalma eğilimi göstermektedir.

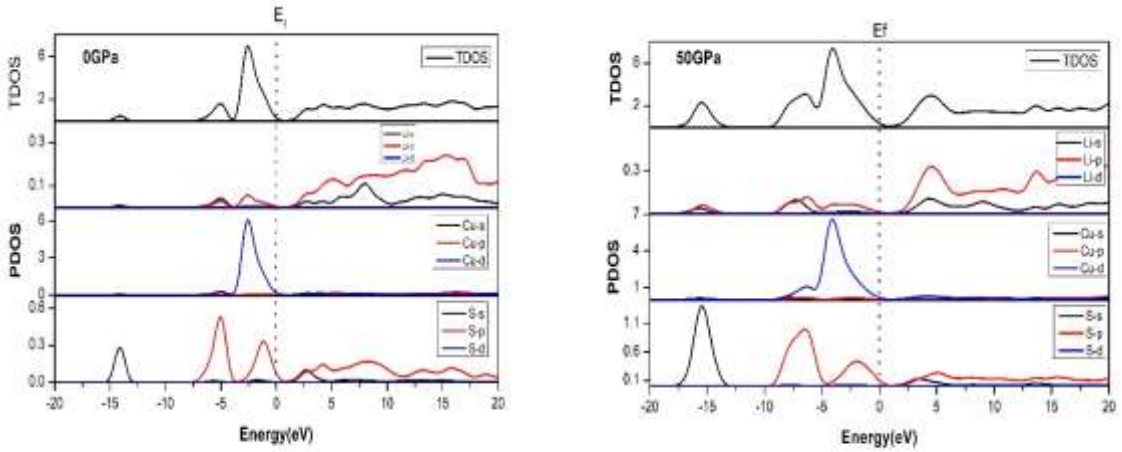


Şekil 3. 0 ve 50 GPa basınç altında elektronik band yapısı



Şekil 4.Basınçla band aralığının değişimi

LiCuS bileşiğinin kısmi ve toplam durum yoğunluk (DOS) grafiği 0 ve 50 GPa basınç altında Şekil 5'te gösterilmiştir. 0 GPa için valans bandında -15 ev civarı S atomunun s bandından katkı gelmektedir. Valans bandında Fermi enerjisinin sol tarafı -7 -0 eV arası coğunlukla Cu-d orbitalinden olmak üzere az miktarda S-p orbitalinden de gelmektedir. Fermi enerjisinin sağ tarafında iletkenlik bandında Li-p ve S-p bandından katkı gelmektedir. Basınç uygulnmasıyla 50 GPa altında DOS şekli değişmemiştir. Sadece az miktarda DOS değerleri artmakta ve pikler çok az düşük enerji bölgesine doğru kaymaktadır.



Şekil 5. LiCuS bileşiğinin kısmi ve toplam durum yoğunluğu

C. Elastik Properties

Bir malzemenin elastik özellikleri, birçok farklı temel katı hal özelliği ile yakından ilişkilidir. Özellikle, yapısal kararlılık, bitişik atomik düzlemler arasındaki bağ karakteristiği ve bir bileşikteki bağın anizotropik karakteri hakkında içgörü sağlarlar. Özellikle, elastik sabitler (C_{ij}), malzemelerin mekanik özelliklerinin belirlenmesi için temel ve vazgeçilmezdir. Bir kübik kristal için, C_{11} uzunluktaki elastikiyeti, C_{12} ve C_{44} ise şekil elastikiyetini karakterize eder. Sabit hacimle şekil değişikliği, boyuna gerinim C_{11}'i değiştirirken, enine gerinim tarafından oluşturulur.

Küçük gerinimler Hooke yasasına uyar: basınç altındaki elastik sertlik tensörleri, gerilim ve gerinim tensörleri ile ilişkilidir. Mekanik özelliklerin hesaplanması için elastik tensör, örgü üzerinde sonlu distorsiyonlar uygulanarak ve elastik sabitler zor-zorlanma ilişkisinden türetilerek belirlenir. Kuvvetler ve elastik sabitler sırasıyla potansiyellerin birinci ve ikinci derece türevlerinin fonksiyonlarıdır. Burada, MgAgAs yapısındaki bu bileşiğin kararlılığının incelemek amacıyla denge örgü parametresinde elastik sabitleri hesapladık. C_{11}, C_{44}'ten daha büyüktür. Bu, alaşımın saf kayma deformasyonuna karşı tek yönlü dirençten daha güçlü bir direnç gösterdiği anlamına gelir.

Tablo 2'de gösterildiği gibi, kübik elastik sabitler pozitiftir ve Born-Huang (BH) stabilite kriterlerini sağlar:

$$C_{11}>0, C_{12}>0, C_{44}>0, C_{12}<B<C_{11}, C_{11}-C_{12}>0, C_{11}+2C_{12}>0 \quad (1)$$

Bu kriterler, LiCuS bileşiğinin mekanik olarak kararlı olduğunu doğrulamaktadır.

Elastik sabitlerin basınca bağımlılığı, kristallerin karakterizasyonu için önemlidir. Değişen basınç altında ikinci dereceden elastik sabitler (Cij), "zor-zorlanma" tekniği kullanılarak hesaplanmıştır. Hesaplanan elastik sabitler Tablo 2'de listelenmiştir. Bildiğimiz kadarıyla, literatürde LiCuS bileşiğinin basınç altındaki elastik özellikleri üzerine ne deneysel ne de teorik veri bulunmaktadır. Dolayısıyla, burada sunulan elastik sabitlerin mevcut literatüre değerli veriler ekleyebileceğini söyleyebiliriz.

Basınç, fiziksel özellikler üzerinde önemli bir rol oynar. Malzemelerin değişen basınç altındaki elastik özellikleri daha fazla incelenmiştir. Teorik hesaplamalar azalan hacimlerde sürdürülmüş ve Tablo 2, sabit uygulanan hidrostatik basınç 50 GPa'ya kadar 5 GPa aralıklarla artırıldığında her değeri göstermektedir. Bu basınç değerlerinde tam bir geometrik optimizasyon gerçekleştirilmiş ve basınca göre elastik sabitlerin (C_{11}, C_{12} ve C_{44}) değişimleri Tablo2 'de sunulmuştur. Artan basınç değerlerinde C_{11} ve C_{12} elastik sabitleri daha hızlı artarken, C_{44} daha yavaş basınçla değişir. C_{11} ve C_{12}, uzunluktaki elastiklikle ilgili olup basınçla hızla

artar. Aslında, C44 şekil elastikiyetiyle ilgilidir ve şekil değişimindeki sertlik ile ilişkilidir. Elastik sabitler ortalama bağ kuvvetiyle ilişkilidir.

Çeşitli mekanik özellikler, Poisson oranı (ν), Young modülü (E) ve Kayma modülü ($G = (C_{11}-C_{12}+2C_{44})/4$) elastik sabitlerden belirlenebilir. Tablo 2'de de görüldüğü gibi, bu mekanik özellikler bir malzemenin mukavemetini belirler. Yüksek kayma modülü kovalent doğayı yansıtır. Tablo 2'de gösterildiği gibi, LiCuS düşük Young ve kayma modüllerine sahiptir, bu da sert bir malzeme olmadığını gösterir. Basınca bağlı olarak Bulk modülü basınçla neredeyse doğrusal olarak artar ancak kayma modülü Young modülünden daha yavaş azalır. Pugh, bulk ve kayma modüllerinin (B/G) basit bir ilişkisini, süneklik tahmini için önermiştir. Kayma modülü G, plastik deformasyona direnci temsil ederken, yığın modülü B kırılmaya karşı direnci temsil eder. Süneklik ve kırılgan malzemeleri ayıran kritik değer 1.75'dir, yani B/G basınçlar (0–50 GPa) için değeri 1.75 den büyüktür. Bu bileşiğin doğada sünek olduğunu gösterir. B/G oranının uygulanan basınçla artmaktadır ve bu durumun LiCuS'nin sünek özelliklerinin basınç altında belirgin hale geldiğini görmek de mümkündür. 0GPa için Hv sertlik değeri 4.8 Gpa olarak elde edilmiştir ve basınçla birlikte artmakta ve 50 Gpa için 6.6 Gpa olmuştur.

Tablo2. Basınç altında elastik özellikler

P	**C_{11}**(GPa)	**C_{12}**(GPa)	**C_{44}**(GPa)	**B**(GPa)	**G**(GPa)	**E**(GPa)	**υ**	**B/G**	**Hυ**(GPa)
0	125.5	54.4	50.1	78.1	43.6	110.2	0.2646	1.791	4.8
[8]	103.6	46.0	57.1	65.2					
5	146.7	70.6	55.6	95.9	47.7	112.7	0.2866	2.01	5.3
10	166.3	86	59.6	112.7	50.8	132.4	0.304	2.218	5.6
15	184.4	100.4	62.1	128.4	53	139.7	0.3185	2.422	5.8
20	201.7	114.8	64.5	143.7	55	146.3	0.3302	2.612	6.1
25	218.2	128.7	66.1	158.5	56.5	151.4	0.3406	2.805	6.2
30	233.9	142	67	172.6	57.5	155.2	0.35	3.001	6.3
35	249.2	155.1	67.6	186.4	58.4	158.6	0.3581	3.191	6.4
40	264.1	168	68.1	200	59.1	161.4	0.3654	3.384	6.5
45	278.6	180.8	68.4	213.4	59.7	163.8	0.372	3.68	6.6
50	292.9	193.4	68.5	226.5	60.2	165.9	0.3779	3.762	6.6

III. SONUÇLAR

MgAgAs tipi yapıya sahip LiCuS, yarı iletken özellikleri ve optoelektronik uygulamalardaki potansiyeli ile dikkat çeken bir yarı-Heusler bileşiğidir. Bu çalışmada, ab initio yöntemi kullanılarak LiCuS'nin yapısal, mekanik, elektronik, dinamik ve optik özellikleri çeşitli koşullar altında detaylı bir şekilde incelenmiştir. Elde edilen denge kafes parametresi 5.47Å olup, önceki teorik sonuçlarla uyumludur. Enerji-hacim verileri Murnaghan durum denklemi kullanılarak oturtulmuş ve Bulk modülü belirlenmiştir, bu da mekanik kararlılığı göstermektedir. Denge koşulunda ve 50 GPa'ya kadar değişen basınçlarda elastik sabitler (Cij) zor-zorlanma yöntemi ile hesaplanmıştır. Sonuçlar, LiCuS'nin mekanik olarak kararlı olduğunu ve Born-Huang kararlılık kriterlerini sağladığını doğrulamaktadır. Bileşik, anizotropik mekanik davranış sergiler. Elektronik bant yapısı ve yoğunluk durumu (DOS) hesaplamaları, LiCuS'nin 0 GPa'da 1.05 eV bant aralığına sahip doğrudan bir yarı iletken olduğunu ortaya koymaktadır. LiCuS'nin kapsamlı ab initio incelemesi, yapısal, mekanik, elektronik özellikleri hakkında değerli bilgiler sağlamıştır. Bileşik, mekanik

olarak kararlı, anizotropik davranış sergileyen ve optoelektronik ve güneş hücresi uygulamaları için önemli potansiyele sahip bir malzeme olarak öne çıkmaktadır. Bant aralığının basınçla değişimi ve elastik sabitlerin yüksek basınç davranışı, bu bileşiğin çeşitli koşullar altındaki performansına yönelik önemli bulgular sunmakta ve ileri teknoloji uygulamalarında kullanılabilirliğini vurgulamaktadır.

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Türkiye'de Döviz Kuru Hareketlerinin Uluslararası Hizmet Ticaretine Etkisi: ARDL Modelinden Bulgular

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Özet – Son asırlara kadar tüm dünyada ekonomilerin temelini tarımsal üretim oluşturmakta iken Sanayi Devrimi ile birlikte endüstriyel üretim de önemli bir paya ulaşmıştır. Ancak, son yüzyılda hizmet sektörünün hızla büyümesi uluslararası ticarette de hizmet sektörünün payını artırmıştır. Uluslararası mal ticaretinin döviz kuru ile ilişkisi birçok çalışmaya konu olmuş, bu konuda belirli bir ampirik uzlaşı ortaya çıkmıştır. Bu çalışmada ise hizmet sektöründe gerçekleştirilen ithalat ve ihracatın döviz kuru hareketleriyle ilişkisi Türkiye örneğinde, zaman serileri analizi kullanılarak araştırılmıştır. Elde edilen bulgular, teorik beklentilerle uyumlu olarak, yerli paradaki değerlenmenin hizmet ihracatını olumlu, ithalatı ise olumsuz yönde etkilediğine işaret etmektedir. Ayrıca tahminler, Türkiye'de hizmet sektörü açısından Marshall-Lerner koşulunun tam olarak sağlanmadığını da ortaya koymaktadır.

Anahtar Kelimeler: Hizmet sektörü, ihracat, ithalat, zaman serileri analizi, Marshall-Lerner koşulu

I. GİRİŞ

Üretim ve ulaştırma teknolojilerinin hızla gelişmesi uluslararası ticaretin tarihte görülmemiş bir yoğunluğa ulaşmasına neden olmuştur. Günümüzde artık çok daha fazla çeşit ve hacimde mal, çok daha uzak piyasalara, çok daha hızlı bir şekilde ulaştırılmaktadır. Doğal ve beşerî kaynakların dengeli bir şekilde dağılmadığı dünyada ticaret, çok eski zamanlardan beri olduğu gibi söz konusu dengesizliği azaltırken hem satıcı hem de alıcı ülkede üretim ve kalkınmaya katkı sağlamaktadır. Uluslararası ticaretin gelişmesi ihracatçı ülke açısından önemli bir gelir kaynağı yaratırken ithalatçı ülkenin de ihtiyaçlarının karşılanması yoluyla refah artışına hizmet etmektedir [1].

Son asırlara kadar tüm dünyada ekonomilerin temelini tarımsal üretim oluşturmakta iken Sanayi Devrimi bazı Avrupa ülkelerinin sanayi ağırlıklı kalkınma modeline geçmelerine neden olmuştur. Yayılma etkisiyle sınai üretimin ağırlığı diğer birçok ekonomide de artış gösterirken, gelir artışına bağlı olarak yükselen refah düzeyinin de etkisiyle 20. yüzyılda hizmet sektörünün tüm dünyada hızlı bir şekilde genişlediği gözlenmiştir. Bunun doğal bir sonucu olarak son yüzyılda geleneksel mal ticaretinin yanı sıra uluslararası hizmet ticareti de büyük bir gelişme göstermiştir. Özellikle 2000'li yıllardan itibaren dünya genelinde internetin yaygınlaşmasıyla iletişim ve haberleşme imkânlarının gelişmesinin doğurduğu dijitalleşme uluslararası hizmet ticaretinin kapsam ve hacim olarak genişlemesine imkân tanımıştır. DTÖ verilerine göre 2005'te 1 trilyon ABD doları civarında olan dünya hizmet ticareti hacmi 2023 itibariyle 3,9 trilyon ABD dolarına ulaşmıştır. Bu ticaretin yarıdan fazlası (%56) hizmetin sunulduğu ülkedeki temsilciliklerle (Mod 3) sağlanırken %34 kadarı sınırlar arası işlemler (Mod 1) yoluyla gerçekleşmektedir [2].

Dış ticaret gerek ihracat gerekse ithalat yönüyle tüm ekonomiler açısından büyük önem taşımaktadır. Bir yandan ihracat hacmini ve ihracat gelirlerini artırmak bir yandan da tüketim malları ithalatını azaltarak dış ticaret dengesini korumak ekonomi yönetimlerinin başlıca hedeflerinden biridir. Hizmet ticaretinin de bu açıdan mal ticaretinden farklı olduğu söylenemez. Bu noktada hükümetlere manevra alanı sağlayan önemli bir politika aracı döviz kuru kontrolüdür. Bu nedenle, hizmet ticaretinin ekonomi ve uluslararası ticaretteki giderek artan ağırlığı dikkate alındığında uluslararası hizmet ticaretinin döviz kuru hareketleri karşısındaki

davranışını incelemek uygulanacak döviz kuru politikalarının etkinliğini belirlemek bakımından önem taşımaktadır. Bu çalışmada konu, hizmet sektörünün katma içindeki payının %70'i aştığı Türkiye örneğinde ele alınmaktadır.

II. HİZMET SEKTÖRÜ VE TÜRKİYE'DE HİZMET SEKTÖRÜNÜN GELİŞİMİ

Günümüzde hizmetler sektörü, ekonomilerin en temel sektörlerinden biri durumundadır. Ancak, dünya iktisadi tarihi açısından düşünüldüğünde yakın zamanlara kadar hizmet sektörü ülkeler tarafından ikinci, hatta üçüncü derecede bir faaliyet alanı olarak görülmekteydi. Birçok ülkede hizmet sektörlerinin daha çok emek yoğun ve verimliliği düşük sektörler olduğu, dolayısıyla büyüme ve kalkınmada sanayi sektörüne ağırlık verilmesi gerektiği yönünde yaygın bir düşünce hâkimdi [3].

Hizmetlerin tanımlanması ve sınıflandırılması açısından teorik olarak bir uzlaşıdan bahsetmek mümkün değildir. Bu belirsizliğin temel nedeni hizmet kavramının kapsam ve sınır olarak net olmaması ve gelişime oldukça açık çok dinamik bir zemine sahip olmasıdır. Bu nedenle hizmet sektörü, birincil (tarım) ve ikincil (sanayi) sektörler dışındaki tüm ekonomik alanları kapsar ve bu anlamda "artık sektör" olarak tanımlanabilir [4]. Geniş anlamda "hizmetler" terimi, taşımacılık ve lojistik, telekomünikasyon ve bilgisayar hizmetleri, inşaat, finansal hizmetler, toptan ve perakende dağıtım, otel ve yemek hizmetleri, sigorta, emlak, sağlık ve eğitim, profesyonel pazarlama ve diğer iş destekleri, hükümet, toplum, görsel-işitsel medya, eğlence ve ev hizmetleri gibi çok çeşitli maddi olmayan ve farklı ürün ve faaliyetleri kapsamaktadır [5].

Hizmet ticareti ile mal ticaretin arasındaki temel fark ürün ve üretim süreçlerinin farklı olmasından kaynaklanmaktadır. Hizmetlerin maddi bir yapısının olmaması, depolanamaz ve transfer edilemez olması (genellikle üretildiği anda ve yerde tüketilmesi), üretici ve tüketici arasında doğrudan bir etkileşim yaratması hizmet sektörünü tarımsal ve endüstriyel üretim sektörlerinden ayırmaktadır.

Cumhuriyetin kurulduğu yıllarda hâlâ bir tarım toplumu olan Türkiye'de, sanayileşme hamlesiyle birlikte tarımın ekonomideki ağırlığı azalmaya başlamış, 1980'li yılların başında liberalleşme politikasının benimsenmesiyle birlikte hizmet sektöründe önemli bir gelişme trendi yakalanmıştır. Hizmet sektörü, tarım ve sanayi sektörlerine kıyasla daha fazla önem kazanmıştır. Özellikle tarım sektörünün payı önemli ölçüde azalmıştır. Bu süreçte sektörel dönüşümün yanı sıra demografik ve sosyal değişimin de etkili olduğu söylenebilir [6]. Türkiye, hizmet ihracatı bakımından özellikle turizm, inşaat, sağlık hizmetleri ve havayolu taşımacılığı alanında dünyada önemli bir paya sahiptir.

Türkiye'de 1980 yılından sonra ekonomide liberalleşme ile birlikte hayata geçirilen ihracata dayalı büyüme politikası Türkiye'nin ihracat hacmini artırsa da bu artış beklentileri karşılayamamıştır. Bunun temel sebebi, dış ticarete konu olan mal ve hizmetlerde nitelik bakımından derinliğin yakalanmamasıdır. Başka bir ifadeyle ihracat fasıllarının genel olarak düşük katma değerli emek yoğun mal ve hizmetlerden oluşmasına karşın, ithal edilen mal ve hizmetlerin ise daha fazla sermaye yoğun mallardan oluşmasıdır. Türkiye'de dış ticaret derinlemesine incelendiğinde, ihraç edilmesi planlanan malların üretilmesi için gereken hammadde ve ara girdilerin ithalata konu fasıllarda önemli bir yer tuttuğu gözlemlenmektedir. Bu durum ise ihracata konu olan malların üretiminin ithal girdilere bağlı olduğunu ve dolayısıyla Türkiye'nin dış ticaret gelirlerinin önemli bir kısmının ithal mal ve hizmetlere bağlı olduğunu ifade etmektedir. Böylece ihracat kazançlarının büyük bir kısmının ithalat yoluyla yeniden ülkeyi terk ettiği görülmektedir [7].

III. DIŞ TİCARET -DÖVİZ KURU İLİŞKİSİ

Uluslararası iktisat literatürü incelendiğinde ihracatın yurtdışı gelir düzeyi ve nispi fiyatların (reel döviz kuru), ithalatın ise yurtiçi gelir düzeyi ve nispi fiyatların bir fonksiyonu olarak modellendiği görülmektedir. Buna göre, reel döviz kurundaki (RDK) değişimlerin dış ticaret dengesi üzerine etkilerine ilişkin teorik beklentiler, dolaylı kotasyon yöntemi çerçevesinde, RDK artışlarının (azalışlarının) ülkenin ihraç ürünlerinin fiyat rekabeti gücünü azaltması (artırması) ve ithalatın maliyetini düşürerek (yükselterek) ithalatı artırması (azaltması) dolayısıyla dış ticaret dengesini bozması (iyileştirmesi) yönündedir [8].

Geleneksel olarak yurtiçi ve yurtdışı gelir düzeyi ile reel döviz kurunun dış ticaret dengesinin temel belirleyicileri olması dolayısıyla dış ticaret politikalarının etkinliği büyük ölçüde ihracat ve ithalat talep fonksiyonlarının gelir ve fiyat esnekliklerinin anlamlılığına ve büyüklüğüne bağlıdır. Dış ticarette fiyat ve

gelir esnekliklerinin önemi esneklik yaklaşımı (elasticity approach) çerçevesinde incelenmektedir. Esneklik yaklaşımının temelinde ise Marshall-Lerner (ML) koşulu bulunmaktadır [9].

Uluslararası iktisat teorisinde bir ülkenin ulusal parasının reel olarak değer kaybetmesinin dış ticaret dengesi üzerindeki uzun dönem etkileri ML koşulu tarafından tanımlanmaktadır. Uzun dönemli bir ilişki olarak analizlere konu olan ML koşulu, ihracat ve ithalatın arz esnekliklerinin sonsuz olduğu varsayımı altında, bir ülkenin ulusal parasının değerindeki bir düşüşün ticaret dengesini iyileştirebilmesi için ihracat ve ithalat talebi fiyat esneklikleri toplamının (mutlak anlamda) 1'den büyük olması gerektiğini ifade etmektedir. ML koşulu, bir ülkenin ulusal parasının değerindeki düşüşe bağlı olarak ortaya çıkan pozitif miktar etkisi ve negatif maliyet etkisi ile açıklanabilir. Buna göre bir ülkenin ulusal parası diğer ülke paraları karşısında değer kaybettiğinde, bir yandan ithal mallarının ulusal para cinsinden fiyatı artarken, diğer yandan da ihraç mallarının yabancı para cinsinden fiyatı azalmaktadır. Bu fiyat değişimlerinden dolayı ihraç malları miktarındaki artışa ve ithal malları miktarındaki düşüşe bağlı olarak ticaret dengesinde görülen iyileşmeler pozitif miktar etkisi olarak adlandırılmaktadır. Buna karşılık, fiyat değişimlerinin ihraç mallarını eskisinden daha ucuz ve ithal mallarını daha pahalı bir hale getirerek ticaret dengesini bozması ise negatif fiyat etkisi olarak tanımlanmaktadır [10].

Reel kurun değer kaybetmesinin dış ticaret dengesi üzerindeki kısa dönem etkileri ise J-eğrisi etkisi kavramı altında incelenmektedir. Bir ülkenin ulusal parasının yabancı ülkelerin paraları karşısında değer kaybetmesi karşılığında söz konusu ülkenin ticaret dengesinin öncelikle bozulacağı ve ticaret dengesindeki iyileşmelerin zaman alacağı argümanı iktisat literatüründe J-eğrisi etkisi olarak adlandırılmaktadır [11]. J-eğrisi etkisi, bir ülkenin ulusal parasındaki reel değer kaybının ardından ticaret dengesinde neden iyileşme görülmediğini açıklayan ML koşuluna dayanmaktadır. Ulusal paranın reel olarak değer kaybetmesinin ardından ithalatın daha pahalı ve ihracatın daha ucuz olması, buna karşılık ihracat ve ithalat miktarlarının hemen bu değişen koşullarına uyarlanamaması (ML koşulunun gerçekleşememesi) nedeniyle dış ticaret dengesi kısa dönemde kötüleşmektedir. Uzun dönemde ise miktar etkilerinin ortaya çıkacağı (ML koşulunun gerçekleşeceği) ve ticaret dengesinin iyileşeceği ifade edilmektedir [12].

IV. MATERYAL VE YÖNTEM

Analizde Bahmani-Oskooee ve Saha'nın [13] Cheng ([14], [15])'i izleyerek oluşturduğu modelleme yaklaşımına başvurulmuştur.

$$LIHR_t = \alpha_0 + \alpha_1 LRDK_t + \alpha_2 G_t^D + u_t$$

$$LITH_t = \beta_0 + \beta_1 LRDK_t + \beta_2 G_t^T + v_t$$

Burada *IHR* Türkiye'den yapılan hizmet ihracatının, *ITH* ise Türkiye'nin yaptığı hizmet ithalatının değerini göstermektedir. *RDK* reel döviz kurunu, *G* ise gelir düzeyini temsil etmektedir. Türkiye'nin hizmetleri için ihracat talebini etkileyen faktör dünya gelir düzeyi (G^D), Türkiye'nin yabancı (ithal) hizmetlere olan talebini etkileyen faktör ise yurtiçi gelir düzeyidir (G^T). Teorik olarak, yerli paranın (TL) değer kaybetmesi yabancı para (döviz) cinsinden ihracat gelirlerini artıracağından $\alpha_1 < 0$, aksine ithalat maliyetini artıracağından $\beta_1 > 0$ olması beklenir. Gelir artışı satın alma gücünü artırarak ithal mal ve hizmet talebini artıracağından gelir değişkeninin katsayısının her iki denklemde pozitif işaretli olması ($\alpha_2, \beta_2 > 0$) beklenmektedir.

Yukarıdaki denklemler herhangi bir yöntemle tahmin edilerek uzun dönem ilişkisine ait katsayı tahminleri elde edilebilir. Kısa dönem tahminleri için ise denklemler [16]'yı takiben koşullu (kısıtlanmamış) hata düzeltme formatında aşağıdaki gibi yeniden formüle edilebilir:

$$\Delta LIHR_t = \mu_0 + \sum_{j=1}^{n1} \mu_{1j} \Delta LIHR_{t-j} + \sum_{j=0}^{n2} \mu_{2j} \Delta LRDK_{t-j} + \sum_{j=0}^{n3} \mu_{3j} \Delta G_{t-j}^D$$

$$+\rho_0 LIHR_{t-1} + \rho_1 LRDK_{t-1} + \rho_2 G_{t-1}^D + \varepsilon_t$$

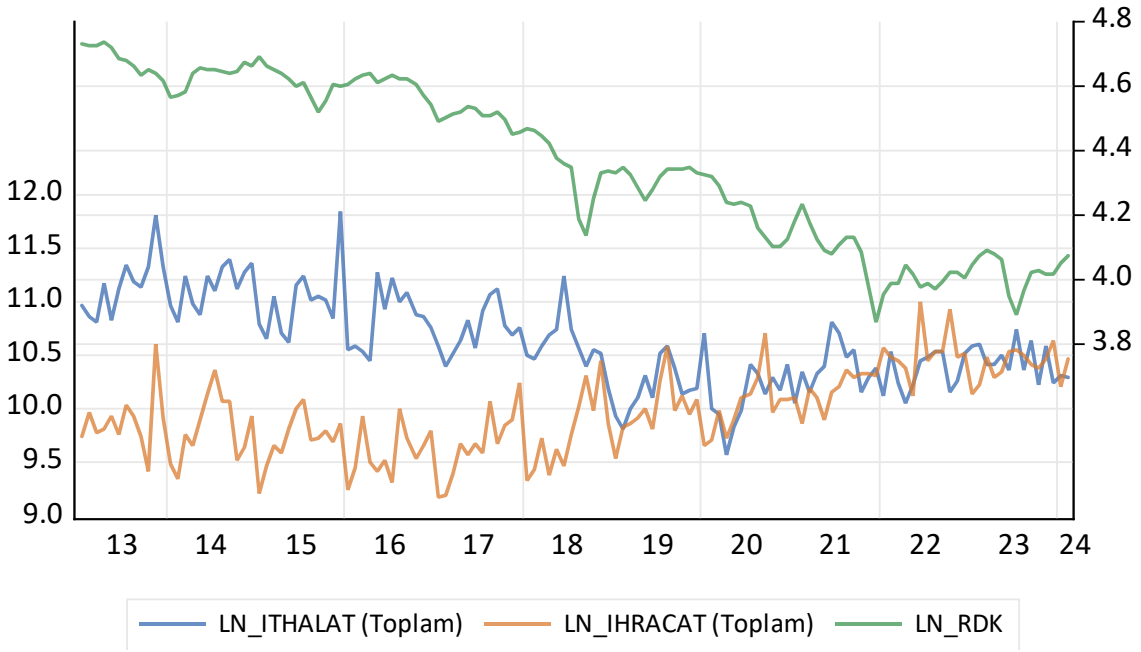
$$\Delta LITH_t = \delta_0 + \sum_{j=1}^{n1} \delta_{1j} \Delta LITH_{t-j} + \sum_{j=0}^{n2} \delta_{2j} \Delta LRDK_{t-j} + \sum_{j=0}^{n3} \delta_{3j} \Delta G_{t-j}^{T}$$

$$+\varphi_0 LITH_{t-1} + \varphi_1 LRDK_{t-1} + \varphi_2 G_{t-1}^{T} + \omega_t$$

Burada $\mu_{1j} - \mu_{3j}$ ve $\delta_{1j} - \delta_{3j}$ katsayıları kısa dönemli, ρ ve φ katsayıları ise uzun dönemli ilişkileri yansıtmaktadır. Uzun dönemli etkilerin anlamlı olabilmesi için [16] iki eşbütünleşme testi önermektedir. Standart bir F testi, her iki modeldeki gecikmeli seviye değişkenlerinin ortak anlamlılığını belirlemek için kullanılmaktadır. Diğer test ise hata düzeltme denklemlerinin anlamlılığını değerlendirmek için bir t-testidir. Her iki test de standart olmayan dağılımlara sahiptir ve bu nedenle kritik değerleri tablolaştırılmıştır.

V. BULGULAR

Şekil 1'de son 11 yılı kapsayan örneklem dönemi içinde Türkiye'de hizmet ithalatı ve ihracatının seyri görülmektedir. 2018 sonuna kadar Türkiye'nin hizmet ticaretinde sürekli açık verdiğini ancak 2019'dan itibaren dönem dönem açık görülmekle birlikte genel olarak ithalat ve ihracatın benzer hacimde seyrettiği göze çarpmaktadır. Bu noktada, 2019'a kadar olan dönemde hizmet ithalatının genel olarak bir azalma trendi sergilediği, buna karşılık 2018'den itibaren hizmet ihracatının artma eğilimi gösterdiği, 2019 sonrasında ise her iki göstergenin benzer hacimlerle yukarı yönlü harekete devam ettiği dikkati çekmektedir.



Şekil 1. İthalat, ihracat ve döviz kurunun örneklem dönemindeki seyri

Zaman serileri analizinde standart bir uygulama olarak, öncelikle serilerin durağan olup olmadıkları birim-kök testi ile araştırılmıştır. Genişletilmiş Dickey-Fuller testinden elde edilen sonuçlar Tablo 1'de rapor edilmiştir. Bulgulara göre reel döviz kuru ve OECD ülkeleri sanayi üretim endeksi serileri düzey değerleri itibariyle durağan olmayan bir davranış sergilemektedirler. Diğer seriler ise orijinal değerleriyle durağan görünmektedir.

Hizmet ticareti ve reel döviz kuruna ait 2013 Ocak-2024 Şubat dönemini kapsayan aylık veriler TCMB-EVDS veri tabanından derlenmiştir. Hizmet ihracat ve ithalatı verileri bilgi ve iletişim, yayıncılık, sinema-tv-müzik yayıncılığı, mimarlık ve mühendislik hizmetleri, kültür-sanat-eğlence-spor, gösteri sanatları, kütüphanecilik, mesleki bilimsel ve teknik faaliyetler ile diğer profesyonel bilimsel ve teknik faaliyetlerden kapsamaktadır. Döviz kuru verisi 2003=100 olmak üzere TÜFE bazlı reel efektif döviz kuru değerlerinden oluşmaktadır. TÜFE bazlı reel efektif döviz kuru Türkiye'deki fiyat düzeyinin, dış ticaret yapılan 36

ülkenin fiyat düzeylerine oranının ağırlıklı ortalaması alınarak hesaplanmaktadır. Türkiye Cumhuriyet Merkez Bankası (TCMB) tarafından her ay hesaplanıp yayınlanan reel efektif döviz kuru endeksinin 100'ün altına inmesi Türk lirasının değer kaybettiğini, 100'ün üstüne çıkması ise değer kazandığını göstermektedir. Türkiye ve OECD ülkelerinin sanayi üretim endeksi verileri ise OECD istatistiklerinden elde edilmiştir. İthalat, ihracat ve döviz kuru serileri logaritmik dönüşümden geçirilerek analizde kullanılmıştır.

Tablo1. ADF birim-kök testi sonuçları

	Düzey		Fark		
	Sabit	Sabit + Trend	Sabit	Sabit + Trend	Karar
RDK	-1,0382 0,7382	**-2,9529** **0,1497**	**-9,7504** **< 0,001**	-9,7195 < 0,001	I(1)
SUE_TR	-1,3647 0,5978	**-4,0829** **< 0,001**	**-13,1259** **< 0,001**	-13,0748 < 0,001	I(0)
SUE_OECD	**-2,7495** **0,0686**	-3,5062 0,0428	**-9,5963** **< 0,001**	-9,5613 < 0,001	I(1)
IHR	-3,4261 0,0117	**-7,2169** **< 0,001**	**-12,9030** **< 0,001**	-8,1829 < 0,001	I(0)
ITH	-2,9611 0,0413	**-4,6327** **0,0014**	**-16,8561** **< 0,001**	-16,7914 < 0,001	I(0)

Not: Test sürecinde uygun gecikme uzunluğu SBC kriterine göre eleme usulüyle belirlenmiştir. Her bir hücrede ilk değer test istatistiğini, ikinci değer p-değerini göstermektedir. SBC kriterine göre uygun spesifikasyon koyu olarak belirtilmiştir.

ARDL modeli biçimindeki ihracat denkleminin tahmini Tablo 2'de görülmektedir. Akaike bilgi kriterine göre yapılan eleme sonucunda en uygun spesifikasyonun ARDL (1,0,1) modeli olduğu belirlenmiştir. Sınır testi F-değeri oldukça yüksektir (22,03) ve %1 anlamlılık düzeyinde değişkenler arasında bir eşbütünleşme ilişkisinin geçerliliğini ortaya koymaktadır. Hata düzeltme teriminin (ECM) katsayısı (-0,66) kabul edilebilir sınırlar içinde ve anlamlıdır. Bu da kısa dönemli dengesizliklerin hızlı bir şekilde telafi edildiğini, uzun dönem dengesinin korunduğuna işaret etmektedir. Tahminlere göre reel döviz kuru endeksindeki düşüş (TL'nin değer kaybetmesi) Türkiye'nin hizmet ihracatını artırmaktadır. Gelir düzeyini temsilen denklemde yer alan OECD ülkeleri ortalama sanayi üretim endeksinin ise Türkiye'nin hizmet ihracatı üzerinde istatistiksel olarak anlamlı bir etkisi olmadığı görülmektedir.

Tabloda verilen istatistiksel göstergeler (J-B, χ^2_{B-G}, χ^2_W istatistikleri) hata teriminin normal dağılımlı, otokorelasyonsuz ve sabit varyanslı olduğunu, dolayısıyla modelin güvenilir ve yeterli olduğunu belirtmektedir. Yine CUSUM ve CUSUM-kare istatistikleri katsayıların istikrarlı olduğuna işaret etmektedir. Eşbütünleşme ilişkisinin FMOLS tahminleri tablonun en alt kısmında görülmektedir. Büyüklük olarak farklılık olsa da FMOLS katsayı tahminleri ile EKK tahminleri işaret olarak benzeşmektedirler.

Tablo 2. İhracat denklemi tahmini: ARDL(1,0,1)

Değişken	**Katsayı**	**St. Hata**	**t-istatistiği**	**p-değeri**
IHR(-1)	0,3435	0,0809	4,2428	< 0,010
RDK	-0,7501	0,1416	-5,2958	< 0,010
SUE_OECD	0,0172	0,0148	1,1644	0,2464
SUE_OECD(-1)	-0,0216	0,0146	-1,4756	0,1425
Sabit	10,2611	1,6827	6,0979	< 0,010
ECM	-0,6588	0,0806	-8,1718	< 0,010
R^2	0,5600	Akaike bilgi kriteri		0,1841
Düz. R^2	0,5463	Schwarz bilgi kriteri		0,2927
Sınır testi F-istatistiği	22,0290	p-değeri		< 0,010
J-B	13,9118	p-değeri		< 0,010
χ^2_{B-G}	4,0464	p-değeri		0,1322
χ^2_W	7,0809	p-değeri		0,9315
CUSUM	Stabil	CUSUM_kare		Stabil

FMOLS tahmini:				
Değişken	**Katsayı**	**St. Hata**	**t-istatistiği**	**p-değeri**
RDK	-1,1661	0,1591	-7,3274	< 0,010
SUE_OECD	-0,0105	0,0111	-0,9454	0,3462
Sabit	16,1385	1,6479	9,7928	< 0,010

Tablo 3'te ise ithalat denkleminin tahminleri görülmektedir. Akaike bilgi kriterine dikkate alındığında en uygun spesifikasyonun ARDL (1,0,0) modeli olduğu belirlenmiştir. Sınır testi F-değeri oldukça yüksektir (22,16) ve %1 anlamlılık düzeyinde değişkenlerin eşbütünleşme ilişkisi içinde olduklarını ortaya koymaktadır. Hata düzeltme teriminin (ECM) katsayısı (-0,61) kabul edilebilir sınırlar içinde ve anlamlıdır. Buna göre kısa dönemli dengesizlikler %61 oranında izleyen dönemde telafi edilmektedir. Tahminlere göre reel döviz kuru endeksindeki düşüş (TL'nin değer kaybetmesi) Türkiye'nin hizmet ithalatını artırıcı etkide bulunmaktadır. İthalat talebini etkileyen önemli bir faktör olan gelir düzeyini temsilen denklemde yer alan Türkiye'nin sanayi üretim endeksinin ise Türkiye'nin hizmet ithalatı üzerinde istatistiksel olarak anlamlı bir etkisi olduğu görülmektedir.

Breusch-Godfrey ve White test istatistikleri (sırasıyla χ^2_{B-G}, χ^2_W) hata teriminin otokorelasyonsuz ve sabit varyanslı olduğunu, dolayısıyla modelin güvenilir ve yeterli olduğunu belirtmektedir. CUSUM ve CUSUM-kare istatistikleri ise zaman içinde katsayıların istikrarlı olduğuna işaret etmektedir. Eşbütünleşme ilişkisinin FMOLS tahminleri de işaret olarak EKK ile elde edilen bulguları desteklemektedir.

Tablo 3. İthalat denklemi tahmini: ARDL(1,0,0)

Değişken	**Katsayı**	**St, Hata**	**t-istatistiği**	**p-değeri**
ITH(-1)	0,3881	0,0791	4,9084	< 0,010
RDK	0,2011	0,3087	0,6515	0,5158
SUE_TR	0,0144	0,0036	3,9827	< 0,010
Trend	-0,0099	0,0025	-3,9944	< 0,010
Sabit	4,6257	1,6404	2,8198	< 0,010
ECM	-0,6118	0,0781	-7,8367	< 0,010
R^2	0,6646	Akaike info criterion		0,0780
Düz. R^2	0,6542	Schwarz criterion		0,1866
Sınır testi F-istatistiği	20,1567	p-değeri		< 0,010
J-B	14,1793	p-değeri		< 0,010
χ^2_{B-G}	2,0387	p-değeri		0,3608
χ^2_W	10,2623	p-değeri		0,7428
CUSUM	Stabil	CUSUM_kare		Stabil
FMOLS tahmini:				
Değişken	**Katsayı**	**St, Hata**	**t-istatistiği**	**p-değeri**
RDK	2,2517	0,4088	5,5081	< 0,010
SUE_TR	0,0159	0,0054	2,9282	< 0,010
Sabit	-1,0318	2,3732	-0,4348	0,6644

VI. TARTIŞMA

ARDL modeline dayalı analiz sonuçları, teorik beklentilerle uyumlu olarak, uzun dönemde reel döviz kuru endeksinin Türkiye'nin hizmet ihracatını negatif, hizmet ithalatını ise pozitif yönde etkilediğini göstermektedir. İhracat fonksiyonunda dış alem gelir düzeyi anlamlı bir etkiye sahip görünmemektedir. Bu durum Türkiye'den ihraç edilen hizmetlerin nispi fiyatlarının düşük olmasından kaynaklanıyor olabilir. Buna karşılık hizmet ithalatında Türkiye gelir düzeyinin anlamlı ve pozitif etkide bulunması, ithal hizmetlerin nispi fiyatlarının yüksek olması dikkate alındığında önceki çıkarımı daha anlamlı hale getirmektedir. Hizmet ihracatı ve ithalatı için reel döviz kuru esnekliklerinin mutlak değerlerinin toplamının

1'den küçük olması (0,952) Türkiye için Marshall-Lerner koşulunun sağlanmadığını, dolayısıyla döviz kuru düzenlemelerinin hizmet ticaretinde dış ticaret açığını gidermede yeterince etkili olmadığını göstermektedir.

VII. SONUÇLAR

Günümüzde ülkeler arasında yoğun bir ticari ilişki yaşanmaktadır. Nihai, ham ya da aramalı şeklinde onbinlerce çeşit ürün sınırlar arasında hareket etmektedir. Son yüz yılda gelişen ulaştırma ve haberleşme teknolojileri geleneksel mal ticaretinin yanı sıra hizmetlerin de giderek artan bir şekilde daha fazla uluslararası ticarete konu olmasını sağlamıştır. Dış ticaret hacmini hem ihracat hem de ithalat yönünden etkileme potansiyeline sahip olan kilit faktörlerden biri döviz kurudur. Somut mallardan farklı bir yapıya sahip olan hizmet ürünlerinin ticaretinin de döviz kuru hareketlerinden etkilenmesi mümkündür.

Bu çalışmada döviz kuru dalgalanmalarının hizmet ihracat ve ithalatı ile ilişkisi Türkiye örneğinde ampirik olarak ele alınmıştır. ARDL modeline dayalı analiz sonuçları, teorik beklentilerle uyumlu olarak, uzun dönemde reel döviz kuru endeksinin Türkiye'nin hizmet ihracatını negatif, hizmet ithalatını ise pozitif yönde etkilediğini göstermektedir. Ayrıca Türkiye için hizmet ticaretinde Marshall-Lerner koşulunun sağlanmadığı da analizden elde edilen bir diğer bulgudur.

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Efficiency Measurements with Data Envelopment Analysis in Marketing

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Abstract **–** Organizations need to allocate resources to the marketing department in a competitive environment dominated by a customer-oriented approach. Therefore, it is important for marketing departments for organizations to use their resources effectively and efficiently by making performance evaluations. The Data Envelopment Analysis (DEA) method is widely used in performance evaluation. For this reason, the current study aims to present a holistic perspective by examining the studies conducted using the DEA method in the marketing field in the Web of Science database. Suggestions align with the sustainability objectives of studies in the relevant field. As a result of the common entity keyword analysis, social media, social sharing platforms, advertising, and sustainable education issues attract attention. The most basic sustainability goal of the studies has been determined as industry innovation and infrastructure. It can be said that current studies in the relevant field are related to innovation and social media.

Keywords – Marketing, Efficiency, Sustainability, Visual Mapping, Data Envelopment Analysis

I. INTRODUCTION

Marketing is an important business function that allows meeting the needs and desires of customers and keeping them satisfied. While goods and services are the desired benefit for consumers, for marketers, it is expressed as a product design that meets the expectations and characteristics of consumers [1]. Within the framework of the modern marketing approach, this function also includes the marketing of goods, services, and ideas. The contemporary concept of customer-oriented marketing, whose function is to meet human demands and needs, is a business activity that must meet the needs of customers profitably by offering value propositions [2]. Businesses that face many adverse conditions must use their resources effectively and efficiently to continue their operations sustainably. The optimal use of resources of companies operating in both national and global markets will provide them with opportunities to maintain their market shares and expand into new markets [3]. Marketing activities aim to indirectly generate income by creating value for consumers. Therefore, organizations need to make performance evaluations and use scarce resources effectively and efficiently.

Performance, which is one of the concepts that form the basis of modern understanding [4], can be defined as an indicator of the success of an organization in a certain period. A quality-oriented approach necessitates the effective use of resources. Methods for measuring marketing effectiveness show that its function is related to the performance of the business [5]. Since a customer-oriented approach requires spending more on marketing, the marketing department is a unit that needs to be allocated resources [6]. It is important to see how effective marketing expenditures produce results, that is, to what extent marketing goals are achieved because of which marketing investments are selected. Marketing effectiveness, which is the correct execution of marketing activities with the most appropriate input-output ratio, is closely related to the financial performance of the company [7]. In this context, effectiveness measurement is a tool that

guides organizations and is a measurement that appropriately presents the roles of resources in the input and output process [8]. In the literature, the Data Envelopment Analysis (DEA) method is used for efficiency measurement. DEA, which evaluates the efficiency of a single unit by comparing it with the efficiency of other units in the data set, is used as a measurement method in different fields. Therefore, the current study aimed to contribute to the literature by making a general review of articles in the field of marketing using the DEA method in the Web of Science database.

II. Data Envelopment Analysis

DEA is a non-parametric analysis method that provides the opportunity to measure the relative efficiency of decision-making units. It is used to calculate the relative effectiveness of decision-making units with common features and similar purposes [9]. In this method, since input and output are the factors that will determine the efficiency score, great care is taken when selecting the variables. The method is frequently used in different sectors with different input/output variables [10, 11, 12]. The basis of DEA is Farrell's [13] theoretical approach to determining performance efficiency. While the CCR model, which is based on constant variable returns to scale, consists of the initials of authors named Charnes, Cooper, and Rhodes, the BCC model, which is based on variable returns to scale, consists of the initials of authors named Banker, Charnes, and Rhodes [14, 16]. The DEA method, which was previously used to measure the effectiveness of non-profit organizations, continues to be widely used to measure the effectiveness of for-profit organizations.

Table 1. CRS and CRS-SE Model

Input-Oriented CRS	**Input-Oriented CRS-SE**
$\min \theta_t$	$\min \theta_t$
$s.t.$	$s.t.$
$\sum_{j=1}^{n} \lambda_j x_{ij} \le \theta_t x_{it}, \ \ i = 1,\ldots,m$ (1)	$\sum_{\substack{j=1 \\ j \ne t}}^{n} \lambda_j x_{ij} \le \theta_t x_{it}, \ \ i = 1,\ldots,m$ (2)
$\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rt}, \ \ r = 1,\ldots,s$	$\sum_{\substack{j=1 \\ j \ne t}}^{n} \lambda_j y_{rj} \ge y_{rt}, \ \ r = 1,\ldots,s$
$\lambda_j \ge 0, \ \ j = 1,\ldots,n$	$\lambda_j \ge 0, \ \ j = 1,\ldots,n$

Source: Charnes et al. [15] Doğan and Ersoy [16]

The input-oriented CCR model, model number (1), and the input-oriented CCR super-efficiency model, model number (2), are seen in Table 1. In the model numbered (1), θ 0 refers to KVB0 'ı, λ j whose efficiency is evaluated, where refers to non-negative scalars. In model (1), the efficiency score must be 1 for the decision-making unit to be effective. In model (2), the efficiency score must be 1 or greater than 1 for the decision-making units to be effective [16].

III. Materials and Method

The bibliometric analysis method, which refers to quantitative research on a specific theme, provides a better understanding of the information. For this reason, within the scope of the current study, quantitative analysis of the studies in the literature was conducted using the bibliometric analysis method. In the study, articles in the WoS database that use the DEA method in the field of marketing were examined. Keyword analysis was conducted using VOSviewer, a program that allows for the revealing of the strength of the relationship and the distances between items [17]. Relevant data were obtained from WoS, the largest database of scientific literature. To access the information in the database, the Boolean operator "and" search method, which combines the keywords "Marketing" and "Data Envelopment Analysis", was used. The search criteria are not limited to any period. Searches were made with the expressions Marketing

(keyword authors) and "Data Envelopment Analysis" (abstract). As a result, a total of 36 studies were reached, including 26 articles and 10 proceeding papers, to be included in the review.

IV. RESULTS

Within the scope of the research, a descriptive statistical analysis of the number of publications by country was conducted. In this context, it has been determined that there are publications from 20 countries. The country with the most publications in the relevant field is China, with 21 publications. Taiwan 7 and USA 6 follow this, respectively. When the WoS categories and the number of publications of the studies are examined, the fields with the most publications are Management (15), Operations Research Management Science (14), and Business (9). 35 of these publications were written in English and 1 in Chinese. When evaluated in terms of WOS indexes, it is seen that most of them are Social Sciences Citation Index (16) and Science Citation Index Expanded (14). The annual distribution of the studies is shown in Figure 1.

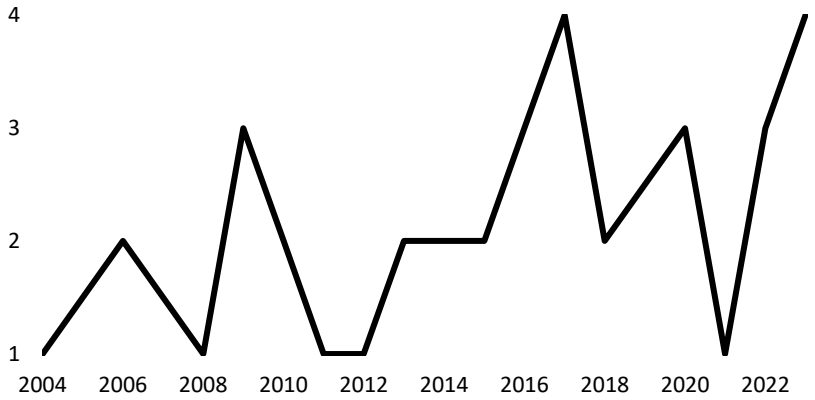

Fig. 1 Annual Distribution

Figure 1 shows that studies contributing to the field of marketing with the DEA method were carried out in 2004. Although there are few studies in the relevant field, it would be right to say that the trend has shown an increasing trend in recent years. The most basic sustainability goal of the research was determined as "Industry Innovation and Infrastructure." The word cloud for the sustainable development goal is shown in Figure 3.

Fig. 2 Sustainable Development Goal Word Cloud

Within the scope of the research, a data visualization technique was used for keyword analysis, which allows the content of studies that contribute to the field of marketing to be evaluated using the DEA method. In this context, by using VOSviewer, a network structure showing the map of their strengths and research trends was obtained by combining the same colors in the relationships between keywords, which is presented in Figure 3.

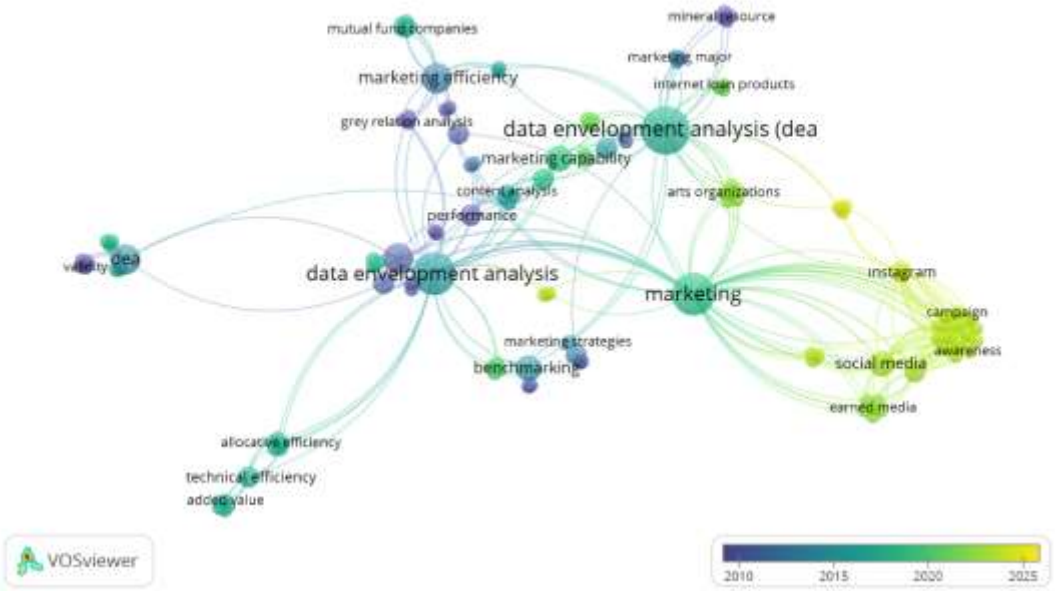

Fig. 3 Keywords Network Visualization

The minimum number of occurrences of keywords in the relevant field was determined as 1, and a total of 158 keywords were detected. Irrelevant keywords, such as country names, were removed. As a result, 128 keywords were included in the analysis. In Figure 3, the size of the circle shows the most discussed topic. There appears to be a cluster in the yellow areas after 2020. This indicates that studies on DEA and marketing have focused on social networking sites in recent years. According to the size of the environment and the number of connections, the keywords social media, social sharing platforms, advertising, sustainable education, e-learning/e-teaching social, marketing effectiveness, operational capacity, and sales performance were examined together with other relevant clusters within the scope of market and DEA.

V. CONCLUSION

The modern marketing approach requires organizations to allocate resources to the relevant department in order to satisfy both their internal and external customers. Organizations need to use resources effectively and efficiently to continue their activities sustainably. Therefore, they need to conduct performance evaluations. One of the most used methods for efficiency measurement in the literature is DEA. For this reason, the current study focuses on research conducted using the DEA method in the field of marketing. Relevant studies in WoS, the largest multidisciplinary database of the scientific field, were examined. As a result of the analysis, 36 studies were discovered. It was determined that the country that conducted the most studies in the relevant field was China, and most of the studies were in the SCI-E and SSCI categories. As a result of the common entity keyword analysis, social media, social sharing platforms, advertising, and sustainable education issues also attract attention. In recent years, studies have been conducted on social networking platforms. An important result of the research is related to sustainability goals. This purpose has been determined as “Industry Innovation and Infrastructure.” It would not be wrong to say that current studies in the relevant field are related to innovation and social media.

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Equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposites

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Abstract – In this study, rGO/MnO_2/PTTh nanocomposite was presented for 4 different equivalent circuit model evaluations. It was set up with a 2-electrode system on stainless steel electrode for rGO/MnO_2/PTTh nanocomposite. The simulation programme of ZSimpWin 3,22 was used for equivalent circuit model of R(QR), RQ, R(CR), LR(QR). In addition, the circuit parameters of (L, R, C, Q, etc.) in each circuit parameters were explained specifically for each circuit.

Keywords – Equivalent circuit model, supercapacitor, reduced graphene oxide, MnO_2, constant phase element

I. INTRODUCTION

Supercapacitors are significantly important devices for energy storage systems [1]. Electrode active materials play an important role to determine the electrochemical performance of supercapacitors [2]. In this study, reduced graphene oxide was used in electroactive materials. Manganese oxide (MnO_2) was used with metal oxide in Faradaic reactions to enhance electrochemical performance due to their low stability and low power density [3]. Conducting polymers such as polyterthiophene (PTTh) can be used for supercapacitors both in electrochemical double layer capacitance (EDLC) and pseudocapacitance [4]. The specific capacitance of pseudocapacitors are higher than EDLCs, but are lower when compared according to their power densities [5]. A hybrid capacitor has a battery type Faradaic electrode as an energy source, while the alternative is a capacitive electrode as a power source [6]. Electrodes are prepared by rGO, MnO_2 and PTTh [7]. The electrodes show the capacitance characteristics of both EDLC and pseudocapacitors.

Materials and Method

In this study, 1-Butyl-3-methylimidazolium tetrafluoroborate ionic liquid, stainless steel electrode, kapton tape and *N*-Methyl-2-pyrrolidone material were used in the fabrication of supercapacitor devices.

A. Used Devices

In this study, rGO/MnO_2/PTTh nanocomposite was synthesized as ternary nanocomposite. Electrochemical performance measurements were carried out using EIS method using IVIUMSTAT device and equivalent circuit model analysis, programme ZSimpWin 3,22.

II. RESULTS & DISCUSSION

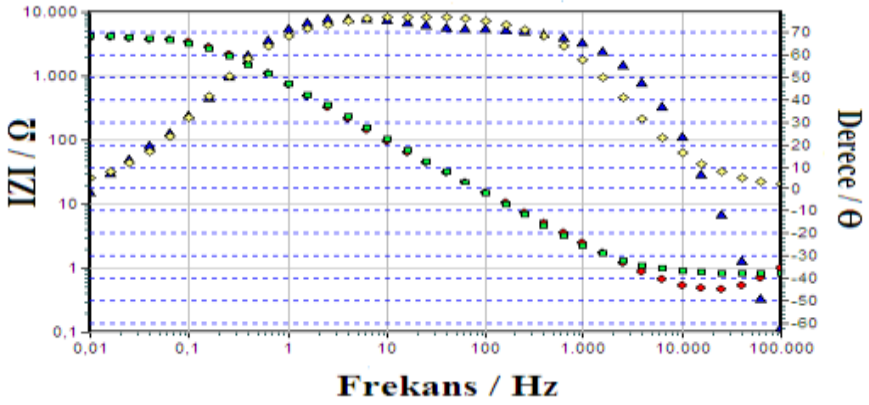

Fig. 1 Equivalent circuit model analysis R(QR) of rGO/MnO_2/PTTh nanocomposite for initial feed ratio of $[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:1 for Bode-Magnitude and Bode-phase plots.

Table 1. Results of R(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1/Ω**	**R_2/Ω**	**CPE,Yo [S.Sec^n]**	**Fred power,n [0<n<1]**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:1	0,8125	437,7	$2,528\times10^{-4}$	0,8705

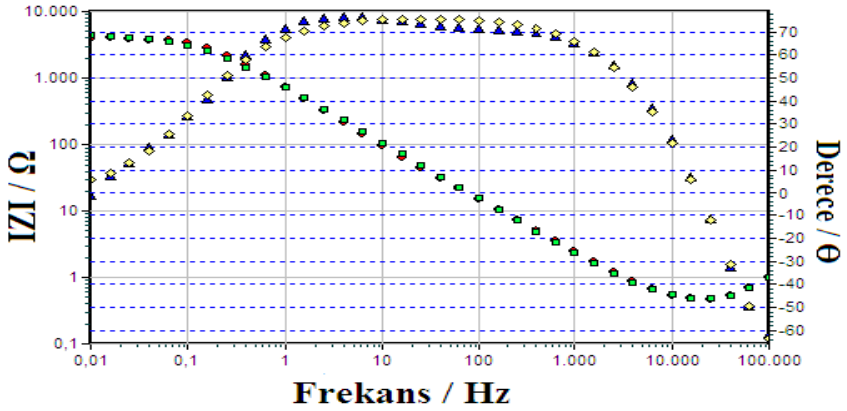

Fig. 2 Equivalent circuit model analysis LR(QR) of rGO/MnO_2 nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 2. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**L/Henri**	**R_1 / Ω**	**CPE,Yo [S.Sec^n]**	**Fredpower,n [0<n<1]**	**R_2/ Ω**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:1	$1,47\times10^{-6}$	0,4323	$2,7\times10^{-4}$	0,8521	4497

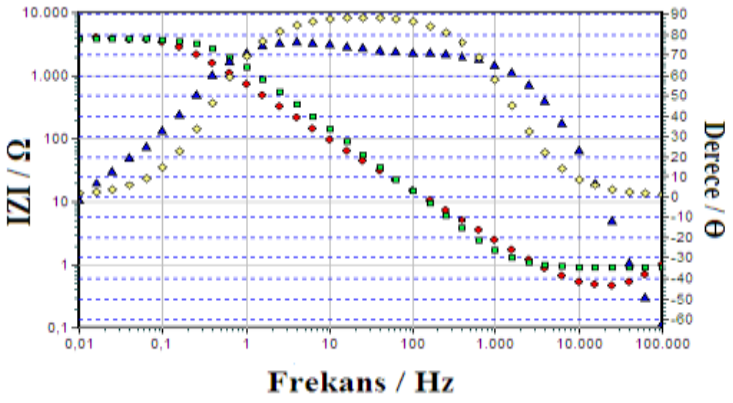

Fig. 3 Equivalent circuit model analysis R(CR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 3. Results of R(CR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1/Ω**	**R_2/Ω**	**C/ F**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:1	0,902	3893	$1{,}092\times10^{-4}$

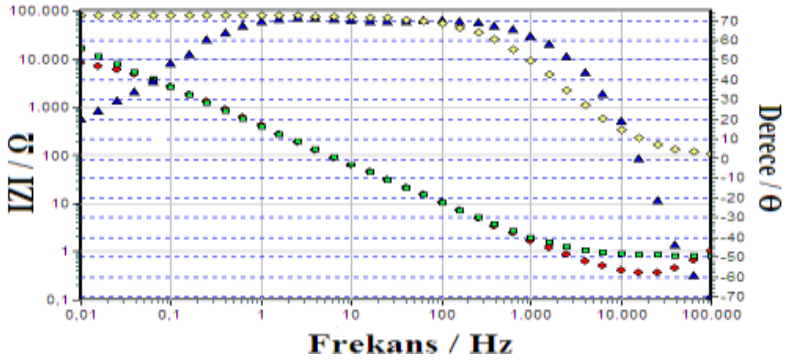

Fig. 4 Equivalent circuit model analysis RQ of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 4. Results of RQ equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_s/Ω**	**CPE,Yo[S.Sec^n]**	**Fred power, n [0<n<1]**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:2	0,801	$5{,}507\times10^{-4}$	0,8067

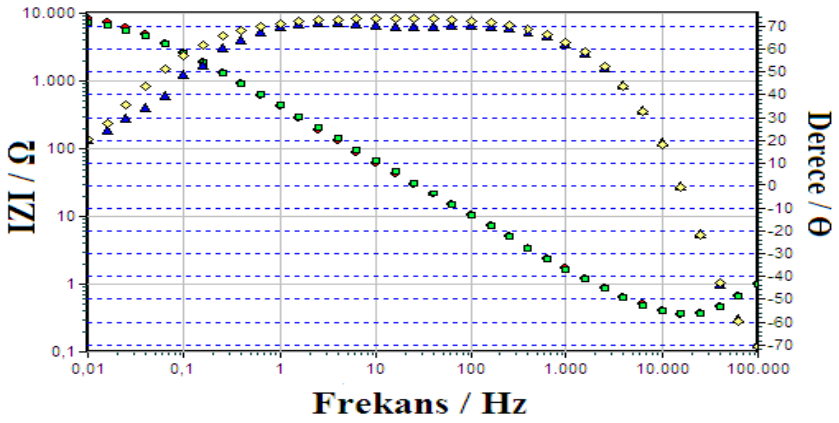

Fig. 5 Equivalent circuit model analysis LR(QR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 5. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**L/Henri**	**R_1/Ω**	**CPE,Yo [S.Sec^n]**	**Fredpower,n[0<n<1]**	**R_2/Ω**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:2	$1{,}54\times10^{-6}$	0,3192	$4{,}9\times10^{-4}$	0,8221	8721

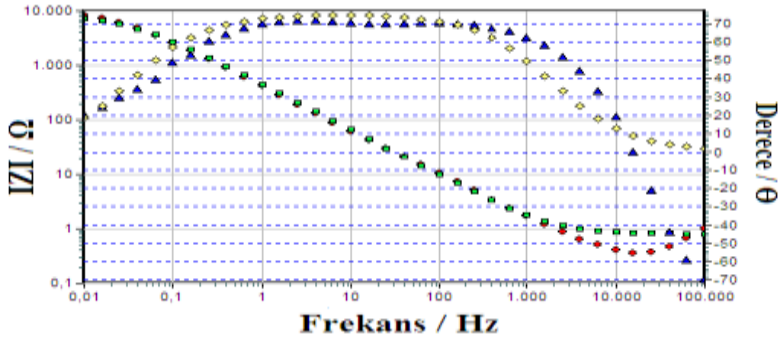

Fig. 6 Equivalent circuit model analysis R(QR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 6. Results of R(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1/Ω**	**CPE,Yo [S.Sec^n]**	**Fredpower,n[0<n<1]**	**R_2/Ω**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:2	0,7944	$4{,}65\times10^{-4}$	0,8393	8329

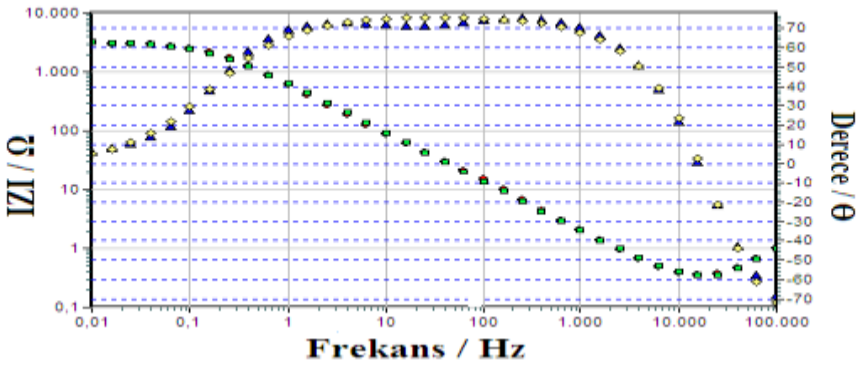

Fig. 7 Equivalent circuit model analysis LR(QR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 7. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**L/Henri**	**R_2/Ω**	**CPE,Yo [S.Sec^n]**	**Fred power, n [0<n<1]**	**R_2/Ω**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:3	$1,59\times10^{-6}$	0,3066	$3,103\times10^{-4}$	0,8495	3279

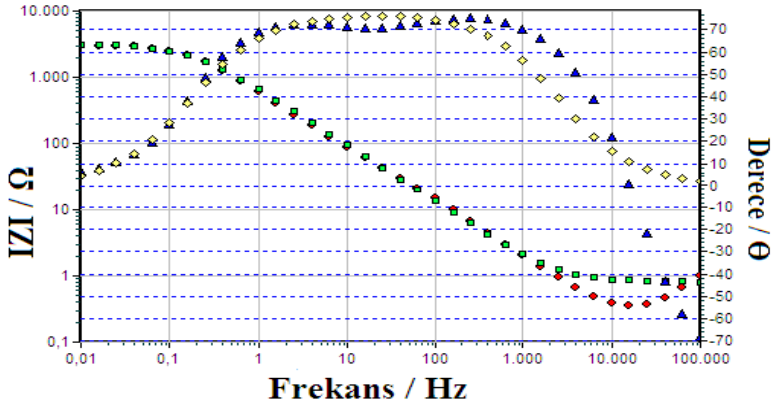

Fig. 8 Equivalent circuit model analysis R(QR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 8. Results of R(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1/Ω**	**R_2/Ω**	**C/ F**	**CPE,Yo[S.Sec^n]**	**Fred power, n [0<n<1]**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:3	0,9142	3509	$1,19\times10^{-4}$	$4,081\times10^{-4}$	0,8202

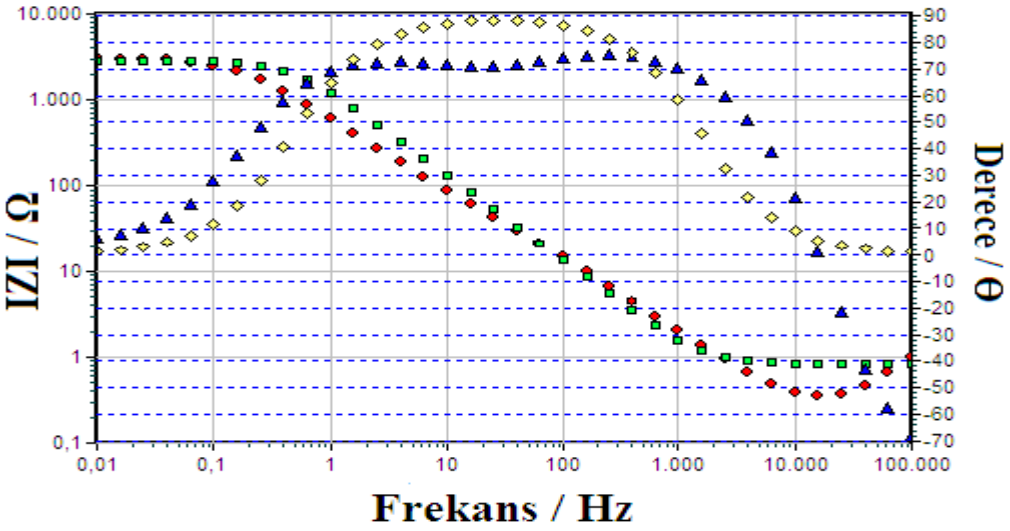

Fig. 9 Equivalent circuit model analysis R(CR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 9. Results of R(CR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1 / Ω**	**R_2 / Ω**	**C/ F**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:3	0,8245	2879	$1{,}188\times10^{-4}$

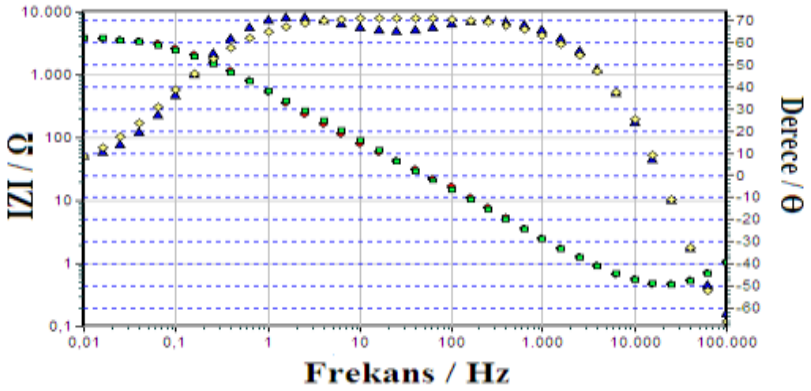

Fig. 10 Equivalent circuit model analysis $R_1(QR_2)$ of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 10. Results of $R_1(QR_2)$ equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1 / Ω**	**R_2 /Ω**	**CPE,Yo [S.Sec^n]**	**Fred power, n [0<n<1]**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:5	0,8158	4210	$4{,}081\times10^{-4}$	0,8202

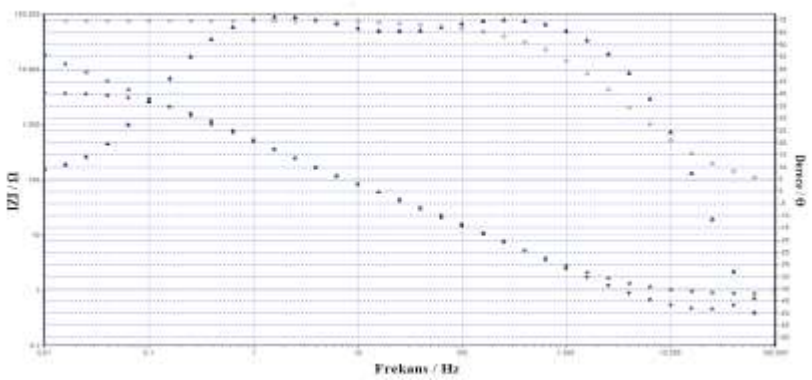

Fig. 11 Equivalent circuit model analysis RQ of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 11. Results of RQ equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1 / Ω**	**CPE,Yo [S.Sec^n]**	**Fred power, n [0<n<1]**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:5	0,8229	$5{,}242\times10^{-4}$	0,7768

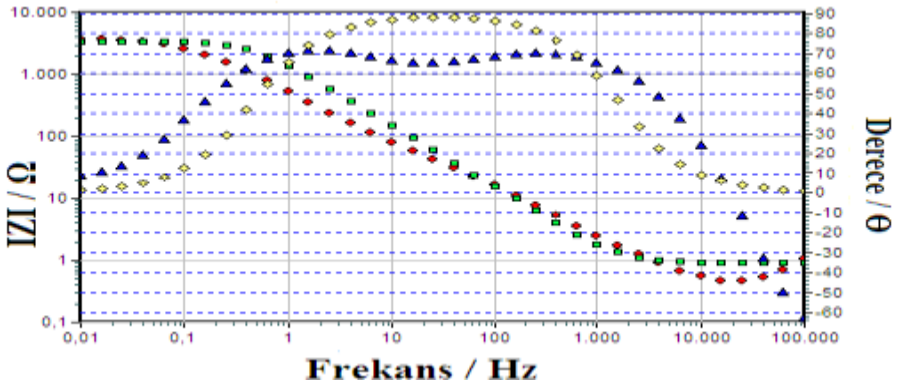

Fig. 12 Equivalent circuit model analysis R(CR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 12. Results of R(CR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**R_1 / Ω**	**R_2 / Ω**	**C/F**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$=1:1:5	0,9142	3509	$1{,}19\times10^{-4}$

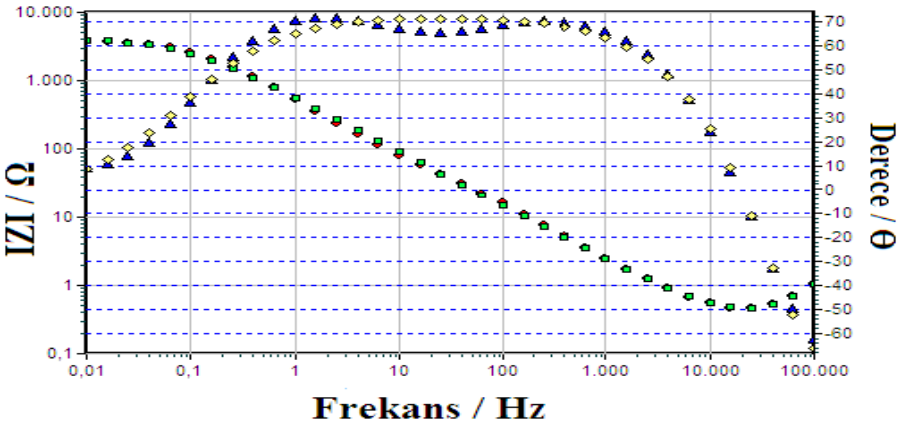

Fig. 13 Equivalent circuit model analysis LR(QR) of rGO/MnO_2/PTTh nanocomposite for Bode-Magnitude and Bode-phase plots.

Table 13. Results of LR(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite.

Circuit parameters	**L/Henri**	**R_1 / Ω**	**CPE,Y_o[S.Sec^n]**	**Fred,power,n[0<n<1]**	**R_2 /Ω**
$[rGO]_o/[MnO_2]_o/[PTTh]_o$ =1:1:5	$1,57\times10^{-6}$	0,3978	$3,9\times10^{-4}$	0.8044	4230

III. CONCLUSION

The results obtained after applying the equivalent circuit model are given in Table 1 to Table 13. As a result, equivalent circuit model studies of rGO/MnO_2/PTTh was given using the EIS data of the nanocomposites using ZSimpWin 3.22. 4 different equivalent circuit model was given in this study. It was carried out in the circuit programme. In addition, an equivalent circuit model analysis of R(QR) was presented at different initial feed ratios of $[rGO]_o/[MnO_2]_o/[PTTh]_o$= 1/1/1, 1/1/3, 1/1/5. The lowest charge transfer resistance (R_{ct}) was obtained as R_{ct}= 437,7 Ω for equivalent circuit models of $[rGO]_o/[MnO_2]_o/[PTTh]_o$= 1/1/1. If the R_{ct} is low, the capacitance of the supercapacitor should be higher value. The other circuit parameters were given in Table 14.

Table 14. Results of R(QR) equivalent circuit model analysis of rGO/MnO_2/PTTh nanocomposite for $[rGO]_o/[MnO_2]_o/[PTTh]_o$= 1/1/1, 1/1/3, 1/1/5.

Parametre	**$[rGO]_o/[MnO_2]_o/[PTTh]_o$=**			
	1/1/1	**1/1/2**	**1/1/3**	**1/1/5**
R_1 /Ω	0,8125	0,7944	0,7978	0,8158
CPE, Yo [S×Sec^n]	$2,528\times10^{-4}$	$4,656\times10^{-4}$	$2,904\times10^{-4}$	$4,081\times10^{-4}$
Fred power, n [0<n<1]	0,8705	0,8393	0,8642	0,8202
R_2 /Ω	437,7	8329	3212	4209

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Investigation of Hyperparameter Tuning Performance on Different Deep Learning Models with Meta Heuristic Algorithms

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Abstract – The optimization process is a process that must be carried out meticulously and carefully and is repeated until certain criteria are met. In this study, Convolutional Neural Networks", VGG-19 and "Long-Short Term Memory" models were used on wild animal and yoga data obtained from Kaggle, as well as Particle Swarm Optimization and Genetic Algorithm, which are meta-heuristic approaches, were applied for hyperparameter tuning and the results were compared in tables. Hyper parameter adjustment with Particle Swarm Optimization and Genetic Algorithm, which are meta-heuristic approaches, was applied to wild animal and yoga data obtained from the Kaggle platform, using Convolutional Neural Networks, VGG-19 and Long-Short Term Memory models. It is explained and shown in the table of loss function values of the validation data set that the VGG-19 model is the most successful model and that the Genetic algorithm is better than Particle Swarm Optimization in 4 out of 6 different cases. It was concluded that the VGG-19 model was the best model among the 3 models used, with an average success rate of 92%.

Keywords – Meta Heuristic Optimization Methods, Particle Swarm Optimization, Genetic Algorithm, Hyperparameter Tuning, Deep Learning

I. INTRODUCTION

Engineering problems are generally difficult to solve and have limitations. In general, although a method may not be successful in solving every problem, it is known to be very good in some [1] cases.

Meta heuristic optimization (MHO) methods comes into play there. Generally, the optimization process is defined as a set of iterations that iteratively repeats under certain conditions and limits and aims to find the best solution [2]. Although the types of these experiments show some differences, they are designed to improve the existing ones. Meta-heuristic methods are problem-independent and unaffected by restrictions, which is why their application area is wide. According to the "no free lunch" theorem, not every optimization method can solve every problem [3]. Metaheuristic methods, that could be physics-based, biology-based or nature-inspired types, play an active role in solving the problem.

Machine Learning provides the opportunity to solve more complex data and more complex problems. Nonlinearity emerged to capture this nonlinear relationship between variables in data in real-world problems [4]. In scenarios where metaheuristic methods and machine learning methods are used together, it is aimed to optimize larger data [5] [6]. The magnitude of encountered problems depends to some extent on the size of the data. In real life problems, the data it has in many different forms such as images, videos, text and even the value table is very important in small data sets. Deep Learning models have been formed to handle these different types of data and to find solutions based on these data [7].

II. METHODS

A. METAHEURISTIC OPTIMIZATION METHODS

1) PARTICLE SWARM OPTIMIZATION

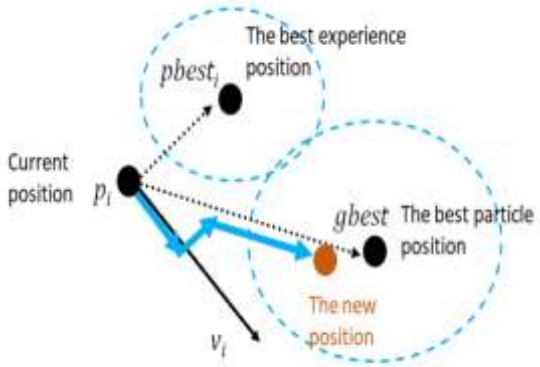

Fig. 1 Particle Swarm Optimization [8]

This algorithm is based on communication, which is a social skill of birds. The birds in the flock communicate with each other and move towards where the better solution is. They constantly update their positions according to their best position and the best position of the herd, rearranging themselves to ensure an optimal formation [9]. With this method, we aim to reach the best solution in our scenario by using herd intelligence. In this algorithm, searches are made at intervals determined by some randomly initialized parameters. Each search represents a potential solution. Then, it makes a calculation by considering the current positions of the individuals in the herd, and as a result of this calculation, a velocity vector is obtained, the direction of this vector is determined. During the iteration process, it is aimed to achieve better results up to the stopping criteria. Stopping criteria are criteria such as reaching the maximum iteration or the size of the velocity vector to be obtained being too small, which indicates that the flock cannot progress any further and indicates convergence, as shown in Fig 1.

2) GENETIC ALGORITHM

Genetic algorithm is an optimization method inspired by natural selection and genetics. In this method, individuals in a given population are randomly initialized at given intervals. All of these individuals are considered to have a potential best solution. Then, the fitness values are calculated, the selected new individuals are used as input in the next stage. During these processes, events such as part change and mutation occur, and the unique characteristics of these individuals change in this way. The aim is to obtain the individual or offspring that provide the best solution until the stopping criterion is met [10].

To explain the concept of *Elitism* used in this method, *Elitism* is the copying of the characteristics of the individual that gives the best results in terms of the fitness function of a generation and using them for crossover purposes in the next generation. In this way, individuals will tend to produce better results as generations pass. In the method created without the use of *elitism*, more generations would be needed to obtain better results. In this regard, it is known that elitism leads to the desired result faster. For both, it is exhaustive and exhaustive and elaborate process in training phase.

Crossover and *mutation* are effective concepts in this optimization method that will provide diversity of individuals and their potential solutions. This meta-heuristic is unique due to these two concepts. With

these two events occurring at certain rates and probabilities, it is aimed to reach the optimum level of the hyper parameters we want to improve. The parameter values used are shown in Table 1.

Table 1. Genetic Algorithm Parameters

Parameters	Intervals/Used Values
Fitness Max	1
Learning_rate	(0.0001, 0.01)
Batch_size	(8, 64)
Individual Number	1
Mutation Rate(indpb)	0.1
Indiviual Number For Tournament	3

To explain the parameters in the function we use in the Genetic Algorithm, the *Fitness Max* parameter, which uses a single objective function and aims to maximize, secondly, the parameter we use to randomly initialize the *Learning_rate* parameter at specified intervals, and another
parameter is the parameter we use to randomly initialize the *Batch_size* parameter at specified intervals. The other parameter is a parameter that determines how many individuals will be generated from the combination of *Batch size* and *learning_rate* parameters, the next parameter is the *indpb* parameter, which determines the probability rate of mutation that will occur in the specified intervals, and the parameter that creates a tournament from the last selected ones, and a function that evaluates the training, validation and test data.

B. DEEP LEARNING MODELS

1) CONVOLUTIONAL NEURAL NETWORKS

Convolutional Neural Networks (CNN) is a deep learning model that is widely used in image data and captures the relationships between pixels due to its structure [11]. Although convolutional neural networks are an ancient method, they are still used in some academic studies [12]. Convolutional neural networks try to make sense of image data by making mathematical calculations, considering the RGB value of each pixel. Since each color has a pixel equivalent, different classes are distinguished due to the differences of each pixel.

The overall image data is considered as a matrix. In this matrix, information about each color and its position in the x and y plane is important and operations are carried out accordingly. The results of this process, called cross-correlation, are values represented by each class. Feature Maps of images belonging to the same class are expected to be similar. To obtain feature maps, the elements in 2 matrices are multiplied respectively and a new matrix is formed as a result. This multiplication is then handled with activation functions and feature maps are created as a result.

2) VGG-19

This classic model created by Visual Geometry Group and could be nice to use. This model, which is a type of Convolutional Neural Network (CNN), is much more complex than the other model and consists of 19 layers in total [13]. Transfer Learning was also used in this model, which was used for 224x224 image data. Transfer Learning is the use of a model as it has been trained before, without being trained from scratch. In our study, we created our final model by freezing the top layer and adding a Dense layer as last. The purpose of using this method is to achieve better results faster. In a standard training process,

weights are first calculated and then the weights are updated by various algorithms as time passes. It is thought that this could give good result.

3) HYBRID MODEL (CNN+LSTM)

Considering the studies [14] where hybrid models were used and successful results were obtained, we concluded that one of the models we used in our study could be a hybrid. Hybrid models are models that use two or more different models together. By combining the advantages of these models used together, it is aimed that these models will give better results.

Long-Short Term Memory, which is a part of the hybrid model we used in our study, is generally preferred for sequence data, that is, data flowing in frames such as video [15]. In such models, the input of the current model of the sequence per unit time is determined by the output of the model at the previous moment. Due to this chain-like structure, the information held and transferred in transitions is important [16]. The *Forget Gate* decides whether to keep the incoming data we have and whether the kept data will interact with the data coming from other gates in the next stages and affect the result.

III. DATA ACQUISITION

In the study, 3 deep learning models were used on 2 different data sets and 2 different meta-heuristic optimization methods were used for hyper parameter tuning. The algorithms and meta-heuristic optimization methods used in the study constitute preliminary preparation for the master's thesis. CNN, VGG-19 and Hybrid (CNN+LSTM) models were used in both data sets. In addition, these models were applied to the light of 2 different optimization methods, namely Genetic Algorithm and Particle Swarm Optimization, and hyperparameter adjustment was performed. The data distribution is shown as Table 2.

Table 2. Data Distribution

	Train	Validation	Test
Wild Animal Species	676 (%70)	116 (%12)	164 (%18)
Yoga	485 (%61)	168 (%21)	137 (%18)

The features of all the created models are shown in table 3. These parameters both provide information about the general operations and show that they are applied to both data sets.

Table 3. Dataset Configuration

Optimizer	Adaptive Moment Estimation
Epoch	10
Early Stopping	5
Image Size	224x224
# Number of Image	1756
Rescaling	1./255
Loss Function	Sparse Categorical Cross Entropy
Pooling	Maximum
# of classes	4

$$Specificity = \frac{TN}{TN+FP} \quad (3.1)$$

$$Precision = \frac{TP}{TP+FP} \quad (3.2)$$

$$F1\ Score = \frac{(2*TP)}{(2*TP+FP+FN)} \quad (3.3)$$

$$Accuracy = \frac{(TP+TN)}{(TP+TN\ FP+FN)} \quad (3.4)$$

As shown in formulas 3.1-3.4, the classification metrics are calculated according to relevant datasets and cases. It is determined whether model predicts the input as true or false. After carrying out this operation for all images, this operation returns relevant values. Further calculations could be done by regarding these values. Mentioned formulas are widely recognized for classification tasks.

IV. RESULTS & DISCUSSION

The results are presented in Table 5&6 by considering the classification metrics and the values of the fitness functions. According to this table, the model with the lowest fitness value, or in other words, the best model in which the problem is optimized, is the VGG-19 model used with transfer learning. When we compare the metaheuristic methods, we see that 4 out of 6 different cases give better results with the Genetic algorithm and the others with Particle Swarm optimization. Based on this table, we can say that both methods give good results at certain points, as table 5 shows.

Table 5. Fitness Values of Models with Respect to Metaheuristic Methods for Datasets

Datasets	Models	Metaheutistic Methods	Fitness Values
Wild Animal Species	VGG-19	GA	**-0.28**
		PSO	-0.48
	CNN	GA	-2.29
		PSO	**-0.68**
	HYBRID (CNN+ LSTM)	GA	**-0.33**
		PSO	-1.2
Yoga	VGG-19	GA	**-0.13**
		PSO	-0.33
	CNN	GA	-54.3
		PSO	**-0.15**

	HYBRID (CNN + LSTM)	GA	**-0.64**
		PSO	-0.65

Table 6. Classification Metrics Results

Dataset	Models	MHO	Accuracy	Specificity	Precision	F-1 Score
Wild Animal Species	VGG-19	GA	**0.92**	0.92	0.91	0.91
		PSO	0.9	0.9	0.9	0.9
	CNN	GA	0.65	0.64	0.66	0.63
		PSO	**0.69**	0.69	0.72	0.7
	HYBRID (CNN + LSTM)	GA	**0.89**	0.89	0.89	0.88
		PSO	0.67	0.67	0.7	0.67
Yoga	VGG-19	GA	**0.94**	0.94	0.94	0.94
		PSO	0.92	0.92	0.92	0.92
	CNN	GA	0.7	0.7	0.761	0.71
		PSO	**0.92**	0.92	0.93	0.92
	HYBRID (CNN+ LSTM)	GA	0.74	0.74	0.74	0.74
		PSO	**0.75**	0.75	0.75	0.75

As seen in Table 6, the parameters in the models, algorithms and functions were kept the same for a total of 12 different cases, so that by trying to find only the best hyper parameters in a certain range, it can be seen how much the objective function changes and how much the metrics improve.

V. CONCLUSION

In this study, we aimed to find good results by trying multiple values at the same time rather than a single value. We tried to get a good result in a much longer time than a standard model training

process and tried to show it in a table. We also used default values, in a sense, by making sure that the values used in model training of the search space were between the upper and lower limits. It has been observed that determining the search space correctly is a difficult and careful process. We saw during the training process that the lower and upper bounds in the search space are one of the most appropriate solutions in that range. It is planned that we could work on newly released metaheuristic as future work.

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DEEPFAKE DETECTION WITH A TRADITIONAL HYBRID METHOD (LBP + HOG)

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Abstract – Nowadays, the term Deepfake is increasingly appearing in many areas. Deepfake refers to the creation of fake photos, videos, and audio data using artificial intelligence and deep learning methods. With this technology a person's face and voice can be altered or a non-existent person can be made to appear real. Such forgeries can lead to cyberbullying, blackmail, manipulation, defamation, and fake news, causing significant security issues. This situation brings many dangers and can lead to fatal consequences. Creating a new person or altering an existing one might not be easily detectable by humans. To mitigate these problems it aims to classify Deepfake data using a traditional hybrid method automatically. In the study, a data set containing 8659 two-class visual data was used. The dataset consists of images of human faces as men, women and children. LBP and HOG methods were used separately for feature extraction. These methods can perform feature extraction very powerfully and quickly. A new hybrid method was subsequently proposed by combining the two methods. This traditional hybrid method (LBP + HOG) was applied to the Deepfake dataset for feature extraction. Then extracted features were classified using an SVM classifier. As a result of the training an accuracy rate of 75.8% was achieved.

Keywords – Deepfake, image processing, traditional feature extraction, hybrid, LBP, HOG, SVM.

I. INTRODUCTION

Deepfake is a general term used for creating non-existent images and sounds through artificial intelligence techniques. While this concept is sometimes used in art and entertainment, it is highly susceptible to malicious use. The fake faces generated with Deepfake technology can facilitate the creation of fake news, manipulation, and blackmail. This leads to various security and privacy breaches [1].

Detecting such forgeries with the naked eye is quite challenging. In this study, traditional feature extraction methods are employed to automatically detect Deepfakes. Instead of modern feature extraction methods (such as deep learning, neural networks, and certain machine learning techniques), traditional feature extraction methods (LBP + HOG) are utilized. There are several reasons for preferring traditional feature extraction methods in this study. The most important reasons for this are that feature extraction using traditional methods is less costly and can provide effective results even in small data sets.

In this study, a hybrid model was obtained by combining traditional feature extraction methods. It is aimed to detect Deepfakes through visual data with the help of the proposed model. An open source dataset called deepfake was used in the implementation of the application. The data set contains various images. The created hybrid LBP + HOG model was trained with the deepfake dataset. As a result of the training the feature extraction phase has been completed. The features obtained here were combined and given as input to the SVM classifier. The classification process was completed using SVM. As a result of the tests performed it was seen that the classification process reached a success rate of 75.8%.

II. ARCHITECTURES OF LOCAL BINARY PATTERN AND HISTOGRAM OF ORIENTED GRADIENTS

A. Local Binary Pattern

In the field of image processing most commonly used feature extraction method is LBP. It is frequently used by researchers to perform powerful feature extraction especially in applications such as pattern and face recognition. LBP is attempts to recognize patterns and capture unique features in dataset it processes. For this purpose each pixel divides its surroundings into matrices of various sizes. Sizes of this matrices generally 3×3, 5×5 or 7×7. It compares density of pixels and creates a pattern for each pixel. LBP dont need high computational cost when applying approach and performs effectively on small data. Low calculation times and can be calculated easily is important advantages of LBP. LBP used in many areas like object recognition, texture classification and image comparison. LBP also been used for human and face recognition in many studies [2], [3]. LBP working architecture is seen Figure 1 and steps like below [4], [5];

1. Pixel selection: LBP is the stage where the center pixel selection is made to create the feature vector.
2. Region determination: A 3×3 region is determined around the pixel selected in the previous stage. This region consists of pixels adjacent to the center pixel.
3. Threshold determination: The selected threshold value is compared with neighboring pixels and a value is assigned as 0 or 1.
4. Binary transformation: Binary conversion is applied to the assigned values.
5. Histogram creation: A histogram is created with the obtained patterns. The feature vector is obtained by combining all the created histograms.

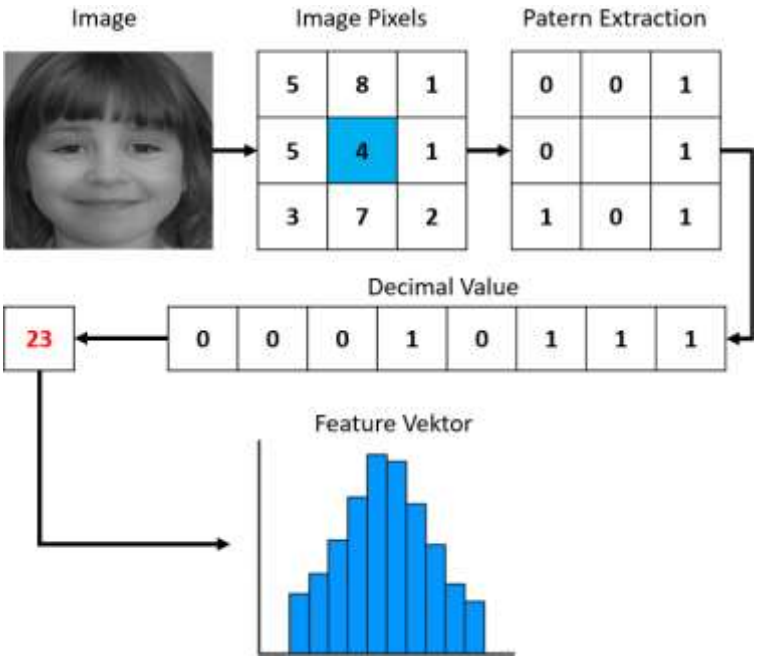

Fig. 1 LBP Working Architecture

B. Histogram of Oriented Gradients

Another method for feature extraction used in image processing, motion detection and human recognition. It is used to detect the shape and edges of the object on image. Objects, shapes and appearance information must be determined. HOG uses edge orientations and gradient density information to perform this operation. This method can provide important success rates in small data sets. It performs with generalization ability and good representation of patterns. The reason for this is powerful in geometric and photometric transformations. HOG used in image classification, face recognition, human recognition and motion detection [6], [7], [8]. HOG working architecture is as follows[9];

1. Pixel selection: At this stage, HOG selects pixels to extract features.

2. Gradient computation: Gradient calculation is performed to determine the edges of the selected pixels(Sobel filter is generally used). At the end of this stage, the direction change and size of the pixels are calculated.
3. Cell division: The image is divided into cells of different sizes. These cells are usually 8x8 or 16x16 in size.
4. Determination of orientation histogram: A direction histogram of the cells obtained from the previous stage is created.
5. Block formation and normalization: Cells are combined and made into blocks. The created blocks are normalized.
6. Generation of feature vector: As a result all of these operations, a feature vector is created.

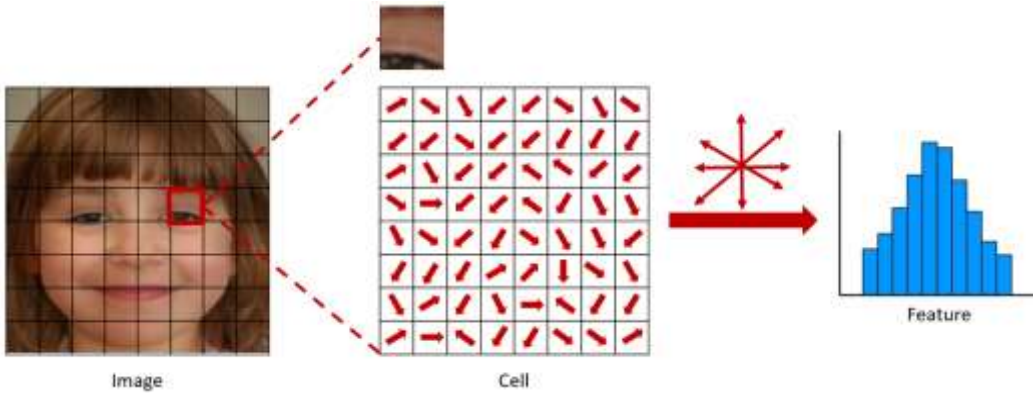

Fig. 2 HOG Working Architecture

III. LITERATURE REVIEW

There are various methods and studies related to Deepfake and facial recognition. This section presents a literature review conducted on Deepfake and facial recognition. The literature table summarizes the methods used in the studies, the datasets employed, and the results achieved.

Table 1 Literature table

Referance number	Method	Dataset	Results
[10]	YOLO + LBP	CelebDF-FaceForensics++(c23)	% 92.45
[11]	CNN	Kaggle DeepFake Video dataset	% 95.77
[12]	KNN(a) SVM(b)	(a)CELEBA Vs ATTGAN (b)CELEBA Vs STARGAN:	(a) % 92.67 (b) % 93.17

[13]	EfficientNet	OpenForensics (Resized)	% 89.30
[14]	A new model created with a facial recognition network and a context recognition network.	(a) Celeb-DF-v2 (b) FaceForensics++	(a) % 60 (b) %75
[15]	Xception - MobileNet	FaceForensics++	% 91-98
[16]	LBP + HOG	Infrared human dataset obtained with ThermoVision A40.	%98.6
[17]	LBP + HOG	INRIA	% 95
[18]	Two different methods have been proposed named Meso-4 and MesoInception-4.	"The Deepfake video dataset created by the team was utilized."	% 95
[19]	Two-stream network	A new dataset has been created	% 92.7
[20]	CNN (Resnet – DenseNet)	DFDC	% 94
[21]	ResNet-Swish-Dense54	DFDC, FaceForensic++ ve CelebDF	% 99.9

IV. DATASET AND PROPOSED METHOD

A. DATASET

In this study, a publicly available Deepfake dataset published on the Kaggle platform was used. The dataset comprises 4182 Deepfake images and 4477 real images, comprising noisy and noise-free data. The noisy and noise-free example images of Deepfake and real individuals in the dataset are shown in Figure 3.

Fig. 3 Example of Dataset

B. METHOD

To detect Deepfake analysis, this study combines the traditional LBP and HOG methods, which yield significant results with less data and are more cost-effective. A hybrid model is formed based on the combination of LBP and HOG feature extractors. The proposed model for Deepfake detection consists of four main components. The model proposed for Deepfake detection is shown in Figure 4.

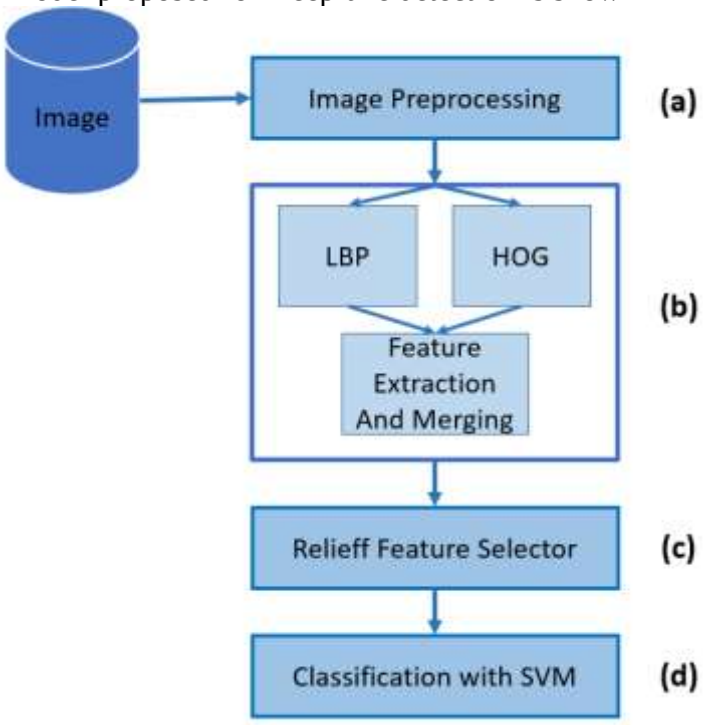

Fig. 4 Proposed Traditional Hybrid Method

The proposed model consists of four main components, which are photo preprocessing (a), feature extraction (b), feature selection (c), and finally classification (d) stages.

(a) Photo Preprocessing - In this stage, all the photos in the dataset are read. Then, each read photo is resized to 224 × 224. Resized photos are then divided into patches of size 28 × 28. The reason for dividing photo data into patches is to ensure computational efficiency and facilitate parallel processing. The data is now ready for the next stage.

(b) Feature Extraction - In this stage, traditional feature extraction methods, namely LBP and HOG, are utilized. LBP and HOG are used to extract features separately from each patch. A new feature vector is obtained by combining the extracted features. The joint creation of a vector rather than using the two methods separately has positively influenced accuracy.

(c) Feature Selection - In this stage, feature selection is performed from the generated feature vector. Relieff is used for feature selection. Relieff measures the contribution of data points to classification performance and selects the most significant features (400). One of the reasons for using Relieff is its ability to act sensitively and quickly, thus saving costs.

(d) Classification - Finally, a classification process is applied to the obtained features. The classification process for the created hybrid method is performed using Support Vector Machine (SVM). The selection of SVM as the classifier in this study is due to its applicability to high-dimensional feature spaces and its effectiveness in low-dimensional settings.

V. EXPERIMENTAL RESULTS

The processed dataset underwent training using the hybrid method created by combining the proposed traditional methods. Features were extracted using LBP and HOG methods. 400 features were selected from the extracted features using the Relieff method, and finally, they were classified using the SVM classifier. 5-fold cross-validation was applied for this purpose. The confusion matrix obtained after training is provided in Figure 5. All experimental results were obtained using the Matlab program.

Fig. 5 The confusion matrix of the proposed method

The accuracy, recall, precision, and F1 score values of the method were calculated using the TN, TP, FN, and FP values obtained in the matrix. The calculated performance metrics are presented in Table 2.

Table 2 Performance Metrics

Accuracy	%75.8
Recall	%61.34
Precision	% 76.71
F1 Score	%68.16

Additionally, the ROC curve used to measure the system performance after training is shown in Figure 6. The ROC curve displays performance metrics such as sensitivity, specificity, and precision at different threshold values in detail.

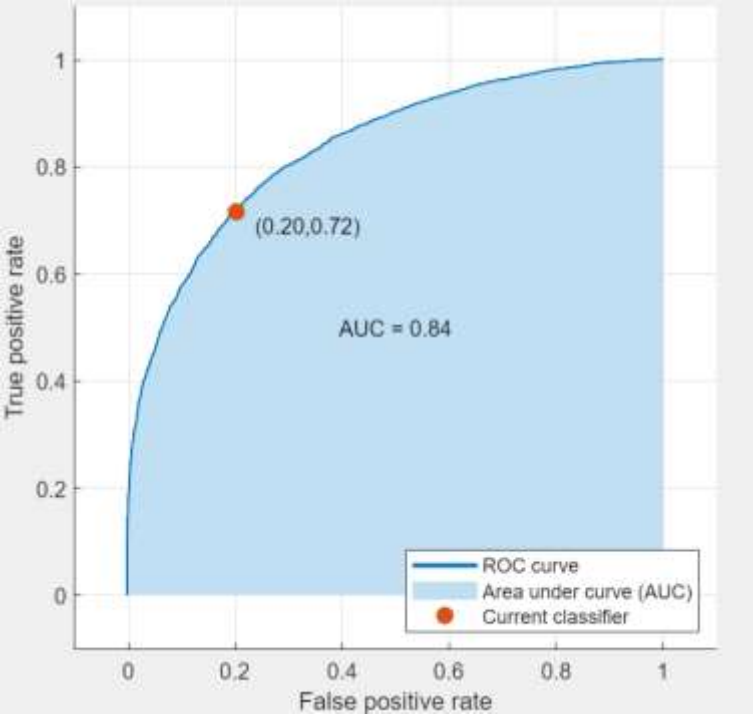

Fig. 6 ROC Curve of the Proposed Model

VI. DISCUSSIONS AND CONCLUSION

In this study, a traditional hybrid architecture was proposed for Deepfake detection in photo data. The proposed hybrid architecture includes LBP, HOG, and SVM methods. The created traditional hybrid method was tested on a Deepfake dataset containing a total of 8,659 (4182 + 4477) visual data. As a result of the tests, an accuracy of 75.8% was achieved. The success rate obtained depends on the dataset used. For example, the dataset used in this study is noisy and diverse. Additionally, the value of the obtained accuracy rate is also related to the method used. In this study, traditional methods were used to save cost and time. In future studies, it is planned to strengthen the method and dataset used.

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Pazarlama Profesörlerinin Yüksek Öğretim Bilgi Sisteminde (YÖKSİS) Yer Alan Anahtar Kelimelerinin Sistematik Bir İncelemesi

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Özet – Bu çalışma, Türkiye'de eğitim veren üniversitelerde kadrolu veya sözleşmeli olarak görev yapan pazarlama profesörlerinin YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında yer alan pazarlama bilim alanına ait anahtar kelimelerinin sistematik incelemesini amaçlamaktadır. Bu kapsamda 131 kadın, 129 erkek olmak üzere toplam 260 profesöre ait YÖKSİS'teki anahtar kelimeler çalışmanın kapsamına dahil edilerek değerlendirilmiştir. Anahtar kelimeler için elde edilen bibliyometrik verilerin analizi VOSviewer bibliyometrik haritalama programı kullanılarak gerçekleştirilmiştir. YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında pazarlama bilim alanına ait 17 anahtar kelime yer almaktadır. Bu anahtar kelimelerden "tüketici davranışları" (157 kişi), "ürün ve marka yönetimi" (80 kişi) ve "hizmet pazarlaması" (77 kişi) en fazla tercih edilen anahtar kelimelerdir. "Tüketici davranışları" ve "hizmet pazarlaması" anahtar kelimeleri aynı kümede yer alırken, "ürün ve marka yönetimi" anahtar kelimesi farklı kümede yer almaktadır. Anahtar kelimelerin birlikte farklı kümeler oluşturması, pazarlama profesörlerinin YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranına kayıtlı anahtar kelimeler arasındaki bağlantı gücünün baskın olmasından kaynaklanmaktadır. Toplam bağlantı gücü en fazla olan anahtar kelimeler sırasıyla "tüketici davranışları" (toplam bağlantı gücü=279), "ürün ve marka yönetimi" (toplam bağlantı gücü=151) ve "hizmet pazarlaması" (toplam bağlantı gücü=141) olarak gerçekleşmiştir. Çalışmada 12 pazarlama profesörünün YÖKSİS aktif alan bilgisi ekranında herhangi bir anahtar kelimesi yer almamaktadır. Ayrıca pazarlama profesörü sayısının en fazla olduğu ilk üç üniversite sırasıyla Marmara Üniversitesi (13 profesör), Dokuz Eylül Üniversitesi (11 profesör) ve Ankara Hacı Bayram Veli Üniversitesi (9 profesör) olduğu görülmektedir.

Anahtar Kelimeler – Pazarlama Profesörleri, Anahtar Kelimeler, YÖKSİS, VOSviewer, Bibliyometrik Analiz

I. GİRİŞ

Toplumsal gelişimin merkezi sayılan, küresel anlamda toplumların sosyal ve ekonomik refahı için yaşamsal bilgiyi üreten ve yayan üniversiteler, toplumda önemli ve saygın bir yere sahip eğitim ve öğretim kurumlarıdır. Bu kurumlarda akademisyen olarak görev yapan, en yüksek düzeydeki akademik rütbe profesör ünvanıdır. Üniversite kurumlarında görev yapan öğretim üyeleri (Dr. Öğretim Üyesi, Doçent ve Profesör) lisans ve lisansüstü öğrencilerine eğitim materyalleri hazırlamak, ilgili dersleri öğretmek ve süreli akademik yayınlarda yer alabilecek bilim alanıyla ilgili orijinal araştırma ve analizleri yayımlamakla sorumludur.

Bibliyometrik analiz, son yıllarda iş dünyası ve akademik alanda büyük bir popülerlik kazanmıştır [1]. Sahip olduğu değerlere rağmen, bibliyometrik analiz birçok durumda potansiyelinden tam olarak faydalanılamamaktadır [2]. Bibliyometrik analiz, bilimsel yayınların sistematik olarak incelenmesini sağlayan nicel bir analiz yöntemi olmakla birlikte [3], akademisyen ve araştırmacıların tek noktadan genel bir bakış imkanına sahip olmalarını, bilgi boşluklarını belirlemelerini ve yeni bilgiler elde etmelerini [4], ilgilendikleri konuyu konumlandırabilmeleri ve sınırlarını belirleyebilmelerini [5], geniş çaplı verileri

anlamlandırarak toplam bilimsel bilgiyi açıklamak ve görselleştirmek için araştırmacılara imkan veren etkili bir yöntemdir [6].

Yapılan literatür taramasında bibliyometrik analiz yöntemi kullanılarak gerçekleştirilen akademik çalışmaların ağırlıklı olarak makale, yüksek lisans veya doktora tezleri üzerinde yoğunlaştığı görülmektedir [7]. Literatür taramasında bu çalışmanın konusuna benzer sadece bir çalışmaya rastlanmıştır. Sevgi (2016) tarafından yapılan çalışmada Doçentlik sınavlarında kullanılan anahtar kelime sütununda bulunan ifadelerin analizi ve değerlendirilmesi konu edinirken [8], bu çalışmada pazarlama profesör ünvanlı öğretim üyelerinin YÖKSİS sisteminde kayıtlı olan pazarlama bilim alanına ait anahtar kelimelerinden yola çıkarak nicel bir analiz olan bibliyometrik analiz yöntemi ile istatistiksel ve matematiksel çıkarımlar elde edilerek yorumlanmıştır. Dolayısıyla bu çalışma Sevgi (2016) tarafından gerçekleştirilen çalışmadan farklılık göstermektedir.

Bu çalışmanın organizasyon yapısı şu şekildedir: Materyal ve yöntem bölümü anlatılmaktadır. Daha sonra bulgular rapor edilmektedir. Çalışma sonuç ve tartışma bölümüyle sona ermektedir.

II. MATERYAL VE YÖNTEM

Bu çalışmanın amacı, pazarlama profesörlerinin YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında yer alan pazarlama bilimine ait anahtar kelimelerini incelemektir. Tablo 1'de YÖKSİS aktif alan bilgisi ekranında yer alan pazarlama bilim alanı anahtar kelimeleri verilmektedir. Bununla birlikte, bu anahtar kelimelerden en fazla 3 tanesinin pazarlama profesörleri tarafından tercih edilebileceği bilinmektedir.

Tablo 1. YÖKSİS ÜAK Temel Alan Aktif Alan Bilgisi Ekranında Yer Alan Pazarlama Bilim Alanı Anahtar Kelimeleri

Sıra	**Temel Alan**	**Bilim Alanı**	**Anahtar Kelime**
1	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Dijital Pazarlama
2	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Endüstriyel Pazarlama
3	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Girişimcilik ve Pazarlama
4	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Hizmet Pazarlaması
5	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Müşteri İlişkileri Yönetimi
6	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Pazarlama Araştırmaları
7	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Pazarlama Etiği
8	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Pazarlama İletişimi
9	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Reklam
10	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Satış Yönetimi
11	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Sayısal Analiz
12	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Sosyal Pazarlama ve Sürdürülebilirlik
13	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Tarımsal Pazarlama
14	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Tüketici Davranışları
15	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Uluslararası Pazarlama
16	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Ürün Tasarımı
17	Sosyal, Beşeri ve İdari Bilimler	Pazarlama	Ürün ve Marka Yönetimi

Yükseköğretim Kurulu (YÖK) Akademik Arama sitesi üzerinden akademisyen ve profesör ünvan filtrelemesi kullanılarak "pazarlama" anahtar kelimesiyle arama yapılarak 340 profesöre ulaşılmıştır. Arama sonucunda ulaşılan 340 profesör arasından, temel alanı "Sosyal, Beşeri ve İdari Bilimler" ve bilim alanı "Pazarlama" olan 260 pazarlama profesörünün tercih ettikleri pazarlama bilimine ait anahtar kelimeler değerlendirmeye alınmıştır. Her pazarlama profesörü için ayrı bir EndNote dosyası oluşturulmuştur. Pazarlama profesörünün tercih ettiği pazarlama bilimine ait anahtar kelime ya da kelimeler, o profesör için oluşturulan EndNote dosyasına yazılmıştır. Pazarlama profesörü herhangi bir anahtar kelime tercih etmemişse EndNote dosyasına herhangi bir anahtar kelime yazılmamıştır. Böylece 260 adet EndNote dosyası VOSviewer ile çalıştırılmıştır.

III. BULGULAR

Tablo 2'ye bakıldığında kadın profesör sayısı (n=131; %50,8) erkek profesörlerden (n=129; %49,6) daha fazladır. 195 pazarlama profesörü devlet üniversitesinde kadrolu olarak görev yaparken (%75,0), 65 pazarlama profesörü özel/vakıf üniversitesinde sözleşmeli olarak görev yapmaktadır (%25,0). En az bir pazarlama profesörünün görev yaptığı üniversite sayısının 106 olduğu saptanmıştır. 106 üniversitenin 42'sinde birer pazarlama profesörü görev yaparken, en fazla pazarlama profesörünün bulunduğu Marmara Üniversitesi'nde 13 pazarlama profesörü görev yapmaktadır (%5,0).

Tablo 2. Pazarlama Profesörlerinin Bilgisi

Cinsiyet	**f**	**%**	**Kadro Durumu**	**f**	**%**
Kadın	131	50,38	Kadrolu	195	75,0
Erkek	129	49,62	Sözleşmeli	65	25,0
Toplam	**260**	**100,0**	**Toplam**	**260**	**100,0**
Kadro Yeri	**f**	**%**	**Kadro Yeri**	**f**	**%**
Adana Alparslan Türkeş Bilim ve Teknoloji Üniversitesi	2	0,77	İstanbul Ticaret Üniversitesi	2	0,77
Afyon Kocatepe Üniversitesi	3	1,15	İstanbul Üniversitesi	7	2,69
Akdeniz Üniversitesi	4	1,54	İstanbul Yeni Yüzyıl Üniversitesi	1	0,38
Aksaray Üniversitesi	3	1,15	İzmir Demokrasi Üniversitesi	1	0,38
Anadolu Üniversitesi	7	2,69	İzmir Ekonomi Üniversitesi	5	1,92
Ankara Hacı Bayram Veli Üniversitesi	**9**	**3,46**	İzmir Kâtip Çelebi Üniversitesi	2	0,77
Ankara Üniversitesi	2	0,77	İzmir Tınaztepe Üniversitesi	1	0,38
Antalya Bilim Üniversitesi	1	0,38	İzmir Yüksek Teknoloji Enstitüsü	1	0,38
Atatürk Üniversitesi	1	0,38	Kadir Has Üniversitesi	2	0,77
Atılım Üniversitesi	1	0,38	Kafkas Üniversitesi	2	0,77
Aydın Adnan Menderes Üniversitesi	2	0,77	Kahramanmaraş Sütçü İmam Üniversitesi	2	0,77
Bahçeşehir Üniversitesi	4	1,54	Karabük Üniversitesi	3	1,15
Balıkesir Üniversitesi	1	0,38	Karadeniz Teknik Üniversitesi	3	1,15
Bandırma Onyedi Eylül Üniversitesi	3	1,15	Kastamonu Üniversitesi	1	0,38
Başkent Üniversitesi	4	1,54	Kıbrıs İlim Üniversitesi	2	0,77
Bilecik Şeyh Edebali Üniversitesi	3	1,15	Kırıkkale Üniversitesi	2	0,77
Boğaziçi Üniversitesi	3	1,15	Kırklareli Üniversitesi	2	0,77
Bolu Abant İzzet Baysal Üniversitesi	6	2,31	Kocaeli Üniversitesi	3	1,15
Bursa Uludağ Üniversitesi	4	1,54	Koç Üniversitesi	4	1,54
Bursa Teknik Üniversitesi	1	0,38	KTO Karatay Üniversitesi	1	0,38
Çağ Üniversitesi	1	0,38	Kütahya Dumlupınar Üniversitesi	3	1,15
Çankaya Üniversitesi	1	0,38	Manisa Celâl Bayar Üniversitesi	1	0,38
Çankırı Karatekin Üniversitesi	1	0,38	**Marmara Üniversitesi**	**13**	**5,0**
Çukurova Üniversitesi	6	2,31	Mersin Üniversitesi	3	1,15
Doğu Akdeniz Üniversitesi	2	0,77	Muğla Sıtkı Koçman Üniversitesi	2	0,77
Dokuz Eylül Üniversitesi	**11**	**4,23**	Necmettin Erbakan Üniversitesi	1	0,38
Düzce Üniversitesi	2	0,77	Nevşehir Hacı Bektaş Veli Üniversitesi	2	0,77
Ege Üniversitesi	5	1,92	Niğde Ömer Halisdemir Üniversitesi	4	1,54
Erciyes Üniversitesi	3	1,15	Ondokuz Mayıs Üniversitesi	1	0,38
Eskişehir Osmangazi Üniversitesi	2	0,77	Orta Doğu Teknik Üniversitesi	1	0,38
Eskişehir Teknik Üniversitesi	2	0,77	Osmaniye Korkut Ata Üniversitesi	1	0,38
Galatasaray Üniversitesi	1	0,38	OSTİM Teknik Üniversitesi	1	0,38
Gaziantep Üniversitesi	1	0,38	Özyeğin Üniversitesi	2	0,77
Gebze Teknik Üniversitesi	1	0,38	Pamukkale Üniversitesi	4	1,54
Gümüşhane Üniversitesi	3	1,15	Sabancı Üniversitesi	1	0,38
Hacettepe Üniversitesi	4	1,54	Sakarya Üniversitesi	6	2,31
Haliç Üniversitesi	1	0,38	Samsun Üniversitesi	1	0,38

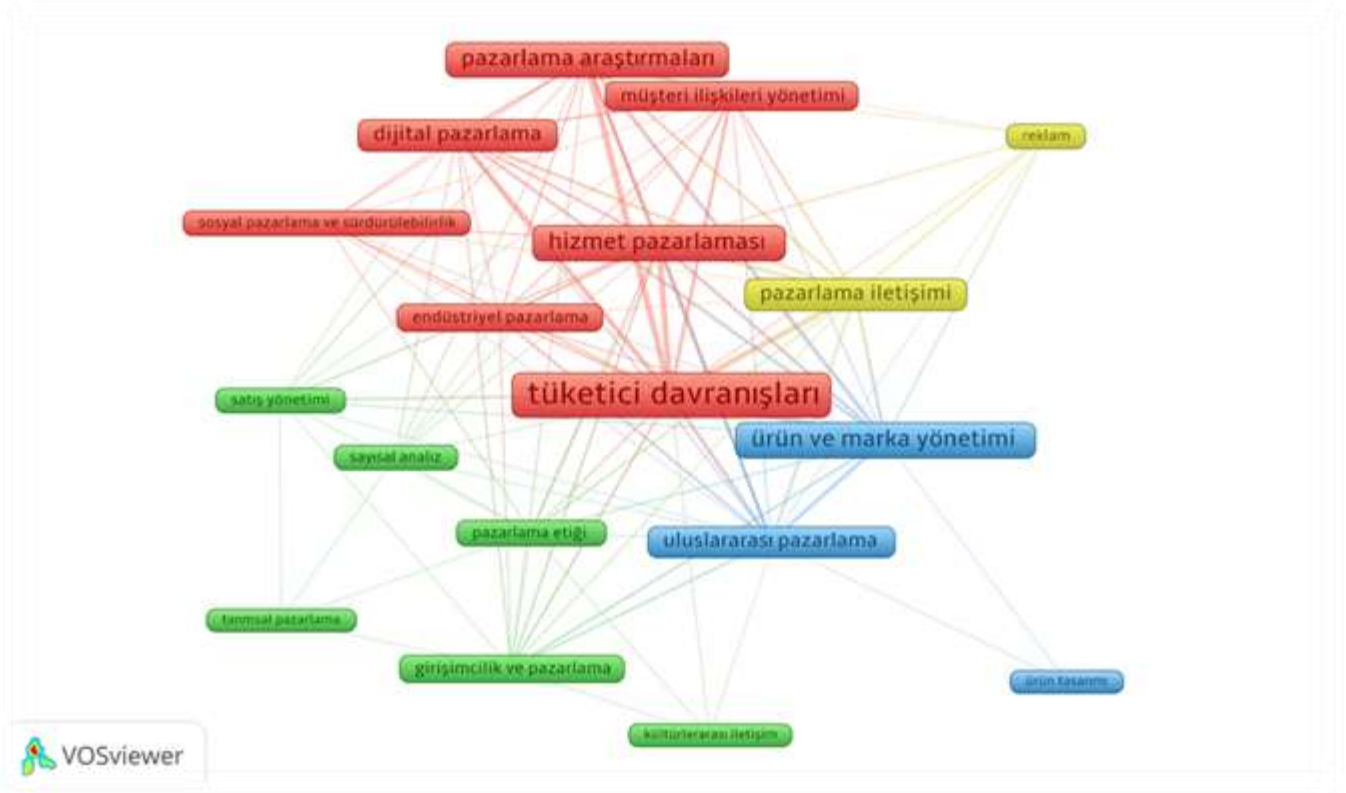
Harran Üniversitesi	2	0,77	Selçuk Üniversitesi	1	0,38
Hitit Üniversitesi	2	0,77	Sivas Cumhuriyet Üniversitesi	2	0,77
Isparta Uygulamalı Bilimler Üniversitesi	1	0,38	Süleyman Demirel Üniversitesi	2	0,77
İhsan Doğramacı Bilkent Üniversitesi	1	0,38	Tarsus Üniversitesi	1	0,38
İnönü Üniversitesi	1	0,38	Tekirdağ Namık Kemal Üniversitesi	2	0,77
İskenderun Teknik Üniversitesi	1	0,38	TOBB Ekonomi ve Teknoloji Üniversitesi	1	0,38
İstanbul Arel Üniversitesi	4	1,54	Trabzon Üniversitesi	1	0,38
İstanbul Aydın Üniversitesi	2	0,77	Trakya Üniversitesi	2	0,77
İstanbul Beykent Üniversitesi	5	1,92	Uluslararası Final Üniversitesi	1	0,38
İstanbul Bilgi Üniversitesi	2	0,77	Uluslararası Kıbrıs Üniversitesi	2	0,77
İstanbul Galata Üniversitesi	1	0,38	Van Yüzüncü Yıl Üniversitesi	1	0,38
İstanbul Gelişim Üniversitesi	2	0,77	Yalova Üniversitesi	1	0,38
İstanbul Medeniyet Üniversitesi	1	0,38	Yaşar Üniversitesi	3	1,15
İstanbul Medipol Üniversitesi	1	0,38	Yeditepe Üniversitesi	3	1,15
İstanbul Nişantaşı Üniversitesi	1	0,38	Yıldız Teknik Üniversitesi	1	0,38
İstanbul Teknik Üniversitesi	2	0,77	Zonguldak Bülent Ecevit Üniversitesi	2	0,77
Toplam				**260**	**100,0**

Öncellikle 260 pazarlama profesörü arasından 12 profesörün herhangi bir pazarlama anahtar kelimesini tercih etmediği görülürken, 2 profesörün YÖKSİS'teki pazarlama bilim alanına ait anahtar kelimelerini güncellemediği bu nedenle daha önce pazarlama anahtar kelimeleri içerisinde yer alan "Kültürlerarası iletişim" anahtar kelimesi de Tablo 3'te yer almaktadır. Dolayısıyla, Tablo 3'te toplam 18 anahtar kelime yer almaktadır. Sırasıyla, "tüketici davranışları" (157 kişi), "ürün ve marka yönetimi" (80 kişi) ve "hizmet pazarlaması" (77 kişi) anahtar kelimeleri pazarlama profesörleri tarafından en çok tercih edilen anahtar kelimelerdir. Bu üç anahtar kelimenin toplam bağlantı gücünün yüksek olduğu görülmektedir. "Tüketici davranışları" (toplam bağlantı gücü=279), "ürün ve marka yönetimi" (toplam bağlantı gücü=151) ve "hizmet pazarlaması" (toplam bağlantı gücü=141) anahtar kelimelerinin her biri, diğer anahtar kelimelerle karşılaştırıldığında daha yüksek toplam bağlantı gücüne sahiptir. Tablo 3'te anahtar kelimelerin birbirleri ile olan baskın bağlantı gücüne bağlı olarak farklı kümelerin meydana geldiği görülmektedir. Diğer bir ifade ile belirli anahtar kelimelerinin herhangi bir pazarlama profesörü tarafından eş zamanlı olarak tercih edilmesi ve böylece birbirleri ile yakın konumda olması onların aralarındaki ilişkiden kaynaklı olarak farklı kümelerin meydana gelmesine neden olmuştur.

Tablo 3. Pazarlama Profesörlerinin YÖKSİS ÜAK Temel Alan Aktif Alan Ekranında Yer Alan Anahtar Kelimeleri

Kümeler	**Anahtar Kelimeler**	**Pazarlama Profesörü Sayısı**	**Toplam Bağlantı Gücü**
Küme 1	Dijital pazarlama	51	93
	Endüstriyel Pazarlama	23	43
	Hizmet Pazarlaması	**77**	**141**
	Müşteri ilişkileri yönetimi	31	59
	Pazarlama araştırmaları	72	133
	Sosyal pazarlama ve sürdürülebilirlik	11	21
	Tüketici davranışları	**157**	**279**
Küme 2	Girişimcilik ve pazarlama	19	35
	Kültürlerarası iletişim	2	4
	Pazarlama etiği	13	24
	Satış Yönetimi	11	19
	Sayısal Analiz	7	11
	Tarımsal pazarlama	2	4
Küme 3	Uluslararası pazarlama	46	88
	Ürün tasarımı	1	2
	Ürün ve marka yönetimi	**80**	**151**
Küme 4	Pazarlama iletişimi	58	110
	Reklam	9	17

Dört farklı kümenin haritalaması Görsel 1'de görülmektedir. Ağ, kırmızı, mavi, yeşil ve sarı olmak üzere 4 farklı kümeden oluşmaktadır. Ağda aynı renkteki düğümler kümeleri, düğümlerin büyüklüğü de anahtar kelimelerin sıklığını göstermektedir. Bununla birlikte, düğümler arasındaki bağlantıların kalınlığı da birlikte kullanım sıklığını göstermektedir. Analiz sonucunda kırmızı kümede yer alan "tüketici davranışları" anahtar kelimesinin birlikte daha sık kullanıldığı anahtar kelimeler "hizmet pazarlaması" ve "pazarlama araştırmaları" anahtar kelimeleri olurken, yeşil kümede yer alan "girişimcilik ve pazarlama" anahtar kelimesi "pazarlama etiği" anahtar kelimesiyle daha sık kullanılmıştır. Mavi renkli kümede yer alan "ürün ve marka yönetimi" anahtar kelimesi de "uluslararası pazarlama" anahtar kelimesiyle daha sık kullanıldığı görülmektedir.



Görsel 1: Eş Anahtar Kelime Ağı

IV. SONUÇ VE TARTIŞMA

Bu çalışmada 106 üniversitede görev yapan 260 profesörün YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında yer alan pazarlama bilim alanına ait anahtar kelimeleri veri alarak, bibliyometrik analiz yöntemi ile yorumlanmaya çalışılmıştır. Devlet üniversitelerinde kadrolu olarak görev yapan pazarlama profesörü sayısı 195 iken, 65 pazarlama profesörü özel/vakıf üniversitesinde sözleşmeli olarak görev yapmaktadır. Profesör ünvanlı öğretim üyelerinin 131'i kadın 129'u erkektir. En fazla profesörün bulunduğu üniversite Marmara Üniversitesi (13 kişi) olurken, 42 üniversitede sadece 1'er pazarlama profesörünün görev yaptığı belirlenmiştir. YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında yer alan pazarlama bilimine ait 17 anahtar kelime içerisinden, en fazla tercih edilen "tüketici davranışları" (157 kişi) anahtar kelimesidir. "Ürün tasarımı" anahtar kelimesinin sadece 1 profesör tarafından tercih edildiği görülmüştür. 12 profesörün ise herhangi bir pazarlama anahtar kelimesini tercih etmediği diğer bir ifadeyle YÖKSİS'teki ÜAK temel alan aktif alan bilgisi sistemine bilgi girişi yapmadığı belirlenmiştir. Anahtar kelimeler arasındaki toplam bağlantı gücünün yüksek olduğu kelimeler "tüketici davranışları", (157 kişi), "ürün ve marka yönetimi" (80 kişi) ve "hizmet pazarlaması" (70 kişi) anahtar kelimeleridir. Çalışmada yapılan eş birliktelik ağı analizi sonucunda 4 kümenin oluştuğu görülmüştür. Bu durum pazarlama bilim alanına ait 17 anahtar kelimenin dört farklı anahtar kelime etrafında yoğunlaştığı şeklinde yorumlanabilir. Anahtar kelime gruplarını oluşturan "1. Küme" 7 anahtar kelimeyle en fazla kelimeyi barındıran küme olarak belirlenirken, "4. Küme" 2 anahtar kelimeyle en az anahtar kelimeye

sahip kümedir. “Tüketici davranışları” anahtar kelimesi toplam bağlantı gücünün (279) en yüksek olduğu anahtar kelime olarak belirlenirken, toplam bağlantı gücünün en düşük olduğu (2) anahtar kelime “ürün tasarımı” anahtar kelimesidir. Anahtar kelimelerin farklı kümeler oluşturması, pazarlama profesörlerinin YÖKSİS, ÜAK temel alan, aktif alan bilgisi ekranında yer alan anahtar kelimeler arasındaki bağlantı gücünün baskın olmasından kaynaklanmaktadır. Diğer bir ifadeyle 17 anahtar kelime arasında yer alan 3 anahtar kelime (tüketici davranışları, ürün ve marka yönetimi ve hizmet pazarlaması) profesörler tarafından en fazla tercih edilen ve diğer anahtar kelimelerle bağlantı gücü en yüksek olan anahtar kelimelerdir.

Sonuç olarak, ÜAK doçentlik atamasında belirleyici rolü olan ve bu çalışmaya konu olan anahtar kelimelerin gelişen ve değişen günümüz ekonomi dünyası ve pazar şartlarına göre güncellenmesi gerektiğini bu bağlamda, finansal yatırım araçlarının geliştiği ve çeşitlendiği günümüzde “finansal pazarlama” anahtar kelimesi, toplum üzerinde oldukça derin ve geniş bir etkiye sahip olan ve toplumun her alanını etkileyen siyasetin pazarlama bilim alanındaki karşılığı olarak “politik” veya “siyasal pazarlama” anahtar kelimesi, ulusal ve uluslararası rekabet gücünü arttıran ve sürdürülebilir kalkınmanın itici gücü olarak kabul edilen inovasyonun karşılığı olarak “pazarlama inovasyonu” anahtar kelimeleri pazarlama alanı anahtar kelimeleri arasına eklenebileceğini düşünmekteyiz.

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Production of Few-Layer Boron Sheets by Sonication-Assisted Liquid-Phase Exfoliation

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Abstract – Two-dimensional (2D) materials have started to attract a lot of attention in recent years because they have a wide variety of application areas. Among these materials, Graphene has attracted a lot of attention in the scientific world due to its flexible structure and excellent electrical and thermal conductivity properties. While no new material could be discovered to compete with graphene for a long time, a new and perfect material emerged with the synthesis of borophene in 2015. Borophene consists of boron atoms arranged in a hexagonal structure. Stronger, more flexible than graphene, it is a material with the potential to revolutionize electrochemistry, nanosensor and catalyst chemistry. Borophene could be synthesized as a single layer for the first time in 2015 by the molecular beam epitaxy (MBE) method. There are a few successful studies on the synthesis of borophene in the literature. When these studies were examined, single-layer borophene could be synthesized in studies using chemical vapor deposition (CVD) and MBE. New synthesis methods for borophene are under investigation. In this study, borophene will be synthesized using the Sonication-Assisted Liquid-Phase Exfoliation. The methods applied for borophene synthesis play a major role in determining the properties of the final product. In this study, water was used as the solvent and a bath type sonicator and probe type sonicator were used. The results were analyzed by SEM and XRD and it was revealed that several layers of borophene were obtained.

Keywords – Borophene, Sonochemical Exfoliation,

I. INTRODUCTION

Two-dimensional (2D) materials batteries, hydrogen storage, flexible electronics, supercapacitors, superconductors, electronic and optical circuits used in biomedical devices, biosensors, catalysts, temperature management systems, new generation wearable vehicles, quantum computers, nanocomposite materials, polymer and ceramic matrix composites They have started to attract a lot of attention in recent years because they have a wide variety of application areas such as drug delivery systems. Among 2D materials, borophene has attracted great attention in the scientific world in recent years due to its unique chemical structure, effective electronic conductivity and surface properties. The emergence of borophene, the two-dimensional boron allotrope and the lightest elemental Dirac material, has been remarkable due to the unique structural and electronic properties of the X3 and β12 phases [1]. With its unique properties and high potential for technological applications, borophene has become a promising material, but in order for it to be commercialized, there are few studies in the literature regarding its structural properties and production methods and more studies are needed.

A different method available in the literature for borophene synthesis is the sonochemical exfoliation method that has emerged in recent years [2-5]. In some studies in the literature, there are concerns that it

may be difficult to obtain borophene with these methods, since there is no van der Waals molecular attraction between boron layers. Two recent studies have shown that borophene can be obtained by sonochemical exfoliation [1-2]. However, an in-depth theoretical and experimental understanding of the exfoliation of borophene has not yet been established and it continues to be a question that needs to be explained in the scientific world.

In the study, borophene was synthesized by sonochemical exfoliation method. The methods applied for the synthesis of borophene play a major role in determining the properties of the final product. By choosing the appropriate solvent and optimizing the sonication time, the formation of the borophene layer has been tried to be achieved. Different sonication times were used with a bath sonicator (BluLab) and a probe sonicator (Sonics & Materials Inc., USA). Characterization of the final product obtained was made by SEM and XRD.

II. MATERIALS AND METHOD

99.5% purity boron was added separately at 1 mg/ml in DI water solvent [2]. The 1 mg/ml mixture was sonicated in an ultrasonic bath. Afterwards, sonication was applied at different times in a probe type sonicator. The prepared dispersion was centrifuged to precipitate, washed repeatedly and dried in a vacuum oven. Exfoliation depends on properties such as the polarity of the solvent and the H-bonding present. The products obtained as a result of the experiments were characterized by SEM and XRD.

III. RESULTS

The few-layer B sheets were exfoliated from bulk B using the sonication-assisted liquid-phase exfoliation technique, as illustrated in Figure 1. Water was used as solvent.

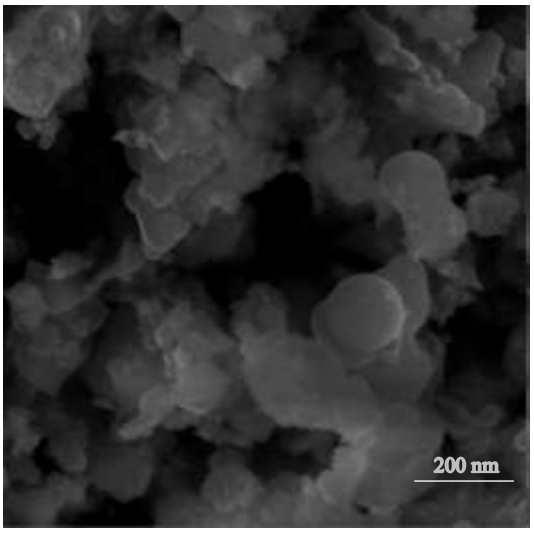

Figure 1. SEM images of the few-layer B sheets

XRD patterns of the exfoliation using water as exfoliating solvents, B sheets retain the crystallinity of the original bulk B in Figure 2 [2].

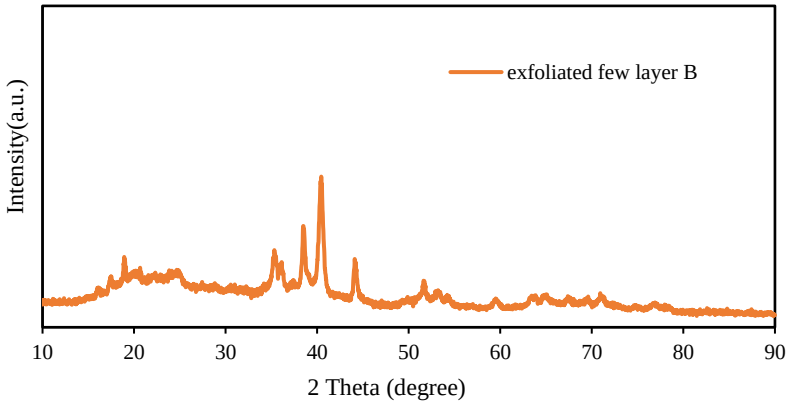

Figure 2. XRD patterns of the few-layer B sheets

IV. CONCLUSION

This study demonstrates that the synthesis of borophene using the sonication-assisted liquid-phase exfoliation method is possible. The methods used in the study were effective in determining the properties of the borophene sheets. The borophene sheets obtained using water were analyzed by SEM and XRD, showing that they retained the crystallinity of the original bulk B. Structurally, borophene possesses excellent properties and demonstrates superior performance in terms of electronic and thermal conductivity. Therefore, it is concluded that borophene has great potential for future applications in electronic devices, energy storage systems, and catalysis. Future studies should focus on optimizing this method and using different solvents to obtain higher quality borophene sheets. Additionally, issues related to scalability and cost-effectiveness in borophene production should also be addressed.

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Photovoltaic Energy Production Forecasting with Machine Learning

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Abstract – The release of carbon dioxide (CO_2) and the greenhouse gases, which is one of the main reasons for climate change that we feel more and more every day. Therefore, there is an increasing interest in renewable energy sources such as photovoltaic (PV) solar systems with the aim of combating the climate change and achieving cleaner air. The dependence of PV systems on weather conditions causes instability in PV power output, voltage fluctuations, and interruptions. This disadvantage of PV systems makes them difficult to be integrated into grids. Predicting output power of PV systems in advance will allow for the reduction of fossil fuel use, will provide efficient use of renewable energy sources, will lead to efficient operation of the electricity grid, as well as will ensure optimal management of production and storage, and consequently will help in reduction of electricity production costs. In this study, firstly, five different machine learning methods, Decision Tree (DT), Artificial Neural Networks (ANN), Gradient Boosting (GB), Random Forest (RF), and K Nearest Neighbors (KNN), which learn faster and perform with high accuracy, overcoming the disadvantages of overlearning and short term power prediction that are common in machine learning models in the literature, were subjected to training and testing with our own dataset. Subsequently, the method that best performs the estimation of the power generation (*P*) was selected. As a result, it was observed and concluded that the RF model performs better than the other four machine learning models.

Keywords – Machine Learning, Solar Power Plant, Prediction, Random Forest, Artificial Neural Networks

I. INTRODUCTION

The increasing World population, technological advancements, industrialization, adoption of comfortable lifestyles and the recent surge in the use of electric vehicles in transportation bring a continuous increase of the demand to electricity. As the World becomes increasingly globalized and developed, the demand for electricity is expected to rise further [1]. Various sources such as hydraulic power, coal, natural gas, nuclear energy, wind energy, solar energy, and the biomass are utilized for electricity generation. However, generating electricity through the consumption of fossil fuels has unfortunately several adverse environmental impacts. The release of carbon dioxide (CO_2) and greenhouse gases, one of the main contributors to climate change that we increasingly feel every day, is driving interest in renewable energy sources. According to the Global Energy Review, World renewable energy sources contributed 30% to electricity production in 2022, and this contribution is projected to reach nearly 50% by 2030 [2]. According to Türkiye's National Energy Plan the share of renewable energy sources in Türkiye's installed power

capacity, which was approximately 52% in 2020, is estimated to reach 64.7% by 2035 [3]. The primary driver behind the growth of renewable energy is the declining cost of wind and solar energy, which is especially resulted by the rapid technological developments in those sectors [4]. Increased interest in renewable energy sources is enabling the widespread adoption of solar power plants thanks to the decreasing manufacturing costs of solar panels. In addition to existing plants, more and more solar power plants are being built. While these solar power plants significantly contribute to renewable energy production, the widespread adoption of solar electricity generation brings challenges. As in the case of wind energy, the electricity generated from solar power is an intermittent renewable energy source. Solar electricity can only be produced intermittently at specific times and under suitable weather conditions. For instance, due to shadow problems of solar cells or in the cloudy days, unfortunately it may not be so possible to generate a high quality solar power. Since this intermittent energy can cause an imbalance between current electricity generation and demand, the amount of electricity generated by current power plants must be known in advance [5]. Accurate prediction of PV power output beforehand allows for efficient operation of the electricity grid, reduction of fossil fuel use, efficient utilization of renewable energy sources, optimal management of production and storage; and consequently a significant decrease of electricity generation costs will be obtained. Another advantage is that solar power plant investors can predict electricity generation a month in advance, allowing for the smooth trading of the generated power on the electricity market [6]. Due to the rising costs of materials, labor, and currency fluctuations, investors are interested in building solar power plants as well as they are also curious about the amortization periods. Accurate forecastings of the electricity generation enable easy determination of amortization periods for solar power plants that are being built. This also facilitates cost-benefit analysis for the solar power plant investor.

There are numerous studies in the literature regarding the output power prediction of PV facilities. Accordingly, some of the scientific studies on output power estimations of PV facilities are provided. Lurwan et al., presented a Matlab based Hottel model for predicting solar radiation. This model, using weather information, geographical location, and technical specifications of solar modules, provided as inputs, has achieved an accuracy rate of 97%, in the predictions [7]. In an another study, predictions of the electricity generation and consumption of İzmir Bakırçay University Solar Power Plant (İBÜGES) have been conducted. In this regards, artificial neural networks and regression analysis were used to estimate the electricity production. Nonlinear autoregressive (NAR) and nonlinear autoregressive with exogenous inputs (NARX) models were utilized in the prediction operations performed by the artificial neural networks (ANNs). Experiments were conducted using the Bayesian optimization algorithm and the Levenberg-Marquardt algorithm. The findings indicated that the most effective model was the NARX network, and the most successful training algorithm was the Bayesian optimization algorithm [8]. On the other hand, Theocharides et al. compared the performances of machine learning methods. The normalized root mean squared error (NRMSE) values of the artificial neural networks (ANNs), support vector regression (SVR), and the regression trees (RT) models were, respectively, 1.13% for both SVR and RT, while ANN has achieved the highest performance with an error value corresponding to 0.6%. A test center at the University of Cyprus was utilized for one-year to test the prediction performance of each model, creating a meteorological dataset [9]. In another study, the analysis results conducted with RETScreen software for PV power plants, assumed to be installed at 10 locations in Türkiye as input for machine learning models were used. By running the developed algorithms for these models, the PV power was predicted for 125 different locations. Among the total data, 30% of the experimental data was used to test the models obtained using machine learning methods, while 70% of the cumulative was used to train the models. The highest R^2 value during the training phase of the ANN models was 0.959, while the lowest error values for mean absolute error (MAE), mean squared error (MSE) were shown to correspond to 0.039 and 0.002 respectively. It was demonstrated that the best performance of the three models was obtained with the ANN model. Furthermore, the results have indicated that PV electric power can be predicted with high accuracy

using machine learning-based prediction algorithms [10]. Sarmas et al., recognizing that the challenge in predicting PV plant power output data lies in the lack of power data or gaps in the data in newly established PV plants, have successfully overcome this challenge using their proposed long short term memory (LTSM) model, as evidenced by the performance indicators root mean squared error (RMSE), mean absolute error (MAE), normalized root mean squared error (NRMSE), and R^2. The performance of three different transfer learning strategies was tested on training data obtained from six different PV plants in Portugal, over a period of 30 months. The lowest RMSE was determined as 1.46, MAE was concluded to correspond 0.69, and RMSE was conducted as 26.97, while the highest R^2 value was reported to correspond 96.76 [11]. Scott et al. used random forest (RF), neural networks (NN), support vector machines (SVM), and the linear regression (LR) type of machine learning methods for predicting energy obtained from PV systems. They have chosen some atmospheric parameters including the cloudiness (%), humidity (%), precipitation (mm), air pressure (mb), temperature (^oC), and wind speed (mph) as the input parameters for the algorithms. The RMSE value was reported to be the best for the RF algorithm with 32, followed by 32.3 for SVM, 36.5 for LR, and finally 38.9 for NN. The study concluded that the RF algorithm has been the best performing prediction method with the least amount of data [22]. Gaboitaolelwe et al. compared the performance of support vector regressor (SVR), support vector machine (SVM), random forest (RF), gradient boosting (GB), extreme gradient boosting (XGB) and multi-layer perceptron algorithms used in PV power prediction taking six different evaluation parameters into account. They have found that among the algorithms used, GBoost with default hyperparameters demonstrated the best performance with a skill score (SS) of 37.326%, while the RF model with optimized hyperparameters showed the best performance with a skill score (SS) of 37.33% [12].

II. Materials and Method

The PV panels generate renewable energy by converting sunlight into useful electricity. Unfortunately, not all solar energy can be converted into electricity by the solar cells. The solar cell efficiency represents the percentage of this energy that can be converted into electricity by the solar cell. While the theoretical maximum solar cell efficiency is 29%, the efficiency of solar cells on the market is relatively lower that reaches a maximum of 26% [13]. There are various factors that affect the performance and accuracy of solar PV power prediction. These factors include weather parameters such as solar irradiance, air temperature, humidity, and the wind; as well as physical condition parameters such as panel shading and panel cleanliness are important parameters that influence the performance and the accuracy of the estimations. The PV solar cells are made from semiconductor materials like silicon, making them sensitive to the temperature changes. An ideal temperature for maximum power output from PV panels is 25 ^oC [2]. When silicon solar cells overheat, power loss occurs due to the voltage drops, and accordingly the cell efficiency decreases. Above 25 ^oC, panel power output decreases by 0.25% for amorphous cells. Besides the range of the percentage decrease for panel output power corresponding to the interval of 0.4% - 0.5% for crystalline cells will occur for every degree increase in the temperature [14]. On the other hand, the efficiency decrease due to overheating can be overcome by cooling the panel. To cool the PV panel, techniques such as installing the panel in a way that allows cold wind to flow over it during the design process, using heat absorbers, or using water flushing techniques can be employed [15]. In this context, wind flowing over the PV panel reduces the panel's temperature, leading to higher voltage generation and positively impacting the power production. The humidity present in the air creates a layer of water vapor on the solar panel, which hinders the absorption of the solar energy and negatively impacts the PV panel's power generation [16].

A review of literature studies reveals the use of different machine learning models for predicting energy production in PV systems. The type of algorithm that is used can vary depending on the type of problem to be solved, the number of inputs, and the dataset. A lack of demonstration of model superiority and diversity

in prediction models was observed in these studies. Furthermore, a review of the studies indicates that shorter term power predictions are performed, meaning that the data used is based on the recent past. This study utilizes machine learning methods to predict solar power on a dataset using four different input parameters. The superiority of machine learning methods to each other is demonstrated using the root mean squared error (RMSE) value, a performance criterion. Beyond its contribution to the literature, this study could also guide existing and future PV power plant applications. This study evaluates the performance of models utilizing five different machine learning methods: decision tree (DT), artificial neural networks (ANN), gradient boosting (GB), random forest (RF) and K Nearest Neighbors (KNN). The dataset is divided into data clusters allocated 80% for training of the data and the rest of 20% for testing of the data. The model is trained with machine learning algorithms in the training dataset to create a model suitable for solar energy prediction. Machine learning libraries available in the Python programming language were used to create the model. In the test dataset, the model uses meteorological data to predict the amount of the electricity generation, and the prediction results are compared with respect to the real production values. This verifies the accuracy of the model's predictions. After performing machine learning with the training data, the test data is analyzed for prediction purposes. The statistical RMSE value, which indicates the average magnitude of the difference between actual values and their counterpart predicted values, is calculated to evaluate the model's performance. Data predictions were performed using the created models, and the obtained results are displayed graphically separately for each solar power plant. This comparison has shown that the effectiveness of RF outperforms the other four machine learning models.

A. K Nearest Neighbors

One of the commonly used machine learning methods for predicting energy produced from a PV panel is the KNN algorithm. It uses the influence of the K nearest neighbors, determined beforehand by the user, as positive integers surrounding the data for data categorization. Euclidean distance can be used as a distance metric to find the similarities between data points [17].

Table 1. K-nearest neighbors algorithm parameters

Parameters	**Value**
n_neighbors	5

B. Decision Tree

The decision tree algorithm is a machine learning method used to classify or predict data. The algorithm uses a tree-like structure to classify data. The algorithm constructs a tree until all data is classified [18]. When building a decision tree model, selecting the correct parameters will affect the model's accuracy and influence on the generalization ability.

Table 2. Decision tree algorithm parameters

Parameters	**Value**
random_state	42

C. *Random Forest*

The random forest model constructs random trees during the training phase, each taking different parts of the data. Since each tree considers a different portion of the data, it makes independent decisions [19]. Because the tree randomly determines which part of the data to focus on, it prevents overfitting and encourages the model's generalization. The random forest algorithm makes a prediction by averaging the predictions from each tree or using the majority voting [20]. In classification, the class with the most votes is chosen as the prediction. In regression, the average of all the trees' predictions is taken to make the prediction. As the random forest algorithm arrives at a conclusion based on the predictions of many decision trees, increasing the number of the trees in the forest, using large amounts of data increases the accuracy of the prediction [21].

Table 3. Random forest algorithm parameters

Parameters	**Value**
n_estimators	100
random_state	42

D. *Gradient Boosting*

Gradient boosting, XGBoost, LightGBM and CatBoost models are powerful machine learning techniques that utilize decision trees when predicting the PV power. Adding enough regression trees to the model during prediction can lead to more optimized results. Gradient boosting models generally yield very effective results in solving prediction problems by optimizing parameters [22]. The simplicity of the model setup and the prediction performance can make the gradient boosting algorithm surpass other algorithms.

Table 4. Gradient boosting algorithm parameters

Parameters	**Value**
n_estimators	100
learning_rate	0.1
random_state	42

E. *Artificial Neural Networks*

When creating an artificial neural network model, factors like the number of layers, the interconnection pattern of neurons, the summation and activation functions used by the model, the learning method, the learning rule, the selection of the algorithm, dataset construction, and the determination of training and test

datasets are crucial [23]. The success of the constructed model is directly related to the optimal determination of the model parameters. The design of the ANN model influences the algorithm's ability to provide the most accurate and stable prediction results and the response time of the algorithm. If the ANN model is designed in the most accurate way, the system complexity decreases, the model becomes stable, and eventually it provides accurate results.

Table 5. Artificial neural networks algorithm parameters

Parameters	**Value**
hidden_layer_sizes	(100, 50)
activation	'relu'
solver	'adam'
max_iter	500
random_state	42

The entire dataset related to the solar power plants was uploaded to Google Drive, a cloud-based storage service offered by Google, in Excel format. A connection to the dataset was established through Google's Colaboratory application. All analyses were performed using the Python programming language and the Colaboratory application. Meteorological parameters such as temperature, humidity, wind speed, and the global radiation were used as inputs, while the power output from the PV panel served as the required output. Five different machine learning methods were used for prediction and the comparisons of the implemented methods have been presented and reported. The machine learning algorithms were trained to predict the power output from the panel based on changes in environmental parameters, and then predictions were made. This section details the locations of the power plants used in the training dataset and the data used in the study.

F. Dataset

The production data used in this study was generated using real-time electricity production values from the Energy Markets Operation Inc. (EPIAŞ) Transparency Platform. Hourly electricity production data for the entire year where electricity generation occurred was obtained from the specified platform for each solar power plant. The annual production data downloaded in Excel format was merged to create a separate Excel file showing the total electricity generated by each power plant until 2024. The names, station numbers, latitude, longitude, and altitude information of the four solar power plants used in the study are presented in Table 6. Data was requested from district meteorological stations affiliated with the General Directorate of Meteorology of the Ministry of Environment, Urbanization, and Climate Change of the Republic of Türkiye for the meteorological data in the region where the solar power plants used in the study are located. The data obtained from the Meteorological Data Information Presentation Sales System (MEVBİS) of the General Directorate of Meteorology are global radiation (kWh/m²), relative humidity (%), wind speed (m/s) and temperature (°C). Since the hourly global radiation data obtained from the Meteorological Data Information Presentation Sales System (MEVBİS) of the General Directorate of Meteorology was in Excel format, while hourly relative humidity, wind speed, and temperature were in txt

format, the data format was first organized, and all data was converted to txt file format. It was observed that the data obtained from MEVBİS was incomplete due to factors such as sensor malfunctions and adverse physical parameters. There were hours in the dataset where electricity production information was missing; therefore, a final dataset was created by applying linear interpolation to fill these gaps.

Table 6. Solar power plants information

Solar Power Plants	Station Number	Station Name	Province	District	Altitude
Özgüçlü	18341	ADIYAMAN ÜNİVERSİTESİ	Adıyaman	Merkez	700
Solentegre	17201	ELAZIĞ BÖLGE	Elazığ	Merkez	989
İota	17199	MALATYA	Malatya	Yeşilyurt	950
RA Güneş Mardin	17275	MARDİN	Mardin	Artuklu	1040

G. Performance Evaluation Criteria

Evaluating the performance of machine learning models is crucial. Performance functions calculate the difference between the desired output values and the values produced by the network. The performance metrics including R^2, MSE, RMSE, and MAE are used to evaluate the model performance in the literature [24]. The RMSE measures the average magnitude of the difference between actual values and the predicted values while taking the square root of the average of the differences between actual and predicted values. When evaluating the performance of a model, different error metrics should be considered together, depending on the characteristics of the dataset and the model's objectives [25]. In this way decision on the superior model could be given more effectively. The mathematical model of the RMSE performance metric is described below.

$$RMSE = \sqrt{MSE}, MSE = \left(\frac{1}{n}\right).\sum\left(y - y_{pred}\right)^2 \quad (1)$$

In Eq. (1), the designation *n* indicates the number of the data points considered for the predictions; *y* is the actual values. These are the true values that the model is attempting to predict and y_{pred} is the predicted values. These are the predictions made by the model with using methods.

III. RESULTS

The results of the RMSE method that are used to evaluate the performance of the five different machine learning models considered in the current study, in which the study was conducted using electricity production values obtained from the Adıyaman Özgüçlü, Elazığ Solentegre, Malatya İota and RA Güneş Mardin solar power plants are presented in Table 7.

When interpreting on the RMSE value, a value closer to 0 indicates a higher accuracy of the model's prediction. In this case, in the current study, it is concluded that the random forest algorithm was the most accurate predictor across all solar power plants.

Table 7. Test set RMSE values of the different machine learning models.

	SOLAR POWER PLANTS			
MODELS	**Özgüçlü**	**Solentegre**	**İota**	**RA Güneş Mardin**
ANN	1.3296	1.3246	1.7108	1.5868
DT	1.2221	0.9932	1.3817	1.0922
GB	1.0264	0.7726	1.0728	0.9450
KNN	1.8910	1.0921	1.6859	1.4778
RF	0.8731	0.7046	0.9778	0.8182

Distribution graphs of the actual and predicted electricity production results for the Adıyaman Özgüçlü solar power plant, Elazığ Solentegre solar power plant, Malatya İota solar power plant, and RA Güneş Mardin solar power plant are presented individually. The actual and the predicted electricity production values for the Adıyaman Özgüçlü solar power plant are shown in Fig. 1, below. As it is clear from the figure that the RF and DT models have performed superior prediction performance when compared to other three models, that are all computationally tested on the real observed curve of the solar energy function. In this regards, the approach of the RF and DT type of models approach so close to the real function.

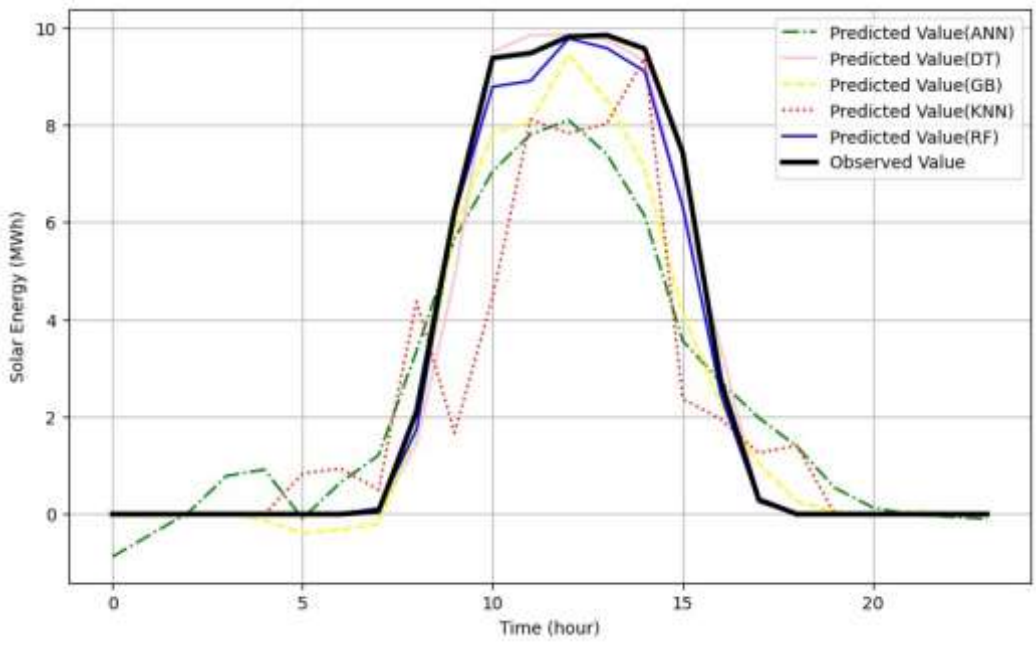

Fig. 1 Comparison of forecasted results for Özgüçlü solar power plant

The actual and predicted electricity production values for the Elazığ Solentegre solar power plant are shown in Fig. 2, below. Slightly different from the former station, the RF and GB models have turned with predictions having the highest accuracies.

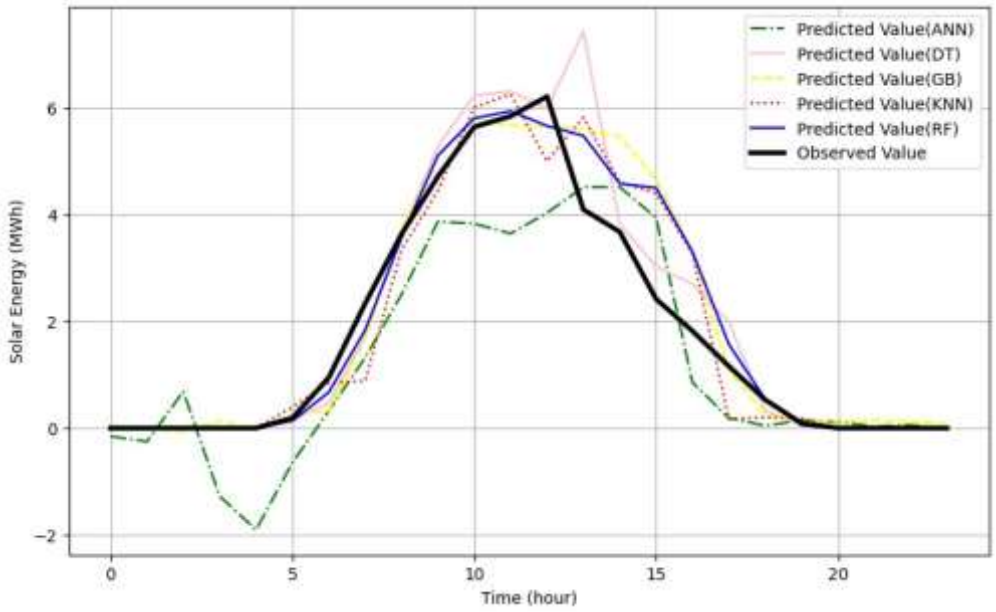

Fig. 2 Comparison of forecasted results for Solentegre solar power plant

Furthermore, the actual and forecasted electricity production values for the Malatya İota solar power plant are shown in Fig. 3. As similar to Elazığ Solentegre solar power plant, the RF and GB models have resulted estimations with the highest accuracy. Especially, almost a perfect fit to the real observed function was observed as soon as the anticipations were executed under the utilization of the RF function.

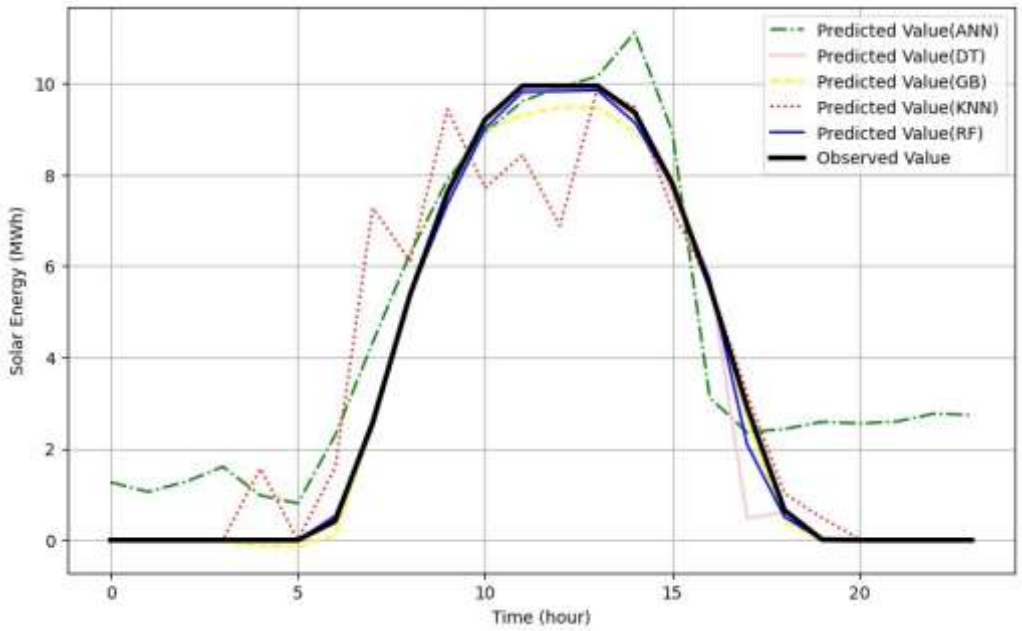

Fig. 3 Comparison of forecasted results for İota solar power plant

Eventually, the actual and the presumed electricity production values for the RA Güneş Mardin solar power plant are shown in Fig. 4, below. Again, the RF and GB models have generated the predictions with the highest accuracy and the most close matches.

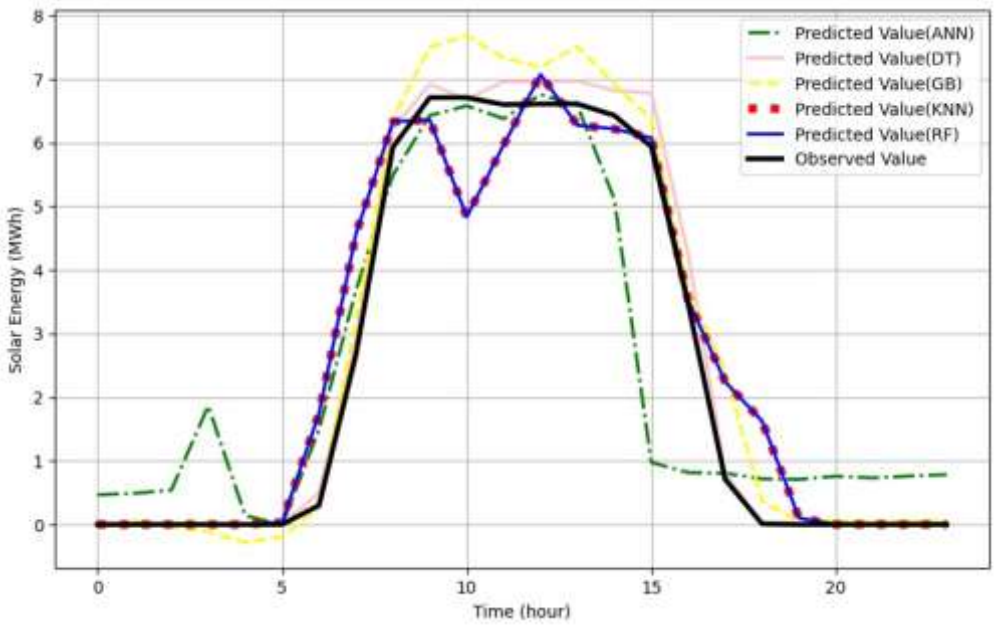

Fig. 4 Comparison of forecasted results for RA Güneş Mardin solar power plant

IV. DISCUSSION

This study evaluates the performance of models utilizing five different machine learning methods: decision tree (DT), artificial neural network (ANN), gradient boosting (GB), random forest (RF) and K Nearest Neighbours (KNN). The superiority of machine learning methods to each other is demonstrated using the root mean squared error (RMSE) value, a performance criterion. Beyond its contribution to the literature, this study could also guide existing and future PV power plant applications. Accurate prediction of PV power output beforehand allows for efficient operation of the electricity grid, reduction of fossil fuel use, efficient utilization of renewable energy sources, optimal management of production and storage; and consequently a significant decrease of electricity generation costs will be obtained.

V. CONCLUSION

In this study, the machine learning methods have been used in order to perform forecasts on the hourly solar energy output power. In this context, the input parameters were defined as solar irradiance, wind speed, temperature, and the humidity. Besides, decision trees, random forest, artificial neural networks, k-nearest neighbors, and the gradient boosting algorithms were employed for the predictions. The performance of the estimation models used for each solar power plant was evaluated. The distribution graphs of the actual and the predicted electricity production results were presented individually for Adıyaman Özgüçlü solar power plant, Elazığ Solentegre solar power plant, Malatya İota solar power plant, and RA Güneş Mardin solar power plant.

Numerous studies exist in the literature for predicting the output power of PV facilities. However, this study differs from previous studies by predicting electricity production values for four different solar power plants in the provinces of Adıyaman, Elazığ, Malatya, and Mardin, using five different machine learning methods. The actual energy generated by each power plant was compared to the predicted energy values using the graphical methods, i.e., the actual data distributions for every power plant have been represented with respect to the counterpart predictions, under the utilization of a variety of prediction models, shown on the same graph for every station. On the other hand, the RMSE criterion was used to interpret the success of the estimation results. Examination of the results reveals that the developed RF prediction model outperforms all the other prediction models, which are simultaneously considered. This study is open to the

improvement by expanding the input data type, for the prediction models employed. Additionally, the RF model, which made the most accurate predictions, can contribute to the efficient operation of the electricity grid, effective utilization of renewable energy sources, as well as optimal management of production and storage. And, consequently, a significant reduction in electricity generation costs would be obtained through accurate predictions performed by this model on the electricity production of PV power plants.

ACKNOWLEDGMENT

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Vibration Analysis of a Real-Time Bullet Casing Inspection System

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Abstract – In this study, a vibration analysis of a real-time bullet casing inspection station, which holds significant importance for the defense industry, was conducted. The primary objective of this analysis is to identify and implement the necessary conditions to prevent the cameras from taking blurry images. By doing so, the cameras will be able to capture clearer images, and the image processing system will operate more effectively. To verify whether the cameras, located in the model and at three different stations, can capture clear images, a Random Vibration Analysis was performed. The main reason for selecting Random Vibration Analysis is the irregular nature of the vibrations coming from the ground on which the chassis is mounted. These irregular vibrations originate from various machine systems (such as presses, coating machines, conveyor systems, filling benches, cutting benches, etc.) operating together in the same area, transmitting vibrations to the ground. These vibrations travel through the concrete floor, reaching the feet of the chassis and being transmitted to the chassis. Accelerometers were placed at the points where the feet of the machine contact the ground in the area where the machine is to be installed, and the force effects acting on the machine from the ground were measured and converted into g^2/Hz. The cameras used in the system are advanced cameras with an exposure time of 8-16 microseconds. Calculations were made considering the lower and upper limits of the cameras' exposure times, and blur control was checked with these calculations. As a result of the vibration analysis, it was observed that the system is safe in terms of mechanical strength, deformation, and blur, and that the inspection cabin can perform its function safely under the analysis conditions when the system is operated.

Keywords –Defense industry, Frequency analysis, Image processing, Inspection station, Random vibration

I. INTRODUCTION

Real-time bullet casing inspection systems hold strategic importance in today's defense and security sectors. Developed to enhance the reliability and usability of ammunition, these systems play a critical role in military and security operations. Compared to traditional inspection methods, real-time bullet casing inspection systems possess the capability to determine the condition of used ammunition quickly, accurately, and reliably. Through the use of high-resolution cameras, sensors, and data analytics algorithms, these systems can instantly detect deformations, damages, or other critical features of bullet casings. This capability accelerates the evaluation process of determining whether the ammunition is suitable for reloading, simultaneously reducing safety risks and operational costs. In modern military and security operations, real-time bullet casing inspection systems are crucial for reliability, efficiency, and effectiveness, and they are poised to become an even more integral part of defense technologies in the future [1-3].

In real-time bullet casing inspection systems, the cameras and optical systems that inspect the bullet casings typically follow a multi-step process. These systems are generally equipped with high-resolution cameras and sensors such as laser scanners. Among the technologies used in real-time bullet casing inspection systems, the mouth control camera is paramount. This camera scans the mouth of the bullet casing in detail and analyzes the images to detect any deformations, damage, or other significant features. Subsequently, the camera that checks the circularity of the rear part of the casing comes into play [4, 5]. This camera scans the rear of the casing 360 degrees and inspects the geometry of the casing to identify any deviations or deformations. Next, laser gauging technology is employed. This technology scans the interior of the casing and precisely measures the inner diameter, length, and other critical dimensions. Finally, cameras that capture a 360-degree view and inspect the perimeter of the casing are used. These cameras comprehensively scan the exterior surface of the bullet casings to detect any external damage or deformation. All these steps ensure the effectiveness and reliability of real-time bullet casing inspection systems. This process provides a comprehensive inspection of the bullet casings through combined image and data analysis. Ultimately, the data analytics algorithms present in these systems process the obtained data and evaluate the results. If a damaged casing is detected as a result of the evaluation, it is directed to the defective product box located at the end of the station [5-8].

In this study, a vibration analysis of a real-time bullet casing inspection station, which is of significant importance to the defense industry, was conducted. The primary objective of this analysis is to identify and implement the necessary conditions to prevent the cameras from capturing blurry images. By doing so, the cameras will be able to capture clearer images, and the image processing system will function more effectively. Prior to conducting the vibration analysis, research was carried out to determine the type of analysis to be performed. As a result of the research, it was determined that the suitability of random vibration analysis (random vibration) was appropriate, considering the simultaneous operation of multiple machines in the field. The PSD loads, which are required input data for the random analysis, were measured with an accelerometer from the surface where the inspection cabin's feet make contact and included in the analysis.

II. Materials and Method

The primary reason for selecting random vibration analysis is the irregular nature of the vibrations coming from the ground on which the chassis is mounted.

It is assumed that the properties of the selected material will be the same at every point, meaning the material properties do not vary with location.

The material is free of defects such as cracks or voids.

Welded and bolted connections have at least the same strength as the base material, and these connections do not separate from each other.

The mechanical properties of the material (yield strength, Poisson's ratio, modulus of elasticity, damping properties, isotropic properties, density, etc.) are data included in the program. These data are assumed to be accurate.

The CAD program solves the analysis with the most accurate convergence and assumptions under the given conditions, and these data are reliable.

The product was analyzed under room temperature conditions, and the operating environment will be at room temperature.

The values measured with the accelerometer were applied as PSD in the form of base excitation. The measured and converted PSD values are considered to be of acceptable accuracy and tolerance.

The product will operate safely as long as it is run within the boundary conditions under which the analysis was conducted. It is assumed that the actual working conditions are those provided by the company.

It is assumed that there are no other external forces acting on the product besides the PSD force values provided by the company.

A. Model Information

The main chassis of the model is constructed by welding 40x40x4mm profiles together. The material chosen for the profiles is S235 (St37). Figure 1 shows the 3D visualization of the inspection cabin modeled and assembled with NX. The model consists of three different stations with cameras that detect the front and rear circularity and peripheral defects. There is one camera each for checking the front and rear circularity, and eight cameras for inspecting peripheral defects. These cameras have been excluded from the model, and instead, remote masses have been applied in their places.

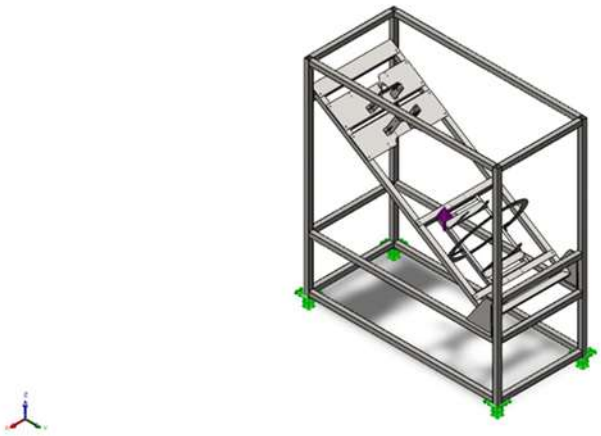


Fig. 1. The real-time inspection cabin modeled with NX

Similarly, side panels, upper, and middle panels were excluded from the model and replaced with point masses. The forces transmitted from the ground to the model were chosen to be applied to the fixed feet. Apart from remote loads/masses and PSD base excitation, it is assumed that there are no other external influences.

Table 1 shows the boundary conditions and study specifications applied for frequency analysis. As seen in the table, the analysis type was linear dynamic (random vibration), with a lower frequency limit of 5 Hz, an upper frequency limit of 345 Hz, fully correlated correlation type, and the analysis environment temperature set at room temperature (298 K). The analysis was conducted under these conditions.

Table 1. Boundary Conditions and Study Specifications Applied in the Analysis

Study Name	Dynamic
Analysis Type	Linear Dynamic Analysis
Mesh type	solid mesh
Number of Frequencies	40
Solver Type	FFEPlus
Incompatible Constraint Options	Automatic
Thermal Option	Add thermal loads
Zero Stress Temperature	298 Kelvin
Lower Frequency Limit	5 Hz
upper frequency limit	345 Hz
output frequency count	5
correlation	fully correlated

The inspection station to be subjected to analysis has been applied to a simplified model with simplified meshing processes to expedite and accurately analyze the thermal loads. Due to varying sizes (very large and very small) of elements in assembly and precise transitions between their faces, curvature-based meshing was selected. Figure 2 depicts the real-time inspection station with meshing applied.

Figure 2. Image of the model with applied meshing

The largest mesh size was automatically assigned by the program as 25 mm, while the smallest mesh size was set to 1.25 mm. When evaluating mesh quality, it was observed that the mesh achieved high quality.

B. Boundary Conditions

The operating temperature of the inspection booth is assumed to be room temperature, and the model is anchored to the ground through its four legs. To expedite and improve the accuracy of the vibration analysis of the inspection booth, the model has been simplified, and the masses of excluded components have been applied as remote loads/masses. The simplification of the model has significantly reduced the number of nodes and elements, thereby reducing the computational load and shortening the analysis time. Figure 3 shows the remote loads/masses applied to the excluded components from the model. By applying remote loads/masses, the effects of the excluded components have been incorporated into the analysis, leading to more accurate results.

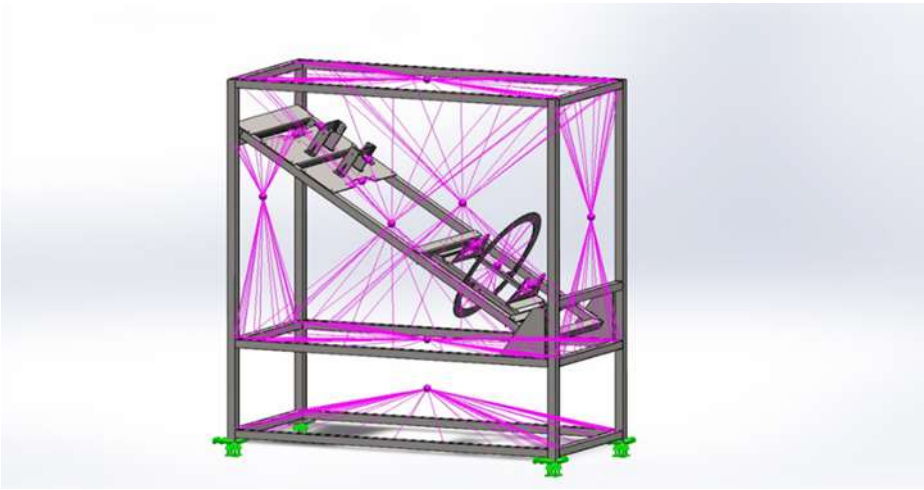


Fig 3. Representation of all included remote loads / masses in the analysis

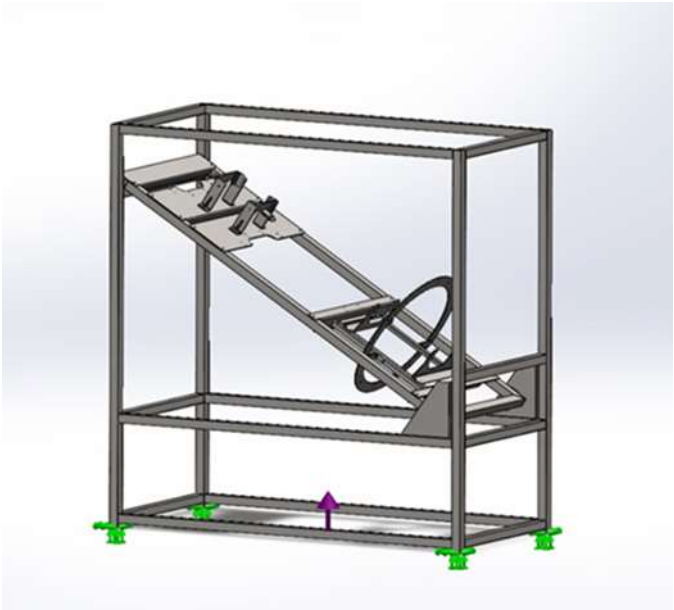


Figure 4. Single-base excitation (PSD load application points: fixed geometry points)

The interaction between assembled components has been selected as inseparable (welded) for all components. Due to the presence of threaded and bolted connections in the system, with the only external force being the PSD load, and absence of dynamic and variable loads, the inseparable (welded) option was chosen.

The effect of machines and systems in the area where the inspection booth operates has been applied as PSD load, upward from the four legs of the booth. Figure 4 illustrates the vibration load (PSD single-base excitation) transmitted to the inspection booth from the ground.

C. Cameras Technical İnformation

İt is needed to know how vibration affects image quality when a camera operates on a vibrating surface, considering factors like vibration frequency and amplitude, camera resolution, lens characteristics, and exposure time. Here's a summary of the key points and calculations provided:To assess the impact of vibration on image quality:

Vibration Frequency and Amplitude: Higher vibration frequencies and amplitudes, especially if they exceed the pixel size of the camera sensor, can cause blurring. Rapid changes in vibration speed over or near the exposure time can also contribute to motion blur.

Exposure Time: Long exposure times (covering multiple periods of vibration) amplify motion blur due to vibration. Short exposure times (covering only a fraction of the vibration period) reduce motion blur.

Motion Blur Calculation: Motion blur length (blur length) is calculated as:

Blur length=Speed × Exposure Time

Where "speed" represents the movement speed of the vibrating surface, and can be expressed as:

Speed = Amplitude×2π×Frequency

Pixel Conversion: Given measurements, such as a diameter of 7.62 calibre mouth being 160 pixels, equating to approximately 7.92 mm. This translates to a pixel length of approximately 0.05 mm per pixel.

Impact Threshold: It is inferred that displacements below 0.05 mm will not noticeably affect the image due to the pixel size.

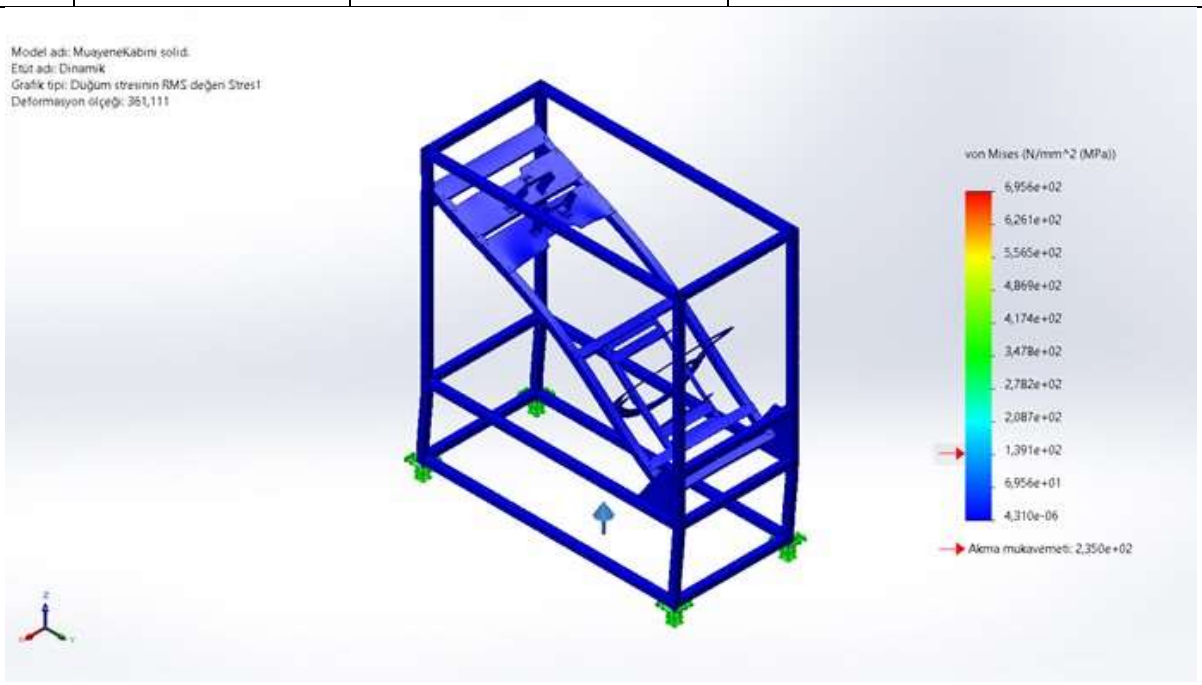
Exposure Time Range: The exposure time is observed to range between 8 microseconds to 16.777 microseconds.

Based on these calculations, assuming a hypothetical amplitude value, it is concluded that if the vibration amplitude is below 0.025 mm, no noticeable blurring will occur at any frequency value.This analysis helps in understanding how vibrations affect image quality and provides guidelines on exposure time and vibration conditions to minimize motion blur in camera images.

III. RESULTS AND DISCUSSION

Table 3. Von Mises Stress Values

Ad	Tip	Min	Maks.
Stres1	VON: von Mises Stress	4,310e-06N/mm^2 (MPa) Node: 707537	1,39e+02N/mm^2 (MPa) Node: 105478

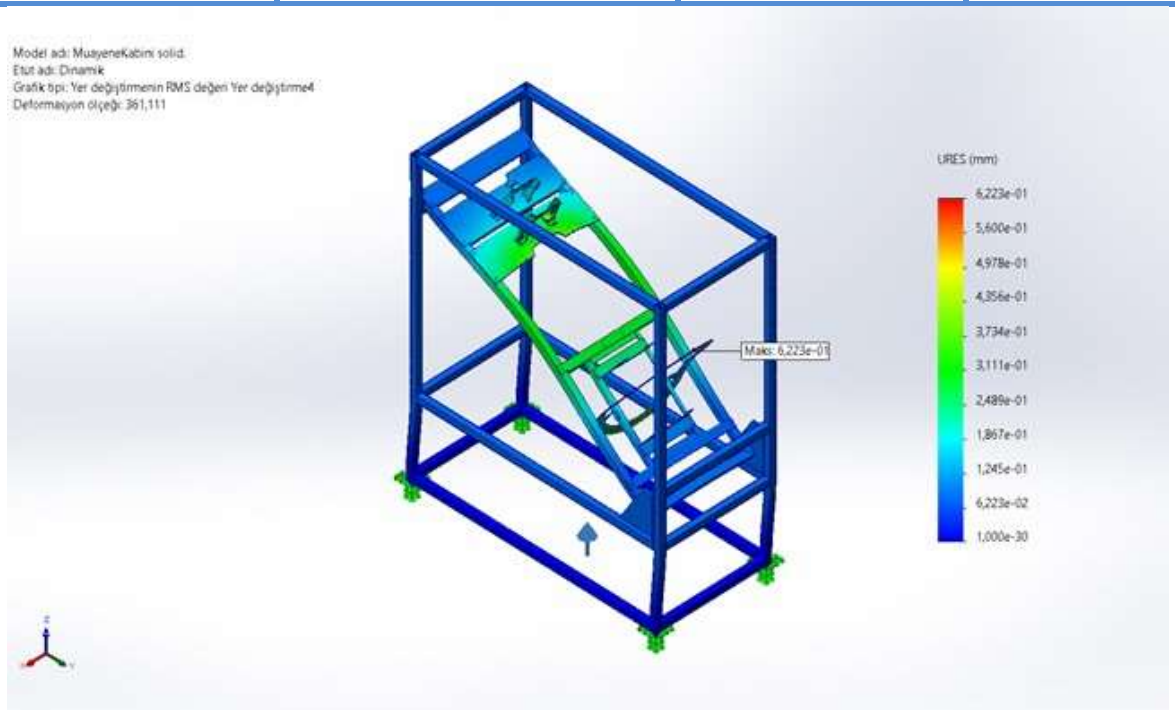


Inspection Booth Solid Dynamic-Stress-Stress1

Table 3 shows the Von Mises stress values in detail. Upon examining the Von Mises stress values and the color scale, it is observed that the maximum stress value occurring in the structure is 1.39 x 10^2 MPa. Given that the yield strength of St37 material is 235 MPa, it has been calculated that the system designed under these conditions is approximately 1.6 times safer.

Table 4. URES displacement values

Ad	Tip	Min	Maks.
Final Displacement	URES: Final Displacement	0,000e+00mm Node: 34746	6,223e-01mm Node: 764599



The maximum deformation value occurring in the system occurs in the hollow cylindrical part to which the cameras are attached. The calculated deformation amount measures a maximum of 0.622 mm. The exposure time of the camera used in the system ranges from 8 to 16 microseconds. In the system, the minimum frequency value measured is 31.871 Hz and the maximum period value is calculated as 0.031377 seconds. The maximum frequency value is 344.61 Hz and the minimum period value is 0.0029018 seconds. The maximum period of the occurring deformation is 31.377 milliseconds. The exposure time of the camera is a maximum of 0.016 milliseconds. If the exposure time of the camera were 31.377 milliseconds, the displacement amount reflected to the camera would be 0.622 mm, potentially causing blurry images. However, since the duration of the deformation is much shorter than the camera's exposure time, the displacement amount reflected to the camera is approximately 3.17 x 10^-4 mm. When these calculated values are evaluated together, it is evident that the camera does not capture blurry images.

In frequency analysis and frequency-based dynamic analyses, it is desired that the mass participation ratios exceed 80%. Table 5 presents the mass participation ratios based on mode numbers. The Z-axis is defined as perpendicular to the horizontal plane on which the chassis is mounted. The axes inclined to deformation are considered as the Y and X axes, with the table indicating mass participation ratios of 91% in these axes. The calculated deformations are therefore concluded to be highly accurate, as the mass participation ratios in the Y and X axes, which are prone to deformation, significantly exceed the 80% threshold.

Table 5. Mass Participation Ratios

Number of modes	Frequency (Hertz)	X direction	Y direction	Z direction
1	31,871	0,91386	0,00048911	4,7497e-06
2	32,22	0,00050771	0,88056	0,0081945
3	48,449	0,00012305	0,00096193	0,0013799
4	48,816	7,7535e-06	0,017307	0,025501
5	54,918	2,1997e-08	0,018613	0,22128
6	62,429	3,3217e-06	1,6754e-06	9,2177e-05
7	93,901	2,1417e-09	9,4872e-06	0,0002903
8	100,94	2,0317e-09	0,00029266	0,0092248
9	111,67	0,0024264	2,7285e-09	2,3724e-08
10	119,75	1,4307e-08	1,1006e-05	0,0016486
37	317,33	8,9447e-12	2,614e-06	0,065384
38	331,28	0,00034324	6,3704e-08	8,216e-05
39	336,88	3,107e-06	4,3791e-06	0,003373
40	344,61	2,6482e-05	5,0522e-08	8,5907e-05
		Toplam X = 0,91839	Toplam Y = 0,91834	Toplam Z = 0,72671

IV. CONCLUSION

A. Mechanical Strength

Upon examining the Von Mises stress values and the color scale, the maximum stress value occurring in the structure is found to be 1.39 x 10^2 MPa. Given that the yield strength of St37 material is 235 MPa, it has been calculated that the system designed under these conditions is approximately 1.6 times safer. There is no stress in the system that poses a risk.

- ✓ The system is safe in terms of strength.

B. Mass Participation Ratios

In frequency analysis and frequency-based dynamic analyses, mass participation ratios exceeding 80% are desired. The Z-axis is defined as perpendicular to the horizontal plane on which the chassis is mounted. The axes inclined to deformation are evaluated as the Y and X axes, with the table indicating mass participation ratios of 91% in these axes. Since the mass participation ratios in the Y and X axes, which are prone to deformation, significantly exceed the 80% threshold, it is concluded that the calculated deformation values are highly accurate.

- ✓ Mass participation ratios are within a safe range.

C. Impact of Vibration on Camera Image Quality

The maximum deformation value occurring in the system occurs in the hollow cylindrical part to which the cameras are attached. The calculated deformation amount measures a maximum of 0.622 mm. The exposure time of the camera used in the system ranges from 8 to 16 microseconds. In the system, the minimum frequency value measured is 31.871 Hz and the maximum period value is calculated as 0.031377 seconds. The maximum frequency value is 344.61 Hz and the minimum period value is 0.0029018 seconds. The maximum period of the occurring deformation is 31.377 milliseconds. The exposure time of the camera is a maximum of 0.016 milliseconds. If the exposure time of the camera were 31.377 milliseconds, the displacement amount reflected to the camera would be 0.622 mm, potentially causing blurry images. However, since the duration of the deformation is much shorter than the camera's exposure time, the displacement amount reflected to the camera is approximately 3.17 x 10^-4 mm. When these calculated values, along with the pixel length calculated for the camera (0.05 mm), are considered together:

- ✓ It is observed that the camera does not capture blurry images.

D. Final Evaluation

- ✓ Based on the dynamic analysis conducted, it is observed that the system is safe both in terms of strength and camera image quality. Under the boundary conditions entered in the analysis, it is concluded that the system will operate safely and fulfill its function.section.

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We would like to express our gratitude to Yeter Makina, a company specializing in custom machine and system design and manufacturing, for the opportunities and contributions they provide.

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Investigation of the Effect of Surfactants on Crude Oil Rheology

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Abstract – Crude oil plays a critical role for many countries in meeting energy needs such as industry, electricity generation and transportation. Transporting and processing such crude oil using traditional methods can be a challenging process. Heavy and extra-heavy crude oil obtained from many oil fields around the world causes transportability problems. In pipeline transportation, different techniques are used to reduce the viscosity of crude oil. These techniques include reducing the viscosity of crude oil by diluting it with lighter feedstocks, reducing viscosity by adding alcohols, and using surfactants and nanoparticles. These methods allow crude oil to be transported more effectively. However, new problems can arise when crude oil needs to be transported to cold regions, remote areas or underwater. As a result, the fact that crude oil is a critical resource for world economies increases the importance of technical developments and research in this field.

This study proposal aims to provide potential solutions on the transportability and processability of crude oil. Adding surfactants to crude oil and modifying them is a strategy used to improve the flow properties of crude oil. This research, which aims to facilitate the transport and processing of heavy crude oil through extended experiments examining the effects of surfactant SDS (Sodium dodecyl sulfate), aims to make a significant contribution to the energy sector.

Keywords – Rheology, crude oil, nanoparticle.

I. INTRODUCTION

Crude oil, which is formed by the decay of liquid hydrocarbons underground under pressure for millions of years, plays an important role in the world in energy consumption such as industry, electricity production and transportation [1]. Once oil is generally extracted from wells, it undergoes a series of logistical steps to be transported to refineries, storage facilities, and finally to consumers. As one of the cornerstones of modern industry, oil meets a large portion of global energy demand. However, this strategic resource can have varying viscosity characteristics, and particularly viscous oil can exhibit non-Newtonian flow behavior during transportation through pipelines, causing significant difficulties in the oil and gas industry. Viscous oil is crude oil that has a high viscosity structure due to the dense and complex hydrocarbon components it contains This high viscosity is a characteristic of oil and determines its fluidity. Considering that viscosity is a measure that defines the internal resistance of the liquid, this property plays an important role during the transportability and processing of viscous oil [2]. Rheology is a branch of science that studies the flow behavior of liquids. In this context, viscous fluids are generally divided into two main categories: Newtonian and non-Newtonian fluids. Newtonian fluids are fluids in which the shear stress of the fluid is directly proportional and the viscosity does not depend on the shear rate [3]. This means that they obey

Newton's law of viscosity. On the other hand, non-Newtonian fluids do not obey Newton's law of viscosity and the viscosity may vary depending on the shear rate. Non-Newtonian fluids generally exhibit various types of nonlinear behavior, such as pseudoplastic, dilatant, plastic and bingham. Pseudoplastic fluids exhibit a behavior in which viscosity decreases as shear rate increases, while dilatant fluids exhibit a behavior in which viscosity increases as shear rate increases. This refers to shear thinning or shear thickening of the fluid. Heavy and high viscosity crude oil, whose demand is increasing worldwide, causes portability problems due to this non-Newtonian flow behavior. In pipeline transportation, different techniques are used to reduce the viscosity of crude oil. These techniques include reducing the viscosity of crude oil by diluting it with lighter feedstocks, reducing viscosity by adding alcohols, using surfactants and nanoparticles. However, under special conditions, such as transportation to cold, remote or submerged areas, new challenges may arise. This may affect the economic demand and consumption of crude oil worldwide, increasing the importance of technical developments and research in this field. More efficient transportation and processing of crude oil could be a critical step to increase efficiency in the energy sector and meet global energy demand.

II. MATERIALS AND METHOD

Crude oil, which is the starting material, will be supplied from the "Midland Oil" company affiliated with the Iraqi Ministry of National Petroleum. Surfactants SDS added to crude oil and viscous behavior investigated. All rheological measurements will be carried out at temperatures of 25^{o}C, using a stress-controlled rheometer (Malvern Kinexus Pro, United Kingdom) equipped with a cone-plate system. The angle and diameter of the cone to be used will be 10^{0} and 60mm respectively. The distance between the cone and the plate will be kept constant at 0.05mm. Temperature control during measurements will be provided through a Peltier plate with ±0.1 accuracy. Thus, their effects on rheological behavior were examined.

III. DISCUSSION

Shear rate and shear viscosity for Crude oil and Crude oil-SDS is presented for the temperature of 25 °C, shown in Fig. 1. A clear Newtonian behavior of pure crude oil for the studied temperature. For crude oil-SDS, a decrease in viscosity is observed as the shear rate increases. This behavior appears to be non-Newtonian at the temperature studied. It is also seen that viscosity decreases with the surfactant effect.

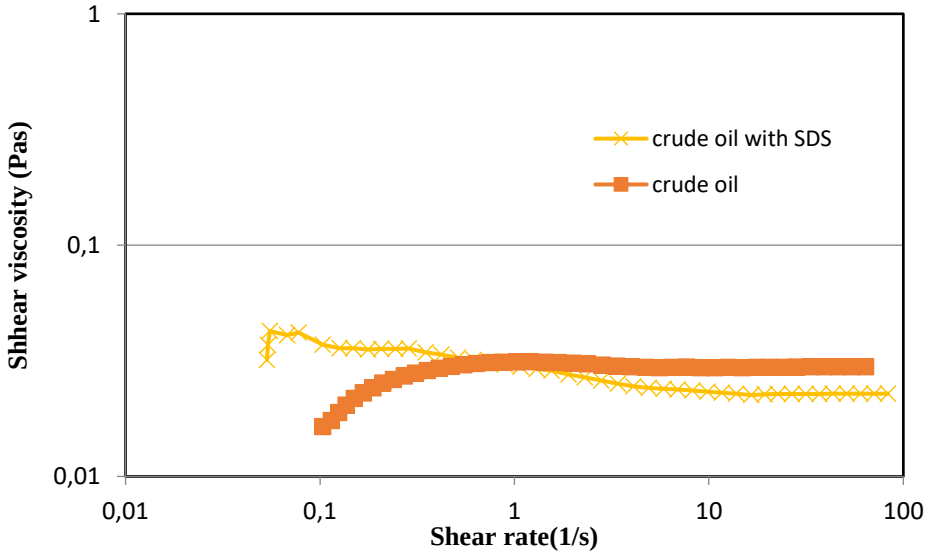

Figure 1. Shear viscosity and shear rate variation of Crude oil and Crude oil-SDS at 25 ^{0}C

IV. CONCLUSION

Through this experiment and the figure shown, we conclude that in heavy crude oil, viscosity have an inverse relationship. Adding the surfactant reduces the viscosity, thus facilitating the process of transporting heavy crude oil and facilitating the process of filtering the product in oil refineries.

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Micromixing of two liquids using a micromixer with inclined baffles

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Abstract **–** Different microfluidic devices or lab-on-chips have been employed to analyze biological processes and chemical reactions, such as medical diagnosis, food processing, environmental aspects, etc. This paper examines the influence of inclined baffles embedded in square mixing chambers on the mixing index and pressure drop. Numerical simulations are performed for incompressible and Newtonian fluids by using COMSOL Multiphysics software. Four geometries are introduced based on the variations of the baffle angle. The results demonstrate that the baffle angle does not affect the MI and Δp significantly. For instance, MI changes from 27.66 to 24.60 when the baffle angle is increased from 30º to 90º. In other words, for a creeping flow regime, the impact of the baffle angle on MI and Δp is negligible. It is expected that this effect is augmented by enhancing the inlet flow rate.

Keywords – Microfluidics, Passive micromixer, Baffle, Mixing index

I. INTRODUCTION

Micromixers are categorized into two groups, i.e., passive and active, based on the mixing mechanism. Passive micromixers do not use external energy; however, active ones utilize external forces [1]. Numerous investigators have performed many researches on passive micromixers [2-5]. For instance, Hong et al. [6] proposed a passive micromixer that worked based on the Coanda effect. Bhagat et al. [7] introduced a planar micromixer that could work efficiently at low values of Reynolds number (Re).

Wu and Chen [8] presented a rectangular fractal micromixer by considering the influences of the number of obstacles, their height and spacing, and inlet flow rate on mixing quality and pressure drop. They compared two fractal heights of 150 and 200 μm and found that the mixing index is improved by 20% when 200-μm fractals are used. It was reported that the location of the obstacles affects the mixing quality. Also, their spacing has a considerable impact on the mixing process.

Wu et al. [9] introduced a passive micromixer with cylindrical obstacles and saw tooth notches. They compared their numerical results with experimental data and reported good agreement between the results. They experimentally observed that the desired mixing quality can be achieved after 0.08 s when the inlet velocity is 0.499 m/s. It was demonstrated that mixing quality is a strong function of the inlet flow rate. For the Stokes flow regime, they reported that the mixing index is enhanced with inlet velocity.

The present paper employs square mixing chambers in which inclined baffles are mounted to improve the mixing quality of two liquids. Depending on the inclination angle of baffles, several geometries are proposed (Fig. 1). The inlet velocity is 1 m/s. Liquids are water with a density of 977 kg/m^3 and a dynamic viscosity of 10^{-3} Pa.s. Practically, two syringe pumps are required to inject the liquids into the inlets. It should be pointed out that two liquids have different initial concentrations of 1 and 0.

II. GOVERNING EQUATIONS

The steady governing equations, including continuity and Navier-Stokes equations, for incompressible and Newtonian fluids are:

$$\nabla \cdot \vec{V} = 0 \tag{1}$$

$$\rho\left(\vec{V} \cdot \nabla\vec{V}\right) = -\nabla P + \mu\nabla^2\vec{V} \tag{2}$$

where $\vec{V}$, ρ, μ, and P represent velocity, density, dynamic viscosity, and pressure, respectively.

The convection-diffusion transport equation is:

$$\frac{\partial C}{\partial t} + \vec{V} \cdot \nabla C = D\nabla^2 C \tag{3}$$

where C and D are the concentration and molecular diffusivity, respectively. Besides, the mixing index (MI) is calculated as:

$$MI = \left(1 - \left(\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{c_i - \bar{c}}{\bar{c}}\right)^2}\right)\right) \times 100 \tag{4}$$

where c_i is the local concentration and $\bar{c}$ is the average amount of c_i. N is the total number of grid points in a desired cross-section.

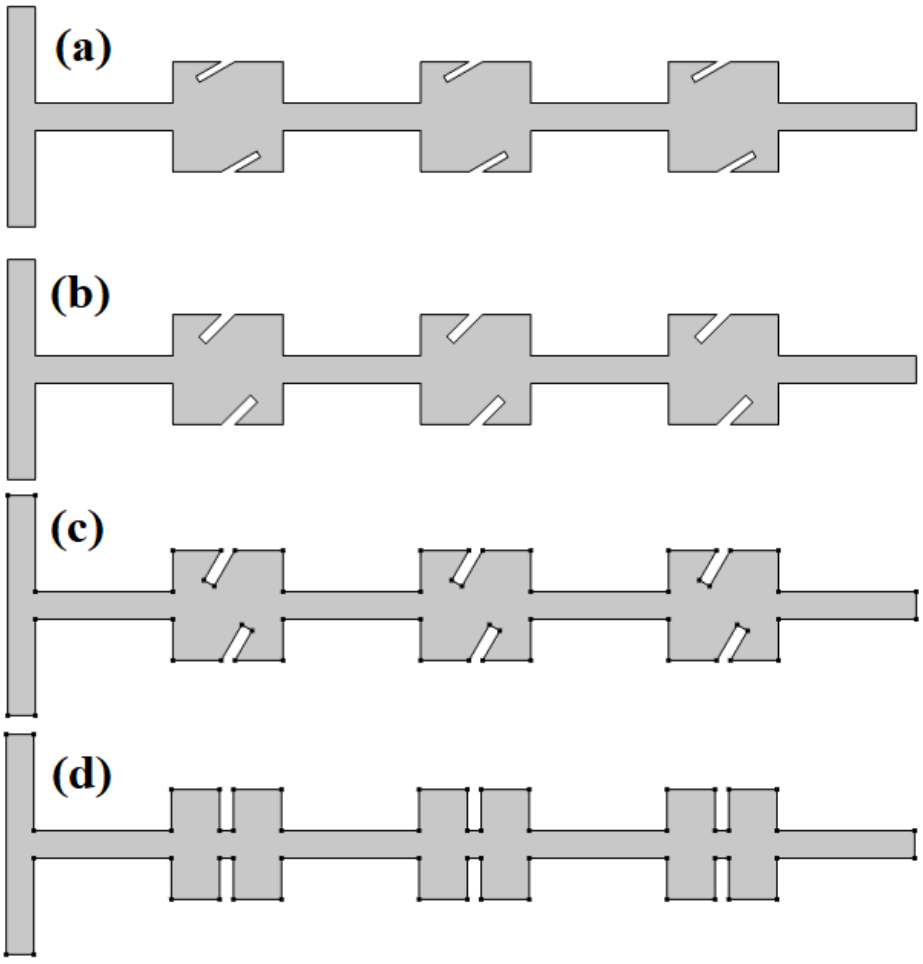

Fig. 1 Schematic of the present micromixer: (a) θ = 30º, (b) θ = 45º, (c) θ = 60º, and (d) θ = 90º.

III. RESULTS

In this section, the micromixing process of two liquids in a micromixer with inclined baffles is assessed. Fig. 1 demonstrates the concentration contours along the micromixers with (a) $\theta = 30^{o}$, (b) $\theta = 45^{o}$, (c) $\theta = 60^{o}$, and (d) $\theta = 90^{o}$. Since the mixing quality is not different significantly, it is needed to calculate the amount of MI using Eq. 4. Also, because the value of pressure drop is important in designing passive micromixers, it is estimated by differencing the value of pressure at the inlet and outlet. Table 1 gives the values of MI and Δp. It is observed that the baffle angle does not affect the MI and Δp. For instance, MI changes from 27.66 to 24.60 when the baffle angle is increased from 30^{o} to 90^{o}. In other words, for a creeping flow regime, the impact of baffle angle on MI and Δp is negligible. It is expected that this effect is augmented by enhancing the inlet flow rate.

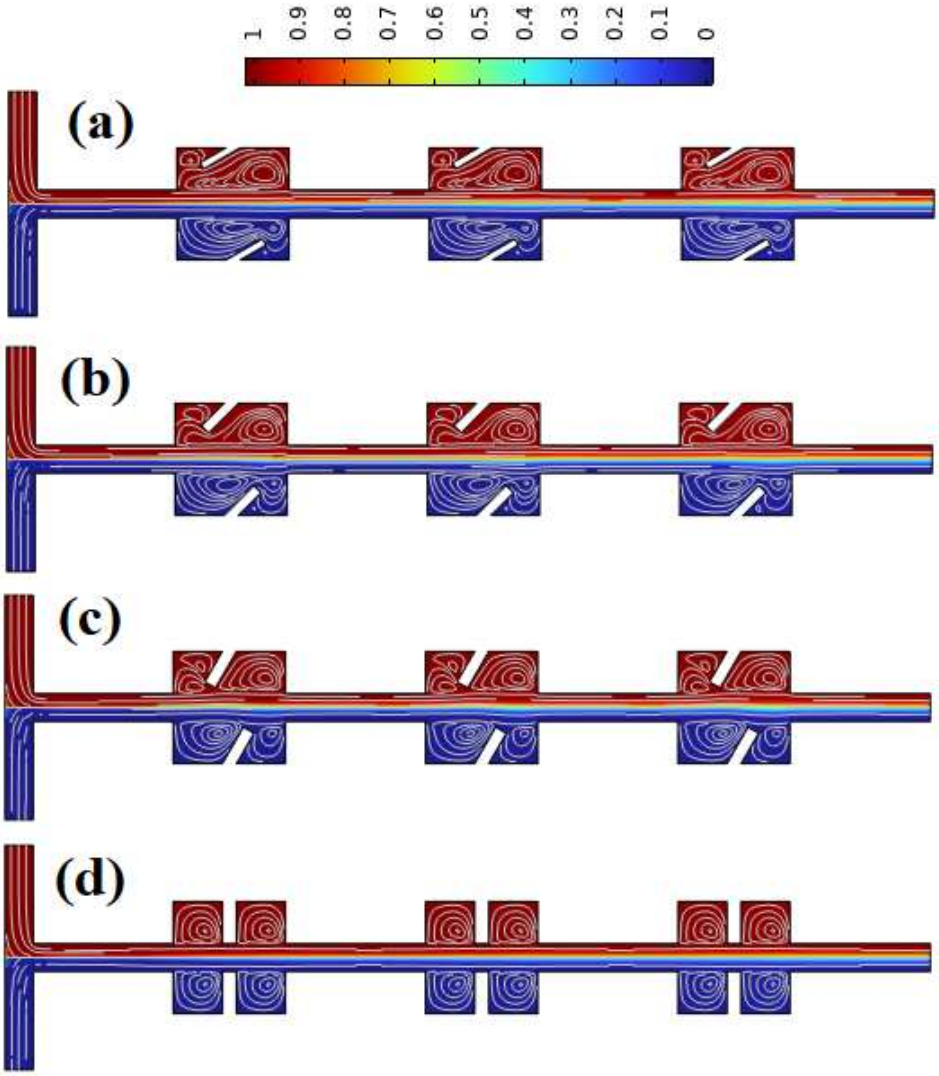

Fig. 2 Concentration contours for: (a) $\theta = 30^{o}$, (b) $\theta = 45^{o}$, (c) $\theta = 60^{o}$, and (d) $\theta = 90^{o}$.

Table 1. MI and Δp for different baffle angles.

Baffle angle	MI (%)	Δp (Pa)
30^{o}	27.66	9883
45^{o}	26.77	9879
60^{o}	25.14	9828
90^{o}	24.60	9802

IV. CONCLUSION

Micromixers are divided into passive and active ones. This paper examines the performance of a passive micromixer consisting of mixing chambers and inclined baffles. The influence of inclined baffles embedded in square mixing chambers is evaluated on the mixing index and pressure drop. Numerical simulations are performed for incompressible and Newtonian fluids by using COMSOL Multiphysics software. Four geometries are introduced based on the variations of the baffle angle. The results demonstrate that the baffle angle does not affect the MI and Δp. For instance, MI changes from 27.66 to 24.60 when the baffle angle is increased from 30° to 90°. In other words, for a creeping flow regime, the impact of baffle angle on MI and Δp is negligible. It is expected that this effect will be increased by enhancing the inlet velocity.

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Effect of inlet velocity on the mixing of liquids in a passive micromixer with baffles

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Abstract – Micromixers are one of the essential components of microfluidics. In the present paper, a passive micromixer with square-shaped mixing chambers is introduced. Mixing chambers involve inclined baffles with an inclination angle of 30º. The presence of baffles leads to an enhancement in the mixing quality due to the generation of vortices. The mixing index is an ascending function of inlet velocity. For example, the mixing index changes from 21.56 to 27.66 when the inlet velocity is enhanced from 0.005 m/s to 1 m/s. On the other hand, the pressure drop is a descending function of inlet velocity. For example, when inlet velocity is enhanced from 0.005 m/s to 1 m/s, the pressure drop is augmented from 29.74 Pa to 9883 Pa, indicating that these two parameters, i.e., mixing index and pressure drop, should be considered to evaluate the micromixer performance.

Keywords – Passive micromixer, Baffle, Inlet velocity, Mixing index, Pressure drop

I. INTRODUCTION

Microfluidic devices have been employed in numerous applications, such as chemical reactions and bioengineering [1, 2]. Micromixers are one of the essential components of microfluidics [3]. They are divided into passive and active devices [4]. Passive techniques do not use external energy while active ones employ external actuators to improve mixing quality [5].

Obstacle-based micromixers have been utilized to enhance the mixing index by inducing chaotic advection. Many investigators have used these devices. For instance, Alam et al. [6] used several cylindrical obstacles in a curved microchannel to mix water and ethanol when the Reynolds number (Re) changed from 0.1 to 60. They compared the performance of their proposed micromixer with a T-shaped one with circular obstacles and a simple curved one. It was found that the mixing index is improved as the height of obstacles increases. They also demonstrated that pressure drop is an ascending function of Re.

Bhagat et al. [7] designed a planar micromixer to mix liquids when Re changed from 0.01 to 100. Their experimental work was conducted for Re = 0.02-10. They reported that circular, triangular, smooth diamond, and stepped diamond obstructions can provide mixing efficiencies of 30%, 22%, 28%, and 11%, respectively.

In the present paper, a passive micromixer with square-shaped mixing chambers is introduced. Mixing chambers involve inclined baffles with an inclination angle of 30º. The presence of baffles leads to an enhancement in the mixing quality due to the generation of vortices. This paper examines the impact of inlet velocity on mixing index and pressure drop. Fig. 1 shows a schematic of the micromixer.

II. GOVERNING EQUATIONS

The steady governing equations, including continuity and Navier-Stokes equations, for incompressible and Newtonian fluids are:

$$\nabla \cdot \vec{V} = 0 \tag{1}$$

$$\rho\left(\vec{V} \cdot \nabla\vec{V}\right) = -\nabla P + \mu\nabla^2\vec{V} \tag{2}$$

where $\vec{V}$, ρ, μ, and P represent velocity, density, dynamic viscosity, and pressure, respectively.

The convection-diffusion transport equation is:

$$\frac{\partial C}{\partial t} + \vec{V} \cdot \nabla C = D\nabla^2 C \tag{3}$$

where C and D are the concentration and molecular diffusivity, respectively. Besides, the mixing index (MI) is calculated as:

$$MI = \left(1 - \left(\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{c_i - \bar{c}}{\bar{c}}\right)^2}\right)\right) \times 100 \tag{4}$$

where c_i is the local concentration and $\bar{c}$ is the average amount of c_i. N is the total number of grid points in a desired cross-section.

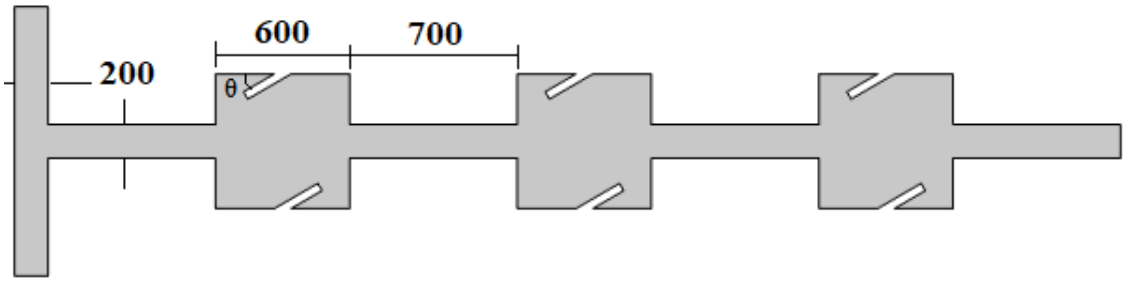

Fig. 1 Schematic of the micromixer.

III. RESULTS

This section evaluates the mixing index and pressure drop of the proposed micromixer. Fig. 2 depicts the variations of concentration contour along the micromixer by changing the inlet velocity. It is observed that the size of vortices created in mixing chambers is enhanced by increasing the inlet velocity. Hence, it is expected that the mixing index is improved with the inlet velocity. Table 1 confirms that the mixing index is an ascending function of inlet velocity. For example, mixing index changes from 21.56 to 27.66 when the inlet velocity is enhanced from 0.005 m/s to 1 m/s. On the other hand, the pressure drop is a descending function of inlet velocity. For example, when inlet velocity is enhanced from 0.005 m/s to 1 m/s, the pressure drop is augmented from 29.74 Pa to 9883 Pa, indicating that these two parameters, i.e., mixing index and pressure drop, should be considered to evaluate the micromixer performance.

IV. CONCLUSION

Microfluidic devices have been employed in numerous applications, such as chemical reactions and bioengineering. In the present paper, a passive micromixer with square-shaped mixing chambers is introduced. Mixing chambers involve inclined baffles with an inclination angle of 30º. The presence of baffles leads to an enhancement in the mixing quality due to the generation of vortices. The mixing index is an ascending function of inlet velocity. For example, mixing index changes from 21.56 to 27.66 when the inlet velocity is enhanced from 0.005 m/s to 1 m/s. On the other hand, the pressure drop is a descending function of inlet velocity. For example, when inlet velocity is enhanced from 0.005 m/s to 1

m/s, the pressure drop is augmented from 29.74 Pa to 9883 Pa, indicating that these two parameters, i.e., mixing index and pressure drop, should be considered to evaluate the micromixer performance.

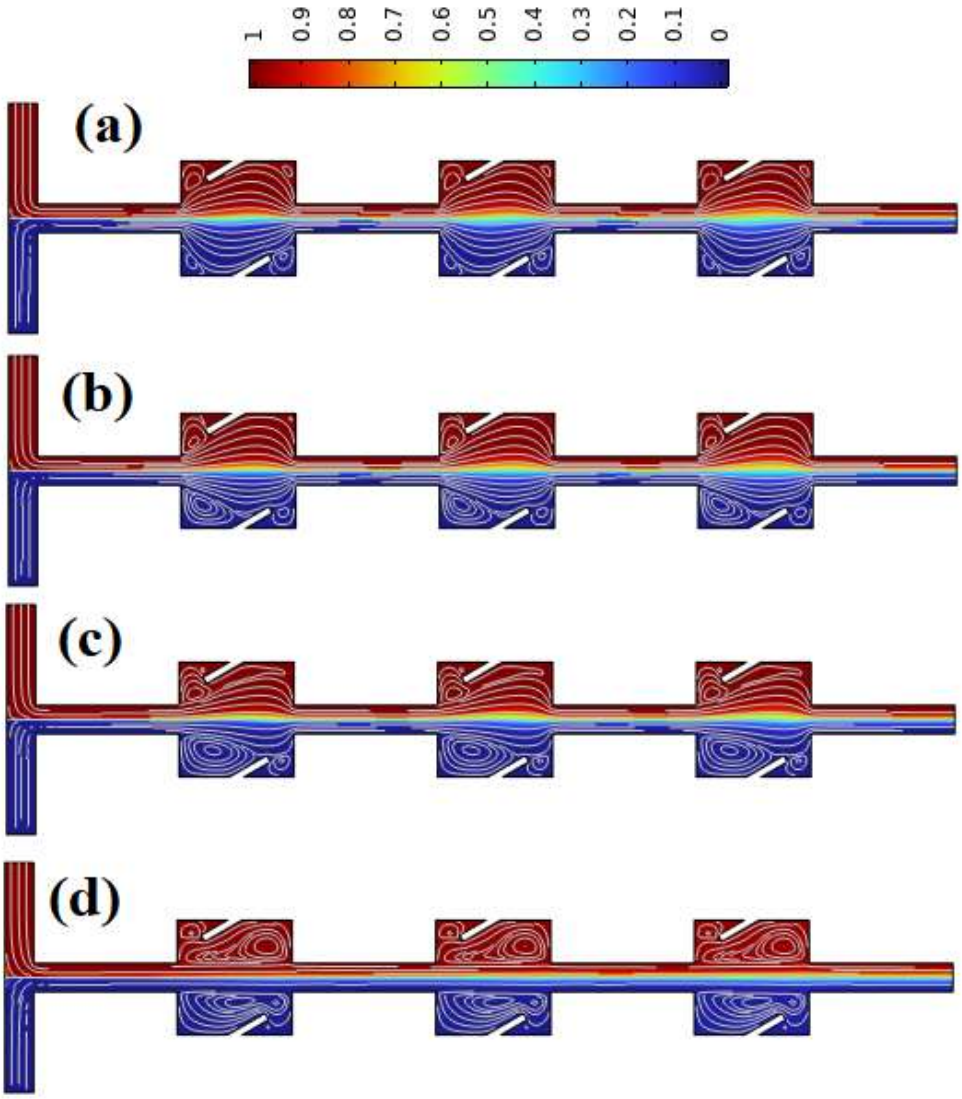

Fig. 2 Concentration contours for: (a) u_{in} = 0.005 m/s, (b) u_{in} = 0.05 m/s, (c) u_{in} = 0.1 m/s, and (d) u_{in} = 1.0 m/s.

Table 1. MI and Δp for different inlet velocities.

Inlet velocity (m/s)	MI (%)	Δp (Pa)
0.005	21.56	29.74
0.05	21.35	306.9
0.1	22.22	643.6
1.0	27.66	9883

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Designing Titanium Surgical Clips with a Biomimetic Approach

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Abstract – Surgical clips, one of the developed biomaterials, are one of the most commonly used specific materials. Surgical clips are a binding device that grasps tissue, vascular and nerve structures and interrupts blood and nerve conduction to that area and remains in the body for a long time. Clips used in many surgical fields vary in size depending on the procedure in which they are used. Biomaterials are produced by taking the organ or structure to be used as a role model. Biomimetics as another role model; It is a working area that allows nature to imitate the environment. New solutions to problems can be found with the biomimetic approach in designing biomaterials. The change in the design of titanium surgical clips, which are available in many varieties, will be designed by examining animal mouth structures. The proposed study is to redesign titanium surgical clips in an aesthetic, economical and safe manner, while being solution-oriented in design, taking into account the problems caused by titanium surgical clips both before and after the surgical procedure, with a biomimetic approach and an engineering approach.

Keywords–titaniumsurgicalclip, biomimetic, biomaterials

I. INTRODUCTION

Today's developing health sector and the variety of surgical procedures have triggered the development of biomaterials. Since ancient times, various treatment methods have been used and surgical methods have been developed to maintain human well-being. With the development of developing health treatment methods, the need for biomaterials has increased and biomaterials have been developed in many areas.

As a result of the research, there are many types of titanium surgical clips on the market, depending on the desired size and cost [1]. They are distinguished from each other according to the type of material used and their design. According to preliminary research, the problems are; The clips remain stuck in the applicator and create difficulties during the procedure, they cannot fully grasp the tissue and necrose it, there is a leakage, they slip on the tissue over time, the patient feels a stinging sensation over time, the formation of artifacts, there is no domestic production, the cost is high, they are used in large quantities in the procedures, It has been observed that it is inadequate due to its sizing problem, inability to prevent vibration, and has been used in many surgical fields. [2]

There are certain problems that titanium surgical clips cause before and after surgical procedures. Considering these problems, different solution suggestions have been produced and it is thought that the change in design has contributed greatly to this situation [3]. However, redesigning the design with a biomimetic approach rather than upon request has produced a new solution. By examining the mouth structure of various animals, biomimetic solutions are sought to the problems found in clips. In this way, it is ensured that it is designed with a biomimetic approach.

Considering these problems, the solution is to redesign the selected animal mouths by imitating them while making design changes [1]. The first thing to be done is to examine the titanium surgical clips on the market, identify the problems, anatomically examine the animal mouth structures that will be preferred as biomimetics, as a result of the examination, redesign the clip's internal and external structure by imitating it, and model the new designed clip [4].

II. Materials and Method

The need for tools and equipment used as a result of developing surgical methods in the field of medicine is increasing day by day. In this way, biomedical equipment with a wide product range is developed and used with the necessary designs[5].

The scarcity of domestic biomedical materials, changing needs and problems have brought a new perspective to biomaterials[6]. As a result of developing technologies, there is a wide range of products and many medical materials used in the market. Despite this, the need cannot be met and the problems in biomedical materials have always varied depending on the surgical field in which they are used. When we go into specific detail, problems in biomedical materials affect many healthcare institutions with both the surgical procedure and the cost.

In our country, health institutions procure these products with allowances based on the medical supplies used. When the frequently used medical materials are examined, they are generally imported and not domestically produced, and the fact that the existing product is insufficient to meet the demands of the physician who uses it has brought a new perspective to engineers. In this regard, new designs have been used in many engineering fields by biomimetically imitating other animals. Contribution to domestic production will be made in biomedical materials by designing them on problems with a biomimetic approach. In addition, biomedical materials are designed by improving their shortcomings and encourage domestic production[7].

Designed titanium clips are domestic production and will affect the dependence on imported materials to some extent. The biomimetic approach will bring a new perspective to biomaterials and provide direction to different models. Unlike the products on the market, it will be a problem-solving biomedical product thanks to its design. Modeling in biomedical products will provide new business lines and employment in terms of production. There will be a gain in terms of surgical material costs.

Surgical titanium clips on the market will first be examined and the design on the material will be determined accordingly[8]- [9]. Titanium will still be the basis for material selection, but the approach to design will be biomimetic. Based on the mouth and tooth-replacing filters of bald whales, the external appearance of the mouth will resemble a clip, while the internal structure will be developed by imitating the internal structure of snail teeth. In order to avoid leakage, the inner part is designed to only serve as a closure without damaging the tissue, nerve or vein, while the tip is designed to be compatible with the existing applicator and will try to prevent slipping where it is placed. In this way, a new solution to the problems in biomaterials will be found in terms of biomimetics.Although they are small biomedical

materials in size, clips used in many surgical fields provide ease of operation but have disadvantages and problems. Changing the design with solution suggestions using a biomimetic approach would be a different way.

III. RESULTS

When the clips on the market are examined, it is necessary to make changes in the inner surface and outer structure according to the problems.

When animal mouth structures are examined, the whale's mouth structure can be made differently from u-clips in terms of closure, as seen in the figure.

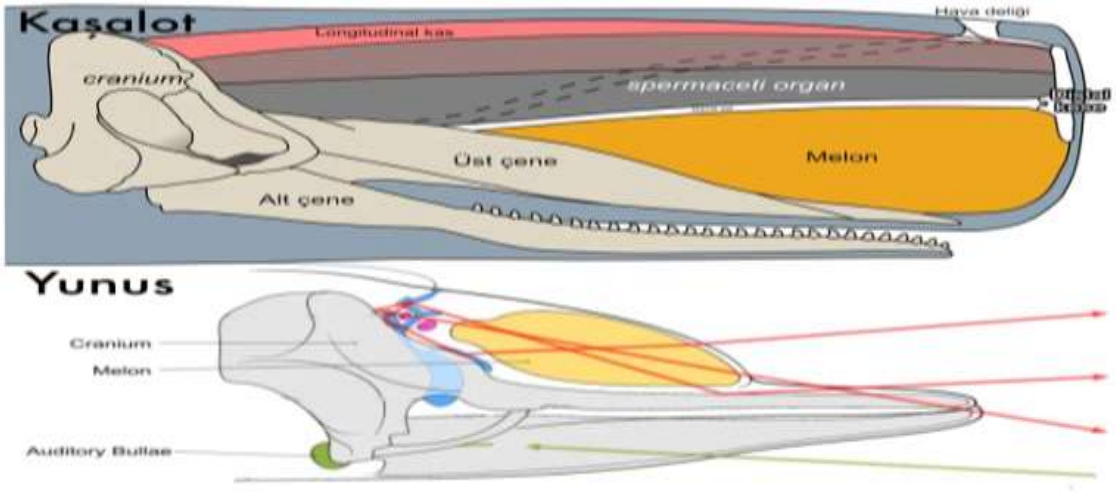

Figure-1 Whale Mouth Structure [13]

When interior surface designs are taken into consideration, surface treatments that do not fully grasp the superficial texture and cause a feeling of slipping and sinking over time have been encountered[10]- [11] -[12]-The snail tooth structure is imitated in the inner surface. Teeth called radula were examined considering the snails' attachment to a particular area. The design modeling was done this way. The modeled clip has not been used anywhere.

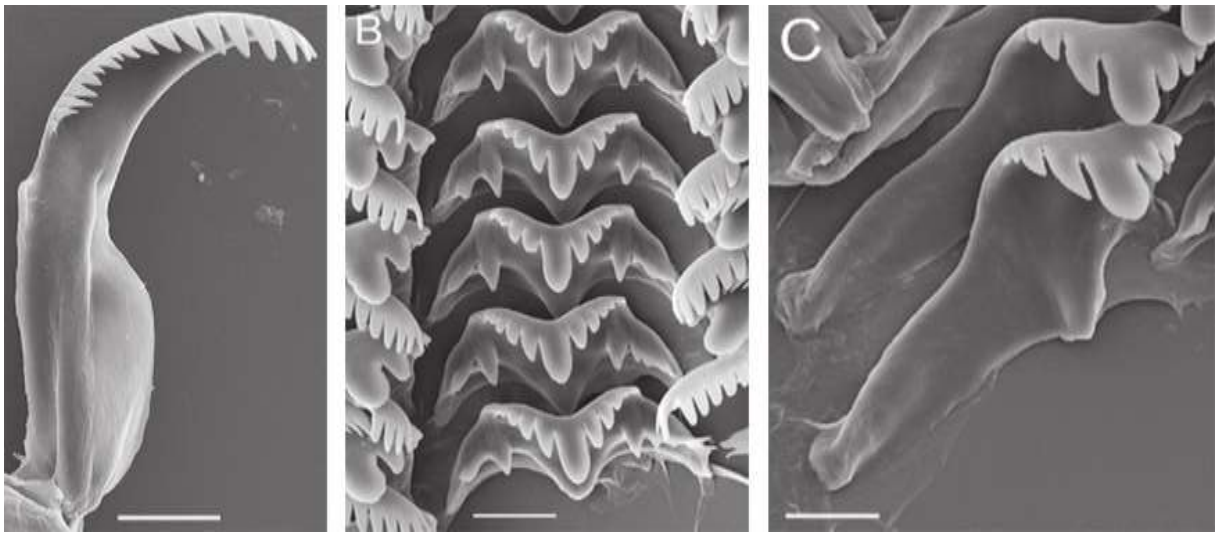

Figure-2 Snail Radula Teeth Sets[14]

Figure-3 Biomimetic Design Example

Figure-4 Biomimetic Design Example

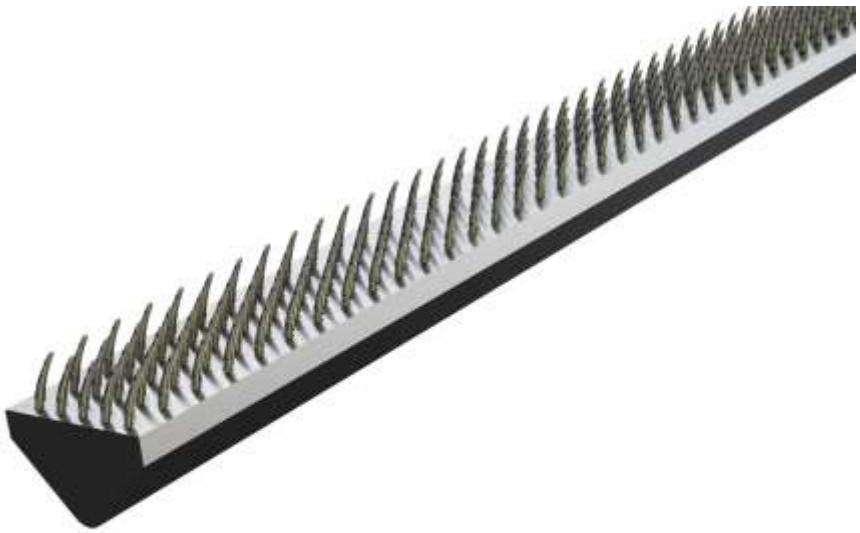

Figure-5 Biomimetic Design Example

Design modeling has been done as shown in the figures. The modeled clip has not been used anywhere.

IV. DISCUSSION

Titanium surgical clips are a biomedical material that interrupts the blood, tissue and nerve conduction of an organ with another organ, the size of which varies depending on the surgical procedure performed. Brain surgery, general surgery, pediatric surgery, gastroenterology, cardiovascular surgery, etc. It is used in many surgical fields. Especially in separating cancerous tissue and preventing metastasis, clips are preferred in areas with high risk of bleeding in order to separate tissues that cannot be stitched, cut or burned with cautery and lose their functionality.

- Disadvantages of titanium surgical clips: The clips remain stuck in the applicator, creating difficulties during the procedure.
- Failure to fully grasp the tissue and necrosis or disintegrate the tissue
- Sealing
- It slips on the tissue it is located on over time.
- The patient feels a stinging sensation over time.
- Formation of artifacts
- Lack of local production

- High cost, large number of uses
- The end part is not interlocking like polymer clips
- Sizing problem
- Not affected by ambient temperature PH
- Must be able to select vibration
- Having a sinusoidal surface

When the studies are examined, "Clips are usually displaced in the compression axis, but rarely can be displaced in more than one plane." problems like this have been observed[15].

V. CONCLUSION

Modeling was done with a biomimetic approach, considering the problems of clips, which are biomedical products. Such a solution has been a study for domestic production of biomedical materials, which have high costs and disadvantages.

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Gaz Türbin Kanatçığında One-Way FSI ile Ömür Tayini

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Özet **–** Gaz türbinli motorlar, havacılıkta ve endüstriyel elektrik santrallerinde sıklıkla kullanılır. Teknolojinin gelişmesi ile araştırmacılar, gaz türbinli motorlardan daha yüksek verim elde etmenin yollarını aramıştır. Bu yollardan biri de türbin giriş sıcaklığının arttırılmasıdır. Yanma odasında hava-yakıt karışımının yanması neticesinde yüksek sıcaklık ve basınca sahip yanmış gaz yüksek basınç türbininde stator kanatçığına yönlendirilir. Türbin kanatçığının yapısal dayanımının sınırlı olması nedeni ile yanma odası çıkış sıcaklığı yükseltilemiyor. Bu nedenle araştırmacılar, kanat soğutma teknikleri üzerine çalışmalar gerçekleştirmiştir. Bu kapsamda stator kanatçığı için soğutma konfigürasyonu tasarlanmıştır. Gerçekleştirilen nihai tasarımın akış analizleri gerçekleştirilmiştir. Türbin kanatçığının üzerinde maksimum basınç 1.198 MPa, maksimum sıcaklık ise 1240 K olarak elde edilmiştir. Bu çalışmada ise akış analizi gerçekleştirilen türbin stator kanatçığı One-Way FSI metodu ile analizi gerçekleştirilerek sıcaklık ve basınç yüklerine maruz kalan türbin stator kanatçığı üzerindeki gerilmeler tespit edilmiştir. Türbin stator kanatçığında oluşan maksimum Von-Mises eşdeğer gerilme 449.49 MPa olarak tespit edilmiştir. Elde edilen gerilme değerleri ve sıcaklık bilgileri kullanılarak Larson-Miller parametresi hesaplanarak türbin stator kanatçığının ömür tayini gerçekleştirilmiştir. Türbin stator kanatçığının ömrü 8500 saat olarak belirlenmiştir. Bu araştırma sayesinde ülkemizde gelişmekte olan gaz türbin teknolojisine katkı sağlanması, artan enerji talebinin ve fosil yakıt kullanımının azaltılması hedeflenmektedir.

Anahtar Kelimeler – One-Way FSI , Larson-Miller , Türbin Kanatçık Soğutma

I. GİRİŞ

Son yıllarda gelişen teknoloji ile birlikte dünya genelinde sanayi devriminden günümüze kadar her yıl enerji talebi büyük ölçüde artmıştır. Aynı zamanda insanlı havacılığın başlamasıyla birlikte, "Havacılık ve uzay çalışmalarında daha fazla nasıl itki sağlanabilir?", "Daha az yatırım maliyeti ve daha az yakıt ile nasıl daha fazla enerji elde edilir?" gibi sorular, gelişmiş ülkeler ve hali hazırda gelişmekte olan ülkeler için önemli bir araştırma konusu haline gelmiştir.

Gaz türbinleri; elektrik, enerji, buhar, mekanik güç gibi konularda dünya genelinde en ileri teknolojiler arasına girmiştir. Gaz türbinli motorlarda verim artışının birçok parametresi bulunmaktadır. Bunlardan en önemlisi türbin giriş sıcaklığı parametresidir. Söz konusu parametre daha da yükseltilerek ısıl verim arttırılır, dolayısıyla gaz türbinli motorun genel verimi de artar. Türbin giriş sıcaklığının yükseltilmesi, yanma odasında gerçekleşen hava-yakıt karışımının yanma verimi ile doğrudan ilişkilidir. 1900'lü yılların ortasında gelişen teknoloji ile beraber türbin bölgesindeki sıcaklıklar 750°C-850°C seviyelerine erişmekteydi. Günümüzde ise türbin giriş sıcaklığının 1500-1600°C seviyelerine ulaştığı biliniyor [1]. Gelinen bu noktada yüksek türbin giriş sıcaklıkları, gaz türbinli motorların ısıl verimini artırıyor ancak malzeme dayanımının bu sıcaklıklara ulaşamaması sebebiyle bu alanda çalışan firmaları yeni teknoloji arayışlarına itmiştir. Öncelikle türbin kanatlarının ömrünü uzatmak için kaplama yöntemleri geliştirilmiştir. Özellikle yüksek sıcaklıklara maruz kalan yüksek basınç türbin kademesinde bu yöntem sıklıkla kullanılmaktadır. Ancak bu yöntemde hedeflenen verim ihtiyacına ulaşılamadığından yetersiz kalmıştır. Bu sebep, araştırmacıları türbin kanatlarının iç geometrisini kullanarak soğutma konfigürasyonlarının

tasarlanmasına itmiştir. Soğutma konfigürasyonu tasarlanmış nihai türbin kanatçıklarının bir de yapısal dayanımı bakımından değerlendirilmelidir. Türbin kanatçıklarında yapısal gerilmeleri, toplam deformasyon gibi parametreleri belirlemek için sonlu elemanlar metodu kullanılmaktadır. Sonlu elemanlar yöntemi, karmaşık mühendislik problemlerinde ve matematiksel modellerde uygulanılan bir sayısal analiz tekniğidir [2]. Mühendislik uygulamalarında akış analizlerinde elde edilen basınç, sıcaklık gibi yüklerin yapısal analiz kısmına aktarılması için FSI (Fluid-structure interaction) metodu kullanılmaktadır. FSI yöntemi, bir veya daha fazla katının iç veya dış akış ile etkileşime girmesi ile oluşan problemlerde kullanılmaktadır [3]. FSI analiz metodu one-way ve two-way olmak üzere iki yönteme ayrılır. One-way FSI yöntemi, akışkanın yapı üzerindeki etkisini belirlemek için kullanılan bir metot olması ile beraber yapı üzerindeki deformasyonun akışkan üzerindeki etkilere geri dönüşü ihmal edilir. Yapı üzerindeki akışın akışkan üzerindeki akışa etkisinin önemli olduğu durumlarda two-way FSI yöntemi kullanılabilir [4].

Dhopade vd. (2010), gaz türbinlerine yönelik çalışmalarını AYE analizleri kullanarak gerçekleştirmiştir. Gaz türbinlerinin hava girişinde bulunan fan kanatları üzerine çalışan ekip, AYE analizlerini kullanarak, fan kanatlarında oluşabilecek düşük ve yüksek devirli yorulma olasılığı ile ilgilenmiştir. Daha sonra, bahsedilen parçalar için ömür hesabı yapılmıştır. Çift yönlü AYE analizleri kullanılarak 32 döner kanatçık ve bu döner kanatçıkların önünde yer alan 18 sabit kanatçık içeren bir modelle çalışmışlardır [5].

Mekhonoshina vd. (2015), AYE analizlerini bir kompresör sisteminde duran ve dönen kanatçıklar için uygulayarak, zamana bağlı olarak değişen gerilmeleri araştırmışlardır. On iki sabit ve on iki dönen kanatçıktan oluşan modellerinde basitleştirme yapabilmek adına, modelin on ikide birlik kısmını analizlerinde kullanmışlardır. ANSYS CFX ve ANSYS Mechanical yazılımlarını kullanan Mekhonoshina, akışkan-yapı etkileşim bölgesi olarak dönen kanatçığı seçmiş ve sabit kanatçığın hava akışı sırasında şekil değiştirmediği varsayımını kullanmışlardır. Döner kanatlar için farklı dönme hızlarındaki en büyük şekil değişimi değerlerini, belirledikleri bir referans noktasına göre elde etmişlerdir [6].

Reyhani ve ekibi (2013), gaz türbinli motorlarda en çok zorlanan parçalar olan güç türbini kanatçıklarının ömür değerlerini hesaplamak amacıyla kanatçıklar üzerinde oluşan sıcaklık dağılımını incelemişlerdir. Araştırmacılar, türbin kanatçıklarına gelen havanın sıcaklığının artmasıyla gaz türbinli motorların verimliliğinin arttığını belirtmişlerdir. Bu durumda, malzemelerin dayanımı ve parçaların kullanımının mümkün olabilmesi için sıcaklık değerinin sabitlenmesi gerektiğini ifade etmişlerdir. Kanatçıkların sıcaklıklarının ömür hesabı için oldukça önemli olduğunu vurgulayan ekip, sıcaklıkla değişen malzeme özelliklerini hesaba katmak için detaylı bir sıcaklık analizi gerçekleştirmiştir [7].

Souza ve ekibi (2019) türbin giriş sıcaklığı olarak 900-1200 ºC olarak belirledikleri gaz türbin kanatçıklarının kaplama yöntemi ile soğutulması ve yapısal analizlerini gerçekleştirmiştir. Gerçekleştirilen çalışmanın sonucunda maksimum gerilmenin hub kısmında 333.4 MPa, maksimum deformasyonun shroud kısmında 0.04 mm olarak gerçekleştiği tespit edilmiştir [8].

Bu çalışmada ise akış analizi gerçekleştirilen türbin stator kanatçığı One-Way FSI metodu ile analizi gerçekleştirilerek sıcaklık ve basınç yüklerine maruz kalan türbin stator kanatçığı üzerindeki gerilmeler tespit edilmiştir. Ayrıca, elde edilen gerilme değerleri ve sıcaklık bilgileri kullanılarak Larson-Miller parametresi hesaplanarak türbin stator kanatçığının ömür tayini gerçekleştirilmiştir.

II. MATERYAL VE YÖNTEM

Gaz türbin stator kanatçığının akışkan-yapı etkileşimi analizlerinin gerçekleştirilmesi için öncelikle bir akış analizi gerçekleştirilmiştir. One-way FSI yöntemi ile akış analizi sonuçları Ansys programının static structural modülüne import edilmiştir. Türbin kanatçık malzemesi olarak Mar-M-247 malzemesi kullanılmıştır. Mukavemet analizi sonucunda elde edilen veriler, Larson-miller metodunda kullanılarak ömür tayini gerçekleştirilmiştir.

A. Mar-M-247 malzeme özellikleri

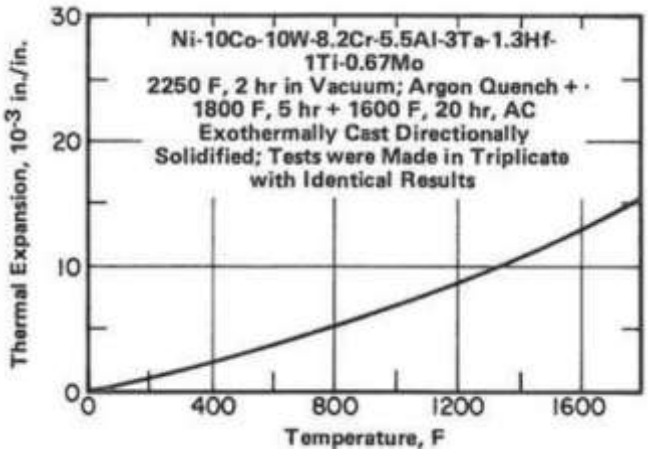
MAR-M-247, yüksek sıcaklık uygulamaları için geliştirilmiş, nikel esaslı bir süper alaşımdır. Bu malzeme özellikle havacılık, uzay sanayisi ve enerji sektörlerinde, yüksek sıcaklık ve aşındırıcı ortamlarda

çalışan bileşenlerde kullanılmak üzere tasarlanmıştır. Tablo 1'de Mar-M-247 malzemesinin kimyasal bileşimi verilmiştir.

Tablo 1. Mar-M-247 malzemesinin kimyasal bileşimi [9]

Composition	Weight %	Composition	Weight %
Aluminum	5.4	Molybdenum	0.66
Boron	0.012	Nickel	Balance
Carbon	0.13	Tantalum	3.0
Cobalt	9.9	Titanium	1.0
Chromium	8.3	Tungsten	9.8
Hafnium	1.3	Zirconium	0.05

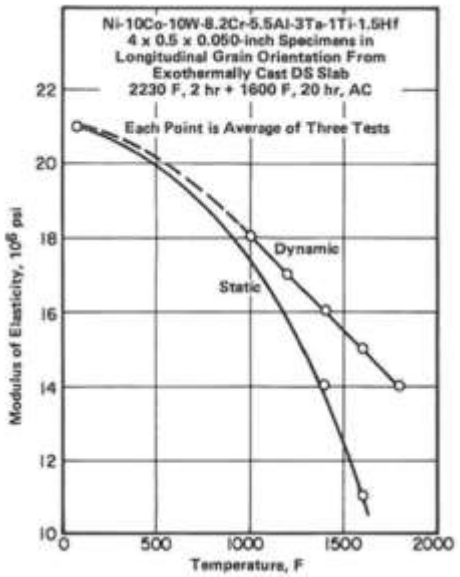
Mar-M-247 malzemesinin yoğunluğu 0.308 lb/in3 (8.54 g/cm3)' dur [10]. Şekil 1'de ısıl genleşme ve sıfır termal gerilim referansı için izotropik sekant katsayısı verilmiştir.



Şekil 1. Isıl genleşme ve sıfır termal gerilim referansı için izontropik sekant katsayısı [11]

Mar-M-247 malzemesinin erime aralığı 2380 - 2490 °F (1305 - 1365 °C) olarak literatür taraması sonucu elde edilmiştir [12].

Elastisite modülü için literatür taraması neticesinde sıcaklığa bağlı elastisite modülü değişimi grafiği elde edilmiştir. Şekil 2'de sıcaklığa bağlı elastisite modülü değişimi grafiği verilmiştir.



Şekil 2. Sıcaklığa bağlı elastisite modülü değişimi [11]

Mar-M-247 malzemesinin poisson oranı literatür taraması sonucu 0.3 olarak tespit edilmiştir. Akma dayanımı için ise oda sıcaklığı ve 1400 F (1033 K)' da Şekil 3'deki gibi elde edilmiştir.

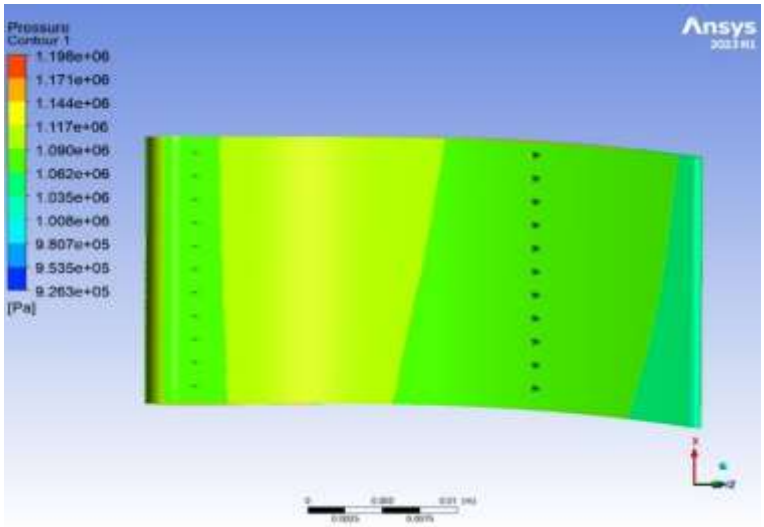
Mold	Ultimate tensile strength, MPa (ksi)	0.2-Percent yield strength, MPa (ksi)	Elongation, percent	Reduction of area, percent
(a) Tests at Room Temperature				
1	1147 (166)	856 (124)	12.8	14.8
2	1171 (170)	864 (125)	11.2	11.7
3	1218 (177)	854 (124)	12.1	12.2
4	1196 (173)	863 (125)	12.8	16.0
5	1254 (182)	872 (126)	13.3	14.2
6	1154 (167)	854 (124)	13.4	16.5
7	1172 (170)	832 (121)	12.5	16.0
8	1182 (172)	845 (123)	15.0	16.5
9	1131 (164)	849 (123)	12.0	16.1
10	1231 (179)	896 (130)	13.1	14.4
11	1153 (167)	887 (129)	12.9	16.5
12	1232 (179)	914 (133)	12.3	13.8
13	1170 (170)	903 (131)	10.9	15.7
14,15	Not tested			
(b) Tests at 1033°K (1400°F)				
1	1172 (170)	973 (141)	8.3	12.4
2	1121 (163)	880 (128)	7.0	14.2
3	1173 (170)	956 (139)	13.3	20.8
4	1176 (171)	947 (137)	13.5	20.7
5	1082 (157)	845 (123)	16.4	26.4
6	1176 (171)	976 (142)	10.9	16.2
7	1150 (167)	911 (135)	16.2	23.7
8	1131 (164)	896 (130)	12.7	17.8
9	1123 (163)	925 (134)	2.9	4.6
10	1188 (172)	951 (138)	13.5	19.5
11	1180 (171)	962 (140)	11.5	15.1
12	1189 (173)	972 (141)	12.4	16.6
13	1207 (175)	965 (140)	11.1	13.3
14,15	Not tested			

Şekil 3. Mar-M-247 malzemesine ait çeşitli sıcaklıklarda akma dayanımı değeri [12]

B. *Akış analizi sonuçları*

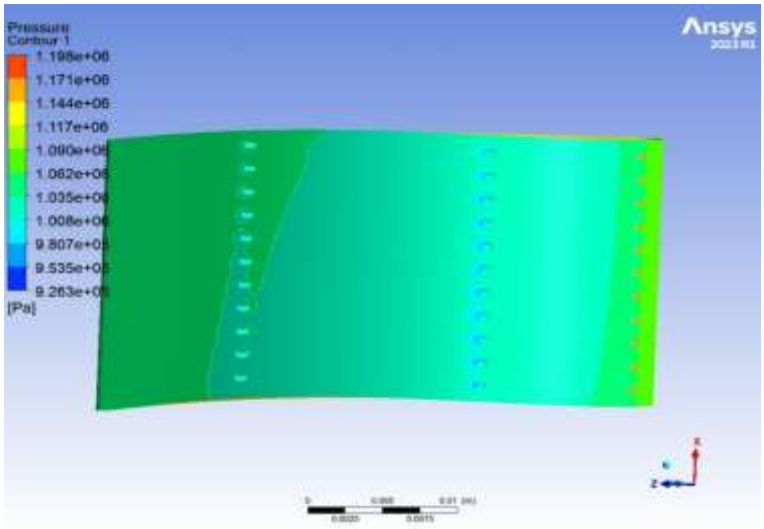
Yüksek sıcaklık ve basınca maruz kalan türbin stator kanatçıkları, çeşitli soğutma teknikleri uygulanarak soğutulmaktadır. Tasarım çalışmasında türbin kanatçığına soğutma konfigürasyonu tasarlanmıştır. Hesaplamaları ve CFD analizleri gerçekleştirilen türbin stator kanatçığının akış analiz sonuçlarındaki basınç ve sıcaklık statik analize girdi olarak sağlanacaktır.

Şekil 4'de gerçekleştirilen akış analizinin sonucu olarak türbin stator kanatçığının basma kenarındaki basınç alanı verilmiştir. Analiz sonucu incelendiğinde, basma kenarında maksimum basınç 1.144 MPa olarak görülmüştür.



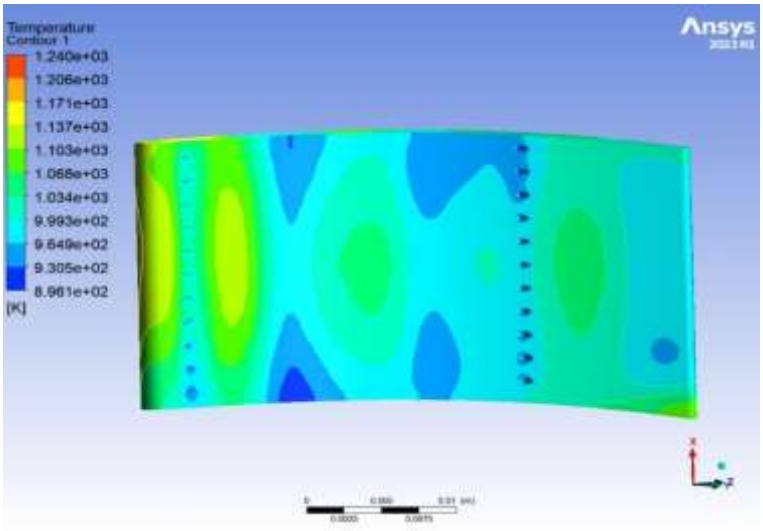
Şekil 4. Türbin stator kanatçığının basma kenarındaki basınç alanı

Şekil 5'de gerçekleştirilen akış analizinin sonucu olarak türbin stator kanatçığının basma kenarındaki sıcaklık alanı verilmiştir. Türbin stator kanatçığının emme kenarında maksimum basınç 1.117 MPa olarak tespit edilmiştir. Buradan da anlaşılacağı üzere türbin stator kanatçığının üzerindeki maksimum basınç basma kenarında görülmektedir.



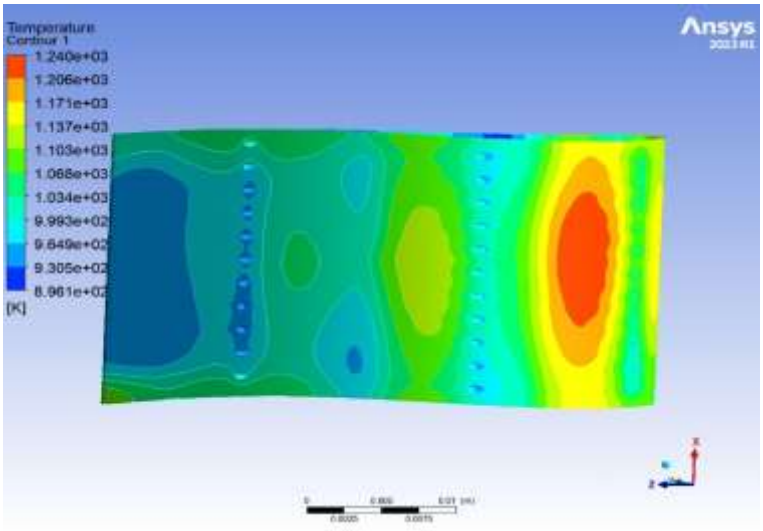
Şekil 5. Türbin stator kanatçığının emme kenarındaki basınç alanı

Şekil 6'da türbin stator kanatçığının emme kenarındaki sıcaklık alanını gösteren analiz sonucu görülmektedir. Analiz sonucu incelendiğinde, basma kenarında maksimum sıcaklık olarak 1171 K görülmüştür.



Şekil 6. Türbin stator kanatçığının basma kenarındaki sıcaklık alanı

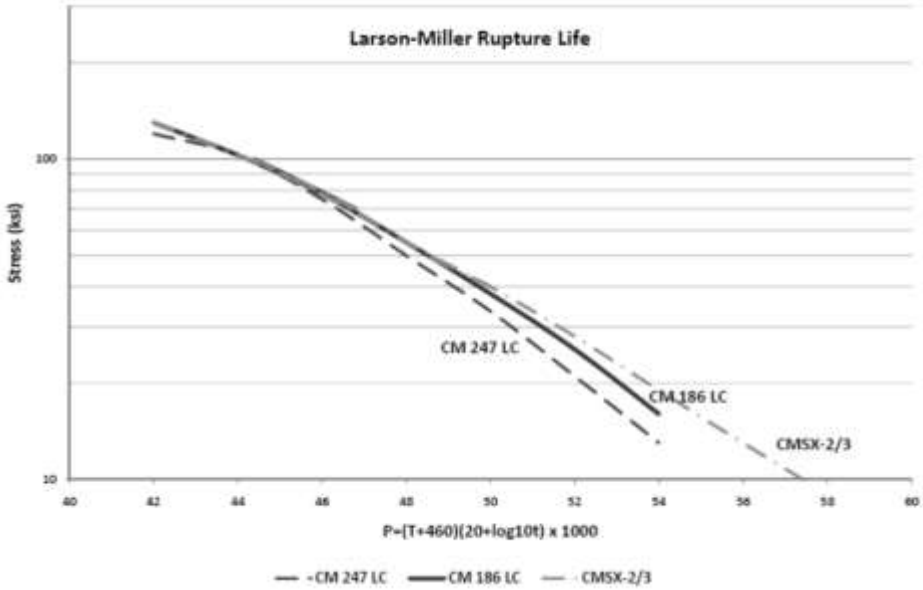
Şekil 7'de türbin stator kanatçığının emme kenarındaki sıcaklık alanının gösteren analiz sonucu görülmektedir. Türbin stator kanatçığının emme kenarında maksimum sıcaklık 1240 K olarak tespit edilmiştir. Buradan da anlaşılacağı üzere türbin stator kanatçığının üzerindeki maksimum sıcaklık emme kenarında ve leading edge kısmında görülmektedir.



Şekil 7. Türbin stator kanatçığının emme kenarındaki sıcaklık alanı

C. *Yapısal Analiz*

Gerilme analizi Ansys'in Static Structural Modulü kullanılarak gerçekleştirilmiştir. Akışkan-Yapı Etkileşimi (AYE) analizi için One-Way FSI yöntemi kullanılmıştır. İlk olarak Akışkan-Yapı Etkileşimi Analizi için akış analizinin Static Structural analizine aktarılmıştır. Ardından Mar-M-247 malzemesine ait özellikler tanımlanmıştır. Sonrasında mesh işlemi gerçekleştirilerek akış analizinde elde edilen sıcaklık ve basınç yükleri statik analize import edilmiştir. Ardından analiz gerçekleştirilmiştir.



Şekil 8. Mar-M-247 malzemesine ait Larson-miller grafiği [14]

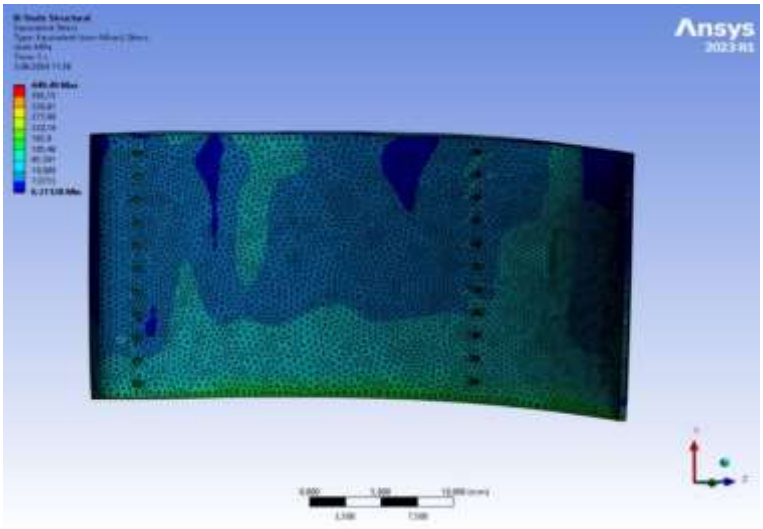
Ömür hesabı, bir bileşenin veya malzemenin belirli bir süre boyunca güvenli ve işlevsel bir şekilde çalışmasını sağlayan bir analizdir. Larson-Miller, malzemenin kritik sıcaklık ve gerilme seviyelerindeki ömrünü tahmin etmek için kullanılan bir yöntemdir. Bu yöntemde, malzemenin sıcaklık ve gerilmeye maruz kalma süresi birleştirilerek bir ömür parametresi hesaplanır. Şekil 8'de bulunan Larson-Miller grafiğinden tespit edildiği üzere 450 MPa (65,26 ksi) gerilmeye karşılık gelen Larson-Miller parametresi 45 olarak bulunmuştur. Denklem (1) kullanılarak ömür hesabı gerçekleştirilmiştir.

$$P = [1504^0F\ + 460]\ x\ [20\ + \log\ (t)\ ]\ x\ 10^{-3} = 47 \qquad (1)$$

Türbin stator kanatçığında oluşan maksimum gerilme 450 MPa olarak gözlemlenmiştir. Mar-M-247 malzemesine ait Larson-Miller grafiğinden ve denklem (1) kullanılarak elde edilmiştir. Türbin stator kanatçığının ömrü 8500 saat olarak belirlenmiştir.

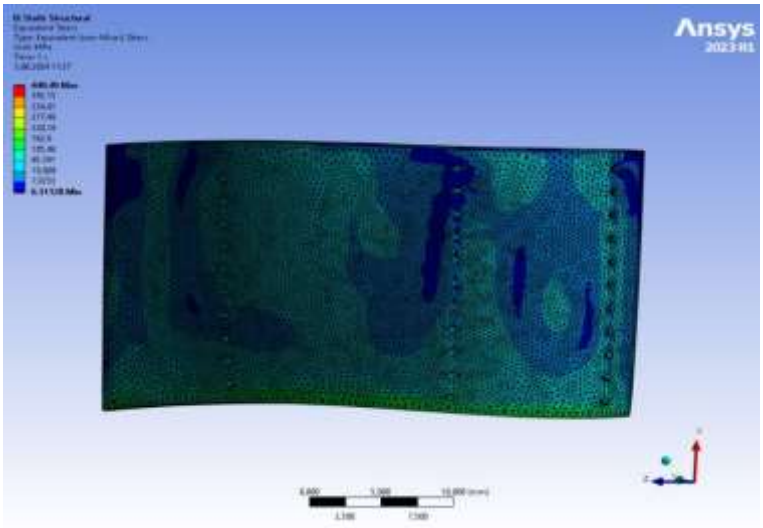
III. BULGULAR

Bu çalışmada, Ansys Static Structural Modülü kullanılarak türbin kanatçığında yapısal analiz gerçekleştirilmiştir. Şekil 9'da Türbin stator kanatçığının basma kenarında oluşan gerilmeler gösterilmiştir. Türbin stator kanatçığının basma kenarında oluşan maksimum gerilme kanatçığın hub bağlantı tarafında konum olarak trailing edge dolaylarında gözlenmiştir.



Şekil 9. Türbin stator kanatçığının basma kenarında oluşan eşdeğer gerilmeler

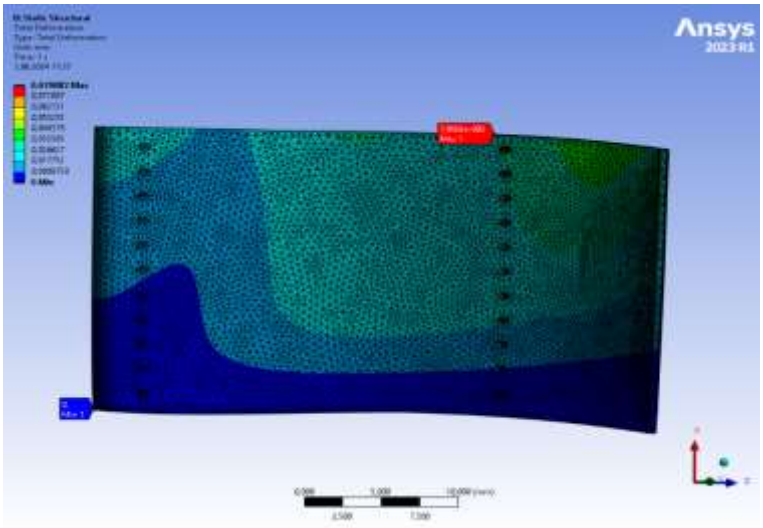
Şekil 10'da türbin stator kanatçığının emme kenarında oluşan gerilmeler gösterilmiştir. Türbin stator kanatçığının emme kenarında oluşan maksimum gerilme kanatçığın hub bağlantı tarafında konum olarak trailing edge dolaylarında gözlenmiştir. Akış analizinden elde edilen basınç yükleri ve sıcaklık yükleri sonucunda türbin stator kanatçığında oluşan maksimum gerilmeler Trailing edge kısmındaki göbek bağlantısında yaklaşık 450 MPa olarak gözlemlenmiştir.



Şekil 10. Türbin stator kanatçığının emme kenarında oluşan gerilmeler

Şekil 11 'de türbin stator kanatçığının basma kenarında oluşan toplam deformasyon miktarı verilmiştir. Türbin stator kanatçığının basma kenarında basınç ve termal gerilmelerin oluşturduğu etkilerden dolayı hub

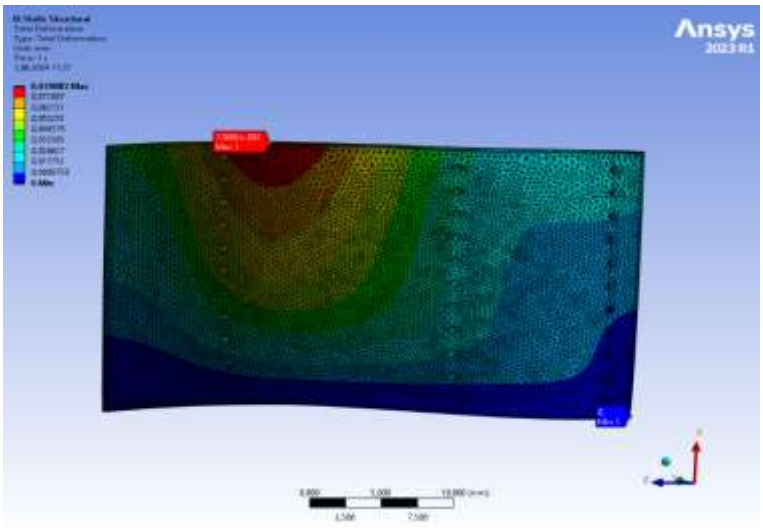
tarafından shroud tarafına doğru giderek artan bir deformasyon miktarı gözlemlenmiştir. Analiz sonucunda türbin stator kanatçığının basma kenarında oluşan maksimum deformasyon miktarı 0,079882 mm olarak gözlemlenmiştir.



Şekil 11. Türbin stator kanatçığının basma kenarında oluşan toplam deformasyon miktarı

Şekil 12'de türbin stator kanatçığının emme kenarında oluşan toplam deformasyon miktarı gösterilmiştir. Türbin stator kanatçığının emme kenarında basınç ve termal gerilmelerin oluşturduğu etkilerden dolayı hub tarafından shroud tarafına doğru giderek artan bir deformasyon miktarı gözlemlenmiştir.

Akış analizinden elde edilen basınç yükleri ve sıcaklık yükleri sonucunda türbin stator kanatçığında oluşan maksimum toplam deformasyon miktarı emme kenarının shroud dolaylarında gözlemlenmiştir. Maksimum deformasyon miktarı 0.079882 mm olarak tespit edilmiştir.



Şekil 12. Türbin stator kanatçığının emme kenarında oluşan toplam deformasyon miktarı

IV. TARTIŞMA

Türbin stator kanatçıkları yüksek sıcaklık ve basınç altında akışı rotor kanatçıklarına yönlendiren kanatçıklardır. Kanatçıklar yüksek sıcaklıları ve basınçlara maruz kalmaktadırlar. Kanatçıkların bu yüksek sıcaklılara ve basınçlara dayanabilmesi için soğutmaların iyi tasarlanması gerekmektedir. Bu nedenle, kanatçık malzemelerinin yüksek sıcaklıklara ve basınçlara dayanması önemlidir. Soğutma tasarımı

sayesinde kanat yüzeyinde sıcaklık düşürülmüştü. Gerçekleştirilen one-way FSI analizi sayesinde kanatçık üzerindeki sıcaklık ve basınç yüklerinin kanatın ömrüne etkisi incelenmiştir. Çalışma sonucunda elde edilen veriler literatür ile karşılaştırıldığında benzer sonuçlar elde edilmiştir (Souza ve arkı. 2019).

Türbin stator kanatçığının ömür tayini çalışmasında kanatçığın maksimum çalışma saatini arttırmak amacıyla şunlar gerçekleştirilebilir:

- Türbin kanatçığının soğutma konfigürasyonu daha iyi optimize edilerek yüzey sıcaklığı daha da düşürebilir. Lakin türbin verimi akışkanın sıcaklığı ve basıncına bağlı olduğundan dolayı soğutma konfigürasyonu türbinin verimi dikkate alarak tasarlanmalıdır.
- Türbin kanatçığının malzemesi farklı alternatiflerle değiştirilip tekrar analiz edilebilir. Malzemenin termal genleşme katsayısı, young modülü, ısı iletim katsayısı gibi parametreleri kanatçık için ömür tayini yapılırken doğrudan etkili olabilir.

V. SONUÇLAR

Bu çalışmada türbin kanatçığının dayanımı incelenmiştir. Akış analizi sonucu elde edilen veriler one-way FSI metodu kullanılarak Static Structural'a aktarılmıştır. Gerçekleştirilen yapısal analiz sonrasında türbin stator kanatçığının hub kısmının trailing edge dolaylarında 450 MPa eşdeğer gerilme gözlemlenmiştir. Maksimum toplam deformasyon ise türbin kanatçığının shroud kısmında gözlemlenmiştir. Larson-miller parametresi ile kanatçığın ömür tayini hesaplamaları yapılmış ve maksimum 8500 saat çalışma kapasitesi olduğu belirlenmiştir. Soğutma konfigürasyonunun iyileştirilmesi, termal genleşme katsayısının daha düşük olan bir malzemenin seçilmesi işlemleri kanatçık dayanımını daha verimli bir hale getirebildiği anlaşılmaktadır.

TEŞEKKÜR

Bu çalışma Türkiye Bilimsel ve Teknolojik Araştırmalar Kurumu tarafından desteklenmiş olup TÜBİTAK 2209A lisans projeleri kapsamında gerçekleştirilmiştir.

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TBDY 2018'e Göre Modellenen Bir Betonarme Yapının DD-1 ve DD-2'ye Göre Tasarlanması Durumuna ait Maliyet Karşılaştırması

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Özet **–** Kentleşmenin hızla arttığı ve nüfus yoğunluğunun giderek yükseldiği günümüzde, yapıların dayanıklılığı ve güvenliği öncelikli konular arasında yer almaktadır. Özellikle deprem bölgelerinde, yapıların sağlamlığı ve güvenilirliği hayati önem taşımaktadır. Betonarme yapılar, yüksek dayanıklılıkta ve uzun ömürlü olma özellikleri nedeniyle yaygın olarak tercih edilen yapı türleri arasında bulunmaktadır. Ancak, deprem gibi doğal afetler bu yapıların maliyet ve tasarım süreçlerini doğrudan etkilemektedir. Deprem yer hareketleri, betonarme yapılarda büyük zorlanmalara sebep olur ve bu durumların karşılanabilmesi için de yapının tasarımından inşasına kadar her aşamada ilave maliyetler ortaya çıkabilmektedir. Deprem bölgelerinde betonarme yapıların inşasında, yapının deprem performansını artırmak amacıyla çeşitli mühendislik yaklaşımlarıyla tasarımsal önlemler alınmaktadır. Bu önlemler, yüksek kaliteli beton ve çelik donatıların kullanımı, gelişmiş mühendislik hizmetleri ve daha karmaşık inşaat yöntemlerini içerebilir. Bu faktörler, yapı maliyetlerini artırırken, uzun vadede can ve mal kayıplarını minimize ederek ekonomik ve güvenlik açısından avantaj sağlamaktadır.

Bu çalışma kapsamında, bünyesinde çoklu mesken barındıran (apartman tipi) betonarme bir yapının taşıyıcı sistem modeli kurulmuş ve deprem yer hareket düzeyleri DD-1 ve DD-2'ye göre ayrı ayrı analiz edilmiştir. Oluşturulan tasarımların analiz edilmesiyle ortaya çıkan betonarme taşıyıcı sistemlere ait metrajlar hesaplanmıştır. Her iki yapı modeli üzerinde maliyet hesaplamaları karşılıklıklı olarak irdelenmiştir. Dolayısıyla, bu tür yapıların güvenlik ve maliyet dengesini nasıl sağlanabileceği konusunda önemli bulgular elde edilmiştir. Böylece, deprem bölgelerinde betonarme yapıların maliyetlerinin nasıl optimize edilebileceği ve hangi faktörlerin maliyetleri etkilediği konusunda bir perspektif ortaya çıkmıştır.

Anahtar Kelimeler – Deprem , Betonarme Yapı , İdeCAD , Metraj, Maliyet

Giriş

Türkiye, coğrafi konumu nedeniyle tarih boyunca birçok yıkıcı depreme maruz kalmış bir ülkedir. Üç ana fay hattının (Kuzey Anadolu, Doğu Anadolu ve Batı Anadolu fay hatları) kesişim noktasında bulunan Türkiye, büyük depremlerin sıkça yaşandığı bir bölgedir. Örneğin Kuzey Anadolu Fayı, Türkiye'nin en aktif ve en tehlikeli fay hatlarından biridir. Bu fay hattında meydana gelen en büyük depremlerden biri, 1939 Erzincan Depremi'dir. 27 Aralık 1939'da meydana gelen bu deprem, Ms 7.8 büyüklüğünde olup 32.000'den fazla kişinin ölümüne ve 100.000'den fazla kişinin yaralanmasına neden olmuştur. Bir diğer önemli deprem ise, 17 Ağustos 1999 tarihinde İzmit (Kocaeli) şehrinde meydana gelen Ms 7.6 büyüklüğündeki depremdir. Bu depremde 17.000'den fazla kişi hayatını kaybetmiş ve 50.000'den fazla kişi yaralanmıştır. Doğu Anadolu Fayı, Türkiye'nin doğusunda yer alan önemli bir fay hattıdır. Bu fay üzerinde belgelenmiş en büyük deprem, 1905 yılında merkezi kısımda meydana gelen Ms 6.8 büyüklüğündeki depremdir. Ancak, 6 Şubat 2023 tarihinde güney Türkiye'de, Suriye sınırına yakın bir bölgede meydana gelen Ms 7.8 büyüklüğündeki deprem, Doğu Anadolu Fay Hattı üzerindeki en büyük ve yıkıcı depremlerden biri olmuştur. Bu depremi, 9 saat kadar sonra, bir önceki merkez üssünden yaklaşık 90 km kuzeyde meydana gelen Ms 7.5 büyüklüğündeki bir başka deprem izlemiştir [8-11] . Batı Anadolu, genişleme rejimi altında olan bir bölgedir ve burada da birçok büyük deprem meydana gelmiştir. Bu bölgedeki depremler genellikle daha düşük şiddetlerde olsa da, 1999 Düzce Depremi (Ms 7.2) gibi önemli sismik olaylar yaşanmıştır. Bu deprem, önemli seviyede can kaybı ve binlerce yaralanma vakası meydana gelirken, doğrudan ya da dolaylı olarak mal kaybı ve ekonomik olumuzluklar meydana gelmmiştir [13].

Gerçekleşen bu olaylar üzerine gelecekte yaşanması muhtemel olan afetlere karşı, depreme dayanıklı yapı tasarımı ve inşaat uygulamaları konusunda kapsamlı düzenlemelerin gerçekleştirilmesi zorunlu hale gelmektedir. Yürürlükte olan Deprem Bölgelerinde Yapılacak Binalar Hakkındaki yönetmelik, deprem anında can ve mal kaybını en aza indirmek amacıyla, betonarme yapılarda uygulanması gereken standartları ve kriterleri belirlemektedir. Yönetmelik, çeşitli deprem yer hareket düzeylerini ve bu düzeylere karşılık gelen tasarım spektrumlarını belirlemektedir. Bu düzeyler, yapıların maruz kalabileceği olası deprem etkilerine karşı gerekli tasarım ihtiyacının karşılanması hususunda hem yol gösterici hem de sıırlandırıcı konumda bulunmaktadır.

Yönetmelik, deprem yer hareket düzeylerini dört ana kategoriye ayırmaktadır: BDD-1 (Deprem Düzeyi 1): Çok nadir görülen, büyük depremler için tasarım düzeyi. DD-2 (Deprem Düzeyi 2): Nadir görülen, fakat ciddi hasar potansiyeli olan depremler için tasarım düzeyi. DD-3 (Deprem Düzeyi 3): Daha sık görülen, orta büyüklükte depremler için tasarım düzeyi. DD-4 (Deprem Düzeyi 4): En sık görülen, küçük depremler için tasarım referans düzeyleridir. [3]

Bu çalışma kapsamında, Sakarya ili Ferizili ilçesinde bulunan mevcut bir betonarme yapının ideCAD paket proramın vasıtasıyla üç boyutlu modeli oluşturulmuştur. Oluşturulan model hem (Deprem düzeyi 1) DD-1, (Deprem düzeyi 2) DD-2 referans alınarak modellenmiştir. İki modelin de, taşıyıcı sistem metrajları hazırlanmış ve 2 farklı durumdan elde edilen verilerle yapı metrajı ile birlikte kullanım alanındaki değişiklikler de hesaplanmıştır. Tasarımda DD-1 dikkate alındığında meydana gelen kullanım alanı kayıpları ve ek maliyetler incelenmiştir. Maliyeti teşkil eden parametreler malzeme ve işçilik giderleri olarak 2 ana başlığa ayrılabilir. İşçilik konusu her iki modelleme de de benzer olduğundan her iki durumda da yaklaşık aynı kalacaktır. Malzeme kısmı ise kendi içerisinde kaba inşaat ve ince inşaat olarak 2 başlığa ayrılmaktadır. İnce inşaattaki maliyet kalemleri her iki modellemede de işçilikte olduğu gibi benzer maliyetlere sebep olmaktadır. Ancak kaba inşaat olarak adlandırılan kısım doğrudan yapının betonarme taşıyıcı sistemini temsil etmektedir. Bu taşıyıcı sistem ana bileşen olarak demir ve beton malzemelerden oluşmaktadır. Bu sebeple her iki model de ideal bir değerlendirme yapabilmek için, olası maliyet farklılıklarına sebebiyet verecek olan, donatı ve beton metrajları açısından karşılaştırılarak değerlendirilmiştir.

Sayısal Model ve Analizler

Bu bölümde çalışmada kullanılacak olan paket program ile bilgiler verilmektedir. Ayrıca binanın statik özellikleri ve deprem düzeyleri hakkında da değerlendirmeler yapılmıştır.

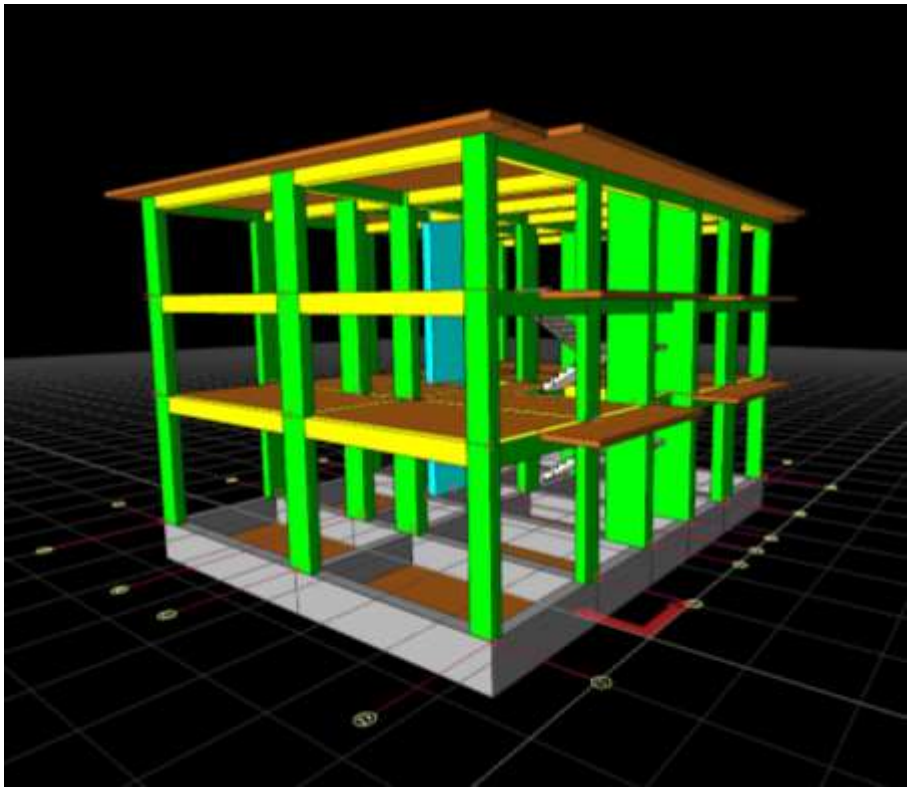
Deprem Düzeyleri

1900 yılından günümüze kadar ülkemizde birçok deprem meydana gelmiştir. Bu depremler sonucu oluşan hasarlar dikkate alınarak deprem haritaları oluşturulmuştur. Türkiye'de ilk olarak 1945 yılında hazırlanan deprem haritasında iki deprem bölgesi öngörülmüştür. Zaman içinde meydana gelen depremler ve gelişen deprem mühendisliği sayesinde bu haritalar yenilenmiştir. İlk değişiklik 1949 yılında yapılmış ve ardından 1963, 1972 ve 1999 yıllarında revizyonlar gerçekleştirilmiştir. En son olarak 2018 yılında yayınlanan Türkiye Bina Deprem Yönetmeliği ile deprem tehlike haritası güncellenmiştir. Yeni haritada, maksimum yer ivme değerlerine göre yeni bir deprem tehlike haritası oluşturulmuştur. Bu harita incelendiğinde, Konya, Karaman ve İçel illerinin deprem tehlikesi açısından en düşük risk taşıyan bölgeler olduğu görülmektedir. Deprem tehlikesi en yüksek olan bölgeler ise Van Gölü'nden başlayıp, Marmara Denizi ve Çanakkale Boğazı'nı kapsayan Kuzey Anadolu Fayı ile Ege Bölgesi'nin önemli bir bölümünü içermektedir. Bu bölgeler coğrafi, ekonomik ve nüfus açısından önemli alanlardır. [2]

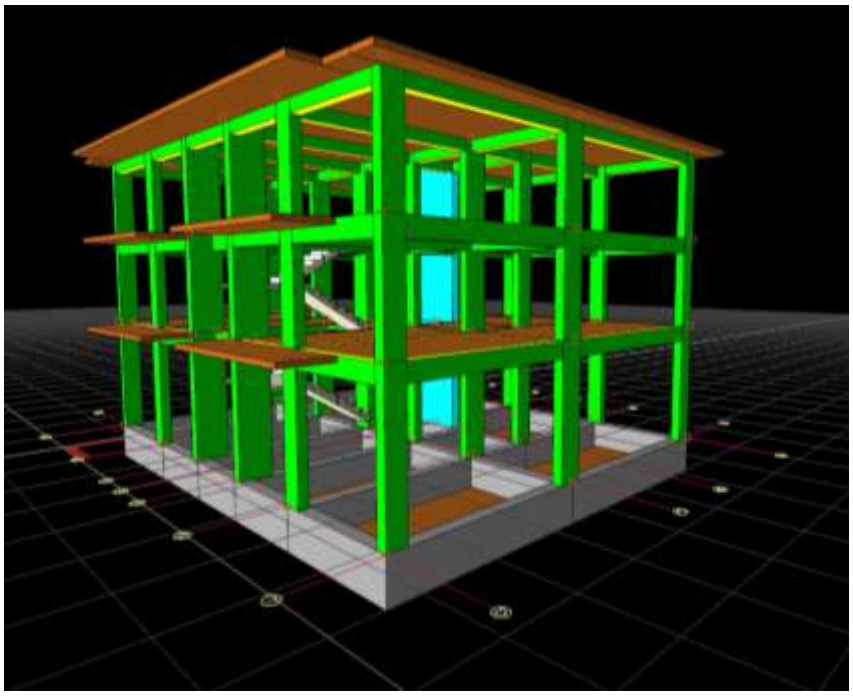
Yeni yönetmelik ile deprem yer hareketi düzeyleri, deprem tasarım sınıflarına göre yeni yapılacak veya mevcut binalar için performans hedefleri ve uygulanacak değerlendirme/tasarım yaklaşımlarının belirlenmesinde kullanılmaktadır. 2007 deprem yönetmeliğinde önceden de kullanılan tasarım depremi altında can güvenliği performans hedefi tanımlaması uygulanmaydı. Söz konusu tasarım depremi 2018 yönetmeliğinde DD-2 deprem düzeyine karşılık gelmektedir. Konut türü yapılarda DD-2 deprem düzeyi için, can güvenliğine karşılık için Kontrollü Hasar Performans Düzeyi tanımlanmaktadır. Dolayısıyla binaların kullanım amaçlarına bakılarak deprem düzeylerinin seçimleri tanımlanmalıdır [4-5].

İdeCAD (V10) Paket Programı

İdeCAD paket programı, yapı sistemlerinin yönetmeliklere uygun modelleme ve analiz işlemlerini yapmak ve tasarım işlemini gerçekleştirmek için kullanılmakta olan bir programdır. Program kapsamında modelleme işlemleri, sonlu elemanlara göre analiz işlemleri, TBDY 2018 ve TS500 yönetmeliklerine göre tasarım kontrolü, performans değerlendirmesi ve güçlendirme çalışmaları yapılabilmektedir. Aynı zamanda rijit diyaframlı, rijit diyaframsız veya kısmen rijit diyaframlı yapıların analiz işlemleri de gerçekleştirilebilmektedir. Taşıyıcı yapı elemanları olan perde, kolon, kiriş, döşeme ve temel elemanlarının hepsinin analizi aynı anda bütünleşik olarak yapılabilmektedir. Yapılan modellemelerde donatı olarak B420C nervürlü inşaat çeliği, beton olarakta betonarme binaların yapımında kullanımı oldukça yaygın olan C25 sınıfı beton kullanılmıştır. Yapısal modellemelere ait görsellerden şekil 1'de DD-1, Şekil 2'de de DD-2 referanslı modellere ait 3 boyutlu görünümler görülmektedir.



Şekil 1. Betonarme yapının DD-1 e göre modellenmiş olan statik Model



Şekil 2. Betonarme yapının DD-2 e göre modellenmiş olan statik Model

Sonuçlar

Her iki modelde de aynı taban oturum alanı, vaziyet planı ve döşeme yapılanması bulunmaktadır. Yapı tasarımında düşey taşıyıcı elemanlar, kullanım alanlarını etkileyen önemli bir faktördür. Her bir taşıyıcı

eleman, içinde bulunduğu hacimde bir alan kaybına neden olmaktadır. Bu nedenle, bu iki model arasında sınırlı farklılıkların olduğu net kullanım alanlarını dikkate almamız gerekmektedir.

Çalışmanın kapsamı, sadece metraj hesaplamalarıyla sınırlı kalmamakta, aynı zamanda net kullanım alanları arasındaki farklılıkları da ele almaktadır. Bu bağlamda, kolon alanları hesaplanmıştır. Ancak, betonarme sistem içindeki düşey taşıyıcıların toplam kesit alanları, DD-1 modeline göre oluşturulan ile DD-2 modeline göre oluşturulan arasında karşılaştırılmıştır.

Düşey taşıyıcı kesit alanları arasındaki fark oldukça sınırlı düzeyde kalmıştır. Bu fark, ekonomik açıdan önemsizdir ve değerlendirme sürecinde dikkate alınmamıştır, çünkü belirgin bir ekonomik etkiye yol açmamaktadır.

Fark, metraj ve maliyet açısından ele alındığında, DD-1'e göre modellenen betonarme yapının beton metrajı 321.4 m³, DD-2'ye göre modellenen betonarme yapının beton metrajı ise 307.1 m³ olarak belirlenmiştir. İki model arasındaki beton metraj farkının %4.65 seviyesinde olduğu tespit edilmiştir. Donatı açısından benzer bir hesaplama yapıldığında, DD-1'e göre modellenen betonarme yapının donatı metrajı 37286.6 kg, DD-2'ye göre modellenen betonarme yapının donatı metrajı ise 32321.1 kg olarak hesaplanmıştır. İki model arasındaki donatı metraj farkının %15.7 seviyesinde kaldığı belirlenmiştir (Tablo 1-3).

Tablo 1. DD1'e göre modellenen yapıya ait metraj verileri

	Beton Metrajı (m^3)	**Donatı Metrajı (kg)**
2. kat	73.116	7265.88
1. kat	62.718	7834.59
Zemin kat	185.600	22186.08
Toplam	321.433	37286.55

Tablo 2. DD2'e göre modellenen yapıya ait metraj verileri

	Beton Metrajı (m^3)	**Donatı Metrajı (kg)**
2. kat	69.188	7563.8
1. kat	59.019	7014.67
Zemin kat	178.900	18742.59
Toplam	307.107	33321.06

Tablo 3. Her iki yapıya ait metraj verilerin arasındaki fark

	Beton Metrajı (m^3)	**Donatı Metrajı (kg)**
DD-1	321.433	37286.55
DD-2	307.107	33321.06
Fark	14.326	3965.49

Betonarme yapıların imalatında, malzeme ve işçilik olmak üzere iki ana kalemde harcama yapılmaktadır. Bu çalışma kapsamındaki değişkenler, işçilik açısından herhangi bir farklılık yaratmamaktadır ve bu nedenle işçilik açısından hesaplama yapılmamıştır.

Yapılan saha incelemesi sonucunda, Haziran 2024 itibarıyla beton fiyatının 3050 TL/m³ ve donatı fiyatının ise 24 TL/kg olduğu belirlenmiştir. Toplam maliyet her iki durum için de hesaplanmıştır. Elde vedilen verilerin DD-1'e göre olanları Tablo 4'de, DD-2'ye göre olanları ise Tablo 5'de toplu olarak verilmiştir.

Tablo 4. DD1'e göre modellenen yapıya ait maliyet hesabı

	Toplam Metraj	**Birim Fiyat**	**Toplam Tutar (TL)**
Toplam Beton Metrajı (m3)	321.344	3050	980099.2
Toplam Donatı Metrajı (kg)	37286.55	24	894877.2
TOPLAM			1874976,4

Tablo 5. DD2'e göre modellenen yapıya ait maliyet hesabı

	Toplam Metraj	**Birim Fiyat**	**Toplam Tutar (TL)**
Toplam Beton Metrajı (m3)	307.107	3050	936676.35
Toplam Donatı Metrajı (kg)	33321.06	24	799705.44

TOPLAM	1736381.79

İki farklı tasarım yaklaşımı arasındaki maliyet farkı 138594,6 TL seviyesinde kalmaktadır. Bu fark, toplam taşıyıcı sistem malzeme maliyetine oranlandığında %7,4'lük bir maliyet farkı ortaya çıkmaktadır. Özel istek ve tasarımlara sahip yapılarda, imalata önemli harcamalar yapılabilmektedir. Bu bağlamda, bu tür yapının daha dayanıklı olarak tasarlanmasının ortaya çıkan maliyet farkının oldukça sınırlı olduğu görülmektedir. Bu nedenle, betonarme bir yapı olarak tasarlanacak yapıların sahipleri, hizmet alımı sürecinde bu durumu göz önünde bulundurarak minimum kriterlere bağlı kalmak yerine can ve mal güvenliği açısından faydalı olabilecek iyileştirmeleri tercih etmelidirler.

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A review of the mixing of oil and ethanol to produce biodiesel

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Abstract **–** Different microfluidic devices can be employed to produce biodiesel. This review paper examines the micromixers used to improve the mixing quality of oil and ethanol utilizing passive and active techniques. Various geometries are considered and the influences of crucial parameters are evaluated. This review demonstrates that various parameters affect the production rate of biodiesel. These factors include microreactor geometry, oil/ethanol(methanol) molar ratio, operating condition (particularly temperature), inlet flow rate, etc. It can be expressed that more numerical assessments are required to provide a comprehensive understanding of biodiesel production using microreactors.

Keywords – Microfluidics, Micromixer, Oil, Ethanol, Biodiesel

I. INTRODUCTION

The biodiesel is produced by using a transesterification reaction [1]. Different microfluidic devices have been used to synthesize biodiesel [2-7]. These devices have considered the influences of geometrical variables, type of materials, and operating conditions on the synthesis process. Since the mixing process is considered in this review paper, relevant governing equations are presented in the following.

The steady governing equations, including continuity and Navier-Stokes equations, for incompressible and Newtonian fluids are:

$$\nabla \cdot \vec{V} = 0 \tag{1}$$

$$\rho\left(\vec{V} \cdot \nabla \vec{V}\right) = -\nabla P + \mu \nabla^2 \vec{V} \tag{2}$$

where $\vec{V}$, ρ, μ, and P represent velocity, density, dynamic viscosity, and pressure, respectively.

The convection-diffusion transport equation is:

$$\frac{\partial C}{\partial t} + \vec{V} \cdot \nabla C = D \nabla^2 C \tag{3}$$

where C and D are the concentration and molecular diffusivity, respectively. Besides, the mixing index (MI) is calculated as:

$$MI = \left(1 - \left(\sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(\frac{c_i - \bar{c}}{\bar{c}}\right)^2}\right)\right) \times 100 \tag{4}$$

where c_i is the local concentration and $\bar{c}$ is the average amount of c_i. N is the total number of grid points in a desired cross-section.

II. Biodiesel Production

In this section, the recent advances in the field of biodiesel production are outlined and some particular aspects are introduced. Schematics of the micromixer used are compared.

Numerous researchers have examined biodiesel production [8-16]. For example, Santana et al. [1] utilized a static micromixer to produce biodiesel (Fig. 1). They compared the micromixer performance with a T-shaped micromixer when the Reynolds number (Re) changed from 0.1 to 100. The molar ratio of oil to ethanol was 6/12. They found that the maximum mixing index can be found at Re = 100. The optimal value of oil conversion was 91.53%, corresponding to an ethanol/oil molar ratio of 9.

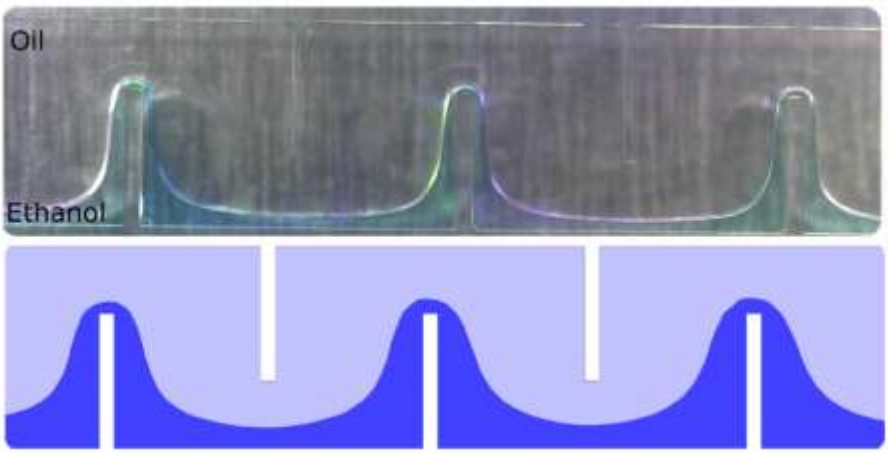

Fig. 1 Comparison between numerical and experimental results of Santana et al. [1].

Guan et al. [3] examined the mixing process of sunflower oil and ethanol in a microtube reactor (Fig. 2). They reported that four factors, including the length and diameter of the microtube, the molar ratio of two liquids, and reaction temperature, affect the process. They assessed the relation between the oil conversion and flow pattern in the microtube.

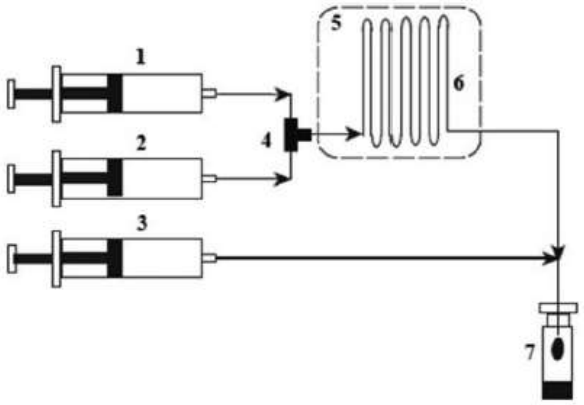

Fig. 2 Experimental setup employed by Guan et al. [1].

Wen et al. [4] utilized a zigzag microchannel to synthesize biodiesel (Fig. 3). They observed that higher mixing efficiency can be obtained by reducing the channel size (decreasing the hydraulic diameter) and enhancing the channel turns because small droplets are generated, leading to better mixing process. They showed that the energy cost of their proposed micro-reactor is less than stirrer reactors; hence, it can be employed in practical applications.

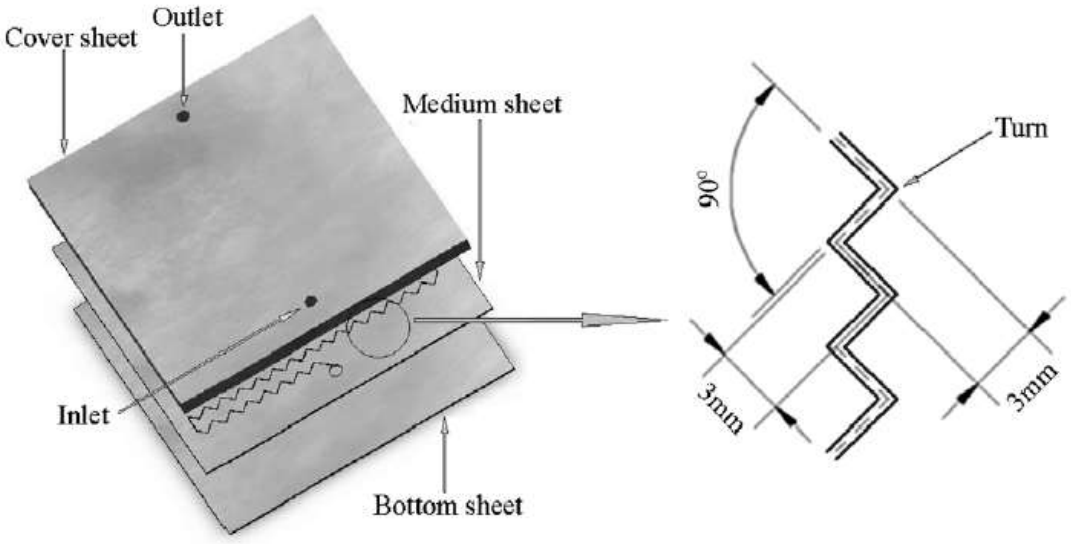

Fig. 3 Zigzag microchannel reactor [4].

Edgar et al. [9] considered three geometries to assess the impact of temperature, structure, ethanol/caster oil molar ratio, etc. on biodiesel production. They found that the geometry of the microreactor plays a crucial role in synthesizing biodiesel. Between their proposed microreactor, the Tesla-shaped one resulted in maximum efficiency compared to T-shaped and omega-shaped ones.

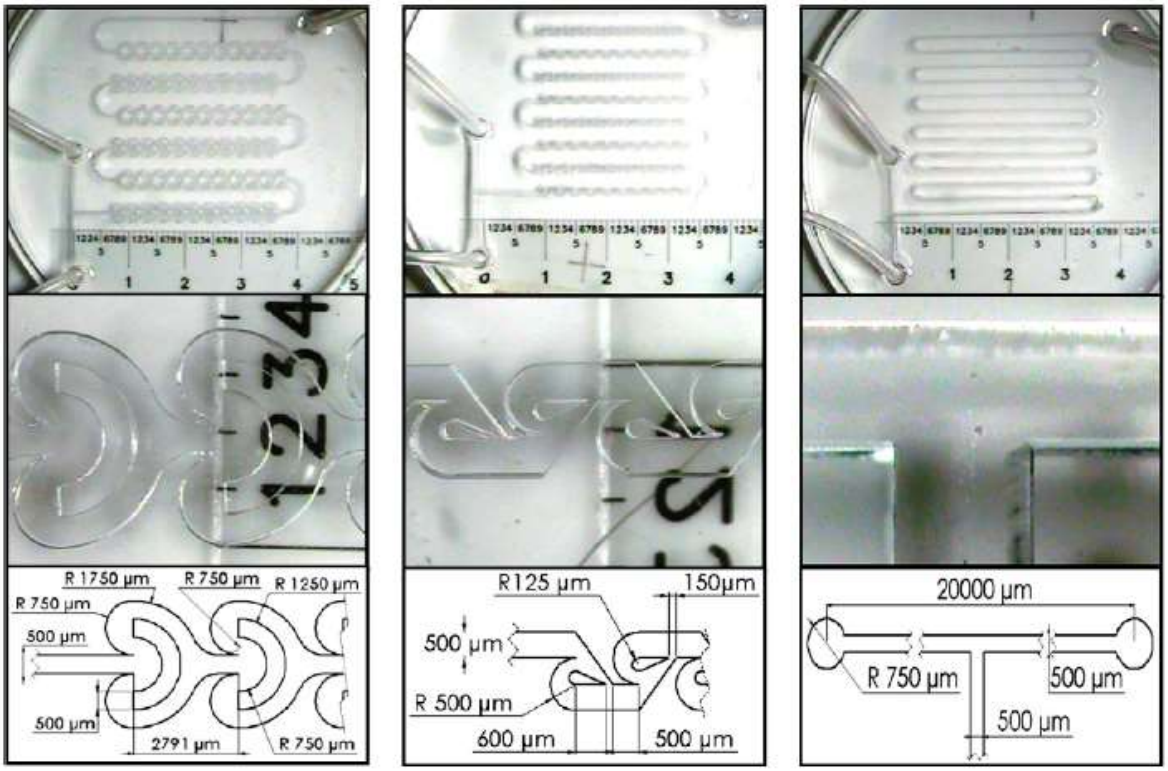

Fig. 4 Three types of microreactors used to produce biodiesel [9].

Aghel et al. [10] utilized a wire coil to enhance the rate of biodiesel production (Fig. 5). They used soybean oil and methanol solution with different molar ratios. They evaluated the impact of microreactor

geometry and operating conditions on the mixing process and reached a reaction efficiency of 99% when the residence time was 180 s for an optimal case.

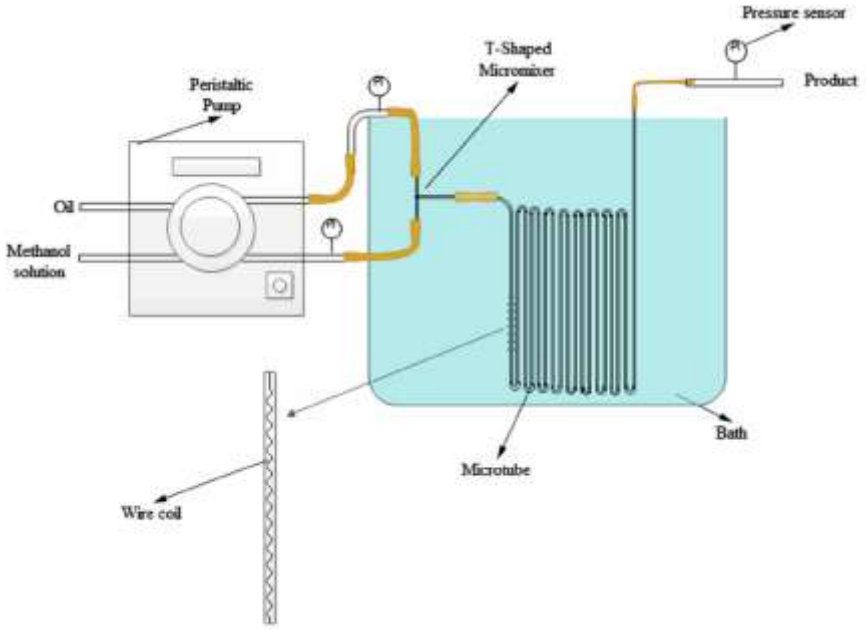

Fig. 5 Using a wire coil to enhance the rate of biodiesel production [10].

III. CONCLUSION

The biodiesel is produced by using a transesterification reaction. Different microfluidic devices have been used to synthesize biodiesel. This review paper examines the micromixers used to improve the mixing quality of oil and ethanol utilizing passive and active techniques. Various geometries are considered and the influences of crucial parameters are evaluated. This review demonstrates that various parameters affect the production rate of biodiesel. These factors include microreactor geometry, oil/ethanol(methanol) molar ratio, operating condition (particularly temperature), inlet flow rate, etc. It can be expressed that more numerical assessments are required to provide a comprehensive understanding of biodiesel production using microreactors.

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The impact of fixed capital, trade openness and renewable energy on environmental degradation in G7 countries

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Abstract – This study tests the impact of fixed capital, trade openness and renewable energy use on environmental degradation in G7 countries over the period 1990-2019. The study estimates a model of CO2 emissions with new panel data techniques. In the empirical estimations obtained, it is seen that the cross-sectional dependence and slope heterogeneity are in the panel data. There is a cointegration between the series. Panel AMG estimates indicate that the use of renewable energy reduces CO2 emissions and thus environmental degradation. Fixed capital and trade openness play an encouraging role. Panel causality findings, on the other hand, point to a two-way causality between fixed capital, trade openness and renewable energy use and CO2 emissions. The findings of the study imply that environmental degradation can be combated by providing important recommendations to policymakers regarding renewable energy sources.

Keywords – CO2 emissions, Renewable energy, G7 countries, Panel AMG, Causality

I. INTRODUCTION

G7 economies provide a significant part of the world's population and national income, as well as being responsible for a large part of CO2 emissions. For this reason, combating environmental pollution is among the most important strategic goals of the G7 economies. Data from BP (2022) confirm this development.

The literature focuses on different variables as determinants of CO2 emissions. For example; financial development (Bui, 2020), renewable energy use (Charfeddine and Kahia, 2019), globalization (Zaidi et al., 2019), ICT (N'dri et al., 2021) and human capital (Yao et al., 2020) are among these determinants.

This study intensifies the following research questions: 1) Does the use of renewable energy play a role in preventing environmental degradation in G7 countries? 2) How do fixed capital and trade openness affect environmental degradation in these economies? 3) What kind of policy recommendations are needed to prevent environmental degradation?

In this context, the study has a feature that can make some contributions to the literature. First of all; Following many studies in the literature, it prefers CO2 emissions to represent environmental degradation. Therefore, it estimates the CO2 emissions model for G7 economies by taking fixed capital, trade openness and renewable energy use as explanatory variables. Secondly; The relationship between variables is analyzed with the help of new panel techniques such as Westerlund cointegration, panel AMG estimation technique and Dumitrescu-Hurlin panel causality approach. Thirdly; A negative renewable energy coefficient means that renewable energy sources can be used effectively to prevent environmental degradation. Thus, it will be possible to develop policy recommendations for the G7 economies.

The second part of the study focuses on the model, data and methodology, while the third part presents the empirical findings and discussion. Finally, the study concludes with a section on conclusion and policy recommendations.

II. MATERIALS AND METHOD

This study, which is a balanced panel data, analyzes the relationship between fixed capital, trade openness and renewable energy use and CO_2 emissions. CO_2 emissions, which are the criterion of environmental pollution, characterize the dependent variable, while fixed capital, trade openness and renewable energy use characterize the explanatory variables. The relationship between the variables can be estimated by a linear panel data equation as follows:

$$lnCO_{2it} = \alpha + \gamma_1 lnFC_{it} + \gamma_2 lnTR_{it} + \gamma_3 lnREN_{it} + \varepsilon_{it} \quad (1)$$

In the equation above, α is the constant term, ε is the error term, and , γ_1, γ_2, and γ_3 are the coefficients. These coefficients are also known as elasticity coefficients as each variable's logarithm is taken and included in the analysis. In the study, in which panel data for the 1990-2019 period were used, it is possible to find detailed information about what each variable means, its criteria and sources from Table 1.

Table 1. Descriptions of variables

Variables	Symbol	Measure	Source
CO_2 emissions	CO_2	Million tonnes	OECD
Fixed capital	FC	Gross fixed capital formation (% of GDP)	WDI
Trade openness	TR	Trade (% of GDP)	WDI
Renewable energy use	REN	Renewable energy supply (% of primary energy supply)	OECD

The panel data methodology used in the study can be explained as follows. First of all; Cross-sectional dependency and slope heterogeneity analysis are performed, which can help determine what the basic tests to be used in the future may be. For the first analysis, Pesaran (2004) CD test is used, and for the second analysis, Pesaran-Yamagata (2008) approach is used. Secondly; The stationarity properties of the variables are investigated with the help of the CADF test of Pesaran (2007). Thirdly; The presence of cointegration is analyzed by two tests of Westerlund (2005; 2007). Fourthly; Long-term predictions of each variable are made with Eberhard-Teal (2011)'s panel AMG estimator. Finally; In particular, the results obtained from long-term forecasts are switched to causality analysis, which helps to determine policy trends. For this purpose, the Dumitrescu-Hurlin (2012) causality approach is included.

3. EMPIRICAL RESULTS AND DISCUSSION

In the context of the findings, descriptive statistics can be looked at first. There is a panel data with a total of 210 observation values for the period 1990-2019. Table 2 shows that the highest mean value belongs to $lnCO_2$ and the lowest average value belongs to lnREN. The correlation status of the variables is shown in Table 3. At first glance, lnTR and lnREN are negatively correlated with $lnCO_2$. On the other hand, there is a negative correlation between lnFC and $lnCO_2$.

Table 2. Descriptive statistics

	$lnCO_2$	lnFC	lnTR	lnREN
Mean	2.882	1.327	1.650	0.756
Median	2.729	1.322	1.702	0.768
Std. dev.	0.382	0.064	0.188	0.359
Min.	2.467	1.194	1.198	-0.318
Max.	3.758	1.550	1.947	1.258
Skewness	1.283	0.728	-0.667	-0.674
Kurtosis	3.486	4.254	2.459	3.242
Obs.	210	210	210	210

Table 3. Correlation matrix

	$lnCO_2$	lnFC	lnTR	lnREN
$lnCO_2$	1.000			
lnFC	0.232	1.000		
lnTR	-0.684	-0.519	1.000	
lnREN	-0.196	-0.084	0.385	1.000

Table 4 shows the findings associated with cross-sectional dependence. Pesaran test results indicate the presence of cross-sectional dependency for each variable. Table 5 gives the outputs related to slope heterogeneity. The outputs prove that there is a slope heterogeneity, and therefore the existence of a heterogeneous panel state. These results also shape the tests that can be applied in future predictions.

Table 4. Cross-sectional dependence

Variables	Pesaran CD	
	Statistic	Prob.
$lnCO_2$	7.47	0.000
lnFC	2.25	0.025
lnTR	17.06	0.000
lnREN	12.80	0.000

Table 5. Slope-heterogeneity

Test statistics	t-statistics	p-value
$\tilde{\Delta}$	14.582	0.000
$\tilde{\Delta}_{adj.}$	15.974	0.000

The outputs obtained from the CADF test used for unit root analysis are presented in Table 6. The outputs show that each variable becomes stationary when the first difference is taken, so the degree of integration of the variables is 1. After that, the cointegration analysis stage is started. Table 7 presents the findings of Westerlund's two cointegration tests. The results show evidence for the existence of a cointegration between the variables.

Table 6. CADF findings

Variables	Constant	
	$I(0)$	$I(1)$
$lnCO_2$	-2.008	-4.331^{***}
lnFC	-1.750	-3.026^{***}
lnTR	-2.131	-2.609^{**}
lnREN	-1.028	-3.647^{***}

Note: *** and ** show significance at 1% and 5% level, respectively.

Table 7. Cointegration findings

Panel A. Westerlund (2007)	Value	*z*-value	Robust *p*-value
Gt	-2.740	-0.111	0.380
Ga	-10.353	1.704	0.120
Pt	-7.425*	-0.965	0.070
Pa	-9.253	1.012	0.190
Panel B. Westerlund (2005)		Statistic	*p*-value
Variance ratio		-1.484*	0.068

Note: * shows significance at 10% level.

With the determination of cointegration, the coefficient estimations of the variables are started and the results obtained are reported in Table 8. Initial findings determine the lnFC coefficient (0.123) as positive and significant. 1% increase in fixed capital supports CO_2 emissions by 0.123%. In addition, the lnTR coefficient (0.093) is also determined as positive and significant. This finding can be interpreted to mean that a 1% increase in trade openness would result in a 0.093% increase in CO_2 emissions. Finally; Since the lnREN coefficient (-0.120) is negative and significant, it can be explained that a 1% increase in the use of renewable energy causes a 0.120% decrease in CO_2 emissions.

Table 8. AMG findings

Regressors	Coefficients	Std. err.	p-value
lnFC	0.123*	0.070	0.079
lnTR	0.093***	0.032	0.004
lnREN	-0.120***	0.044	0.006
Constant	2.635***	0.177	0.000
Wald χ^2	18.88		
Prob.	0.000		
RMSE	0.009		
Observation	210		
Number of countries	7		

Note: ***and * denote significance at 1% and 10% level, respectively.

The final findings of the study are related to causality analysis, as can be seen from Table 9. The findings point to a two-way causality between fixed capital and CO_2 emissions. A two-way causality is also found between trade openness and CO_2 emissions. In addition, there is a bidirectional causality between the use of renewable energy and CO_2 emissions.

Table 9. Panel causality analysis

Null Hypothesis	W-stat.	Zbar-stat.	p-value	Causality
lnFC ≠> $lnCO_2$	3.322	1.780*	0.080	Two-way
$lnCO_2$ ≠> lnFC	3.994	2.638***	0.008	
lnTR ≠> $lnCO_2$	4.140	5.876***	0.000	Two-way
$lnCO_2$ ≠> lnTR	3.030	3.798***	0.000	
lnREN ≠> $lnCO_2$	6.101	9.544***	0.000	Two-way
$lnCO_2$ ≠> lnREN	3.832	5.299***	0.000	

Note: ***and * denote significance at 1% and 10% level, respectively.

4. CONCLUSION AND POLCY IMPLICATIONS

The study empirically investigates the effects of fixed capital, trade openness and renewable energy use as determinants of CO_2 emissions on environmental degradation for G7 economies in the period 1990-2019. It uses the CADF test for unit root analysis, Westerlund tests for cointegration analysis, the AMG approach for long-term forecasts and the Dumitrescu-Hurlin technique for causality analysis.

The study supports the existence of a cointegration, that is, a long-term relationship between the variables. Empirical evidence suggests that fixed capital increases CO_2 emissions. Similarly, trade openness plays a role in incentivizing CO_2 emissions. On the contrary, the use of renewable energy serves to reduce CO_2 emissions. Thus, just as the first two variables fuel environmental degradation, the last variable improves environmental degradation.

The study reveals a bidirectional causality between fixed capital, trade openness and the use of renewable energy and CO_2 emissions. These findings support long-term predictions. In other words, fixed capital, trade openness and the use of renewable energy can be considered as determinants of CO_2 emissions, that is, environmental degradation. Therefore, policymakers should take measures to encourage the supply and use of renewable energy, and implement practices that will minimize this impact, as fixed capital investments and trade openness fuel environmental degradation.

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Incorporating Plastic Aggregates in Concrete: Effects on Workability, Strength, and Durability Properties

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Abstract – This study investigates the use of plastic waste as a partial replacement for natural aggregates in concrete, addressing both environmental concerns and construction industry sustainability. Plastic aggregates derived from PET and HDPE waste were incorporated into concrete mixtures at 0%, 10%, 20%, and 30% replacement levels by volume. The research examined the effects on workability, compressive strength, tensile strength, water absorption, and porosity. Results showed that increasing plastic aggregate content improved workability, with a 30% replacement leading to a 46.7% increase in slump. However, mechanical properties decreased, with compressive and tensile strengths reducing by up to 33.7% and 34.4%, respectively, at 30% replacement. Water absorption decreased with higher plastic content, while porosity increased. The study concludes that a 10% replacement offers the best balance between improved workability and acceptable strength reduction for general applications. Higher replacement levels may be suitable for non-structural uses. This research contributes to the development of sustainable concrete solutions and effective plastic waste management strategies.

Keywords – Plastic aggregate concrete, Strength Properties, Water absorption, Workability.

I. INTRODUCTION

With a projected 380 million metric tons of plastic trash created yearly as of 2023, the global plastic waste epidemic has reached previously unheard-of heights [1, 2]. This startling statistic highlights the critical need for creative approaches to waste management and recycling of plastic materials. Concurrently, there is a challenge and an opportunity to solve environmental issues posed by the building sector, which contributes nearly 40% of global carbon emissions [3]. The most popular building material in the world, concrete, uses a tremendous amount of natural resources. The manufacturing of cement alone accounts for almost 8% of global CO_2 emissions. Given this, managing plastic waste and reducing the high carbon footprint of building materials are two major environmental challenges that might be addressed concurrently by using plastic waste as aggregates in concrete. The circular economy and waste valuation concepts are in line with the idea of employing plastic aggregates in concrete [4]. By reusing plastic garbage that might otherwise wind up in landfills or the ocean, this method not only lessens pollution in the environment but also preserves natural resources that are often utilized as aggregates for concrete. Research on the performance and viability of concrete using plastic aggregates has exploded in the past several years [5]. Numerous forms of plastic trash have been investigated in studies, such as mixed plastic waste, polyvinyl chloride (PVC) from construction debris, high-density polyethylene (HDPE) from containers, and polyethylene terephthalate (PET) from bottles. These studies have provided

information on how plastic aggregates affect the strength, workability, durability, and thermal insulation of concrete. While there are many advantages to using plastic aggregates in concrete, there are also certain issues that need to be addressed. These include making certain that the plastic aggregates are uniformly of high quality, strengthening the connection between the plastic particles and the cement paste, and taking care of any possible issues with long-term durability [6].

The purpose of this article is to provide a thorough summary of the status of the research on the use of flexible aggregates in concrete. This article will examine the many kinds of plastic garbage that are used, how they affect the characteristics of concrete, durability issues, and the possible environmental benefits of this creative method. The essay will also go over the obstacles to the widespread use of plastic aggregate concrete and point out potential directions for further study and advancement.

II. Materials and Method

II.1. Materials

II.1.1. Cement:

Ordinary Portland Cement (OPC) conforming to ASTM C150 Type I was used as the primary binder. The cement had a specific gravity of 3.17 and a Blaine fineness of 350 m^2/kg.

II.1.2. Natural Aggregates:

- Fine Aggregates: We used Oued sand, which has a specific gravity of 2.65 and a fineness modulus of 2.8.
- Coarse Aggregates: We used crushed limestone with a maximum size of 20 mm, a specific gravity of 2.70, and a water absorption of 0.6%.

II.1.3. Plastic Aggregates:

Two types of plastic waste were processed into aggregates:

- PET (Polyethylene Terephthalate): Obtained from post-consumer plastic bottles.
- HDPE (High-Density Polyethylene): Obtained from discarded containers and pipes.

We cleaned, shredded, and processed the plastic waste to achieve particle sizes similar to the natural aggregates they were replacing.

II.1.4. Water:

Potable water free from impurities was used for mixing and curing.

II.1.5. Admixtures:

A polycarboxylate-based superplasticizer was used to maintain workability in mixes with higher plastic aggregate content.

II.2. Methods

II.2.1. Preparation of Plastic Aggregates:

- Sorting and Cleaning: Plastic waste was manually sorted to remove contaminants and washed with water.
- Shredding: A mechanical shredder was used to reduce the plastic to sizes ranging from 0.1 to 20 mm.
- Grading: Shredded plastic was sieved to match the gradation of the natural aggregates being replaced.

II.2.2. Mix Design:

A control mix was designed according to ACI 211.1 with a target compressive strength of 30 MPa at 28 days. Plastic aggregates were then used to replace natural aggregates in proportions of 0%, 10%, 20%, and 30% by volume. The water-cement ratio was kept constant at 0.50 for all mixes.

II.2.3. Mixing Procedure:

Concrete was mixed in a laboratory drum mixer. The mixing sequence was as follows:

1. Coarse aggregates and 50% of mixing water
2. Fine aggregates and plastic aggregates
3. Cement

4. Remaining water and superplasticizer

Mixing continued for 3 minutes, followed by a 2-minute rest, and a final 2 minutes of mixing.

II.2.4. Specimen Preparation:
- Cube specimens (100x 100 x100 mm) for compressive strength testing, water absorption and porosity.
- Prism specimens (100 x 100 x 400 mm) for tensile strength.

Specimens were cast in steel molds, compacted using a vibrating table, and cured in water at 20 ± 2°C until the testing age.

II.2.5. Testing Methods:
1- Workability: Slump test and flow table test.
2- Compressive Strength: Tested at 7, 28, and 90 days.
3- Tensile Strength, Water Absorption and Porosity: Tested at 28 days.

III. RESULTS

III.1 Workability

III.1.1. Slump Test
- Control Mix (0% plastic): 75.4 mm
- 10% Plastic Aggregate: 85.1 mm
- 20% Plastic Aggregate: 95.2 mm
- 30% Plastic Aggregate: 110.2 mm

The slump increased with higher percentages of plastic aggregate replacement, indicating improved workability. This can be attributed to the lower water absorption of plastic particles compared to natural aggregates.

III.1.2. Flow Table Test
- Control Mix (0% plastic): 450.0 mm
- 10% Plastic Aggregate: 475.0 mm
- 20% Plastic Aggregate: 500.5 mm
- 30% Plastic Aggregate: 530.5 mm

The flow diameter increased with higher plastic content, confirming the trend observed in the slump test. The smoother surface of plastic particles likely contributed to better flowability.

III.2 Compressive Strength

Table 1. Results of Compressive Strength

Mix	7 days	28 days	90 days
Control (0%)	22.5	31.2	35.8
10% Plastic	20.1	28.5	32.7
20% Plastic	17.3	24.9	28.6
30% Plastic	14.2	20.7	23.9

Compressive strength decreased with increasing plastic aggregate content. At 28 days, the reduction was approximately 8.7%, 20.2%, and 33.7% for 10%, 20%, and 30% replacement, respectively. The strength development pattern remained consistent across all mixes, with significant gains between 7 and 28 days, and slower increases from 28 to 90 days.

III.3 Tensile Strength

Table 2. Results of Tensile Strength

Mix	28 days	90 days
Control (0%)	3.2	3.6
10% Plastic	2.9	3.3
20% Plastic	2.5	2.9
30% Plastic	2.1	2.4

Tensile strength showed a similar trend to compressive strength, decreasing with higher plastic content. The reduction was approximately 9.4%, 21.9%, and 34.4% for 10%, 20%, and 30% replacement, respectively.

III.4 Water Absorption

Table 3. Results of Water Absorption (%)

Mix	28 days	90 days
Control (0%)	5.8	5.5
10% Plastic	5.2	4.9
20% Plastic	4.5	4.0
30% Plastic	3.9	3.7

Water absorption decreased with increasing plastic aggregate content due to the hydrophobic nature of plastic particles. This reduction in water absorption could potentially improve the durability of concrete in certain environments.

III.5 Porosity

Table 4. Results of Porosity (%)

Mix	28 days	90 days
Control (0%)	12.5	12.2
10% Plastic	13.2	13.0
20% Plastic	14.1	13.9
30% Plastic	15.3	15.1

Despite the decrease in water absorption, porosity increased with higher plastic aggregate content [7]. This can be attributed to the poor bond between plastic particles and cement paste, creating additional voids in the concrete matrix.

IV. DISCUSSION

The results demonstrate that incorporating plastic aggregates in concrete leads to improved workability but decreased strength properties. The reduction in compressive and tensile strength can be primarily attributed to the weak bond between plastic particles and cement paste, as well as the lower strength of plastic compared to natural aggregates [8].

The decreased water absorption with increased plastic content suggests potential benefits in terms of durability, particularly in environments where water ingress is a concern. However, the increased porosity indicates a more complex internal structure that may have implications for long-term durability and needs further investigation.

The trade-off between improved workability and decreased strength properties presents both challenges and opportunities. For non-structural applications where high strength is not critical, the improved workability and potential durability benefits of plastic aggregate concrete could be advantageous.

However, for structural applications, careful consideration must be given to the design mix and the percentage of plastic aggregate used to ensure that strength requirements are met.

These results highlight the need for further research into methods to improve the bond between plastic aggregates and cement paste, which could potentially mitigate the observed strength reductions while maintaining the benefits of plastic aggregate incorporation.

V. CONCLUSION

The incorporation of plastic aggregates in concrete as a partial replacement for natural aggregates has significant impacts on both fresh and hardened properties of concrete. Based on the comprehensive experimental study conducted, the following conclusions can be drawn:

- The addition of plastic aggregates consistently improved the workability of concrete, as evidenced by increased slump.
- A 30% replacement of natural aggregates with plastic resulted in a 46.7% increase in slump and a 17.8% increase in flow diameter.
- This enhanced workability can be attributed to the smooth surface and lower water absorption of plastic particles compared to natural aggregates.
- Compressive strength decreased with increasing plastic aggregate content.
- Water absorption decreased with increasing plastic content, Conversely, porosity increased for the same replacement levels.
- Based on the balance between workability improvements, strength reductions, and other property changes, a 10% replacement of natural aggregates with plastic appears to offer the most promising compromise for general applications.
- Higher replacement levels may be suitable for non-structural applications where is prioritized over strength.

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ADIMPARA UYGULAMA VE APK ANALİZİ

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Özet – Mobil cihazların yaygınlaşmasıyla birlikte, mobil uygulamaların kullanımı artmış ve bu da güvenlik risklerini beraberinde getirmiştir. Adli vakaların artışı, mobil uygulamaların güvenliği ve adli analizi açısından büyük önem taşımaktadır. Bu bağlamda, AdımPara uygulamasının incelenmesi, mobil forensic alanında kritik bir adımdır. Uygulama, adımları sayarak kullanıcıları ödüllendirirken, güvenlik ve veri koruması konularında dikkat gerektirmektedir. Yapılan apk analizi ve uygulama incelemesi, AdımPara'nın güvenilirlik seviyesini belirlemeye yönelik önemli bir adımdır. Elde edilen veriler, uygulamanın genel olarak güvenilir olduğunu ancak bazı iyileştirmelere ihtiyaç duyabileceğini göstermektedir. Yapılan analizler, kullanıcı verilerinin korunması ve uygulamanın güvenliğinin sağlanması için gerekli önlemlerin alınması gerektiğini vurgulamaktadır.

Anahtar Kelimeler – APK, AdımPara, Android, Statik Analiz, Dinamik Analiz

I. GİRİŞ

Teknolojinin gelişmesi ile birlikte mobil cihaz kullanımı önemli bir hal almıştır. Mobil cihaz kullanımının artması ile mobil market üzerinde bulunan uygulama çeşidi ve kategorisi de artış göstermiştir. Her geçen gün kullanılan uygulamaların kullanıcılar açısından daha fazla işlevsel hale getirilebilmesi için yeni, güncel ve geliştirilmiş uygulamalar oluşturulmaktadır[1]. Fazlalaşan ve yeterince kontrol edilemeyen uygulamalar, beraberinde zafiyetlerden faydalanmak isteyen saldırganların artışını da mümkün kılarak kimlik hırsızlığı, dolandırıcılık, kişisel verilerin çalınması gibi bir çok örneği olabilecek adli vakaların oluşmasına ortam hazırlamaktadır. Oluşan adli vakalar sonucunda kullanıcıların veri kaybı yaşaması, bilgileri ve izinleri olmaksızın kişisel bilgilerinin alınarak kullanılması vb. gibi mağduriyetler yaşanacaktır. Mağduriyetlerin giderilmesi, vakaların çözümlenerek suç unsurunun bulunması ve suçlu kimliğinin ortaya çıkarılabilmesi için uygulama adli analizi gerekmektedir. Bu nedenle mobil forensic mühim bir alan olarak karşımıza çıkmaktadır[2].

Bu dokümanda AdımPara uygulamasının apk analizine yer verilmiştir. 2021 yılında yayımlanan, AdımPara uygulaması hem App store hem de Google play store üzerinde bulunmaktadır. Google play store üzerinde uygulamanın kullanılabilmesi için Android 6.0 ve sonrası sürümlerin; App store üzerinde ise iOS 13.0 ve sonrası sürümlerin gerekli olduğu hakkında bilgi bulunmaktadır. Google app store'de indirme sayısı bir milyonun üzerinde olan uygulamanın 311 bin kadar yorum sayısı bulunmaktadır. Yorumların puan derecelemesi ise 4.5 olarak gözlemlenmiştir. App store üzerinde ise uygulamanın 88 bin kadar yoruma sahip olduğu; yorumların puan derecelendirmesinin ise 4.8 olduğu saptanmıştır. Her iki markette de ücretsiz olarak bulunan uygulama sağlık ve fitness kategorisinde bulunmaktadır.

AdımPara, mobil cihaz ve akıllı saatlerdeki adım sayma teknolojisini kullanarak adım sayma işlemini gerçekleştirir. Uygulamanın, Sayılan adımların adım paraya dönüştürülmesi karşılığında para ve çeşitli ödüllerin kazanılmasına yönelik oluşturulduğu karşımıza çıkmaktadır. Uygulama üzerinde çeşitli bonusların kullanılarak adım para kazanımlarının artırılması mümkün hale getirilmiştir. Uygulama üzerinde

arkadaşları takip edebilme, farklı kullanıcılar ile yürüyüş etkinliklikleri oluşturma, AdımPara Lig'te sıralamaya girerek adım sayar uygulamasındaki diğer kullanıcılarla yarışabilme gibi özelliklerin de yer aldığı gözlemlenmiştir.

Uygulamaya ait detaylı bilgiler https://www.adimpara.com/ sayfasında bulunmakta olup uygulamaya ait sosyal medya hesapları Tablo 1'de verilmiştir.

Tablo 1. AdımPara uygulamasına ait sosyal medya hesapları

Sosyal Medya	Erişim
instagram\facebook	@adimpara
twitter	https://twitter.com/adimpara
tiktok	https://vm.tiktok.com/ZSd13kpn3

Adım para uygulamasının mobil marketler üzerinde bulunan yorumları incelenmiş ve kullanıcıların uygulama ile ilişkili olarak şikayetlerinin fazla sayıda bulunduğu gözlemlenmiştir. Şikayetlerin genel olarak kullanıcı adımlarının doğru sayılmaması, hesabın kendiliğinden silinmesi ile eski verilere ulaşamama, hesaba giriş gerçekleştirememe gibi nedenlere bağlı olarak oluştuğu saptanmıştır. Şikayetlerin herhangi bir zararlıya bağlı olup olmadığının test edilmesi, uygulamanın arka planda kullanıcının bilgisi olmaksızın zararlı alanlara erişim yönlendirmesinin yapılıp yapılmadığı hakkında kontrolleri yapılması, uygulama güvenilirliğinin hangi oranda olduğunun tespit edilebilmesi adli bilişim araştırmacıları için önemli bir araştırma alanı oluşturmuştur. Bu dökümanda kullanıcıların şikayetlerinin kök nedenlerinin araştırılması amacı ile uygulama üzerinde analizler gerçekleştirilmiştir. Literatür üzerinde AdımPara uygulamasına ait analiz konusu ile ilişkili veri bulunmamaktadır. Bu nedenle ilgili doküman Adım para uygulamasına ait analiz ile ilişkili olarak ilk olma özelliği taşımaktadır.

II. MATERYAL VE YÖNTEM

AdımPara uygulama analizi çalışmasında uygulamanın analizi için öncelikli olarak genymotion emülatör[3] üzerinde sanal telefon oluşturulmuş ve sanal telefon üzerine AdımPara uygulamasına ait apk uygulaması indirilerek kurulumu sağlanmıştır. Kurulumu gerçekleştirilen uygulamanın arayüzü incelenmiş, ne şekilde kullanılabileceği hakkında bilgiler elde edilmiştir. Adım atılarak uygulamanın adım sayma işlemini gerçekleştirmesi; adımları AdımParaya dönüştürme işlemlerinin gerçekleştirilmesi sağlamıştır.

AdımPara uygulamasında oluşan verilerin analizinin sonuçları ticari adli bilişim yazılımları ile elde edilemeyeceği için manuel ve açık kaynak kodlu araçlar kullanılmıştır. Bahsedilen analiz yönteminin adımları aşağıda verilmiştir:

1. Mobsf aracının Windows cihaza kurulumu gerçekleştirilir[4].
2. AdımPara uygulamasının apk dosyası elde edilir.
3. Virustotal [5] üzerinde apk dosyası hash hesaplaması ve analizi gerçekleştirilir.
4. Paloalto wildfire sandbox aracı ile apk dosyasının statik analizi gerçekleştirilir.
5. Mobsf aracı ile elde edilen apk dosyasının statik analizi gerçekleştirilir.
6. Mobsf aracı ile sanal cihaz üzerinde bulunan AdımPara uygulamasının çalıştırılarak dinamik analizi gerçekleştirilir.
7. Analizler sonucunda iletişim kurulan IP adreslerinin toplu olarak reputasyonunun alınmasını sağlayan script yazılır ve IP dreslerinin reputasyonları çıktı olarak alınır.
8. Uygulamaya ait kodlar jadx aracı ile incelenir.
9. Cihazda AdımPara uygulamasının oluşturduğu veritabanı dosyaları Es dosya yöneticisi ile çıkarılır.
10. Çıkarılan uygulama verileri bilgisayara kopyalanır.
11. AdımPara uygulamasına ait database dosyaları sqllite DB browser ile incelenir[6] .
12. Elde edilen tüm sonuçlar yorumlanarak raporlanır.

AdımPara uygulama analizinde;

Statik analiz, manifest dosyası analizi, kod analizi, domain/ip analizi, virustotal üzerinde gerçekleştirilen analiz, dinamik analiz, database analizi yöntemleri kullanılmış olup elde edilen veriler bu çalışmada sunulmuştur.

- Apk 1.8 versiyonu kullanılmıştır.
- VirtualBox-6.1.32, genymotion 3.2.1 versiyonu kullanılmıştır.
- Mobsf v3.5 beta kullanılarak statik ve dinamik analiz gerçekleştirilmiştir.
- Cihaz olarak 4 işlemcili,1000 MB ana belleği olan Samsung S 10 modelli sanal bir cihaz kullanılmıştır.
- Es dosya yöneticisi v 4.2.0.2.1 uygulaması mobil cihazda kök dizine erişmek ,görüntülemek ve uygulamanın tuttuğu database dosyalarını çıkarmak için kullanılmıştır.
- Sqllite db browser 3.12.2 uygulaması ile database dosyalarını incelenmiştir
- Jadx gui 1.3.4 kullanılarak uyulamaya ait kod dosyalarının incelenmesi sağlanmıştır.

A. Statik Analiz

İlgili bölümde Mobsf ve Palo alto Wildfire sandbox ile gerçekleştilen analiz sonuçları yer almaktadır. MobSF ile gerçekleştirilen statik analiz [7] sonucunda adım para uygulamasının güvenlik skoru Şekil 1'de görüleceği üzere; 36/100(High), risk skor sınıfı Şekil 2'de görüleceği üzere "C" olarak belirlenmiş olup Trackersler 14/427 olarak tespit edilmiştir.

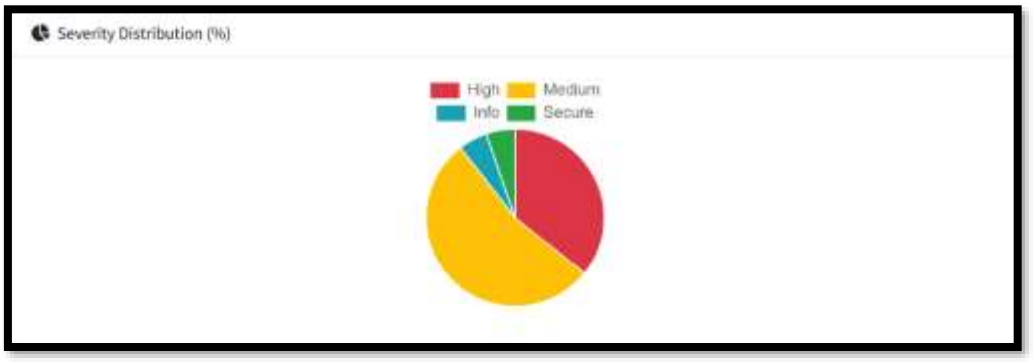
Şekil 1. Adım Para Uygulaması Güvenlik Skoru

Şekil 2. Adım Para Uygulaması Risk Skor Sınıflandırması

MobSF statik analizi sonucunda elde edilen bulguların severity değerleri Şekil 3'te sunulmuştur.

Şekil 3. Adım Para Uygulaması Bulgulara Ait Severity Değerleri

Paloalto Wildfire ile gerçekleştirilen statik analiz sonucunda uygulamanın "Benign" (Zararlı olarak nitelendirilmeyen) olarak değerlendirildiği elde edilmektedir. AdımPara uygulaması bulgulara ait dağılım grafiği Şekil 4'te verilmiştir.



Şekil 4. Adım Para Uygulaması Bulgulara Ait Dağılım Grafiği

Uygulamaya ait dosya bilgileri aşağıda verilmiştir:

- File Name: AdımPara.apk
- Size: 8.29MB
- MD5: 189dc3151e5826d79aa53e9b01e9b603
- SHA1: ee2904e131ff7460a23564ada60ca58c548264d6
- SHA256: ad45fd2e45bb0b8504a0211704636806b967b56257ca066c0ec9e1cdb4dd3674

Uygulama Bilgileri aşağıda verilmiştir:

- App Name: AdımPara
- Package Name: com.omicron.adimpara
- Main Activity: com.omicron.adimpara.MainActivity
- Target SDK: 32
- Min SDK: 23
- Max SDK:
- Android Version Name: 1.8
- Android Version Code: 42

Uygulama Bileşenlerine ait bilgiler aşağıda verilmiştir.

- Activities: 38
- Services: 16
- Receivers: 14
- Providers: 13

- Exported Activities: 5
- Exported Services: 3
- Exported Receivers: 2
- Exported Providers: 0

Adım Para uygulamasında bulunan uygulama bileşenleri Activities, Services, Receivers ve Providers olmak üzere 4 adet olarak gözlemlenmektedir.

- Activities, kullanıcılar ile uygulama arasındaki iletişimi sağlamaktadır. Kullanıcıların uygulama içerisinde işlemler yapmasını sağlayan tek bir ekranı temsil etmektedir.
- Services, Uygulamaların arka planda yapılması gereken işlemleri gerçekleştirmektedir.
- Providers, uygulamalar arası veri iletimini sağlamaktadır.
- Receivers, sistemden ya da diğer uygulamalardan gelen mesajlara yanıt verilmesi işlemlerini gerçekleştirmektedir.

Apk dosyasının imzalı olduğu ve v1,v2,v3 imzalarının doğrulanmış olduğu bilgisi elde edilmiştir. Sertifika bilgilerine ait detaylı bilgi Şekil 5' te verilmiştir.

SHA1	SHA256	Format	File Location	Owner	Issuer	MD5
05B911326D2A77B5FC5B58C36932ACD58E959A55	8C7B3D37F0C1C9A77BAD3665CA7B2FCA5BC0F2DDC8F5F4553752E4A3CBAE5CCF	certificate	android_v2_sign.cert	CN=Android, OU=Android, O=Google Inc., L=Mountain View, ST=California, C=US	CN=Android, OU=Android, O=Google Inc., L=Mountain View, ST=California, C=US	10B3905C38D88252 0E645951C753C82D
05B911326D2A77B5FC5B58C36932ACD58E959A55	8C7B3D37F0C1C9A77BAD3665CA7B2FCA5BC0F2DDC8F5F4553752E4A3CBAE5CCF	certificate	META-INF/BNDLTOOL.RSA	CN=Android, OU=Android, O=Google Inc., L=Mountain View, ST=California, C=US	CN=Android, OU=Android, O=Google Inc., L=Mountain View, ST=California, C=US	10B3905C38D88252 0E645951C753C82D

Şekil 5. Sertifika bilgilerine ait detaylı bilgi

MobSF analizi sonucunda sertifika bilgilerinde elde edilen bulgu ve detayları Tablo 2'de verilmiştir.

Tablo 2. MobSF analizi sonucunda sertifika bilgilerinde elde edilen bulgular

Başlık	Derece	Açıklama
Signed Application	Info	Uygulamanın bir kod imzalama sertifikası ile imzalandığını belirtmektedir.
Application vulnerable to Janus Vulnerability	Warning	Android sürümü (5.0–8.0) olan cihazlarda yalnızca v1 ile imzalanan Uygulamalar, Janus Güvenlik Açığı'na karşı savunmasızdır. Android sürümü (5.0–7.0) olan cihazlarda v1 ayrıca v2, v3 veya her ikisi ile imzalanmış uygulamalar, Janus Güvenlik Açığı'na karşı savunmasızdır.

Analizde elde edilen uygulama izinleri Şekil 6'da verilmiştir.

Şekil 6. Uygulama izinleri

Analizde elde edilen uygulama izinlerine dair açıklamalar Tablo 3'te verilmiştir [8].

Tablo 3. Uygulama izinlerine dair detay bilgiler

İzinler	**Durum**	**Bilgi**	**Açıklama**
android.permission.ınternet	Normal	Tüm İnternet erişimleri	Uygulamanın ağ soketleri oluşturmasına izin verildiğini belirtmektedir.
ndroid.permission.access_ network_state	Normal	Ağ bilgilerini görüntüleme	Uygulamanın tüm ağ durumunu görüntülemesine izin verildiğini belirtmektedir.
android.permission.access_ wıfı_state	Normal	Wi-Fi durumunu görüntüleme	Uygulamanın wifi durumunu görüntülemesine izin verildiğini belirtmektedir.
android.permission.actıvıty _recognıtıon	Dangerous	Uygulamanın fiziksel aktiviteyi tanıması durumu	Bir uygulamanın fiziksel aktiviteleri tanımasına izin verildiğini belirtmektedir.
com.google.android.gms. permission.ad_ıd	Unknown	Reklam kimliği okuma	Uygulamanın cihazda bulunan reklam kimliğini okumak için izin verilmesini belirtmektedir.
android.permission.camera	Dangerous	Resim ve videoları alma	Uygulamanın kamera ile fotoğraf ve video çekmesine izin verildiğini belirtmektedir. Ayrıca herhangi bir zamanda uygulama görüntüleri toplamak için izin verildiğini de belirtmektedir.
android.permission.read_ external_storage	Dangerous	Harici depolama içeriğini okuma	Uygulamanın harici depolama içeriğini okuma durumuna izin verildiğini belirtmektedir.
android.permission.query_ all_packages	Normal		Uygulamanın cihazdaki herhangi bir uygulamanın sorgulanmasına izin verildiğini belirtmektedir.
android.permission.wake_ lock	Normal	Telefonun uyumasını önleme	Uygulamanın, telefonun uyku moduna geçmesini engelleme izninin verildiğini belirtmektedir.
com.google.android.c2dm. permission.receıve	Signature	C2DM izinleri	Buluttan cihaza mesajlaşma izninin verildiğini belirtmektedir.
com.google.android.finsky. permission.bınd_get_ınstall _referrer_servıce	Unknown		

android.permission.receıve _boot_completed	Normal	Otomatik olarak boot işlemini başlatma	Uygulamanın, sistem önyüklemesinin biter bitmez kendisini başlatmasına izin verildiğini belirtmektedir.
android.permission. foreground_servıce	Normal		Uygulamanın Service.startForeground'ı kullanmasına izin verir.

B. Manifest Dosyası Analizi

Manifest dosyası analizi sonucu elde edilen verilerin bir kısmı ve açıklamaları Tablo 4'te verilmiştir.

Tablo 4. Manifest dosyası analizi sonucu elde edilen veriler

Konu	**Derece**	**Açıklama**
Uygulamanın ağ güvenliği yapısı bulunmaktadır. [android:networkSecurityConfig= @xml/ network_security_config]	Info	Ağ Güvenliği Yapılandırması özelliği, uygulamaların, uygulama kodunu değiştirmeden güvenli, bildirime dayalı bir yapılandırma dosyasında ağ güvenlik ayarlarını özelleştirmesine olanak tanımaktadır. Bu ayarlar, belirli alanlar ve belirli bir uygulama için yapılandırılabilir.
Uygulama Verileri Yedeklenebilir durumdadır. android:allowBackup=true]	Warning	Bu, herkesin uygulama verilerini adb aracılığıyla yedeklemesine izin vermektedir. USB hata ayıklamasını etkinleştiren kullanıcıların uygulama verilerini cihazdan kopyalamasına olanak tanımaktadır.
Activity korumalı durumda değildir. (com.facebook.CustomTabActiviy) [android:exported=true]	High	Bir aktivitenin cihazdaki diğer uygulamalarla paylaşıldığı ve cihazdaki herhangi bir uygulama tarafından erişilebilir durumda olduğu tespit edilmektedir.
Activity korumalı durumda değildir. (com.canhub.cropper.CropImageAc tivity) [android:exported=true]	High	Bir aktivitenin cihazdaki diğer uygulamalarla paylaşıldığı ve cihazdaki herhangi bir uygulama tarafından erişilebilir durumda olduğu tespit edilmektedir.
Activity korumalı durumda değildir. (androidx.test.core.app. InstrumentationActivityInvoker$Bo otstrapActivity) [android:exported=true]	High	Bir aktivitenin cihazdaki diğer uygulamalarla paylaşıldığı ve cihazdaki herhangi bir uygulama tarafından erişilebilir durumda olduğu tespit edilmektedir.
Activity korumalı durumda değildir. (androidx.test.core.app.Instrumenta tion ActivityInvoker$EmptyActivity) [android:exported=true]	High	Bir aktivitenin cihazdaki diğer uygulamalarla paylaşıldığı ve cihazdaki herhangi bir uygulama tarafından erişilebilir durumda olduğu tespit edilmektedir.
Activity korumalı durumda değildir. (androidx.test.core.app.Instrumenta tion ActivityInvoker$EmptyFloatingAct ivity) [android:exported=true]	High	Bir aktivitenin cihazdaki diğer uygulamalarla paylaşıldığı ve cihazdaki herhangi bir uygulama tarafından erişilebilir durumda olduğu tespit edilmektedir.

C. Kod Analizi

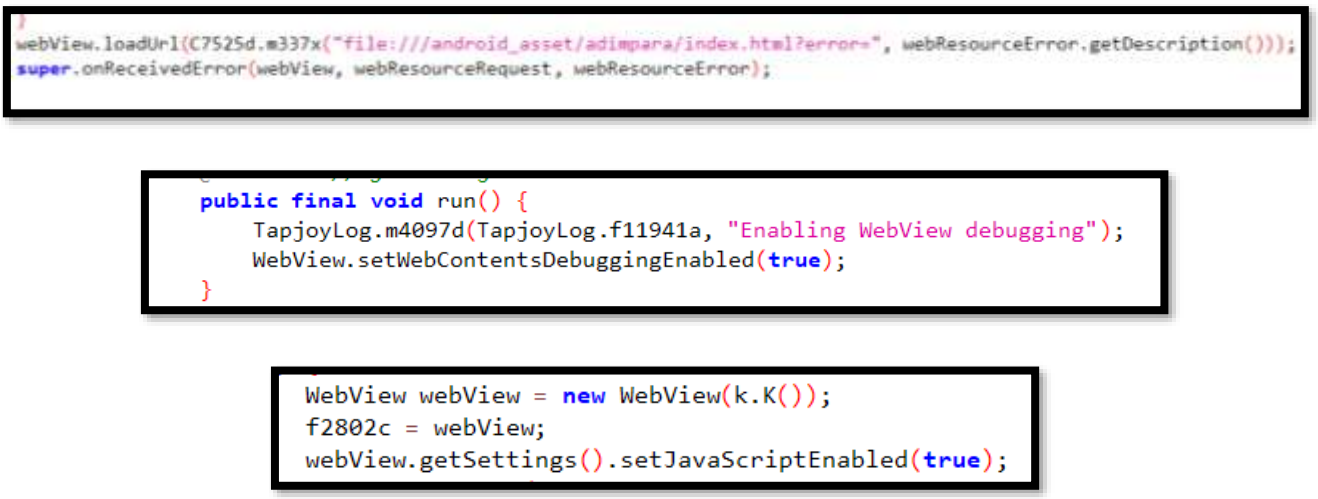
Gerçekleştirilen kod analizi sonucu elde edilen verilerin bir kısmı ve açıklamaları Tablo 5'te verilmiştir.

Tablo 5. Kod analizi sonucu elde edilen veriler

Konu	Severity	Standart	Dosyalar
Güvensiz WebView Uygulaması. Webview'da kullanıcı tarafından denetlenen kodun yürütülmesi kritik bir güvenlik açığıdır	Warning	CWE: CWE-749: Exposed Dangerous Method or Function OWASP Top 10: M1: Improper Platform Usage OWASP MASVS: MSTG-PLATFORM-7	com/unity3d/services/core/webview/WebView.java c2/t3.java com/unity3d/services/ads/webplayer/WebPlayerView.java com/omicron/adimpara/MainActivity.java
Uygulama, SQLite Veritabanını kullanır ve ham SQL sorgusu yürütür. Ham SQL sorgularında güvenilmeyen kullanıcı girişi SQL Injection'a neden olabilir. Ayrıca hassas bilgiler şifrelenmeli ve veritabanına yazılmalıdır.	Warning	Cwe: cwe-89: ımproper neutralization of special elements used in an sql command ('sql ınjection') Owasp top 10: m7: client code quality	com/tapjoy/internal/f.java d1/f.java com/vungle/warren/persistence/Repository.java n3/p.java/DatabaseHelper.java
Uygulama, Harici Depolama Alanına okuyabilir/yazabilir. Herhangi bir Uygulama, Harici Depolamaya yazılan verileri okuyabilir.	Warning	Cwe: cwe-276: ıncorrect default permissions owasp top 10: m2: ınsecure data storage owasp masvs: mstg-storage-2	com/vungle/warren/persistence/Repository.java com/ironsource/mediationsdk/utils/h.java com/ironsource/environment/h.java com/unity3d/services/core/cache/CacheDirectory.java
Dosyalar kullanıcı adları, şifreler, anahtarlar vb. gibi sabit kodlanmış hassas bilgiler içerebilir.	Warning	Cwe: cwe-312: cleartext storage of sensitive Information Owasp top 10: m9: reverse engineering Owasp masvs: mstg-storage-14	com/ironsource/adapters/vungle/VungleAdapter.java com/applovin/mediation/ads/MaxAdView.java com/ironsource/adapters/adcolony/AdColonyAdapter.java
Remote WebView debugging is enabled.	High	Cwe: cwe-919: weaknesses in mobile applications Owasp top 10: m1: ımproper platform usage Owasp masvs: mstg-resılıence-2	com/tapjoy/TapjoyLog.java com/applovin/impl/adview/d.java com/ironsource/sdk/controller/w.java

Uygulama, güvenli olmayan bir Rastgele Sayı Üreticisi kullanıyor	Warning	Cwe: cwe-330: use of ınsufficiently random values Owasp top 10: m5: ınsufficient cryptography Owasp masvs: mstg-crypto-6	com/inmobi/media/al.java com/inmobi/media/ay.java f6/k.java i8/a.java com/ironsource/mediationsdk/utils/e.java com/ironsource/mediationsdk/utils/g.java com/applovin/impl/a/l.java

Webview ile ilişkili olarak eld edilen kod parçalarına ait veriler Şekil 7'de verilmiştir.



Şekil 7. Webview ile ilişkili kod parçaları

D. *Domain/IP Analizi*

Statik analizde elde edilen domainlerin ilişkili olduğu ip adres ve reputasyonları Abuseip db API ile bağlantılı olarak yazılan script yoluyla elde edilmiştir. Elde edilen sonuçlarda riskli olarak değerlendirilen veri gözlemlenmemiştir. Örnek veriler Tablo 6'da verilmiştir.

Tablo 6. Kod analizi sonucu elde edilen veriler

IP	Skor
2.19.113.58	0
104.18.230.100	0
20.123.100.81	0
23.72.241.57	0
104.45.180.93	0
80.239.138.33	0

E. *Trackers*

Elde edilen trackers bilgileri Tablo 7' de verilmiştir.

Tablo 7. Trackers bilgileri

Tracker	Kategoriler	URL
Facebook Share	Facebook Entegration	https://reports.exodus-privacy.eu.org/trackers/70
Google AdMob	Advertisement	https://reports.exodus-privacy.eu.org/trackers/312
Google Firebase Analytics	Analytics	https://reports.exodus-privacy.eu.org/trackers/49
IAB Open Measurement	Identification, Advertisement	https://reports.exodus-privacy.eu.org/trackers/328
Inmobi	Advertisement	https://reports.exodus-privacy.eu.org/trackers/106
Tapjoy	Advertisement	https://reports.exodus-privacy.eu.org/trackers/199
Unity3d Ads	Advertisement	https://reports.exodus-privacy.eu.org/trackers/121
Vungle	Advertisement	https://reports.exodus-privacy.eu.org/trackers/169
ironSource	Analytics	https://reports.exodus-privacy.eu.org/trackers/146

F. Şüpheli Görülen Patternler

Wildfire analiz raporunda tespit edilen şüpheli pattern bilgilerinin bir kısmı [9] Tablo 8'de verilmiştir.

Tablo 8. Şüpheli görülen patternler

Dosya Konumu	Özellik	Açıklama
classes.dex/v1/f.smali	intent passive	APK dosyası, pasif izleme amacı eylemlerini içerir;android.intent.action. DEVICE_STORAGE_LOW
assets/audience_network.dex	has dex	APK dosyası dex dosyalarını içerir;dex
classes.dex/e0/g.smali	java reflection	APK dosyası java reflection tekniği kullanmaktadır. String:android.grap hics.FontFamily|createFromFa miliesWithDefault|r|Typeface CompatApi21Impl|addFontWeightStyle
classes.dex	dex class name malform	APK dosyası, dex'te hatalı biçimlendirilmiş sınıf adı içermektedir;La1/c$a;
classes2.dex/com/ironsource/ environment/h.smali	shell cmd	APK dosyası, shell komut dizelerini içermektedir;/system/xbin/
AndroidManifest.xml	intent passive	APK dosyası, pasif izleme amacı eylemlerini içerir;android.intent.action. BATTERY_LOW
classes2.dex/v8/f.smali	connect socket	APK dosyası soket üzerinden bağlantı kurar API:Ljava/net/InetSocketAddress;-><init>, Permission:android.permission.INTERNET
AndroidManifest.xml	intent sys	APK dosyası, yalnızca sistem uygulamalarının uygulayabileceği amaç eylemlerini içerir; android.intent.action.

		D EVICE_STORAGE_OK
AndroidManifest.xml	intent sys	APK dosyası, yalnızca sistem uygulamalarının uygulayabileceği amaç eylemlerini içerir; android.intent.action.BATTERY_LOW
AndroidManifest.xml	intent sys	APK dosyası, yalnızca sistem uygulamalarının uygulayabileceği amaç eylemlerini içerir;android.intent.action.TIMEZONE_CHANGED
classes2.dex/v8/c.smali	java reflection	APK dosyası java reflection tekniği kullanmaktadır;String:Failed to connect to |throw with null exception|Connection{|closed |>> CONNECTION %s
AndroidManifest.xml	listen cable status	APK dosyası cihaz kablosu durumunu dinler (takılı durumda/takılı durumda değil);androidx.work.impl.background.systemalarm.ConstraintProxy$BatteryChargingProxy
classes.dex/e/g$g.smali	intent passive	APK dosyası, pasif izleme amacı eylemlerini içerir;android.intent.action. TIME_TICK
classes.dex/v1/a.smali	intent passive	APK dosyası, pasif izleme amacı eylemlerini içerir;android.intent.action. BATTERY_CHANGED
classes2.dex/com/ironsource/environment/h.smali	query packages	APK dosyası yüklü paketleri cihaza alır; API:Landroid/content/p m/PackageManager;->getInstalledApplications

G. Virustotal ile Gerçekleştirilen Analiz

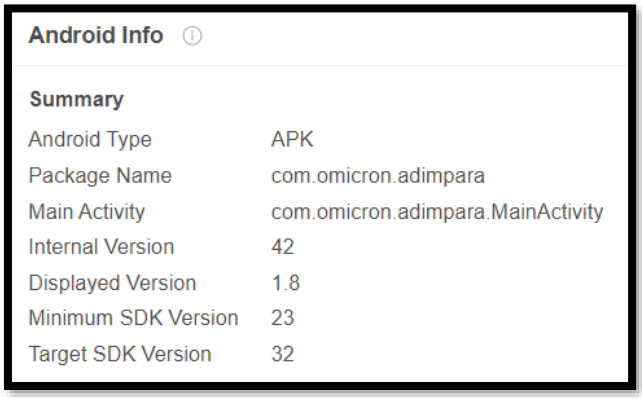
Virustotal üzerinde gerçekleştirilen analizde ilgili apk dosyasının risk skoru Şekil 8'de de görüleceği üzere 0 olarak gözlemlenmiştir.

Şekil 8. Virustotal üzerinde hash ile ilişkili elde edilen risk skoru çıktısı

Virustotal üzerinde adımpara.apk uygulaması risksiz olarak tanımlanmaktadır. Apk dosyasına ait temel özellikler Şekil 9'da verilmiştir.

Şekil 9. AdımPara apk dosyasının virustotal üzerinde görülen temel özellikleri

Adım para uygulamasına ait Android Bilgileri Şekil 10'da verilmiştir.

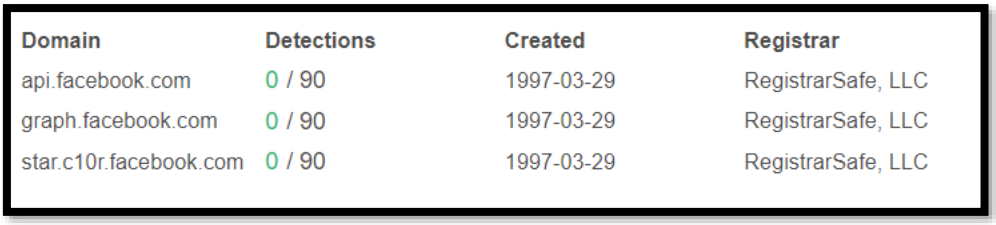


Şekil 10. Adımpara uygulamasına ait android bilgileri

Virustotal üzerinde AdımPara uygulamasına ait olarak görülen sertifika bilgileri Şekil 11'de verilmiştir.

Şekil 11. AdımPara uygulamasına ait sertifika bilgileri

Uygulamanın ilişkili olduğu domainler, ilgili domainlere ait tespit oranları, oluşturulma zamanları ve kayıt bilgileri Şekil 12'de verilmiştir.



Şekil 12. Uygulamanın ilişkili olduğu domain ve domain ile ilişkili bilgiler

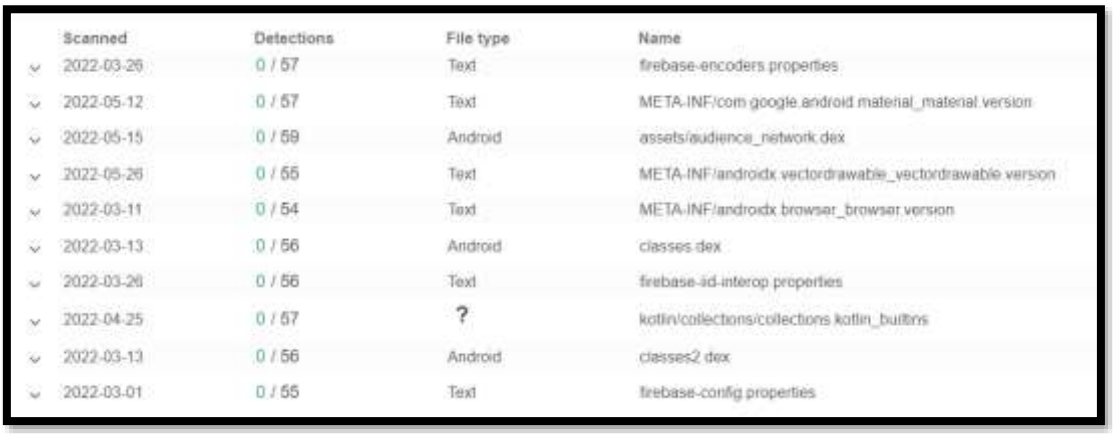
Elde edilen bilgilere göre şüpheli olarak değerlendirilen bir ilişkilendirme gözlemlenmemiştir. İletişim kurulan IP adresi 157.240.229.17 olarak tespit edilmiştir. İlgili IP adresinin tespit edilen bir riski görülmemekle birlikte ilişkili diğer bilgileri Şekil 13'te verilmiştir.

IP	Detections	Autonomous System	Country
157.240.229.17	0 / 90	32934	US

Şekil 13. İletişim kurulan ip adresi ile ilişkili bilgiler

IP adresine ait reputasyon değeri Abuseıp db, IBM X-Force Exchange üzerinde araştırılmış olup risk skoru gözlemlenmemiştir. IP adresinin ISP bilgisi Facebook Inc. Ülke bilgisi ise United States of America olarak gözlemlenmiştir.

Virustotal üzerinde adım para uygulaması ile ilişkili olarak bulunan paketlerden bazıları ve paketlere dair tespit, dosya tipi, dosya adı bilgileri Şekil 14'te verilmiştir.



Scanned	Detections	File type	Name
2022-03-26	0 / 57	Text	firebase-encoders.properties
2022-05-12	0 / 57	Text	META-INF/com.google.android.material_material.version
2022-05-15	0 / 59	Android	assets/audience_network.dex
2022-05-26	0 / 55	Text	META-INF/androidx.vectordrawable_vectordrawable.version
2022-03-11	0 / 54	Text	META-INF/androidx.browser_browser.version
2022-03-13	0 / 56	Android	classes.dex
2022-03-26	0 / 56	Text	firebase-iid-interop.properties
2022-04-25	0 / 57	?	kotlin/collections/collections.kotlin_builtins
2022-03-13	0 / 56	Android	classes2.dex
2022-03-01	0 / 55	Text	firebase-config.properties

Şekil 14. AdımPara uygulaması ile ilişkili paketler ve paketlere dair veriler

H. *Dinamik Analiz*

Mobsf ile gerçekleştirilen dinamik analiz sonucunda elde edilen veriler bu bölümde yer almaktadır[10]. Analiz raporları sonucunda elde edilen domain adreslerinin ilişkili olduğu IP adreslerinin reputasyon değerlerini hesaplamak için Abuseıp db API kullanılarak script oluşturulmuştur. Scriptin çalıştırılması sonucu reputasyon değeri olan ip adresleri ile ilişkili detaylı bilgiler Tablo 9'da verilmiştir.

Tablo 9. Reputasyon değeri bilgileri

IP	**Skor**	**ISP**	**Reputasyon**	**Ülke**	**Kaynak**
216.239.32.21	25	Facebook Inc	Malware		
69.16.175.42	23	Highwinds Network Group Inc.	Fraud Orders Malware Malicious	United States of America	Abuseıpdb Virustotal
35.241.52.229	20	Google LLC	Port Scan	United States of America	Abuseıpdb
34.120.195.249	19	Google LLC	Port Scan	United States of America	Abuseıpdb

					Virustotal
151.101.1.195	18	Fastly	Ddos Attack Malware Malicious	United States of America	Abuseıpdb Virustotal
151.101.2.132	18	Fastly	Port Scan Malware	United States of America	Abuseıpdb Virustotal
23.185.0.4	15	Pantheon	Email Spam Malware	United States of America	Abuseıpdb Virustotal
99.83.190.102	11	Amazon.com Inc.	Phishing Malware	United States of America	Abuseıpdb Virustotal
141.193.213.20	11	WPEngine Inc.	Fraud Orders	United States of America	Abuseıpdb Virustotal
76.76.21.21	6	Vercel Inc	Port Scan	United States of America	Abuseıpdb Virustotal
151.101.2.217	4	Fastly	Fraud Orders Malware	United States of America	Abuseıpdb Virustotal
128.30.52.100	3	Massachusetts Institute of Technology	Ddos Attack Malware	United States of America	Abuseıpdb Virustotal
172.217.20.78	2	Google LLC	Port Scan	United States of America	Abuseıpdb Virustotal
172.217.17.238	2	Google LLC	Port Scan	United States of America	Abuseıpdb Virustotal
172.217.17.238	2	Google LLC	Port Scan	United States of America	Abuseıpdb Virustotal

Mobsf ile gerçekleştirilen dinamik analiz sonucunda uygulama üzerinde bulunan database dosyaları aşağıdaki gibidir.

- datadatacom.omicron.adimparaapp_fiverocksevents2
- datadatacom.omicron.adimparaapp_webviewCookies
- datadatacom.omicron.adimparaapp_webviewWeb_Data
- datadatacom.omicron.adimparadatabasesadc_events_db
- datadatacom.omicron.adimparadatabasesads.db
- datadatacom.omicron.adimparadatabasescom.google.android.datatransport.events
- datadatacom.omicron.adimparadatabasescom.im_10.0.1.db
- datadatacom.omicron.adimparadatabasesgoogle_app_measurement_local.db
- datadatacom.omicron.adimparadatabasessupersonic_sdk.db
- datadatacom.omicron.adimparano_backupandroidx.work.workdb

İ. Database Analizi

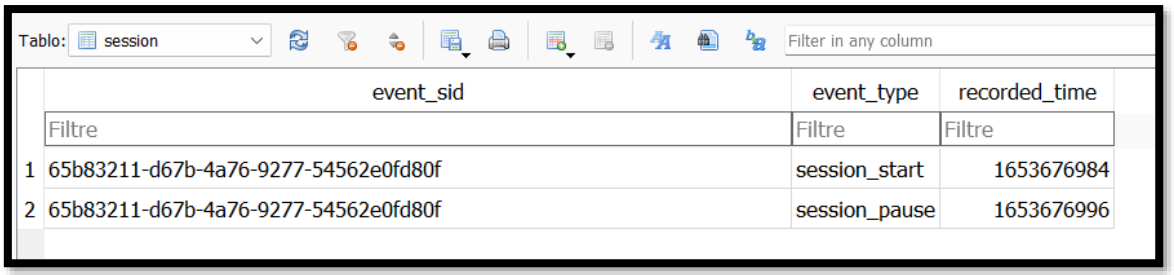
Android Samsung S10 mobil cihazı üzerinde Es File manager kullanılarak Uygulama üzerinde bulunan database dosyasına ait veriler elde edilmiştir. Database dosyasına ait path "/data/data/com.omicron.adimpara/databases" şeklindedir. Database dosyaları ise;

- adc_events_db
- ads.db

- com.im10.0.1.db
- google_app_measurement_local.db
- supersonic_sdk.db

olarak tespit edilmiştir. İlgili dosyaların içeriğinin incelenmesi için sqllite db browser kullanılmıştır. Yapılan incelemelerde db tabloları içeriğinde fazla sayıda adli veri görüntülenmemiştir.

adc_events_db içeriğinde android_metadata, config, events, session tabloları bulunmaktadır. Session tablosu içeriğinde Şekil 15'te de görüleceği üzere event sid, event_type, recorded_time bilgileri gözlemlenmiştir. Recorded_ time bilgileri ile oturumun başlama ve bitiş zamanları elde edilmiştir.


Tablo: session

Filter in any column

	event_sid	event_type	recorded_time
	Filtre	Filtre	Filtre
1	65b83211-d67b-4a76-9277-54562e0fd80f	session_start	1653676984
2	65b83211-d67b-4a76-9277-54562e0fd80f	session_pause	1653676996

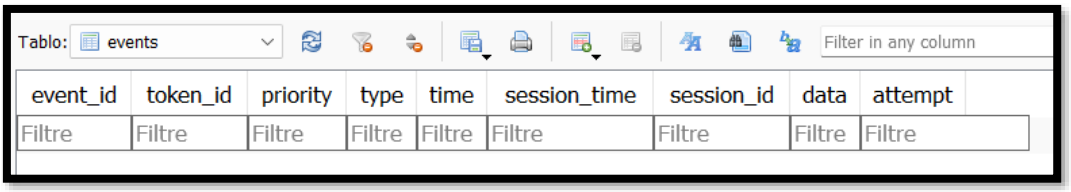
Şekil 15. Session tablosu

- com.im10.0.1.db içeriğinde android_metadata, asset, click, config_db, crash, sqlite_sequence, telemetry tabloları bulunmaktadır.

- google_app_measurement_local.db içeriğinde android_metadata, messages tabloları bulunmaktadır.

- supersonic_sdk.db içeriğinde android_metadata, events tabloları bulunmaktadır.

- ads.db içeriğinde Şekil 16'da görüleceği üzere android_metadata, tokens,events tabloları bulunmaktadır. İçeriğinde veri gözlemlenmemiştir.


Tablo: events

Filter in any column

event_id	token_id	priority	type	time	session_time	session_id	data	attempt
Filtre	Filtre	Filtre	Filtre	Filtre	Filtre	Filtre	Filtre	Filtre

Şekil 16. Ads.db events tablosu

III. BULGULAR

AdımPara uygulamasının APK ve uygulama analizi, Mobsf ve Wildfire araçlarıyla statik analiz işlemleri, Mobsf ile dinamik analiz işlemi, Virustotal ile analiz işlemi, IP/domain analizi işlemleri, kod analizi işlemi, manifest dosyası analizi işlemi ve veritabanı analizi gerçekleştirilmiştir. Virustotal'da uygulama ile ilişkilendirilen herhangi bir zararlı veriye rastlanmamıştır. Ayrıca, uygulamanın erişim kurduğu IP adresi belirlenmiş olup, bu IP ile ilişkili diğer analizler yapıldığında herhangi bir şüpheli veriye rastlanmamıştır.

Dinamik analiz sonucunda elde edilen IP adreslerinin itibar bilgilerini almak için AbuseIPDB API kullanılarak bir script oluşturulmuş ve bu script çalıştırılarak itibar değerleri elde edilmiştir. İncelenen itibar sonuçlarına göre, risk skoru en fazla %25 olarak belirlenmiştir. Veritabanı analizi sırasında, uygulamanın veritabanı yapısından çok az veri elde edilebildiği gözlemlenmiştir.

Statik analizler sonucunda elde edilen bulgular incelenmiş ve yazılımın daha güvenli hale getirilmesi için gerekli önlemlerin ve iyileştirmelerin gerçekleştirilmesi gerektiği sonucuna varılmıştır.

IV. TARTIŞMA

Şikayetler alınan AdımPara uygulaması içi apk ve uygulama analizi gerçekleştirilmiş olup şikayetlerin hehangi bir zararlıya bağlı olup olmadığının test edilmesi, uygulamanın arka planda kullanıcının bilgisi olmaksızın zararlı alanlara erişim yönlendirmesinin yapılıp yapılmadığı hakkında kontrollerin yapılması, uygulama güvenilirliğinin hangi oranda olduğunun tespit edilebilmesi için uygulama üzerinde analizler gerçekleştirilmiştir. Gerçekleştirilen literatür taramalarından ilham alınarak analizlerde farklı yöntemler kullanılmıştır. Yapılan çalışmalarda Literatür üzerinde Adımpara uygulamasına ait analiz konusu ile ilişkili veri bulunmamaktadır. Bu nedenle ilgili doküman Adım para uygulamasına ait analiz ile ilişkili olarak ilk olma özelliği taşımaktadır. Kullanılan yöntem ve elde edilen sonuçların farklı uygulama analizleri çalışmalarına ışık tutarak fayda sağlayacağı değerlendirilmektedir.

V. SONUÇLAR

Mobil apk analiz incelemeleri uygulama güvenliği, adli bilişim ve bilgi güvenliği açısından önem arz eden alanlardan biridir. Bu dökümanda AdımPara uygulaması için apk ve uygulama analiz metodolojisi, yöntemleri, analizleri yer almaktadır. Analiz işlemleri için AdımPara uygulamasına ait apk dosyası kullanılmıştır. Ugulama apk dosyası, virustotal üzerinde eklenerek uygulamaya ait reputasyon değeri, apk yapısı, bağlantılı olunan IP adresi elde edilmiştir. Uygulamanın statik analizleri Palo Alto wildfire ve Mobsf araçları ile gerçekleştirilmiştir. Uygulamanın çalıştırılması ile gerçekleştirilmesine dayanan dinamik analiz için genymotion üzerinde kurulumu sağlanan sanal cihaz kullanılmıştır. Sanal cihaz üzerinde apk dosyası çalıştırılarak mobsf aracı ile dinamik analiz gerçekleştirilmiştir. Araçların kullanımı sonucunda uygulamaya ait elde edilen kod verilerinin incelenmesi için jadx kullanılmıştır.

Dinamik ve statik analizler dışında uygulamanın database yapısı çıkarılmış ve ne tür veriler tutabileceği değerlendirilmiştir. Kullanılan metodoloji ile elde edilen tüm veriler ile kullanıcı şikayetlerine neden olabilecek herhangi bir zararlı ile ilişkisinin var olup olmadığı incelenmiş, uygulamanın güvenilirliği değerlendirilmiş, database yapısının adli veri içerip içermediği araştırılmıştır. Çalışma sonucunda uygulamanın riskli olarak değerlendirilebilecek bir reputasyonu olmadığı, şüpheli olarak değerlendirilebilecek ağ bağlantısı kurmadığı yorumlanmıştır. Uygulamaya ait kodların geliştirilmesi ile uygulamanın daha güvenilir olabileceği değerlendirilmiştir.

Kullanılan metodoloji ile elde edilmiş sonuçlar, Android mobil cihazlarda AdımPara uygulamasının apk ve uygulama analizini sağlar. İlgili çalışma literatürde ilk AdımPara uygulama ve apk analiz metodolojisidir. Elde edilen sonuçlar sadece Android mobil cihazını içermektedir.

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Bilgisayarlı Görme Uygulaması için Yeni Bir Evrişimsel Sinir Ağı Modeli: Trafik İşareti Tanıma

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Özet – Akıllı ulaşım sistemlerinde otonom sürüş için nesnelerin tespiti ve tanımlanması bilgisayarlı görme alanlarında önemli bir konudur. Yol işaretlerindeki bazı değişikliklerin yol işaretlerini tanımlamada hatalara sebep olabilmektedir. İnsan hayatının korunmasında önemli olan bu durum araştırmacıların ilgilendiği önemli konulardan biri haline gelmiştir. Bu makale yol işaretlerini tanıma performansını artırmak için yeni bir evrişimsel sinir ağı (CNN) modeli öne sürülmektedir. Bilgisayarlı görme, görüntü işleme ve örüntü tanıma alanlarında bazı araştırmacılar tarafından yapılan evrişimsel sinir ağı uygulamalarının ve makine öğrenme yöntemlerinin iyi çalıştığını göstermiştir. Trafik Tabelası Tanıma gibi bilgisayarla görme uygulamalarında kullanılan teknikler çok farklılık göstermektedir. Geliştirilen derin öğrenme tabanlı sistemlerde gerçek veriler ile modelin tahmin sonucu arasındaki fark kayıp fonksiyonları kullanılarak ölçülmektedir. Önerilen modelin Accuracy, F1 score, Loss, Precision ve Recall değerlerine göre doğruluk grafikleri çizilmiştir. Bu değerlerin benzer çalışmalarla karşılaştırması yapılarak bir sonraki yapmayı planladığımız uygulama önerilerimiz ifade edilmiştir. Biz trafik ışıkları tanıma uygulaması için yeni bir CNN modeli önerdik ve buradaki kayıp fonksiyonları hesaplatarak doğruluk oranı tahmini yapılmıştır. Bu model için deneylerimizi halka açık olan "Kaggle'ın Traffic Sign Dataset – Classification" veri seti üzerinde eğittik ve test ettik. Veri setinde yaklaşık 58 sınıf vardır ve her sınıfta yaklaşık 120 resim bulunur. Test edilebilecek yaklaşık toplam 2000 dosya bulunmaktadır. Önerilen CNN modeli ile %99'a yakın bir doğruluk oranı test edilerek doğrulanmıştır.

Anahtar Kelimeler – Derin öğrenme, Derin Evrişimli Sinir Ağı, Trafik işareti tanıma, Akıllı ulaşım Sistemleri, CNN

I. GİRİŞ

Yakın zamanda birçok araştırmacı karayolu güvenliğinde insan hayatının korunmasında çok büyük öneme sahip trafik işaretleri tanıma sistemlerine odaklandı. Araştırmacılar makine öğrenme, derin öğrenme ve görüntü işleme tekniklerinden olan evrişimsel sinir ağı temelli mimarileri kullanarak sonuçlar üretmişlerdir [1]. Sürücü destek sistemleri bilgisayarlı görme, yapay zekanın en sıcak araştırma alanlarından biridir. Otonom sürüş teknolojisi, yüz tanıma ihtiyacı ve evrişimsel sinir ağlarının geliştirilmesi ve araştırılması, bilgisayarlı görmeyi son yıllarda en hızlı büyüyen yapay zeka alanlarından biri haline getirdi. Otonom sürüş teknolojisinin popülaritesinin artmasıyla birlikte, makine görü alanında yol işareti tanıma teknolojisi, otonom sürüş teknolojisinin yükselişindeki en önemli konulardan biridir. Ancak hatalı yol işareti tanıma sistemleri sonucu meydana gelen sorunlar görülebilmektedir. Sokak tabelalarına etiket yapıştırmak, üzerindeki boyasının eskimesi gibi sebeplerden dolayı sürücüsüz araçların kafasını karıştırabilmektedir [2].

Mevcut duruma göre, yol işareti tanıma sistemleri istenilen seviyede değillerdir. Birçok teknolojinin hâlâ iyileştirilmesi gerekmektedir. Teknik olarak otonom araçlar şu dört modüle ayrılabilir: verinin algılanması ve alınması, sensör tarafından verinin belirgin hale getirilmesi, işlemci tarafından verinin işlenmesi ve aracın hareketinin sağlanması. Algılama, aracın çevresini nasıl tanıdığını ifade eder [3]. Basit bir çıkartma

veya değiştirilmiş bir işaret, bir arabanın tanımlama sistemini karıştırabiliyorsa, sürücüsüz arabalar yollardaki en büyük güvenlik tehlikesi olacaktır. Bu nedenle, yoldaki sürücüsüz araçların güvenlik tehlikelerini azaltmak ve yol güvenliğinin kalitesini artırmak amacıyla mevcut yol işareti tanıma ve sınıflandırma teknolojisi algoritmalarını geliştirerek yol işareti sınıflandırmasının doğruluğunu artırmayı amaçlanmaktadır. Resimleri sınıflandırmak ve doğruluklarını elde etmek için evrişimli sinir ağı modeli yöntemini kullanacağız. Günümüzde rutin yapılan işleri otomatikleştirerek hayatımızı kolaylaştırıyoruz. Araba sürerken dikkatimiz genellikle ana yol üzerine odaklanılmaktadır. Bu araç hızlı ise odaklanma daha yoğun hale dönmektedir. Bu yoğunluk durumunda yol kenarındaki işaretleri kaçırabiliriz. Bu bizim ve çevremizdeki insanlar için büyük tehlikeli sonuçlar üretebilir. Bu gibi durumların öne geçilebilmesi için sürücü uyarılması gerekmektedir. Trafik işareti algılama ve tanıma sistemleri trafik işaretlerini algılayıp tanıyan sistemlerdir [4]. Bu sistemler herhangi bir trafik işareti yaklaştığında sürücüyü uyarmaktadır. Bu konuda sürücünün erken uyarılarak kaza yapma olasılığının düşürülmesi hedeflenmektedir. Böylece sürücü alışılmadık yollarda rahat hareketini ve yol güvenliğini artıracaktır. Bazen işaretleri ve diğer uyarıları anlamak zor olabilir. Bu yaklaşımı kullanarak sürücülerin tabelaları anlamaya çalışmaları gerekmeyecek. Dünya genelinde trafik kazalarından kaynaklanan ölüm sayısı önemli derecede artmıştır. Hız araç kazalarının önde gelen nedenlerinden biridir. Fakat ikinci en yaygın nedenin kişinin belirli bir trafik işaretinin sürücüler tarafından ne anlama geldiğini anlamaması olduğunu gösterdi[5]. Dünya Sağlık Örgütü'ne göre, dünya çapında meydana gelen yıllık trafik kazalarının bir sonucu olarak '1,3 milyon ölüm ve '20-50 milyon ölümcül olmayan yaralanma' bulunmaktadır. Karayolu trafik kazaları çoğu ülkede gayri safi yurt içi hasılanın (GSYİH) %3'üne mal oluyor. 2015 ile 2030 yılları arasında trafik kazalarının küresel ekonomiye 1,8 trilyon ABD dolarına, yani küresel GSYH'nin %0,12'sine mal olacağı tahmin edilmektedir [5].

Trafik işareti tanıma, akıllı ulaşım sistemlerinde yol güvenliğini artırabilecek ve kazaları azaltabilecek önemli bir görevdir [4]. Otomotiv endüstrisindeki yapay zeka, otomobil üreticilerinin, yapay zeka destekli gelişmiş sürücü destek sistemleri ve trafik işareti tanıma gibi otomatik sürüş sistemlerinin entegrasyonu yoluyla akıllı ve otonom araçlar üretmesine olanak tanır [6]. Derin öğrenmeye dayalı algoritmalar, son yıllarda trafik işareti tanımada dikkate değer sonuçlar elde etti [7]. Teknolojide yapay zeka kullanılmaya başlandıktan sonra hayatımızı kolaylaştırmaktadır [2], [8]–[11]. Teknoloji destekli trafik sistemi otomotiv endüstrisinde otonom araçların gelişmesiyle otomotiv sektöründe değişimlere yol açmıştır. Otonom arabaların yakın gelecekte daha yaygın hale geleceği kesin gözükmekle beraber güvenli ve sorunsuz olması istenmektedir. Trafik İşareti sınıflandırılması otonom araçların en önemli zorlu işlevlerindendir. Trafik işaretleri kaynaklı kazaları önlemek ve otonom araçların güvenilirliğini artırmak için bu sınıflandırmayı doğru güvenilir şekilde yapmasını amaçlıyoruz. Diğer durumda trafik ekolojisini tehlikeye atabilir, maddi ve manevi problemlerin oluşmasına sebep olabilir.

Makalenin bundan sonraki bölümleri aşağıdaki şekilde planlanmıştır. İkinci bölümde makale kapsamında kullanılan veriseti ve önerilen CNN modeli detaylı olarak anlatılmaktadır. Üçüncü bölümde, makale kapsamında gerçekleştirilen deneysel çalışmalar incelenmiştir. Dördüncü bölümde deneysel sonuçlar tartışmalı olarak anlatılmıştır ve son bölümde çalışmanın sonuçları özetlenerek ileride yapılması düşünülen çalışmalardan bahsedilmiştir.

II. MATERYAL VE YÖNTEM

Deneylerimizi halka açık olan “Kaggle’ın Traffic Sign Dataset – Classification” veri seti üzerinde eğittik ve test ettik. Veri setinde yaklaşık 58 sınıf vardır ve her sınıfta yaklaşık 120 resim bulunur. Test edilebilecek yaklaşık toplam 2000 dosya bulunmaktadır [12].

Evrişim katmanı ağırlık hesaplamalarının daha hızlı yapılabilmesi için görüntünün boyutunu küçültür. Görüntü verisi üzerindeki önemsiz gürültüyü evrişim sinir ağı ortadan kaldırırken görüntünün önemli özelliklerini ve görüntünün temel özelliklerini korur.

A. CNN Katmanları

CNN, görüntülerden özelliklerin mekansal bilgilerini otomatik olarak çıkarabilen bir tür derin sinir ağıdır. Bir CNN'nin mimarisi evrişim, havuzlama ve tam bağlantı katmanlardan oluşur. Evrişimli katmanlar, bir dizi öğrenilmiş filtreyle evrişimler gerçekleştirerek giriş görüntülerinden yerel özellikleri çıkarır [13]. Havuzlama katmanları, özellik haritalarının uzamsal boyutlarını azaltır. Tam bağlantılı katmanlar softmax gibi fonksiyonlar ile özellikleri farklı kategorilerde sınıflandırır. Bir CNN modeli giriş görüntüsünden özellikleri çıkarmak ve azaltmak için evrişim ve havuzlama işlemlerini gerçekleştiren birden fazla katmandan oluşur. Evrişimli katmanlar, özellik haritaları üretmek için filtreler kullanır. Havuzlama katmanları, uzamsal boyutları azaltmak için özellik haritaları örnekler. Daha sonra evrişim ve havuzlama katmanlarından elde edilen özelliklere göre sınıflandırma gerçekleştiren tam bağlantı katmanını besler [14]. CNN'lerin görsel görevlerde sürücüsüz arabalar, tıbbi görüntü analizi ve yüz tanıma dahil olmak üzere çeşitli uygulamalarda başarılı olduğu kanıtlanmıştır [15]–[19].

Evrişim: Evrişim, bir nesnenin özelliklerini bir görüntüden yerel düzeyde çıkarmak için kullanılır. Bu, ağın görüntüdeki belirli desenleri algılayacağı ve bunları görüntünün tamamında tanıyabileceği anlamına gelir. Bir bilgisayar görüntünün 3×3 gibi bir filtreyle tarar. Özellik haritaları öğe bazında tarama işleminden sonra oluşturulur. Evrişimden sonra görüntü boyutu küçültülür.

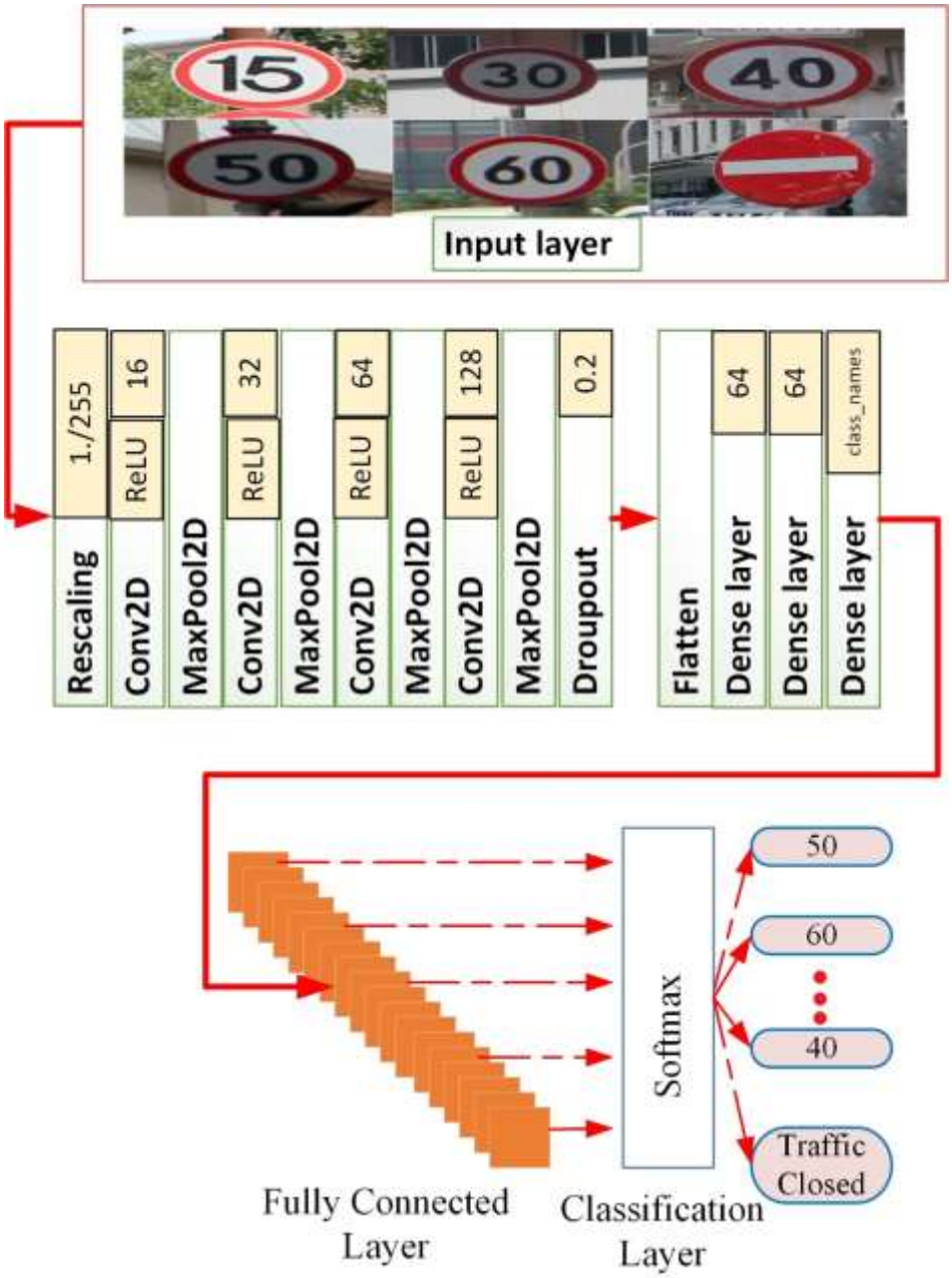
Doğrusal Olmama (ReLU): ReLU fonksiyonu aktivasyon fonksiyonu olarak negatif değere sahip tüm piksellerin değeri sıfırla değiştirerek kullanılmıştır.

Havuzlama İşlemi: Girdi görüntüleri boyutlarını azaltmak için havuzlama birleştirilir. İşlemin hesaplama karmaşıklığını azaltmak için gerçekleştirilerek adım ve boyut ayarlanır. Özellik haritasının maksimum değerini kullanmak, giriş görüntüsünü havuza almanın yaygın bir yoludur. Ayrıca bir havuzlama işlemi olan ortalama da vardır. Bu işlem, öne çıkan haritanın boyutunu önemli ölçüde azaltır.

Tam Bağlantı Katmanı: Giriş görüntüsündeki işaretleri sınıflandırmak için geleneksel bir YSA son katmanıdır. Önceki katmanın tüm nöronları softmax aktivasyon fonksiyonu ile sınıflandırılır.

Şekil 1'de önerilen CNN modeli gösterilmiştir. Bu model günümüzde sıklıkla kullanılan derin öğrenme mimari gruplarından birisidir.

Önerilen modelde görüntü verilerinin yeniden boyutlandırma işlemi Rescaling fonksiyonu ile gerçekleştirildi. Her bir görüntüde 3x3 filtreden oluşan ReLU aktivasyon fonksiyonuna sahip dört adet konvolüsyon katmanı kullanılmıştır. Her konvolüsyon katmanı sonrası 1 adet maksimum havuzlama (MaxPooling2D) ve son havuzlama katmanından sonra sonra 1 adet Dropout (unutma) kullanılmıştır. Unutma katmanından sonra Flatten (düzleştirme), 1 adet ReLU aktivasyon fonksiyonlu Dense katmanı, 1 adet toplu normalleştirme, 1 adet Dropout (unutma)kullanılmıştır. Unutma katmanından sonra 2 adet ReLU aktivasyon fonksiyonlu Dense katmanı, 1 adet softmax aktivasyon fonksiyonlu sınıflandırıcı katmanı kullanılmıştır. "class_names" dosyası içerisindeki sınıf bilgisine göre sınıflandırma yapılmıştır. Genel olarak önerilen modelin katman sıralaması yukarıda belirtildiği şekildedir.

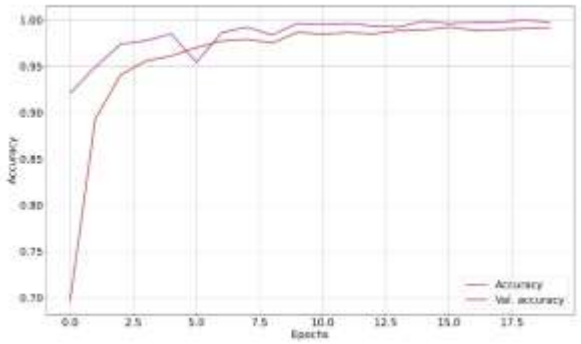


Şekil 1. Önerilen CNN modeli

Optimizasyon yöntemleri makine öğrenim modeli eğitmede hata oranını en aza indirecek şekilde kullanılan ana yaklaşımdır. Önerilen CNN modeli performans sonuçları Adam optimizasyon yöntemi ile test edilmiştir.

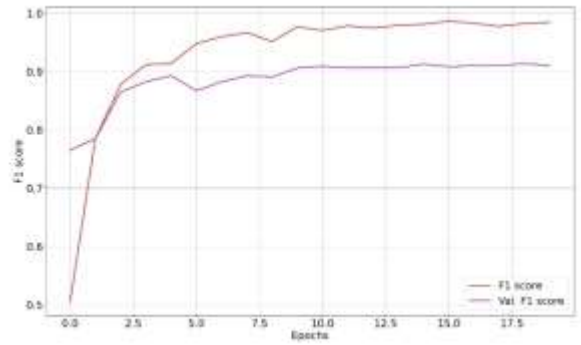
III. BULGULAR

Kullanılan adam optimizasyon yöntemi ile elde edilen eğitim ve test performans sonuçları Şekil 2'da verilmiştir. Şekil 2 incelendiğinde "accuracy" değerinin 0.6966626644134521 başlayarak 0.9910607933998108 ve 0.9916567206382751 değerine ulaştığı görülmektedir. "val_accuracy" değerleri ise 0.9209876656532288 başlayarak 0.9975308775901794 ve 1.0, 0.9975308775901794 değerine ulaştığı görülmektedir.



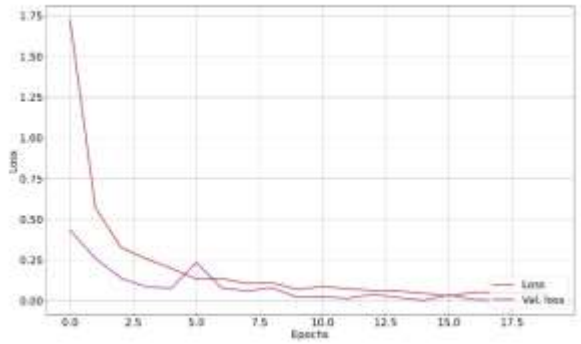
Şekil 2. Önerilen CNN Modelin Eğitim ve Test Doğruluk grafiği

Öne sürülen CNN modelin adam optimizasyon yöntemi ile elde edilen "f1_score" değerinin Şekil 3 incelendiğinde 0.5051260590553284 başlayarak 0.9825475215911865 ve 0.9846116304397583 değerinde ulaştığı görülmektedir. "val_f1_score" değerinin 0.7649663686752319 başlayarak 0.9137930870056152 ve 0.9101805686950684 değerine ulaştığı görülmektedir.



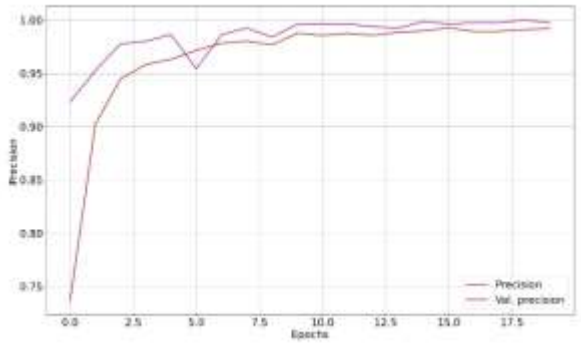
Şekil 3. Önerilen CNN Modelin Eğitim F1 score ve Test F1 score grafiği

"loss" değerinin Şekil 4 incelendiğinde 1.7232218980789185 başlayarak 0.04633501172065735 ve 0.04377853497862816 değerine ulaştığı görülmüştür. "val_loss" değerinin 0.4337146580219269 değerinden başlayarak 0.00019257214444223791 ve 0.01030648685991764 değerine ulaştığı görülmüştür.



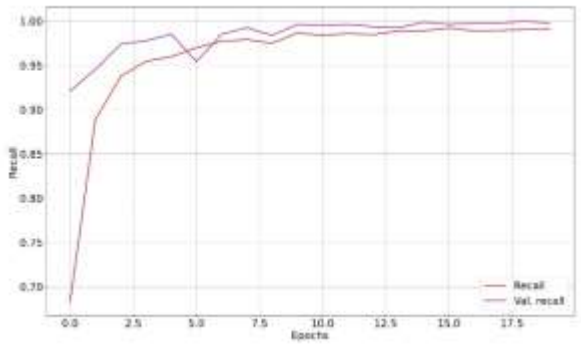
Şekil 4. Önerilen CNN Modelin Eğitim Loss ve Test Loss grafiği

Öne sürülen CNN modelin adam optimizasyon yöntemi ile elde edilen "precision" değerinin Şekil 5 incelendiğinde 0.7365884780883789 başlayarak 0.9910581111907959 ve 0.9922434091567993 değerine ulaştığı görülmektedir. "val_precision" değerinin 0.9232673048973083 başlayarak 1.0 ve 0.9975308775901794 değerine ulaştığı görülmektedir.



Şekil 5. Önerilen CNN Modelin Eğitim Precison ve Test Precision grafiği

Öne sürülen CNN modelin adam optimizasyon yöntemi ile elde edilen "recall" değerinin Şekil 6 incelendiğinde 0.6832538843154907 den başlayarak 0.9907628297805786 ve 0.9910607933998108 değerine ulaştığı görülmektedir. “val_recall" değerinin 0.9209876656532288 den başlayarak 1.0 ve 0.9975308775901794 değerine ulaştığı görülmüştür.



Şekil 6. Önerilen CNN Modelin Eğitim Recall ve Test Recall grafiği

Adam optimizasyonu, birinci dereceden ve ikinci dereceden momentlerin uyarlanabilir tahminine dayanan stokastik bir gradyan iniş yöntemidir. Aynı zamanda Adam, uyarlanabilir moment tahmini anlamına gelir ve mevcut gradyanları hesaplamak için geçmiş gradyanları kullanmanın başka bir yoludur. Adam ayrıca önceki gradyanların kesirlerini mevcut gradyanlara ekleyerek momentum kavramını kullanır. Bu optimize edici oldukça yaygınlaştı ve sinir ağlarının eğitiminde kullanım için pratik olarak kabul edildi. Bu yeni optimize edicilerden bazılarının karmaşıklığı içinde kaybolmak kolaydır. Sadece hepsinin aynı amacı olduğunu unutmayın: Kayıp fonksiyonumuzu en aza indirmek. Bunu yapmanın en karmaşık yolları bile özünde basittir [20].

Softmax Sınıflandırıcı çoklu sınıfın pozitif olasılığını verdiğinden, CNN modelini derlemek için kullanılan Kayıp fonksiyonu Kategorik Çapraz Entropidir. Kategorik çapraz entropi kaybı fonksiyonu, aşağıdaki Denklem 1’de toplamı hesaplayarak bir örneğin kaybını hesaplar:

$$Loss = -\sum_{i=1}^{Output\ size} y_i * \log \hat{y}_i \quad (1)$$

$\hat{y}_i$ model çıktısındaki i'inci skaler değer olduğunda, y_i hedef değerdir. Bu kayıp, iki ayrık olasılık dağılımını ayırt etmek için iyi bir ölçüdür. Eksi işareti, dağılımlar birbirine yaklaştıkça kaybın azalmasını sağlar [20].

IV. TARTIŞMA

Trafik işaretlerini tanıması için önerilen CNN tabanlı model optimizasyon algoritmalarından bir tanesi olan Adam optimizasyon yöntemi kullanılarak derlenmiştir [21]. Trafik işaretlerini tanıma konusunda gerçekleştirilen çalışma ile literatürdeki mevcut çalışmalar ile etkili bir şekilde rekabet edebilecek bir sistem oluşturulmuştur. Tablo 1'de gösterilen model performans çıktıları incelendiğinde literatürdeki benzer çalışmalar ile rekabet edebildiği gözlenmektedir. Gerçekleştirilen performans karşılaştırması neticesinde elde edilen performans metrikleri sonuçlarından sadece iki tanesi ile elde edilen performans sonuçları verilmiştir. Bunların haricinde precision, recall gibi performans metrikleri ile de elde edilen sonuçlar önceki bölümlerde sunulmuştur.

Tablo 1. Farklı algoritmalar kullanılarak elde edilen sonuçların karşılaştırılması

Algoritma	**Accuracy** (%)	**F1 score**
Önerilen Model	99.75	0.98
CNN ve ResNet[4]	98.7-99.2	0.98-0.99
ResNet50-AlexNet[22]	98.63-99.74	0.93-0.95

Bu öne sürülen CNN model sonuçlar güncel literatürde yaygın olarak kullanılan performans ölçütlerinden F1 puanı ve doğruluk ölçüt değerlerine göre değerlendirilmiştir. Önerilen model ve kullanılan adam optimizasyon yönteminin trafik tabelaların tanımlanması ve sınıflandırmak için faydalı bir model olabileceği kanısına varılmaktadır.

V. SONUÇLAR

Gün geçtikçe insanların rutin yaptığı işlevler makinalara yaptırılmaya çalışılmaktadır. Otomatik olarak gerçekleşen işlerdeki güvenlik teknolojilerinin sürekli gelişimi otonom teknolojisini hızlı değiştirmektedir. Tüm otonom sistemlerde sürüş görevlerini yerine getirebilen ve kazaya yol açabilecek tehlikeli durumlardan kaçınarak hayat kurtarmaya ve yaralanmaları önlemeye yardımcı olan bir CNN modeli sunmayı amaçladık.

58 adet trafik işaretinin sınıflandırmasını gerçekleştirilen CNN tabanlı model ile yapılan karşılaştırmalar neticesinde iyi bir sonuç alındığı görülmektedir. Elde edilen performans sonuçları, CNN tabanlı çalışmalardan elde edilen performans metriklerinden olan precision, recall, F1 score ve accuracy değerlerine göre incelenmiştir. Elde edilen sonuçlar, literatürdeki sonuçlarla ile karşılaştırıldığında önerilen modelin trafik tabelalarını sınıflandırmak için yeterli olduğu sonucuna varılabilir.

Donanım, yazılım farklılığı ve ülkelere göre trafik işareti veri kümelerinin çokluğu göz önüne alındığında, bir aktarım öğrenme mekanizması kullanarak diğer ülkelere ait trafik işareti kategorilerini tanıyacak şekilde çalışmalarımızı genişletmeyi planlıyoruz. Esp32, Raspberry Pi 5 gibi maliyeti düşük donanım mimarilerine sahip gömülü bir sistemlerde uygulamak ve sonuçlarını gerçek dünyadaki araba testleriyle karşılaştırmak istiyoruz. Son olarak çalışmalarımıza değer katmak adına yerli otomobil üreticileriyle iş birliği yapmayı düşünüyoruz.

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Stress-Strain behavior of Variously Shaped FRP-Confined Electronic Waste Aggregates Concrete Cylinders

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Abstract – Improper disposal of electronic waste (E-waste) poses significant environmental and health risks in developing countries. This study focuses on evaluating the performance of concrete columns, confined with carbon fiber-reinforced polymer (CFRP) wraps, incorporating shredded E-waste as aggregate under axial compression. The research aims to investigate the structural behavior of columns with various cross-sectional shapes by replacing coarse and fine aggregates with E-waste aggregates (EWA) and confining them with CFRP wraps. Sixty-three samples were produced and tested, considering factors such as cross-sectional geometry, the partial substitution of 20% natural aggregates with EWA, the impact of corners in non-circular columns, and the number of CFRP wraps. The results indicate a reduction in axial compressive strength when natural aggregates are partially substituted with EWA. However, the axial strength of circular, square, and rectangular samples increased by up to 71%, 33%, and 25%, respectively, due to the external CFRP wrapping.

Keywords – Electronic waste aggregates; strengthening; CFRP wraps; sustainability; Axial compressive strength

I. INTRODUCTION

The rapid advancement of electronic materials over recent decades has significantly enhanced human life, especially in information technology, defense, and healthcare. These materials have brought about numerous innovations, but electronic waste (E-waste) has now become a serious environmental issue [1]. In developing countries, the absence of robust regulatory bodies means that informal E-waste processing can lead to pollution and health problems. The main goal of current research is to efficiently utilize recyclable aggregates, including plastic waste from various sectors, in concrete manufacturing. This approach supports a sustainable ecosystem [2]. The surge in sales of electronic products like laptops, monitors, TVs, and LE/CDs has led to a tremendous increase in E-waste. While E-waste aggregate concrete is an eco-friendly, lightweight, and cost-effective option, its reduced strength limits its use to non-structural applications, hindering widespread adoption. The demand for concrete aggregates is continuously rising, projected to reach 59% by 2025 [3]. The constant production of concrete products depletes virgin aggregate resources, adversely affecting the environment [4]. In the current era of electronics, halting device production by ordinary people is unrealistic. Therefore, it is essential to recover usable components from E-waste to create sustainable concrete and mitigate environmental harm

[5, 6]. One sustainable solution is incorporating E-waste into concrete. By heating E-waste below its melting point in a kiln, plastic aggregates are formed, which are then crushed to a specific size. In this study, CFRP wraps were used to enhance concrete samples' compressive performance.

Wang et al. [7] observed that coating reinforced concrete columns with steel tubes and grout significantly increased their axial stiffness, strength, and ductility. Sakr et al. [8] investigated reinforced concrete columns confined by high-strength coatings, finding that thicker jackets, improved core surface roughness, and adequate dowels could achieve monolithic performance. Research on reinforced concrete columns with fiber-reinforced polymer (FRP) wraps under eccentric loads revealed that combining longitudinal and transverse CFRP wraps significantly reduced axial strength's transverse deflection [9, 10]. Using CFRP wraps as anchors increased ductility without significantly affecting axial stiffness [11]. However, samples with longitudinally anchored CFRP wraps showed improved moment capacity and stiffness. Yan et al. studied reinforced concrete columns with CFRP wraps under blast loads, finding that CFRP wraps enhanced damage tolerance, ductility, and reduced residual displacements and secondary blast particles [12]. However, CFRP impacts both compression and tension faces' failure mechanisms.

This study aims to examine the axial compressive performance of compression members made of E-waste concrete reinforced with one or two CFRP wraps and 20% E-waste aggregates instead of natural coarse and fine aggregates. Sixty-three samples with various shapes (circular, square, and rectangular) were tested under axial compression using different strengthening methods. The study explored the effects of partial E-waste substitution, aggregate morphology, and CFRP wraps on strengthening. Axial compressive strength and stress-strain curves of the samples were also analyzed. This research promotes sustainable concrete development by conserving natural resources, reducing pollution, and addressing health issues associated with increased E-waste production.

II. EXPERIMENTAL SETUP

A. Material Properties

Research was conducted using ASTM C150/C150M standards and grade 43, type II cement [13]. Electronic waste aggregates were sourced from computer waste in Rawalpindi. The waste was softened in a kiln below its melting point to produce E-waste aggregates. These aggregates were created by mechanically hammering the waste. Figure 1 shows the E-waste aggregates used in this study. Natural coarse aggregates meeting ASTM C33/C33M-18 criteria were sourced from the Margalla crushing plant, with the largest size being 12.5 mm [14]. Lawrencepur sand with a fineness modulus of 3.1 was used as natural fine aggregates. Table 1 lists the properties of both natural and E-waste aggregates. A uniform concrete mix was achieved using Sika ViscoCrete®-3425, a superplasticizer.

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(a) (b)

Fig. 1 E-waste aggregates (a) fine aggregates (b) coarse aggregates

Table 1. Example Specifications of both coarse and fine aggregates

Property	Natural fine-aggregates	Natural coarse-aggregates	E-waste fine-aggregates	E-waste coarse-aggregates
Specific gravity	2.6	2.64	0.97	1.03
Water absorption (%)	0.78	1.6	0.5	0.8
Dry density (kg/m^3)	1565	1528	575	540
Fineness modulus	3.2	7.47	3.51	7.58
Maximum size (mm)	4.75	12.5	4.75	19
Minimum size (mm)	-	4.75	0.075	4.75

B. Fabrication of Samples

The objective of this study is to investigate the structural behavior of concrete columns incorporating plastic waste aggregates compared to those without. Initial tests focused on the axial stress-strain behavior of the concrete, followed by assessments of its fresh and hardened properties. A constant water-cement ratio of 0.50 was maintained throughout the tests. The aggregate density was used to determine the E-waste content in each sample. A total of 21 batches were prepared, with three samples per batch. Samples were categorized into square (S), circular (C), and rectangular (R) shapes. A 20% partial replacement of aggregates with E-waste is indicated by the number 20. The abbreviations EC and EF represent electronic waste coarse and fine aggregates, respectively. L0 indicates no CFRP sheet, LI represents a single layer of CFRP wrap, and LII indicates double wrapping with CFRP.

In total, 63 samples were cast in three different geometries: square, circular, and rectangular, as shown in Figure 2. The circular samples had a diagonal length of 150 mm. The square and rectangular samples had cross-sectional dimensions of 150 mm x 150 mm and 212 mm x 106 mm, respectively. The casting process consisted of two phases. In the first phase, 20% of the natural coarse aggregates in the circular, square, and rectangular samples were replaced with E-waste coarse aggregates. In the second phase, 20% of the natural fine aggregates were substituted with E-waste fine aggregates of the same shape (circular, square, and rectangular). In both phases, each blend and shape was reinforced with CFRP wraps in single and double layers with a 150 mm overlap, substituting E-waste coarse and fine aggregates for natural aggregates.

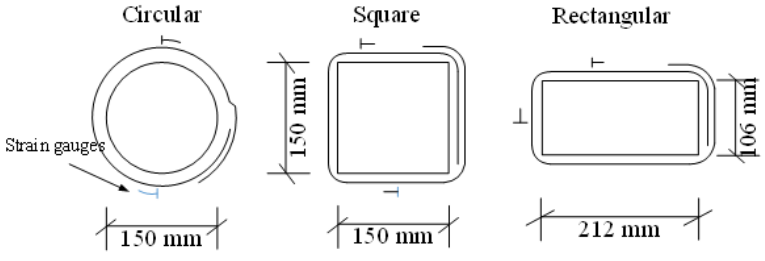

Figure 2. Information on geometry, FRP overlaps, and position of strain gauges

Two linear strain gauges, each 60 mm in length, were installed at the mid-height and 1800 mm apart in opposite directions for each specimen. These gauges are employed to measure the lateral strain in concrete. In addition to the strain gauges, three 50 mm gauge length extensometers were positioned at mid-height, spaced 120° apart from each other, to monitor the axial strain of the specimen. The lateral

strain of specimens wrapped in CFRP wraps was assessed using the KFGS-30 lateral strain gauge, while the concrete in cylinders without CFRP wraps was assessed using the KC-60 lateral strain gauge. To ensure safety during the axial strain measurement process, linear variable differential transformers with 150 mm gauge lengths were also installed. All tests were conducted using a 5000 kN capacity load-controlled Universal Testing Machine (UTM). A preload was applied at a compression rate of 0.06 MPa/sec until the sample reached the preload parameters within 33 seconds. Subsequently, a service load was applied at a rate of 0.030 MPa/sec until failure.

III. Results

The stress-strain behaviours of circular, square, and rectangular concrete samples with varying aggregate substitutions and CFRP wrapping configurations was evaluated. The stress-strain curves for circular samples indicated that replacing natural aggregates with E-waste aggregates decreased the axial compressive strength, with the sample containing 20% E-waste aggregates and no lateral wrapping showing the poorest performance. The highest stress values were observed in circular samples with two CFRP wraps. For square samples, the substitution of E-waste aggregates similarly reduced strength, though samples with single-layer CFRP wraps demonstrated enhanced ductility and stiffness. The rectangular sample with a single CFRP wrap and 20% fine aggregate substitution outperformed other configurations, including those with two CFRP wraps. Comparatively, circular samples exhibited superior overall performance in stress-strain behaviour due to the failure of CFRP wraps at the corners of square and rectangular samples. This suggests that rounding the corners of these samples could prevent premature wrap failure and enhance structural integrity.

IV. Discussion Of Results

The stress-strain behaviour of circular samples for both axial and lateral strains is shown in Figure 3. The average results of the stress-strain graphs for each set of three samples were plotted to ensure accuracy. Due to the use of a load-controlled testing apparatus, the complete stress-strain curves of the samples were not obtained in this study. Replacing natural aggregates with E-waste aggregates reduces the axial compressive strength of concrete, as reported in the literature. The control circular sample with natural aggregates exhibited better stress-strain behavior compared to samples with substituted manufactured aggregates without lateral wrapping [15-20]. The circular sample without lateral CFRP wrapping and with a 20% substitution of aggregates had the lowest stress values at the lateral and axial strains, indicating poorer structural performance and lower ductility. Among all samples, including the control, the circular sample C20EFLII had the highest stress values against axial and lateral strains. When compared to circular samples with a 20% substitution of coarse aggregates, those with two CFRP wraps and the same substitution revealed relatively lower axial stress levels. This is because substituting fine aggregates with E-waste aggregates is more effective than substituting coarse aggregates, resulting in stiffer and denser concrete. Stronger concrete tends to fail at lower strain values and exhibits less ductility [21]. As the literature describes, CFRP wrapping of E-waste concrete columns benefits the samples' axial stiffness, axial strength, and ductility [22]. Applying the CFRP sheet lateral strengthening technique significantly enhances the lower axial compressive strength of circular concrete columns made with E-waste aggregate.

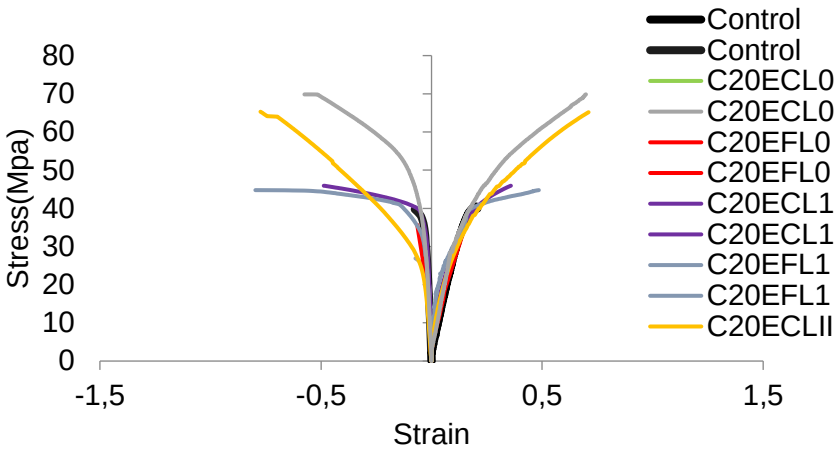

Figure 3. The axial stresses against axial strains and lateral strains of circular samples

Figure 4 illustrates the full stress-strain responses of square samples. The control square samples had higher stress values at relevant strains compared to samples with a 20% substitution of virgin aggregates with E-waste aggregates without CFRP wraps. Substituting aggregates with E-waste reduces concrete strength, necessitating reinforcement. The S20EFLII square sample exhibited the highest stress values against axial and lateral strains among all samples, including the control. Similarly, square samples with two CFRP wraps and a 20% substitution of coarse aggregates with Easte aggregates showed lower axial stress values compared to other samples. Replacing fine aggregates with E-waste aggregates is more effective than replacing coarse aggregates due to their superior filling capabilities, resulting in stiffer and denser concrete [20]. Square samples with a single layer of CFRP wraps demonstrated improved stress-strain behavior compared to control samples, showing stronger ductility and stiffness at various values of axial and lateral strain. Therefore, CFRP wrapping of E-waste concrete columns is beneficial in terms of axial strength, axial stiffness, and ductility, as stated in the literature [22, 23]. Lateral wrapping enhances the axial stress-axial strain and axial stress-lateral strain responses of square E-waste concrete columns.

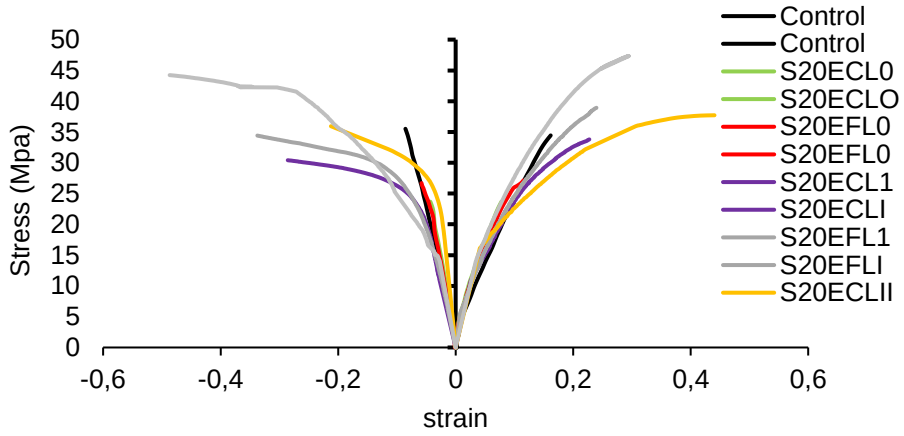

Figure 4. The axial stresses against axial strains and lateral strains of square samples

The rectangular sample with a 20% fine aggregate substitution with E-waste aggregates confined laterally with a single CFRP sheet (R20EFLI) outperformed all other samples, including the control and samples confined with two CFRP wraps, in stress-strain response. Even though round and square samples performed better with two CFRP wraps and 20% fine aggregate substitution, rectangular samples with fine aggregate substitution and single CFRP wraps showed excellent axial strength. Figure 5 depicts the stress-strain behavior of rectangular samples under axial and lateral strains. For axial stress-axial strain response, the control rectangular sample with natural aggregates ranked fourth in stress-strain behavior (after R20EFLI, R20EFLII, and R20ECLII) and third in axial stress-lateral strain behavior (after R20EFLI and R20EFLII). Substitution of E-waste aggregates resulted in lower stress values relative to

control samples, necessitating structural reinforcement [16, 18, 20]. Rectangular samples (R20EFL0 and R20ECL0) without lateral CFRP wrapping and with a 20% aggregate substitution exhibited the lowest stress values at lateral and axial strains, indicating poorer structural performance and lower ductility. The axial stress values for the rectangular sample R20ECLII were noticeably lower than those for R20EFLII. This can be attributed to the higher packing capabilities of E-waste aggregates when substituting fine aggregates rather than coarse aggregates, resulting in stiffer and denser concrete [15, 20]. Samples with a single layer of CFRP wraps showed improved stress-strain behavior compared to reference samples, demonstrating stronger ductility and stiffness. Circular samples showed better performance when comparing the full stress-strain behavior of all three geometrical shapes (circular, square, and rectangular). This may be due to the failure of CFRP wraps at the sharp corners of square and rectangular columns, ultimately leading to sample failure. To avoid early failure of CFRP wraps and samples, the corners of rectangular and square samples should be rounded.

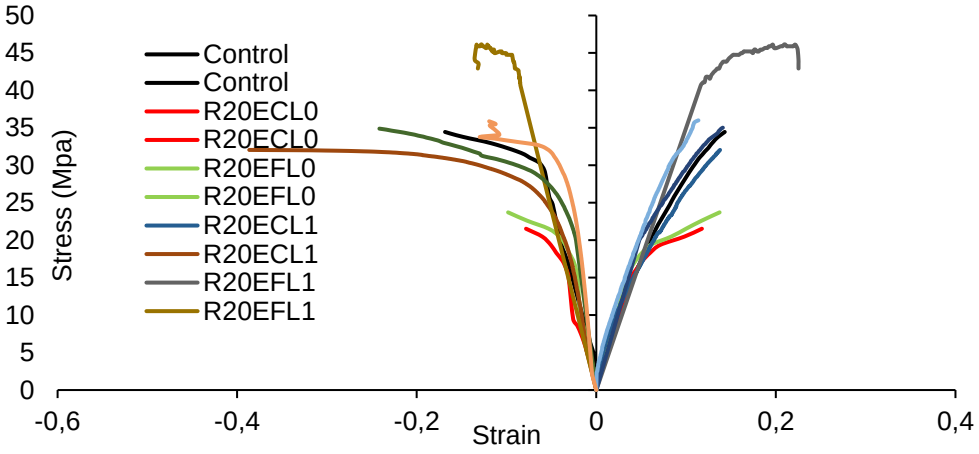

Figure 5. The axial stresses against axial strains and lateral strains of rectangular samples

V. CONCLUSION

The investigation has highlighted several key factors at this stage:

1. When natural aggregates are partially replaced (20% substitution of both coarse and fine aggregates), the strength of concrete decreases, and the failure time lengthens. Specifically, for circular samples, substituting 20% of coarse aggregates with E-waste reduces compressive strength by 33%, while replacing 20% of fine aggregates results in a 12% reduction. For square samples, there is a 33% reduction with coarse aggregate substitution and a 16% reduction with fine aggregate substitution. Rectangular samples show a 40% reduction for coarse aggregate substitution and a 35% reduction for fine aggregate substitution.
2. Circular samples using the control mix with natural aggregates and no lateral wrapping exhibited higher axial compressive strength compared to square and rectangular samples. The axial strengths of the circular control samples were 14.4% and 17.9% higher than those of the square and rectangular control samples, respectively.

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Dijital Toplum ve Dijital Yeteneklerin Gelişimi Üzerine Sistematik Literatür Analizi

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Özet – Bu çalışma toplumun dijital dönüşümü ve dijital toplumun gerekliliklerinden biri olan toplumun dijital yeteneklerinin gelişimi üzerine değerlendirme yapmayı amaçlamaktadır. Toplumun dijital dönüşümü, genel olarak toplumun dijitalleşme süreçlerini tanımlamak için kullanılmaktadır. Daha özel anlamıyla, dijital teknolojilerin günlük yaşamda kullanımı da dahil olmak üzere, insanların toplumu yorumlama ve anlama yoluyla toplumun yaşama biçimini yeniden şekillendirdiği bir süreci ifade etmektedir. Dijital toplum kavramı ise büyük ölçüde ve kapsamlı olarak dijital bilgi çağının kendine özgü koşullarıyla şekillenen, sosyal, politik ve ekonomik yapı içinde bir arada yaşayan insanların bütününü temsil etmektedir. Avrupa Komisyonu'nun DigComp Çerçevesine göre dijital beceri, dijital teknolojilerin kendinden emin, eleştirel ve sorumlu bir şekilde kullanılmasını; ayrıca öğrenme sürecinde, iş yerinde ve topluma katılımda bu teknolojilerle etkileşime geçilmesini içermektedir.
Yeni teknolojilerin hızlı ilerleyişi ve hayatın her alanına entegrasyonun doğal bir getirisi olarak toplumun dijital yeteneklere sahip olması veya mevcut yeteneklerini güçlendirmesi beklenmektedir. Ancak, bu beklentiyi tatmin edecek düzeyde topluma katkı sağlayan çalışmaların yapıldığı tartışma konusudur. Bu çalışmada, Türkiye'de yayınlanan akademik hakemli dergiler için elektronik ortamda barındırma ve editoryal süreç yönetimi hizmeti sunan DergiPark altyapısını kullanan dergiler taranmış ve 46 araştırma incelenmiştir. Araştırma sonucunda, dijital beceri konusunun Türkiye'deki dergiler için oldukça yeni bir alan olduğunu söylemek mümkündür. Bu alanda yapılan çalışmaların çoğu eğitim sektörüne yöneliktir. Toplumun dijital becerilerini geliştirmeye yönelik strateji ve programlara açıkça ihtiyaç bulunmaktadır. Bu nedenle, dergilerin konu üzerine yapacağı özel sayıların ve ilgili kuruluşların sağlayacağı proje desteklerinin, dijital dönüşümün toplumsal boyutunu güçlendireceği düşünülmektedir. Bu çalışmanın, Türkiye'deki dergiler özelinde dijital beceri konusunda bulunan boşluğa dikkat çekmesi ve alanyazının geliştirilmesine yönelik öneriler sunması bakımından alana katkı sunması beklenmektedir.

Anahtar Kelimeler – Dijital Dönüşüm, Dijital Toplum, Dijital Beceri, DergiPark, Sistematik Literatür Analizi

I. GİRİŞ

Dijital teknolojilerin günlük hayatı kararlı bir şekilde şekillendirdiği bir çağda yaşamaktayız. Geçtiğimiz birkaç yılda, iletişim şekillerinden çalışma yöntemlerine, eğitim ve eğlenceye kadar hızlı bir dijital dönüşüme tanıklık edilmektedir. Bir zamanlar istisna olarak kabul edilebilecek dijital teknolojilere bağımlılık artık yeni normal olarak değerlendirilmektedir. Mevcut kurumsal ve teknik dijital dönüşüme ek olarak; toplumu bütünüyle sürece dahil eden bir dönüşümden bahsetmek mümkündür. Toplumun dijital dönüşümü, genel olarak toplumun dijitalleşme süreçlerini tanımlamak için kullanılmaktadır. Daha özel anlamıyla, dijital teknolojilerin günlük yaşamda kullanımı da dahil olmak üzere, insanların toplumu yorumlama ve anlama yoluyla toplumun yaşama biçimini yeniden şekillendirdiği bir süreci ifade etmektedir. Başka bir deyişle, dijital toplum olma yolunda ilerleme olarak özetlenebilir. Dijital toplum kavramı ise büyük ölçüde ve kapsamlı olarak dijital bilgi çağının kendine özgü koşullarıyla şekillenen, sosyal, politik ve ekonomik yapı içinde bir arada yaşayan insanların bütününü temsil etmektedir. Dijital

toplumda verilerin dijitalleşmesine bağlı olarak, hayatın her alanı derinden etkilenmektedir: iletişim kanallarından, sosyalleşme şekillerine; çalışma stillerinden, öğrenme yöntemlerine; hatta sağlıklı yaşama formüllerine kadar. Dijital toplum kavramı, aynı zamanda, üyeliğin dijital dünyaya kadar uzandığı, geleneksel toplumun yanı sıra paralel bir varlığı da işaret etmektedir.

Dijital yenilikler toplumu, ekonomiyi ve endüstrileri daha önce hiç olmadığı kadar büyük ölçekte ve hızda yeniden şekillendirmektedir. Mobil ve bulut teknolojileri, Büyük Veri ve Nesnelerin İnterneti, sağlık hizmetleri, ulaşım, enerji, tarım, üretim, perakende ve kamu yönetimi gibi birçok alanda büyümeyi teşvik ederek, vatandaşların yaşamlarını iyileştirme ve verimliliği artırma gibi önemli fırsatlar sunmaktadır. Politika yapıcıların daha iyi kararlar almasına ve vatandaşların katılımına yardımcı olarak yönetim sürecini de geliştirebilmektedir. İnternet, ifade özgürlüğü ve bilgi edinme özgürlüğü gibi demokrasiyi, kültürel çeşitliliği ve insan haklarını teşvik etme konusunda önemli bir potansiyele sahiptir. Bununla birlikte, bu değişimlerin boyutu ve hızı tüketicilerin, kullanıcıların, vatandaşların ve çalışanların, kısaca "dijital kişilerin", sosyal ve özel hayatını, eğitimini ve çalışma biçimlerini, bilimi, hükümetleri ve iş dünyasını da etkilemekte ve dönüştürmektedir.

Bu toplumsal dönüşümde rol oynayan internet, çevrimiçi platformlar, yapay zeka, robotik ve akıllı sistemler gibi yeni bilgi ve iletişim teknolojileri beraberinde yeni becerilere duyulan ihtiyacı da getirmektedir. Son yıllarda dijital beceri kavramı, politika belgelerinde, akademik literatürde, eğitim programlarında ve eylem planlarında önemli bir yer edinmektedir. Dijital beceri kavramının yerine literatürde farklı terimler de kullanılabilmektedir. Dijital okuryazarlık, dijital yeterlilik, e-okuryazarlık, e-beceriler, e-yetkinlik, bilgisayar okuryazarlığı ve medya okuryazarlığı gibi kavramlar bunlardan başlıcalarıdır. Birebir aynı anlamı karşılamasa da bazen birbirlerinin yerine kullanıldığı görülmüştür. Avrupa Komisyonu'nun tanımına göre dijital beceri, dijital teknolojilerin kendinden emin, eleştirel ve sorumlu bir şekilde kullanılmasını ve öğrenme sürecinde, iş yerinde ve topluma katılımda bu teknolojilerle etkileşime geçilmesini içermektedir [1]. Bu tanım kapsamında, dijital beceri kavramı bilgi ve veri okuryazarlığı, iletişim ve işbirliği, medya okuryazarlığı, dijital içerik oluşturma (programlama dahil), güvenlik (dijital refah ve siber güvenlikle ilgili yeterlilikler dahil), fikri mülkiyetle ilgili sorular, problem çözme ve eleştirel düşünmeyi içermektedir.

Günümüzün dinamik dijital dünyasında dijital becerilere sahip olmak büyük önem taşımaktadır. Dijital yeterlilikler, teknoloji odaklı bir ortamda etkin işleyişin temelidir ve bunları geliştirmek, yaşamın çeşitli alanlarında başarı sağlamak için gereklidir. Ancak, bu becerilerin gelişimi bireylerin tek başına üstlenebileceği sorumluluk alanı olarak görülmemelidir. Devlet organlarına, özel kuruluşlara ve bilimsel topluluklara bu anlamda ciddi rol düşmektedir. Bu çalışmada, söz konusu aktörlerden bilimsel yayınlara dikkat çekilmiş ve Türkiye'de yayınlanan dergilerin dijital dönüşüm yolunda toplumun dijital becerilerinin gelişimine olan katkısı incelenmiştir. Araştırmada DergiPark altyapısını kullanan dergiler taranmış ve 46 araştırma incelenmiştir. Araştırma sonucunda, dijital beceri konusunun Türkiye'deki dergiler için oldukça yeni bir alan olduğu görülmüştür. Alandaki çalışmalar, eğitim sektöründe yoğunlaşmaktadır. Türkiye'deki dergiler kapsamında, toplumun dijital becerilerini geliştirmeye yönelik strateji ve programlar bağlamında boşluk bulunmaktadır.

Çalışmanın ikinci bölümünde, araştırmada kullanılan materyal ve yöntemler anlatılmaktadır. Araştırmanın amacı, araştırma sorusu, veri toplama yöntemi ve verilerin analizi hakkında bilgi verilmektedir. Üçüncü bölümde, verilerin analizi sonucunda elde edilen araştırma çıktılarından bahsedilmektedir. Taranan dergilerde, toplumun dijital dönüşümüne destek veren veya dijital dönüşümün ihtiyaç duyduğu dijital becerilere yönelik çalışmaların sistematik analizi yapılacaktır. Dördüncü bölümde, çalışma bulgularının önemi ve çalışmanın ala katkısı tartışılmaktadır. Son olarak, çalışmanın ana sonuçları ve gelecek çalışmalar için öneriler sunulmaktadır.

II. MATERYAL VE YÖNTEM

Bu çalışmanın amacı, dijital dönüşüm sürecinde bilimsel yayınların toplumun dijital becerilerinin gelişimine katkısını Türkiye özelinde incelemektir. Araştırma alanı olarak Türkiye'de yayın yapan dergiler hedeflenmiştir. Bu nedenle, Türkiye'de yayınlanan akademik hakemli dergiler için elektronik

ortamda barındırma ve editoryal süreç yönetimi hizmeti sunan DergiPark altyapısını kullanan dergiler taranmıştır. Araştırma verisini oluşturacak bilimsel çalışmalar, araştırma sorularına ve arama kıstaslarına göre süzgeçten geçirilmiştir.

Araştırmanın zeminini oluşturan araştırma soruları aşağıda belirtilmiştir:

1. Dijital dönüşüm süreci, toplumun becerilerini nasıl etkilemektedir?
2. Türkiye'de yayın yapan dergiler dijital beceri kavramını ve dijital becerileri nasıl ele almaktadır?
3. Türkiye'de yayın yapan dergilerin, toplumun dijital becerilerini geliştirmeye yönelik katkısı nedir?

Yukarıdaki araştırma soruları çerçevesinde, DergiPark bünyesinde yayınlanan dergiler başlıca anahtar kelimeler doğrultusunda taranmıştır. Tarama sırasında, arama kısmına her bir arama için "dijital beceri", "dijital beceriler", "dijital yetenek", "dijital yetenekler" ve "dijital toplum" anahtar kelimeleri girilmiştir. Tarama sonucunda toplam 63 araştırmaya ulaşılmıştır. Araştırma amacına ve sorularına ve sorularına cevap vermeyen çalışmalar araştırma kapsamından çıkarılmıştır. "Dijital beceri" dışındaki becerilere değinen, dijital becerilere yönelik bir analiz ortaya koymayan, fenomenolojik araştırma yapan ve dijital beceriyi yalnızca mevcut veri setinin bir bölümü olarak ele alan çalışmalar kapsam dışı bırakılmıştır. Tarama sonucunda toplam 46 çalışma araştırma kapsamında ele alınmıştır.

III. BULGULAR

Bu bölümde, DergiPark bünyesinde yer alan dergilerin sistematik literatür analizi (SLA) sonucu elde edilen bulgular sunulmuştur. Araştırma kapsamında incelenen 46 bilimsel çalışmanın iki tanesi hariç [2][3] hepsi 2020 yılı ve sonrası yayınlanmıştır. Çalışmaların yarısı, eğitim sektörüne yöneliktir. Bunun dışında, ülke karşılaştırmaları [4], ölçek ve veri seti çalışmaları [5][6] ve kamu çalışanlarının dijital becerilerine yönelik araştırmalar [7] yer almaktadır.

Çalışmaların çoğuna 2020 yılında ortaya çıkan Koronavirüs pandemisi zemin oluşturmaktadır. Küresel salgınla birlikte süreçlerin dijital ortamlara taşınması çalışmalara yön veren başlıca etmenlerden biri olmaktadır. Bu nedenle, eğitim sektöründe yapılan çalışmaların öncelikli amacı yeni öğretim teknolojilerinin hem eğiticiler hem de öğrenciler tarafından kullanımını araştırmaktır. Diğer bir amaç ise, dijital içeriklerin eklendiği eğitim modellerinin dijital becerilere etkisini değerlendirmektir [8].

Çalışmaların önemli bir kısmı dijitalleşmeyle beraber gelen yeni fırsatlara ek olarak ortaya çıkan zorluklara da işaret etmektedir. Teknolojik araçlara erişim, hizmet içi eğitimler, dijital içerikler ve dijital evrenler başlıca fırsatları oluştururken; sosyo-ekonomik koşullar, dijital mahremiyet ve hakların belirsizliği, nitelikli eğitim eksikliği ve mesleki kaygılar öne çıkan zorluklar arasında sayılmaktadır.

SLA kapsamında incelenen çalışmaların çoğu dijital becerilerin kendiliğinden gelişmeyeceğini; nitelikli, erişilebilir, içerik olarak çeşitli eğitim programlarının geliştirilmesi gerektiğini savunmaktadır [9]. Analiz sonucunda elde edilen diğer önemli bulgu ise dijital haklar ve beceriler konusunda yasal boşlukların bulunduğudur. Özellikle mesleki beceri ve dijital okuryazarlık anlamında, uluslararası alanda karşılaşılan yasal boşluklardan kaynaklanan risklere karşı yasal düzenlemelerin yapılması gerekliliği ortak bulgulardan biridir [10][11].

IV. TARTIŞMA

SLA sonucu elde edilen bulgular neticesinde söylemek mümkündür ki bireyler ne kadar teknolojik imkanların ortasına doğsalar da bu durum onların teknolojik aygıtları yeterli ve doğru kullanacağını garanti etmemektedir. Bu hususta, toplumsal dijital becerilerin gelişimini desteklemek için dijital eşitsizlik/bölünme [9][12], teknik ve mesleki eğitim yetersizliği [13], ebeveyn arabuluculuğu [11] ve dijital liderlik [14] gibi sorun alanlarının üzerinde çalışılması gerekmektedir.

Diğer yandan, gündelik hayatın hızlı dijitalleştiği yadsınamaz bir gerçektir. Dijitalleşen gündelik hayat sonucu bireyler belli düzeyde teknik bilgi ve kullanıma sahip olmaktadır [15]. Jenny Preece dijitalleşmeye zorlanan bu yapıyı çevrimiçi topluluk (*online community*) olarak adlandırmakta ve teknolojinin oluşturduğu sosyal alan ile topluluk faaliyeti arasında belirleyicilik ilişkisi kurmaktadır [16]. Kısaca, dijital yerli olarak adlandırılan bireyler dijital becerileri kendiliğinden edinmese bile bu temel dijital becerileri deneyimlemeye zorlanmaktadır. Özellikle e-spor gibi daha etkileşimli ve eğlenceli bir deneyim sunan [17] dijital dönüşümler bu zorlanmayı gönüllü hale getirmektedir.

Dijitalleşmenin yeni meslek grupları ortaya çıkarması ve bu mesleklerin hızla popülerleşmesi de dijital yeteneklerin gelişiminde belirleyici unsurlardan biri olmuştur. Hatta belirli bir altyapı veya donanım gerekmediği halde bazı meslek gruplarının toplumları dijitalleşme ekseninde dönüştürücü etkisinin fazla olduğu düşünülmektedir. Bu bağlamda verilebilecek en iyi örneklerden biri dijital içerik üreticileridir. Bu nedenle, literatürde "toplumsal bir tip" olarak ele alınmaktadır [18].

V. SONUÇLAR

Çalışmanın sonucunda, dijital dönüşüm sürecini bireysel veya kurumsal olarak tek başına ele almaktan ziyade; toplumsal bir süreç olarak değerlendirmenin daha doğru olacağı kanısına varılmıştır. Bu dönüşüm süreci, gündelik alışkanlıklardan karmaşık işlemlere kadar hayatın tüm alanına sirayet etmekte ve toplumun becerilerini de beraberinde gelişmeye teşvik etmektedir. Ancak, söz konusu teşvik her zaman beklenen olumlu etkiyi yaratamamaktadır. Toplumun bazı kesimleri bu dönüşüm sürecinin herhangi bir aşamasında veya kategorisinde yer alırken; bazı kesimleri ise süreçten ya habersiz kalmakta ya da bilinçli olarak süreçten dışlanmaktadır. Bu dışlanma bireysel bir tercih olabildiği gibi içinde bulunulan sos-ekonomik durumun bir getirisi de olabilmektedir. Sonuç olarak da yetenekler bağlamında toplumsal dijital eşitsizliklerin ve uçurumun arttığı gözlemlenmektedir.

Türkiye'de yapan dergiler, dijital beceri kavramını çoğunlukla dijital okuryazarlık üzerinden değerlendirmektedir. Özellikle Covid-19 pandemisiyle beraber kamusal hizmetlerin (bilhassa eğitim hizmetlerinin) çevrimiçi platformlar aracılığıyla sunulması toplumsal hazırlık seviyesinin önemine dikkat çekmiştir. Bu nedenle, hizmetlerden faydalanacak olanların ivedilikle hizmetlerin asgari düzeyde sunulabilmesi için platformları kullanabilmesine odaklanılmıştır. Oysaki zamanla toplumun ne düzeyde dijital araçları kullanabildiği, nasıl kullandığı ve dijital tehditlere karşı savunmasızlığının esas üzerinde durulması gereken konular olduğu öne çıkmıştır. Bu aslında beklenmedik olayların veya toplumsal krizlerin doğal bir süreci olarak değerlendirilebilir. Pandemi, toplumları zorunlu hızlandırılmış bir dönüşüm sürecine ittiğinden esas önceliklerin ikinci planda kalarak sonrasında değerlendirilmeye alınması olağandır.

Dijital yeteneklerin gelişimi ve dijital toplum oluşumu Türkiye'de yayın yapan dergiler için yeni çalışma alanları olarak değerlendirilebilir. Pandemi sürecinde karşılaşılan zorluk ve fırsatların değerlendirildiği çalışmalar, süreçten ders çıkararak hem teorik hem de tatbiki anlamda eksikliklerin tamamlanması bakımından oldukça önemlidir. Başlangıç aşamasında derleme çalışmalarının olması, kavramsal muğlaklığı gidermek adına katkı vericidir. Pandeminin etkisinin azaldığı ve olağan olarak değerlendirilebilecek süreç yönetimlerinden ve hizmet sunumlarından bahsedilebilecek dönemlere gelindiği kabul görürse, bundan sonraki çalışmalarda dijital okuryazarlığın ötesinde ampirik çalışmalara ihtiyaç duyulmaktadır. Bu kapsamda, toplumsal dijital yeteneklerin geliştirilmesi için gereken yaklaşımlar (örneğin katılımcı inovasyon / katılımcı dijitalleşme), dijital liderlik, kurumsal ve yönetimsel tasarımlar, dijital ortaklıklar, paydaşlar arası güven (özellikle kişiler arası), kullanıcı katılımı ve deneyimi (doğru kullanıcıya doğru yetenek) ve siber güvenlik (bireysel, kurumsal, toplumsal) gibi alanlarda bilimsel araştırmalara ihtiyaç duyulmaktadır.

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Evaluating Push-and-Pull Factors of Migration from West African Communities to Turkey through Labour Market Related SDG Indicators

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Abstract – This article presents exploratory research on the migration of citizens from Sub-Saharan Africa to Türkiye, which in recent years due to the rapid growth of migratory movement between the two regions has opened a field of study for possible evaluations of migration between African countries and Türkiye. For these reasons, we selected the 16 West African countries for our research and carried out a bibliographical review of the literature on migratory movements and contextualized the topic in the field of economics through the theories and models of different authors and economic schools.

During our research, we discovered that the concept of "international migration" has a direct connection with economic development, and as it is known that development is one of the phenomena that influences migration, we also accept that migration from different perspectives also influences the economic development of both parties (origin and destination). During our investigation we concluded that people migrate in order to find better living conditions than in their places of origin. We also identified through SDG indicators the main factors that lead West African migrants to move from their country of origin to Türkiye. Given the current conditions, Türkiye is offering better working conditions and protection of worker' rights comparing to the West African countries.

Keywords – International Migration, Push-Pull Factors, Labour Market, Sustainable Development Goals, West African Communities, Türkiye.

I. INTRODUCTION

The content linked to migration and its impact on the development of the country's economy, as well as the societies of both origin and destination, has been examined in various academic disciplines, including sociology and economics. Since then, the majority of research has concentrated on the role of migrants as the primary factor in a country's economic development, particularly during periods of expansion.

Migration is utilized in countries facing a decrease in the youth population and demographic imbalances to alleviate these disparities. The implementation of these immigration policies in these countries is motivated by a future-oriented perspective. Various studies have shown that a deficiency in human resources can hinder a country's economic advancement. These factors collectively highlight a deficiency in the existing labour force of the country.

While labour factor movements have the potential to contribute to the development of countries, economic, demographic, social, political and/or geographical differences between countries also determine the direction of these movements. 'Push factors' include factors that may cause an international migration decision, and 'pull factors' could be effective in determining the destination country.

Nevertheless, Türkiye has been acknowledged as a host nation from the era of the Ottoman Empire until the establishment of the Turkish Republic in 1923 [1, p. 77]. The geographical location is a primary catalyst

of the continuous influx of immigrants into the country. Located in the central of the globe, Türkiye is already recognized as a transit country for immigrants aiming to reach countries such as France, Italy, England, Germany, Canada, and others. Türkiye as a transit bridge to Europe has contributed to the segmentation of immigrants into two distinct groups. The first group consists of immigrants who intend to use the country as a passage to reach their final destinations, while the second group includes those who have left their home countries due to economic and political conditions to reside in Türkiye [2, p. 188].

The impact of African immigration to Western countries on economic prosperity has been the focus of various scientific studies and political analyses. However, our literature evaluation revealed that research and analysis on the flow of immigrants from Africa to Türkiye is relatively restricted, which can realistically assess the value of this study and its impact on academic literature.

This study aims to evaluate the factors that may motivate migration from West African countries to Türkiye. To contextualize the topic, we started with theoretical approaches of migration from micro and macro perspectives, studies in the economic literature related to both internal and external migration, and historical backgrounds and some stylized facts about West African countries and Türkiye. We consulted the publications of official studies by non-governmental organizations such as the UN, the World Bank, the International Labour Organization (ILO) and the International Organization for Migration (IOM), and on the other hand we consulted Turkish institutions such as the Turkish Statistical Institute (TUIK) and the Türkiye Immigration Administration and used data provided by them. By comparing the data, especially those focusing on Labour Market Related SDG indicators, we tried to reveal the potential push-and-pull factors of international migration from West African countries to Türkiye.

II. The Concept of Migration

Migration, considered one of the oldest activities in human history, is nothing more than moving from one region to another. The term is defined far beyond displacement, designated as a process of intertwining different communities. The concept of migration is broadly defined as the movement of people or groups from one place to another; these movements involve crossing borders towards the place of destination [3, p. 124]. On the other hand, the concept of migration can be summed up as the movement of individuals in and out of a country and includes economic, political, cultural and demographic mobility. Migration can also be defined as the permanent or periodic movement of people from one region to another, either voluntarily or compulsorily. Since ancient times, humanity has sought shelter to feel safe from natural disasters, lack of nutrition, insecurity and so on, but it all started for economic, political and social reasons [4, p. 3].

According to [5], migration refers to crossing the border of a given administrative territory for a long or short period of time. This phenomenon involves the following: economic migration, refugee migration (forced displacement), as well as the migration of individuals who move for other reasons or the attraction of certain influencing factors, such as family reunions.

Reference [6] also defined migration as a simple displacement that results in a permanent or periodic change of residence, without considering “distance” as a fundamental factor, but the author considers migration to be a simple way of moving from one neighbourhood to another or from one country to another in order to reside. The United Nations defines migration by saying that a migrant is any living being who moves from one region to another for habitation, and further states that migration is the displacement between political and administrative spaces for a certain period, a change that results in residing/habiting, differentiating this displacement with other mobilities that do not contain the intentions of residing [7, p. 9].

III. General Theories of Immigration

Migratory movements in the economic science are analysed from two major perspectives: microeconomics and macroeconomics. The microeconomic approach on migratory movements examines the behaviour of individual elements in a specific region or economy to predict their behaviours under scarcity constraints. The focus of this analysis is the study of the behaviour of the individual components of a particular economy, namely the connections developed between consumers and producers. In the

macroeconomic perspective, considered the most comprehensive, the behaviour and activities of the economy are analysed, obtaining data from business forces to provide information such as: the unemployment rate, the world price level and the total value of a nation's income [8, p. 33].

A. Micro Perspectives: The Classical, Neo-Classical, Push-Pull and Human Capital Theories

Reference [9], through his first paragraph in his article "Economic Development with Unlimited Supplies of Labor" led him to be considered one of the first authors who proposed a classical model to explain immigration. In the propositions mentioned in his article, Lewis pointed out two main sectors:

- ✓ Subsistence,
- ✓ Capitalist,

The logic of dualistic model, 'Subsistence' is generally considered to be the sector that includes rural areas and agricultural activities, and 'Capitalist' is also understood to be the sector that encompasses all the industrialized and urban sectors of society (in classical and Lewis' terminology). Accordingly, he did not specifically define the subsistence sector, but consisted of people receiving subsistence wages [10, p. 74]. However, the model assumed that surplus labour in the subsistence sector pays subsistence wages equal to the marginal product of labour (MPLA = 0), compared to the capitalist sector, in which surplus labour pays wages higher than the marginal product of labour (MPL > 0), making it the main attractive factor for the unlimited supply of labour.

Lewis again considers immigration to be a result of the wage gap between the capitalist sector (in the capitalist sector, wages are set higher than in the subsistence sector) and the subsistence sector [9, p. 410]. According to him, the wage rate in the urban area is approximately 30% higher than the wage rate in the rural area; on the other hand, labour in the urban area is considered scarce compared to the rural area [11]. The displacement of labour caused by the slowdown in capital accumulation results in both internal and external immigration, although there are other factors that some authors consider to be the main reason for immigration. For Lewis, the main reason for immigration is the wage differential between the capitalist sector and the subsistence sector. The model was satisfactory in terms of its successful description of migration movements between rural and urban areas, but it did not take into consideration various possibilities of unemployment in metropolitan areas. Several perspectives evolved regarding Lewis's opinion and his evaluations of immigration.

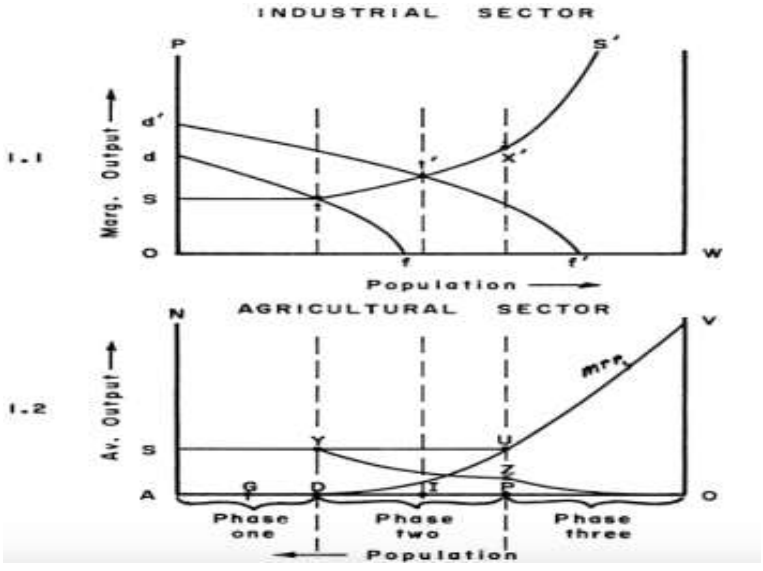

Fig. 1 The Fei-Ranis "Interpretation of Lewis Model" [12, p. 535]

Reference [12] heavily attacked Lewis for disregarding the agriculture sector in his model. The model established by Gustav Ranis and John C. H. Fei took a step further by arguing that the agricultural sector plays an incredibly essential role in the growth and expansion of the industrial sector. They demonstrated that the growth rate of the industrial sector increases with the help of the amount of total surplus in the agricultural sector and the quantity of profits achieved in the industrial sector (Fig. 1) [12, p. 534].

Reference [13] contradicted the neoclassical line since it neglected to take into consideration a social orientation in the economic perspective of migration. Indeed, he underlined that immigrants should not be defined as distinct people but should be classified as part of social groups that directed their paths of socio-economic mobility. He further developed his ideas on content, basing them on the influence of the center on the periphery, intermediary groups, ethnic groups, the informal economy and so on. The same author stated that these individuals, when they are making rational decisions, they clearly consider not only economic issues, but also the expectations of the family and the groups to which they belong.

Reference [14], in their article "The New Economics of Labor Migration", argued that the decision to immigrate does not depend on one person, but is a decision made collectively by a group or units such as a family. People act collectively during the decision-making process, aiming not only to maximize their expected income, but also to minimize the various limitations of the labour market in the host countries.

During our research of classical school explanations for migration, as defended by authors such as [9], we discovered many factors that cause migratory movements, including a surplus of labour in the subsistence sector that is attracted by the capitalist sector using its basic mechanisms, climate change, and influences caused by groups or family members.

The neo-classical theory of immigration is basically like other economic theories of immigration that have also deepened their approaches in search of an explanation of migration patterns by focusing on the basic principles of economics, 'supply and demand'. The theory focused on the rational behaviours of individuals and how they evaluate the costs and benefits linked to their decisions to migrate, with a view to better living conditions and individual utility.

Reference [15], the neo-classical economists developed their theories of international immigration based on the difference in wage income rates between countries. Reference [15], reinforced their arguments by claiming that the neoclassical model pointed to the success of a migrant through their level of education, work experience, language proficiency in the host country, living in the destination country for a long period of time and other important human capital factors [15, p. 6].

The Push and Pull model point out that the main reason for migrants' decisions is their individual desire to find the best economic conditions, and this decision is made based on the information available regarding living conditions in the country of origin and the possible conditions in the host country. These comparisons are generally made based on salary and economic conditions. Ravenstein tried to use data from the 1871 and 1881 censuses [16], in which he further developed his theory on internal and external (international) migratory flows, generalizing the movement of individuals. The study included several variables such as economic status, gender, technology, distance and other variables [17]. He assumed in his study that economic causes between two regions were the main motivation for migratory movements. These considerations led him to reflect on some of the analyses he carried out on migration theories, using the Push-Pull model.

The Push factors are the living conditions that create a pressure and force people to leave their regions/homes to find a better life, that is the regions or countries from which these people migrate. The push factors also are the lack of sufficient livelihood opportunities, poverty, the speed of population growth outstripping available resources, living conditions, desertification, drought and famine, loss of marriage and natural disasters. And while the Pull factors are the completely opposite of the factors of repulsion. These factors attract people who live in poor conditions in the places where the push factors are found. The pull factors can be mentioned as follows: job opportunities and better living conditions, the ease of obtaining land for agricultural activities, economic/political and religious freedom, better education and welfare systems, transportation facilities, a better health system and security [18, p. 108].

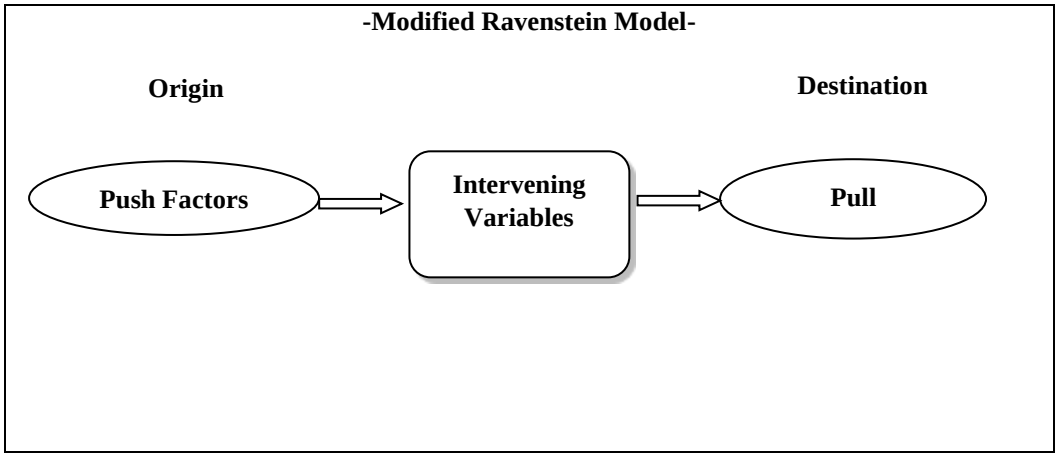

Fig. 2 Modified Ravenstein Model (Adopted from [8, p. 46]

In the modification of Ravenstein's model illustrated in Fig. 2, there is a clear demonstration of migrants' decisions. Considering that the decisions made to migrate are related to economic causes, in which these decisions are made in a rational and particular way, it remains one of the most influential theories among all migration theories, based on the model of Push and Pull. Ravenstein's theoretical contribution is still considered one of the best attempts to explain migratory movements.

The studies involved in the human capital theory have been developed in various countries, mainly in the United States of America. The theory originated in the mid-1950s. Specifically, it emerged in 1962 following the publication of the article "*Investment in Human Resources*" by Theodore William Schultz in 1961, a professor in the economics department at the University of Chicago. The term was first used in an article published by this author in the "*American Review" Journal of Political Economy*, in which the result showed that in the USA, the benefits of investment in human capital through education and professional training of people is higher than the result of investment in physical capital [19, p. 32]. Various authors have defended this theory [20, 21, 22], but it is obvious that the primary sources of this theory came from Adam Smith, Alfred Marshall and the studies of Irving Fisher at the beginning of the 19th century.

Reference [20], one of the main authors of human capital theory, has also been a major reference in migration studies. According to [20], human capital can be seen as an activity that influences future real growth in order to obtain more resources in people. It all started when economists related the differences in physical capital between individuals and families, in which wealth was more invested in physical capital, however, the richest people had more physical capital in relation to others, from this comparison they ended up discovering that there are other influencing factors more important than expected, human capital as one of these factors can be useful in understanding the difference in income between individuals [20, p. 9].

Most of the authors with major contributions have used the direct impact of income to explain income differentials between countries, but some authors such as [23] have emphasized the importance of the role of this phenomenon in studies of differences in productivity.

B. Macro Perspectives: Labour Market Segmentation (Dual), Informal Economy and Ethnic Enclaves

Macroeconomics emerged after the onset of the Great Depression in the 1930s, although it is true that most of economists who have worked on the subject have identified the start of Modern Macroeconomics with the publication of John Maynard Keynes' "The General Theory of Employment, Interest, and Money", published in 1936 [24, p. 4]. During that period, the unemployment rate in the labour market reached a very high level (25%) in the United States of America [25, p. 373]. Moreover, during the Great Depression, economists noticed that neoclassical principles and microeconomic tools were insufficient to shed light on large-scale economic phenomena, such as very high unemployment or a very deep economic recession.

To contextualize the subject of our paper in macroeconomic terms, it is pertinent to first consider the countries of origin of migrants. The movement of migrants from their place of origin to their destination is intrinsically linked to the phenomenon of the export of labour (labour factor). There is a macroeconomic

impact through the revenue raised by the countries of origin, which serves as compensation and profit for the costs corresponding to the participation of migrants in the production process of their home countries.

Reference [26], considered one of the pion eering authors of this theory, argues that in the labour market there are two (2) fundamental elements that somehow fit together, these elements are classified as the native worker and the migrant worker. In terms of work, the two actors work in two different markets, the primary and the secondary.

Pigou cited by [27], one of the leading economists of the classical school, argued that, on several occasions, the labour market failed in creating equilibrium as indicated by the classical comparative model, thus causing the lack of involvement of workers in a total competition of employees in the market. This idea was reinforced by the institutional nature, highlighting the availability of compensation in the labour market, and this and other factors led to the failure of the classical model [27, p. 67].

Immigrants have been the target of attraction for the secondary market in the host country, but a number of particular cases have been considered in order to identify the factors attracting migratory flows, and among these factors the informal economy areas have been singled out. The term defines activities that take place outside of the regulations and laws established regarding working conditions, the provision of social security rights or worker inspection regimes. In these activities, the recruitment of workers outside the regulations accelerates the informal economy and ends up driving away natives and attracting immigrants. Furthermore, in many similar cases, migrants from less developed countries with few opportunities are recruited: “they accept these job offers, even with abnormal conditions, as they can improve the standard of living, that they previously had” [28, p. 23].

In the last twenty (20) years of the twentieth century, there has been an accelerated growth of economic activities in the informal sector, caused by different implications such as the economic crisis, restrictions on the formal sector labour market, growth in the unemployment rate, growth in disposable incomes in the informal sector in response to the needs of consumers of goods and services [29, p. 60].

IV. The Historical Development of Migration in Türkiye

The migratory movements observed following the establishment of the Republic of Türkiye in 1923 were a consequence of the territorial losses during the final years of the Ottoman Empire [30, p. 46]. Between 1923 and 1960, a significant number of Turks migrated to Greece, to Caucasus, and particularly to the Balkans, driven by a trend towards population homogenization [3, p. 127]. In this context, the country implemented various migration policies to boost its population. As part of its efforts to stabilize and consolidate itself as a nation, the Republic of Türkiye adopted migration policies designed to attract demographic mobility and enhance population quality, in accordance with state-established laws.

Migration from Türkiye to Europe saw a substantial increase in the mid-twentieth century. In 1961 alone, it is estimated that between 80,000 and 100,000 individuals migrated from Turkey to Europe in search of employment. The labour dispatch agreement signed between Turkey and Germany that same year formalized the migration process, adding a more structured dimension to the phenomenon [3, p. 131].

Türkiye has gained the character of a transit country with the change of government in Iran in 1979, the occupation of Afghanistan by the Soviet Union in the same year, the Iraq and Iran war in the 80’s, followed by the Gulf war and the collapse of the Soviet Union in 1991, the invasion of Iraq by the United States of America (USA) in 2003, the human movement called ‘Arab Spring’ in 2010 and the Syrian War in 2011 [31, p. 164, 32, p. 63]. The occurrence of these important incidents in history has led to a significant increase in migration and asylum seekers in Turkey. Later, migration from Latin America and African countries (especially Somalia, Nigeria, Ghana, Senegal, etc.) to Turkey to reach their destination points has been an important reason for Türkiye to be a transit country.

According to the first census conducted in Türkiye in 1927, the population was recorded as 13,648,270 individuals [33, p. 4]. As of today, the population has grown to 85,372,377 [34]. Since 1927, alongside natural population growth, dynamic migration has played a significant role in this increase.

V. Migration Between West African Countries and Türkiye

The concept of international migration encompasses three main dimensions: geographical location (place of residence), time (temporary or permanent), and societal impact (changes within society, including social and legal status). It can be defined as follows: first, it involves movement across a defined administrative boundary; second, migration must be a continuous movement within a specified period; and third, it must constitute a social change, leading to an alteration of social status and relationships within the existing environment at the destination.

Fig. 3 details the specific patterns of migration flows between 2015 and 2020 for both males (on right side) and females (on the left side) across different regions of the globe. Territorial proximity significantly influences migratory movements. The figure illustrates the frequency of migration between regions such as South Asia and West Asia, Latin America and North America, and Sub-Saharan Africa (SSA) and Europe and etc... The substantial volume of migratory flows within these regions is often attributed to the free movement of people and goods, as well as the ease of obtaining visas through bilateral and diplomatic agreements.

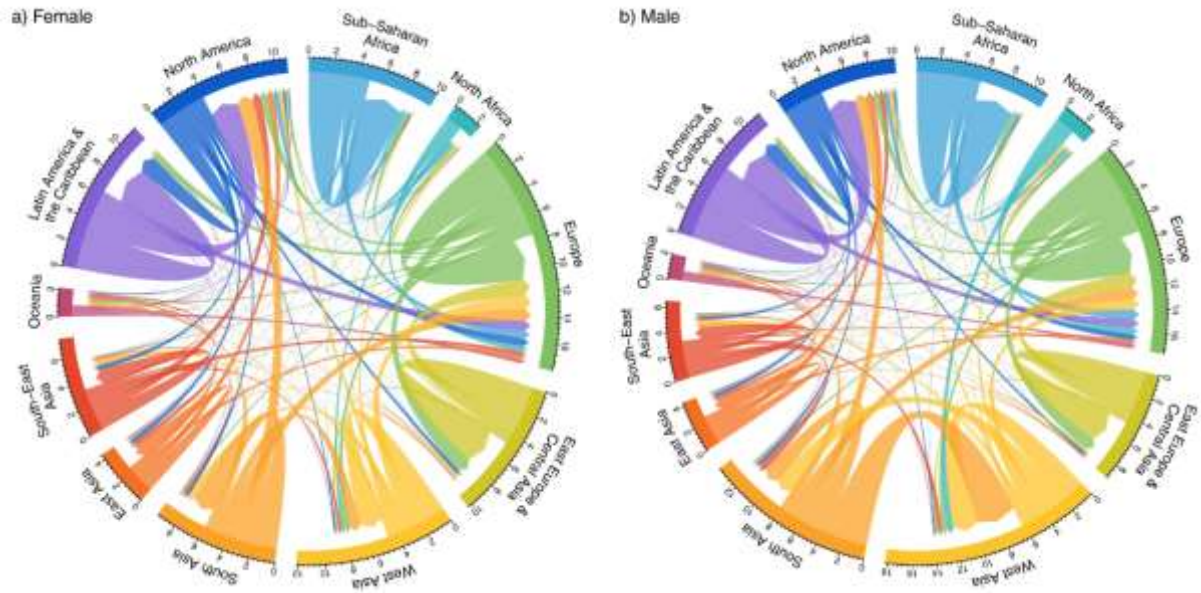

Fig. 3 Chord Diagrams of estimated Male and female Migration Flows 2015-2020 [35, p. 4]

According to UN DESA's 2017 annual report, the total number of international migrants reached 257.7 million, with women comprising 48.4% of this population. At that time, migrants accounted for 3.4% of the global population. In Turkey, the total number of migrants in 2017 was 466,333, representing a 22.4% increase from the previous year [36].

On the distribution of international migrants, Table 1 shows that international migrants constitute 7.2% of the population in Turkey. According to UN statistical data in 2020, Turkey hosted 6,052,652 migrants, among which only 3 West African countries are mentioned; Nigeria, Ghana and Senegal, due to the low volume of migratory flows of citizens from this region compared to neighbouring countries such as Syria, Bulgaria, Iraq and so on [37]. Therefore, it could be said that migrants from other countries in the region are included under the category 'Other' due to their smaller number of migrants.

Table 1. International Migrant Stock Profile, Türkiye-2020* [37]

Total	**6052652**
% of migrants	**%7.2**
International Migrant Stock by Country	
1.Syrian Arab Republic	3792505
2. Bulgaria	661438
3. Germany	376288
4. Iraq	233288

5. North Macedonia	198004
49. Nigeria	1204
83. Ghana	196
90. Senegal	88
Other	139511

*Includes only estimates were derived from data on the foreign-born population and the number of refugees or persons in refugee-like situations.

Table 2 shows that the countries of the Economic Community of West African States (ECOWAS) are categorized under either lower-middle-income country (LMIC) or low-income countries (LIC) according to the United Nations country classification according to income per capita [38]. LMIC includes such as Benin, Cabo Verde, Côte d'Ivoire, Ghana, Mauritania, Nigeria and Senegal. Other West African countries such as Burkina Faso, Gambia, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Sierra Leone and Togo are categorized in LIC. Although Senegal, Mauritania and Benin are included in LMIC in the classification made according to income level, these countries are also considered as least developed countries (LDC) by the United Nations when some other development indicators (human assets index and an economic and environmental vulnerability index) are taken into account [38].

Table 2. Top 5 Migration 'Corridors' of West African Communities, 2020 [37]

From	**To**	**Migrant Stock**	**From**	**To**	**Migrant Stock**
Benin* (LMIC)	*Nigeria*	377169	Burkina Faso* (LIC)	*Côte d'Ivoire*	1376350
	Togo	72330		*Ghana*	67431
	Côte d'Ivoire	70576		*Mali*	62291
	Gabon	52460		*Niger*	24683
	France	23352		*Togo*	13765
Cabo Verde (LMIC)	Portugal	68299	Côte d'Ivoire (LMIC)	*Burkina Faso*	562117
	United States of America	36082		*Mali*	195271
	France	25501		France	102889
	Netherlands	12091		*Ghana*	74228
	Angola	9215		United States of America	41873
Gambia, the* (LIC)	United States of America	33653	Ghana (LMIC)	*Nigeria*	238284
	Italy	23086		United States of America	201086
	Spain	19489		United Kingdom	131095
	Germany	17200		*Côte d'Ivoire*	111708
	United Kingdom	10015		Italy	54680
Guinea* (LIC)	*Côte d'Ivoire*	167516	Guinea-Bissau* (LIC)	Portugal	32607
	Senegal	53430		*Senegal*	30550
	Gambia, The	45215		*Gambia, The*	13808
	Mali	41960		Spain	7246
	Sierra Leone	36058		*Cabo Verde*	5330
Liberia* (LIC)	United States of America	105233	Mali* (LIC)	*Côte d'Ivoire*	522146
	Ghana	34940		*Nigeria*	172481
	Côte d'Ivoire	28134		*Mauritania*	114379
	Nigeria	22009		*Niger*	108802
	Sierra Leone	9097		France	86437
Mauritania* (LMIC)	*Senegal*	46376	Niger* (LIC)	*Nigeria*	120797
	Mali	24197		*Benin*	78124
	France	20324		*Côte d'Ivoire*	68184
	Côte d'Ivoire	12739		*Togo*	66332
	Spain	8879		*Mali*	13340
Nigeria (LMIC)	United States of America	402186	Senegal* (LMIC)	France	134848
	United Kingdom	205773		*Gambia, The*	132678
	Cameroon	169602		Italy	113444
	Niger	154739		United States of America	61497
	Italy	103462		Spain	59549
Sierra Leone* (LIC)	United States of America	44384	Togo* (LIC)	*Nigeria*	158262
	United Kingdom	26657		*Benin*	113502

	Liberia	16853		*Ghana*	103799
	Senegal	15453		*Côte d'Ivoire*	41508
	Guinea	8342		France	27183

Note: Countries in italics are countries included in free movement within the scope of ECOWAS. LIC indicates lower income countries and LMIC indicates lower-middle income counrtries. * also shows least developed countries according to [39].

According to the information in Table 2, it can be said that the agreement on the free movement of people and goods through the protocol to the treaty established by ECOWAS in May 1979 in Dakar, the capital of Senegal, influenced the high migratory flow in the region. In LIC countries except The Gambia, international migration is mainly through free movement of peoples and goods stablished by ECOWAS and tends to be directed towards LMIC countries in this region. In LMIC countries, it is directed towards LMIC countries in ECOWAS or developed countries in Western regions such as the United States of America and the United Kingdom, France, Italy, Spain, Portugal.

Côte d'Ivoire appears to be an important destination country for immigrants from other West African countries. The free movement of people and goods between ECOWAS countries, which has led to a high export of labour for cocoa cultivation (most of the time) and other services in Côte d'Ivoire. The reciprocal flow of migrants between Burkina Faso and Côte d'Ivoire is also remarkable: Côte d'Ivoire has a stock of 1,376,350 Burkina Faso migrants, while Burkina Faso has 562,117 Ivorian migrants. The Burkina Faso population, who live in the extremely poor rural areas of Burkina Faso, move to Côte d'Ivoire to work in the fields, a movement that is also facilitated by the free movement of people in the region (ECOWAS protocol) and the low cost of travel due to neighbourhood. The massive migration of the Burkina Faso, a land-locked country, people to Côte d'Ivoire and the hostility has become a concern for the Ivorian government, however, with child labour and trafficking taking place mainly in the cocoa plantation fields.

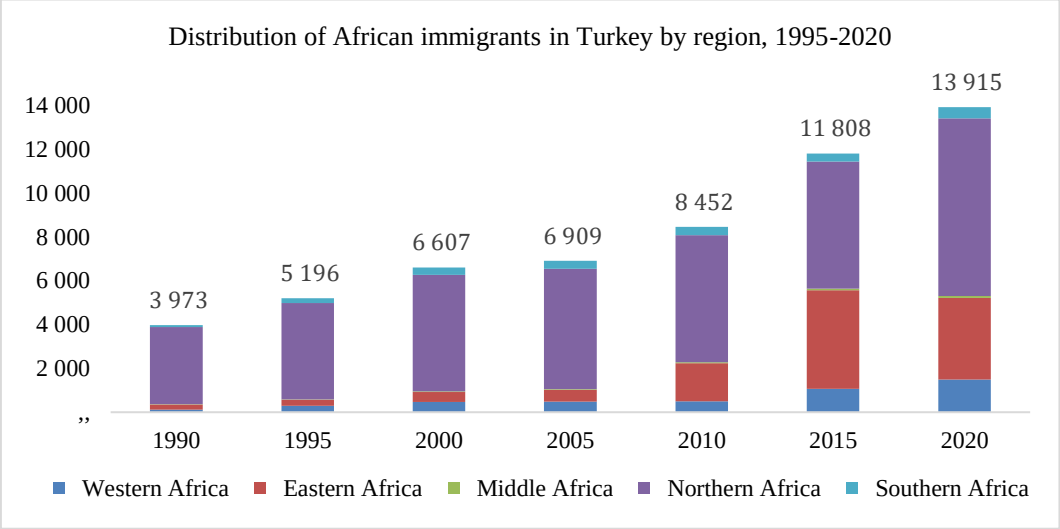

Fig. 4 Distribution of African immigrants in Türkiye by region, 1995-2020 [37]

When Table 1 and Table 2 are evaluated together, it can be said that Türkiye is not among the most preferred destination countries for migrants from West African countries. But the migration of Africans to Türkiye goes back to the Ottoman Empire, mainly to North African countries due to the political allies at the time. Migration movements from both North Africa and Sub-Saharan Africa (SSA) increased significantly in the last decade of the 20th century. Since then, the number of migrants has continued to rise. Türkiye experienced an economic boom in the early years of the 21st century, which attracted more African migrants to choose Türkiye as their destination. Fig. 4 shows the distribution of migrants from the different regions of Africa residing in Turkey between at the end of the 20st century and early years of the 21st century. The number of African immigrants in Turkey increased continuously between 1990-2020 and reached 13,915 in 2020. Migrants from Western Africa represent a lower number than migrants from Northern Africa and Eastern Africa, due to the diplomatic relations developed in these regions (e.g. Northern Africa; Morocco, Egypt etc. and Eastern Africa; Somalia, Kenya and others). However, there is

an increase in both the West African immigrant stock in Turkey and the share of West African immigrants among those migrating from Africa to Turkey in the 1990-2020 period.

The geostrategic importance of the African continent and its natural wealth has attracted the attention of more developed countries, and Türkiye has become involved in the struggle to exploit these natural resources. As a result of this competition on the continent, Türkiye has extended its foreign policies to Africa. In the context of deepening the Africa-Türkiye relation, migrants from West African countries as well as from other regions of the continent living in Türkiye represent an important and exploitative model in this context. The growth in trade, humanitarian aid policies and some other policies for the development of a healthy Türkiye-Africa relationship involved discussions regarding refugees and West African residents in the country. Türkiye's new foreign policies towards Africa have taken a new step and open direction. This step seems like new, but the Ottoman Empire has had good connection with African countries.

In fact, majority of West African migrants do not intend to stay in Türkiye permanently. Almost all the West African migrants use the Airplanes to reach to the country, and they come legally with a periodic visa (most with 1 month or 90 days tourist visa) [40, p. 11], some of them change their status by applying for asylum to stay legally after the expiration of the visa, but some do not apply because of the asymmetric information. It is clearly that the goal may change during their staying.

VI. Evaluation of Push-Pull Factors between Türkiye and West African Countries

The fact that West African countries experience low- or lower-middle-income levels is likely the primary motivation (push factor) driving residents to migrate to other countries. In contrast, Türkiye is considered a higher income country relative to West African nations. Despite this, residents of West Africa are keen to seize any opportunity to leave their home countries. Over the past 15 years, Türkiye has increasingly become a migration target due to the development of diplomatic relations in the region.

According to [41], Türkiye has a total of 382 industrial zones in 2022. Despite experiencing high inflation, Turkey maintains substantial industrial production. These economic activities, among others, attract migrants (Türkiye's pull factor), making Türkiye an appealing destination due to the relative ease of finding employment and the quality of life in the country.

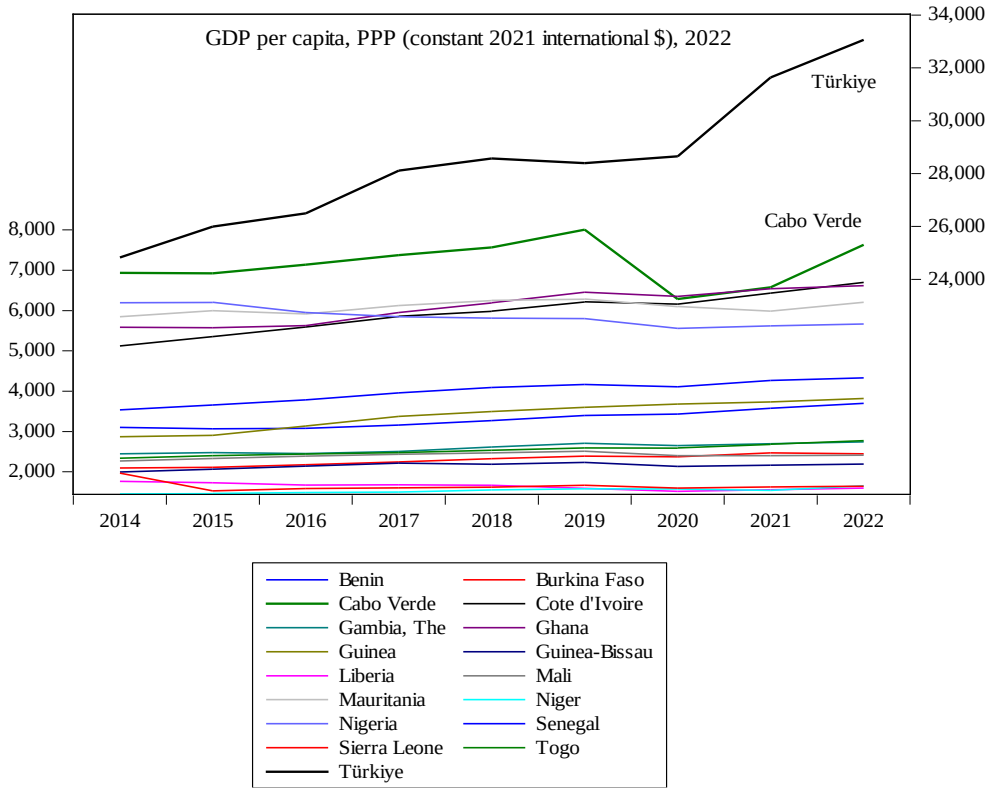

Fig. 5 GDP Per capita (PPP) (constant 2021 international $), 2022 [42]

Note: Türkiye-Right Axis, West African Communities-Left Axis

According to Fig. 5, real per capita income of people living in West African countries except for Cabo Verde, Côte d'Ivoire, Ghana, Mauritania and Nigeria, is lower than 5,000 international dollar in 2014-2022 period. GDP per capita according to purchasing power parity in Turkey is approximately 4 times higher than that in Cabo Verde, the West African country that has highest income per capita level. In this respect, Cabo Verde has a potential being a centre of migration for the sub-regional countries (West African countries). Geographically, Türkiye is centrally positioned, connecting Africa, Asia, and Europe, while Cabo Verde shares the same strategic characteristic, lying between Europe, South America, and Africa [43, p. 1]. Since the 1990s, Cabo Verde has experienced significant migratory flows from West African countries such as Guinea-Bissau, Nigeria, and Senegal. This increase is largely due to the protocol of the free movement of people and goods, established by the Economic Community of West African States (ECOWAS). The agreement, initially signed in May 1979 in Dakar, Senegal, amended after years by the Cabo Verdean government through law no. 18/11/82 [43, p. 1]. However, Cabo Verde is not known traditionally as an immigration destination until, after 90s the country start being evolved into both a transit and destination country for some migrants. This activities in migratory flows can be attributed to several factors, including sustained economic growth, political stability, and higher incomes compared to other countries in the sub-region [44]. Additionally, the ease of entry facilitated by the agreement (mentioned above) of ECOWAS countries has also played a significant role in increasing of migrants. But the main destination countries for international migration within West Africa are Côte d'Ivoire, ranks second in terms of per capita real income and has highest migrant stock with 2,564,857 migrants, and Nigeria, hosted 1,308,568, rather than Cabo Verde in mid-2020 [45]. This can be explained by the fact that Cabo Verde is an island country and implies that distance and transportation opportunities, as well as income level, are among the most important factors in determining the destination.

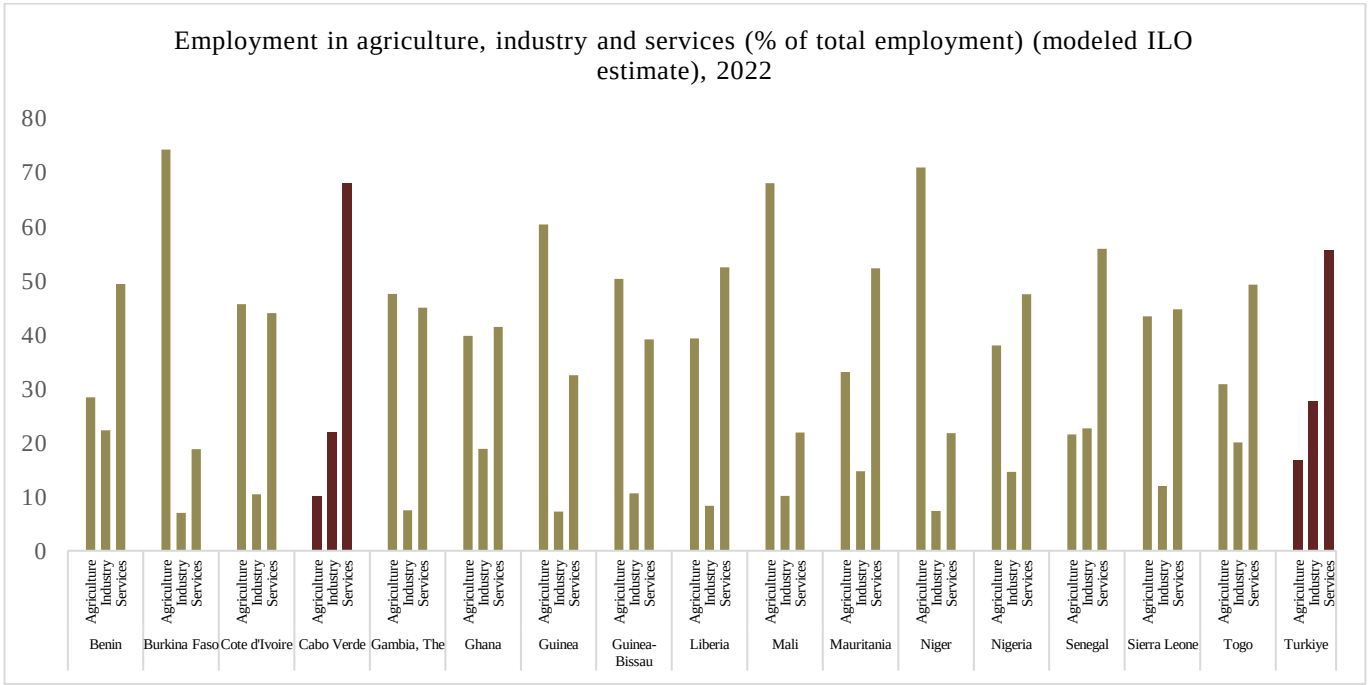

Fig. 6 Employment in agriculture, industry and services [42]

The distribution of production, and therefore employment, by sectors can be considered as a determinant of the difference between countries' income and, in some way, development levels. In countries with a higher level of development, the share of employment in the agricultural sector in total employment is lower. The factors of economic expansion and modernisation in both countries have led to an increase in labour in the industrial and service sectors. Fig. 6 shows that countries such as Burkina Faso, Guinea, Guinea-Bissau, Mali and Niger are countries with extreme poverty and a large number of the population (especially the rural population, which depends highly on agricultural activities) live off the labour used in

the primary/subsistence sector. The population draws heavily on its fertile soils to support itself. The subsistence sector makes up the largest percentage of this country's GDP. In countries with a high West African migrant stock, such as Côte d'Ivoire and Nigeria, it can be said that the industry and services sectors are also alternatives in terms of employment, although the share of agricultural sector employment in total employment is not very low. Cabo Verde is the West African country that is most similar to Turkey in terms of the distribution of total employment by sectors.

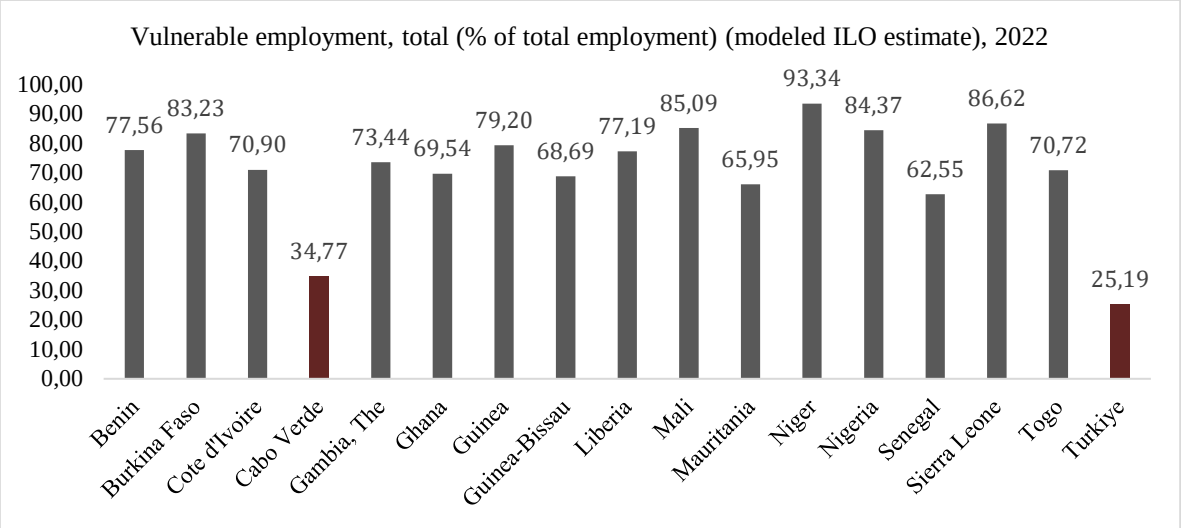

Fig. 7 Vulnerable employment rate [42]

Vulnerable employment includes those who work as family workers and those who are self-employed [42]. This type of employment, that is more common in labour markets in less developed and developing countries where agriculture-based production predominates, tends to be lack of social protection and labour right. Fig. 7 illustrated the evidence of how informal jobs, without right protection or other legal or judicial status, can push migrants to leave their places of origin to migrate to another country in the hope of earning a high income with a more legal and secure status, or at least with higher income even under the similar conditions. The graph shows that Cabo Verde, with the lowest rate (34.77%) of vulnerability at work compared to the other sub-regional countries, is closer to Türkiye (with 25.19%). When Fig. 6 and Fig. 7 are examined together, it can be said that vulnerable employment is lower in countries where the share of the industrial sector in employment is relatively high. from this context, workers' rights, legal and judicial protection can be a ‘pull’ factor for low-income and lack-of-rights worker in West African countries. can be attractive (pull factor) for migrants. However, it is noteworthy that the share of vulnerable employment in total employment is still high in the main destination countries, such as Cote d'ivoire, Nigeria, and Ghana.

A. *Evaluating Labour Market Related SDG Indicators as Potential Push-and-Pull Factors*

In 2015, 193 UN member countries, including Turkey and West African countries, cooperated for a globally sustainable development within the framework of 17 goals and targets related to these goals. Within the scope of this cooperation, the contribution of immigrants to inclusive growth and sustainable development is emphasized [38]. Data on SDG targets to monitor the current situation of countries and progress towards these targets are provided by country governments. Differences between countries in some SDG indicators related to labour markets have the potential to be a push or pull factor in terms of international migration.

In this part, 9 labour market related SDG indicators under four sustainable development goals (Goal 1: No Poverty, Goal 8: Decent Work and Economic Growth, Goal 9: Industry Innovation and Infrastructure, and Goal 10: Reduced Inequalities) evaluated by comparing West African Countries and Türkiye.

A1. SDG Indicator 1.1.1 - Working Poverty Rate

Fig. 8 shows that Cabo Verde (0.3%) is the West African country with the lowest working poverty rate for workers over 15 years of age, while Niger (46.2%) has the highest rate. The West African average for

this indicator (23.9%) shows that approximately one out of every four people in these countries is in working poverty. The value obtained for Turkey is 0.1%. The relative position of the West African Communities and Türkiye in terms of working poverty could be a potential push factor for those from these countries who want to come to Türkiye to work.

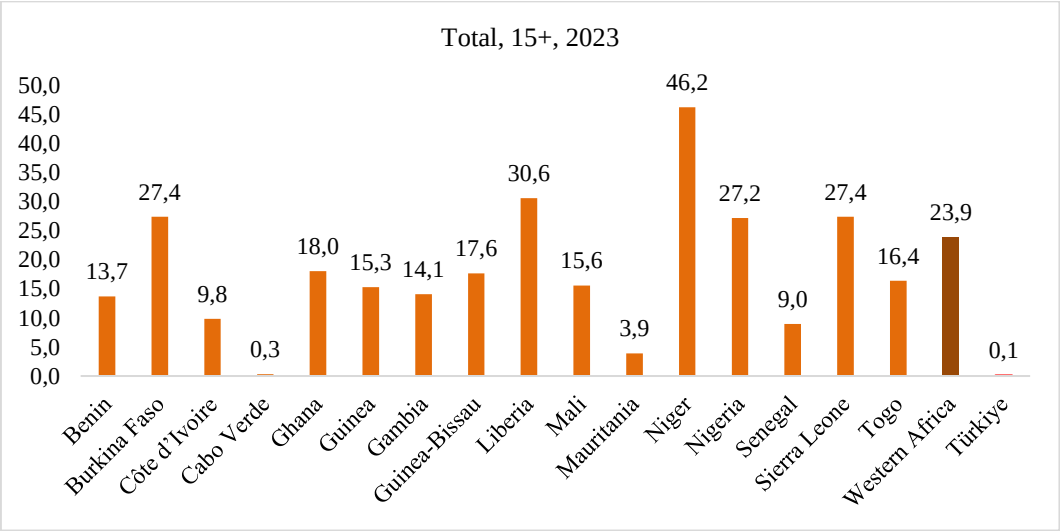

Fig. 8 Working poverty rate (percentage of employed living below US$2.15 PPP, 15+) (%) [46]

As it shown Fig. 9 when the working poverty rate is evaluated for the young population (ages between 15-24), it can be said that the potential of this indicator to be a driving factor will be higher for young people. In West African countries, approximately one out of every three young worker experience working poverty. The low youth working poverty rate in Turkey can be considered as a pull factor for young people in these countries.

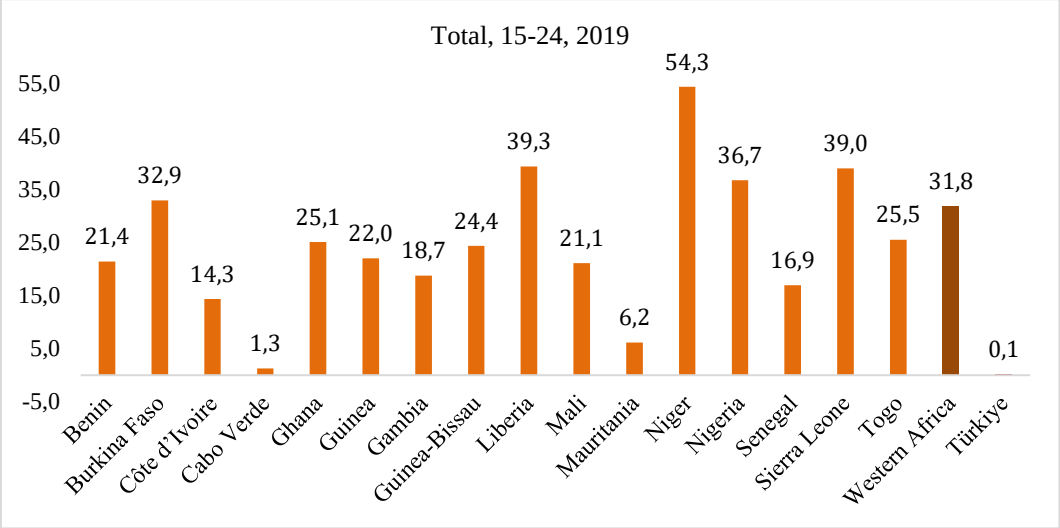

Fig. 9 Working poverty rate (percentage of employed living below US$2.15 PPP, 15-24) (%) [46]

A2. SDG Indicator 1.3.1 - Proportion of Population Covered by Social Protection Floors/Systems

If we look at the population covered by at least one social protection benefit in Fig. 10, we find that among the sub-regional countries of West Africa, the Cabo Verde is still the country with the highest levels of social protection (with 39.9%), followed by Togo with 38.7%. Although there is a large gap between these countries and Türkiye (with 64%), they are the only countries in West Africa that are close to Türkiye. The large gap of social protection between West African countries and Turkey can be included among the driving factors for migrants, who is working without social protection.

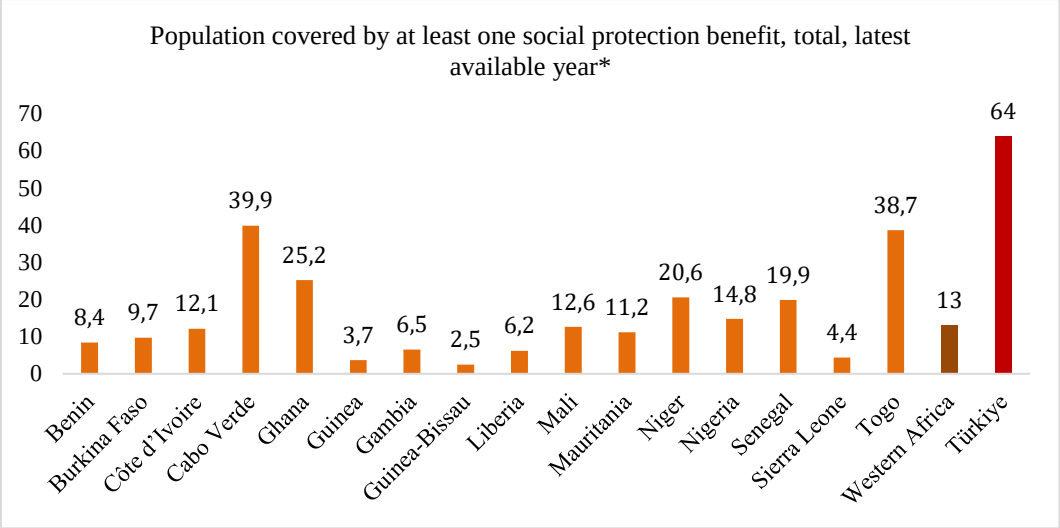

Fig. 10 Population covered by at least one social protection benefit (%) [46]
*2019 for Gambia, and Niger; 2020 for Benin, Guinea-Bissau, Liberia, Mauritania, Sierra Leone, and Western Africa; 2021 for Burkina Faso, Cabo Verde, and Guinea; 2022 for others.

Fig. 11 also shows that Cabo Verde is the country in the West African sub-region with the highest number of citizens above retirement age receiving their pensions. It can again be seen that Cabo Verde (85.6%), even though it is a West African country, has a similar potential with Türkiye (85.9%) in terms of paying pensioners' pensions (refer to retirement person). When this indicator is evaluated for the West African average, it can be said that only one in 10 people of retirement age is covered by the social protection system in a way that entitles them to receive a pension during the working period.

Fig. 11 Persons above retirement age receiving a pension (%) [46]
*2019 for Gambia, and Niger; 2020 for Benin, Guinea-Bissau, Liberia, Mauritania, Sierra Leone, and Western Africa; 2021 for Burkina Faso, Cabo Verde, and Guinea; 2022 for others.

Regarding workers' rights and protection, as we mentioned earlier, Cabo Verde with 48.7 is the only West African country with the highest workers' rights and protection compared to other countries in the sub-region. We can see that Guinea Bissau, despite being a sister country, still has a huge difference between the two countries, 'Cabo Verde 48.7 and Guinea Bissau 1.5'. However, in terms of coverage of possible accidents caused by work, Fig. 12 shows that Cabo Verde (48.7) is the only country that comes close to Türkiye (76.5). Therefore, the coverage given by workers to possible accidents caused by work may has a major impact on the pull factor. In the absence of such coverage, it can cause a drain on labour (push factor).

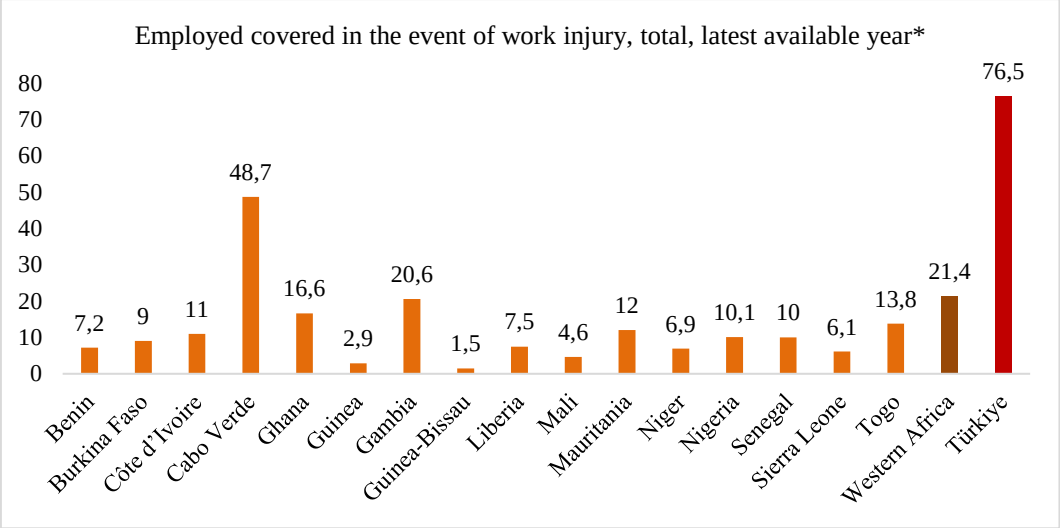

Fig.12 Employed covered in the event of work injury (%) [46]

*2019 for Ghana, Gambia, Liberia, Niger, Senegal, and Sierra Leone; 2020 for Benin, Guinea-Bissau, Mauritania, and Western Africa; 2021 for Burkina Faso, Cabo Verde, and Guinea; 2022 for others.

A3. SDG Indicator 8.2.1 - Annual Growth Rate of Output per Worker

Fig. 13 illustrates the annual production growth rate per worker of West African countries and Türkiye, so Cabo Verde still has a very similar growth rate Türkiye, with a very close proximity. According to Fig. 13, in 2022 to 2023, Cabo Verde's Gross Domestic Product (GDP) growth rate was 1.76%, while Turkey's Gross Domestic Product (GDP) growth rate was 1.60%. When this indicator is evaluated in terms of labor productivity, it can be said that labor productivity increased in 2023 compared to the previous year in countries other than Ghana, Niger, Nigeria and Sierra Leone. Considering the West African average (0.01%), it is not possible to talk about a significant increase in labor productivity in this region in 2023. Thus, people living in this region may choose to migrate to countries/regions where they can work with higher efficiency and therefore may earn higher income.

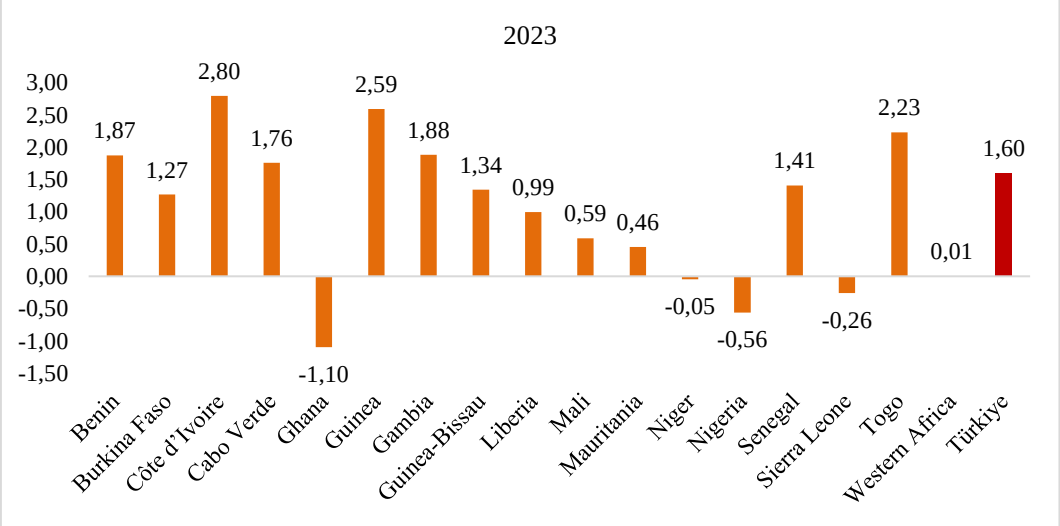

Fig. 13 Annual growth rate of output per worker (GDP constant 2017 international $ at PPP) (%) [46]

A4. SDG Indicator 8.3.1 - Proportion of Informal Employment in Total Employment

The informal labour sector is the most prevalent in West African countries, and most migrants resort to this sector due to the lack of bureaucracy and little control and inspection by the countries' governments. The fact that production is generally based on agriculture is one of the possible reasons why informal working conditions such as unpaid family labour is common. Corruption in the internal politics of countries continues to cause negative impacts, so these are some reasons why there is the predominance of the

informal sector. Fig. 14 shows that Cabo Verde, despite its very high rate, still has a low rate compared to the countries in the sub-region. If we compare Cabo Verde's 63.82% with Turkey's 28.2%, we can see that there is a huge difference, due to the reality of West African countries.

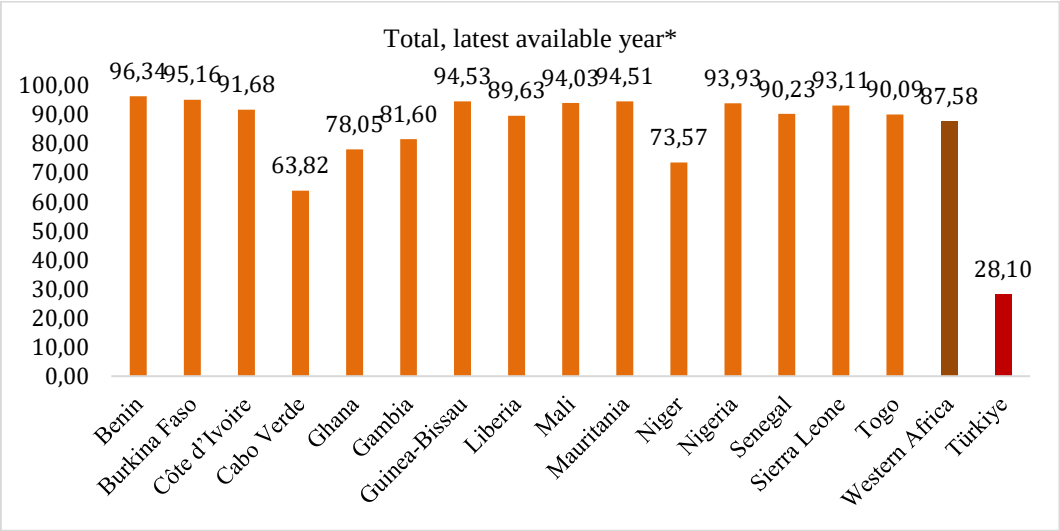

Fig.14 Proportion of informal employment in total employment (%) [46]

*2015 for Cabo Verde, and Ghana; 2017 for Liberia, Mauritania, Niger, and Togo; 2018 for Sierre Leone; 2019 for Côte d'Ivoire, and Senegal; 2020 for Mali; 2022 for Benin, Guinea-Büssau, Nigeria, and Türkiye, 2023 for others. Data for Guinea is not available.

A5. SDG Indicator 8.5.2 - Unemployment Rate

Among the West African countries, Cabo Verde and Mauritania have similar unemployment rates from 15 upwards. Fig. 15 shows that the two countries can be compared with Türkiye. Cabo Verde has an unemployment rate of 11.29%, Mauritania 10.42% and Türkiye 9.39%. In Niger, fewer of the unemployed are actively looking for a job. Since unemployment rate statistics are calculated only on job seekers through official channels, it may not be surprising that unemployment rates are low in West African countries where informal work is common. However, with its approximately 10% unemployment rate, Turkey may not be the most attractive destination country for those who live in West African countries and want to work formally.

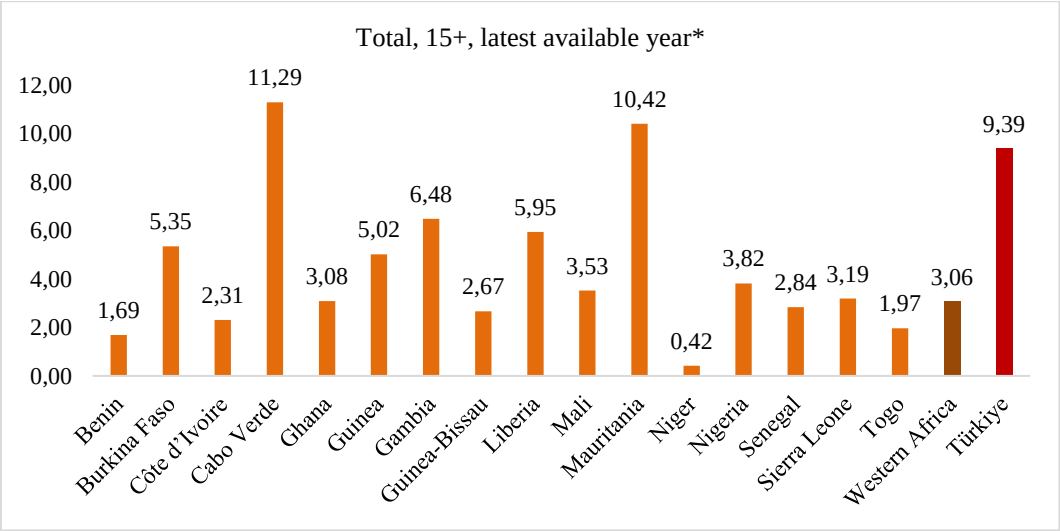

Fig. 15 Unemployment rate, 15+ (%) [46]

*2017 for Liberia; 2018 for Sierra Leone; 2019 for Cabo Verde, Guinea, and Mauritania; 2020 for Mali; 2022 for Benin, Côte d'Ivoire, Ghana, Guinea-Bissau, Niger, Nigeria, Senegal, and Togo; 2023 for others.

According to Fig. 16, the youth unemployment rate is higher than total unemployment rate both for West African countries and Türkiye. Therefore, young people are struggling to find work and may consider international migration much more. With the high youth unemployment rate, Turkey may not be a permanent host country for young people from West Africa who migrate to work.

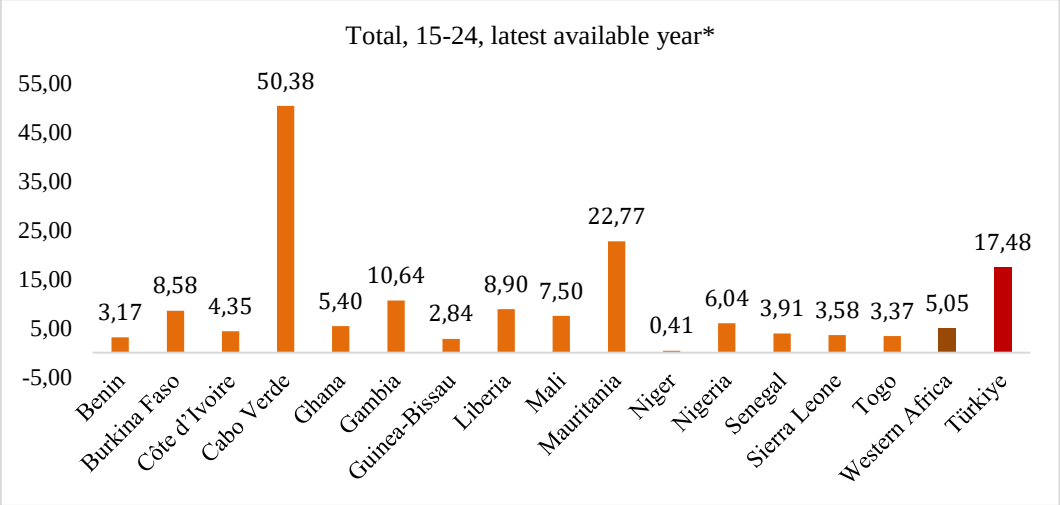

Fig. 16 Unemployment rate, 15-24 (%) [46]
*2017 for Liberia; 2018 for Sierra Leone; 2019 for Cabo Verde, and Mauritania; 2020 for Mali; 2022 for Benin, Côte d'Ivoire, Ghana, Guinea-Bissau, Niger, Nigeria, Senegal, and Togo; 2023 for others. Data for Guinea is not available.

A6. SDG Indicator 8.6.1 - Proportion of Youth (aged 15-24 years) not in Education, Employment or Training

In the evaluation of the total proportion of young people between the ages of 15 and 25 who are not studying, working or taking part in any vocational training from Fig.17, Côte d'Ivoire has 18.78% of all young people who are not studying, working or taking part in any training. The country is close to Türkiye, which also recorded 22.42% of young people not studying or working. The countries that stand out in the figure are Guinea, Liberia and Mauritania. In these countries, the majority of parents and guardians send their children to traditional schools (Quranic schools where most of them are boarded), and these schools are not included in the education system. In Guinea Bissau and Burkina Faso, for example, along with the other three countries mentioned, the school drop-out rate is considered to be very high and international organizations such as Plan International, the World Food Programme, UNICEF and other non-governmental organizations are playing a very important role in the fight against school drop-out.

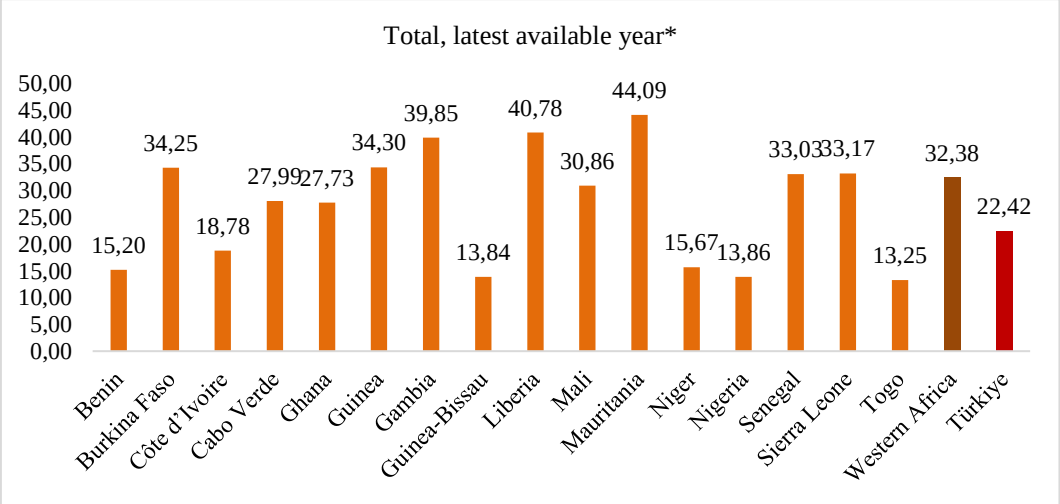

Fig. 17 Proportion of youth (aged 15-24 years) not in education, employment or training (%) [46]
*2017 for Liberia; 2018 for Sierra Leone; 2019 for Cabo Verde, Guinea, and Mauritania; 2020 for Mali; 2022 for Benin, Côte d'Ivoire, Ghana, Guinea-Bissau, Niger, Nigeria, Senegal, and Togo; 2023 for others.

A7. SDG Indicator 8.8.2 - Level of National Compliance with Labour Rights (Freedom of Association and Collective Bargaining)

The Organization of Trade Unions of West Africa (OTUWA) intends to function as the workers' union in West Africa in collaboration with ECOWAS. One of the proposals given to the organization is to start some studies of the current situation of the development and approval of policies within the largest sub-regional organization (ECOWAS), policies that directly affect the labour sector, equality and employment. Policies to protect workers' rights [47, p. 19]. According to Fig. 18, the level of compliance with labour rights varies between countries in the sub-region, with Cabo Verde showing a very low level (between 0-0.5). Countries that are more similar to Türkiye in terms of this indicator are Guinea-Bissau and Nigeria. Labour rights that are ignored due to the influence of political instability, considered as a push factor for West African citizens to migrate.

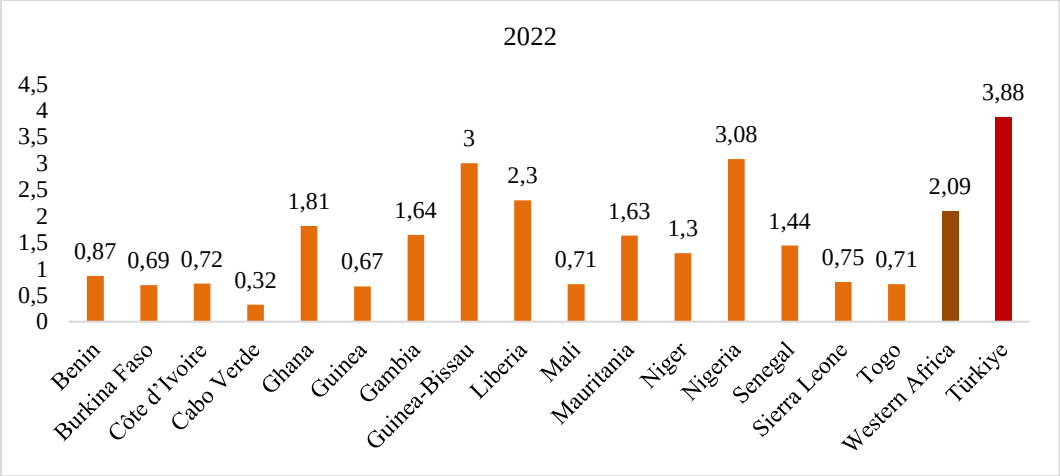

Fig. 18 Level of national compliance with labour rights (freedom of association and collective bargaining) [46]

A8. SDG Indicator 9.2.2 - Manufacturing Employment as a Proportion of Total Employment

In Fig. 19, we can see that Benin (the largest cotton producer in Africa), Burkina Faso, Nigeria, Senegal and Togo are some of the countries with the most employers in the manufacturing sector in West Africa. Despite the fact that they are applied more to traditional production such as agriculture, there is a huge impact on the economic activities of these countries. In this figure, we can still see that Türkiye is far beyond the West African countries. Turkey has already developed its manufacturing sector since its creation as a republic in 1923, while at that time all West African countries were under the colonial rule of Western countries.

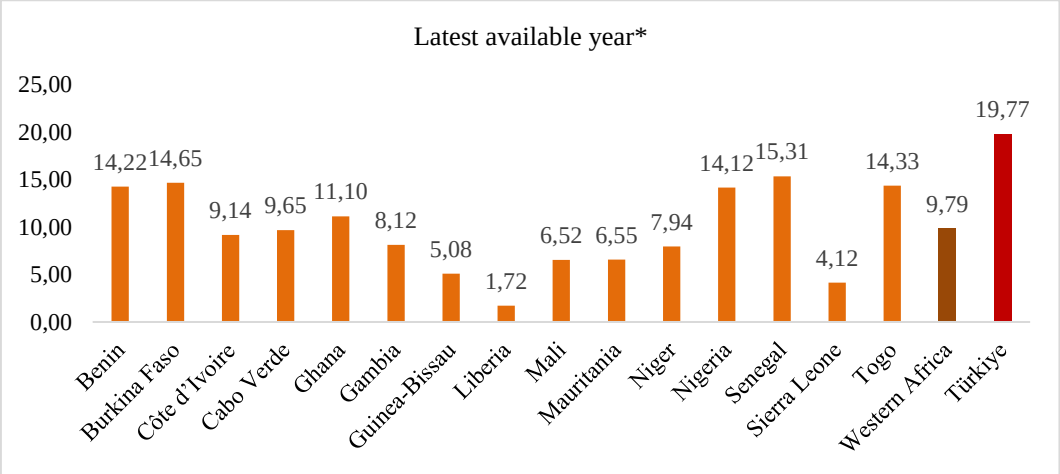

Fig. 19 Manufacturing employment as a proportion of total employment (%) [46]

*2017 for Liberia; 2018 for Sierra Leone; 2019 for Cabo Verde, and Mauritania; 2020 for Mali; 2022 for Benin, Côte d'Ivoire, Ghana, Guinea-Bissau, Niger, Nigeria, Senegal, Togo, and Western Africa; 2023 for others. Data for Guinea is not available.

A9. SDG Indicator 10.4.1 - Labour Income Share as a Percent of GDP

In the evaluation of share of labour income in the annual Gross Domestic Product (GDP) of West African countries and Türkiye in Fig. 20, the one that draws attention is Nigeria, with almost 80% of labour share in country's GDP. According to data from the World Bank, Nigeria had a population over 213.4 million in 2021. Nigeria's economy is linked to the primary sector, specifically oil production, and is one of the largest oil exporters in the world, yet the population lives in extreme poverty due to political corruption in the country. Share of labour income in Türkiye's GDP is almost 35%, it has the appearance of a country where the labour factor is at a disadvantage within the framework of the share of production factors in income.

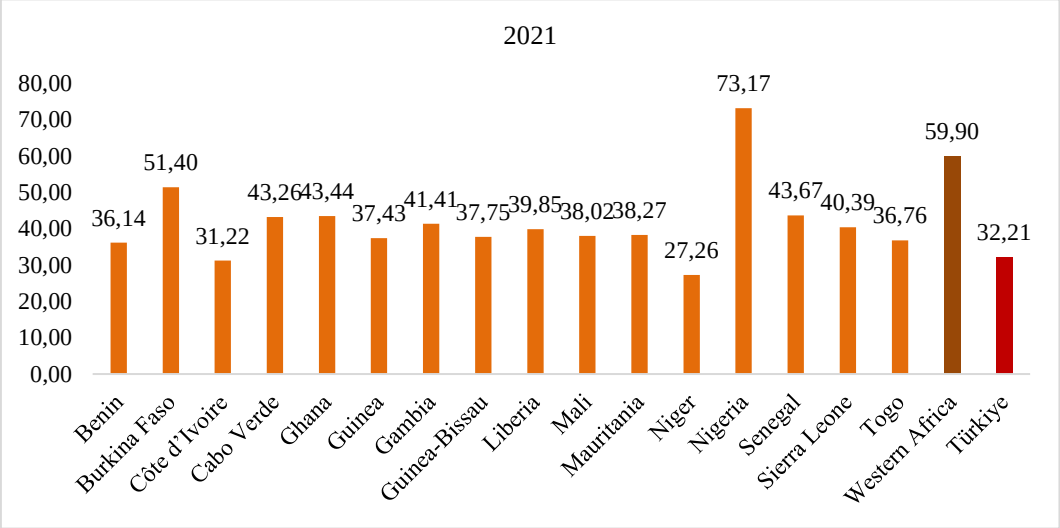

Fig. 20 Labour income share as a percent of GDP (%) [46]

VII. CONCLUSIONS AND RECOMMENDATIONS

Although they do not have a significant share in the migrant stock in Turkey, the number of West African people choosing Turkey as a destination country for both education and work is increasing. It can be said that Turkey's geographical location, the connections established with African countries within the framework of foreign policy, the historical background and the push and pull factors evaluated in the study have effects on this. While the positive effects of immigrants on economic growth and sustainable development are emphasized within the framework of global Sustainable Development Goals, the extent to which host countries benefit from this potential may remain limited. For example, in Istanbul, one of the most popular economic activities that foreigners do is work in factories, trying to fit into the secondary sector, 'ÇABUK ÇABUK' is the most common name among foreigners, and another more popular one is work in clinics. These sectors often don't require any professional experience, but a command of the foreign language and the desire to work in the secondary sector is all that matters. In addition, with regulations aimed at taking better advantage of their potential to provide employment and increase production, West African migrants carrying out their business (cargo shipping places, clothing stores, barber shops, restaurants, etc.) will be able to contribute more to the economy.

Many countries with the same characteristics as Türkiye, generally pay a little attention to public policies that maximise the positive impact of the migrants. However, overlooking migrants in strategic development policies can result in a huge loss for the country. Countries such as Türkiye, which has a high potential to become a destination country for immigrants due to its pull factors, should consider:

- ✓ Adopt migration policies according to the needs of the labour market.
- ✓ Maximise the impact of migrants' contribution to economic growth and development.
- ✓ Develop laws to protect the rights of migrants and fight any discrimination that occurs in the country.

✓ Invest in migrants' vocational training and integration. This can result in a quality (skilled) labour force.

✓ Final one, closely monitor and analyse their impact on economic growth and development.

Türkiye is currently an attractive country for West Africans, not only because of its economic stability or better working conditions and high income, but also because of the expansion of Turkish soap operas, series and movies in the region in recent years. However, Türkiye cannot escape its reality of being a transit country, but it can improve with migrant policies to reduce the tendency for migrants to pass through and also the country can take advantage of the labour force by investing in professional quality.

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Nesne Sınıflandırmasına Yönelik YOLOv5 ve YOLOv6 Model Performansının Karşılaştırmalı Analizi

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Özet **–**Bilgisayarla Görme, görüntüleri ve görüntüleri tanımlamaya yönelik tekniklerin geliştirilmesine yardımcı olan son yılların en popüler ve hızlı gelişen bir çalışma alanıdır. Bilgisayarla görmenin en önemli alt alanlarından biri, görüntülerde veya video karelerinde insanlar, arabalar ve hayvanlar gibi önceden tanımlanmış belirli sınıf/sınıfların anlamsal nesnelerinin örneklerinin tespit edilmesini içeren nesne algılamasıdır. Günümüzde nesne algılama, yüz algılama, araç algılama, web görüntüleri ve güvenlik sistemleri için kullanılmaktadır. "You Only Look Once" (YOLO) algoritması, nesne tespiti alanında çığır açan bir gelişme olarak öne çıkmış ve diğer popüler nesne tespit yöntemlerinden, özellikle R-CNN ve Fast R-CNN'den farklı olarak, bir dizi avantaj sunmaktadır. YOLO, performanstan ödün vermeden etkili nesne algılama özelliğine sahiptir. Bu çalışmada, YOLOv5 ve YOLOv6 modellerinin performansı, Kaggle açık erişim bulut işleme altyapısı kullanılarak edinilen veri setinde değerlendirilmektedir. Performanslar; hassasiyet, geri çağırma, mAP0.5 ve mAP0.5:0.95 metrikleri, öğrenme ve işleme süresi dikkate alınarak analiz edilmiştir. Sonuçlar değerlendirildiğinde ise Sonuçlar değerlendirildiğinde en uygun model için veri seti bütüklüğü, karmaşıklığı gibi parametreler değişkenlik gösterse de gelişen algoritmaların mimari yapısı olarak daha pozitif sonuçlar elde ettiğini göstermektedir.

Anahtar Kelimeler – Bilgisayarlı Görü, nesne tanıma, YOLO v5, YOLO v6, performans

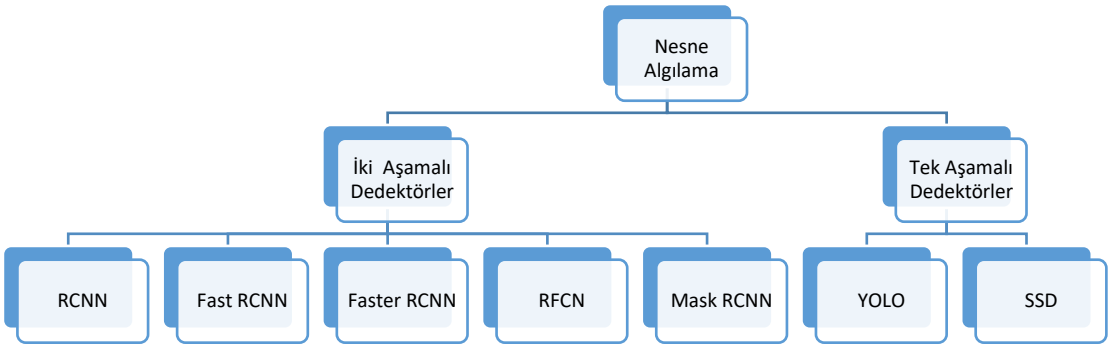
I. GİRİŞ

Bilgisayarlı görme, bilgisayarların görsel bilgileri insanlarla aynı şekilde yorumlayıp anlamasını sağlamayı amaçlayan, hızla gelişen bir alandır. Görüntüleri ve videoları analiz edebilen, anlayabilen ve onlardan yararlı bilgiler çıkarabilen algoritmaların, modellerin ve sistemlerin geliştirilmesini içermektedir [1]. Bilgisayarla görmenin en önemli alanlarından biri, görüntülerde veya video karelerinde insanlar, arabalar ve hayvanlar gibi önceden tanımlanmış belirli sınıf/sınıfların anlamsal nesnelerinin örneklerinin tespit edilmesini içeren nesne algılamasıdır [2].

Nesne algılama alanı, öncelikle derin öğrenme algoritmalarındaki gelişmelerin yönlendirdiği, dönüştürücü bir evrim yaşamıştır. Bir görüntüdeki nesneleri tanımlama ve konumlandırma görevi olan nesne algılama, otonom araçlardan tıbbi görüntülemeye, gözetleme ve artırılmış gerçekliğe kadar çok sayıda uygulamanın odağında yer almaktadır. Büyük ölçüde el yapımı özelliklere ve klasik makine öğrenimi tekniklerine dayanan geleneksel nesne algılama yöntemlerinin doğruluğu ve ölçeklenebilirliği genellikle sınırlıydı [3]. Ancak derin öğrenmenin ortaya çıkışı bu alanda bir dönüşüm yaratarak hem hız hem de hassasiyet açısından önemli gelişmeler sağlamıştır.

Nesne tanımlamadaki dönüşüm, görüntü sınıflandırma görevlerinde dikkate değer yetenekler sergileyen Evrişimli Sinir Ağlarının (CNN'ler) tanıtılmasıyla başlamıştır. Bu, bölge bazlı algılama için CNN'lerden yararlanan ve benzeri görülmemiş bir doğruluk elde eden R-CNN, Fast R-CNN ve Faster R-CNN gibi öncü modellerin geliştirilmesine yol açmıştır [4-7]. Daha sonra YOLO (Yalnızca Bir Kez Bakarsınız) ve SSD (Tek Atışlı Çoklu Kutu Dedektörü) gibi tek atışlı dedektörlerin ortaya çıkışı, sınırları daha da zorladı ve performanstan çok fazla ödün vermeden gerçek zamanlı algılama yetenekleri gelişmiştir [8].

Nesne algılama algoritmaları, giriş görüntüsünün bir ağ üzerinden kaç kez geçtiğine bağlı olarak genel olarak iki kategoriye ayrılmaktadır. Şekil 1' de nesne tanımada kullanılan algoritmaların sınıflandırılması gösterilmektedir.



Şekil 1. Nesne Tanımada Kullanılan Algoritmalarının Sınıflandırılması [9]

Nesne tanımada gerçekleşen bu gelişmeler yalnızca nesne algılama sistemlerinin teknik yeteneklerini artırmakla kalmamış, aynı zamanda çeşitli endüstrilerde uygulanabilirliğini de genişletmiştir. Otonom araçlar güvenli bir şekilde yol alabilmek için bu algoritmalara güvenmekte, tıp uzmanları teşhis görüntülerindeki anormallikleri tespit etmek için bunları kullanmakta ve güvenlik sistemleri bunları gelişmiş izleme ve tehdit tespiti için tercih etmektedir. Araştırmalar devam ettikçe, gerçek zamanlı algılamayı, 3 boyutlu nesne tanımayı ve büyük miktarlarda etiketlenmemiş veriden yararlanmak için denetimsiz öğrenme tekniklerinin kullanımını geliştirmeye yönelik devam eden çabalarla nesne algılamanın geleceği daha da parlak olacaktır.

Nesne algılamaya yönelik derin öğrenme algoritmalarının gelişimi, sürekli yenilikler ve önemli atılımlarla dikkat çeken dikkate değer bir ilerleme göstermektedir. Bu ilerleme, endüstrileri yeniden şekillendirmekte ve akıllı sistemlerin günlük yaşamlarımızda uygulanması için yeni olanaklar oluşturmaktadır.

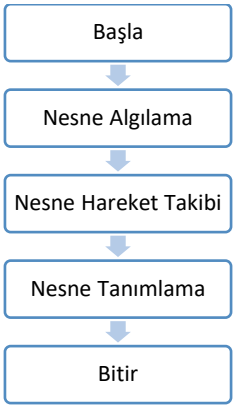
Bu çalışmada, nesnelerin tanınmasında tek aşamalı dedektör algoritmalarından olan YOLO' nun v5 ve v6 altı modelinin Trafik İşaret Tespiti veri setindeki performans metrikleri incelenerek versiyonlar arasındaki korelasyon ortaya konulmaya çalışılacaktır. Performanslar; hassasiyet, geri çağırma, mAP0.5 ve mAP0.5:0.95 metrikleri, öğrenme ve işleme süresi dikkate alınarak analiz edilmiştir. Bu çalışmanın başlıca hedefleri;

- YOLO algoritmasının her türlü nesneyi tanıması.
- Izgara görüntülerinin daha yüksek hızda analiz edilmesi.
- Versiyon gelişmelerinin hızlanmasıdır.

Çalışmanın devamı şu şekilde organize edilmiştir; 2. Bölümde nesne tanıma ve YOLO algoritmalarının kullanımıyla ilgili kaynak taraması gerçekleştirilmiştir. 3. Bölümde ise materyal ve metod kısmında özellikle YOLOv5 ve YOLOv6 modellerinin eğitimi için veri seti kümesinin kapsamlı bir açıklaması ayrıca YOLOv5 ve YOLOv6 algoritmalarının temel özellikleri sunulmaktadır. Bölüm 4, elde edilen sonuçların ayrıntılı bir tartışmasını ve veri seti için en iyi modelin seçilmesine yönelik öneriler sunmaktadır. Son olarak, Bölüm 5 makaleyi sonuçlandırarak, ana bulguları özetlemekte ve daha ileri araştırmalar için öneriler bakış açısı sunmaktadır.

II. LİTERATÜR ÖZETİ

Nesne Algılama hem nesne sınıflandırmasına hem de nesnelerin konum sorunlarına sahiptir. Son adım, sınır kutularına ve etiketli resimlere sahip olmaktır. Görüntü sınıflandırmasında araştırmacılar genellikle Evrişimli Sinir Ağlarına (CNN'ler) odaklanır. Öncelikle sınıflandırma amacıyla VGNET ve Inception gibi CNN'ler kullanıldı. Görüntü sınıflandırma işlemi, çoklu etiket sınıflandırması sırasında bir sınıfın veya birden fazla sınıfın girdisini alır ve çıktısını döndürmektedir [10-12].



Şekil 2. Nesne Tanımanın Akış Şeması [13].

Nesne tespiti için derin öğrenme algoritmalarındaki gelişmeler, literatürde kapsamlı bir şekilde incelenmiş, çeşitli yaklaşımlar, metodolojiler ve uygulamalar derlenmiştir.

Nesne algılamaya yönelik derin öğrenme algoritmalarının geliştirilmesine ilişkin karşılaştırmalı çalışmalar tablosu Tablo 1' de verilmiştir. Bu tablo temel yöntemleri, bunların ana katkılarını, güçlü yönlerini ve sınırlamalarını içermektedir.

Tablo 1. Nesne algılamaya yönelik derin öğrenme algoritmalarının karşılaştırmalı analizi

Yöntem / Algoritma	Katkılar	Güçlü Yönler	Sınırlamalar
Haar Cascades	El yapımı özellikleri ve basamaklı sınıflandırıcıları kullanan ilk yöntem [10]	Gerçek zamanlı uygulamalar için basit ve hızlı	Sınırlı doğruluk, yüksek yanlış pozitiflik oranı
HOG-SVM	Özellik çıkarımı için Yönlendirilmiş Gradyanların Histogramının ve sınıflandırma için SVM'nin kullanılması [14]	Aydınlatma ve pozlamadaki değişikliklere karşı dayanıklı	Hesaplama açısından yoğun, hassas özellik mühendisliği gerektirir
AlexNet	ImageNet yarışmasını kazanan derin CNN'lerin tanıtımı [15]	Otomatik özellik öğrenme, yüksek doğruluk	Büyük etiketli veri kümeleri ve yüksek hesaplama kaynakları gerektirir
R-CNN	Bölge önerileri için seçici arama özelliğine sahip bölge tabanlı CNN [3]	Yüksek doğruluk, iyi yerelleştirme	Her bölge için ayrı CNN değerlendirmesi nedeniyle yavaş
Fast R-CNN	Paylaşılan CNN hesaplamalarıyla R-CNN'e göre iyileştirme [16]	R-CNN'den daha hızlı, iyi doğruluk	bölge teklifi hesaplaması gerektirir
Faster R-CNN	Bölge Teklif Ağının (RPN) Tanıtılması [7]	Verimli bölge önerileri, yüksek doğruluk	Hesaplama açısından yoğun, gerçek zamanlı uygulamalar için uygun değil
YOLO	Tek çekimli algılama, nesne algılamayı regresyon olarak çerçeveleme [8]	Son derece hızlı, gerçek zamanlı uygulamalara uygun	Küçük nesnelerde ve karmaşık arka planlarda daha düşük doğruluk
SSD	Tek atış tespitini çok ölçekli özellik haritalarıyla birleştirir [17]	Hız ve doğruluk dengesi, değişen nesne boyutları için iyi	Bölge bazlı yöntemlere kıyasla küçük nesnelerde daha az doğruluk
RetinaNet	Sınıf dengesizliğini gidermek için Odak Kaybını sunar [18]	Özellikle algılanması zor nesnelerde yüksek doğruluk	YOLO ve SSD'den daha yavaş
EfficientDet	Verimli ve ölçeklenebilir algılama için bileşik ölçeklendirmeyi kullanır [19]	Daha düşük hesaplama maliyetiyle yüksek doğruluk	Ölçeklendirme sürecindeki karmaşıklık
DETR	Uçtan uca eğitimle transformatörleri nesne algılamaya uygular [20]	Basitleştirilmiş tespit hattı, büyük veri kümelerinde iyi performans	Büyük veri kümeleri gerektirir ve hesaplama açısından pahalıdır

Krizhevsky ve ark. (2012) AlexNet ile birlikte görüntü sınıflandırmada derin öğrenmenin temelini attı ve geleneksel yöntemlere göre önemli gelişmeler gösterdi [15]. Simonyan ve Zisserman (2014), küçük filtrelere sahip daha derin ağların yüksek doğruluk elde edebileceğini göstermiştir [11]. Szegedy ve ark. (2015), hesaplama verimliliğini ve doğruluğunu artıran başlangıç modülünü tanıttı [21]. He ve ark. (2016) ResNet ile artık bağlantılar üzerinden çok derin ağlar sağlayarak alana yenilik katmıştır [22]. Huang ve diğerleri. (2017) DenseNet ile gradyan akışını ve parametre verimliliğini iyileştirerek performansı artırdı [23]. Howard ve diğerleri. (2017) MobileNet ile mobil uygulamalara yönelik hafif modellere, hız ve doğruluğu dengelemeye odaklandı [24]. EfficientNet ile Tan ve Le (2019), model performansını ve verimliliğini optimize etmek için sistematik bir ölçeklendirme yöntemini tanıttı [19]. Dosovitskiy ve ark. (2020) Vision Transformer (ViT) ile transformatör modellerini görüntü sınıflandırmaya uygulayarak, öz-dikkat mekanizmalarıyla yüksek doğruluk elde etti [25]. Liu ve diğerleri. (2022) ConvNeXt ile ConvNet'lerin ve transformatörlerin en iyilerini birleştirerek son teknoloji ürünü performansa ulaşmıştır [17].

Bu gelişmeler genel anlamda incelendiğinde endüstrileri yeniden şekillendirmekte ve farklı uygulamalar geliştirmektedir. Bu kapsamda nesne tanıma ile ilgili bazı alanlara yönelik karşılaştırmalı analizlere Tablo 2' de yer verilmiştir.

Tablo 2. Nesne Tanımada endüstriyel uygulamalara örnekler

Yöntem / Algoritma	**Katkılar**	**Güçlü Yönler**	**Sınırlamalar**
Otonom Araçlar	Navigasyon ve güvenlik için nesne algılamayı kullanır [26]	Gerçek zamanlı karar verme açısından kritik	Yüksek doğruluk ve gerçek zamanlı işleme gerektirir
Medikal Görüntüleme	Tümörlerin ve anormalliklerin belirlenmesine yardımcı olur [27]	Tanısal doğruluğu ve verimliliği artırır	Yanlış pozitif/negatiflere karşı hassas, yüksek hassasiyet gerektirir
Gözetim ve Güvenlik	Gelişmiş izleme ve tehdit tespiti [28]	Büyük ölçekli izleme için etkili	Gizlilik endişeleri, sağlam ve doğru tespit algoritmaları gerektirir

YOLO algoritmaları kullanılarak gerçekleştirilen çalışmaların bir bölümü Tablo 3'te sunulmaktadır.

Tablo 3. YOLO algoritmalarına örnek çalışmalar

Kaynak	**Veriseti**	**Metot**	**Performans**
Baccouche et al. [29]	Private dataset	YOLO, CycleGAN	Doğruluk: %94, Hassasiyet: %94, Geri Çağırma: %94, Hassasiyet: %95, AUC: 95
Chen et al. [30]	Private dataset	Multiview Vision Transformers	AUC = 0.818
Lu et al. [31]	Wine Grape Dataset	Faster R-CNN, YOLO, Swin-TYOLOv5 Faster R-CNN:	mAP: %53,54, F1-Skoru: 0,67, YOLOv3: harita: %78,93, F1-Skoru: 0,72, YOLOv4: harita: %83,45, F1-Skoru: 0,76, YOLOv5: harita: %93,64, F1-Skoru: 0,83, Swin-T-YOLOv5: mAP: %97,19, F1-Skoru: 0,89 AP: NEU'da: 43,3, DAGM2007'de: 65,9, açık RSDD'ler: 50,6
Yang et al. [32]	NEU, DAGM2007, RSDDs	ST-CA YOLOv5	AP: NEU'da: 43,3, DAGM2007'de: 65,9, açık RSDD'ler: 50,6
Vasanthi et al. [33]	PASCAL, VOC	YOLO	PASCAL: mAP: %87,7, Hassasiyet: %85,2, Geri Çağırma: %81,4

III. MATERYAL VE YÖNTEM

A. Veri Toplama

Bu çalışmada, Kaggle açık erişim bulut işleme altyapısı kullanılarak edinilen "Trafik İşaret Tespiti" veri seti kullanılmıştır [34]. Veri seti, 55 sınıf benzersiz trafik işareti içermektedir. Ancak, 4 temel ana kategori bulunmaktadır. Her sınıfın adında, trafik işaretinin kategorisini belirten öneklerden biri bulunmaktadır.

Bunlar sırasıyla; yasak, bilgilendirici, zorunlu ve uyarı şeklindedir. Veri setinin temel özellikleri incelendiğinde ise her görüntünün 640x640 piksel boyutunda olduğu, doğal boyutta esneme veya küçülme yapılamayacağı bilinmektedir.

B. YOLO v5

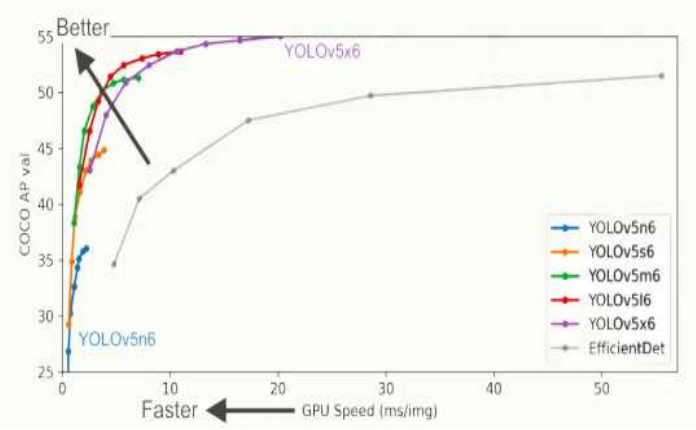
YOLO v5, önceki sürümlerden önemli bir farkla, EfficientNet mimarisini temel alan EfficientDet adı verilen daha verimli bir sinir ağı mimarisinin kullanılmasıyla 2020 yılında kullanılmaya başlanmıştır. EfficientDet, bir dizi kıyaslama veri kümesinde en son teknolojiye sahip performansa ulaşmış bir görüntü sınıflandırma modelidir. EfficientDet mimarisi, hesaplama ve bellek kullanımı açısından verimli olacak ve aynı zamanda yüksek doğruluk elde edecek şekilde tasarlanmıştır.

YOLO v5'in bir diğer önemli farkı ise YOLO'nun önceki versiyonlarında kullanılan bağlantı kutularına olan ihtiyacı ortadan kaldıran çapasız algılamanın kullanılmasıdır. YOLO v5, bağlantı kutuları yerine sınırlayıcı kutu koordinatlarını doğrudan tahmin etmek için tek bir evrişimli katman kullanır; bu da modelin daha esnek olmasını ve farklı nesne şekillerine ve boyutlarına uyarlanabilmesini sağlamaktadır.

YOLO v5 ayrıca modelin doğruluğunu artırmak için "Çapraz mini toplu normalleştirme" (CmBN) adı verilen bir teknik kullanmaktadır. CmBN, sinir ağının aktivasyonlarını normalleştirmek için kullanılan standart toplu normalleştirme tekniğinin bir çeşididir [35].

Eğitimle ilgili olarak YOLO v5, büyük bir veri kümesinde önceden eğitilmesine ve daha sonra daha küçük bir veri kümesinde ince ayar yapılmasına olanak tanıyan transfer öğrenmeyi tercih etmektedir. Bu, modelin geniş bir veri yelpazesinden öğrenmesine ve yeni verilere daha iyi genelleme yapmasına olanak tanımaktadır.

YOLO v5' in farklı versiyonlarında COCO veri seti uygulamasının performans metrikleri Şekil 3' te gösterilmektedir.



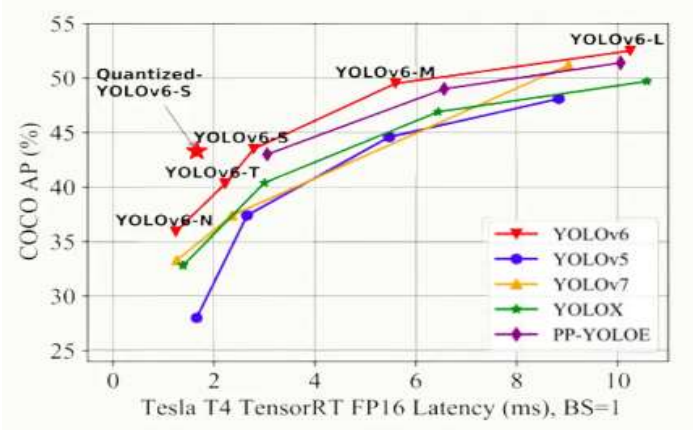
Şekil 3. YOLO v5 performans metrikleri

C. YOLO v6

YOLO v6 ile önceki sürümler arasındaki dikkate değer bir fark, daha verimli ve hafif bir sinir ağı mimarisinin kullanılmasıdır. Bu durum, YOLO v6'nın daha hızlı ve daha az hesaplama kaynağıyla çalışmasına olanak tanımaktadır. YOLO v6, sınırlı hesaplama kaynaklarına sahip çeşitli cihazlarda çalıştırılabilen bir dizi hafif modelden oluşan "EfficientNet-Lite" mimarisi kullanılmaktadır.

YOLO v6 ayrıca modelin sağlamlığını ve genelleştirilmesini geliştirmek için veri artırma tekniklerini de içermektedir. Bu, eğitim sırasında giriş görüntülerine döndürme, ölçeklendirme ve çevirme gibi rastgele dönüşümler uygulanarak gerçekleştirilmektedir [36].

YOLO v6' nın farklı versiyonlarında COCO veri seti uygulamasının performans metrikleri Şekil 4' te gösterilmektedir.



Şekil 4. YOLO v6 performans metrikleri

D. *Yöntem*

Trafik işaretlerini ve nesnelerini hızlı ve doğru bir şekilde tespit etme yeteneği, otonom sürüş sistemlerinin işlevselliğini ve güvenilirliğini önemli ölçüde artırabilir. Bu nedenle, farklı YOLO versiyonlarının güçlü ve zayıf yönlerini anlamak, belirli uygulamalar için doğru modelin seçilmesine imkân tanımaktadır. Ayrıca elde edilen sonuçlar operasyonel verimliliği ve etkinliği üst düzeye taşımaktadır (Şekil 5).

Şekil 5. Trafik İşaret Tespiti veri seti örneklemi

Bu çalışmada:

- *Model Eğitimi ve Değerlendirme*: YOLO versiyonlarını bir veri kümesi üzerinde eğitmek ve temel ölçümleri kullanarak performanslarını değerlendirmek.
- *Karşılaştırmalı Analiz*: Modeller arasında karşılaştırmalar yapmak için sonuçların analiz edilmesi, modellerin hızına, doğruluğuna ve genel etkililiğine ve verimliliğine odaklanılması.
- *Uygulama Uygunluğu Değerlendirmesi*: Analize dayalı olarak belirli gerçek dünya uygulamaları için hangi YOLO sürümünün en uygun olduğuna dair öneriler sunabilmek.

IV. ARAŞTIRMA BULGULARI

Bu çalışmada, "Trafik İşaret Tespiti" veriseti aracılığıyla YOLO'nun farklı versiyonlarını (YOLOv5 ve YOLOv6) değerlendirmeye ve karşılaştırmaya odaklanmaktadır. YOLO v5 için elde edilen bulgular şu şekildedir.

- *Hassasiyet-Güven Eğrisi*; Eğri, 0,0 güven seviyesinde %35 hassasiyetle başlamaktadır. 0,5 güven eşiğinde %80 hassasiyete ulaşana kadar artmaya devam etmekte ve 0,7 güven eşiğinde ise %82'ye yükselmektedir.

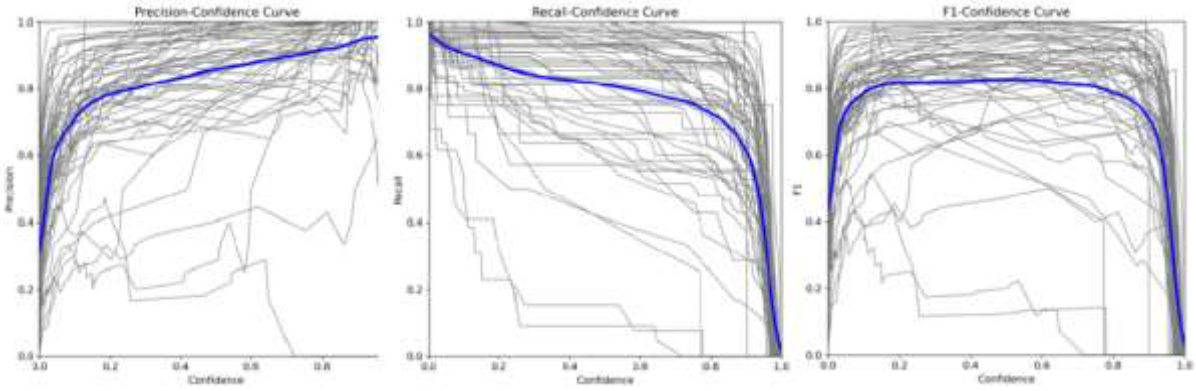
Eşik arttıkça model yaklaşık %95 ve %100 kesinliğe ulaşmaktadır. Bu durum, modelin yüksek güvenle doğru hassasiyeti yaptığını ancak aynı zamanda yanlış negatiflerin sayısının da arttığını göstermektedir. Genel olarak bu eğri, modelimizin yeterli güvenle mükemmel performans gösterdiğini ifade edebiliriz.

- *Hatırlama-Güven Eğrisi*; Geri Çağırma-Güven aralıkları %96 civarında yüksek bir oranla ve düşük bir güven eşiğiyle başlamaktadır. Güven eşiği arttıkça modeller %90 ile %80 arasında ortalamanın üzerinde bir geri çağırma elde etmeye devam etmektedir.

Eşik 0,70'e ulaştıktan sonra geri çağırma azalmaya başlamakta ve bu durum yüksek güven oranlarıyla yanlış pozitifliğin arttığını göstermektedir. Genel olarak bu eğri, modelin yeterli bir güven eşiğiyle yüksek hatırlama puanlarına ulaştığını göstermektedir.

- *F1-Güven Eğrisi*; F1 puanı hem hatırlama hem de kesinlik puanları arasındaki ilişkiyi göstermektedir.

F1-Güven eğrisi, yaklaşık 0,79'luk bir güven eşiğine kadar sabit bir F1 puanı gösterir ve ardından düşmeye başlamaktadır. Genel olarak, bu eğri etkili bir şekilde modelimizin iyi bir hassasiyetini ve hatırlanmasını göstermektedir.



Şekil 6. YOLO v5 performans metrikleri

YOLO v6 için elde edilen bulgular şu şekildedir.

- *Hassasiyet-Güven Eğrisi*; Eğri, 0,0 güven seviyesinde %34 hassasiyetle başlar ve 0,5 güven eşiğinde %82 hassasiyete ulaşana kadar artmaya devam etmekte ve 0,7 güven eşiğinde %84'e yükselmektedir

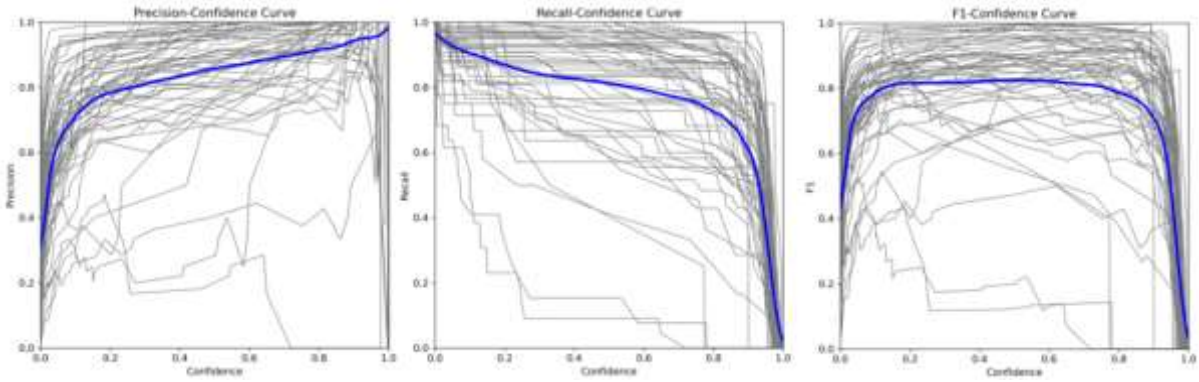
Eşik arttıkça model yaklaşık %95 ve %100 kesinliğe ulaşmaktadır. Bu durum, modelin yüksek güvenle doğru hassasiyeti yaptığını ancak aynı zamanda yanlış negatiflerin sayısının arttığını da göstermektedir. Genel olarak bu eğri, modelimizin yeterli güvenle mükemmel performans gösterdiğini ifade etmektedir.

- *Hatırlama-Güven Eğrisi*; Geri Çağırma-Güven aralıkları %96 civarında yüksek bir oranla ve düşük bir güven eşiğiyle başlamaktadır. Güven eşiği arttıkça modeller %90 ile %75 arasında yüksek bir geri çağırma elde etmeye devam etmektedir.

Eşik 0,7'ye ulaştıktan sonra geri çağırma azalmaya başlamakta ve bu da yüksek güven oranlarıyla yanlış pozitifliğin arttığını göstermektedir. Genel olarak bu eğri, modelimizin yeterli bir güven eşiğiyle yüksek hatırlama puanlarına ulaştığını göstermektedir.

- *F1-Güven Eğrisi*; Bahsedildiği üzere hem hatırlama hem de kesinlik puanları arasındaki ilişkiyi göstermektedir.

F1-Güven eğrisi, yaklaşık 0,75'lik bir güven eşiğine kadar sabit bir F1 puanı göstermekte ve ardından düşmektedir. Genel olarak, bu eğri etkili bir şekilde modelimizin iyi bir hassasiyetini ve hatırlanmasını göstermektedir.



Şekil 7. YOLO v6 performans metrikleri

YOLO v5 ve YOLO v6 algoritmalarının performans metrikleri Tablo 4' te gösterilmektedir.

Tablo 4. YOLO v5 ve YOLO v6 algoritmalarının performans metrikleri

Versiyon	Hassasiyet	Geri Çağırma	mAP50	mAP50-95	Ön İşlem Zamanı	Çıkarım Süresi	İşlem Sonrası Süre	Toplam Zaman	Doğruluk
YOLOv5	0.827	0.805	0.872	0.768	2.0	24.8	0.9	27.9	0.827
YOLOv6	0.846	0.823	0.902	0.796	1.7	26.8	0.9	29.8	0.846

V. SONUÇLAR

Hassasiyet ve geri çağırma, YOLOv5 ve YOLOv6'ya kıyasla sırasıyla ortalama 0.816, 0.8345 ile hem hassasiyet hem de geri çağırma açısından biraz daha düşük performans sergilemektedir. Bu performanstaki hafif düşüşün kabul edilebilir olduğu daha az kritik veri setleri için daha uygun olduğunu göstermektedir.

mAP50 ve mAP50-95, YOLOv5 ve YOLOv6' nın her ikisi de mAP50 ve mAP50-95'te biraz düşük performans sergilemektedir. Bu durum, en yüksek algılama performansının o kadar kritik olmadığı uygulamalar için uygun olabileceklerini ifade etmektedir.

Toplam işlem süresi, YOLOv5 en iyi genel hızı sunarak, özellikle toplam işlem süresi ve çıkarım süresi açısından mükemmel bir performans sergileyerek gerçek zamanlı uygulamalar için ideal olabileceğini göstermektedir. YOLOv6, YOLOv5'e çok benzer bir performans göstererek, yaklaşık 29.8 ms'lik ortalama süre ile onu gerçek zamanlı kullanım için takip etmektedir.

YOLOv5 ve YOLOv6, Trafik İşareti Algılama için oldukça idealdir. Hem YOLOv5 hem de YOLOv6, düşük toplam işlem süreleriyle (sırasıyla 27.9 ms ve 29.8 ms) oldukça verimli bir durum sergilemektedir. Hızlı çıkarım süreleri (24.8 ms ve 26,8 ms), onları otonom sürüş sistemleri veya gerçek zamanlı trafik yönetimi gibi gerçek zamanlı trafik işareti algılama uygulamaları için ideal kılacaktır. Dengeli hassasiyet ve geri çağırma oranları ise, güvenliğin kritik olduğu ortamlar için çok önemli olan güvenilir ve tutarlı performanslar sağlayacaktır.

Sonuç olarak, YOLOv5 veya YOLOv6 gibi bir derin öğrenme mimarisinin seçimi, amaçlanan işlev, mevcut donanım ve eğitim için zaman kısıtlamaları dahil olmak üzere çeşitli faktörlere bağlı kalmaktadır. Zamanın sorun olmadığı görüntü işleme görevleri için daha karmaşık modelleri yüksek doğrulukla tanımlayabileceklerdir.

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Düve Buzağılarında İshale Bağlı Ölümler ve Sebepleri

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Özet **–**Buzağıların immun sistemi, hastalıkları aktif olarak bizzat geçirmeleriyle ya da pasif olarak antikor oluşumunu uyaracak fakat hastalık yapmayacak şekilde zayıflatılmış antijenlerin verilmesi (aşılama) ile gelişir. Doğduktan sonra zamanında, yeterli miktarda ve kaliteli kolostrum tüketimi buzağıda doğal (pasif) bağışıklığın gelişmesinde en önemli role sahiptir. Kolostrumun kalitesini ineğin yaşı, ırkı, gebelik öncesi beslenme düzeyi, kuruda kalma süresi, güç doğum ve aşılanması gibi faktörler belirler. Kolostrumun kalitesini etkileyen bir diğer faktör ise annenin daha önce doğum yapıp yapmamasıdır. Bazı çalışmalar düvelerde kolostrum kalitesinin yaşlılara oranla daha düşük olduğunu göstermiştir. Bunun nedeni muhtemelen yaşlı hayvanların çiftliğe özgü patojenlere daha uzun süre maruz kalmasıdır. İkiden fazla doğum yapan ineklerde kolostrum kalitesinin arttığı belirlenmiştir. Burdur Mehmet Akif Ersoy Üniversitesi Veteriner Fakültesi Hayvan Hastanesine ishalli olduğu anamnezi ile 2 canlı 2 ölü buzağı gelmiştir. Kliniğimize getirilen iki buzağıda yapılan dışkı antijen testleri sonucu *E.coli* ile enfekte oldukları tespit edilmiştir. Tedavileri yapılan buzağılar taburcu edilmiştir. Ancak birkaç gün sonra öldükleri bildirilmiştir. Alınan anamnezde çiftlikte daha önce ishale bağlı ölümler görüldüğü ve ölen buzağıların hepsinin düvelerden kolostrum aldığı belirlenmiştir. Düvelerden kolostrum alan buzağılarda *E.coli*'ye bağlı ölümler gerçekleşirken daha yaşlı ve fazla doğum yapmış ineklerden kolostrum alan buzağılarda hastalığın daha hafif ve ölümcül olmadan geçtiği tespit edilmiştir. Bunun sebebinin pasif transfer yetmezliği olabileceği veya düvelerdeki kolostrum kalitesinin daha düşük olabileceği düşünülmektedir. Ancak çiftlikte herhangi bir kolostrum yönetim probleminin olup olmadığı ve immunglobulin düzeylerinin inceleneceği ayrıntılı bir çalışmaya ihtiyaç vardır.

Anahtar Kelimeler: Buzağı, Kolostrum, Düve, İnek, E.coli

1. GİRİŞ

Buzağıların immun sistemi, hastalıkları aktif olarak bizzat geçirmeleriyle ya da pasif olarak antikor oluşumunu uyaracak fakat hastalık yapmayacak şekilde zayıflatılmış antijenlerin verilmesi (aşılama) ile gelişir [1]. Doğduktan sonra zamanında, yeterli miktarda ve kaliteli kolostrum tüketimi buzağıda doğal (pasif) bağışıklığın gelişmesinde en önemli role sahiptir [1]. Kolostrumun kalitesi, içerdiği IgG miktarı ile doğrudan ilişkilidir. Bu kalite doğumdan sonra zaman geçtikçe azalır. Kolostrumun kalitesini ineğin yaşı, ırkı, gebelik öncesi beslenme düzeyi, kuruda kalma süresi, güç doğum ve aşılanması gibi faktörler belirler [2]. Kolostrumun kalitesini etkileyen bir diğer faktör ise annenin daha önce doğum yapıp yapmamasıdır. Bazı çalışmalar düvelerde kolostrum kalitesinin yaşlılara oranla daha düşük olduğunu göstermiştir. Bunun nedeni muhtemelen yaşlı hayvanların çiftliğe özgü patojenlere daha uzun süre maruz kalmasıdır ([3],[4]). İshal, neonatal süt ve besi buzağılarının en önemli hastalıklarından biridir. Morbidite ve mortalitenin artması, tedavi masrafları ve büyüme oranlarının düşmesi sonucunda önemli ekonomik kayıplar meydana gelmektedir. Buzağılarda neonatal enteritis tüm dünyada yaygın bir sorundur ([5],[6],[7]). Neonatal buzağı ishalleri, genel olarak buzağının ilk 4 haftalık yaşamında ortaya çıkan kompleks hastalıktır. Buzağılarda ishalin sebepleri viral (rotavirüs, koronavirüs), bakteriyel (Escherichia coli, Salmonella sp.) veya protozoal (Cryptosporidium parvum, Eimeria sp.) kaynaklı olabilir. Bu etkenler tek başına görülebileceği gibi miks olarak da seyredebilirler [8]. Escherichia coli altı patogrupta sınıflandırılabilir: enterotoksijenik E. coli (ETEC), shiga toksini üreten E. coli, enteropatojenik E. coli, enteroinvazif E. coli, enteroagresif E. coli ve enterohaemorajik E. coli ([9],[10]). Bu bakteriler arasında neonatal ishalinin en yaygın nedeni, K99 (genellikle E. coli K99+ olarak adlandırılır) ve ısıya dayanıklı enterotoksin üreten ETEC suşlarıdır [10]. Neonatal buzağılar ETEC enfeksiyonuna en çok doğumdan sonraki ilk 4 gün boyunca duyarlıdır ve enfekte olmaları halinde sulu ishal geliştirirler [11]. Etkeni yutmayı takiben, ETEC bağırsak epitelini enfekte eder ve bağırsak villuslarının enterositlerinde çoğalır. İnce bağırsağın distal kısmı, düşük pH (6,5'ten az) nedeniyle ETEC kolonizasyonu için en uygun ortamı sağlar. İnce bağırsakta enfekte hücrelerin kaybına bağlı villöz atrofi ve laminer propriyada hasar yaygın olarak gözlenir. Bakteriler tutunmak için K99 antijenini eksprese eder [12]. Bağırsak epitelinde kolonizasyonundan sonra, ETEC tarafından indüklenen ısıya dayanıklı toksin üretimi bağırsakta klorür salgılanmasının artmasına neden olur. Bu durum ozmotik olarak suyu bağırsak lümenine çeker ve buzağılarda ishalin gelişmesine yol açar [13].

2. Materyal ve Yöntem

Burdur Mehmet Akif Ersoy Üniversitesi Veteriner Fakültesi Hayvan Hastanesine, ishalli olduğu anamnezi ile 2 ölü 2 canlı buzağı gelmiştir. Gelen canlı buzağılardan bir tanesi 7 günlük diğeri ise 12 günlüktür. Bu buzağılara dışkıda antijen testleri uygulanmıştır. Sonuç olarak ise her iki buzağıda da *E.Coli* antijeni tespit edilmiştir. Kliniğimizde tedavileri uygulanmış ve taburcu edilmişlerdir. Ancak birkaç gün sonra öldükleri bildirilmiştir. Alınan anamnezde çiftlikte daha önce de ishale bağlı ölümler gerçekleştiği ve ölen buzağıların tamamının düvelerden kolostrum aldığı tespit edilmiştir. Düvelerden kolostrum alan buzağılarda *E.Coli*'ye bağlı ölümler gerçekleşirken daha yaşlı ve fazla doğum yapmış ineklerden kolostrum alan buzağılarda hastalığın daha hafif ve ölümcül olmadan geçtiği tespit edilmiştir.

3. SONUÇ

Bahsedilen çiftlikten gelen hayvanların ölüm sebeplerinin pasif transfer yetmezliği olabileceği veya düvelerdeki kolostrum kalitesinin daha düşük olabileceği düşünülmektedir. Bu yüzden bakıcılara birkaç tavsiye verilmiştir. Bunlar yaşlı ve daha fazla doğum yapmış ineklerin kolostrumunun dondurulup düvelerden doğan buzağılara içirilmesi, gebelerin aşı programına uygun şekilde aşılanması, yeni doğan buzağıların ilk 12 saatte yeteri kadar kolostrumu alması, buzağıların kaldığı yerin temiz tutulması, altlıkların düzenli olarak temizlenmesi, hastalık belirtisi gösteren hayvanların ayrılması, altlıkların kuru tutulmasıdır. Fakat ölümlerin sebebinin net olarak anlaşılabilmesi için çiftlikte kolostrum yöntemleri ile

alakalı problem olup olmadığı ve kolostrum immunglobulin seviyelerinin ölçüleceği daha geniş çaplı bir çalışma gerekmektedir.

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Bazı Ülkelerde ve Türkiye'de Köpeklerde Obezite Yaygınlığı

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Özet – Dünyada Köpek ve kedi obezite oranları insanlardakine benzer şekilde pandemik boyutlara ulaştığı bildirilmektedir. Obezite sadece insanlarda değil köpeklerde de giderek artan bir sorundur. Çalışmalar, köpeklerde obezite oranlarının ülkelerde göre farklılık gösterdiğini, bazı ülkelerin diğerlerine göre daha yüksek yaygınlık oranları olduğu gösterilmiştir. Köpeklerde obezitenin son on yılda bildirilen prevalansı ABD'de %34 ile %53 arasında değişmektedir. Veteriner uzmanları tarafından Fransa ve Birleşik Krallık da dahil olmak üzere diğer gelişmiş ülkelerde de benzer oranların (%38,8 ila %52) olduğu rapor edilmiştir. Türkiye'de de köpeklerde obezitenin yaygınlığı da endişe verici bir konu olup olmadığı bilinmemektedir. Bazı veriler farklılık gösterse de çalışmalar Türkiye'de köpeklerde obezite oranının arttığını göstermektedir. Türkiye'de köpeklerde obezitenin kesin prevalansı iyi belgelenmemiştir ancak diğerlerine benzer şekilde önemli bir sorun olduğuna inanılmaktadır. Türkiye'de köpeklerde obezite prevalansının kesin olarak belirlenmesi ve diğer ülkelerle karşılaştırılması için daha fazla araştırma ve veri toplanması gerekmektedir. Köpeklerde obezite oranları farklı ülkelerde değişiklik göstermektedir; bazı ülkeler diğerlerine göre daha yüksek yaygınlık oranları bildirmektedir. Ancak köpeklerde obezitenin küresel bir sorun olduğu ve dostlarımızın daha sağlıklı yaşam tarzlarını teşvik etmek için dikkat ve proaktif önlemler gerektirdiği açıktır. Sonuç olarak, köpeklerde obezite prevalansı Türkiye de dahil olmak üzere farklı ülkeler arasında farklılık göstermeye devam etse de ciddi bir sağlık sorunu olması ortak bir araştırma konusu olmaya devam etmektedir. Daha fazla araştırma ve veri toplama Türkiye'de köpeklerde obezitenin kesin prevalansının belirlenmesi ve diğer ülkelerle karşılaştırılması gerekmektedir. Ayrıca, Türkiye'deki evcil hayvan sahiplerinin ve veteriner hekimlerin düzenli egzersizi, uygun beslenmeyi ve izlemeyi teşvik ederek bu konuyu ele alma konusunda daha proaktif olmaları çok önemlidir.

Anahtar Kelimeler: Köpek, Obezite, Prevalans, Kedi, Türkiye

I. GİRİŞ

Obezite, vücutta aşırı miktarda yağ dokusu birikmesi olarak tanımlanır [1]. Obezite, bir hayvanın normal kilosunun yüzde 15 üzerinde olduğu bir durum olarak tanımlanmıştır [2]. Evcil hayvanlarda yaygın olarak karşılaşılmakla beraber kardiyovasküler hastalıklar, yaşam süresini ve kalitesini azaltabilen metabolik hastalıklar gibi bir dizi ciddi tıbbi durumla ilişkilendirilir ([3], [4], [5]). Obezite ile ilişkili diğer durumlar arasında artan sinirlilik ve solunum sıkıntısı yer almaktadır [2]. Buna ek olarak, obez hayvanların oyun oynamaya isteksiz ve güçlü egzersiz yapamaz hale gelmeleri muhtemeldir [6]. Obezite, köpeklerde en sık görülen beslenme bozukluğudur ([7], [8]). Kapalı alanda yaşamak, hareketsizlik, orta yaş, kısırlaştırılmış olmak, melez olmak ve bazı beslenme faktörleri aşırı kilolu olmakla ilişkilendirilmiştir [2]. Yemek artıklarıyla beslenen köpeklerin daha fazla risk altında olduğu ve 9-12 aylıkken aşırı kilolu olarak değerlendirilen köpeklerin aşırı kilolu yetişkinler olma ihtimalinin bir buçuk kat daha fazla olduğu görülmüştür. Bir evde köpek bulunması halinde kedilerde obezite riskinin azaldığı bildirilmiştir. Birden fazla köpeğin bulunduğu evlerdeki köpeklerin obez olma ihtimalinin daha düşük olup olmadığı net değildir çünkü oyun oynama fırsatları artmış olabileceği gibi beslenme motivasyonları da artabilir ([9], [10], [11]). Metabolizma hızının azalmasının bir sonucu olarak kısırlaştırılmış köpeklerin obez olma olasılığı muhtemelen tüm köpeklerden daha yüksektir [12]. Obezite insidansı hem metabolik hız hem de aktivite azaldıkça yaşla birlikte artar [13]. Çok yaşlı köpekler hariç, obezite dişilerde erkeklerden daha yaygındır. Obez olma riski yüksek olan köpek ırkları arasında Cocker spaniel, Labrador retriever, Collie, Dachshund, Shetland sheepdog, Cairn terrier, Bassett hounds, Cavalier King Charles spaniel ve Beagle bulunmaktadır [2]. Obez sahiplerin obez köpeklere sahip olma olasılığının daha yüksek olabileceği de öne sürülmüştür ancak bunun köpeklerini egzersiz yaptırmadaki başarısızlıkla mı, aşırı yeme ve aşırı besleme arasındaki ilişkiyle mi yoksa evcil hayvanlarındaki obeziteyi fark etmedeki başarısızlıkla mı ilgili olduğu net değildir [14]. Dünyada köpek ve kedi obezite oranları insanlardakine benzer şekilde pandemik boyutlara ulaştığı bildirilmektedir. Obezite sadece insanlarda değil köpeklerde de giderek artan bir sorundur. Çalışmalar, köpeklerde obezite oranlarının ülkelere göre farklılık gösterdiğini, bazı ülkelerde diğerlerine göre daha yüksek yaygınlık oranları olduğu gösterilmiştir.

II. BULGULAR

Amerika'da özel kliniklerde yapılan bir çalışmaya 24.975 yetişkin köpekten vücut kondisyonu bildirilen 21.754 yetişkin köpek dahil edilmiştir. Veteriner hekimler tarafından belirlenen vücut kondisyonuna dayalı olarak bu özel klinik popülasyonunda obezite prevalansı yetişkin köpekler için %5,1; aşırı kilo prevalansı ise %29,0'dır. Sonuç olarak, 1 yaşından büyük köpeklerin toplam %34,1'i ya aşırı kilolu ya da obez olarak bildirilmiştir [15].

Yine Amerika-Kaliforniya'da yapılan bir çalışmaya göre 1 Ocak 2006 ve 31 Aralık 2015 tarihleri arasında kliniklere giden 40,038 hasta arasında obezite ve aşırı kilo prevalansı ölçülmüştür. Bu grup içerisinde ise aşırı kilo (%21,1; n = 8461) ve obezitenin (%20,2; n = 8.089) genel prevalansı %41,3 olarak bildirilmiştir. Yaş grupları arasında, genç köpeklerin %26,8'i aşırı kilolu olarak değerlendirilirken, aşırı kilo prevalansı orta yaşlı ve yaşlı köpeklerde sırasıyla %47,1 ve %45,6 olarak bulunmuştur. Kısırlaştırılmış 34.154 köpeğin %43,5'i obez veya aşırı kilolu olarak değerlendirilirken, 5884 kısırlaştırılmamış köpeğin %29,1'i obez veya aşırı kilolu olarak değerlendirilmiştir [16].

Avustralya'da ele alınan bir çalışmada ise 2661 köpekten sekizi (yüzde 0-3) çok zayıf, 104'ü (yüzde 3-9) zayıf, 1456'sı (yüzde 54-7) ideal (normal), 892'si (yüzde 33-5) fazla kilolu ve 201'i (yüzde 7-6) obez olarak sınıflandırılmıştır [2].

Brezilya'da yapılan çalışmaya 285 köpek dahil edilmiştir. Bu köpeklerden %40,5'i obez veya aşırı kilolu olarak tanımlanmıştır. Bu çalışmada ayrıca obezite ve aşırı kilo oranının kısırlaştırılmışlarda ve dişi köpeklerde daha fazla olduğu da bulunmuştur [17].

Çin'de yapılan ve 2391 köpeğin ele alındığı çalışmada ise obez veya aşırı kilolu köpeklerin prevalansı %44,4 olarak bulunmuştur [18].

Fransa’da ele alınan 309 köpekten yapılan bir çalışmada, köpeklerin yaklaşık %35,3'ünün aşırı vücut ağırlığına sahip olduğunu ve tüm köpeklerin %2,3'ünün obez olduğunu ortaya konmuştur. Önem sırasına göre, aşırı kilo ile ilişkili değişkenler, köpeğin vücut kondisyonunun sahibi tarafından hafife alınması, geriatrik olması, yaşlı olması ve dişi olması olarak bulunmuştur [19].

İspanya’da yapılan bir çalışmada ele alınan 93 köpekten 38’i aşırı kilolu ya da obez bulunmuştur [20].

Kolombiya’da yapılan 194 köpeğin dahil edildiği bir çalışmada ise 1’den 10’a kadar skorlandırılan vücut skorlamasında köpeklerin %23,2’si aşırı kilolu, %1,6’sı obez olarak belirlenmiştir [21].

III. SONUÇLAR

Türkiye’de de köpeklerde obezitenin yaygınlığının endişe verici bir konu olup olmadığı bilinmemektedir. Bazı veriler farklılık gösterse de çalışmalar Türkiye'de köpeklerde obezite oranının arttığını göstermektedir. Türkiye’de köpeklerde obezitenin kesin prevalansı iyi belgelenmemiştir ancak diğer ülkelere benzer şekilde önemli bir sorun olduğuna inanılmaktadır. Türkiye’de köpeklerde obezite prevalansının kesin olarak belirlenmesi ve diğer ülkelerle karşılaştırılması için daha fazla araştırma ve veri toplanması gerekmektedir. Köpeklerde obezite oranları farklı ülkelerde değişiklik göstermektedir; bazı ülkeler diğerlerine göre daha yüksek yaygınlık oranları bildirmektedir. Ancak köpeklerde obezitenin küresel bir sorun olduğu ve dostlarımızın daha sağlıklı yaşam tarzlarını teşvik etmek için dikkat ve proaktif önlemler gerektirdiği açıktır. Sonuç olarak, köpeklerde obezite prevalansı Türkiye de dahil olmak üzere farklı ülkeler arasında farklılık göstermeye devam etse de ciddi bir sağlık sorunu olması ortak bir araştırma konusu olmaya devam etmektedir. Daha fazla araştırma ve veri toplama Türkiye’de köpeklerde obezitenin kesin prevalansının belirlenmesi ve diğer ülkelerle karşılaştırılması gerekmektedir. Ayrıca, Türkiye'deki evcil hayvan sahiplerinin ve veteriner hekimlerin düzenli egzersizi, uygun beslenmeyi ve izlemeyi teşvik ederek bu konuyu ele alma konusunda daha proaktif olmaları çok önemlidir.

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Artificial Neural Network Approach for Acceleration Analysis of the Inverted Slider-Crank Mechanism

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Abstract – In this study, the acceleration analysis of the inverted slider-crank mechanism is presented using a supervised learning algorithm. While the analytical acceleration analysis of slider-crank mechanisms is well-established, no application of such an artificial neural network method to this specific mechanism, particularly inverted slider-crank mechanisms, has been reported. The acceleration analysis of the inverted slider-crank mechanism is first solved analytically, resulting in a total of 50 data sets. Subsequently, the Scaled Conjugate Gradient (SCG) supervised learning algorithm is employed for the neural network solution approach. The SCG supervised learning algorithm is chosen due to its characteristics of efficient convergence, adaptive learning rate, and memory efficiency. The main objective of this study is to assess the ability of using an artificial neural network approach to solve the acceleration analysis problem for inverted slider-crank mechanisms. Additionally, demonstrating another application of the artificial neural network supervised learning algorithm in mechanism design is also aimed. The results show that the SCG algorithm is suitable for the artificial neural network solution approach to mechanisms' acceleration analysis.

Keywords – Inverted slider-crank mechanism, acceleration analysis, artificial neural network, Scaled conjugate gradient algorithm

I. INTRODUCTION

The slider-crank mechanism, a fundamental mechanical system, consists of three main components: a crank, a connecting rod, and a slider. In the traditional configuration, the crank is attached to a rotary input (such as a motor shaft), the connecting rod connects the crank to the slider, and the slider moves along a linear path. In an inverted slider-crank mechanism, the typical orientation of these components is reversed. Specifically, the crank is positioned above the slider, with the connecting rod still connecting the crank to the slider [1-5]. This inversion alters the motion and dynamics of the mechanism compared to the standard configuration. In this inverted configuration, a linear motion in the slider is generated by the motion of the crank (which is now above the slider), rather than the rotary motion seen in the traditional configuration. This change in motion can be useful in various applications where linear motion is required, such as in certain types of engines, pumps, or machinery.

The traditional dynamic modeling of the slider-crank mechanism has been presented in various studies [6-8]. In these studies, dynamic modeling is focused on, and various modeling methods for slider-crank mechanisms are investigated. However, artificial neural network methods are not included in any of these studies. A limited number of studies have combined slider-crank mechanisms with artificial neural network methods [9-11]. In these studies, different neural network methods are applied to dynamic modeling, physical modeling, and control of slider-crank mechanisms. A neural network solution

approach for slider-crank mechanisms is introduced, but no application of neural network methods specifically to inverted slider-crank mechanisms has been reported.

Previously, velocity analysis for the inverted slider-crank mechanism and various applications of artificial neural network algorithms to slider-crank and four-bar linkage mechanisms were presented by Denizhan and Chew [12-16]. In these articles, position kinematic analysis and synthesis were introduced and compared using different neural network algorithm approaches. In this study, the acceleration analysis of the inverted slider-crank mechanism utilizing the Scaled Conjugate Gradient neural network algorithm is investigated. To ensure the accuracy and effectiveness of the algorithm, a total of 50 data sets are employed for training, validation, and testing. Upon completion of the training, validation, and testing phases of the algorithm, the results are presented and discussed.

II. INVERTED SLIDER-CRANK MECHANISM

Previously, the designed inverted slider-crank mechanism was introduced [16] and is shown in Fig. 1. As seen in Fig. 1, Joint *A* and Joint *C* are fixed, and while Link 1 and Link 3 have rotational motion, Link 2 has both rotational and linear motions simultaneously. In Fig. 1, the angle ϕ refers to the driven link angle relative to the horizontal axis ($x-$axis), α_1, α_2 and α_3 represent the angular accelerations of Link 1, Link 2, and Link 3, respectively, x_B and y_B refer to the position coordinates of Joint B on the x and $y-$axes, and x_C refers to the position coordinate of Joint *C* on the $x-$axis.

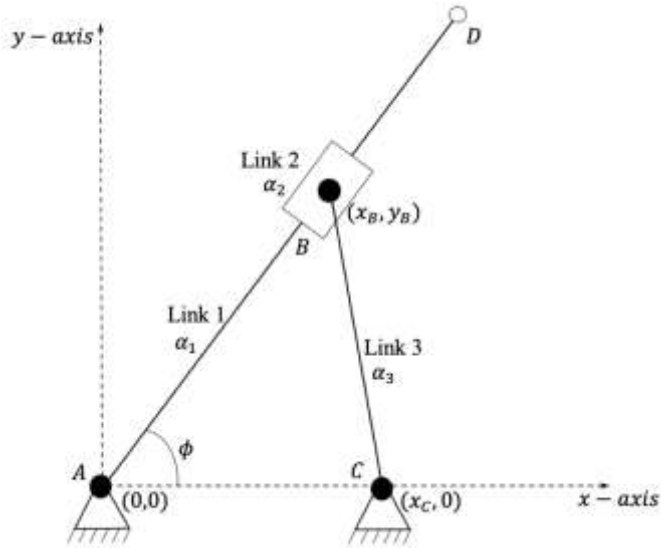

Fig. 1. Designed inverted slider-crank mechanism [16]

In this study, the driven link is Link 1, rotating at a constant speed of 30 rpm (n = 30 rpm). The dimensions of the inverted slider-crank mechanism are as follows: [AC] = 0.15 m, the length of Link 2 is 0.20 m ([BC] = 0.20 m), and the length of Link 3 is 0.35 m ([AD] = 0.35 m).

Joint *A* is fixed at the origin; hence, its coordinates are $x_A = y_A = 0$, where x_A and y_A denote the coordinates of Joint *A* along the x and $y-$axes, respectively. Since Joint *A* is fixed, its velocity V_A is zero ($V_A = 0$). Joint *C* is also fixed, and its coordinates are $x_C = 0$ and $y_C = 0.15$ m, corresponding to [AC] = 0.15 m. Similarly, since Joint *C* is fixed, its velocity V_C is also zero ($V_C = 0$). There is no need to determine the position, velocity and acceleration of Point *D* in this study.

As seen in Fig. 1, Point *B* is the intersection of Link 1, Link 2, and Link 3. A detailed drawing of Joint *B* was previously introduced by Denizhan and Chew [16]. For better understanding, Point B_1 refers to the point on Link 1, Point B_2 refers to the point on Link 2, and Point B_3 represents the point on Link 3.

III. ACCELERATION ANALYSIS OF THE INVERTED SLIDER-CRANK MECHANISM

Previously, velocity analysis of the slider crank mechanism was conducted and results were presented [16]. In this section of the article, the acceleration analysis of the mechanism is introduced. This analysis requires a neural networks approach and data sets. In Fig. 2, the acceleration field for the inverted slider crank mechanism is depicted. In the figure, α_3 denotes the angular acceleration of Link 3, ω_1 represents the angular velocity of Link 1, $V_{B_{21}}$ denotes the relative velocity of B_2 with respect to B_1 on Link 1, $a_{B_{21}}^{cor}$ represents the Coriolis acceleration of B_2 relative to B_1, ϕ refers to the angle of Link 1 with respect to the horizontal axis, $a_{B_3}^n$ and $a_{B_3}^t$ represent the normal and tangential components of acceleration of point B_3 on Link 3, respectively, $a_{B_1}^n$ denotes the normal acceleration component of Point B_1 on Link 1, a_{B_2} denotes the acceleration of point B_2 on Link 2, and $a_{B_{21}}$ denotes the relative acceleration of B_2 with respect to B_1 on Link 1.

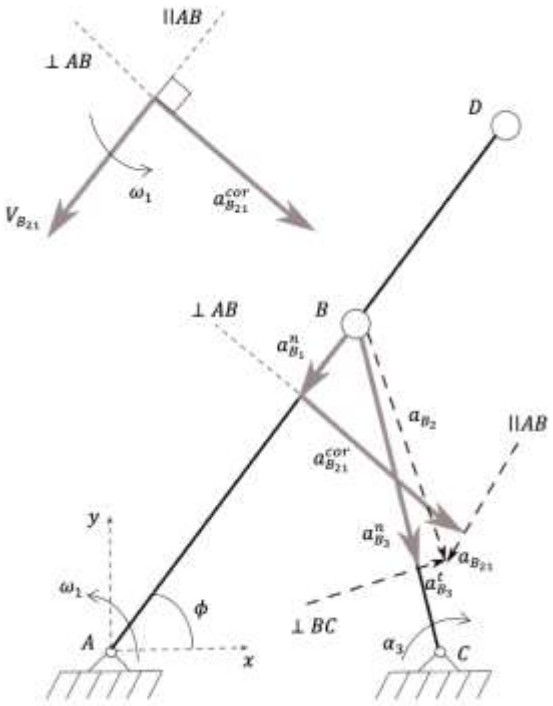

Fig. 2. Acceleration field of the designed inverted slider-crank mechanism [5]

The angular acceleration of Link 1 (α_1) is zero because it has constant velocity. The acceleration of Point B_1 on Link 1 is defined as:

$$a_{B_1} = a_A + \alpha_1 \text{ x } r_B + \omega_1 \text{ x } (\omega_1 \text{ x } r_B) = \alpha_1 \text{ x } r_B - \omega_1^2 r_B \tag{1}$$

where a_{B_1}, a_A, r_B and ω_1 denote the acceleration of Point B_1 on Link 1, acceleration of Point A, position vector of Point B, and the angular velocity of Link 1, respectively.

The velocity of Point B_2 on Link 2 equals the velocity of Point B_3 on Link 3. Therefore, the acceleration of Point B_2 and Point B_3 is equal. Thus, the acceleration of Points B_2, B_3, and C on Link 3 can be expressed as:

$$a_{B_2} = a_{B_3} = a_C + \alpha_3 \text{ x } r_{CB} - \omega_3^2 r_{CB} \tag{2}$$

where $a_{B_2}, a_{B_3}\ a_c, r_{CB},\ \alpha_3$ and ω_3 denote the velocity of Point B_2 on Link 2, the velocity of Point B_3 on Link 3, the acceleration of Joint *C*, the position vector of [CB], angular acceleration of the Link 3 and the angular velocity of the Link 3 respectively. In Eqn. (2), a_C is zero because Point *C* is fixed. After simplification, Eqn. (2) is transformed into:

$$a_{B_2} = a_{B_3} = \alpha_3 \text{ x } r_{CB} - \omega_3^2 r_{CB} \tag{3}$$

The acceleration of Point B_2 on Link 2 is calculated in terms of the acceleration of Point B_1 on Link 1:

$$a_{B_2} = a_{B_1} + a_{B_2B_1}^{rel} + a_{B_2B_1}^{cor} = a_{B_1} + a_{B_{21}} + a_{B_{21}}^{cor} \tag{4}$$

where $a_{B_2B_1}^{rel}, a_{B_2B_1}^{cor}$ and $a_{B_{21}}$ represent to the relative acceleration of B_2 with respect to B_1 on the Link 1, the Coriolis acceleration of B_2 relative to B_1 and the relative acceleration of B_2 with respect to B_1 on Link 1. In Eqn. (4), $a_{B_2B_1}^{rel} = a_{B_{21}}$ and this relative acceleration is parallel to the sliding direction [AB]. The Coriolis acceleration of B_2 relative to B_1 is:

$$a_{B_{21}}^{cor} = 2\omega_1 \text{ x } V_{B_{21}} \tag{5}$$

where $V_{B_{21}}$ denotes the relative velocity of B_2 with respect to B_1 on Link 1, ω_1 represents the angular velocity of Link 1 and $a_{B_{21}}^{cor}$ represents the Coriolis acceleration of B_2 relative to B_1. The relative angular acceleration of Link 2 with respect to Link 3 is defined as:

$$\alpha_{23} = \alpha_2 - \alpha_3 \tag{6}$$

where α_{23}, α_2 and α_3 are the angular relative acceleration of Link 2 with respect to Link 3, the angular acceleration of Link 2, and the angular acceleration of Link 3, respectively, and additionally, $\alpha_2 = \alpha_1 = 0$.

Different values of the constant speed (*n*) for the driven link (Link 1) are used to determine the variables $a_{B_1}, V_{B_{21}}, a_{B_3}$ and α_3 when the angle of Link 1 is 60 degrees ($\phi = 60$ deg.) A total of 50 different values of *n* are determined, and based on these values, the equations presented in this study are utilized to determine $a_{B_1}, a_{B_{21}}, a_{B_3}$ and α_3. Thus, input and output data sets are generated for training, validation, and testing of the neural network algorithm.

IV. Neural Network Analysis Approach for Acceleration Analysis

In this study, a two-layer feed-forward artificial neural network algorithm structure is designed. The SCG backpropagation algorithm is selected for its efficient convergence, adaptive learning rate, and memory efficiency. Figure 3 illustrates the structure of the neural network algorithm for the stages of training, validation, and testing. In Fig. 3, *w* and *b* denote the weights and bias of the algorithm, respectively. Additionally, Fig. 3 shows one input and four outputs.

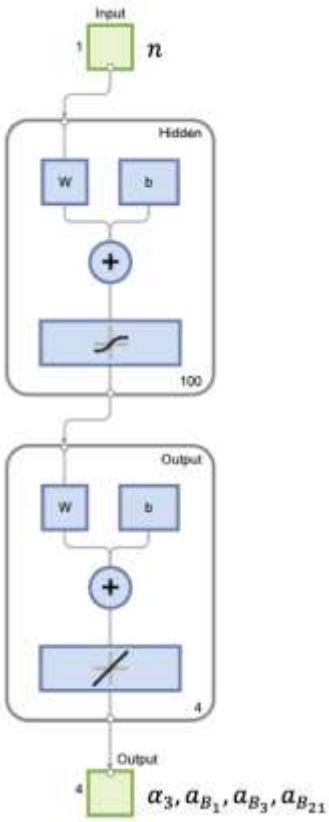

Fig. 3. Feedforward neural network supervised learning algorithm structure

In this study, there is only a single input, which is the velocity of the driven link (n), and there are a total of four outputs: The angular acceleration of Link 3 (α_3), the acceleration of Point B_1 on Link 1 (a_{B_1}) the acceleration of Point B_3 on Link 3 (a_{B_3}) and the relative acceleration of Point B_2 with respect to B_1 on Link 1 $\left(a_{B_{21}}\right)$. The acceleration of Point C on Link 3 (a_C) is zero. Additionally, the angular acceleration of Link 1 (α_1) and Link 2 (α_2) are zero because they have constant velocity.

A hidden layer comprising a total of 100 neurons is utilized. The sigmoid activation function is employed in the hidden layer, while the output layer features the linear activation function. A set of 50 data sets is determined and randomly divided as follows: 70% for training (34 data sets), 15% for validation (8 data sets), and 15% for testing (8 data sets) of the algorithm. The MATLAB Neural Network Fitting App is employed for the process of training, validation, and testing the algorithm.

V. RESULTS

Table 1 displays the training progress of the SCG backpropagation algorithm. Initial and target values of the units are determined by MATLAB. As shown in Table 1, training was halted upon meeting validation criteria after 16 epochs. Table 1 illustrates that the algorithm performs quickly, as indicated by zero elapsed time, and the final values of algorithm performance and gradient closely match their target values.

Table 1. SCG algorithm training progress

Unit	Initial Value	Stopped value	Target value
Epoch	0	16	1000
Elapsed Time	---	00:00:00	---
Performance	372	3.07	0
Gradient	1.48e+03	13.5	1e-06
Validation Checks	0	6	6

Table 2. SCG algorithm training results

	Observations	MSE	R
Training	34	12.9893	0.9538
Validation	8	111.2249	0.6544
Test	8	194.9061	0.5794

Table 2 displays the number of data sets (observations), mean square error (MSE), and regression (R) values of the SCG algorithm. According to Table 2, a total of 34 data sets are allocated for training, 8 data sets for validation, and 8 data sets for testing. As seen in Table 2, training, validation and test regression values are 0.9538, 0.6544 and 0.5794 respectively. While training regression value is almost perfect, regression value for test is not good. Similarly, while MSE value is low for training, MSE value for test is high.

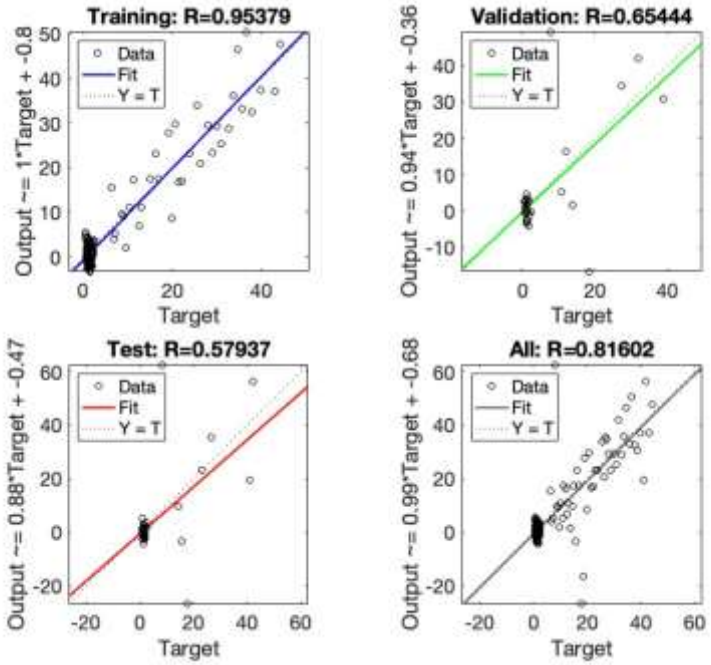

Fig. 4. Regression plots of the SCG algorithm

Figure 4 depicts regression plots of the SCG algorithm during the training, validation, and testing stages. According to Figure 4, the training data sets are not perfectly fitted but are sufficiently good. However, the validation and testing regression plots in Figure 4 are poorly fitted. The overall regression value is 0.81602, indicating that the data sets are adequately fitted.

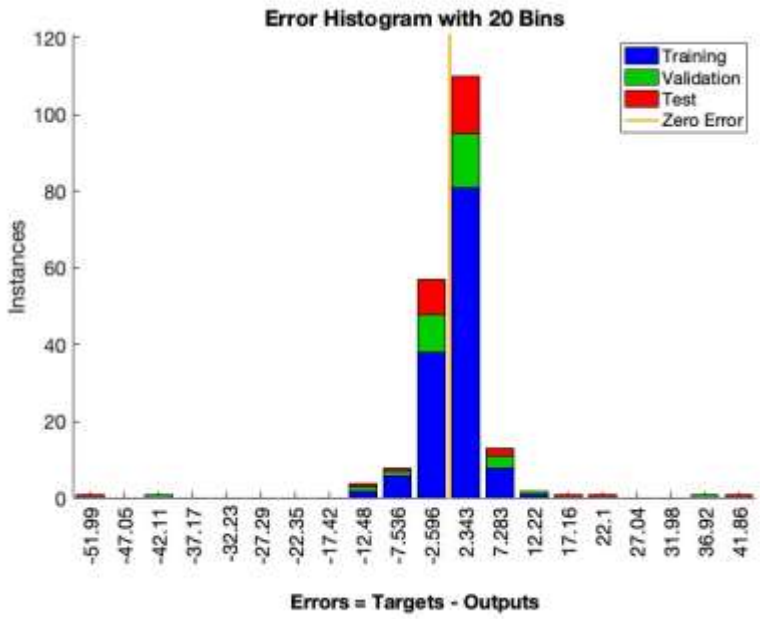

Fig. 5. Error histogram plot of the SCG algorithm

Figure 5 illustrates the error histogram graph of the SCG algorithm. As observed in Fig. 5, the zero-error value is centered around zero, and none of the data sets have a zero-error value. However, most error values of the data sets are near the zero-error value. According to Fig. 5, some data sets exhibit relatively large error values, such as 41.86, -51.99, or -42.11.

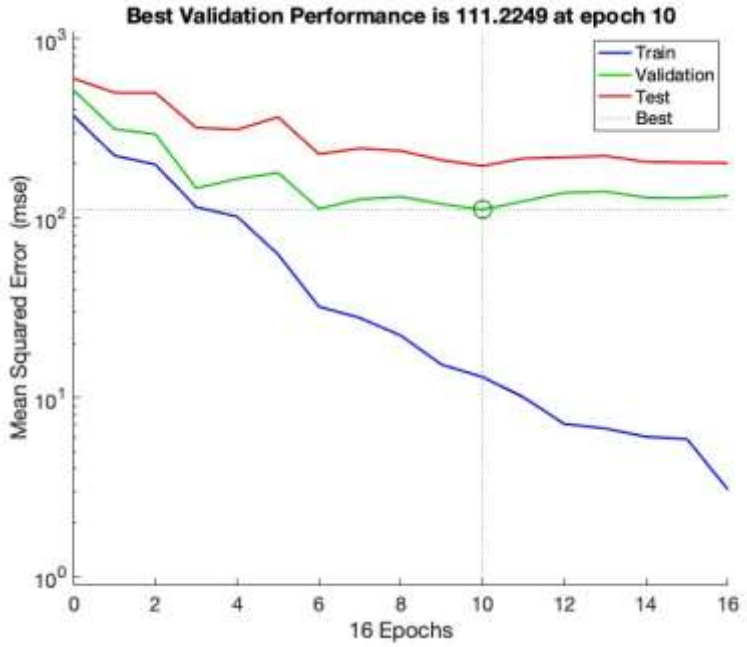

Fig. 6. The best validation plot of the SCG algorithm

According to Fig. 6, the best validation performance of the SCG algorithm is 111.2249 at epoch 10. Figure 6 illustrates that the validation and test MSE values remain almost stable after epoch 10, while the train MSE value continues to decrease.

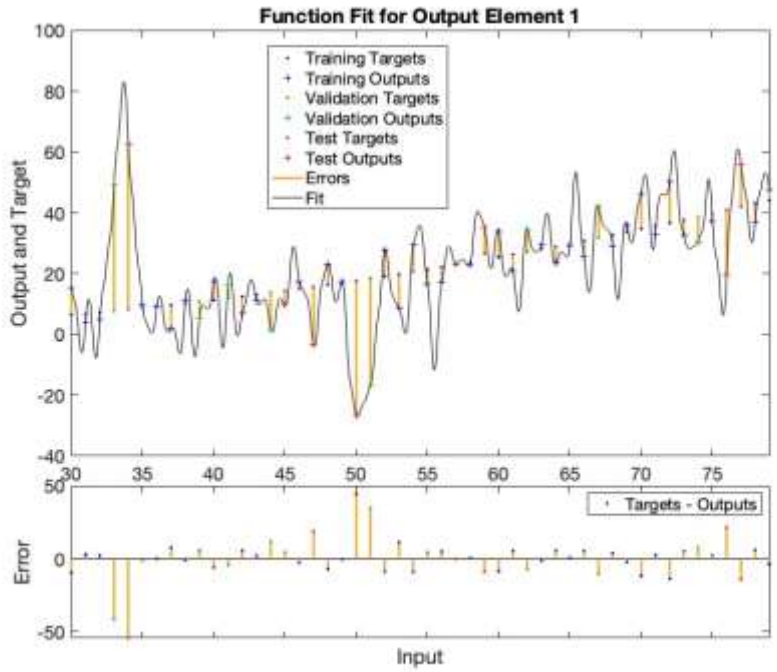

Fig. 7. Function fitting plot of the SCG algorithm

Figure 7 depicts function fitting plot and it shows input-output relationship of the SCG supervised learning algorithm. As seen in Fig. 7, error values between output and target values are low and function curve is fitted accordingly.

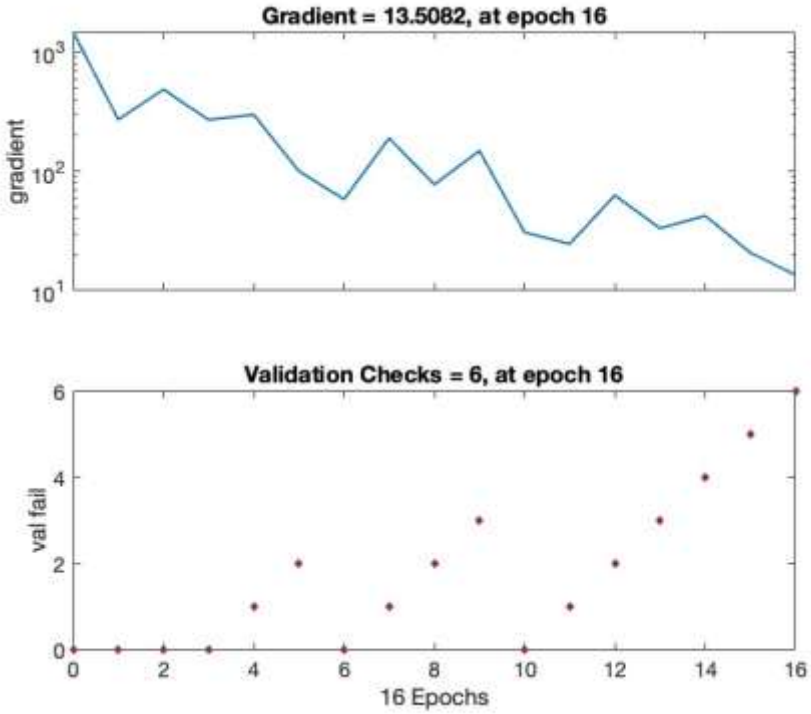

Fig. 8. Training state plots of the SCG algorithm

Figure 8 shows training state plots of the SCG algorithm. In Fig. 8, gradient coefficients with respect to the number of epochs can be seen. As seen in Fig. 8, the lowest and final gradient coefficient is 13.5082 and it is at epoch 16 and the total number of epoch is 16.

VI. DISCUSSION

There are several artificial neural network algorithms available. In this study, the SCG supervised learning algorithm is applied to the dataset, but other neural network algorithms such as Bayesian regularization or Levenberg-Marquardt algorithms could also be applied. Exploring different supervised learning algorithms could be a potential future research direction.

The quantity of the dataset is crucial for training, validation, and testing of neural network algorithms. More datasets are necessary for better algorithm training. However, an increase in datasets can lead to issues such as overfitting. In this study, a total of 50 datasets are used, but this number could be increased.

Furthermore, additional testing with different datasets may be required to assess the performance of the trained algorithm. In this study, additional testing was not conducted, but it represents another potential future direction for this research.

VII. CONCLUSION

In this study, acceleration analysis of the inverted slider-crank mechanism is conducted using an artificial neural network approach. The Scaled Conjugate Gradient (SCG) supervised learning algorithm is selected for the neural network solution approach due to its efficient convergence, adaptive learning rate, and memory efficiency. A total of 50 datasets are utilized for training, validation, and testing of the neural network algorithm. The results indicate that the SCG algorithm is suitable as a supervised learning algorithm for the neural network solution approach to acceleration analysis of inverted slider-crank mechanisms.

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An Ensemble Approach Using Optimized Machine Learning Algorithms for Predicting Video Game Sales Prediction

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Abstract – Artificial intelligence (AI) has become prevalent in almost every aspect of our lives due to its problem-solving capabilities and solutions that simplify human life. Rapid advancements in software and hardware have significantly accelerated this process. Developments in the video game industry with AI are particularly noteworthy. The increased detail in game graphics and AI characters has made the gaming experience more realistic. Additionally, it has become possible to offer more personalized experiences by analyzing player behavior. These advancements demonstrate the potential and impact of AI in the video game industry. Particularly, big data analytics and machine learning techniques play a crucial role in predicting video game sales and developing marketing strategies. This study leverages sales analysis of past games to predict future game sales using AI and regression problem-solving techniques. Using the Video Game Sales dataset, which consists of 11 classes, the dataset was individually trained with MLP, Elastic Net, and Bagging Regression techniques to solve regression problems. After training the techniques, an ensemble model was created to enhance prediction performance. Furthermore, Grid and Bayesian Search hyperparameter optimization was applied to ensure the models operate with the best parameters. To further elevate the performance of these hyperparameter-enhanced techniques, another ensemble model was constructed. This ensemble model was then used to predict video game sales for the next five years across four different regions.

Keywords –MLP, Elastic Net, Bagging Regressor, Machine Learning, Grid Search, Bayes Search, Ensemble Learning

I. INTRODUCTION

In recent years, the video game industry has been rapidly growing, with a continuous increase in global interest from gamers. The wide variety of games available caters to different age groups and interests, supporting personal development and positively impacting mental health. Specifically, genres such as educational games, strategy games, puzzle games, racing games, and sports games enable individuals to enhance their skills, improve problem-solving abilities, and learn while having fun.

The development lifecycle of a video game requires significant effort, time, and computer hardware. To properly manage the process from the game's storyline to the creation of graphics, it is crucial to accurately determine the game's genre and graphics. Therefore, analyzing the demand for existing games in the market is essential for planning the development of a new game.

In this study, determining the genre of the game to be developed is approached as a regression problem. Techniques used in regression problems can provide effective solutions for identifying and managing video game sales. Multilayer Perceptron (MLP), Elastic Net, and Bagging Regression methods were modeled to predict video game sales. The study utilized artificial intelligence to analyze video game sales and make future predictions. The performance results of the models are compared and presented.

II. Materials and Method

In this study, the Video Game Sales dataset, which contains 11 different classes (Rank, Name, Platform, Year, Genre, Publisher, NA_Sales, EU_Sales, JP_Sales, Other_Sales, Global_Sales), was used [1]. The dataset was created through crawling from the vgchartz.com website and includes information on games that have sold over 100,000 copies. For the prediction modeling, MLP, ElasticNet, and Bagging methods were utilized. The models were trained using the Video Game Sales dataset. Performance metrics of the models were examined, and various models were tested by implementing hyperparameter optimization and creating an ensemble model to improve model performance.

A. Multilayer Perceptron

The Multilayer Perceptron (MLP) is a type of artificial neural network commonly used in the field of deep learning [2]. Functionally, MLPs are employed to learn and model complex structures. They are often preferred for various machine learning tasks such as classification and regression problems. Artificial neural networks are inspired by the working principles of biological neurons and apply these principles in a mathematical modeling form. Artificial neural networks consist of layers such as the input layer, hidden layers, and output layer. An MLP is characterized by having multiple hidden layers within the artificial neural network. Each hidden layer may contain one or more hidden neurons. The input layer is the layer where data from the external world enters. Each input is connected to an artificial neuron. The hidden layers are where inputs are processed, and complex relationships are learned. Each artificial neuron in a hidden layer is connected to all neurons in the previous layer. The output layer is the layer that produces the final predictions or results. Each artificial neuron in the output layer typically represents a regression model. Multilayer perceptrons are usually trained on training data. Using the backpropagation algorithm, the parameters of the network are updated by reducing the error rate between the predictions made by the network and the actual results. Multilayer perceptrons have a wide range of applications. Some of these include natural language processing, image processing, regression, and classification problems. Moreover, the results they produce in these fields are highly successful [2,3].

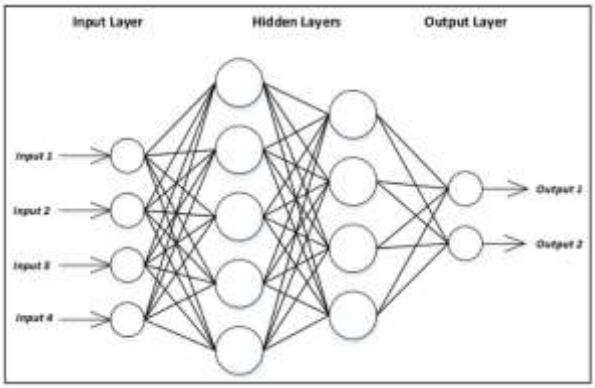


Fig. 1 MLP layer structure [3]

B. ElasticNet

ElasticNet is a regularization technique used in linear regression problems [4]. This technique can be considered a combination of Lasso (L1 norm) and Ridge (L2 norm) regression methods, by drawing a common feature from both [5]. By integrating the best properties of both methods, ElasticNet provides better performance, particularly in high-dimensional datasets and with correlated features. Lasso regression adds the sum of the absolute values of the coefficients as a regularization term. This can lead to some coefficients being exactly zero, effectively performing feature selection. Ridge regression, on the other hand, adds the sum of the squares of the coefficients as a regularization term [6]. This ensures that all coefficients are small but non-zero, which helps in addressing multicollinearity issues encountered with

large datasets. ElasticNet is a combination of regularization methods like Lasso and Ridge. The equation of the model can be expressed as follows:

$$\frac{\sum_{i=1}^{n}\left(y_i - x_i^J\hat{\beta}\right)^2}{2n} + \lambda\left(\frac{1-\alpha}{2}\sum_{j=1}^{m}\hat{\beta}_j^2 + \alpha\sum_{j=1}^{m}\left|\hat{\beta}_j\right|\right) \quad (1)$$

Here, λ1 and λ2 determine the weights of the L1 and L2 regularization terms, respectively. These two parameters need to be carefully tuned to optimize the flexibility and strength of the model. Some advantages of ElasticNet include by incorporating the L1 regularization term, it performs feature selection by shrinking some coefficients to zero. It also balances relationships within the data, creating more robust and reliable models. The regularization terms help reduce overfitting. Being a combination of two models, it has a more flexible structure. However, ElasticNet also has some disadvantages: improper tuning of the regularization parameters can increase model complexity. The computational cost can be high in high-dimensional datasets and feature spaces with many dimensions. ElasticNet is an indispensable tool for data scientists and analysts, facilitating the solution of various data analysis problems due to its broad applicability.

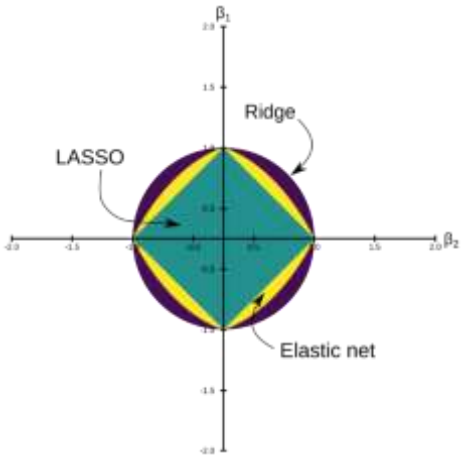


Fig. 2 Comparison of LASSO, Ridge, ElasticNet [7]

C. Bagging Regressor

Bagging Regressor (Bootstrap Aggregating) is a regression model that uses the bagging method, one of the ensembles learning techniques, for prediction [8]. The bagging method aims to create a stronger and more generalized model by combining various weak learners [9]. It is often used with models that have high flexibility, such as decision trees, to correct the overall errors of the model. Bagging is a combination of bootstrap and aggregating processes. Bootstrap refers to the creation of subsets by randomly selecting samples from the original dataset. These subsets can vary in size or be the same size as the original dataset, and data points included in each sample can be selected more than once. Aggregating is the process of combining the predictions of an ensemble model to produce the most accurate prediction. In this method, the final prediction is determined by averaging the predictions of each model. Some advantages of Bagging Regressor include it reduces the mean squared error of the model by decreasing the variance, resulting in more stable and reliable predictions. Using multiple models helps minimize the risk of overfitting, which would otherwise be a significant issue. Its suitability for parallel computation can reduce training time, leading to faster results. However, some disadvantages are training multiple models can take longer than training a single model, requiring more computational power. Interpreting the results can be challenging due to the combination of multiple models. Storing multiple models increases memory usage.

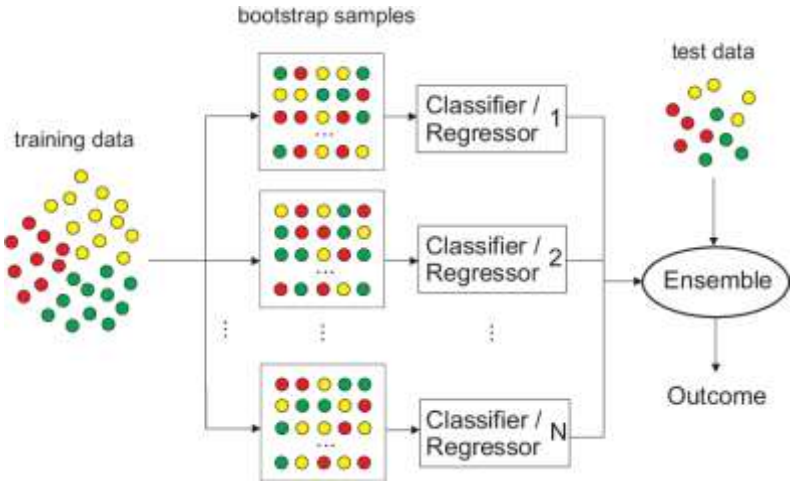


Fig. 3 Bagging Classification [9]

D. *Ensemble Learning Bayesian Hyperparameter Optimization*

Ensemble Learning is a machine learning technique that aims to create a stronger and more stable prediction or classification model by combining different weak learners [10]. Ensemble methods seek to enhance model performance by compensating for the weaknesses of individual models. This technique can significantly improve the accuracy and robustness of machine learning models. A weak learner is a simple model that, on its own, does not provide high accuracy but can enhance performance when combined within an ensemble. Decision trees are an example of such simple models. A strong learner is a model created using ensemble methods that provides high accuracy. It is achieved by combining weak learners. There are four types of ensemble methods: Bagging, Boosting, Stacking, and Voting. In this study, we used the bagging type to create the ensemble model. There are two types of Voting methods: Hard Voting and Soft Voting. Hard Voting is an ensemble method used in classification problems. In this method, the most accurate prediction is made based on the majority rule by looking at the class predictions made by each trained model. In other words, the class that receives the most votes is considered the most accurate prediction and is selected.

In Soft Voting, the class probabilities provided by each trained model are taken into account to make the most accurate prediction. This method sums the probabilities calculated by each trained model for a class and averages them to find the class with the highest average probability, which is then selected as the prediction [11].

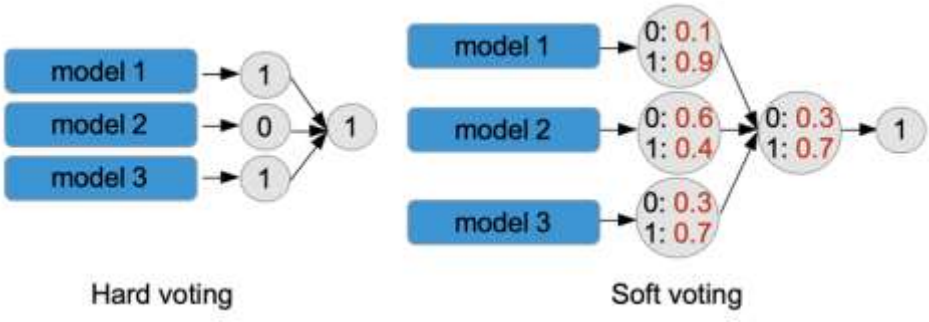


Fig. 4 Hard / Soft Voting Ensemble Model Formation [12]

E. Bayesian Hyperparameter Optimization

Bayesian hyperparameter optimization is an advanced method used to fine-tune the hyperparameters of machine learning models [13]. By offering a more intelligent approach than traditional methods such as Grid Search and Random Search, it not only proves to be more efficient but also operates faster compared to these methods. This leads to quicker results. This method uses a probabilistic model based on Bayes' theorem to predict the performance of the model. By efficiently searching the hyperparameter space, it aims to maximize the model's performance. In this study, Bayesian hyperparameter optimization was conducted to further enhance the performance of the ElasticNet and Bagging Regressor models.

Bayesian Hyperparameter Optimization models the hyperparameter selection process and makes decisions on which hyperparameters to test using statistical methods. Hyperparameters are the parameters that are set during the training of the model and affect the model's performance based on the given parameter settings. If the parameters are not well-chosen, the results obtained from the trained model will not be satisfactory. Therefore, it is important to provide appropriate ranges for the parameters. Examples of hyperparameters include the depth of a decision tree or the learning rate.

Bayes' theorem uses existing data to update the probability value of a hypothesis. In Bayesian optimization, this theorem is used to predict the performance of the given hyperparameters. The acquisition function in Bayesian optimization is a function used to select new sampling points. It selects hyperparameters that aim to enhance the model's performance in the best possible way by providing the most information.

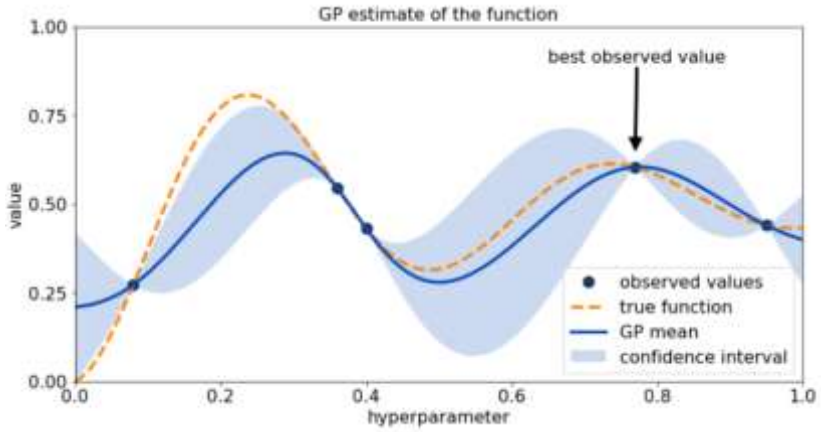


Fig. 5 Bayesian Hyperparameter Optimization Process [14]

F. Grid Hyperparameter Optimization

Grid Search Hyperparameter Optimization is a classic and widely used method to maximize the performance of machine learning models, particularly when their performance is suboptimal or average [15]. This method aims to find a specific combination of hyperparameters by exhaustively trying all possible combinations. Grid Search is based on the principle of testing all possible combinations of hyperparameters and computing the best outcome to determine the optimal results. In this project, Grid Search hyperparameter optimization was applied to improve the performance of the MLP model.

Grid Search divides the hyperparameter space into a grid by creating intervals for the hyperparameters. Each cell in the grid represents a unique combination of hyperparameters on which the model is trained and its performance is evaluated. The working principle of Grid Search is as follows: The parameters to be optimized and their potential values are determined based on the model. All possible combinations of the determined hyperparameter values are created, representing a grid. Each combination is used to train the model, and the performance of the model is evaluated on a validation set. This performance is typically measured using metrics such as F1 Score, MSE, R2 Score, MAE, and MAPE [16]. The model is then retrained with the best hyperparameter combination to achieve the highest performance.

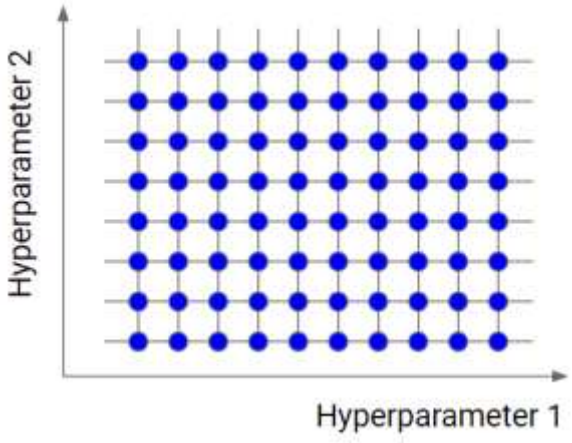


Fig. 6 Tabular Representation of Grid Search Hyperparameter [17]

G. *Performance Evaluation Metrics*

Mean Squared Error (MSE) is the average of the squares of the errors between the predicted and actual values in the dataset. The presence of outliers can cause the MSE value to be high.

$$MSE = \frac{1}{N}\sum_{i=1}^{N}(y_i - \hat{y}_i)^2$$

Mean Absolute Error (MAE) is the average of the absolute errors between the predicted and actual values in the dataset. The lower the MAE value, the better the performance of the model.

$$MAE = \frac{1}{N}\sum_{i=1}^{N}|y_i - \hat{y}_i|$$

Mean Absolute Percentage Error (MAPE) measures the average percentage error of the predictions in the dataset. This metric indicates how large the errors are in percentage terms.

$$MAPE = \frac{100\%}{N}\sum_{i=1}^{N}\left|\frac{y_i - \hat{y}_i}{y_i}\right|$$

R2 Score (R-Squared Score)

The R2 score is a measure of how well the model predicts new, unseen data. The R2 score ranges from 0 to 1, with 1 indicating a perfect model and 0 indicating a model that does not predict better than the mean of the target values. Negative values indicate that the model performs very poorly, even worse than the average prediction.

$$R^2 = 1 - \frac{\sum_i (y_i - \hat{y}i)^2}{\sum_i (y_i - \tilde{y})^2}$$

where y_i is the actual value, $\hat{y}_i$ s the predicted value, $\tilde{y}$ is the mean of the actual values and N is the total number of data points.

III. RESULTS

In this study, video game sales data were analyzed using MLP, ElasticNet, and Bagging Regression models, and future sales predictions were generated. Initially, the models were utilized in their basic forms, and an ensemble model was created using Voting Regressor based on the obtained results. To enhance model performance, hyperparameter optimization was conducted. Grid Search optimization was employed for MLP, while Bayesian Search optimization was used for ElasticNet and Bagging Regressor. After determining the optimal hyperparameters, an ensemble model was re-created with the improved models. The future sales predictions of the model were examined, and the performance metrics such as MSE, MAE, MAPE, and R2 Score were compared to evaluate the results.

The basic MLP model demonstrated an accuracy rate of 81.81% in predicting game sales. Examining this success rate and Figure 7, it can be observed that the model fits the dataset quite well. However, the predictions indicate that further improvements can be achieved by applying hyperparameter optimization to the model.

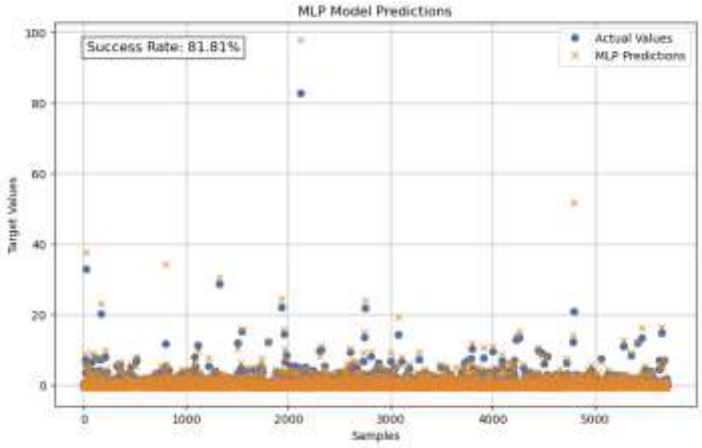


Fig 7. Game Sales Prediction Using Basic MLP Model

The basic ElasticNet model achieved a success rate of 75.35% in predicting game sales. Upon examining this rate and Figure 8, it is evident that the model can make predictions with a certain level of accuracy, but it exhibits lower performance compared to the MLP model. The flexibility in feature selection provided by ElasticNet suggests its potential usefulness in specific scenarios; however, it also indicates a need for further improvement in its current state.

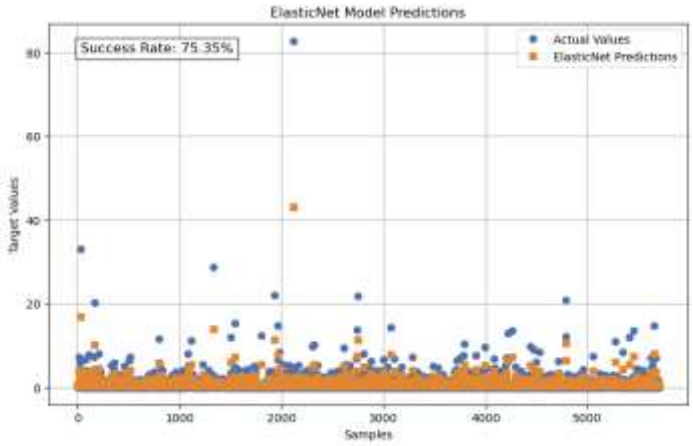


Fig 8. Game Sales Prediction Using Basic ElasticNet Model

The basic Bagging Regression technique achieved a success rate of 87.29% in predicting game sales. The aim of Bagging is to reduce the model's variance and enhance its generalization capability. This high success rate indicates that the Bagging Regression technique can make predictions with a high degree of accuracy and effectively reduce errors in predictions. This outcome demonstrates that the Bagging method fits the dataset well and performs significantly well compared to other models.

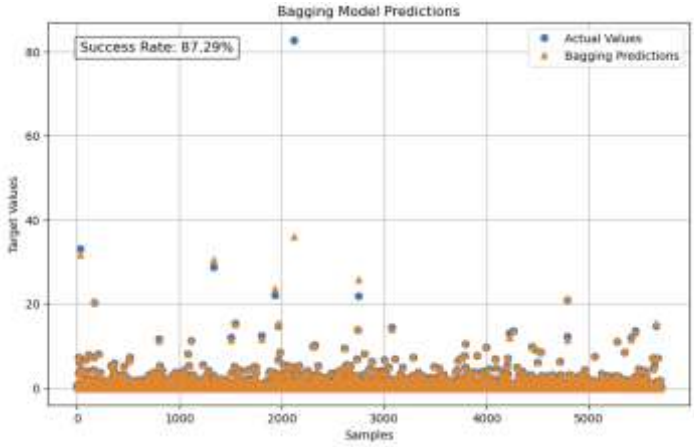


Fig 9. Game Sales Prediction Using Basic Bagging Regressor Model

The ensemble model was created by averaging predictions from three different models, and it achieved the highest performance with a success rate of 94.77%. This result indicates that creating an ensemble model outperforms using individual models in their basic forms and significantly enhances prediction accuracy.

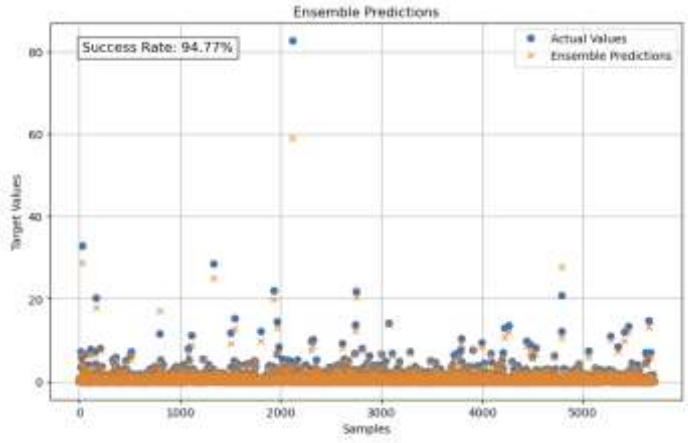


Fig 10. Game Sales Prediction Using Ensemble Model

The R2 scores graph compares the performances of three different models and the Ensemble model. As clearly seen in the graph, the Ensemble model's R2 score is higher compared to the other models. This indicates that the Ensemble model has a higher level of explanatory power and performs better in predictions compared to the other models.

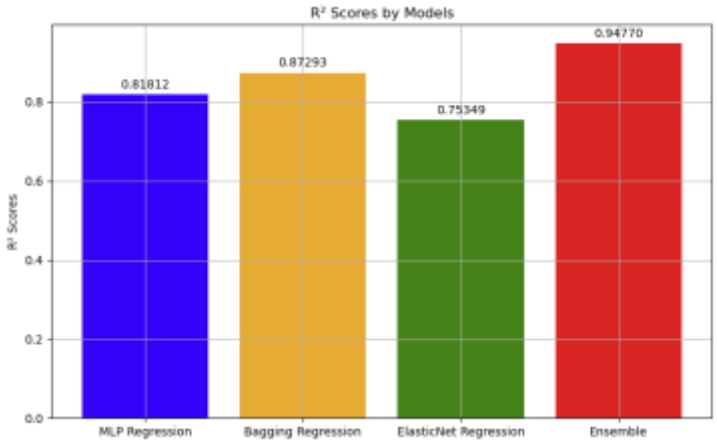


Fig 11. R^2 Score Table of the Three Models Used and the Ensemble Model

In the predictions of future game sales, a comparison was made among three different techniques: MLP, ElasticNet, and Bagging Regression. In this comparison, it is observed that the Bagging Regression model can make more consistent and accurate predictions compared to the other models. While the MLP model also performs quite well, the predictions of the ElasticNet model exhibit a relatively lower level of accuracy. These results indicate that the Bagging Regression model is a more reliable option for forecasting future game sales.

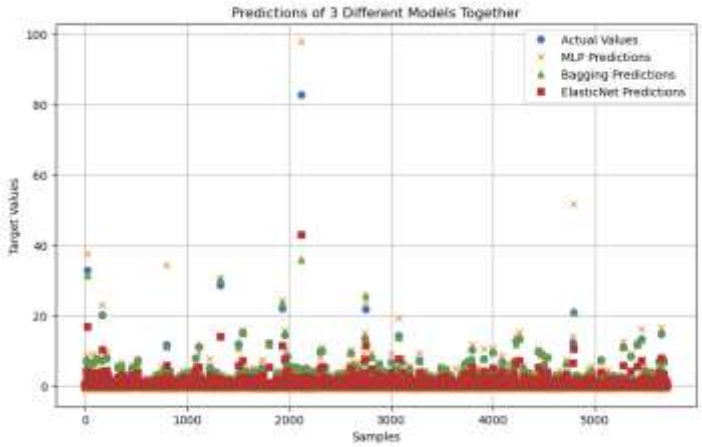


Fig 12. Combined Game Sales Predictions of the Three Models Used

Table 1. Metric Performances of Untuned Techniques and Ensemble Model

Method	**MSE**	**MAE**	**MAPE**	**R^2-SCORE**
MLP	0.55745	0.43405	6.34765	0.81812
ElasticNet	0.75552	0.30274	3.45502	0.75349
Bagging Regressor	0.38946	0.01193	0.00104	0.87293
Ensemble	0.16029	0.12604	1.12735	0.94770

Upon examining the performance metrics, it is observed that the best performance is achieved with the ensemble model. Hyperparameter optimization has been applied to the models to improve their performance.

The fine-tuned MLP technique achieved a success rate of 92.20% in predicting game sales after performing hyperparameter optimization using Grid Search. Upon examining this result and Figure 13, it

is evident that tuning the technique's hyperparameters significantly improves prediction accuracy and enhances its fit with the dataset.

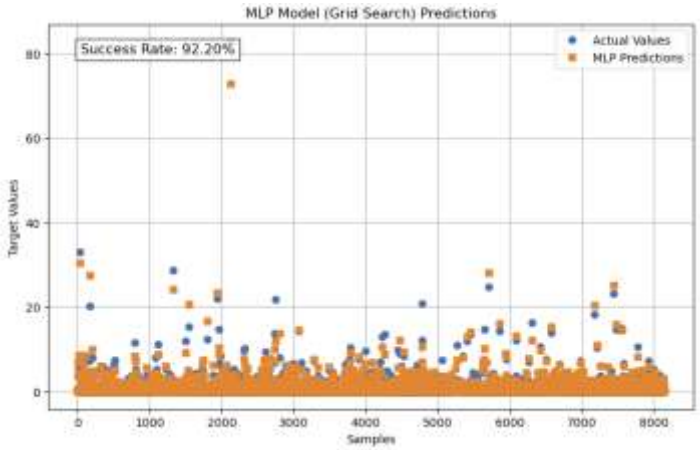


Fig 13. Game Sales Prediction of the Fine-Tuned MLP Model with Hyperparameters

After performing hyperparameter optimization, the ElasticNet technique has achieved a significant improvement with a success rate of 96.88% in predicting game sales. This indicates that the technique can capture more complex relationships and make more accurate predictions, resulting in a substantial increase in overall prediction performance.

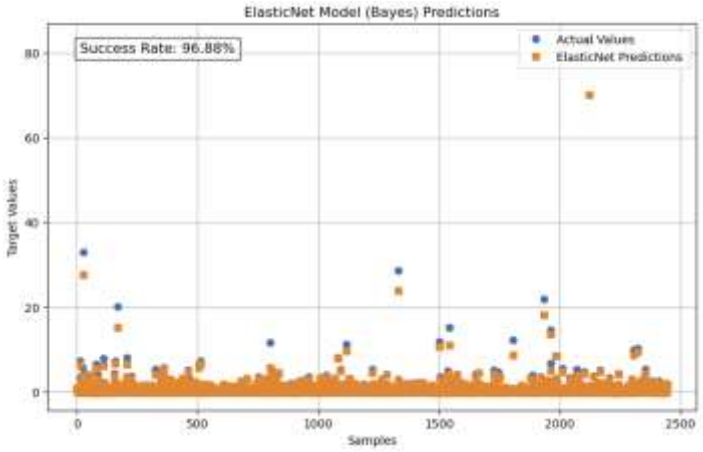


Fig 14. Game Sales Prediction of the Fine-Tuned ElasticNet Model with Hyperparameters

With the added hyperparameters, the Bagging Regression technique achieved a success rate of 91.40% in predicting game sales. This indicates that the Bagging technique obtained higher accuracy and significant improvement in its predictions as a result of extended hyperparameter tuning.

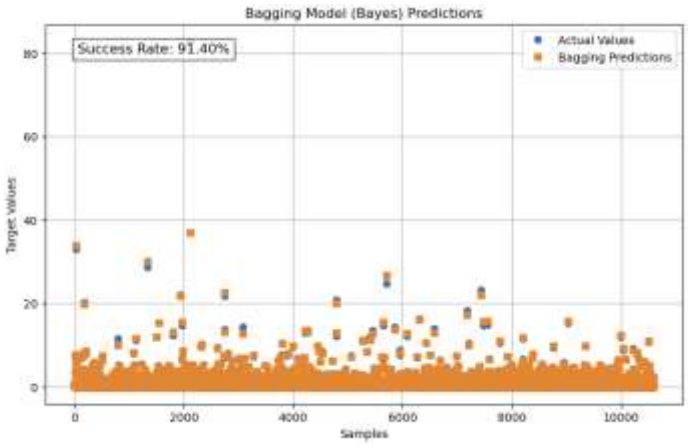


Fig 15. Game Sales Prediction of the Fine-Tuned Bagging Regressor Model with Hyperparameters

After hyperparameter optimization of the three models, the Ensemble model achieved an exceptional success rate of 98.14% in predicting game sales. This high success rate demonstrates that the Ensemble method enhances accuracy and reliability in predictions by leveraging different model combinations. The Ensemble model proves to be a reliable and highly effective option for forecasting future game sales.

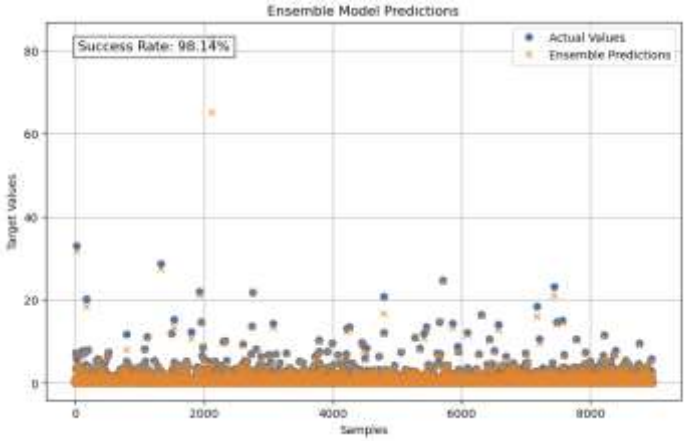
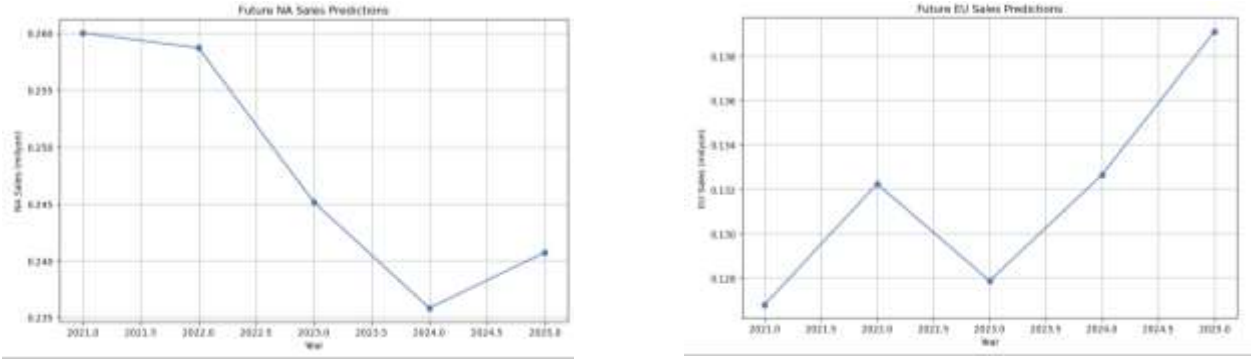


Fig 16. Game Sales Prediction of the Ensemble Model Created with Fine-Tuned Models

Table 2. Hiperparametre Eklendikten Sonraki Tekniklerin ve Ensemble Modelin Metrik Performansları

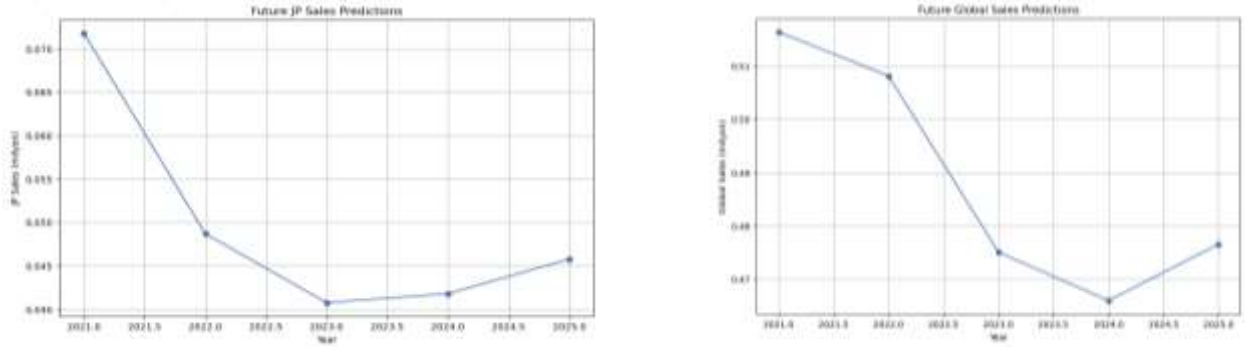
Method	**MSE**	**MAE**	**MAPE**	**R^2-SCORE**
MLP	0.21004	0.19176	1.13833	0.92200
ElasticNet	0.15777	0.11292	0.98254	0.96885
Baggin Regressor	0.20030	0.01255	0.01985	0.91401
Ensemble	0.04748	0.04627	0.35397	0.98137

A Ensemble model was created using models that were enhanced using Grid and Bayes Search optimization algorithms to predict game sales for the NA region, EU region, JP region, and Global market over the next 5 years. Changes in predictions may indicate whether sales in these regions will increase or decrease over time. However, these predictions are based solely on current data, so actual future sales may vary. Therefore, caution is advised regarding the reliability of these predictions. Improving the accuracy of predictions may require additional data and analysis. The visual representation of these predictions is provided below.



(a) *(b)*

Fig 17. Game Sales Prediction by the Ensemble Model (a) NA Region (b) EU Region



(a) *(b)*

Fig 18. Game Sales Prediction by the Ensemble Model (a) JP Region (b) Global

IV. CONCLUSION

In this study, video game sales were approached as a regression problem, and predictive models for future sales were developed. Upon examining the developed models, it is evident that applying hyperparameter optimization significantly improved the model results. Various techniques such as MLP, ElasticNet, and Bagging Regressor underwent training processes and their hyperparameters were optimized using Bayes and Grid Search optimization algorithms. During the model development process, preprocessing steps were applied to make the dataset suitable for prediction tasks.

The ensemble model obtained through the use of Bayes and Grid Search optimization algorithms demonstrated higher accuracy in predicting future video game sales performance compared to other techniques. The predictions obtained using the ensemble model yielded reliable results in tests conducted on different scenarios. Furthermore, it was observed that hyperparameter optimization with Bayes and Grid Search algorithms enhanced the performance of the techniques used and led to more reliable results in future predictions.

This study emphasizes the importance of data analytics and artificial intelligence technologies in the video game industry. Future research aims to further enhance model performance by utilizing larger datasets, applying more complex feature engineering techniques, and exploring different machine learning algorithms. This study contributes to improving data-driven decision-making processes in the video game industry and serves as inspiration for future research. Additionally, the study presents 5-year forecast results obtained from the model, providing insights for firms.

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Development of a Wireless Firefighting Robot with Obstacle Avoidance and Fire Extinguishing Modes

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Abstract **–**This study introduces a multifunctional fire extinguishing robot with wireless communication capabilities designed for both firefighting and obstacle avoidance. Utilizing an Arduino UNO as the microcontroller, the robot is equipped with a suite of sensors including flame sensors, a gas sensor, a DHT22 temperature and humidity sensor, an ultrasonic sensor, and a water level sensor. These sensors enable the robot to detect fire, navigate around obstacles, and monitor environmental conditions. The system also features a water tank with a nozzle controlled by a servo motor to direct water towards detected flames. The robot communicates wirelessly with a control unit via XBee modules, allowing remote monitoring and mode switching between firefighting and obstacle avoidance. The control unit displays real-time data on an LCD and provides user interface options for selecting operational modes. This design was simulated using the Proteus software, validating the robot's ability to autonomously manage fire incidents and navigate through complex environments. The study demonstrates the potential of integrating multiple sensors and wireless communication in developing autonomous firefighting robots capable of enhancing safety and efficiency in fire response scenarios.

Keywords –Extinguishing robot, Wireless control, Arduino UNO, XBee communication, Obstacle avoidance, Sensor integration

I. INTRODUCTION

Arduino and Raspberry Pi platforms can be used effectively in a variety of applications such as smart gloves for sign language, smart wheelchairs for the elderly and disabled, Braille translators for the visually impaired, water quality measurement and weather monitoring [1]–[8]. To emphasize the potential and flexibility of Arduino-based systems, this work addresses the development of an innovative vehicle with fire extinguishing and obstacle avoidance capabilities. This device is specifically designed for use in emergency response and hazardous environments. This vehicle aims to serve the needs of different segments of society in the areas of safety and accessibility.

Wu et al. designed and developed a firefighting robot that moves on tracks driven by DC motors. On top of the tank-like body of the robot is a fire arm carrying a sprayer [9]. The firearm can mimic the movements of a human upper arm and can rotate 360º. Cameras are placed in the center of the robot's body. The camera is mounted on the back of the fire arm and can rotate 360º and transmit images of the current situation back to the control station [10]. The firearm is equipped with a water gun that can spray water at very high pressure, which can extinguish the fire. The various parts of the robot are controlled by the STM32 controller. The entire robot is covered with a strong cover that protects the various parts from heat damage. SaravananP et al. designed and developed the Integrated Semi-Autonomous Fire Fighting Mobile robot that controls four D.C. motors powered by Atmega2560. The system has a navigation system consisting of

integrated ultrasonic sensors and infrared sensors [11]. A wireless camera mounted on the robot captures the video and transmits it to the base station. The fire detection system consists of an LDR and a temperature sensor. In case of fire, the fire sensor detects it and through appropriate control signals the robot can be moved to the source of the fire and then extinguished. The extinguishing system consists of a pump and a BLDC motor connected to the water tank [12]. The device can be operated manually for extreme conditions. It includes a GUI support from which the robot can be controlled from the base station. Prasojo et al. designed a robot that moves like an insect. The robot consists of three parts: i. A UV-Tron fire sensor that detects the presence of fire ii. A DC motor paired with a pump turned ON and OFF by a relay iii. Sixteen ultrasonic sensors mounted around the robot to detect and avoid any obstacles [13]. Fire detection is done by a combination of sensors controlled by a PIC microcontroller. Fire detection is based on inputs from flame sensors, temperature sensors and smoke sensors. Based on the input from these three sensors to the PIC microcontroller, the microcontroller detects the presence of fire and sends appropriate signals that activate the AT89S52 microcontroller, which in turn activates the relay that starts the motor. The motor sprays water or foam to extinguish the fire.

Jesus Garcia et al [14] proposed a method that uses a sensor array to detect obstacles. The IR sensor plays a dominant role in identifying objects. IR (Infrared) sensors detect when obstacles come between the sensor and the reference point, this distance decreases, thus indicating the presence of an obstacle. Miguel A. Olivares-Mendez and Luis Mejias [15] proposed a method for obstacle detection using an optimized fuzzy visual scanning system. It presents an optimized visual fuzzy scanning system for obstacle avoidance task using unmanned aerial vehicle. After obtaining the optimal controller through a series of real tests, tests were conducted with a quadcopter to evaluate the behavior of the controller with excellent results. The visual information of the quadrotor's front camera was used to complete this task. This image is processed externally, and the information is sent to the Fuzzy Logic controller, which sends commands to change the orientation of the aircraft. Another approach proposed by Rahul Sharma et al [16] uses Kalman filters. A Kalman filter is a set of mathematical equations that provide an efficient computational technique for estimating the states of a process by minimizing the mean of the squares. It produces an output with less noise compared to sensors and provides a much more accurate output. Surachai Panich and Nitin Afzulpurkar [17] proposed a navigation approach based on various factors such as sensing, mapping, localization, planning and control. Krishna R Dixit [18] proposed an approach for barrier detection using onboard cameras and reflective beacons.

Fire incidents present a critical challenge in safety management, necessitating the development of advanced autonomous systems capable of detecting and responding to fires promptly. This study details the design and implementation of a wireless-controlled fire extinguishing robot with multifunctional capabilities. The proposed system integrates numerous sensors and actuators to enable autonomous fire detection, suppression, and navigation around obstacles.

This study contributes to the field by combining robust sensor integration with reliable wireless communication using XBee modules. The robot's ability to switch between firefighting and obstacle avoidance modes provides flexibility in various emergency scenarios. By incorporating sensors like DHT22 and flame sensors, the system ensures real-time environmental monitoring, which is crucial for effective fire response.

II. Materials and Method

This study focuses on the design and implementation of a multifunctional firefighter that combines obstacle avoidance property. The system consists of two main components: the robot and the control unit. This section consists of five sub-headings: robot design, control unit, integration and functionality, software implementation and simulation environment. The following hardware components are used in this study:

Flame Sensor: A flame sensor is a device that detects the presence of a flame or fire, often used in safety systems to trigger alarms or fire suppression systems. It operates by sensing infrared radiation emitted by a flame, providing a rapid response to fire presence.

L298 Motor Driver: The L298 is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors. It's commonly used in robotics and automation for controlling the direction and speed of motors.

Gas Sensor: A gas sensor is a device that detects the presence of various gases within an environment, crucial for safety in industries where gas leaks can occur. These sensors can detect a wide range of gases and are used in applications like home safety and environmental monitoring.

Water Level Sensor: Water level sensors are used to measure the level of water in a container, tank, or other environments. They are essential for applications such as flood warning systems, water conservation efforts, and maintaining proper water levels in industrial processes.

DHT22 Sensor: The DHT22 is a digital sensor that measures ambient temperature and humidity. It uses a capacitive humidity sensor and a thermistor to provide accurate readings for environmental monitoring, often used in HVAC systems and weather stations.

Ultrasonic Sensor: Ultrasonic sensors measure distance by emitting ultrasonic waves and detecting the time it takes for the echo to return. They are widely used in robotics for obstacle avoidance and in automotive applications for parking assistance.

Arduino UNO: Arduino UNO is a microcontroller board based on the ATmega328P. It's a versatile board with digital and analog I/O pins, used for building a wide range of electronic projects and prototypes, from simple LED displays to complex robots.

XBee Module: XBee modules are RF devices that enable wireless communication between different electronic components or systems. They are commonly used in remote control systems, telemetry, and IoT applications for their ease of use and reliable connectivity.

A. Firefighting Robot

The core of the firefighting robot is based on the Arduino UNO (MCU A), which manages various sensors and actuators essential for autonomous operation. The robot is equipped with:

1. Sensors: Flame sensors are positioned at the front left, center, and right of the robot to detect fire. Gas sensor monitors the presence of combustible gases. DHT22 sensor: measures temperature and humidity in the environment. Ultrasonic sensor is used for distance measurement in obstacle avoidance mode. Water level sensor monitors the water level in the onboard tank.
2. Actuators: DC Motors and Motor Driver (L298) drive the robot's movement. Servo motor: controls the nozzle to direct water towards the fire. Water pump transfers water from the tank to the nozzle.
3. Wireless Communication: XBee Modules (XBee A and XBee B) facilitate wireless communication between the robot and the control unit, allowing for remote control and real-time data transmission.

The robot is powered by an onboard battery that supplies energy to all components. The integration of sensors and actuators enables the robot to operate in two distinct modes: obstacle avoidance and firefighting.

B. Control Unit

The control unit, managed by another Arduino UNO (MCU B), is designed to wirelessly receive data from the robot and send operational commands. The control unit features:

1. Display: I2C 20x4 LCD shows real-time data including temperature, humidity, water level, and operational mode.
2. User Interface: Button allows the user to switch between operational modes. LED Indicators display the current mode (red for firefighting, green for obstacle avoidance). Buzzer activates when the temperature exceeds a certain threshold, indicating a potential fire.

C. Integration and Functionality

The integration of sensors and wireless communication modules enables seamless data flow and command execution. The XBee modules ensure reliable communication between the robot and the control unit, facilitating real-time updates and control. The operational modes enhance the robot's versatility in emergency scenarios:

1. Fire Fighting Mode: Activated by detecting flames. The robot autonomously navigates towards the fire, directs the nozzle, and extinguishes the fire. And detects the hazardous gases at the same time.
2. Obstacle Avoidance Mode: The robot uses the ultrasonic sensor to navigate around obstacles, ensuring safe movement in complex environments.

D. Software Implementation

The software implementation involves programming the Arduino UNO microcontrollers to handle sensor data, execute control algorithms, and manage wireless communication. Figure 1 shows fire extinguishing robot and control unit algorithm flow.

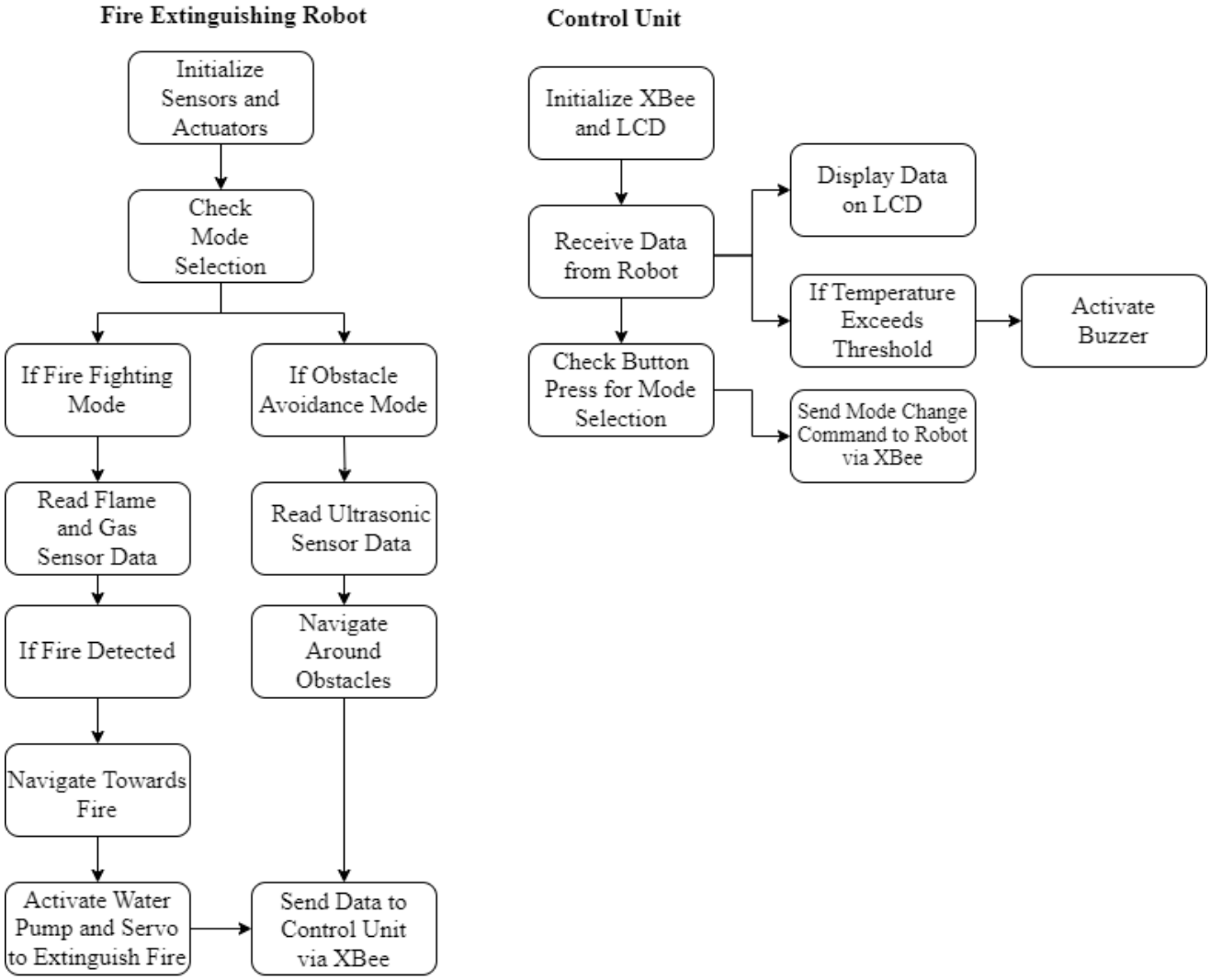

Fig. 1 Algorithm flow of fire extinguishing robot and control unit algorithm flow

E. Simulation Environment

The entire system was simulated using Proteus software, which provided a comprehensive environment for testing and validating the robot's functionalities. The simulation allowed for real-time analysis of sensor data, movement control, and wireless communication performance, ensuring the system's reliability and efficiency in managing fire incidents and navigating obstacles. Figure 2 and Figure 3 show fire extinguishing robot and control unit in simulation environment respectively.

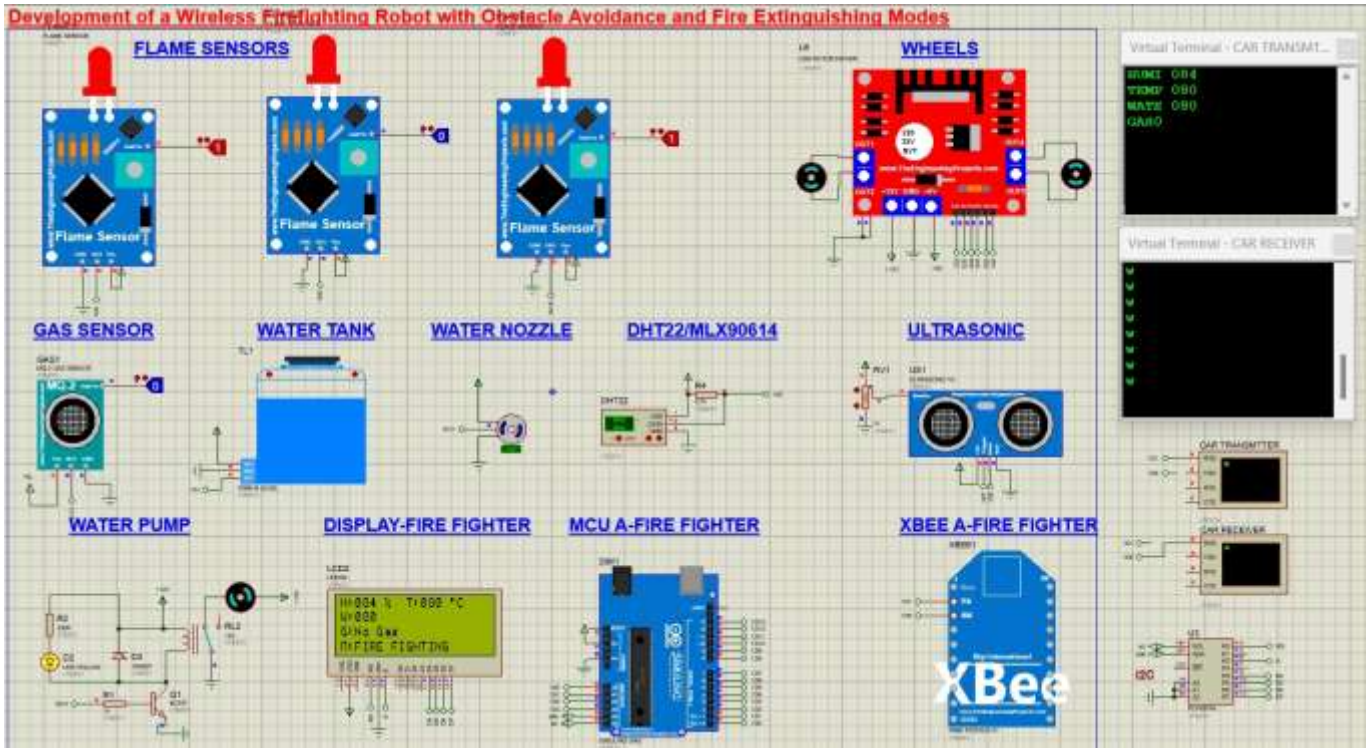

Fig. 2 Fire extinguishing robot in simulation environment

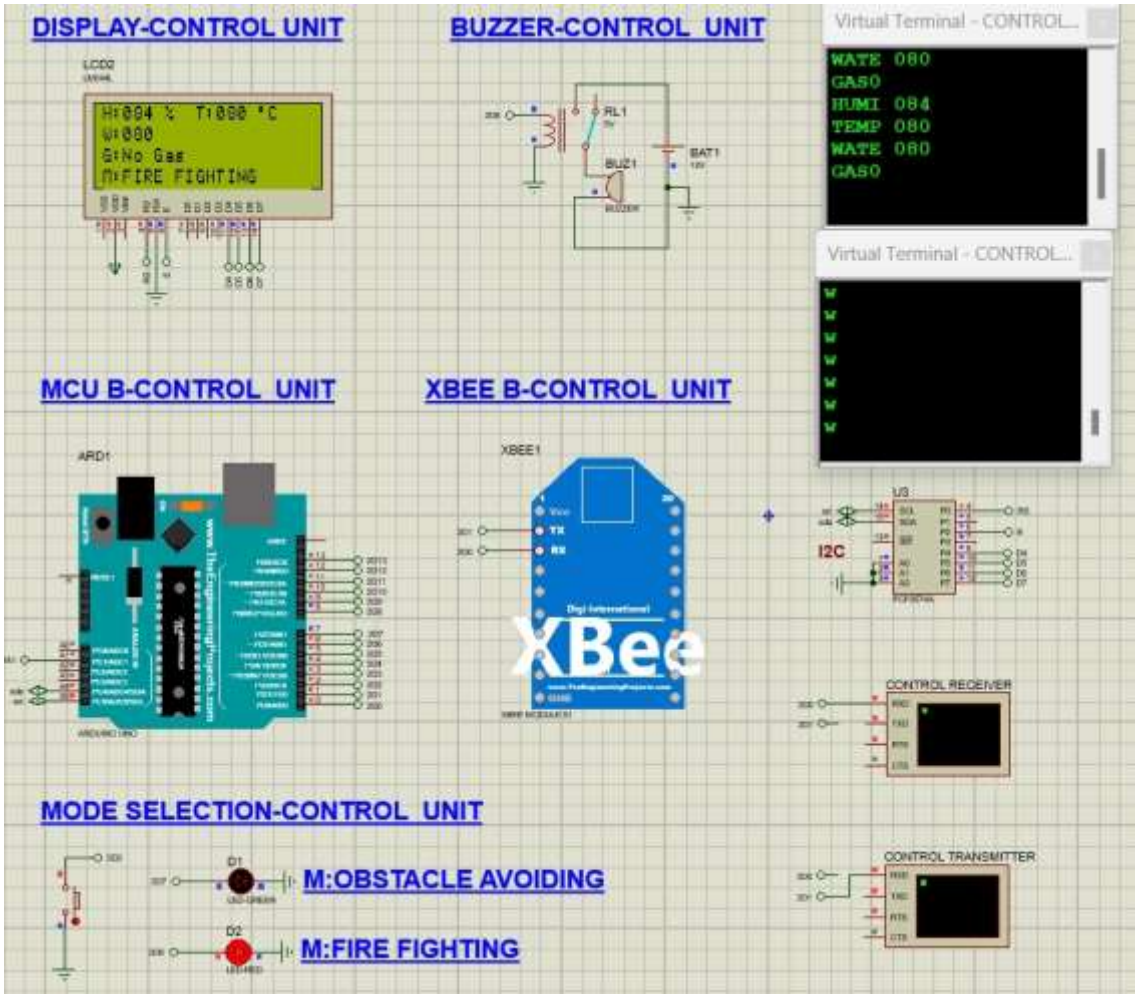

Fig. 3 Control unit in simulation environment

III. RESULTS

The simulation results confirmed the efficacy of the fire extinguishing robot in both firefighting and obstacle avoidance modes. Key findings include sensor accuracy and response, wireless communication reliability, operational mode performance, user interface functionality.

The flame sensors detected fire with high precision and promptly triggered the water pump and servo motor for extinguishing. Gas sensor accurately identified the presence of hazardous gases, prompting an immediate response from the control unit.

The XBee modules provided stable and reliable wireless communication between the robot and the control unit, with no significant delays or data loss observed during testing.

In firefighting mode, the robot successfully navigated towards detected flames and effectively activated the water pump and nozzle system. In obstacle avoidance mode, the robot demonstrated efficient navigation around obstacles, maintaining a safe distance based on ultrasonic sensor readings.

The control unit displayed real-time environmental data accurately on the LCD and allowed seamless mode switching via the button interface.

IV. DISCUSSION

The results underscore the potential of integrating advanced sensors and wireless communication technologies in developing autonomous fire extinguishing robots. Compared to prior studies, this system offers enhanced versatility through dual operational modes and real-time environmental monitoring. The use of XBee modules for wireless communication ensures robust and reliable data exchange, crucial for effective remote control and monitoring.

In the simulation, the DHT22 sensor was used instead of the MLX90614 due to library constraints. However, the MLX90614 could provide the advantage of remote temperature sensing, enhancing the robot's ability to detect and respond to fires from a distance. Future implementations could integrate the MLX90614 for improved thermal detection capabilities.

V. CONCLUSION

This kind of robot can be used in many different scenarios, especially thanks to its fire extinguishing and obstacle detection capabilities. For example, it can quickly detect and respond to fires in fire-hazardous areas, especially in places that are not easily accessible to humans or that could be dangerous. It can also be used for fire monitoring and response in large areas such as factories, warehouses or forest fires.

Thanks to obstacle detection, the robot can move safely even in complex environments and can detect and avoid potential obstacles. This makes it ideal for supporting emergency teams, scouting areas where hazardous materials are present or for use in search and rescue operations.

It can also be used for training and exercise purposes, providing a safe platform for teaching and practicing firefighting procedures. Furthermore, the data collected by the robot can provide valuable information to understand how fires spread and what the most effective response methods are.

Finally, the development and use of this robot can contribute to the development of future intelligent automation systems and emergency response technologies. Real-world applications provide valuable feedback that will lead to continuous improvement of the robot's design and functionality.

This study presents a comprehensive approach to developing a wireless-controlled fire extinguishing robot capable of autonomous operation in firefighting and obstacle avoidance modes. The integration of multiple sensors and actuators, coupled with reliable wireless communication via XBee modules, ensures the system's efficiency and versatility in managing fire incidents and navigating through obstacles. Future work will focus on enhancing the robot’s thermal detection capabilities and exploring additional operational modes to further improve its performance in real-world scenarios.

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Multifunctional Smart Glove: An Innovative Solution for Sign Language Interpretation and Wireless Wheelchair Control

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Abstract **–**This study presents a multifunctional smart assistive glove designed for recognizing sign language and controlling a wheelchair wirelessly. The glove integrates five flex sensors, an Arduino Uno, a 20x4 I2C LCD, an analog multiplexer, Bluetooth communication, and a button. When gloves are worn, flexible sensors detect finger movements and send signals to the Arduino through the multiplexer, which in turn routes these signals to a single analog input. The glove also uses potentiometers in place of an accelerometer for simulating tilts to control the wheelchair's movement. The LCD, connected via I2C to the Arduino, displays letters, words, or messages based on flex sensor data. Movement commands generated by the potentiometers are transmitted via Bluetooth to another Arduino on the wheelchair, which controls two DC motors through a motor driver. The glove's tilt determines the wheelchair's direction (forward, backward, left, or right), while keeping it parallel stops the motors. A button on the glove allows users to toggle between sign language and wheelchair control modes. Pressing the button sends a signal to activate a relay on the wheelchair's Arduino, powering the motor driver. This setup prevents interference between sign language and motion commands. Overall, this glove system demonstrates its versatility in a simulation environment and offers significant potential for customization to meet specific user needs in real-world applications.

Keywords –Smart assistive glove, Sign language recognition, Wheelchair control, Assistive technology, Disability support

I. INTRODUCTION

There are various auxiliary and measurement devices developed using the capabilities of Arduino and Raspberry Pi platforms. These include a smart glove that improves communication for individuals with disabilities by translating sign language into sound; a smart wheelchair offering improved mobility for the elderly and disabled; a Braille system that assists visually impaired individuals; smart water quality meter enabling environmental monitoring; a comprehensive weather station for accurate climate tracking; and a Raspberry Pi-based Braille reader that provides accessible reading for individuals with disabilities. Each project exemplifies the potential of smart technology to improve quality of life and accessibility for all [1]–[8].

In the realm of assistive technologies, devices that enhance the autonomy and communication capabilities of individuals with disabilities have become increasingly significant. This study introduces a multifunctional smart glove designed to aid in both sign language recognition and wireless wheelchair control. The innovation addresses critical needs for improved mobility and communication for individuals with disabilities, particularly those who rely on wheelchairs and use sign language as their primary mode of communication.

Traditional assistive devices often focus on singular functions such as mobility assistance or communication aids. However, combining multiple functionalities into a single device can significantly enhance user experience and efficiency. For example, sign language recognition technologies typically do not integrate with mobility solutions, leading to a fragmented user experience for individuals who require both.

In recent years, there has been significant progress in developing assistive technologies that enhance the mobility and communication abilities of individuals with disabilities. Various techniques and sensors are utilized in the development of electronic systems for sign language interpretation, such as flex sensors, metallic elements, and image processing. Gloves can be designed using flexible sensors to translate sign language into speech. This significantly reduces costs. Different combinations of flexible sensor values can be mapped to bits and then converted into short speech [9]. Flexible sensors can also be paired with accelerometers and gyroscopes to increase freedom of movement and extend the range of gestures. An additional advantage is to make these systems capable of translating sign language into languages other than just English [10], [11]. Such data gloves have wide-ranging potential uses in sectors like virtual reality, robotics, teleoperation, and biomechanics.

Smart gloves offer an innovative solution for wheelchair control and technological advances in this field have the potential to increase users' freedom of movement. Equipped with flexible sensors, these gloves detect the user's hand movements, allowing precise control of the direction and speed of the wheelchair. When combined with additional sensors such as accelerometers and gyroscopes, these systems can detect even more complex maneuvers [12]. Furthermore, the use of these smart gloves provides a more ergonomic and intuitive experience for wheelchair users [13]. Recent research shows that such devices can increase independence in daily life and improve users' quality of life [14], [15].

Building on these advances, this study introduces a smart glove that integrates sign language recognition and wireless wheelchair control in a single device. By combining flex sensors, potentiometers, and Bluetooth communication with an Arduino-based system, our approach not only recognizes sign language but also provides seamless control of a wheelchair, significantly enhancing the user’s autonomy and interaction capabilities. This integration aims to bridge the gap between communication and mobility support, offering a unified solution to improve the quality of life for individuals with disabilities.

To address this gap, we developed a smart glove equipped with various sensors and components that seamlessly integrate sign language recognition and wheelchair control. The glove utilizes five flex sensors to detect finger movements, an Arduino Uno microcontroller for processing, and an I2C-based 20x4 LCD for real-time feedback. A Bluetooth module facilitates wireless communication between the glove and the wheelchair, while an analog multiplexer manages the multiple sensor inputs efficiently.

The glove operates by capturing finger movements through flex sensors, which send analog signals to the Arduino via the multiplexer. Due to the limited number of analog inputs on the Arduino, the multiplexer allows sequential reading of multiple sensor inputs through a single analog pin. Additionally, potentiometers are used to simulate accelerometer data in a simulated environment, providing tilt information for controlling wheelchair movement. The glove’s tilt controls the direction of the wheelchair via Bluetooth, and a dedicated button enables users to switch between modes for sign language communication and wheelchair control.

The Arduino on the wheelchair receives the Bluetooth signals, which then control a motor driver connected to two DC motors, dictating the wheelchair's movements. A relay, activated by the glove’s button, manages the power supply to the motor driver, ensuring safe and precise control.

II. Materials and Method

This study focuses on the design and implementation of a multifunctional smart glove that combines sign language recognition and wireless wheelchair control. The system consists of two main components: the smart glove and the wheelchair interface. The glove is equipped with sensors and microcontroller to capture and interpret hand gestures, while the wheelchair interface receives commands via Bluetooth to control its

movements. This section details the hardware components and their integration, as well as the software logic used to achieve the desired functionalities.

The following hardware components are used in this study.

Analog Flex Sensor: Typically made of a flexible substrate with a conductive ink that changes resistance as the substrate is bent. Used in applications like gloves or surfaces where motion and position need to be tracked.

Arduino Uno: Has 14 digital input/output pins (6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button.

20x4 I2C LCD: The display has an LED backlight and can show text in various fonts and sizes. The I2C interface means you only need two connections (SDA and SCL) to send data, making it ideal for projects with many components.

CD74HC4067 Multiplexer: This chip can work with both analog and digital signals, and the signals can flow in both directions. It's controlled by four control inputs that determine which channel is connected to the output.

L298 Motor Driver: It can drive up to 2A per channel, has thermal shutdown protection, and can handle voltages from 5V to 35V. This driver is often used in robotics for precise control over motor speed and direction.

MPU6050: It is a Micro Electro-Mechanical Systems (MEMS) device that combines a 3-axis accelerometer and a 3-axis gyroscope. This sensor is capable of measuring acceleration, velocity, orientation, displacement, and other motion-related parameters of a system or object. It's widely used in various applications, including robotics, motion tracking, and interactive technology.

HC05 Bluetooth Module: Operates at frequencies between 2.402 GHz and 2.480 GHz and can be powered with 3.3V to 6V. It's perfect for serial communication and can be used as a master or slave module in Bluetooth connections.

These components are commonly used together in projects that require sensing, processing, displaying information, and controlling motors wirelessly.

A. Smart Glove

The glove is fitted with five flex sensors, each positioned along a finger. These sensors measure the bending degree of the fingers and produce corresponding analog voltage signals. An Arduino Uno microcontroller is used for processing the sensor inputs and controlling other components on the glove. Due to the limited number of analog inputs on the Arduino, an analog multiplexer is utilized to handle the five sensor signals efficiently. The glove is powered by a rechargeable battery, providing the necessary voltage to the Arduino and other components. The proposed multifunctional smart glove design is shown in Figure 1.

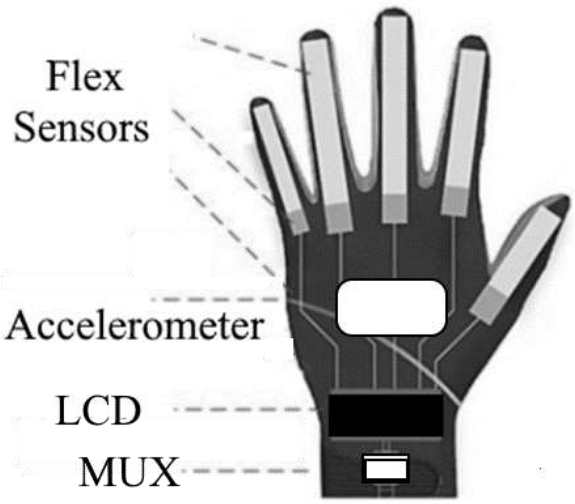

Fig. 1 Multifunctional smart glove design

The multiplexer sequentially channels the analog signals from the flex sensors into a single analog input on the Arduino (A0). It is controlled by four digital pins (D5, D6, D7, and D8) on the Arduino, allowing selection of the sensor signal to be read. In the absence of an accelerometer in the simulation environment, potentiometers are used to simulate the x and y tilt movements of the glove. These are connected to the Arduino's analog inputs (A1 and A2). The glove includes a 20x4 I2C LCD connected to the Arduino's SDA and SCL pins (A4 and A5). This display shows real-time feedback of the flex sensor data, including letters, words, or custom messages as per user input. A Bluetooth module transmits data wirelessly from the glove to the wheelchair's control system. This module interfaces with the Arduino via serial communication. A digital button connected to pin D2 of the Arduino is used to switch between sign language mode and wheelchair control mode. The button's state is monitored by the Arduino to activate or deactivate the wheelchair control functions.

B. Wheelchair Interface

A second Arduino Uno is mounted on the wheelchair to receive commands from the glove and control the movement of the wheelchair. This Arduino communicates with the glove's Bluetooth transmitter to receive directional commands for controlling the wheelchair. The motor driver is connected to two DC motors that drive the wheelchair. The driver receives control signals from the Arduino to adjust the speed and direction of the motors. A relay, controlled by pin D6 of the Arduino, provides or cuts off power to the motor driver based on the button state from the glove, ensuring safe operation. Two DC motors are connected to the motor driver to provide the necessary propulsion for the wheelchair. The wheelchair system is powered by a separate battery that supplies the necessary current to the motors and electronic components.

C. Integration and Functionality

The integration of these components enables the smart glove to perform dual functions, recognizing sign language and controlling the wheelchair.

Sign Language Recognition: The flex sensors detect the bending of the fingers and send analog signals to the Arduino. The multiplexer switches between the sensors, feeding their signals to the Arduino's A0 input. The Arduino processes these signals to determine the corresponding sign language gestures. The interpreted gestures are displayed on the LCD in the form of letters, words, or custom messages.

Wheelchair Control: The potentiometers simulate the glove's tilt in the x and y directions, providing analog input to the Arduino. The Arduino translates these inputs into directional commands and sends them via Bluetooth to the wheelchair's Arduino. The wheelchair's Arduino receives the commands and adjusts the motor driver's signals to control the DC motors. Based on the glove's tilt, the wheelchair moves forward, backward, left, or right. When the glove is held parallel to the ground, the motors stop. The button on the glove toggles the relay, which manages the power supply to the motor driver, enabling or disabling wheelchair movement as needed.

D. Software Implementation

The Arduino microcontrollers are programmed using the Arduino IDE with custom code to handle sensor readings, data processing, and communication. The primary tasks include sensor data acquisition, multiplexer control, signal processing, Bluetooth communication, LCD display management and motor control logic.

Analog inputs from the flex sensors and potentiometers are read and converted into digital values. Digital pins control the multiplexer to cycle through the flex sensor inputs. The acquired data is processed to interpret sign language gestures and tilt movements. Serial communication protocols are used to transmit and receive data between the glove and the wheelchair interface. I2C communication is used to update the LCD with real-time information. The received commands are converted into appropriate signals for the motor driver to control the wheelchair's movements. The software architecture ensures smooth and reliable operation of both sign language recognition and wheelchair control, enhancing the user's ability to communicate and navigate effectively.

The flowchart explains the sign language recognition and wheelchair control functions of the glove and the mode switching process using buttons. Figure 2 shows a flowchart showing the steps of the smart glove process.

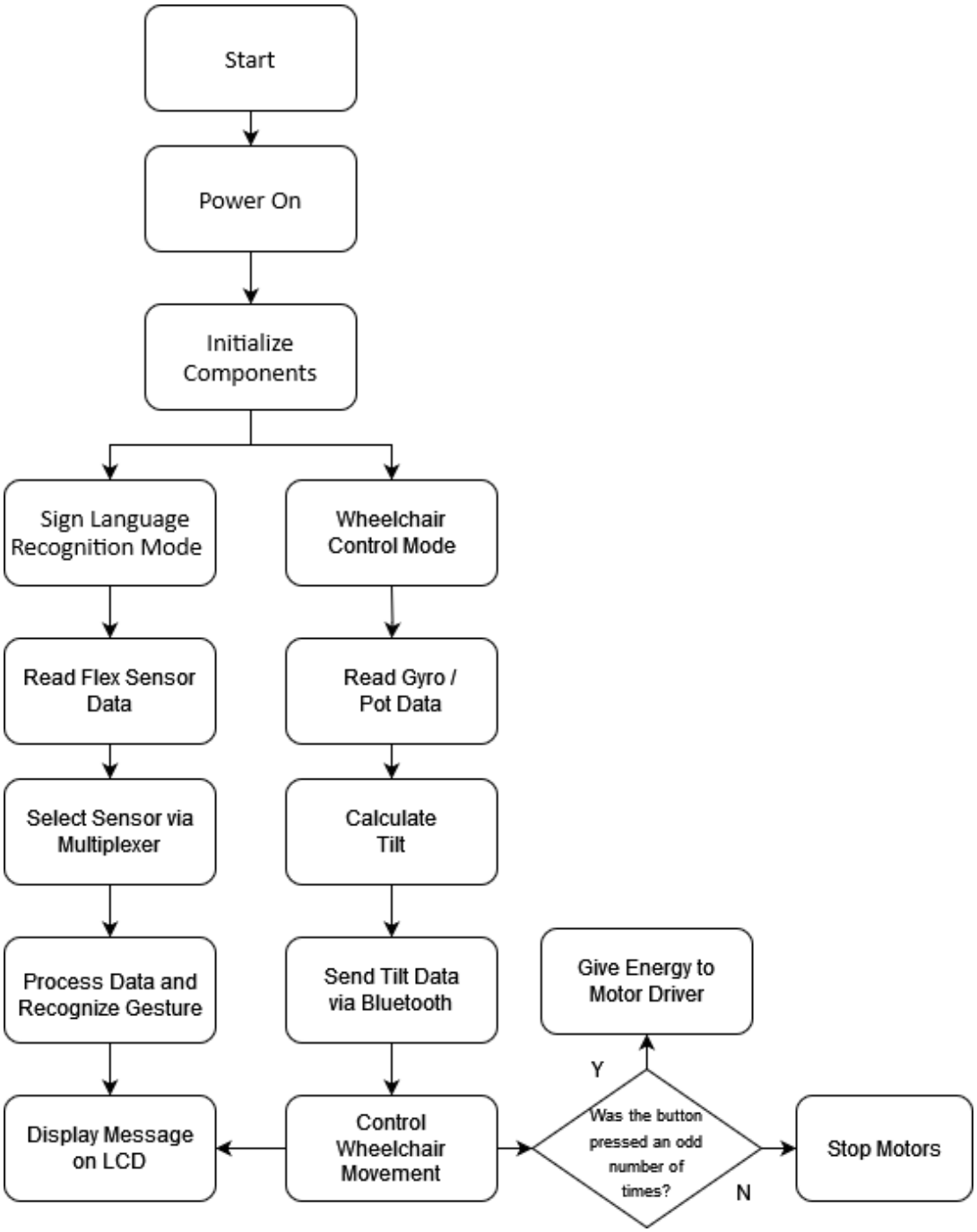

Fig. 2 Flowchart showing the steps of the smart glove operation

E. Simulation Environment

Due to the absence of accelerometer library in simulation environment, potentiometers were used to simulate the glove's tilt for the purpose of controlling the wheelchair. This allowed for accurate testing and validation of the system's functionality in a controlled environment. The simulation setup effectively mimics real-world scenarios and provides a robust platform for further development and customization of the glove system for practical applications. Figure 3 shows the total circuit diagram of the smart glove system.

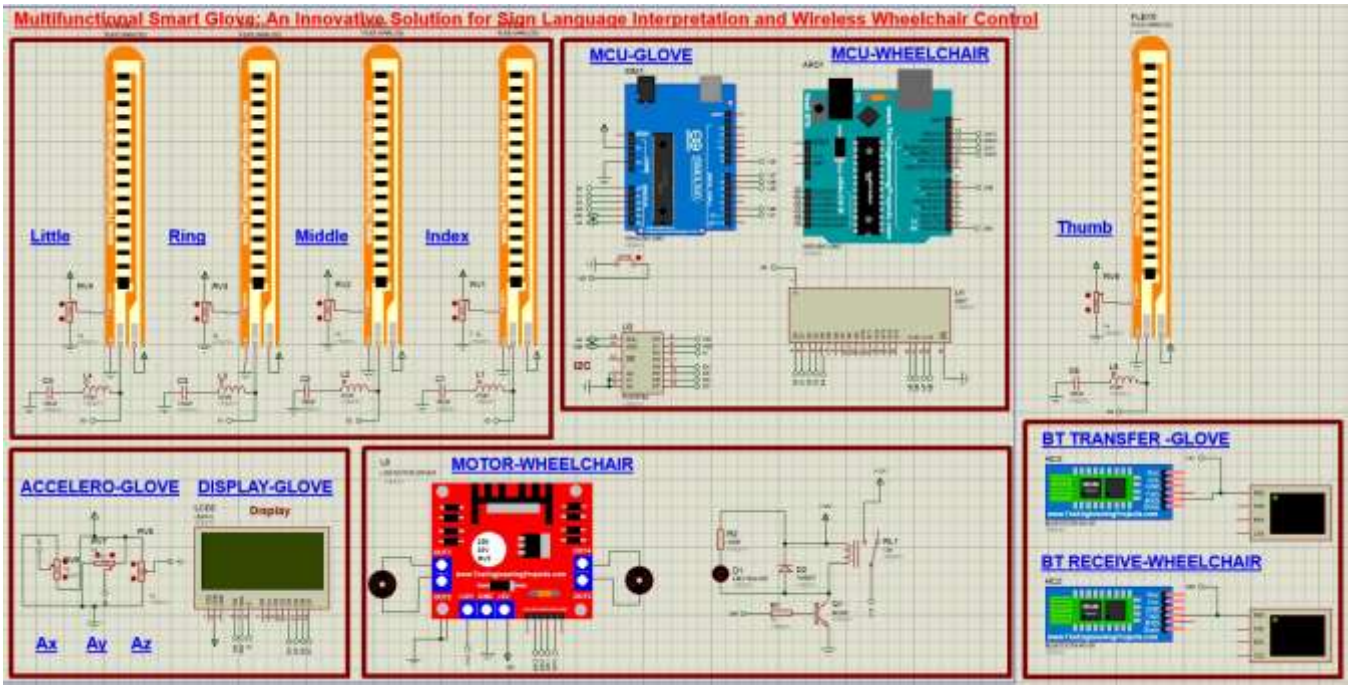

Fig. 3 Total circuit diagram of the smart glove system.

III. RESULTS

The multifunctional smart assistive glove was tested extensively for its ability to recognize sign language. The flex sensors, integrated along each finger, effectively detected the bending movements and transmitted accurate signals to the Arduino Uno via the analog multiplexer. Each flex sensor's response was analyzed under various finger positions. The flex sensors accurately detect finger bends at various angles.

The 20x4 I2C LCD effectively displayed the interpreted gestures in real-time. Custom messages were correctly formed based on the flex sensor input, enhancing the user's ability to communicate through sign language.

The button functionality for switching between sign language recognition and wheelchair control was smooth.

The glove's ability to control a wheelchair wirelessly was evaluated using potentiometers as a substitute for gyroscopic data. This setup aimed to simulate real-world use where the glove’s tilt would control the wheelchair's movements. The potentiometers provided smooth and responsive tilt data to the Arduino. The system translated these inputs into directional commands (forward, backward, left, right) with high precision. In the simulation, the wheelchair successfully responded to tilt commands. The movements were fluid and corresponded accurately to the glove's tilt.

The Bluetooth transmitter on the glove maintained a stable connection with the receiver on the wheelchair. Commands sent from the glove to the wheelchair were executed promptly, ensuring that the wheelchair's movements were synchronized with the user's gestures.

The relay mechanism effectively controlled the motor driver's power. Activation and deactivation of the wheelchair's motion were immediate upon pressing the button, enhancing safety by preventing unintended movements.

The motors stopped instantaneously when the glove was held parallel to the ground, demonstrating the system's ability to halt movement reliably.

IV. DISCUSSION

The results highlight the smart glove's effectiveness in both recognizing sign language and controlling a wheelchair, showcasing its potential as a versatile assistive device. Unlike traditional assistive devices that

focus on a single functionality, the smart glove successfully integrates two critical functionalities—communication and mobility.

The use of an analog multiplexer to manage flex sensor inputs is an efficient solution to the limited analog inputs on the Arduino Uno. This design choice simplifies the hardware requirements while maintaining system performance.

The glove's ability to switch modes through a single button press addresses a significant usability aspect, allowing users to easily transition between communication and mobility control. This feature ensures that the device can be used in a variety of contexts without cumbersome manual adjustments.

The real-time feedback provided by the LCD enhances user interaction, making the system more intuitive and user-friendly.

While the simulation environment provided a robust platform for initial testing, further development is required to adapt the glove for real-world applications. Incorporating actual accelerometers instead of potentiometers will be crucial to accurately capture hand movements and improve the precision of wheelchair control.

V. CONCLUSION

This study presents a novel approach to assistive technology, combining sign language recognition and wheelchair control into a single multifunctional smart glove. The device demonstrates significant potential in providing comprehensive support to individuals with disabilities by addressing both communication and mobility needs. The glove's flex sensors and analog multiplexer setup effectively recognize a wide range of sign language gestures with high accuracy. The wireless control of a wheelchair through Bluetooth communication is responsive and reliable, ensuring smooth and precise movements based on the user's hand gestures.

The integration of dual functionalities within one wearable device highlights a significant advancement in assistive technology. This multifunctional capability can greatly enhance the independence and quality of life for users, reducing the need for multiple devices.

Future development will focus on transitioning from potentiometers to accelerometers for more accurate tilt detection. Additionally, field testing with actual users will provide valuable insights for further refinement. Exploring additional features such as voice commands or expanding gesture libraries for more comprehensive communication can further enhance the glove's utility.

In summary, the smart assistive glove represents a promising step forward in the development of multifunctional assistive devices, offering a versatile solution to meet the diverse needs of individuals with disabilities.

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Interval-Valued Fuzzy Bézier Curve Approximation and its Numerical Example

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Abstract **–**Modeling a curve by using collected data is a challenging process. Most data that are collected will be affected by noise and uncertainty environment. In this paper, interval-valued fuzzy Bézier curve (IVFBC) approximation model will be introduced. Firstly, interval-valued fuzzy control point is defined and introduced. Later, interval-valued fuzzy Bézier curve is developed by blending interval-valued control point with the Bézier blending function. Lastly, The data points or interval-valued fuzzy control points of the basis function is converted into curve that called as IVFBC. With the interval-valued fuzzy concept and its relations, some numerical example can be translated using the introduced model. It shows how one can manipulate these interval-valued fuzzy control points so that they accurately model uncertain data that lies underneath them. The findings suggest that interval-valued fuzzy Bézier curve representation offers improved accuracy, reliability and flexibility when compared to conventional techniques for dealing with uncertainty data. Such application domains like computer graphics, data fitting or engineering design often involve uncertainties which need to be addressed within research approaches like mathematical modeling or methods. Thus, this study integrates fuzzy concepts into Bézier curve approximation making it possible to resolve uncertainty issues associated with this type of approximations which could be utilized in such areas as computer graphics, data fitting or engineering design. In geometric modeling and approximation, this methodology lays down important groundwork providing a platform upon which other applications of fuzzy technology shall be built across different industries.

Keywords – Interval-valued Fuzzy set, Bézier curve, Interval-valued fuzzy control points, approximation method, fuzzy geometric modeling.

I. INTRODUCTION

The fuzzy set theory was developed by [1] Zadeh in 1965 to handle uncertainty. Interval-valued fuzzy sets first were proposed by Zadeh as an extension of fuzzy sets in 1975 [2]). This variation represents the Membership degree values as ranges of numbers than individual values. The advantage of using interval-valued fuzzy sets has been demonstrated in dealing with the uncertainty in a better way as compared to the conventional fuzzy sets. Interval-valued fuzzy sets have been investigated from different viewpoints. Son [3] proposed the concept of interval-valued fuzzy soft sets which describe the values of membership degrees more loosely. In related work, Bustince [4] emphasized the importance of these sets in soft computing, especially in dealing with particular problem solving. The concept was further generalized to hesitant by Verma [5] who expanded the concept to hesitant interval-valued fuzzy sets, introducing novel operations and properties. Together, these studies emphasize the adaptability and utility of interval-valued fuzzy sets

across diverse domains. Given the widespread research and application of interval-valued fuzzy sets, on approximate reasoning [6-7], medical diagnosis [8], multivalued logic [9], decision making [10-12] and image processing [13-14]. Therefore, it is crucial to incorporate interval-valued fuzzy sets in various applications, including fuzzy geometric modeling.

Geometric Modeling is a fundamental application of Computer-Aided Design (CAD) systems, which provides mathematical descriptions of geometric elements for the purpose of representing and manipulating graphical images on a computer screen [15]. Geometric modeling is important for its role in visual representation when developing new designs and modifications, as well as for pre-production testing; that has an economic impact on the cost and time. It is this that makes Bézier techniques so effectively convert some of the complex mathematical matters into a very intuitive and geometric form. A Bézier curve is a way to easily and visually represent a geometric form, developed by Pierre Bézier [16] and properties introduced by Paul de Casteljau [17] that used Bernstein polynomials to define its curve and surface characterization along with the algorithm now known as the de Casteljau algorithm. The relationship between Bernstein polynomials and Bézier curves was discovered by Forrest [18].A geometric perspective on examining Bernstein polynomials is achieved by expressing them as functional Bézier curves. Wahab et al. [19] introduced a geometric modeling concept based on fuzzy numbers theory. They proposed fuzzy control points for fuzzy curves and fuzzy surface models for Computer-Aided Geometric Design (CAGD). The study explored properties related to approximating fuzzy control points using fuzzy Bézier, fuzzy B-spline, and fuzzy NURBS. Several years later, some researchers apply the same concept of integrating fuzzy set theories with geometric model such as [20-23]. A geometric

The concept of interval-valued fuzzy numbers will be explained and defined to show the fundamental theorems. In the following section, interval-valued fuzzy control points will be introduced and defined in the next section. These control points are blended with Bézier basis functions to model the interval-valued fuzzy Bézier curve approximation.

II. PRELIMINARIES

This section introduces the basic concepts of interval-valued fuzzy sets, including interval-valued fuzzy numbers, interval-valued fuzzy relations, and interval-valued fuzzy points.

Definition 1 *[1] Let a fuzzy set A is defined on a universe X as follows*

$$A = \{\langle x, \mu_A(x)\rangle \mid x \in X\} \tag{1}$$

where $\mu_A(x): X \to [0,1]$ *is the membership function A. The membership value* $\mu_A(x)$ *describes the degree of belongingness of in A.* Figure 1 shows an example of fuzzy set *A*.

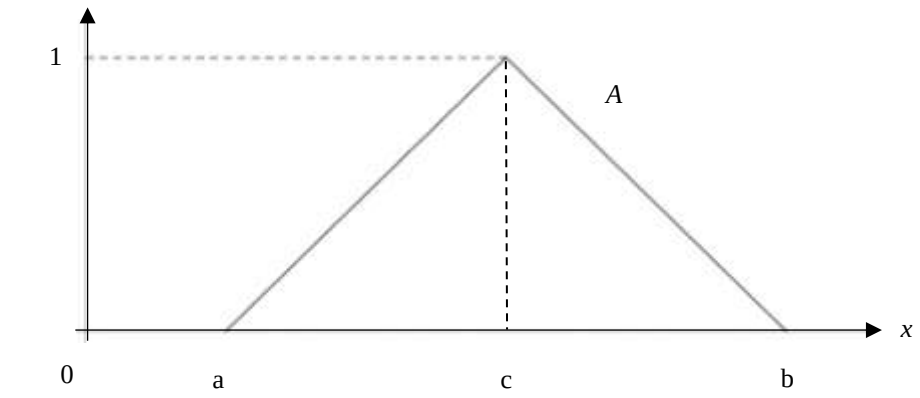

Fig. 1 Fuzzy set *A*

Definition 2 *[2] Let an interval-valued fuzzy set (IVFS)* $\tilde{A}$ *in X be*

$$\tilde{A} = \left\{ \left\langle x, \underline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{A}}(x) \right\rangle \mid x \in X \right\} \tag{2}$$

where $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are the lower and upper bound of the membership degree respectively with the following condition*

$$0 < \underline{\mu}_{\tilde{A}}(x) \le \overline{\mu}_{\tilde{A}}(x) \le 1 \tag{3}$$

The concept of interval-valued fuzzy numbers is from both fuzzy set theory and possibility theory. The theory. Fuzzy numbers was initially introduced in [6]. Definitions 3 and 4 illustrate the interval-valued fuzzy number and the normal triangular interval-valued fuzzy number, respectively.

Definition 3 *An interval-valued fuzzy number (IVFN)* $\tilde{A}$ *is defined as*

i. *normal where there is any* $x_0 \in R$ *such that* $A(x_0) = [1,1]$

ii. *convex for the memberships* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *where* $\underline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \underline{\mu}_{\tilde{A}}(x_1), \underline{\mu}_{\tilde{A}}(x_2)$ *and* $\overline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \overline{\mu}_{\tilde{A}}(x_1), \overline{\mu}_{\tilde{A}}(x_2)$ *for* $\forall x_1, x_2 \in R, \lambda[0,1]$

iii. $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are upper semi-continuous*

iv. *the support of* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are bounded that is the closure of* $\left\{ x \in R : \underline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *and* $\left\{ x \in R : \overline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *are bounded.*

Definition 4 *Suppose that from [23], define the normal triangular interval-valued fuzzy number* $\tilde{A}$ *to be represented by two fuzzy numbers* $\underline{A}_x = (\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}})$ *and* $\overline{A}_x = (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})$ *:*

$$\tilde{A} = [\underline{A}_x, \overline{A}_x]$$

$$\tilde{A} = [(\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}}), (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})] \tag{4}$$

where $\overline{a}_1 \le \underline{a}_1$, $\underline{a}_3 \le \overline{a}_3$ and $\underline{w}_{\tilde{A}} = \overline{w}_{\tilde{A}}$ while $\underline{a}_2 = \overline{a}_2$ is a crisp value and $\underline{w}_{\tilde{A}}$ and $\overline{w}_{\tilde{A}}$ are the heights of $\underline{A}_x$ and $\overline{A}_x$. The IVFN can be shown in Fig. 2.

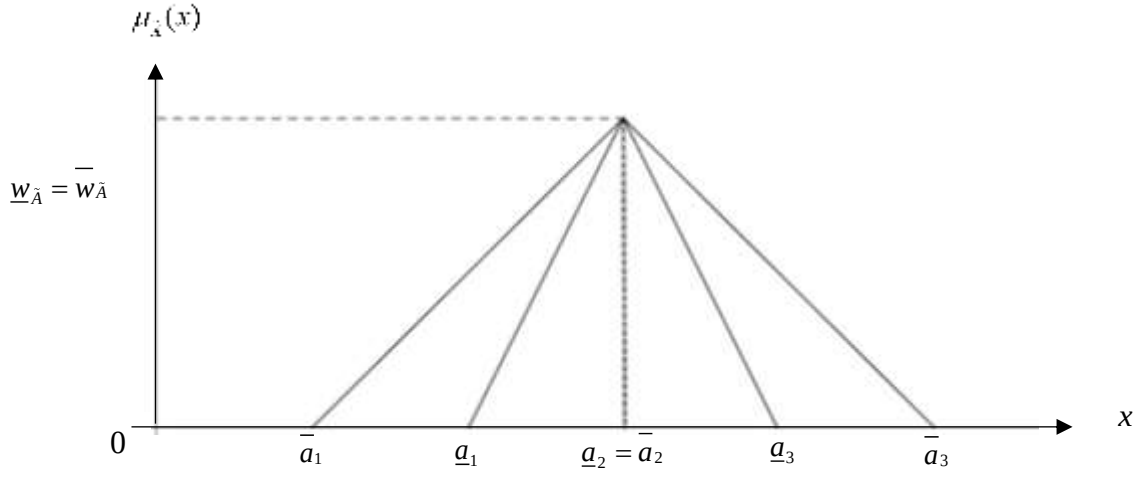

Fig. 2 The normal triangular interval-valued fuzzy number

Interval-valued fuzzy relation has been studied in [25-26]. The concept of the interval-valued fuzzy relation (IVFR) used as a connection between the definition of interval-valued fuzzy numbers (IVFN) and the representation of interval-valued fuzzy data points.

Definition 5 [27] *Let X and Y be non-empty sets and interval-valued fuzzy relation R. Let* $X, Y \subseteq R$ *be universal sets, then*

$$\tilde{R} = \left\{ \underline{R}(x,y), \overline{R}(x,y) \mid (x,y) \in X \times Y \right\} \tag{5}$$

where $\underline{R} : X \times Y \to [0,1]$ and $\overline{R} : X \times Y \to [0,1]$.

Definition 6 *Let* $S, R \in IVFR(X \times Y)$, *then for every* $(x,y) \in X \times Y$ *we can define*

$$S(x,y) \le R(x,y) \Leftrightarrow \underline{S}(x,y) \le \underline{R}(x,y) \le \overline{S}(x,y) \le \overline{R}(x,y) \tag{6}$$

where there are operations on the supremum and infimum in IVFR $(X \times Y)$ respectively as below

$$(S \vee R)(x,y) = \left[\max\left(\underline{S}(x,y), \underline{R}(x,y)\right), \max\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{7}$$

$$(S \wedge R)(x,y) = \left[\min\left(\underline{S}(x,y), \underline{R}(x,y)\right), \min\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{8}$$

III. Interval-valued Fuzzy Bézier Curve Approximation Model

The data points utilized to shape a Bézier curve are called as control points. The control points is denoted by $P_i = P_0, P_1, \ldots, P_i$. Fuzzy control point has been defined in [19].

A. *Interval-Valued Fuzzy Bézier Control Point*

From the definition of interval-valued fuzzy set, interval-valued fuzzy number and interval-valued fuzzy relation, the IVCP is written as follows.

Definition 7 *Let the interval-valued fuzzy set (IVFS) of* $\tilde{P}$ *in space S such that the set of interval-valued fuzzy control point (IVFCP) is defined as*

$$\tilde{P} = \left\{ \tilde{P}_i \right\}_{i=0}^{n} \tag{9}$$

where there exists membership functions of lower left and right, crisp value, and upper left and right bound respectively $\mu_{\tilde{P}}^{\underline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{\overline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{C} : S \to [0,1]$, $\mu_{\tilde{P}}^{\underline{R}} : S \to [0,1]$ *and* $\mu_{\tilde{P}}^{\overline{R}} : S \to [0,1]$.

In the geometric model, the interval-valued fuzzy control point is combined with the basis function of Bézier curve approximation. The interval-valued fuzzy Bézier control points in Equation (9) consists control points with lower left, $\tilde{P}_i^{\underline{L}}$, upper left, $\tilde{P}_i^{\overline{L}}$, crisp value, $\tilde{P}^{C}$, lower right, $\tilde{P}_i^{\underline{R}}$, and upper right, $\tilde{P}_i^{\overline{R}}$.

B. *Interval-Valued Fuzzy Bézier Curve*

Definition 8 *Let* $\tilde{P}$ *be a IVFCP with* $\tilde{P} = P_i : i = \{0,1,2,\ldots,n\}$, *hence the interval-valued fuzzy Bézier curve (IVFBC) is defined as*

$$\tilde{B}(t) = \sum_{i}^{n} \tilde{P}_i J_{n,i}(t), 0 \le t \le 1 \tag{10}$$

where Bernstein polynomials denoted as $J_{n,i}(t) = \binom{n}{i} t^i (1-t)^{n-i}$ *and the binomial coefficients is* $\binom{n}{i} = \frac{n!}{i!(n-i)!}$.

The IVFBC in equation (10) consists of :

$$\tilde{B}^{\underline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{L}}J_{n,i}(t),0\le t\le 1 \tag{11}$$

$$\tilde{B}^{\overline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{L}}J_{n,i}(t),0\le t\le 1 \tag{12}$$

$$\tilde{B}^{C}(t)=\sum_{i}^{n}\tilde{P}_i^{C}J_{n,i}(t),0\le t\le 1 \tag{13}$$

$$\tilde{B}^{\underline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{R}}J_{n,i}(t),0\le t\le 1 \tag{14}$$

$$\tilde{B}^{\overline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{R}}J_{n,i}(t),0\le t\le 1 \tag{15}$$

where $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left IVFBC, upper left IVFBC, crisp IVFBC, lower right IVFBC, and upper right IVFBC respectively.

IV. Modeling of Interval-valued Fuzzy Bézier Curve (IVFBC) Approximation Model

This section will model the interval-valued fuzzy Bézier curve (IVFBC) approximation model for $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left, upper left, crisp, lower right, and upper right of IVFBC respectively with the degree *n=4* since the models are in cubic case. Table 1 shows the IVFCP with their membership values. At the end of this section will demonstrate an algorithm to construct the IVFBCs approximation model.

Table 1. IVCP with the values of their membership

$\tilde{P}_0^4$ \ $\mu_{\tilde{A}}(x)$	0.3	0.5	0.3	0.7	0.8
$\tilde{P}_i^{\overline{L}}$	1.0	1.5	8	12.5	13
$\tilde{P}_i^{\underline{L}}$	2.5	3.0	10	13.5	14
$\tilde{P}_i^{C}$	11	11.5	18	20.5	21
$\tilde{P}_i^{\underline{R}}$	19	19.5	25	27.5	28
$\tilde{P}_i^{\overline{R}}$	20	20.5	27	28.5	29

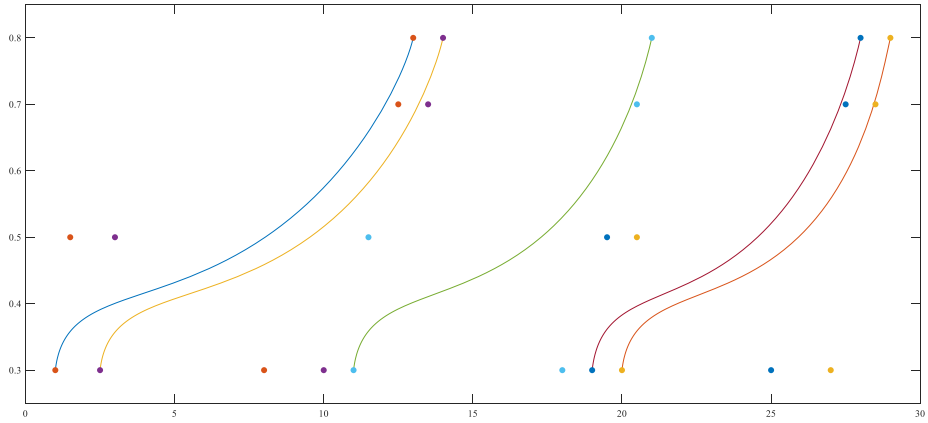

Fig. 3 Interval-valued fuzzy Bézier curve (IVFBC) approximation models

Table 1 shows an example of IVFCP with its corresponding degree of membership degree lower left, upper left, crisp value, lower right and upper right. While figure 3 is the illustrated curve where the IVFCP

is blended with the basis function of Bézier in the geometric model as in equation (10). Figure 3 shows the lower left IVFBC in yellow curve, next to it is the upper left IVFBC with blue curve. At the centre is the crisp IVFBC. While on the right obviously with red and orange curve are the lower right IVFBC and upper right IVFBC respectively.

The algorithm resulting in IVFBC is as follows:

Step 1: The interval-valued fuzzy control points (IVFCP) is determined using .
Step 2 : The interval-valued fuzzy control point is blended with the basis function of Bézier curve approximation in the geometric model using where the membership functions of lower and upper bound is determined.
Step 3 : The data points or IVFCP of the basis function is interpreted into curve that called as IVFBC.

V. CONCLUSION

This paper has introduced interval-valued fuzzy Bézier method where the IVFCP is used as data points. The method has shown that the interval-valued fuzzy data problem has been applied to the geometric modelling. The method and result will be contribute to the fuzzy geometric modeling application on visualization uncertainty data. The examples with practically calculated numbers confirm that the offered method may be effectively implemented. This research shows that there is ample potential for further development and usage of the interval-valued fuzzy methods in curve modeling and relative fields. The flexibility and applicability of the offered method indicate that it may find application in solving real-life problems during data analysis and decision-making. A notable example is Computer-Aided Design and Computer-Aided Manufacturing systems; interval-valued fuzzy Bézier curve approximation to represent and manipulate shapes and contours are excellent for uncertain shapes and contours. This can involve situations where the input data is imprecise, or the specifications are uncertain. Another illustration is pattern recognition tasks that involve imprecision or uncertainty; such as object recognition, gesture recognition, shape analysis in images and videos. In all these situations, interval-valued fuzzy Bézier curves can be used to operate on uncertain and imprecise data that are commonly found in real-world problems.

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Modeling of Interval-Valued Fuzzy Cubic Bézier Curve Approximation Method for Uncertainty Data

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Abstract **–** Modeling curves with data arising from uncertain environments is inherently challenging because of noise and underlying uncertainties. This paper presents a novel approach to approximate cubic Bézier curves through an interval-valued fuzzy method designed specifically for dealing with data uncertainty. Central to this method is the establishment of the foundation elements for constructing the Bézier curve which are in the form of interval-valued fuzzy control points. These fuzzy control points, when integrated into the traditional Bézier blending function, will yield a fuzzy Bézier curve that can effectively capture input data imprecision and variability. Interval-valued fuzzification allows a more flexible and accurate representation of the curve by accommodating uncertainties unattended by standard techniques. This study aims to delve into the theoretical framework that underpins the interval-valued fuzzy cubic Bézier curve approximation method by outlining its mathematical formulations and relationships. Furthermore, numerical examples are provided which will help to illustrate the application and advantages of this model in practice. It is through these examples that we can see how such a technique does not only translate uncertain data into reliable curve approximations but also shows its potential to be applied in engineering, computer graphics, and data analysis among others. By employing the interval-valued fuzzy approach and its associated relationships, the model can translate into some numerical examples.

Keywords – Interval-valued fuzzy set, interval-valued fuzzy Bézier curve, interval-valued fuzzy control point, Bézier curve approximation, fuzzy geometric modeling.

I. INTRODUCTION

The fuzzy set theory, introduced by Zadeh in 1965 [1], was developed to address uncertainty. A decade later, Zadeh expanded on this notion by introducing interval-valued fuzzy Sets (IVFS) as an extension of the fuzzy set theory where the values representing membership degrees are specified as intervals rather than single values [2]. This approach has been proven to be more effective in capturing uncertainty compared to traditional fuzzy sets. Research into IVFS has taken various paths. Son [3] introduced interval-valued fuzzy soft sets for more flexible membership representation. Bustince [4] highlighted their importance in soft computing for specific problems. Verma [5] further extended this concept to hesitant interval-valued fuzzy sets, introducing new operations and properties. Collectively, these studies demonstrate the adaptability and usefulness of IVFS across multiple domains. IVFS have been widely researched and applied in fields

such as approximate reasoning [6-7], medical diagnosis [8], multivalued logic [9], decision making [10-12], and image processing [13-14]. Therefore, incorporating IVFS into applications like Fuzzy geometric modeling is one of big potential in some industries.

Geometric modeling is one of the most important uses of Computer-Aided Design (CAD) systems that essentially entails the use of mathematical descriptions of geometric elements for representing and manipulating graphical images on a computer screen [15]. This procedure supports the visualization of ideas, alterations in designs, and preproduction tests thereby improving cost and time efficiency. Bézier techniques simplify intricate mathematical ideas into an intuitive geometric representation. Pierre Bézier [16] invented the Bézier curve which is a fundamental basis for geometric modeling with properties that were later developed by Paul de Casteljau [17] using Bernstein polynomials in conjunction with the de Casteljau algorithm. Forrest's [18] work discovered how Bernstein polynomials relate to Bézier curves. The functional expression of a Bézier curve provides us with geometrical perspectives on Bernstein Polynomials. Wahab et al. [19] introduced a fuzzy number theory-based geometric modeling concept through which they proposed fuzzy control points for fuzzy curves and surface models in Computer-Aided Geometric Design (CAGD). Furthermore, such concepts were applied by different researchers who combined principles from set theories and geometric models based on fuzziness [20-22].

The next part is to discuss interval-valued fuzzy numbers as well as define them to establish some basic theorems, also interval-valued fuzzy control points will be introduced. The proposed method will show how the interval-valued fuzzy control points blended with Bézier basis functions to create a framework for approximating uncertain data.

II. PRELIMINARIES

This section provides fundamental definitions of interval-valued fuzzy sets, encompassing interval-valued fuzzy numbers, interval-valued fuzzy relations, and interval-valued fuzzy points.

Definition 1 *[1] Let a fuzzy set A is defined on a universe X given as*

$$A = \{\langle x, \mu_A(x)\rangle \mid x \in X\} \tag{1}$$

where $\mu_A(x): X \to [0,1]$ *is the membership function A. The membership value* $\mu_A(x)$ *describes the degree of belongingness of in A.* Figure 1 shows an example of fuzzy set *A.*

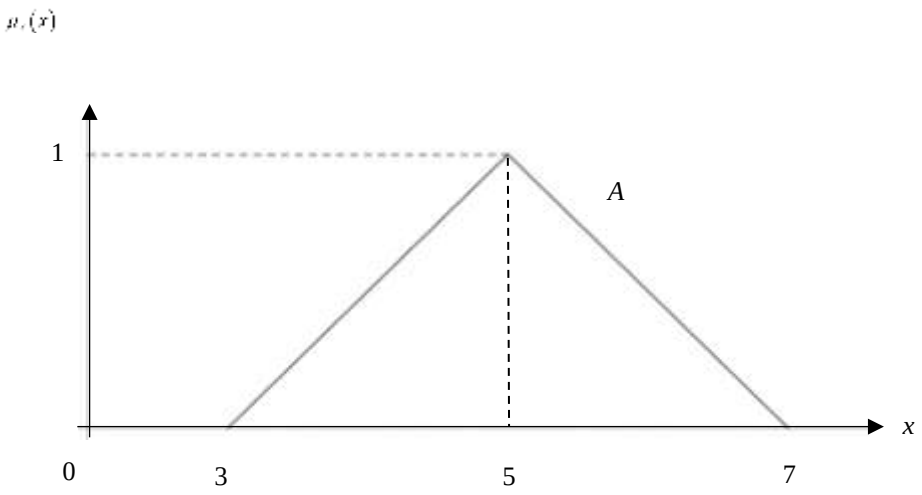

Fig. 1 Fuzzy set *A*

Definition 2 *[2] Let an interval-valued fuzzy set (IVFS)* $\tilde{A}$ *in X given as*

$$\tilde{A} = \left\{ \left\langle x, \underline{\mu}_{\tilde{A}}(x), \overline{\mu}_{\tilde{A}}(x) \right\rangle \mid x \in X \right\} \tag{2}$$

where $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are the lower and upper bound of the membership degree respectively on which fulfil the following condition*

$$0 < \underline{\mu}_{\tilde{A}}(x) \le \overline{\mu}_{\tilde{A}}(x) \le 1 \tag{3}$$

The idea of interval-valued fuzzy numbers has emerged from both fuzzy set theory and possibility theory. The concept of fuzzy numbers was initially introduced in [6]. Definitions 3 and 4 illustrate the interval-valued fuzzy number and the normal triangular interval-valued fuzzy number, respectively.

Definition 3 *An interval-valued fuzzy number (IVFN)* $\tilde{A}$ *is defined as*

i. *normal where there is any* $x_0 \in R$ *such that* $A(x_0) = [1,1]$

ii. *convex for the memberships* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *where* $\underline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \underline{\mu}_{\tilde{A}}(x_1), \underline{\mu}_{\tilde{A}}(x_2)$ *and* $\overline{\mu}_{\tilde{A}}(\lambda x_1 + (1-\lambda)x_2) \ge \min \overline{\mu}_{\tilde{A}}(x_1), \overline{\mu}_{\tilde{A}}(x_2)$ *for* $\forall x_1, x_2 \in R, \lambda[0,1]$

iii. $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are upper semi-continuous*

iv. *the support of* $\underline{\mu}_{\tilde{A}}(x)$ *and* $\overline{\mu}_{\tilde{A}}(x)$ *are bounded that is the closure of* $\left\{ x \in R : \underline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *and* $\left\{ x \in R : \overline{\mu}_{\tilde{A}}(x) > 0 \right\}$ *are bounded.*

Definition 4 *Suppose that from [23], define the normal triangular interval-valued fuzzy number* $\tilde{A}$ *to be represented by two fuzzy numbers* $\underline{A}_x = (\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}})$ *and* $\overline{A}_x = (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})$ *:*

$$\tilde{A} = [\underline{A}_x, \overline{A}_x]$$

$$\tilde{A} = [(\underline{a}_1, \underline{a}_2, \underline{a}_3; \underline{w}_{\tilde{A}}), (\overline{a}_1, \overline{a}_2, \overline{a}_3; \overline{w}_{\tilde{A}})] \tag{4}$$

where $\overline{a}_1 \le \underline{a}_1$, $\underline{a}_3 \le \overline{a}_3$ and $\underline{w}_{\tilde{A}} = \overline{w}_{\tilde{A}}$ while $\underline{a}_2 = \overline{a}_2$ is a crisp value and $\underline{w}_{\tilde{A}}$ and $\overline{w}_{\tilde{A}}$ are the heights of $\underline{A}_x$ and $\overline{A}_x$. The IVFN can be shown in Fig. 2.

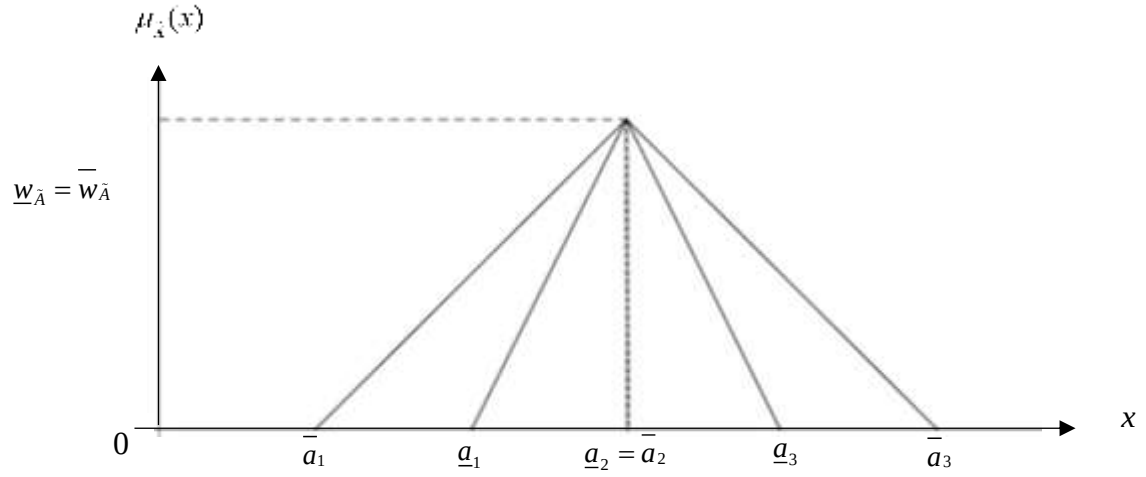

Fig. 2 The normal triangular interval-valued fuzzy number

Interval-valued fuzzy relation has been studied in [24-25]. The introduction of the interval-valued fuzzy relation (IVFR) acts as a bridge, linking the definition of interval-valued fuzzy numbers (IVFN) with the representation of interval-valued fuzzy data points.

Definition 5 [26] *Let X and Y be non-empty sets and interval-valued fuzzy relation R. Let* $X, Y \subseteq R$ *be universal sets, then*

$$\tilde{R} = \left\{ \underline{R}(x,y), \overline{R}(x,y) \mid (x,y) \in X \times Y \right\} \tag{5}$$

where $\underline{R} : X \times Y \to [0,1]$ and $\overline{R} : X \times Y \to [0,1]$.

Definition 6 *Let* $S, R \in IVFR(X \times Y)$, *then for every* $(x,y) \in X \times Y$ *we can define*

$$S(x,y) \le R(x,y) \Leftrightarrow \underline{S}(x,y) \le \underline{R}(x,y) \le \overline{S}(x,y) \le \overline{R}(x,y) \tag{6}$$

where there are operations on the supremum and infimum in IVFR $(X \times Y)$ respectively as below

$$(S \vee R)(x,y) = \left[\max\left(\underline{S}(x,y), \underline{R}(x,y)\right), \max\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{7}$$

$$(S \wedge R)(x,y) = \left[\min\left(\underline{S}(x,y), \underline{R}(x,y)\right), \min\left(\overline{S}(x,y), \overline{R}(x,y)\right) \right] \tag{8}$$

III. Interval-valued Fuzzy Bézier Curve Approximation Model

The data points utilized to shape a Bézier curve are termed control points. The control points is denoted by $P_i = P_0, P_1, \ldots, P_i$. Fuzzy control point has been defined in [19].

A. *Interval-Valued Fuzzy Cubic Bézier Control Point*

From the definition of interval-valued fuzzy set, interval-valued fuzzy number and interval-valued fuzzy relation, the IVCP is written as follows.

Definition 7 *Let the interval-valued fuzzy set (IVFS) of* $\tilde{P}$ *in space S such that the set of interval-valued fuzzy control point (IVFCP) is defined as*

$$\tilde{P} = \left\{ \tilde{P}_i \right\}_{i=0}^{n=4} \tag{9}$$

where there exists membership functions of lower left and right, crisp value, and upper left and right bound respectively $\mu_{\tilde{P}}^{\underline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{\overline{L}} : S \to [0,1]$, $\mu_{\tilde{P}}^{C} : S \to [0,1]$, $\mu_{\tilde{P}}^{\underline{R}} : S \to [0,1]$ *and* $\mu_{\tilde{P}}^{\overline{R}} : S \to [0,1]$.

In the geometric model, the interval-valued fuzzy control point is combined with the basis function of Bézier curve approximation. The interval-valued fuzzy Bézier control points in Equation (9) consists control points with lower left, $\tilde{P}_i^{\underline{L}}$, upper left, $\tilde{P}_i^{\overline{L}}$, crisp value, $\tilde{P}^{C}$, lower right, $\tilde{P}_i^{\underline{R}}$, and upper right, $\tilde{P}_i^{\overline{R}}$.

B. *Interval-Valued Fuzzy Cubic Bézier Curve*

Definition 8 *Let* $\tilde{P}$ *be a IVFCP with* $\tilde{P} = P_i : i = \{0,1,2,3,4\}$, *hence the interval-valued fuzzy cubic Bézier curve (IVFCBC) is defined as*

$$\tilde{B}(t) = \sum_{i}^{n} \tilde{P}_i J_{n,i}(t), 0 \le t \le 1 \tag{10}$$

where Bernstein polynomials denoted as $J_{n,i}(t) = \binom{n}{i} t^i (1-t)^{n-i}$ *and the binomial coefficients is* $\binom{n}{i} = \frac{n!}{i!(n-i)!}$ *where the n values is up until 4 since it is cubic function.*

The IVFCBC in equation (10) consists of :

$$\tilde{B}^{\underline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{L}}J_{n,i}(t),0\le t\le 1 \tag{11}$$

$$\tilde{B}^{\overline{L}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{L}}J_{n,i}(t),0\le t\le 1 \tag{12}$$

$$\tilde{B}^{C}(t)=\sum_{i}^{n}\tilde{P}_i^{C}J_{n,i}(t),0\le t\le 1 \tag{13}$$

$$\tilde{B}^{\underline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\underline{R}}J_{n,i}(t),0\le t\le 1 \tag{14}$$

$$\tilde{B}^{\overline{R}}(t)=\sum_{i}^{n}\tilde{P}_i^{\overline{R}}J_{n,i}(t),0\le t\le 1 \tag{15}$$

where $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left IVFCBC, upper left IVFCBC, crisp IVFCBC, lower right IVFCBC, and upper right IVFCBC respectively.

IV. Modeling of Interval-valued Fuzzy Cubic Bézier Curve (IVFCBC) Approximation Model

This section will model the interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation model for $\tilde{B}^{\underline{L}}$, $\tilde{B}^{\overline{L}}$, $\tilde{B}^{C}$, $\tilde{B}^{\underline{R}}$ and $\tilde{B}^{\overline{R}}$ are lower left, upper left, crisp, lower right, and upper right of IVFCBC respectively with the degree *n=3* since the models are in cubic case. Table 1 shows the IVFCP with their membership values. At the end of this section will demonstrate an algorithm to construct the IVFCBCs approximation model.

Table 1. IVCP with the values of their membership

IVFCPs					**Membership degrees**
$\tilde{P}_i^{\underline{L}}$	$\tilde{P}_i^{\overline{L}}$	$\tilde{P}_i^{C}$	$\tilde{P}_i^{\underline{R}}$	$\tilde{P}_i^{\overline{R}}$	
-2	-1	0	1	2	0.7
-1	0	1	2	3	0.2
0	1	2	3	4	0.9
1	2	3	4	5	0.3

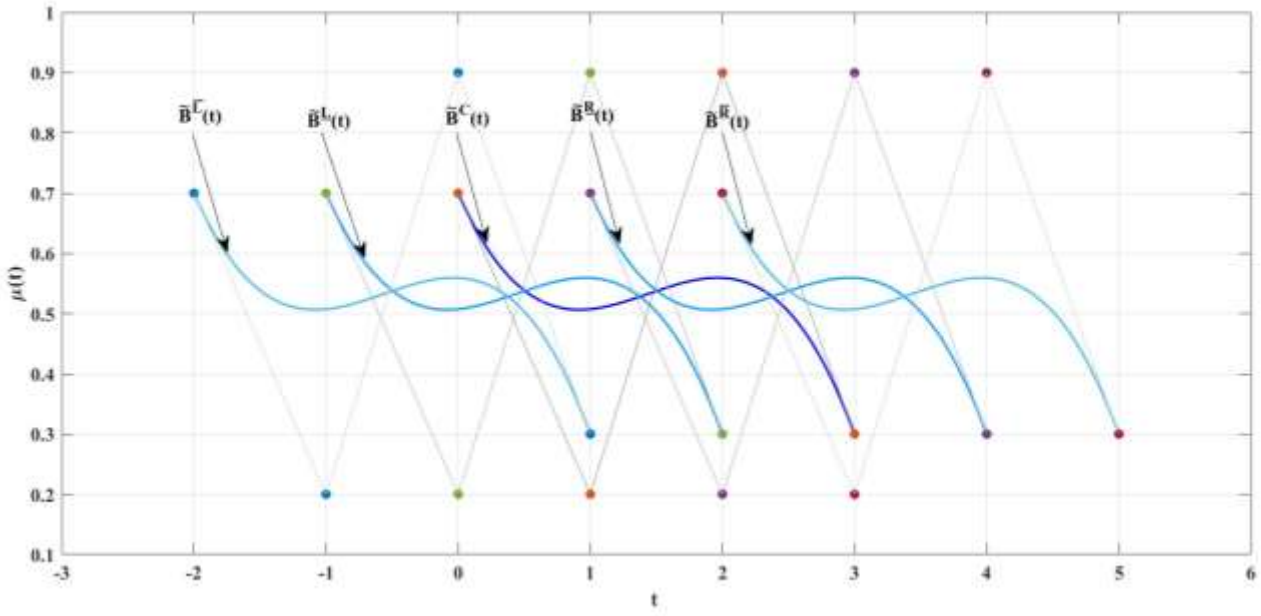

Fig. 3 Interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation models

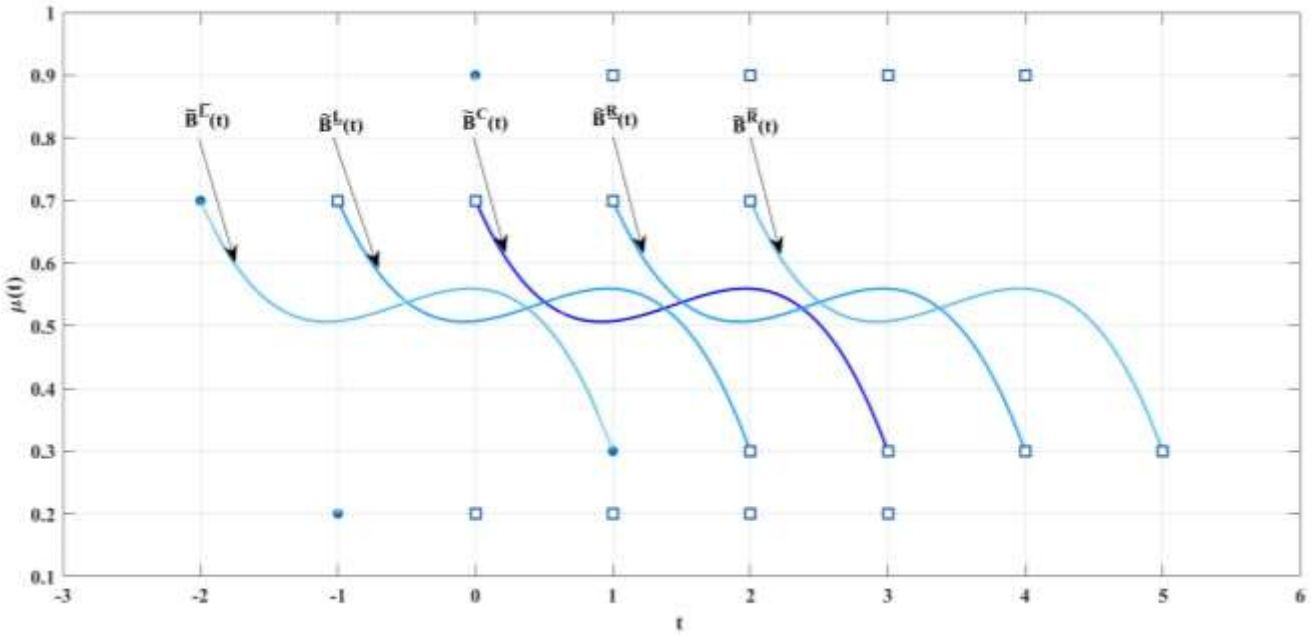

Fig. 4 Interval-valued fuzzy cubic Bézier curve (IVFCBC) approximation models without control polygons

Figure 3 shows how the control polygon will impact the behavior of the curves based on the IVFCPs. Figure 4 illustrates IVFCBC without a control polygon. The curves in the illustration estimate the IVFCP because this study used an approximation method. The following is an algorithm for constructing the IVFCBC:

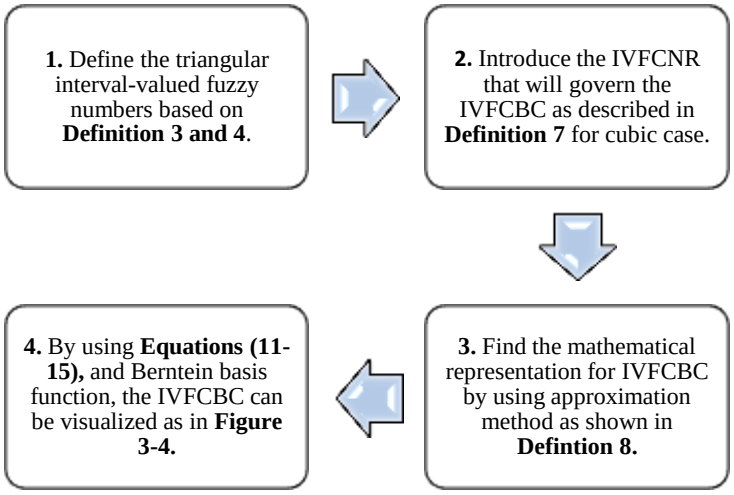

Fig. 5 An algorithm for construct IVFCBC

V. CONCLUSION

In this paper we presented a new optimal method to represent curves under uncertainty using interval-valued fuzzy cubic Bézier curve. By introducing an interval-valued fuzzy set here, the method enriches the classical cubic Bézier curve that becomes more capable of describing data uncertainty and imprecision.

The proposed approach can be an effective alternative for system problems dealing with uncertainty data, which are ordinary in some real-world applications involving computer-aided geometric design, data visualization, and signal processing. In summary, the interval-valued approximate method of fuzzy cubic Bézier curves reveals a major breakthrough in fuzzy modelling and curve approximation. It provides an effective framework for handling and expressing uncertainty in different contexts thereby improving precision and dependability of data-based models and approximations.

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The Model Predictive Control for grid Connected to Wind Turbine System

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Abstract – This paper presents a control strategy for a variable speed wind energy system with a grid-connected permanent magnet synchronous generator. The generator is connected to the grid via a three-phase back-to-back converter. The maximum available power from the wind energy system is harvested by applying the control algorithm to the machine-side converter, which is based on the backstepping technique. Predictive control is applied for the optimal operation of a PMSG wind turbine which is realized using the grid-side converter. A variable-speed wind energy system model based on a direct-drive permanent magnet synchronous generator is developed using the Matlab/Simulink environment. The generator offers good dynamic performance in the event of significant variations in wind speed. The effectiveness of the proposed control approach is validated by simulation results.

Keywords – Wind energy, PMSG, model predictive control, Backstepping

I. INTRODUCTION

On the one hand, the use of wind turbines (WT) for electricity generation is still rather low and limited due to the strong dependence on climatic conditions, as well as the fluctuating random behavior of wind energy [1]. Due to the depletion of fossil fuel reserves and environmental concerns directly caused by the use of fossil fuel sources, wind energy conversion systems (WECS) have attracted considerable attention as an alternative renewable energy source [2]. Wind power is becoming increasingly attractive as an alternative energy source for several reasons: mainly it's mature and clean appearance, the availability of renewable energy technologies, its competitiveness with conventional power plants, the fact that it does not produce greenhouse gases that cause global warming and benefits rural economies [3]. One disadvantage of this type of energy source is that wind speed varies throughout the day. This makes it difficult to reach full power. On the other hand, if the generator is electronically powered, it incorporates a maximum power point tracker to optimize the wind turbine's output [4]. The amount of energy produced by a WECS depends on the accuracy of the overall system and the precision with which the maximum power point is tracked by the WECS Maximum Power Point Tracking (MPPT) controller. In addition, WECS mitigates mechanical stress and acoustic noise, and enables active and reactive power control [5].

Today, manufacturers are developing the use of new, larger wind turbines based on variable-speed operation and pitch control. These large turbines use direct-drive PMSG or dual-feed induction generators (DFIG) [6]. Recent years. To integrate them into wind power systems, variable speed wind energy conversion systems (VS-WECS) are continually being developed. They dominate current technology in the wind energy industry because they offer many advantages over fixed-speed systems, such as the possibility of implementing control MPPT technology to extract maximum power at different wind speeds, higher overall reliability and better power quality.

Various types of wind turbine have become commonplace and widely used. However, due to the attractive properties of PMSGs, variable speed power generation systems are becoming increasingly common with the growing penetration of VS-WECS in power grids worldwide [7], and the use of PMSGs in large wind turbines is increasing rapidly [8]. Connected directly to the turbine, no gearbox is required; it can operate at low speeds and offers other advantages such as increased reliability and efficiency, reduced noise and smaller size [9]. This review focuses on past and advanced concepts and control methods or techniques applied to wind power systems.

II. WIND ENERGY CONVERSION SYSTEM

This section describes the structure of the WECS. It consists of a three-phase PMSG, a Buck-To-Buck converter is used to connect the PMSG to the grid, as shown in figure 1. The Machine-Side-Grid part controlled by the backstepping control and the Grid-Side-Control part controlled by the predictive control to extract maximum power as well as to inject active power into the grid to ensure unity power factor operation.

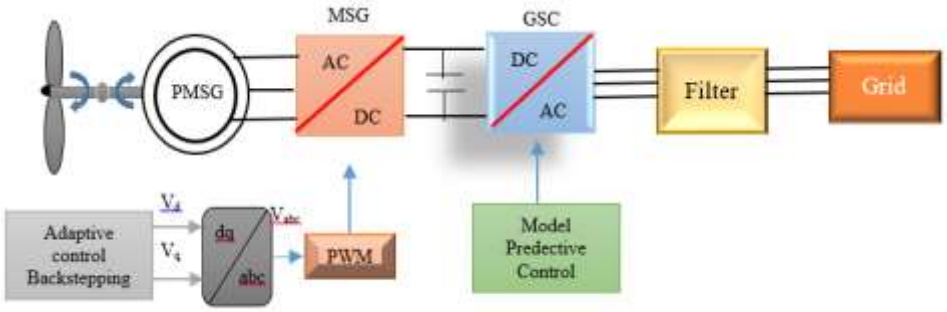


Fig .1 Structure of the system

A. *Wind Turbine Model*

When wind is applied to the turbine, the mechanical power output drives the generator rotor. For a variable-speed turbine, the mechanical power output and torque are given by the following expressions [10].

$$P_t = \frac{1}{2}\rho\pi R^2 C_p(\lambda,\beta)V^3 \quad (1)$$

$$T_m = \frac{P_a}{\omega_m} = \frac{\rho\pi R^2 C_p(\lambda,\beta)V^3}{2\omega_m} \quad (2)$$

Where:

P_t is the turbine output power (Watts) , T_m is the mechanical torque of turbine (Nm), C_p is the turbine power coefficient , ρ is the air density (kg/m), V is the wind speed (m/s), and ω_m is the mechanical angular speed of the turbine (rad/s).

$$\lambda = R\frac{\omega_{rm}}{V} \quad (3)$$

Where:

R is the radius of the turbine blade, λ is a function of both tip speed ratio and the blade pitch angle β.

There are many different versions of the fitted equations for C_p [11], this paper defines C_p as follows:

$$C_p(\lambda,\beta) = c_1\left(\frac{c_2}{\lambda_i} - c_3\beta - c_4\right)e^{\frac{c_5}{\lambda_i}} + c_6\lambda \quad (4)$$

$$\frac{1}{\lambda_i} = \frac{1}{\lambda+0.08\beta} - \frac{0.035}{\beta^3+1} \quad (5)$$

The approximated coefficient values are given as:

C1 = 0.5167, C2 = 116, C3 = 0.4, C4 = 5, C5 = 21, and C6 = 0.0068.

The relation between Cp and λ when β is shown in Fig. 2.

The optimum $C_{p_{opt}}$ value is about 0.48 at λ_{opt}opt = 8.1 [11].

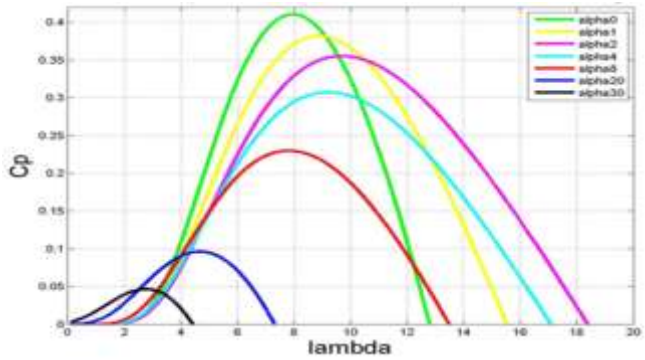


Fig 2 Power coefficient as a function of α and β

B. *Permanent Magnet Synchronous Generator Model*

The voltage equations of a three-phase PMSG expressed in the rotor reference frame using an extended Park transformation as follows [12] :

$$\begin{cases} V_d = R\, i_d + L_d \frac{di_d}{dt} - L_q i_q \omega_e \\ V_q = R\, i_q + L_q \frac{di_q}{dt} + L_d i_d \omega_e + \omega_e \varphi_f \end{cases} \quad (6)$$

Where V_d and V_q represent the stator voltages in the (d, q) axis, id and iq represent the currents in the (d, q) axis, R represents stator resistance, L_d, L_q represent the (d, q) axis inductances, $\omega_e = p\omega_m$ (p is number of pole pairs, ω_m represents the turbine rotor angular speed) and φ is the permanent flux linkage. The developed torque of the PMSG can be expressed as:

$$T_e = \frac{3}{2} p_r \left[\varphi\, i_q + \left(L_d - L_q\right) i_q i_d\right] \quad (7)$$

The mechanical equation of the PMSG is given by:

$$T_m = T_e + f\omega_m + J\frac{d\omega_m}{dt} \quad (8)$$

where: f is the friction coefficient, J is the total moment of inertia, T_m is the mechanical torque produced by a W_T and T_e is electromagnetic torque of PMSG.

III. CONTROL MODEL

A. *Backstopping for MSC.*

For maximum power point tracking, the PMSG reference commands are defined as optimal mechanical angular velocity optimal mechanical angular velocity. $\omega_{rm_ref} = \omega_{rm_opt}$ and desired d-axis current desired d-axis current id $i_{d_ref} = 0$ [13] . Considering the following tracking errors:

$$\begin{cases} e_w = \omega_{rm_opt} - \omega_{rm} \\ e_d = i_{d_ref} - i_d \end{cases} \quad (9)$$

Next, our goal is to design controllers that guarantee that the tracking errors of the system (9) to reach the neighborhoods of the origin despite uncertainties and external disturbances [14].

The PMSG control output is calculated by applying adaptive control backstepping and generating a stabilization function [15].

The strategy based on linear feedback passivity is used to generate the current controller id*. is used to generate the current controller iq* , dq expressed in (10), represents the current reference for the backstepping controller to generate the stabilization function [16,17]:

Firstly, the current tracking error vector is defined as follows:

$$e_{dq} = \begin{bmatrix} e_d \\ e_q \end{bmatrix} = \begin{bmatrix} i^*_d - i_d \\ i^*_q - i_q \end{bmatrix} \quad (10)$$

Using (9) the derivative of (10) is calculated as follows: $e^*{}_{dq} = \begin{bmatrix} e^*{}_d \\ e^*{}_q \end{bmatrix} =$

$$\begin{bmatrix} \frac{R_s}{L_d} i_d - \frac{p\omega_m L_q}{L_d} i_q - \frac{v_d}{L_d} \\ R_s{}^{-1} \frac{d}{dt}\left(\left(-\varphi_q{}^* + p\omega_m \varphi_f\right) + K_f e_{fq}\right) - \left(-\frac{R_s}{L_q} + \frac{p\omega_m L_q}{L_q} - \frac{p\omega_m \varphi_f}{L_q} - \frac{v_q}{L_q}\right) \end{bmatrix} \quad (11)$$

A Lyapunov function is defined as follows:

$$V_e = \frac{1}{2}\left(e^2{}_d - e^2{}_q\right) \quad (12)$$

$$V_e = -k_1 e^2{}_d - k_2 e^2{}_q + e_d \left(\frac{R_s}{L_d} i_d - \frac{p\omega_m L_q}{L_d} i_q - \frac{v_d}{L_d} + k_1 e_d\right) + \left(\frac{R_s}{R_s + k_f L_q} \times \right.$$

$$\left. \begin{bmatrix} -R_s{}^{-1} \varphi^{\cdot *}{}_q + p\omega_m \varphi_f \left(\frac{f_{fv}}{JR_s} + \frac{1}{L_q}\right) + i_q \left(\frac{R_s}{L_q} - \frac{\left(p\varphi_f\right)^2}{JR_s}\right) \\ + \frac{p\varphi_f}{JR_s} T_m - \frac{V_q}{L_q} + k_2 e_q \frac{R_s + k_f L_q}{R_s} \end{bmatrix} \right) \quad (13)$$

After simplification, the Lyapunov function (13) becomes:

$$V_e = -k_1 e^2{}_d - k_2 e^2{}_q < 0 \quad (14)$$

When $k_{fd} > 0$ and $k_{fq} > 0$. The overall asymptotic stability of the closed loop is guaranteed by (14) and the controller V_{dq} must be chosen as follows:

$$v_d = R_s i_d - p\omega_m L_q i_q + k_1 L_d e_d$$

$$v_q = R_s{}^{-1} L_q \varphi^{\cdot *}{}_f + p\omega_m \varphi_f \left(\frac{L_q f_{fv}}{JR_s} + 1\right) + i_q \left(R_s - \frac{L_q \left(p\varphi_f\right)^2}{JR_s}\right) +$$

$$\frac{L_q p\varphi_f}{JR_s} T_m + k_2 L_q e_q \frac{R_s + k_f L_q}{R_s} \quad (15)$$

B. *MPC for GSC.*

Once again, Euler's method is applied to the GSC, the discrete model on the grid side can be written as follows:

$$i_d(k+1) = \left(1 - \frac{T_s R_f}{L_f}\right) * i_d(k) + T_s \omega * i_q(k) + \frac{T_s R_f}{L_f} (v_d(k) - e_d(k)) \quad (16)$$

$$i_q(k+1) = \left(1 - \frac{T_s R_f}{L_f}\right) * i_q(k) + T_s \omega * i_d(k) + \frac{T_s R_f}{L_f} \left(v_q(k) - e_q(k)\right) \quad (17)$$

Where, e_d, e_q are the d-axis and q-axis voltage components of the inverter [18].

i_d, i_q are the d-axis and q-axis grid currents and ω_g is the angular frequency of the grid. L_f is the filter inductance, R_f is the filter resistance, T_s is the sampling time. The cost functions for the GSC are as follows:

$$g = \left|i^*{}_d - i_d(k+1)\right| + \left|i^*{}_q - i_q(k+1)\right| \quad (18)$$

Where, $i^*{}_d$ et $i^*{}_q$ are the reference values of the d-axis and q-axis grid currents. The currents in equations (16) and (17) are calculated for each of the eight possible voltage vectors, giving eight different current predictions. The controller selects the one with the lowest cost function compared to the others, Eq. (18).

IV. Results And Discussion

To demonstrate the validity and efficiency of the system, simulations were carried out using Matlab/Simulink software. The parameters of the system studied are shown in Table 1. To study MPP tracking under different wind speed variations, Fig. 3 shows the wind speed profile. Fig. 4 shows active and reactive power, Fig. 5 shows dc link voltage, which peaks as wind speed varies, Fig. 6 shows grid current and Fig. 7 shows grid voltage, Fig. 8 shows mechanical speed and Fig. 9 shows electromagnetic torque. The power difference between electrical and mechanical power is very small. Furthermore, the system operates at the optimum power factor (0.48). In addition, the blade tip speed ratio reaches its maximum value (8.1). In addition, turbine torque Tm and generator torque coincide well. The grid-side converter controller is examined under a variable wind speed profile. Figure 6 shows the intermediate circuit voltage, grid voltage and current, grid power. The controller regulates the actual value of the intermediate circuit voltage according to the reference level. In order to achieve a uniform power factor, grid voltage and current are kept in phase. The active power injected varies in steps according to wind speed, while the reactive power is zero to obtain a unitary power factor.

Table 1. Type Styles

PMSG parameter	Value
Stator resistance (Rs)	6.25e-3 Ω
Stator inductance (Ldq)	4.229e-3 mH
Wind turbine radius (R)	55 m
Wind density (ρ)	1.22 kg/m2
Pole pairs number (p)	75
Flux linkage (ϕ f)	11.1464 Wb
Total inertia (J)	10000 kg m2
DC-link voltage (Vdc)	5000 V
DC-link capacitor (C)	0.06 F
Grid-filter resistance (Rf)	0 pu
Grid-filter inductance (Lf)	10e-3 pu

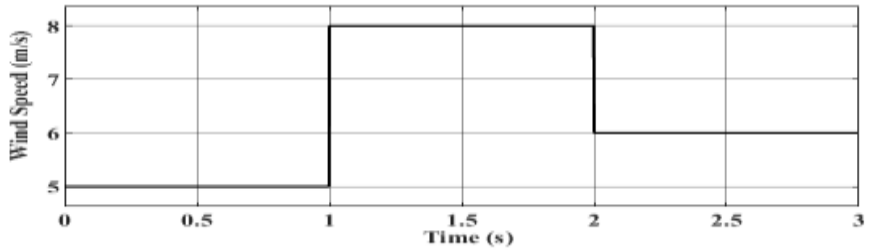
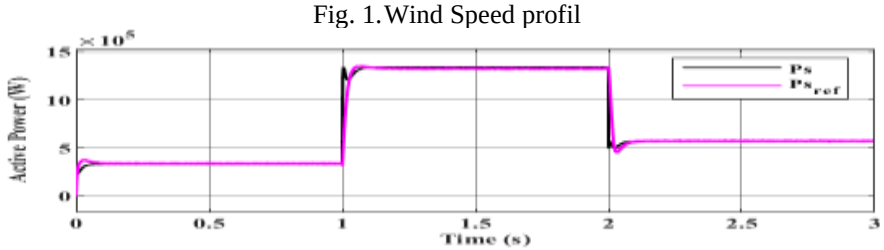
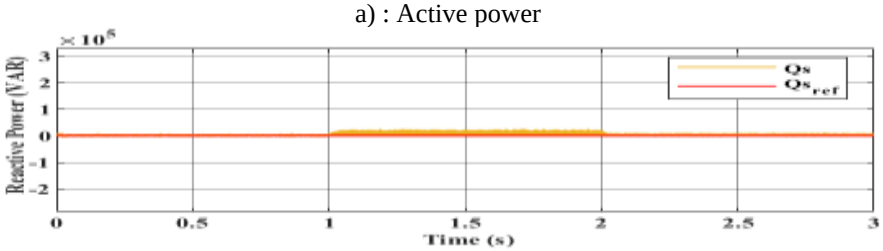


Fig. 1.Wind Speed profil



a) : Active power



b): Reactive power

Fig. 2.Active and reactive power

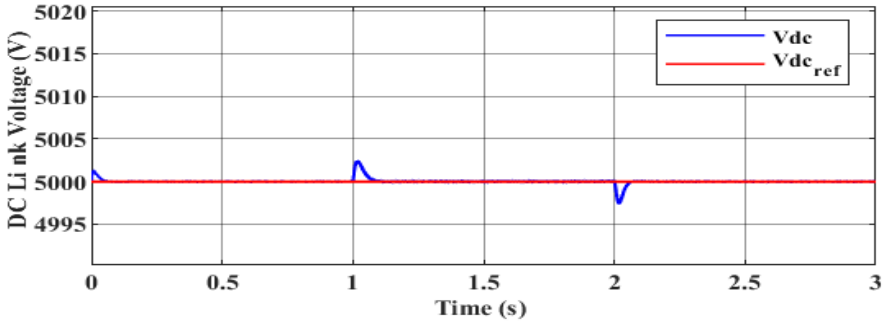


Fig. 3. DC Voltage

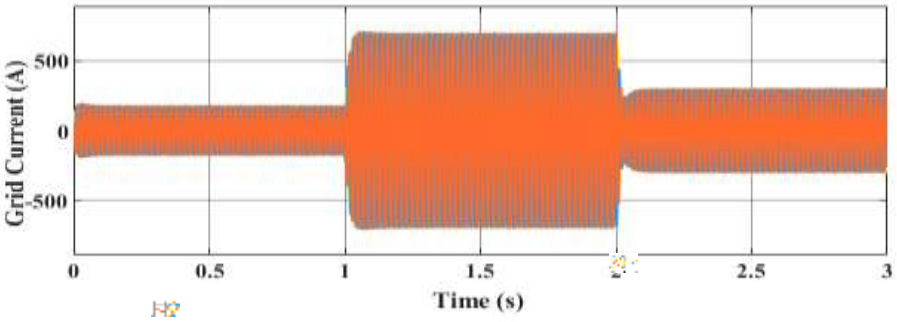


Fig. 4. Grid Current

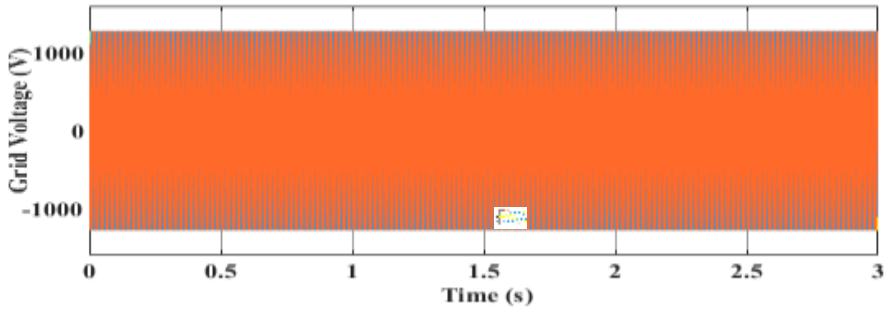


Fig. 5. Grid Voltage

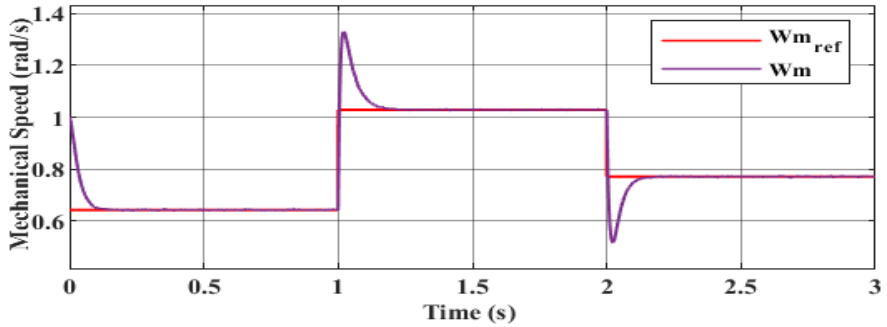


Fig. 6. Vitesse mécanique

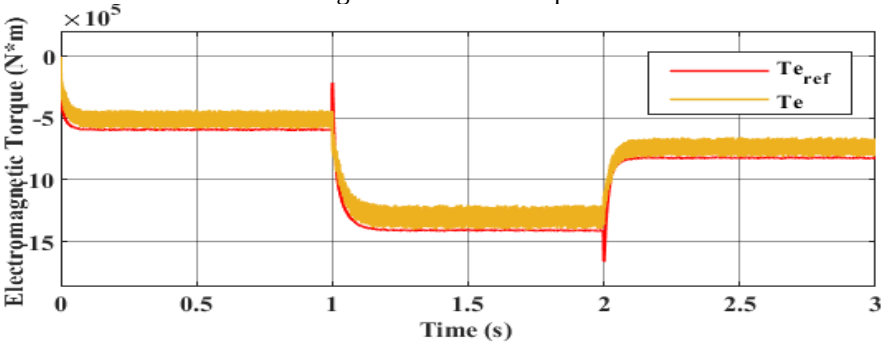


Fig. 7. Electromagnetic torque

V. CONCLUSION

In this article, the wind turbine is controlled by a predictive method called MPC control technique. This is a method for achieving more efficient operation in a variety of applications, and is also used to control drives and electrical machines. It enables voltage control to have a fast dynamic response. A step-up converter is used to increase the DC output voltage on the generator side to generate a higher voltage under low wind speed conditions. Higher voltage under low wind speed conditions. The results are verified and prove that the system is highly efficient and improves the overall performance of the wind energy system.

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Optimization of network reconfiguration by Using League Championship Algorithm (LCA)

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Abstract: This paper proposes an approach based on league championship algorithm (LCA) for optimal sizing, siting, and number of distributed generations (DG) in distribution systems. The objective of the problem is to minimize the power system losses and to improve the voltage profiles as well as voltage stability index. Loss Sensitivity Factor (LSF) is used to determine the optimal installation location of DG units, while LCA is used to find the optimal size of DG units. The proposed method has been tested on IEEE 33-bus and 69-bus radial distribution systems. The obtained results from the LCA have been compared to those of other methods in the literature. Simulated results have demonstrated that the proposed LCA method has a very good performance and effectiveness for the problem of optimal placement and sizing of DG units in distribution systems.

Index terms: Distributed generation (DG); League championship algorithm (LCA); Radial distribution network (RDS).

I. INTRODUCTION

Distributed generation (DG) systems are becoming increasingly important due to the rising demand for electricity. DG systems are small-scale power generators, typically ranging from 1 kW to 50 MW, that use renewable energy sources like solar and wind power[2] and [3].
Radial distribution networks, which are commonly used in low and medium-voltage networks, have a very high resistance-to-reactance ratio (R/X ratio). Traditional power flow techniques such as Gauss-Seidel (GS), Newton-Raphson (NR), and Fast Decoupled Load Flow (FDLF) are not operative in this scenario and most of time fails to converge. Therefore, alternative algorithms have been proposed to address this issue. The Backward Forward Sweep (BFS) approach is the most widely used algorithm [4] and [5].
Researchers worldwide are paying more attention to the use of DG units in radial distribution networks because they can minimise power losses, improve voltage stability, save money, and use renewable energy in a cost-effective way [6]. Different methods have been developed to find the best location and size for DG units, using both classical and meta-heuristic algorithms. One of the most popular methods, called the analytical method, was introduced in [7].suggested using a Grid Search Algorithm (GSA) to minimize overall power losses. Other authors have proposed meta-heuristic approaches like Particle Swarm Optimization (PSO), Modified PSO (MPSO), and Artificial Bee Colony (ABC) [8] and [9].
DG placement and sizing were determined using the MOOP method known as WSM ([10], [11], [12], [13], and [14], which offers several advantages in real-world applications, including computational ease. However, a drawback of these methods is that the weighting variables have a cumulative impact on the answer. To address this, multi-objective evolutionary approaches [15] and [16] were employed to solve optimization problems in power systems, as they have the capability to look at the global optimum. Nevertheless, the difficulty of these approaches has prompted researchers to seek a more straightforward method to expedite convergence.

In this study, the League Championship Algorithm (LCA), a powerful optimization method, was utilized to define the optimal location and size of DG units in radial distribution systems. The effectiveness of the suggested method was demonstrated through testing on various real networks, including the 33-bus and 69-bus test systems. The results were then compared to recently published articles.
This study used the proposed LCA algorithm to calculate the optimal size of DG units in distribution systems. The voltage stability index was used as the objective function to find the best location and size for the DG units. Once the optimal-sized DG units were placed in the best location, various system performance metrics were calculated, such as minimizing real power loss, improving the voltage profile, and enhancing the voltage stability index. The LCA algorithm's results were compared to those of the HSA, TLBO, and SOS algorithms after performing calculations on two test systems: the IEEE 33-bus and the 69-bus radial distribution systems.

II. LOSS SENSITIVITY FACTOR

Based on LSF, DG installation locations can be discovered [17]The benefit of utilizing this approach is that it narrows the problem search space during optimization.
Fig. 1 depicts an illustration of a two-bus distribution system. The following calculation can be used to calculate the LSF at the line segment between buses i and k:

$$P_{ik-loss} = \frac{\left(P_k^2 + Q_k^2\right)R_{ik}}{(V_k)^2} \quad (1)$$

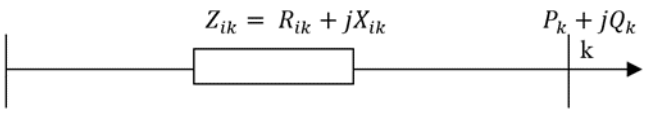

Figure 1. A two bus system one line diagrams [17]

III. OBJECTIVE FUNCTION

The suggested objective function minimizes power losses, enhances voltage profiles, and increases the Voltage Stability Index. It can be solved to obtain the optimal DG locations and sizes.

$$F_t = w_1 f_1 + w_2 f_2 + w_3 f_3 \quad (2)$$

Where f_1 can be expressed as shown in the following equation:

$$f_1 = \frac{\sum_{i=1}^{L}\left(P_{Lineloss}(i)\right)_{after\ DG}}{\sum_{i=1}^{L}\left(P_{Lineloss}(i)\right)_{before\ DG}} \quad (3)$$

f_2 can be defined as the following equation:

$$f_2 = \frac{\sum_{i=1}^{N}\left|V_i - V_{i,ref}\right|_{after\ DG}}{\sum_{i=1}^{N}\left|V_i - V_{i,ref}\right|_{before\ DG}} \quad (4)$$

f_3 can be defined as:

$$f_3 = \frac{1}{VSI(k)_{after\ DG}} \tag{5}$$

Where VSI is formulated as the following Eq:

$$VSI(k) = |V_i|^4 - 4(P_k X_{ik} - Q_k R_{ik})^2 - 4(P_k R_{ik} - Q_k X_{ik})|V_i|^2 \tag{6}$$

$|w_1| + |w_2| + |w_3| = 1$ in this paper, w_1 is taken as 0.5 while w_2 as 0.25 and w_3 as 0.25.

III-1 CONSTRAINTS

III-1-1 LOAD BALANCING CONSTRAINTS

The constraints for each bus are expressed as follows:

$$Pgni - Pdni - Vni \sum_{j=1}^{N} V_{nj} Y_{nj} \cos(\delta_{ni} - \delta_{nj} - \theta_{nj}) = 0 \tag{7}$$

$$Qgni - Qdni - Vni \sum_{j=1}^{N} V_{nj} Y_{nj} \sin(\delta_{ni} - \delta_{nj} - \theta_{nj}) = 0 \tag{8}$$

Where $n_i = 1, 2, 3, \ldots, n_n$.

III.1.2. VOLTAGE CONSTRAINTS

The considered range for the voltage of the buses is as follows:

$$V_{min} \leq V_{ni} \leq V_{max} \tag{9}$$

Where V_{min} is the minimum voltage at bus n_i, V_{max} is the maximum voltage at bus n_i.

III.1.3. DG CONSTRAINTS

The DG source that is utilized must conform to the permissible size and power factor within the specified range:

$$S_{min}^{DG} \leq S_{NI}^{DG} \leq S_{max}^{DG} \tag{10}$$

Where S_{min}^{DG} is minimum apparent power at bus n_i,$S_{max}^{DG}$is maximum apparent power at bus n_i and S_{NI}^{DG} is the apparent power at bus n_i.

IV. LEAGUE CHAMPIONSHIP ALGORITHM (LCA)

IV-1. OVERVIEW

Husseinzadeh Kashan [7] first proposed the LCA technique, a new metaheuristic approach for resolving continuous optimization issues [12]. Like other algorithms inspired by nature, LCA uses a population of solutions to develop to the best one. Each club in the league (each person in the population) stands for a workable solution to the issue at hand. These groups compete for several weeks (iterations) in a made-up league. Teams compete in pairs (i.e., team i plays versus team j) according to the league schedule each week, and the result is decided by each team's playing ability (equivalent to its fitness value) as a result of a certain team composition (solution). The tournament continues for a number of seasons (stopping criterion), and during the recovery period, each team designs the necessary alterations to its formation to set up a new configuration (a new solution is developed) for the next week's game.

IV-2 LCA ALGORITHM

LCA is an evolutionary algorithm that operates on a population of individuals. It begins by creating a league of L teams, where L is the league size. Each team consists of n players, corresponding to the number of variables in the function being optimized. The playing strengths of the teams are evaluated during initialization. Teams with the highest scores are selected to form effective formations.

The next phase is a competition where teams compete against each other in pairs for S x (L - 1) weeks, where S is the number of seasons and t is the week. The outcome of each match is determined solely by the performance of each team, and the winning team is the team with the better performance.

Following the competition phase, the recovery phase begins. In this phase, each team devises a new formation based on successful strategies employed in the previous week and the current configuration of the team. The selection process in LCA is characterized by its voracity, ensuring that the current squad achieves the most optimal formation. This selection process takes into account the superior playing ability of the team members and aims to create a more efficient team structure. In other words, the new formation is considered the most suitable option for the team if it proves to be the best response discovered thus far for a specific member of the population.

The algorithm concludes once the halting criteria are met, indicating that the desired outcome has been achieved.

Algorithm: The League championship algorithm [26]

1. To begin, set the league size (L) and the number of seasons (S). Additionally, assign the value of t = 1;
2. create a league schedule;
3. Afterwards, generate a population of L solutions to initialize team formations. Determine the playing strengths of each team by evaluating their function or fitness value. It is important to note that the initialization

of team formations should also serve as their current best formation;

4. While t is less than or equal to S multiplied by (L - 1), or there has been no change in the last 100 iterations.

5. Identify the victor and loser of each team pairing at week t, utilize a playing strength-based criterion based on the league schedule.

6. t = t + 1;

7. For i = 1 to L

8. Create a new formation for team I for the upcoming game, keeping in mind the team's best formation at the moment and the events of the previous week. Analyze the resulting arrangement's playing strength;

9. View the new formation as the team's current top arrangement if it is determined to be the most fitting one (i.e., the most excellent solution thus far for the ith member of the population);

10. End for

11. If mod (t,L - 1) = 0

12. Generate a league schedule;

13. End if

14. End while.

V. RESULTS AND ANALYSIS OF NUMERICAL DATA

The LCA algorithm under consideration is tested on both the IEEE 33 bus and 69 bus radial distribution systems. To assess its efficacy, it is pitted against the TLBO, HSA, and SOS algorithms. MATLAB software is employed to implement the LCA algorithm and identify the most optimal size and placement of DG within the distribution network.

V-1. THE IEEE 33-BUS RADIAL DISTRIBUTION NETWORK

The testing configuration described in [30] comprises a network with 33 buses and 32 branches. The total active and reactive power loads for the system amount to 3.716 MW and 2.300 MVAr, respectively. The DG units have varying power outputs, with the largest at 3.4952 MVA and the smallest at 0.2 MVA. The system's DG penetration cap is fixed at 4.359 MVA, and the base voltage is established at 12.65 kV.

Power flow calculations show that the system has active and reactive power dissipation of 210.1 kW and 143.14 kVAr, respectively. Based on LSF factors, potential buses for DG placement have been identified. Table 1 shows the LSF values for each bus.

Table 1. LSF values for the 33-bus system

LSF	Bus No.	norm(i) = V (i)/0.95	Base Voltage
0.0173328	6	0.9994401	0.9494681
0.0139414	3	1.0346128	0.9828821
0.0138033	28	0.9826654	0.9335321
0.0103590	29	0.9740129	0.9253122
0.0103223	8	0.9813551	0.9322874
0.0080802	14	1.0188907	0.9679462
0.0080712	4	1.0267079	0.9753725
0.0060563	30	0.9702674	0.9217540
0.0047535	9	0.9746892	0.9259547
0.0047501	24	1.0238154	0.9726247
0.0045614	13	0.9595139	0.9115382
0.0045149	10	0.9685237	0.9200975
0.0037555	27	0.9947096	0.9449741
0.0030365	31	0.9658863	0.9175920
0.0028204	2	1.0494889	0.9970145
0.0027433	26	0.9974088	0.9475384
0.0026717	23	1.0308381	0.9792962
0.0023800	25	1.0203152	0.9692995
0.0022880	20	1.0451668	0.9929084
0.0013972	5	0.9571033	0.9092482
0.0013803	7	0.9957298	0.9459433
0.0013538	12	0.9660146	0.9177139
0.0011808	17	0.9519908	0.9043912
0.0009111	16	0.9541467	0.9064393
0.0008107	15	0.9556014	0.9078213
0.0007965	11	0.9676092	0.9192287
0.0006456	32	0.9649225	0.9166764
0.0004473	18	0.9513452	0.9037779
0.0004155	21	1.0444252	0.9922039
0.0003599	22	1.0437542	0.9915665

0.0003317	19	1.0489327	0.9964861
0.0002027	33	0.9646238	0.9163927

V-1.1. PREDETERMINED NUMBER OF DG UNITS

The proposed solution has demonstrated its effectiveness in addressing the issue, particularly when dealing with a constrained number of DG units, specifically 1, 2, and 3, as illustrated in Table 2. A comparison of the obtained results from the suggested technique with those from established methods such as HSA [28] TLBO [29], and SOS [30] reveals that the proposed method performs better by identifying fewer total losses. The proposed LCA-based approach outperforms the SOS, HSA, and TLBO methods in reducing system power losses for the 33-bus test system. For a single fixed DG unit, the suggested approach achieves a system total loss of 109.07 kW, compared to 115.01 kW for the SOS method, 107.39 kW for the HSA method, and 124.695 kW for the TLBO method. For two fixed DG units, the suggested approach achieves a system total loss of 103.91 kW, compared to 107.39 kW for the HSA method. For three fixed DG units, the proposed approach achieves a system total loss of 101.13 kW, compared to 104.26 kW for the SOS method, 135.69 kW for the HSA method, and 124.695 kW for the TLBO method.

Table 2. Results comparison of the 33-bus system with predetermined number of DG units [28][29][30].

Method	Number of DG Units	Optimal result			
		DG size in MW (location)			Loss (kW)
		DG1	DG2	DG3	
HSA	1	0.8491 (18)	-	-	144.23
	2	0.2012 (18)	0.6932 (17)	-	141.14
	3	0.1913 (18)	0.2133 (17)	0.5927 (16)	135.69
TLBO	1				
	2				
	3	1.1826 (12)	1.1913 (28)	1.1863 (30)	124.695
SOS	1	3.1322 (6)	-	-	115.01
	2	2.2861 (6)	0.8363 (28)	-	107.39
	3	2.2066 (6)	0.2 (28)	0.7167 (29)	104.26
LCA	1	2.0265 (14)	-	-	109.07
	2	1.1681 (14)	0.7232 (24)	-	103.91
	3	0..8523 (14)	0.1129 (24)	0.9012 (29)	101.13

V.1.2. OPTIMAL NUMBER OF DG UNITS

To ascertain the optimal number of DG units for the system, various configurations were tested by installing diverse numbers of DG units, and their impact on active power loss was calculated. Through this analysis, it was determined that the ideal number of DG units could be identified by solving the problem iteratively, with each solution matching to a specific number of DG units. The evaluation spanned a range of DG unit

counts, from 1 to 21. The amount of DG units leading to the minimal power loss was considered the most appropriate choice for the system.
After conducting the tests, it was determined that the minimum active power loss of 74.359 kW occurs when the number of DG units is set at 12. This result is consistent with the active power loss values observed across different DG unit counts. Therefore, it can be concluded that 12 DG units represent the optimal configuration for the 33-bus system, resulting in a total active power loss of 74.359 kW.

Table 3 presents the outcomes of employing the SOS and LCA methods to identify the optimal number of DG units. While the LCA method yields slightly lower power losses compared to the SOS method, both approaches converge on the same optimal number of DG units. The proposed LCA-based method proves highly effective in pinpointing the appropriate location, size, and quantity of DG units for the IEEE 33-bus radial distribution system.

Table 3. Results for the 33-bus system with 12 DG units obtained using both the SOS and LCA methods.

Power loss (KW)		Total DG Power Output (MW)	
SOS	LCA	SOS	LCA
76.967104	74.359012	2.509000089	2.50853254

Figure 2 illustrates the voltage profile curves after installing the optimal number of DG units using the SOS and LCA technics. The figure suggests that both approaches might have an identical impact on voltage profiles.

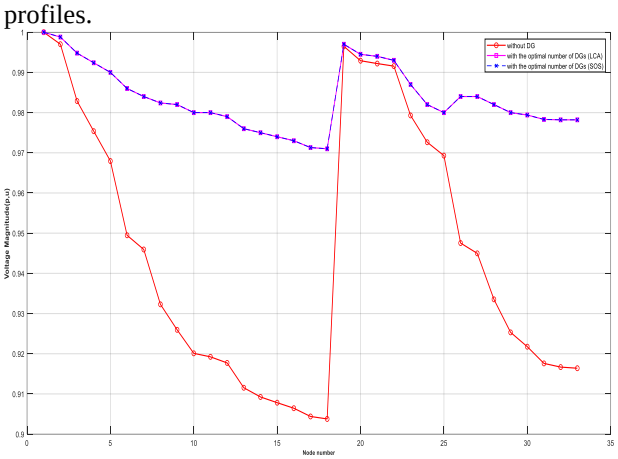

Figure 2. Voltage profile of the 33-bus system with optimal number of distributed generators (DGs).

V.2. THE IEEE 69-BUS RADIAL DISTRIBUTION NETWORK

The next test system, described in [30] study, is a radial distribution network with 69 buses. It exhibits a total load demand of 3.81 MW and 2.70 MVAr. The system incurs active power losses of 225 kW and reactive power losses of 102.16 kVAr. Distributed generation (DG) units within this system generate power ranging from 0.2 MVA to 3.7248 MVA. The base voltage for the system is 12.66 kV, and the DG penetration limit is set at 4.656 MVA

V.2.1. PREDETERMINED NUMBER OF DG UNITS

The issue regarding the number of DG units in the scenario where the amount of DG units is predetermined has been successfully resolved using the suggested approach. A comparison between the outcomes of the suggested technique and existing methods, such as HSA [30], TLBO [30], and SOS [30], has been presented in Table 4. The table clearly demonstrates that the proposed method is capable of achieving a reduced overall power loss when compared to the existing methods.

The proposed method outperforms the HSA, TLBO, and SOS methods in reducing system power losses for all cases with different numbers of DG units. For a single DG unit, the proposed method achieves a total power loss of 110.12 kW, compared to 112.1 kW for the HSA method and 118.62 kW for the SOS method. For two DG units, the suggested method achieves a total power loss of 94.87 kW, compared to 96.56 kW for the HSA method and 102.92 kW for the SOS method. For three DG units, the suggested method accomplishes a total power loss of 82.07 kW, compared to 86.66 kW for the HSA method, 82.172 kW for the TLBO method, and 82.07 kW for the SOS method.

In conclusion, the proposed LCA-based method offers a solution for determining the optimal position, size, and quantity of DG units for the IEEE 69-bus radial distribution system.

Table 4. Evaluating of results for the 69-bus system with Predetermined number of DG units [28][29][30].

Method	Number of DG Units	Optimal result			
		DG size in MW (location)			Loss (kW)
		DG1	DG2	DG3	
HSA	1	1.4363 (65)	-	-	112.10
	2	0.0544 (65)	1.5932 (64)	-	96.56
	3	0.0149 (65)	0.1416 (64)	1.6283 (63)	86.66
TLBO	1			-	
	2			-	
	3	0.9925 (17)	1.1998 (61)	0.7956 (63)	83.2
SOS	1	2.087 (57)	-	-	118.62
	2	0.3612 (57)	1.6948 (58)	-	102.92
	3	0.2588 (57)	0.2 (58)	1.5247 (61)	82.07
LCA	1	2.172 (11)	-	-	110.12
	2	0.3321 (11)	1.7284 (57)	-	94.87
	3	0.2061 (11)	0.1962 (57)	1.2741 (61)	81.74

V.2.2. OPTIMAL NUMBER OF DG UNITS

The suggested technique was tested to determine the impact of different DG unit counts on active power losses and total power losses. The results showed that the smallest active power loss of 71.444166 kW was achieved when there were 8 DG units among the tested values.

Table 5 illustrates the contrast between the proposed method and the SOS method in establishing the optimal number of DG units. The application of the LCA technique to the system with the ideal number of DG units yielded a reduced total power loss in comparison to the SOS method. Specifically, the active power losses calculated by the LCA and SOS techniques using the ideal number of DG units were 71.372133 kW and 71.444166 kW, respectively.

Table 5. Results comparison for the 69-bus system with 8 distributed generation (DG) units

Power loss (KW)		Total DG Power Output (MW)	
SOS	LCA	SOS	LCA
71.444166	71.444166	2.437403138	2.393254123

Figure 3 displays the voltage profiles of the system's buses following the installation of the optimal number of DG units determined by the SOS and LCA methods. Both techniques markedly enhance the voltage levels at the buses, with nearly identical improvements resulting from both SOS and LCA methods.

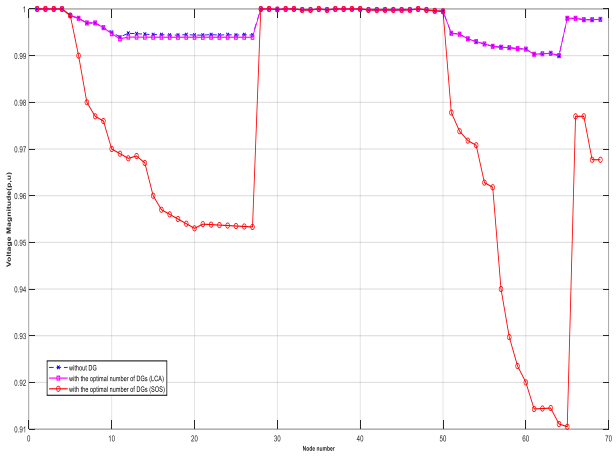

Figure 3. The voltage profile of the 69-bus system with the optimal number of distributed generation (DG) units installed.

CONCLUSION

In this study, a novel approach based on Life Cycle Assessment (LCA) has been successfully applied to tackle the challenge of determining the optimal of distributed generators location within distribution networks. This research specifically focuses on addressing the complexities associated with selecting the appropriate position, size, and quantity of DG units in radial distribution systems. The methodology involves the use of a loss sensitivity factor to prioritize potential DG unit locations and the application of the LCA method to determine the optimal size of DG units for a predefined number of units. The configuration resulting in the lowest overall power loss is then identified as the optimal solution.

To assess the effectiveness of this proposed method, it was rigorously tested on both the IEEE 33-bus and 69-bus radial distribution systems. The obtained results were meticulously compared with outcomes from other methods documented in existing literature. These comparative analyses clearly

demonstrate the efficiency of the suggested LCA-based strategy in effectively addressing the challenge of determining the placement of dispersed generators within distribution networks.

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Shifting Shadows of Heroism: The Evolution of American War Film Portrayals in the Context of the Iraq War

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Abstract – As the Iraq War unfolded, American war films saw a substantial change in their presentation of heroism. Films evolved away from basic storylines of good against evil and iconic heroes in response to changing popular perceptions of the conflict. This research investigates the influence of the Iraq War on American war movies, with an emphasis on how depictions of heroism become more nuanced and ethically complex. The study examines significant films such as *Jarhead*, *The Hurt Locker*, and *American Sniper* and how they dealt with issues of disillusionment, psychological trauma, and the blurring borders between war and terrorism. This paper illustrates how American war films grappled with the reality of the Iraq War, eventually offering a more complicated and thought-provoking perspective on heroism in the modern world.

Keywords –War Films; American Cinema; The Iraq War; Heroism; Portrayals; Impact

I. Introduction

Wars are considered to be ritualistic acts that turn boys into men and the warrior image is presented as the national hero in many instances of life, most notably in Hollywood films. War-combat films made in Hollywood retain the basic characteristics of this ideology and support it by providing legitimization through its filmic narratives. Interestingly, even seemingly anti-war films serve this ideology through overt and covert layers of meaning. War films have long been a prism through which American society perceives and defines heroism, courage, and sacrifice.

From World War II propaganda films that showed American soldiers as icons of power and morality to blockbusters like *Saving Private Ryan*, which portrayed combat fortitude in grand, legendary terms, the genre has regularly offered exaggerated ideals of military valor. However, the beginning of Iraqi combat signaled a change in American combat films. As the battle got more complicated, chaotic, and ethically ambiguous, simple representations of heroism no longer connected with filmmakers and spectators.

The genre has repeatedly challenged traditional notions of military heroism and bravery, ranging from John Wayne representing austere idealism in *Sands of Iwo Jima* (1949) to magnificent displays of devoted sacrifice in *Saving Private Ryan* (1998). However, the post-September 11 era, as well as the battles in Iraq and Afghanistan, marked a turning point in American war films. As the Global War on Terror became more complex, chaotic, and ethically ambiguous, simple representations of heroism no longer resonated with filmmakers and spectators (Majed, 2016).

The 2003 invasion's popularity faded into disappointment as the war's cause was questioned and the occupation failed. The war was no longer presented as a moral binary choice. This skepticism was reflected in films that questioned honor, heroism, and patriotism, instead focusing on the pain, ethical quandaries, and dehumanization faced by troops. Films like *Jarhead*, *In the Valley of Elah*, and *The Hurt Locker* featured heroes struggling with conflict.[1]

The Iraq War led to a shift in American films' portrayal of heroism, with films like *Jarhead*, *The Hurt Locker*, and *American Sniper*[2] abandoning traditional themes of heroism, honor, and patriotism in favor of post-traumatic stress, moral injury, and enemy dehumanization. Instead of using clichés, these films explored the psychological and ethical complexities of soldiers' existence, highlighting the dwindling public support for the invasion.

This study explores the impact of post-9/11 American war films on the perception of military valor for the Iraq War generation. Unlike World War II films, which portrayed valor in patriotic terms, the complexities of Iraq required more introspective, ethically problematic perspectives. The research reveals how current war films redefine heroism in a more uncertain and skeptical period, grappling with the human costs and ethics of modern battles.

Literature Review and Hypothesis

The Iraq War, spanning from 2003 to 2011, profoundly impacted American society and its perception of war and heroism. Public opinion shifted from initial support to disillusionment as the costs of the conflict grew apparent. This shift resonated within American war cinema, leading to a redefinition of heroism compared to prior portrayals.

1. *War and Film in America: Historical and Critical Essays* by Marilyn J. Matelski and Nancy Lynch Street (2017): This book provides a comprehensive analysis of how American war films have evolved over time, including a section dedicated to post-9/11 films like *Jarhead* and *The Hurt Locker*. It examines how these films depict the psychological toll of war on soldiers and challenge traditional notions of heroism by introducing morally complex characters. The authors discuss the shift from clear-cut villains to ambiguous figures, reflecting the complexities of modern conflicts like the Iraq War.

2. Dan O'Meara, Alex Macleod, & Frédérick Gagnon (2016), *Hollywood and the War in Iraq*: provide an insightful look into how the Iraq War has influenced American cinema, focusing on films that portray the war's psychological effects on soldiers. The book discusses examples of how filmmakers have depicted the inner turmoil and moral ambiguity faced by military personnel. The authors explore how these films grapple with the complexities of the conflict, presenting characters who navigate a landscape of uncertain morality and contested justifications for the war.

3. *American War Cinema and Media since Vietnam: Politics, Ideology, and Class* by Patricia Keeton and Peter Scheckner (2013): This book examines the transformation of war cinema from the Vietnam era to the present, including a detailed analysis of Iraq War films like *Jarhead* and *The Hurt Locker*. Keeton and Scheckner

[1] Many of these films spent scant weeks in the theaters and made almost no money. Only *In the Valley of Elah* was praised by critics (mostly owing to Tommy Lee Jones' performance) and did reasonably well at the box office, earning just over $6.5 million.
[2] "Top-US-Grossing War Feature Films With At Least 1,000 Votes", International Movie Data Base, http://www.imdb.com/search/title?genres=war&num_votes=1000,&sort=boxoffice_gross_us&title_type=feature, consulted on 15th May 2015.

explore how these movies challenge traditional hero narratives by focusing on the psychological impacts of war and the morally ambiguous nature of the Iraq conflict. They highlight how these films question the clear-cut distinction between heroes and villains, reflecting the complexities and ethical dilemmas faced by soldiers on the ground.

These books offer in-depth discussions on how contemporary war films have shifted away from traditional heroic portrayals, instead depicting the psychological and moral complexities of modern conflicts like the Iraq War.

Hypothesis

Public perception of war and heroism, shaped by the realities of the Iraq War, led to a significant shift in the portrayal of heroes in American war films. These films moved away from simplistic good vs. evil narratives and archetypal heroes, opting for more nuanced and morally ambiguous characters struggling with the complexities of modern warfare.

This article hypothesizes that post-9/11 American war films reflect dissatisfaction with the Iraq War through more ethically ambiguous and psychologically complex depictions of valor. As popular support for the Iraq War waned, uncomplicated notions of heroism were replaced with more sophisticated investigations into military trauma, ethical gray zones, and the human costs of war. By evaluating shifts in heroism representation, this study intends to illustrate how American war film simultaneously mirrors and shapes public conceptions of the Iraq War.

Aim of the Study

The aim of this study is to explore the transformation of the war hero archetype in the context of the Iraq War, examining how traditional notions of heroism have evolved into more complex and nuanced representations. Unlike previous analyses that often focused on clear-cut distinctions between heroism and villainy, this study delves into the gray areas that define modern conflict and soldier experiences. By highlighting the shift from idealized, morally unambiguous heroes to anti-heroes grappling with ethical dilemmas and psychological challenges, this research provides a deeper understanding of how contemporary warfare shapes our perceptions of heroism. This approach is distinct in its emphasis on the psychological and moral complexities that have redefined what it means to be a hero in the modern age.

Methodology

This study will utilize textual analysis to examine portrayals of heroism in post-9/11 American war films. The analysis will focus on three landmark films that reflect the shifting perspectives: *Jarhead* (2005), *The Hurt Locker* (2009), and *American Sniper* (2015). These films were selected based on their nuanced portrayals of soldier experiences, critical acclaim, and popularity. Together, they encapsulate the range of complex heroism portrayals in post-9/11 American war cinema.

The textual analysis will focus on key themes related to heroism in films, such as disillusionment with war aims, psychological trauma, moral ambiguity, dehumanization of enemies, and loss of purpose or difficulty reintegrating, allowing for a comprehensive examination of shifting notions of heroism. The analysis will also contextualize these films historically about public opinion polls, political speeches, and news media coverage of the Iraq War. This will reveal how the films' themes correlated to and reflected changing public perceptions of the war effort and its combatants.

Textual analysis provides an effective methodology for this study as it reveals complexity within cultural texts and situates them sociohistorically. Examining post-9/11 war films in context illuminates how cinema shaped and was shaped by evolving constructs of heroism in the Iraq War era.

II. From Archetypes to Anti-Heroes: The Evolution of the War Hero

The concept of the war hero has undergone significant transformation over the centuries, evolving from the noble archetypes of classical mythology to the complex, often morally ambiguous figures of modern conflicts. The Iraq War, which began in 2003, serves as a pivotal point in this evolution. Traditional notions of heroism, characterized by clear moral boundaries and honorable actions, have been increasingly challenged by the realities of contemporary warfare.

The Iraq War, with its controversial origins, prolonged engagement, and complex socio-political ramifications, has produced a new type of war hero: the anti-hero. These figures are not defined by their adherence to idealistic principles but by their nuanced, often conflicted humanity. They embody the ethical dilemmas and psychological struggles faced by soldiers in an environment where the lines between right and wrong are frequently blurred. This shift reflects broader societal changes and the increasing recognition of the psychological toll of war, ultimately offering a more nuanced and realistic portrayal of heroism in the modern age.

Traditional Portrayal of Heroes in American War Films

War films have historically depicted heroism and sacrifice in warfare in idealistic terms, particularly during World War II and Vietnam. These films emphasized honor, devotion, and stoicism, portraying soldiers as archetypal warriors who exemplified American principles and persevered despite hardship (Rehm, 2015). Despite the Vietnam War's contentious nature, these films continued to glorify warfare as a test of manly fortitude (Tasker, 1993). Heroism was presented in broad, patriotic strokes with minimal moral ambiguity or psychological subtlety. World War II was seen as a "good war" with moral clarity, emphasizing courage, honor, and responsibility without revealing the darker aspects of battle (Rehm, 2015).

The film *Sands of Iwo Jima* (1949) is an example of how WWII films romanticize soldiers' heroics. It focuses on the Marines' noble sacrifice and fraternity rather than the brutality of warfare. John Wayne personifies leadership, toughness, and stoic patriotism. Other famous films featuring similar concepts include *The Guns of Navarone* (1961) and *The Great Escape* (1963). Leading men embody heroism and bravery with minimal moral uncertainty.

Even films about the Vietnam War, such as *The Green Berets* (1968) and *Apocalypse Now* (1979), portrayed soldiers in legendary grandeur. While addressing complicated subjects, they maintained the emphasis on fighting as a test of courage. According to Tasker (1993), they present combat experience as a "rite of passage" for American males to find their warrior inclinations. Despite the sorrow of Vietnam's loss, heroism remains idealized (Bowen, 2019).

In general, previous war films depicted heroic ideals like courage, honor, and sacrifice in idealized, moralistic terms. Soldiers were exemplars of American virtue who persevered in the face of combat. The romantic ideal of combat gallantry overshadowed the difficult reality of conflict.

Simplistic Good vs. Evil Narratives

The oversimplified moral framing of the battles was an important component of the glorified heroes in early war pictures. As Michael Burleigh (2011) points out, World War II films, in particular, depicted the conflict in stark terms of good and evil. America and its allies exemplified democratic freedom, whereas the Axis countries symbolized fascist oppression. This black-and-white vision extended to combat heroism; American troops fought heroically for a moral cause, while opponents were villainized.

For example, in *Sands of Iwo Jima* (1949), the Japanese forces are solely shown as faceless aggressors who are defeated by the Marine heroes' superior weaponry and fortitude. The enemy's point of view is not explored; it is simply their function as antagonists. Similarly, *The Great Escape* (1963) portrays German forces as oppressive masters without looking into their intentions. Courage is defined as defying evil in the face of overwhelming odds.

Even Vietnam War films presented a basic moral distinction between Americans as heroic underdogs and Vietnamese as scary aggressors (Taylor, 2003). As Douglas McLeod (2009) argues, complicated political realities were neglected in favor of presenting Vietnam as a battleground where American heroism could be tested. Moral dilemmas associated with guerilla warfare and unpopular goals were often avoided.

As a result, previous war films usually focused on simple, even dehumanizing representations of the enemy to highlight the valor and sacrifice of American heroes. Heroes were depicted in sweeping, iconic terms by putting warriors within simplistic moral frameworks of good against evil.

Archetypal Hero Characters

In addition to basic moral framing, previous war films depicted heroism through the employment of iconic core characters who represented idealized values. As Tasker (1993) points out, World War II films, in particular, portrayed heroes as stoic, unwavering symbols of honor and courage.

For example, in *Sands of Iwo Jima*, John Wayne's Sergeant Stryker exemplifies the ideal professional soldier: fierce, uncompromising, and completely devoted to the Marine Corps ethos (Suid & Culbert, 1991). His physical strength, self-sacrifice for his warriors, and personification of rugged American individualism all serve to highlight his heroic traits. Similarly, in *The Great Escape*, Steve McQueen is the perfect cool, rebellious hero, resisting the adversary with ingenuity and tenacity.

During the Vietnam War, films like *The Green Berets* (1968) and *Apocalypse Now* (1979) offered more complex characters while still imbuing them with an iconic warrior mystique. Douglas McLeod (2009) contends that they offer a "model of manliness" to be respected for their fighting accomplishments rather than nuanced humanity. Their conflicts serve as crucibles to confirm their bravery.

In this traditional mold, war films used heroic motifs and typically male attributes such as stoicism, aggressiveness, and individuality to create appealing focal characters whom spectators could admire. Their heroism was portrayed in legendary ways rather than being critically investigated.

III. PRE-IRAQ WAR: HEROISM IN BLACK AND WHITE, EVOLVING TOWARDS NUANCE

Before the Iraq War, the concept of heroism in military contexts was often depicted in stark black-and-white terms, grounded in clear moral distinctions and unambiguous valor. From the ancient epics of Homer to the celebrated figures of World War II, war heroes were traditionally portrayed as paragons of virtue, embodying bravery, honor, and self-sacrifice. However, as the 20th century progressed, especially during conflicts like the Vietnam War, these depictions began to shift. The complexities of modern warfare, characterized by political

ambiguity and the psychological impacts on soldiers, started to emerge in the cultural narrative, gradually introducing shades of gray into the once clear-cut image of the war hero. This evolution set the stage for the more nuanced and conflicted portrayals that would come to define the era of the Iraq War.

The Vietnam War Era

Before the Iraq War, American war films often depicted heroism in black and white, with defined concepts of courage, honor, and morality. World War II films straightforwardly portrayed heroism, with American soldiers battling wicked enemies for noble ideas like liberty and democracy. Characters were archetypes, such as the dashing captain, fresh-faced recruit, and stoic hero. The war was portrayed as a noble journey where men found their full potential. *Apocalypse Now* and *Platoon* contributed shades of gray to Vietnam combat filmmaking, but they continued to present war as a mythical rite of passage. The divisions between good and evil remained mostly unchanged. In the 1990s, films like *Saving Private Ryan* predicted post-9/11 uncertainty, and depictions of enemies became more humanized and less simple. Good and evil blended together, with heroism and savagery sharing the same frame.

A Paradigm of Clarity: Heroic Archetypes and Moral Certainty

During World War II and the Cold War, American combat films presented heroism using a paradigm of moral clarity and conviction. According to Tasker (1993), films of this era depended primarily on iconic characters who represented unflinching belief and courage. From John Wayne as the personification of raw American courage in The *Sands of Iwo Jima* (1949) to Steve McQueen portraying relentless cool defiance in *The Great Escape* (1963), leading males functioned as aspirational military heroes (Suid & Culbert, 1991). Enemies were presented in simplified, often dehumanized terms as cruel villains to be conquered by these courageous heroes (Doherty, 1999).

The complexities of geopolitics were portrayed in unequivocal tones of good against evil, with American soldiers' intentions cast as unquestionably just. Instead of profound contemplation, courage was portrayed as a matter of grit, sacrifice, and obligation. Moral quandaries were ignored in favor of exciting fighting spectacles and celebrations of martial might in the face of hardship. The Hollywood war machine mythologized heroism as a question of might for right by focusing films on clarity and conviction.

Before the Iraq War, American war films frequently adhered to a well-defined moral framework. This framework showed unambiguous contrasts between heroic American protagonists and evil antagonists, reflecting the dominant ideas and experiences of the period, notably during World War II and the Cold War. Examining renowned instances such as *Saving Private Ryan* (1998) exposes the archetypical hero at its heart. Captain Miller and his team represent the idealized soldier: brave, unselfish, and determined to complete their task at any cost. Their voyage emphasizes themes of sacrifice, patriotic responsibility, and steadfast perseverance in the face of adversity.

The enemy, frequently represented by the Nazis in these films, represents pure evil and serves as a stark contrast to the American heroes. This dramatic difference echoed the widespread good vs. evil narrative used to explain battles like WWII, and it generated a feeling of national unity and purpose.

Shifting Ground: Moral Ambiguity and the Emergence of Trauma

While films like *Platoon* (1986) honor the bravery and sacrifice of troops like Chris Taylor, they also stretch the bounds of the standard narrative (Canby, 1986). Sergeant Barnes represents the moral complications that

may occur during combat, demonstrating the capacity for violence and depravity among humans. This ambiguity calls into question the simple presentation of good against evil and encourages viewers to consider the ethical quandaries that arise during battle. Furthermore, *Platoon* explores the long-term psychological effects of combat, highlighting Post-Traumatic Stress Disorder (PTSD) and the difficulty of reintegrating into civilian life (Corliss, 1986). This feature, which was mainly lacking in earlier films, contradicted the idealized image of the indestructible soldier and underlined the ongoing toll of battle.

Oliver Stone's film *Platoon* (1986) stood out as one that challenged the limitations of the standard military narrative. It not only recognized troops' valor and sacrifice, but it also investigated the moral difficulties of combat situations. The figure of Sergeant Barnes, played by Tom Berenger, serves as a dramatic personification of these nuances, highlighting the capacity for violence and evil inside humans even amid battle.

The film questions the oversimplified presentation of good against evil that was typical in previous war films. Sergeant Barnes' dubious acts and judgments push viewers to confront the ethical quandaries that might occur amid combat. The uncertainty surrounding Barnes demonstrates that people on the same side of a war can have dramatically different moral compasses, adding levels of subtlety to the tale.

Oliver Stone, who had participated in the Vietnam War, added a distinct viewpoint to *Platoon*. His experiences inspired the film's portrayal of the psychological effects of war. The film goes beyond presenting conflicts on the battlefield to investigate the long-term repercussions of combat on troops. Stone's portrayal of PTSD and the struggle to reintegrate into normal life adds an element of realism that was mostly lacking in older war pictures.

The depiction of the psychological toll of battle calls into question the idealized image of the indomitable soldier that was common in many previous films. It humanizes the characters by exposing their sensitivity and the challenges they experience in dealing with the trauma of war. This change in emphasis from the heroism of combat to the human cost of fighting represented a divergence from the more typical war tales of the period.

While it's important to remember that the film is a work of fiction, Oliver Stone was inspired by his personal experiences as well as the stories of other Vietnam War veterans. The reality and gritty nature of *Platoon* contributed to its critical acclaim and influence on the representation of war in cinema.

To summarize, *Platoon* is a remarkable example of a film that questioned the standard war narrative by injecting moral ambiguity, investigating the psychological cost of war, and facing the long-term toll of fighting on people. Its sophisticated representation of people and the intricacies of combat situations have had a lasting impression on how war is represented in movies.

Beyond Archetypes: A Spectrum of Representations

It is critical to recognize that American war films prior to the Iraq War were not homogeneous. Films like *The Bridge on the River Kwai* (1957) provided nuanced representations of wartime solidarity and perseverance, while *Casablanca* (1942) portrayed Rick Blaine as a morally complicated protagonist contending with personal wants and wartime decisions against the backdrop of Nazi rule. Even *The Deer Hunter* (1978), published in the Vietnam War era, probed the psychological consequences of the war beyond clear-cut heroics, stressing the ongoing grief and loss endured by a group of friends.

Before the Iraq War, American war cinema was diversified, with complex depictions that went beyond conventional heroics. This intricacy is exemplified by films like *The Bridge on the River Kwai* (1957) and *Casablanca* (1942), each of which offers a distinct viewpoint on wartime situations.

The Bridge on the River Kwai, directed by David Lean, is a World War II film about the intricacies of wartime brotherhood and endurance. The story focuses on British prisoners of war who are forced to build a bridge for their Japanese captors. The film digs into the individuals' moral intricacies as they juggle devotion, duty, and the terrible reality of war. It gained great acclaim for its investigation of the human condition in the midst of conflict.

The iconic film *Casablanca*, directed by Michael Curtiz, is set in Nazi-occupied Morocco during World War II. The film follows Humphrey Bogart's Rick Blaine, a morally complicated protagonist who struggles with personal wants and wartime decisions. *Casablanca* is known for its complex characters and examination of themes like sacrifice, love, and resistance. It has become a cultural classic, acclaimed for its narration and engaging dialogue.

The Deer Hunter (1978), directed by Michael Cimino, is another major picture produced during the Vietnam War era. While the film is set in the context of the war, it goes beyond obvious heroics to investigate the psychological consequences of the fight. The video follows a group of friends from a tiny Pennsylvania town as they recount their experiences in Vietnam and the ongoing anguish and grief they endure upon returning home. *The Deer Hunter* has gained critical acclaim for its portrayal of the human cost of war and the difficulties of the postwar experience.

These films show that, even before the Iraq War, American war cinema dealt with the intricacies of human experience during times of combat. They provided complex portraits of characters dealing with moral quandaries, psychological trauma, and the long-term effects of war on individuals and societies.

While pre-Iraq War films frequently featured traditional heroes and clear-cut conflicts, films such as *Platoon* and *The Deer Hunter* began to include moral ambiguity and psychological concerns, establishing the framework for the substantial shift in hero depictions seen in post-Iraq War films. This history reflects not just evolving attitudes toward war but also an increasing realization of its intricacies and the human cost it imposes on those engaged.

III. IMPACT OF THE IRAQ WAR

The start of the Iraq War in 2003 constituted a watershed moment in both American foreign policy and society. As popular support for the invasion dwindled, a national sense of outrage, disappointment, and reflection evolved (Rehm, 2015). Many people believed that the moral clarity of previous battles had been replaced by a quagmire of dubious intentions, uncertain aims, and leadership deception (Hall & Vassiliou, 2023). This rising doubt and mistrust penetrated American society, including the myth-making myths about war and heroism. The scene was set for a new era in combat pictures, coping with the complexity of the post-9/11 world.

Disillusionment with the War Changed Public Perception

In the months following the 2003 invasion of Iraq, public opinion polls revealed overwhelming support for the war effort and faith in its logic (Newport et al., 2003). However, when the occupation devolved into disorder and the justifications for the invasion were contested, the American people became deeply disillusioned (Althaus and Coe, 2011).

Whereas World War II was largely recognized as the "good war," Iraq came to be regarded as a "mistaken war" motivated by false pretenses (Rehm, 2015). By 2008, two-thirds of Americans thought the decision to invade Iraq was rash, and many drew parallels to the Vietnam War (Holsti, 2011). For many in the public, the big story of America battling evil tyranny no longer resonated (Hall & Vassiliou, 2023).

As Patman (2006) points out, the uncertainties and conflicts surrounding post-9/11 foreign policy sparked an identity crisis over American exceptionalism. The Iraq War replaced the Gulf War's moral clarity with uncertainty of purpose and doubts about the abuse of power (Kellner, 2010). For many residents, the simple ideals of courage, honor, and patriotic duty no longer corresponded to the complicated reality on the ground.

This widespread disenchantment laid the foundation for a new age of American war films striving to make meaning of ethically difficult conflicts, changing views of duty, and the psychological toll of fighting.

This widespread disenchantment paved the way for a new age of American war films that rejected basic ideals and stereotypes in favor of making sense of ethically difficult battles, shifting notions of duty, and the severe psychological toll of fighting on troops. Whereas the films of World War II and Vietnam still offered scope for mythologized images of heroism, the complicated reality surrounding post-9/11 wars needed an approach that challenged established narratives and examined the darker, more traumatic parts of combat experiences.

As the big illusions of the Iraq War dissipated, American viewers were ready for a movie that no longer depicted valor in broad patriotic strokes. Instead of idealized heroes triumphing in conflict, films would now address the ethical ambiguities and emotional consequences suffered by soldiers throughout the War on Terror era. This disappointment influenced both the production and reception of a new generation of war films.

The crumbling justification for the Iraq War paved the way for films that rejected simplistic moral frameworks, instead immersing spectators in the uncertainty of motivations and techniques that marked post-9/11 wars. Where John Wayne personified heroic determination, the new heroes would personify the nation's wounded psyche, searching for meaning amid the complicated human implications of contemporary conflict.

War Films Began Reflecting this Evolving Perspective

As public opinion altered, American war films began to reflect the culture's increasing disenchantment and reject the simple clichés of the past. Instead of supporting nationalistic narratives, films explored the moral complexities and psychological effects of the War on Terror (Rehm, 2015).

Jarhead (2005) was an early sign of this tendency, depicting Marines striving to find purpose in the first Gulf War when it failed to meet their expectations of bravery. As Prince (2009) contends, the film exposes the mismatch between the idealized heroic ideals the characters acquired from Vietnam War movies and the prosaic, confusing reality of their own combat experience.

Later films, such as The Valley of Elah (2007) and *The Hurt Locker* (2008), went further in depicting the upsetting experiences of troops in Iraq, emphasizing the futility and psychological impact of battle (Hegen, 2015). These films avoided glamor in favor of ground-level immersion in the worries and traumas that plagued post-9/11 military personnel.

Whereas earlier war films selectively depicted battle to promote fortitude in the face of adversity, post-9/11 filmmaking expressed conflicting opinions on the purpose and consequences of war. According to Kellner (2010), the new films addressed issues like ineffective leadership, deceit about war goals, and the destruction of PTSD. Heroism was not extolled but questioned.

Earlier war films selectively showed battle to reinforce fortitude in the face of adversity, while post-9/11 cinema expressed more conflicting opinions on the war's purpose and human costs. According to Kellner (2010), films such as The Valley of Elah, Grace is Gone, and The Messenger addressed issues such as ineffective leadership, misinformation about war goals, and the catastrophic effects of PTSD. Heroism was not glorified, but rather shown as more unstable and ethically dubious.

Pheasant-Kelly (2019) contends that post-9/11 films questioned the typical war movie narrative arc of youthful recruits transformed into warriors via conflict. Instead, many people focused on injured and disgruntled soldiers who were trying to reintegrate into society. Their experiences bring into question the long-term significance of wartime heroism.

Rather than traditional demonstrations of heroic sacrifice, contemporary war films concentrate on fragmented psyches, widespread worry, and the moral harm caused by modern asymmetrical conflict (Russell, 2004). Audiences witnessed how incidents such as unintentional civilian fatalities, tense occupations among communities, and ambiguous goals harmed troops' moral and mental health in various ways.

To summarize, post-9/11 war movies called into question basic concepts of heroism and honor by focusing on the hardships troops experienced both during and after the conflict. Their sacrifices were represented as both unsettling and noble.

Initial Portrayals of Heroism and Patriotism in War Films Related to The Iraq War

During the early stages of the Iraq War, war films portrayed valor and patriotism, reflecting popular support and the Bush administration's narrative. However, this support eroded over time. Early films like We Were Soldiers (2002) used traditional images of combat heroism and sacrifice, promoting the nobility of the cause in Iraq. Films like The Kingdom (2007) and Green Zone (2010) presented a more complex, less triumphant view, reflecting growing public doubts about the invasion's rationale. Over time, Iraq War films became more sober, critical, and focused on individual soldiers' experiences rather than ideology or politics. Movies like *The Hurt Locker* (2009) and *American Sniper* (2015) highlighted the ambiguities and psychological impacts of the war.

Traditional Heroism

During the early stages of the Iraq War, films portrayed heroism and purpose, aligning with the Bush administration's moral framing. Films like "Behind Enemy Lines" (2001) and "Tears of the Sun" (2003) depicted selfless American soldiers risking their lives to rescue civilians and fellow soldiers (Kolmer & Semetko, 2013). These films played into the good versus evil narrative, with Saddam depicted as a tyrannical dictator justifying intervention on human rights grounds. Films like "Fair Game" (2010) highlighted Iraqi WMDs as a key rationale. They also evoked patriotic spirit and unwavering national support for the troops, conveying a mood of hope and anticipation about the military campaign.

Cautious Optimism

Even within the traditional war hero genre, some early Iraq War films introduced a level of moral complexity and psychological nuance. As McSweeney notes, movies like *Jarhead* (2003) and "Stop-Loss" (2008) touched on the "brutalizing effects of combat" and the emotional toll faced by soldiers, challenging simplistic heroic tropes (2014). Rather than triumphant victory, these films explored the uncertainties and cruel irony emerging

from a conflict rationalized on dubious grounds. Building on this complexity, other films emphasized the strong bonds of brotherhood forged between soldiers, highlighting the human emotional core of war.

As Daniel Binns discusses, movies like "Black Hawk Down" (2001) and "World Trade Center" (2006) foregrounded the camaraderie and sacrifices made by men for their peers under extreme conditions (2017). This narrative arc granted soldiers individual dignity and purpose, even when the overarching war effort lost moral clarity in the eyes of the public. The soldier thus retained heroic status, even as the war itself was questioned. Diverse perspectives emerged even in the early years. Films like "Fahrenheit 9/11" (2004) and "Syriana" (2005) offered critical views of the war and its justifications, foreshadowing the increasingly nuanced and critical portrayals that would arise later in the decade.

IV. NEW PORTRAYALS OF HEROISM

After 9/11, American movies began to represent courage and sacrifice in more serious tones, moving away from simple moral framing and idealized stereotypes and toward more nuanced investigations of the soldier experience (Bergstrand & Jasper, 2018). This change mirrored the nation's skepticism toward the War on Terror. Following 9/11, war films frequently took on a sad, philosophical tone, depicting troops as broken, disillusioned, and confused, mirroring the country's grappling with the human toll of war. The new movie exposed dizzying intricacies rather than simple heroes.[3]

More Nuanced and Morally ambitious

Moral ambiguity and subtlety are key characteristics of heroic representation in post-9/11 movies. In contrast to the moral clarity of previous conflicts, the War on Terror has featured ambiguous foes, imprecise aims, and asymmetrical fighting circumstances (Russell, 2004). To reflect this complexity, films have shifted away from basic notions of heroism and toward murkier images. Films represent these complexities.

Whereas World War II films told simple stories of virtue triumphing over evil, post-9/11 films wrestle with the ambiguous morality of preemptive invasion, intensified interrogation, and occupation-related quagmires. Just as the public lost consensus on the legitimacy of conflicts, the new war movie accommodates disputed notions of duty and justice (Shepherd, 2008).

Instead of the daring exploits and gallantry of warriors in previous conflicts, current films frequently depict combatants as broken, disillusioned, and tormented. Their sacrifices are portrayed as ethically complex rather than merely heroic. The goal and morality of the wars, like that of the nation, are difficult to comprehend; therefore, the post-9/11 film has embraced ambiguity rather than clarity.

For example, *The Hurt Locker* (2008) centers on an explosive ordnance disposal squad whose psychological toll is compounded by the specific strains of their profession and an uncertain mission mandate. Their heroism is put into doubt when uncontrolled violence and a desire for risk take precedence over professionalism (Tasker & Atakav, 2010). Similarly, *American Sniper* (2014) sparks questions about heroism by depicting Chris Kyle as both a peerlessly lethal warrior and a terribly wounded man, emphasizing inconsistencies (Desplanque, 2015).

As Kalentzi (2016) argues, post-9/11 films encourage ambiguity by commonly depicting protagonists who are both antiheroes and inspirational. Their reasons are diverse, as are their traumas. It is uncommon to find a clear

[3] See for example Tobias, S. (2023, March 17). From *The Hurt Locker* to *American Sniper*: How Hollywood tried to tackle the Iraq War. The Guardian. https://www.theguardian.com/film/2023/mar/16/hollywood-iraq-war-hurt-locker-american-sniper

antagonist. Audiences are asked to analyze nuanced personal and political backgrounds instead of being readily informed about whom to support.

Contemporary war films reflected troops' heroics through a prism of moral doubt that was appropriate for the unstable post-9/11 times, depicting them in shades of gray rather than as prototypes of unwavering fortitude. As the country lost consensus on the legitimacy of far-flung battles, the harm done to civilian populations, and the efficiency of torture, filmmakers dealt with the uncomfortable ethics of contemporary war (Shepherd, 2008).

Whereas John Wayne epitomized unflinching conviction, the new protagonists were plagued with skepticism, not only about their aims but also about their own techniques and involvement. These images paralleled America's introspection about its use of armed might in the service of peace and freedom. Just as society questioned if the human costs were worth the benefits, the post-9/11 film was immersed in similar uncertainty.

Films rejected simple affirmations of heroism by portraying troops' wounds and flaws, instead reflecting the nation's reservations and confused emotions about the War on Terror. Simplicity gives way to difficult contemplation.

Themes of Trauma, Blurred Lines of War, and Terrorism

Another distinguishing element of heroic representation in post-9/11 films is a strong emphasis on trauma. Unlike previous films, which minimized or glorified battle trauma, contemporary films have unflinchingly highlighted the devastating impact of PTSD on troops. Films like Home of the Brave (2006) and Grace Is Gone (2007) focus on characters who have been irreversibly wounded by horrific experiences in Iraq and Afghanistan, putting into doubt the heroism of their sacrifices. According to Pheasant-Kelly (2019), the trauma motif symbolizes America's grappling with the human consequences of the War on Terror, which include high PTSD rates among soldiers (Reuters, 2007).

Traditional heroic tales were further complicated by films like Syriana (2005) and Lions for Lambs (2007), which highlighted the hazy boundary between militants and civilians, calling into question whether the term "hero" could apply in complex, asymmetrical battles. According to Kellner (2010), films' dramatic depictions of collateral damage and civilian casualties reflected rising popular misgivings about the morality of the Iraq invasion. By diving into trauma and moral harm, post-9/11 filmmaking deviated from the romanticism of prior war films to deconstruct the psychological and ethical complexity of the War on Terror.

Furthermore, the visual aesthetics of films like *The Hurt Locker* (2008) and *American Sniper* (2014) reflect the strain and confusion of soldiers' experiences. Shaky camerawork, unexpected violence, and a subdued color palette created an unpleasant mood that avoided glamor. According to Prince (2009), post-9/11 films used a brutally realistic manner to take viewers into the turmoil of battle zones and the loneliness of returning home, challenging selective interpretations of the past. From topic to images, contemporary war films discovered new ways to dismantle old concepts of honor and heroism, instead focusing on the scars left by a cruel, demoralizing combat.

Films Explored Complexity Rather Than Simplistic Heroes

Instead of portraying conflicts in easy moral terms and emphasizing brave patriotic sacrifice, post-9/11 films grappled with difficult issues of ethics, trauma, and purpose. According to Pheasant-Kelly (2019), films such as The Valley of Elah, Stop-Loss, and The Messenger disregarded the traditional war movie model of following

young men who have been transformed by battle experience. Instead, they concentrated on the problems veterans experienced in reintegrating into society, having had their psyches damaged in ethically dubious battles overseas (Gosline, 2024). These videos embody the national atmosphere of sober contemplation on the human consequences of the War on Terror.

Similarly, post-9/11 films investigated the tensions inherent in occupation and counterinsurgency roles, where heroic ideals were hampered by concerns such as a lack of cultural understanding, unintended civilian losses, and an inability to discriminate against opponents. Films such as Green Zone (2010) and Lions for Lambs (2007) pushed audiences to look beyond simplistic concepts of heroism to investigate the unforeseen repercussions of warfare (Kalentzi, 2016). Rather than glorifying heroic motifs, post-9/11 films sought depth in hopes of making sense of ethically and tactically intricate 21st-century conflicts (CSIS, 2006).

Instead of portraying conflicts in easy moral terms and emphasizing brave patriotic sacrifice, post-9/11 films grappled with the difficult complexity of ethics, trauma, and purpose in modern warfare. The idealized heroic images of past times gave way to more somber reflections on the expenses suffered by troops and civilians. Whereas World War II movies told magnificent stories of brave Americans fighting evil, films about Iraq and Afghanistan were morally ambiguous. Clear-cut notions about duty gave way to complex accounts of traumatized soldiers trying to justify their acts and reintegrate into society.

As the country lost consensus on the goals and tactics of the Iraq war, filmmakers lost interest in presenting battles as heroic undertakings. Audiences were faced with careful narratives of suffering, uncertainty, and ambiguous purpose - reflecting the national reckoning with the human effects of ill-defined 21st-century wars.

V. ANALYSIS OF KEY FILMS

An examination of three seminal films: *Jarhead*, *The Hurt Locker*, and *American Sniper*, reveals the changing viewpoints on heroism and sacrifice in post-9/11 American filmmaking. These films capture the variety of methods that contemporary war films have taken in dealing with the uncertainties of modern battle. From *Jarhead*'s philosophical pondering to *The Hurt Locker*'s tight thrills to *American Sniper*'s biographical approach, these films highlight the new perspectives and techniques that directors use to rethink old concepts of heroism under danger. By studying these works side by side, trends emerge concerning the complex engagement of post-9/11 cinema with heroism.

Jarhead (Disillusionment)

Jarhead (2005) captures the disenchantment with war that pervaded American culture in the aftermath of 9/11. The film, based on Anthony Swofford's Gulf War memoir, follows a squad of excited young Marines who arrive in the Middle East prepared for action, only to become bored, lost, and purposeless when the imagined grandeur of war fails to materialize. According to Buchalski (2013), *Jarhead* subverts the typical war movie narrative: there is no climactic fight, inspiring speeches, or opportunities for the heroes to demonstrate their heroism. Instead, they grow increasingly skeptical of nationalistic rhetoric and its aim.

According to Prince (2009), the film emphasizes the protagonists' feelings of emasculation and alienation as battle fails to live up to their expectations shaped by prior pop culture. Their journey through the desert reflects the public mindset toward the ambiguous ethics and need for post-9/11 warfare. As Raphael S. Cohen (2010)

points out, the Gulf War's questionable legacy foreshadows the complexities to come in Iraq and Afghanistan.[4] *Jarhead*'s meditative tone appropriately focuses on the soldiers' growing doubts about military power achieving just ends.

Jarhead reexamined heroism through a leisurely pace and philosophical voiceovers, removing the action and honor that had been important to prior war pictures. The end product was a somber reflection on the sometimes hopeless quest for meaning via conflict. Instead of exhilaration and success, *Jarhead* focuses on the monotony, bewilderment, and seething resentment that result from an anticlimactic conflict (Dwyer, 2016).

Whereas films like *Apocalypse Now* depict war as a hallucinogenic spiral into lunacy, *Jarhead* depicts the surreal grind and absurdity of battle. Revelations arise not from violent fighting but from countless days of preparation and desert patrols. The film defines bravery as persisting in this mundane purgatory.

Jarhead uses silence and reflection to dismantle war film myths. As the protagonists' young idealism deteriorates into jaded cynicism, viewers are forced to consider the futility of achieving glory in modern warfare. The hero's journey is reframed as a gradual death of the soul.

The Hurt Locker **(Psychological Trauma)**

If *Jarhead* hinted at the disenchantment of post-9/11 battles, *The Hurt Locker* steeped moviegoers in the acute psychological toll. The film, which followed an elite Army bomb squad team in Iraq, captured the terrifying tension of asymmetrical urban combat. According to Pheasant-Kelly (2019), the film combines constrained framing and unsteady handheld camerawork to represent the persistent fear of an ambush or explosives. Ordinary streets take on a sinister quality.

The Hurt Locker, rather than glorifying conflict, focuses on its traumatic consequences. Sgt. James' addiction to the adrenaline rush of battle stands in stark contrast to fellow troops who are dulled by tragedy and counting the days until they may leave Iraq. According to Bennett (2011), the film portrays conflict as more terrifying than ennobling. Soldiers are traumatized sufferers, not heroes. As A. O. Scott (2010) pointed out, Sgt. James is a multifaceted protagonist whose gallantry is more reckless than honorable. His psychological breakdown under great stress exemplifies war's ability to pervert morals. *The Hurt Locker* deconstructs heroism through its conflicting character.

The Hurt Locker reframed war as primarily painful by immersing audiences in the tense atmosphere of conflict zones. Courage was not celebrated, but rather probed. *The Hurt Locker*'s emphasis on the devastating impacts of battle is visible not just in the chaotic bomb disposal scenes but also in peeks into troops' lives back at base. As Pheasant-Kelly (2019) points out, instances like Eldridge solemnly lamenting a fallen colleague or Blix drinking himself to sleep illustrate the wounds caused by protracted anxiety and grief. Previous war films exploited "downtime" for companionship and comedy, while *The Hurt Locker* focuses on loneliness, sadness, and estrangement from civilian life back home.

According to Bennett (2011), the film's unorthodox structure accentuates trauma by repeatedly plunging spectators into an unclear combat situation that is currently in progress. This confusion reflects the detached, adrenalized worldview of troops like Sgt. James, for whom war has become an addiction rather than a

[4] For more questions and answers see Rollins, P. C., & O'Connor, J. E. (Eds.). (2008). Why we fought: America's wars in film and history. Film and Media Studies (Vol. 24). University Press of Kentucky. https://uknowledge.uky.edu/upk_film_and_media_studies/24

responsibility. According to Poniewozik (2008), James' recklessness and need to defuse explosives on his show a loss of control. His heroism carries hints of trauma-induced craziness.

In conclusion, James's PTSD and nihilism trumped typical warrior traits such as professionalism, teamwork, and compassion. *The Hurt Locker* deconstructs the concept of heroes in war via its collapse. Their psyches have been blown apart, much like the film's ambiguous sequences.

American Sniper (Blurred Lines)

If *The Hurt Locker* looked at the psychological toll of conflict, *American Sniper* handled the ethical murky zones of war among civilians. The film, loosely based on Navy SEAL Chris Kyle's biography, sparks arguments about personal heroics vs. a larger political context.

Kyle is presented as peerlessly competent and fearless in battle, but with a rigid warrior mentality that makes it difficult for him to adjust to family life, according to Prince (2015). Scenes depicting the destruction perpetrated on Iraqi families challenge his determination to protect fellow soldiers at any cost. According to Kalentzi (2016), the film's mixed reaction resulted from the conflict between Kyle's personal valor and the war's disastrous consequences.

According to Julia Boll (2010), while Kyle is filmed respectfully, previous sequences establishing his motive present the 9/11 events in magical terms that lack the complicated historical backdrop leading up to Iraq's invasion. This muddies the connection between his service and avenging 9/11, calling into question the crusade's uncomplicated righteousness.

The story of *American Sniper* hinges around Kyle's psychological battle to explain collateral harm as unavoidable. His valor is mediated through not just pain, but also the contentious topic of whether the war's goals justified its tactics. The film allows people to draw their own judgments based on inadequate data.

The film's portrayal of Kyle's motivations avoids addressing arguments of the war's legitimacy, instead depicting 9/11 and its aftermath in broad and mythological terms. This portrays Iraqis as uniformly menacing rather than dealing with the strategic reasons that fueled the insurgency. Kyle's desire to return for many deployments becomes a matter of personal commitment rather than politics (CSIS, 2006).

Kalentzi (2016) contends that the film's lavish depictions of Kyle's successful sniper shots aestheticize his abilities by portraying lethal force as a fascinating spectacle. This glorification is juxtaposed with images of dead Iraqi women and children, which highlight the consequences of war for civilians. The film's ambiguous mix of admiration and sobriety toward violence mirrors America's conflicting views on the tactics and consequences of invasion.

Kyle is given the opportunity to justify his behavior, according to Prince (2015), but the film chooses not to address his inconsistencies, instead focusing on his psychological issues. This reluctance toward pure hero worship, yet inability to criticize, echoes the nation's own difficulties reconciling the soldiers' sacrifice with the war's catastrophic repercussions.

VI. CONCLUSION

The Iraq War marked a turning point in American film, leading to a shift from simple, morally straightforward war movies to more nuanced, philosophically introspective depictions of courage and sacrifice. As the War on Terror became a complex issue with questionable intentions, ambiguous aims, and misinformation, filmmakers

shifted from simple, flag-waving war pictures to addressing complex issues of trauma, morality, and purpose in modern combat. Post-9/11 combat films, such as *Jarhead*, *The Hurt Locker*, and *American Sniper*, took a more nuanced approach, scrutinizing heroism rather than mindlessly celebrating it. These films reinvented heroism for an era of uncertainty and fear about the human costs of war, using subtle tones and disturbed plots to question traditional ideals of courage.

Whereas earlier films emphasized heroic moments, post-9/11 filmmaking focused on the harsh, scarred toll of conflict. Films reinvented heroism for an uncertain period by unflinchingly addressing the nation's doubts about Iraq. They gave voice to troops' feelings of bewilderment, fear, and dubious missions that challenged traditional notions of honor. This lens portrayed heroism as a painful, uncertain sacrifice rather than a glorious mission. The idea of magnificent national courage diminished as viewers realized war's horrific human consequences.

Eventually, the film of the Iraq War era progressed beyond basic representations to demonstrate heroism in more deliberate, complicated ways. Films like *Jarhead*, *The Hurt Locker*, and *American Sniper* rejected the simple morals, strong archetypes, and triumphalist tones of earlier war films. In their place arose tormented antiheroes, lens flare-laden Iraq battlescapes, and subtle philosophical narration. By reflecting the public's mistrust and disappointment, post-9/11 films created a study on the nature of heroism in an ambiguous, asymmetrical struggle. They wondered if heroism could exist in conflicts without victory or purpose. Audiences were struck with the unpleasant facts brushed over in past film mythologies.

Faced with the brutal realities of the Iraq War, American filmmakers discovered a new vocabulary of reflection and moral uncertainty. What emerged was a portrait of heroism that acknowledged its great emotional cost, often futility, and ability to both justify and degrade the human spirit. The reduced traditions led to an unsettling examination of sacrifice in all its ambiguities.

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MATTERS OF MORPHOLOGICAL HOMONYMY IN THE ALBANIAN LANGUAGE

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Abstract – The formal alignments in the Albanian language have proceeded in accordance with the general trend of its transition from a synthetic-analytical language to an analytical-synthetic language. The phenomenon of the unification of grammatical forms has not acted equally in all lexical-grammatical categories. So often the same grammatical meanings, grammatical forms have developed in different ways. The speed of their development is conditioned by the general syntactic connections and by the special syntagmatic connections.

In the Albanian language, two contrasting morphological developments are observed: over-characterizations of grammatical forms and units of grammatical forms. However, the developments and trends of these phenomena have been and are of different degrees. Over characterizations are mainly consequences of historical developments, which belong to linguistic periods with generally wide inflection. But this phenomenon has been limited. The process of the unification of grammatical forms has been more extensive because the factors that have influenced this process have been more numerous and more active.

Keywords –adjectival system, grammatical form, morphological homonymy.

Introduction

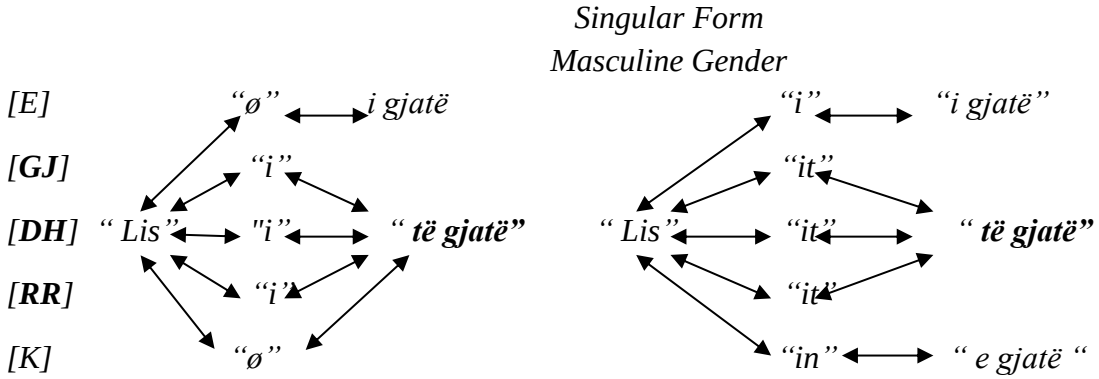
In the progress of the morphology of adjectives, the cyclical formal developments, conditioned by the morphological-syntactic conditions, are observed better than anywhere else. The place of adjectives in the structure of the phrase has been unstable. If we go too far, it is known that languages, in general - including Albanian - have not had an appetite. In this period, which is also called paragrammatical, communication was built according to the successive perception of words. The grammatical stage, or adaptation stage, is represented as the period of grammatical improvement. The adjective, due to its relative semantic independence, as a word that names a feature, necessarily also requires the carrier of the feature, which can be expressed or implied. This is the reason that it is always, and especially in the grammatical period, morphologically adapted to the name.

Demonstration of homonymy

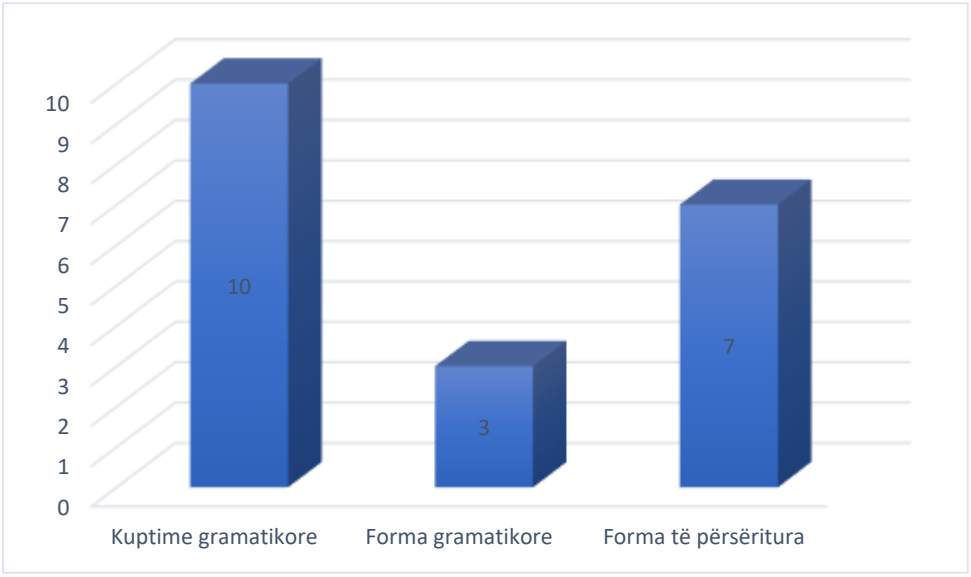
At the beginning of the grammatical period, the morphological adaptation of the adjective to the noun was complete both case by case and tool by tool. The grammatical connection between them is not established through place, but through the same grammatical tool. In the later periods of development, due to the strong semantic connection between thing and feature of the thing, the adjective was drawn from the noun, before or after it, but with the most direct connection to it. At each stage of development, the surname has changed form both by itself and under the influence of the name. In any case, phonetic and analogical factors have also influenced. However, in the initial period of complete eptation, the changes of the eptic means have been slower and more careful not to be completely disfigured, because the connection with the name would be severed; the noun would not "know" the adjective and the adjective would not "know" the noun. In the period of embedding the adjective next to the noun, the changes of the eptical means to one and the other limb of the noun-adjective or adjective-noun syntagm were freer.

In the Albanian language, in general, in the syntagm noun + adjective, the eponymous changes are preserved by the first part of the noun. This is the reason that the adjective in this period of imprinting lost its case endings, thus returning to the almost paragrammatic state. This process, in the new syntactic conditions, was natural, because the language, in general, does not accept eptic overloads. The stable semantic connection - in these conditions - and the direct syntactic one, similar to the connection “I will work”, made the double eption unnecessary in both members of the stable syntagm: both the noun member and the adjectival member. This linguistic truth in Albanian is evidenced by the state of infinitive adjectives, which do not need racial inflection. The idea that the front part of the adjective appeared as a need for a "sui generis" grammatical readjustment, when its case endings were dropped, is not convincing and in many points can be criticized.

In today's Albanian Language, nominative adjectives in the composition of the syntagm noun + adjective change according to the cases the front node, creating the impression that this change also reflects a morphological need. For us, the change of the form of the nodule of adjectives according to cases is a residual linguistic condition. The forms of the front nodes reflect the grammatical forms of the demonstrative pronouns from which the nodes are derived, which had case morphological value for datives, but not for adjectives. One of the convincing proofs of the non-racial values of the front nodes of adjectives is the fact that they, from their acquisition and in all subsequent periods - even today - have tended and tend towards unity. In today's state the racial homonymy of nodes is widely extended; in some cases it is comprehensive:

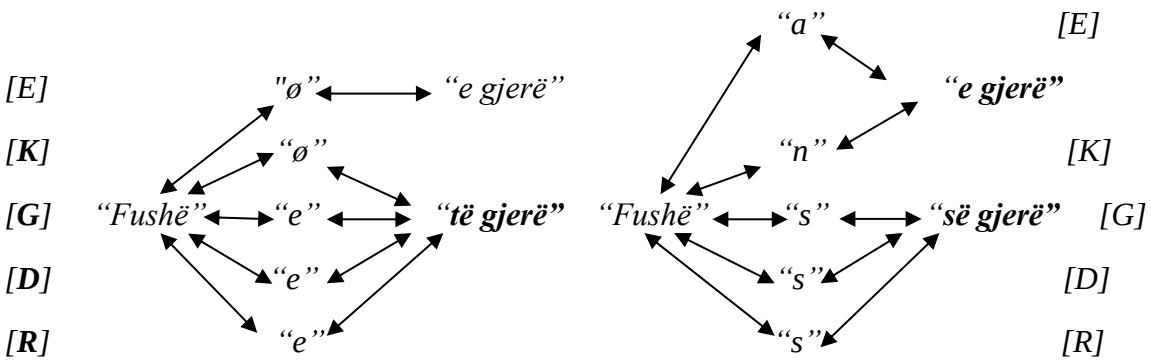


Graphic representation of the reports of meanings with case forms of masculine gender adjectives

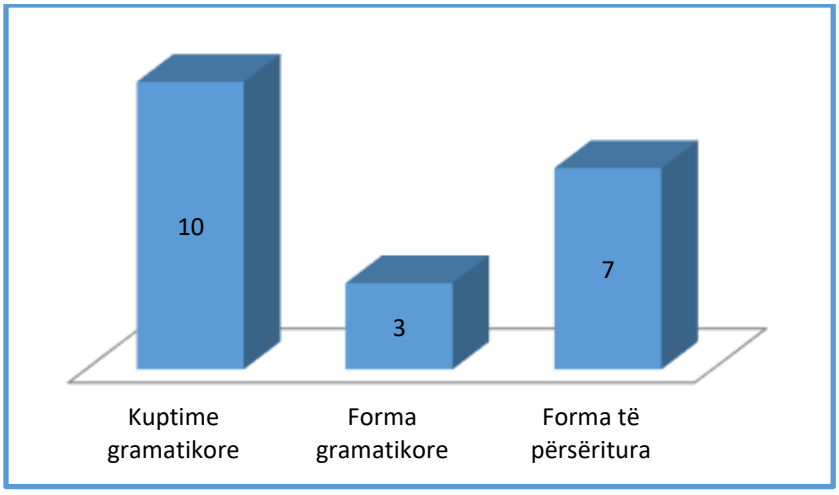


Grammatical meanings *Grammatical form* *Repeated forms*

Feminine Gender



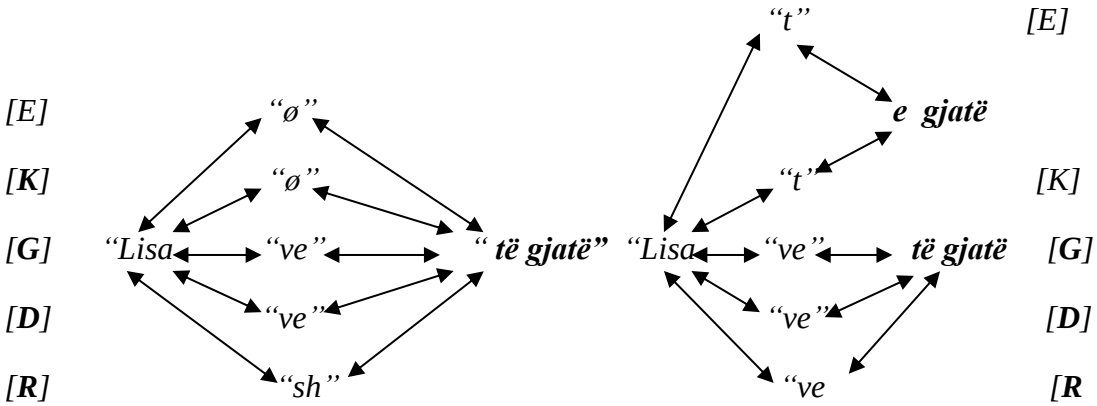
Graphic presentation of the ratios of meanings with case forms of feminine gender adjectives



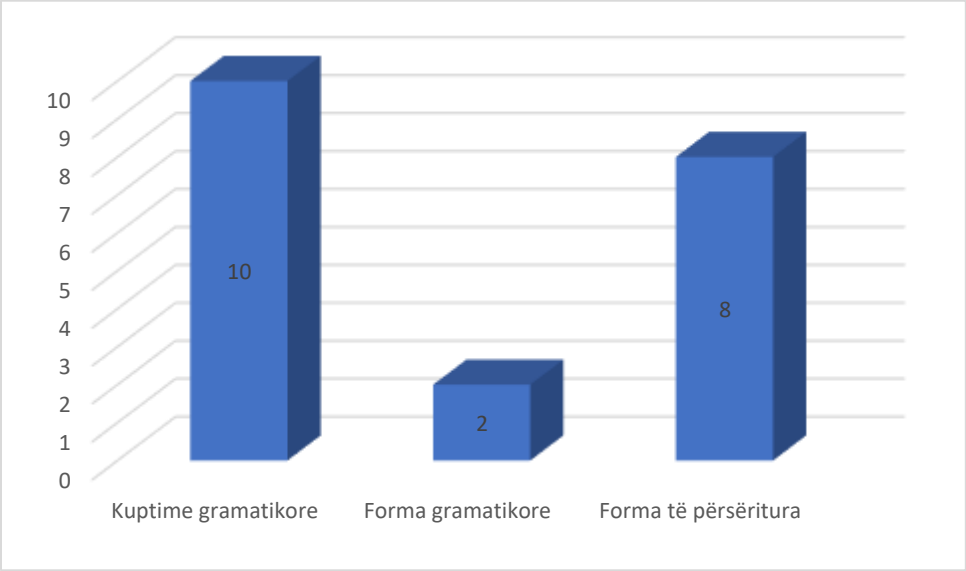
Grammatical meanings *Grammatical form* *Repeated forms*

Number

Plural Form



Graphic representation of the ratios of meanings with casual forms to adjectives in the plural



Grammatical meanings *Grammatical form* *Repeated forms*

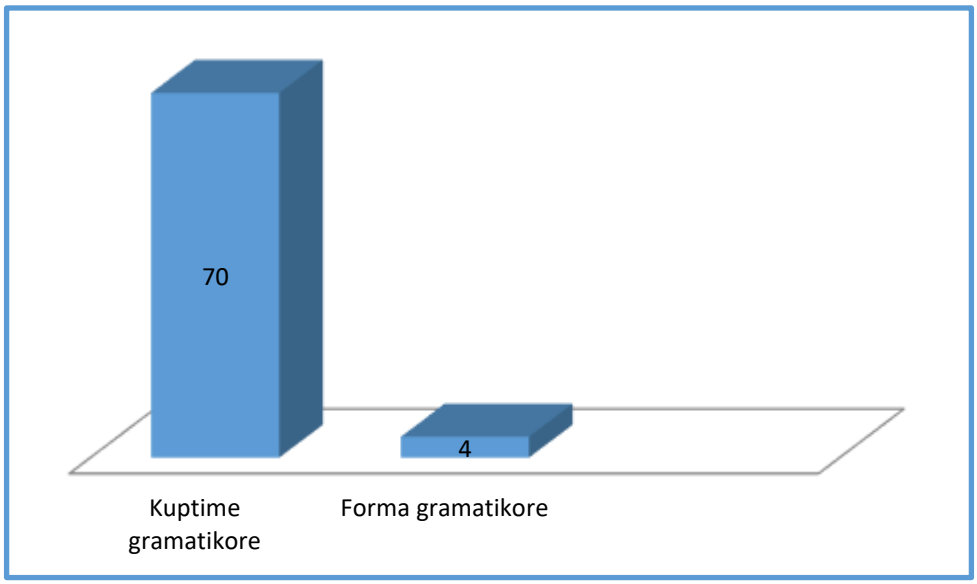
Analysis

In all paradigms of noun + adjective phrases, the nominative is the most stable case form. Other case forms generally do not follow the same line of phonetic development; they do not even have functional stability, in the sense that the same nodal form is always associated with the same racial meaning. Formal developments have followed the line of units. In the plural number, only the nominative and the accusative of adjectives that follow a prominent noun appear with the front node e; in all other cases, after a noun in the unpronounceable, appear with the form of. The homonymy of the anterior nodes has extended well even to the singular number.

After an unpronounceable noun in both genders, only the nominative forms are distinguished; in all other cases and in these paradigms the node is generalized. Only in the paradigm of a distinguished masculine and feminine noun has the adjective clause better preserved the original case condition. In the whole paradigm of nodal adjectives, if we separate it (node) from the basic body of the adjective, internal and external movements are observed. Within a microparadigm, one nodal form is extended to another; outside the microparadigm, nodal forms are alienated from other microparadigms. The most widely used nodal forms are generalized. In this process, preserving or changing the form of the front node is also helped by the form of the back node of the preceding name. The mutual influences of the back and front nodes have been continuous, old and new. In general, it is the node that is most stable; is even more preferred; it has a wider scope, also because the source forms were such or close to it. However, continuous units and interchanges prove that their formative morpheme values have either not been such from the beginning, or they are being transformed into genuine lexical morphemes; only structural analysis has distinguished them or even still distinguishes them from them.

Thus, in his entire paradigm, the adjective comes out with only 4 (four) case forms, expressed with only four nodes: “i”, “e”, “të” and “së”, although he establishes syntactic links with nouns, which are used in about 70 (seventy) grammatical meanings.

General graphical presentation of the relationships between grammatical meanings and grammatical forms of adjectives



Grammatical meanings *Grammatical form*

Conclusion

1. If we keep in mind the circumstance that Albanian adjectives in an early period had the same case endings as nouns, and then, in the new syntactic conditions of embedding their place next to nouns, they lost them as unnecessary, the reappearance of new tools through front nodes, when even the embedded order (noun + adjective) serves itself as an empty grammatical tool, created a new morphological condition.
2. The stable topic of adjectives, which served as a means of connection with the subject noun, was also associated with a new paradigm, expressed with different forms of the front node, which constitutes a double connection, an overcharacterized connection.
3. In this case, we have seen the overcharacterization not simply in the structure of the adjective, but in the structure of the syntagm in the direct approach of the nominative case endings with the responsible nodes according to cases, because the noun + adjective syntagm, in any case of use, is presented as a unit linguistic.
4. In other grammatical categories, of gender and number, the nominative adjective in many cases shows over-characterization both with endings and with the change of the front node.

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Glukokortikoid ile oluşturulan insülin direncinde serum vitamin A ve E düzeyleri üzerine timokinonun etkisi

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Özet – Timokinon (TQ), *Nigella sativa*'nın aktif bileşenidir. Pek çok yararlı etkilerinin yanı sıra, antioksidan ve antiinflamatuar özellikleri de önemlidir. Bu çalışma, deneysel olarak glukokortikoid ile insülin direnci indüklenen ratlarda, serum vitamin (vitamin A, vitamin E) düzeylerine TQ'unetkisini araştırmak için planlandı.

Wistar-Albino ratlar kullanılarak çalışma grupları oluşturuldu. Çalışma grupları; kontrol (K), insülin direnci indüklenen (İD), timokinon verilen (TQ), tedavi (İTQ) ve korunma (TQİ) için TQ verilen ve metformin (İDM) ile tedavi edilen gruplar olarak hazırlandı. Çalışma sonunda elde edilen serum örneklerinde vitamin A ve vitamin E analizleri HPLC ile yapıldı.

Bu analiz sonuçlarına göre; insülin direnci grubunda azalan serum vitamin düzeylerinin, TQ ile tedavi ve korunma gruplarında arttığı ve normale yaklaştığı belirlendi.

Sonuç olarak, insülin direnci nedeniyle azalan serum vitamin düzeylerinin düzelmesinde TQ'un terapötik ve profilaktik amaçlarla uygulamasının faydalı olduğu sonucuna varıldı.

Anahtar Kelimeler –İnsülin direnç, Timokinon, Serum, Vitamin

GİRİŞ

İnsülin direnci, çeşitli fizyolojik ve metabolik nedenlere bağlı olarak ortaya çıkan, klinik olarak, insülinin metabolik etkilerine karşı hassasiyet veya yanıt verme yeteneğinde azalma olarak kabul edilir ve özellikle diyabet gibi metabolik sorunlara yol açabilir (Artunc ve ark., 2016;Özdoğan ve ark., 2017; Hill ve ark., 2021).

Timokinon (TQ), *N. sativa*'nın başlıca etken maddesi olarak, hastalıkların tedavisinde ve önlenmesinde çok sık kullanıma alanı bulmaktadır ve pek çok yararlı özelliklerinin yanında antidiyabetik ve hipoglisemik etkiye de sahiptir (Erkut ve ark., 2016).

Vitaminler, sahip oldukları fonksiyonlara bağlı olarak (antioksidan, antiinflamatuar vs) insülin direnci durumunda farklı şekillerde rol alabilirler. Vitamin eksikliklerinde insülin direnci riskini arttırabileceği ve vitamin uygulanmasının korunma ve tedavide yararlı olabileceği düşünülmektedir (Garcia-Bailo ve ark., 2011).

Bu çalışma, pek çok yararlı etkileri bilinen TQ'un, deneysel olarak glukokortikoid ile indüklenen insülin direnci olan ratlardaki serumdaki vitamin düzeyleri üzerindeki etkisinin gözlemlenmesi amacıyla planlanmıştır.

MATERYAL ve METOT

Bu çalışmada, "***Glukokortikoid ile indüklenen insülin direncinde timokinonun vitamin D metabolizması üzerine etkisi*"** başlıklı yüksek lisans tezinden sağlanan serum örnekleri materyal olarak kullanılmıştır. İnsülin direnci değerleri de bu tezden alınmıştır (Göktuğ, 2022).

Serumların alındığı tez çalışmasının deneysel düzeni aşağıda verilmiştir:

Hayvan materyali

Bu çalışmada, Van Yüzüncü Yıl Üniversitesi Deneysel Uygulama ve Araştırma Merkezi'nden temin edilen, 40 adet Wistar-Albino erkek rat (150-200 gr) kullanıldı. Tez çalışmasından kalan serum örnekleri kullanıldı (Etik Kurul No: 2023/11-05, tarih: 28.09.2023).

Analiz gruplarının hazırlanması

Deney grupları şu şekildeydi: kontrol (K), insülin direnci (İD), timokinon verilen (TQ), timokinon verilen ve insülin direnci oluşturulan (TQİ), insülin direnci oluşturulan ve timokinon verilen (İTQ) ve insülin direnci oluşturulan ve kontrol tedavisi için metformin verilen (IM).[5]

Kan örneklerinin alınması

Deney süresi sonunda alınan kan örneklerinden elde edilen (3000 rpm'de +4°C'de 15 dakika santrifüjlendikten) ve saklanan serum örnekleri çalışmada kullanıldı.

İnsülin direncinin ölçülmesi

İnsülin direncini belirlemek için aşağıdaki formül kullanılmıştır.

HOMA IR= Plazma Glukozu (mg/dL) × Açlık Plazma İnsülini (mu/L)/405

Serum vitamin analizleri

Serum ekstraksiyonları

Serum örneklerinde vitamin A, vitamin E analizlerin yapılışı şöyle özetlenebilir: Serum plastik tüplerine 200 µl serum alındı. 200 µl etanol eklendi ve 1 dakika vortekslendi. Daha sonra 800 µl n-hekzan ilave edildi ve 1 dakika daha vortekslendi. 3000 RPM'de 10 dakika santrifüj edildi ve üstte toplanan hekzan fazından 600 µl alınarak azot gazı altında kurutuldu. Kalıntı 500 µl metanolde çözündürüldü ve HPLC kolonuna enjekte edildi (Zaspel ve Csallany, 1983; Reynolds ve Judd, 1984; Miller ve Yang, 1985).

Sıvı kromatografisi

Vitamin A ve vitamin E için hazırlanan standartlar kullanılarak, cihaz (Agillent 1100 serisi HPLC) kalibre edildi. Hazırlanan ekstraktlardan 20 µl alınarak sıvı kromatografisi kolonuna (C18 kolonundan (4.6 mm x25 cm)) enjekte edildi. DAD (diode-arraydetector) dedektörü kullanılarak sırasıyla 325 ve 290 nm dalga boylarında vitamin A ve vitamin E düzeyleri ölçüldü. Mobil faz olarak metanol-su (98:2) 1.5 ml/dak akış

hızında kullanıldı. Hesaplamalar vitamin A ve vitamin E standartlarının pik alan ve konsantrasyonlarına göre yapıldı(Zaspel ve Csallany, 1983; Reynolds ve Judd, 1984; Miller ve Yang, 1985).

İstatistiksel analiz

Çalışma sonunda yapılan analizlerden elde edilen veriler, SPSS 22.0 paket programı kullanılarak çoklu karşılaştırma testi ile değerlendirildi. Tüm analizlerden elde edilen ham değerler grupların ortalamaları ± standart hata olarak sunuldu.

BULGULAR

İnsülin direnci için Göktuğ (2022)'un yüksek lisans tezinden alınan veriler kullanıldı (Tablo 1). HOMA-IR düzeyleri, beklendiği gibi ID grubunda en yüksek bulunurken, diğer gruplar arasında önemli bir fark bulunmadı. TQ verilen gruplarda ise kontrole yakın olduğu görüldü. Bu tablodan da anlaşılacağı üzere, deneysel insülin dirence karşı TQ kullanılan gruplarda önleyici ve koruyucu olarak kullanılmasının, insülin direncini gerilettiği açıkça görülmektedir (Göktuğ, 2022).

Tablo 1. Çalışma gruplarından elde edilen HOMA-IRsonuçları (Göktuğ, 2022)

Gruplar	**HOMA-IR**
K grubu	544±61,4b
İD grubu	1080±293,8a
TQ grubu	420±122,6b
TQİ grubu	682±125,6ab
İTQ grubu	443±90,75b
İDM grubu	787±120,09ab

Çalışma sonucunda elde edilen serum vitamin düzeyleri aşağıda verilmiştir.

Tablo 2. Çalışma sonucunda elde edilen serum vitamin düzeyleri

GRUPLAR	**Tokoferol (s±sx)**	**Retinol(s±sx)**
K grubu	5,2987±0,3505a	0,4045±0,0185ab
İD grubu	2,1869±0,4496c	0,3661±0,0644abc
TQ grubu	4,3760±0,6801abc	0,2046±0,0459c
TQİ grubu	4,6158±0,6756ab	0,2746±0,0259bc
İTQ grubu	4,3165±0,5032abc	0,4877±0,0123a
İDM grubu	2,8502±0,2522bc	0,1824±0,0140c

Serum vitamin E (a-tokoferol) düzeyleri, insülin direncine bağlı olarak kontrole göre önemli derecede düşüktü. Korunma ve tedavi için TQ verilen gruplarda bu düzeylerin artarak, kontrole yaklaştığı, metformin verilen gruptan daha yüksek olduğu saptandı.

Serum vitamin A (retinol) düzeylerinin, insülin direnci grubunda önemli olmamakla birlikte azaldığı görüldü. Korunma ve tedavi için TQ verilen gruplarda da serum retinol düzeyleri, kontrolden farklı değildi.

TARTIŞMA

İnsülin direncinin nedenleri ve tedavisi üzerinde yapılan çalışmalarda, farklı metabolik mekanizmaların rolünün araştırılmış ve oksidatif, inflamasyon mekanizmaları önemli yer tutmaktadır. İnsülin dirence yol açan bazı durumlarda oksidatif stres artar. Örneğin, aşırı vücut yağı, obezite, yüksek kan şekeri seviyeleri, inflamasyon vs. insülin direncini arttırarak, oksidatif stresin de artmasına katkıda bulunabilir. Sağlıklı bireylerde insülin aracılı glikoz atılımındaki değişiklikler, lipit hidroperoksitlerin ve yağda çözünen antioksidan vitaminlerin kan konsantrasyonları ile önemli ölçüde ilişkilidir ve klinik belirtilerin ortaya çıkmasından önce, toplam lipit peroksidasyonunun arttığına işaret eder (Facchini ve ark., 2000; Wieser ve ark., 2013; Tangvarasittichai, 2015; Kojta ve ark.,2020;Dede ve ark.,2023).

İnsülin direnci, diyabet ve bağlı komplikasyonlarda; özellikle vitamin E, vitamin C, glutatyon, süperoksit dismutaz (SOD), katalaz (CAT) ve glutatyon peroksidaz (GPx) gibi çeşitli antioksidan parametrelerin miktarlarının azaldığı bildirilmektedir. Özellikle vitaminlerin, oksidatif stres kaynaklı hasara karşı, farklı mekanizmalar ile antioksidan etki gösterdiği bilinmektedir ve uzun süreli komplikasyonlardan korunmak için antioksidan diyetlere ilaveten, vitamin takviyesi de önerilmektedir (Meerza ve ark., 2016; Usta ve ark., 2018a; Usta ve ark., 2018b).

İnsülin direncinde yağda çözünen vitaminler ve antioksidan sistemlerinin azalması, insülin direncine karşı beslenmenin düzenlenmesinin önemini göstermektedir. Diyette düşük beta-karoten ve alfa-tokoferolün alınması ve serumdaki konsantrasyonlarının düşük olması, antioksidan durumunun bozulması ve dolayısı ile insülin direnci ve tip 2 diyabet gelişiminde rol aldığı hipotezini desteklemektedir (Shin ve ark., 2006; Arnlöv ve ark., 2009).

İnsülin direnci ve serum retinol düzeyleri arasındaki ilişki, serum retinol bağlayıcı protein 4 (RBP4)'den kaynaklanmaktadır. İnsüline duyarlı glikoz taşıyıcı GLUT4'ün azalması, serum retinol bağlayıcı protein RBP4'ün adipositlerden salgılanmasına neden olduğu için, serum RBP4'ün artan seviyelerinin hem deney hayvanlarında hem de insanlarda sistemik insülin direncinin işareti olarak kabul edilmekte ve bunun bir biyobelirteç olarakdeğerlendirilmesinin, prediyabetik bireylerde aterosklerozun erken tespiti için önemli olabileceği düşünülmektedir (Wolf, 2007; Wang ve ark., 2020; Chauhan ve ark., 2021).

İskelet kası hücrelerinde glikoz oksidaz (GO) kaynaklı insülin direncinin, gama-tokoferol (GT) verilmesinin, oksidatif stres kaynaklı insülin direncini iyileştirdiği, vitamin E takviyesinin hem insülin duyarlılığını hem de salgılanmasını iyileştirdiği, glisemik indeksler ve insülin direnci üzerindeki etkisini HbA1c ve insülin direncini iyileştirmede yararlı bir rolü olduğu ve açlık kan şekerinin düşmesineneden olduğuna dair veriler bulunmaktadır (Singh ve ark., 2008; Xu ve ark., 2016; Zakharova ve ark., 2021; Asbaghi ve ark., 2023).

Bu çalışmada, serum vitamin E (a-tokoferol) düzeylerinin, insülin direncin ile paralel bir değişiklik gösterdiği görüldü. İnsülin direnç grubunda önemli düzeyde azalan vitamin E düzeylerinin TQ'un korunma

ve tedavi amacıyla kullanıldığı gruplarda düzeldiği ve kontrole yaklaştığı görüldü. Aynı şekilde serum vitamin A (retinol) düzeylerinin de, korunma ve tedavi için TQ verilen gruplarda kontrole yaklaştığı belirlendi.

Bu sonuçların TQ'un, antioksidatif etkisi nedeniyle, serum antioksidan vitamin düzeylerini düzeltmesine işaret ettiği düşünülmektedir. Yapılan başka çalışmalarda da TQ'un antidiyabetik etkisinin de antioksidan etkisinden kaynaklandığı saptanmıştır (Usta ve ark., 2018a; Usta ve ark., 2018b). TQ'un insülin direncine karşı yararlı etkilerinin araştırıldığı çalışmalarda terapötik ve profilaktik amaçlarla TQ uygulamasının insülin direnci kaynaklı olarak görülen inflamasyon parametrelerinin gerilemesinde faydalı olduğu bildirilmektedir (Dede ve ark.,2023). Hepatoprotektif etkisi ile insülin direncine bağlı olarak değişen bütün parametreleri iyileştirdiği (Awad ve ark.,2016),insülin direnci kaynaklı olarak görülen inflamasyon parametrelerinin gerilemesinde faydalı olduğu(Kutlu ve ark.,2005)gibi önemli sonuçlar elde edilmiştir.

SONUÇ

Sonuç olarak, bu çalışmada da serum vitamin düzeylerinin deneysel insülin direncine bağlı olarak etkilendiği, TQ verilen, korunma ve tedavi gruplarında serum düzeylerinin kontrol grubu düzeylerinde olduğu saptandı. Bu sonuçlara dayanarak, insülin direncine bağlı olarak oluşabilecek bazı moleküler düzeydeki olumsuzluklara karşı, TQ'un serum vitamin düzeyleri ve buna bağlı mekanizmaları, toplam antioksidan kapasiteyi olumlu yönde düzelterek, yararlı etkilerinin olabileceği sonucuna varıldı.

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SANAL KİMLİKLER ve INSTAGRAM*

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Özet **–** Değişme, tarihsel ve toplumsal sürekliliğin en belirgin dinamiğidir. O, doğası itibariyle yön bildiren bir özellik arz etmemektedir. İleriye doğru gerçekleşebileceği gibi geriye doğru da gerçekleşebilir; olumlu gelişmeler sergileyebileceği gibi olumsuz sonuçlar da doğurabilir. Kaldı ki değişimin yönü ve niteliğine dair belirlemeler yorumcuların göreli konumlarından doğrudan etkilenmektedir.

Toplumlar değişir ve dönüşür. Toplumsal değişmeleri teknolojik gelişmeler ekseninde de tecrübe edebiliriz. Teknolojik gelişme ve sanal düzen kimliklenme biçimlerimizi de değiştirebilmektedir. Çalışmada, kadınların ve erkeklerin kimliklerini inşa etme sürecinde Instagram uygulamasına odaklanılmıştır. Instagram, sosyal medya platformları arasında görüntüyü merkeze koyan yapısı ile öne çıkmaktadır. Göstergelerden beslenen bu uygulamada sanal kimlik sahipleri tercih ettiği bazı özelliklerini vitrine koymakta ve bu özellikleriyle onaylanmayı beklemektedir. Bu çalışma, teknoloji, internet ve özellikle sosyal medyanın kimliklerimizin inşasını değiştirmesi üzerine bir değerlendirme olarak hazırlanmıştır.

Anahtar Kelimeler–Sosyal medya, Instagram, Kimlik, Sanal kimlik, Toplumsal Cinsiyet.

Giriş

Toplumsal değişimler çok yönlüdür. Tüketim toplumu, risk toplumu, enformasyon toplumu, gözetim toplumu, ağ toplumu gibi çeşitli şekillerde açıklanabilir ve teknolojik değişmelerden bağımsız ilerlememektedir. Her teknolojik gelişme, sosyal bir dönüşüme neden olmaktadır (Marcuse 1990: 200). Teknolojik gelişmelerin toplumsal anlamda olduğu gibi bireysel anlamda da dönüştürücü bir gücü vardır. Genel olarak "Teknolojik determinizm" ilkesi ışığında her yeni teknoloji, sosyal değişim ve ilerlemenin koşullarını hazırlamaktadır (Williams 2003: 10-13).

Marshall McLuhan, bilişim ve telekomünikasyon teknolojisindeki gelişmelerle dünyanın küresel bir köye dönüştüğünü belirtmiştir. Küreselleşme ve dünyanın küçülmesi durumu David Harvey (2014: 270) tarafından mekânsal ve zamansal sıkışma şeklinde açıklanmıştır. Küreselleşmenin geri dönüşü olmayan, dünyanın kaçamayacağı kaderi olduğunu belirten Bauman (2012), yaşanan değişiklikleri yeni dünya düzensizliği şeklinde ifade etmiştir. İnternet ve ağ toplumu üzerine yaptığı çalışmalarda Manuel Castells (2016), iletişim teknolojilerinde yaşanan gelişmelerin ve yeni teknolojik paradigmaların sosyo-kültürel anlamda birtakım değişikliklere neden olduğunu vurgulamıştır.

Teknolojik gelişmelerle politik, ekonomik, kültürel, toplumsal değişiklikler tecrübe edildiği gibi; bireysel anlamda da kimliklerde akışkanlık, değişebilirlik ve kişilerin kimlik inşalarında

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alternatiflere yönelme söz konusu olmuştur. Manuel Castells (2008: 3-14) dijitalize olmuş toplumlarda "… insanların anlam ve tecrübe kaynağıdır…" şeklinde vurguladığı kimliklerin sanal formda inşa edilebileceğini vurgulamıştır. İnternet çağında iletişim çevrimiçi olarak, sosyal ağ sitelerinde mümkün olmuştur. Hall Niedzviecki (2019)'nin "Dikizleme Günlüğü" kitabında belirttiği gibi internet; hayatımıza yeni olanaklar sunmakta, hem görmeye hem de görünmeye imkan vermektedir. Niedzviecki (2019: 29), 2008 yılı (özellikle Iphone'nun yeni modelini piyasaya sürdüğü yıl) itibari ile "Dikizleme Kültürü Çağı" na girdiğimizi, yeni bir çağın başladığını belirtmektedir. Dikizleme kültürü insan yaşamının dijitalleşmesi ve elektronik ortamlara kayması anlamına gelmektedir. Bireyin bu dijital ortamda kendisini temsil edecek sanal bir kimlik formuna ihtiyacı vardır. Oluşturdukları gizli ya da açık bir profille bireyler, sistem içerisindeki diğer kişileri görme hem de diğerlerine görünme olanağına sahip olmuştur. Başkalarıyla bağlantıda olan, onlarla sanal etkileşim kuran insan; "Homo dictyous" olarak tanımlanmıştır. Homo, Latincede insan, dicty ise Yunancada ağ anlamına gelmektedir. Ağ insanı görme ve görünme akışındadır (Christakis ve Fowler 2009: 252-304).

Teknolojik etkinliklerin birçok değişimde olduğu gibi kimlik üretiminde de rol aldığını ifade edebiliriz. Enformasyon çağında, ağ toplumları, sosyal medya ile sanal sosyallikleri beraberinde getirmekte; siber ortam, katılımcılara kendilerine uygun bir "kimlik biçme" ya da biçilmiş kimlikleri egzersiz etme olanağı vermektedir (Binark 2005: 124). Dijitalliğin bireylerin kimliğine etkisi, kimliğin sanal olarak yeniden oluşturulmasını mümkün kılan teknolojik bir alt yapı sunmuş olmasıdır. Bireylerin sanal ortamlarda oluşturdukları ve sosyal medya kullanıcıları tarafından profil denilen kavram, dijital kimliklerdir. Ağ teknolojileri bireylerin dijital bir kimlik(profil) edinmesini sağlamaktadır (Ertürk 2017: 73-74). Sanal kimlik ya da dijital kimlikler şeklinde karşımıza çıkan kavrama bilgi ve iletişim teknolojisindeki değişmelere gönderme yaparak "Sosyal medya kimliği" de denilmiştir. Bu kimlik, sosyal medya içerisinde gezinmek için oluşturulmuştur (Yurdigül ve Elitaş 2017: 136-137).

Yöntem ve Teknik

Yeni iletişim olanakları, bireylere kendini dijital ortamlarda sunabilme imkânı tanımıştır. Sosyal medya ve özelde Instagram uygulaması çalışmanın odaklandığı dijital ortamdır. Bu ortamda temsiller, bir profil ya da başka bir deyişle sanal olarak inşa edilen kimliklerle gerçekleşir. Profil/sanal kimlik sahibi, ötekilerle/takipçilerle iç içedir ve kimliği bilinsin, onaylansın ister. Metinde sanal kimlik tanımı, sanal kimliklerin inşa edildiği Instagram platformu, sanal kimlik deneyimlerinin temellendirildiği sembolik etkileşimcilik kuramı, yapılaşma kuramı, kadınlar ve güzellik söylemi, hegemonik erkeklik ve para kazanma söylemi ile ilgili kısa bilgiler verilmiştir. Beğenilme, onaylanma arzusu çalışmada sosyolojik kuramlarla temellendirilerek açıklanmaya çalışılmıştır. Veri toplama sürecinde nicel bir araştırma yapılmıştır. Instagram kullanımını üç açıdan değerlendirmek için geliştirilen "Instagram Kullanımı Ölçüm Aracı"[1] online anket formatında katılımcılara ulaştırılmıştır. Anket sonuçları, çalışmanın kavramsal ve kuramsal çerçevesinde değerlendirilmiş, sonuçta yorumlanmıştır.

1. Sanal Kimlik Tanımı

İnsan toplumsal bir varlıktır. İnsanın nasıl biri olduğuna dair önemli bir parametre ise kimliktir. Kimlik; insana dair birçok şeyi ifade edebilen, çok boyutlu, tarihsel ve güncel bir kavramdır. Ayrıca dinamiklik, kimlik kavramına ait önemli bir özelliktir. İnsanlar içerisinde bulunduğu koşullara

[1] "Instagram Kullanımı Ölçüm Aracı" araştırmacı tarafından Instagram kullanımını üç açıdan değerlendirmek için geliştirilmiştir. Bu ölçüm aracı üç alt ölçekten oluşmaktadır. Bunlar Instagram'ın aşırı kullanımı (harcanan zaman), Instagram'da kendini sunum ve Instagram'da sosyal karşılaştırmadır. Anket, 1 = kesinlikle katılmıyorum ile 5 = kesinlikle katılıyorum arasında değişen 5'li Likert türünde sorulan 23 maddeyi Instagram kullanımının üç yönünün değerlendirilmesini içermektedir (Memiş, 2019).

göre pek çok kimlik edinebilir. Günümüz koşulları dikkate alındığında, ağ toplumunda, sanal ağlarda inşa edilmiş sanal kimliklerden bahsedebilmekteyiz.

Sanal dünya ve özelde sosyal medya platformları bireylere temsil imkânı sunmuştur. Bu gelişmelerin sonucunda kimliğin dönüşmesi de söz konusudur. Dolayısıyla günümüz koşulları dikkate alındığında, ağ toplumunda kimlik olgusunun sanallaşabilmektedir. Ağ toplumunda yaşıyoruz ve neredeyse internet ve sosyal paylaşım sitelerinin olmadığı bir dünyayı hayal bile edilemiyoruz Dijk (2016). Bu koşullarda; internet, özelde sosyal medya alternatif bir kimlik inşa etme olanağı sunmaktadır. Kimlik inşa etme sürecinde sosyal medya, yeni bir mekân ve mecradır. Çok yönlü iletişim, enformasyon olanakları, interaktiflik gibi özellikleriyle kitle iletişim araçlarından ayrılan sosyal medyada kimliklenme biçimlerimiz de haliyle değişebilmekte ve farklı boyutlar kazanabilmektedir.

21. yüzyılda, gelişen bilgi iletişim teknolojileri ve bilgisayar ağları sanal kimliklere ihtiyacı ortaya koymaktadır. Ancak genel, kapsayıcı, tek bir sanal kimlik tanımı yapmak, sanal kimlik inşasında bahsetmek zorlaşmaktadır. Sanal ortamın olanakları ile orantılı olarak kimlik formları da değişmektedir. Bireyler kendilerini sosyal medya öncesi dönemde, farklı sanal platformlarda temsil etmişlerdir. Kimliklerin anonim bir şekilde inşa edildiği koşullar, internetin yaygın olarak kullanılmaya başlandığı 2000'li yıllara işaret etmektedir. Bu dönemde Web 1.0 tabanlı platformda tartışma forumları, e-posta zincirleri, web sitesi, sohbet programları gibi araçlarla sınırlı kalan dijital bir aktivizm söz konusudur (Şener 2013: 254). Görüntülerin, fiziki bilinirliğin dolaşıma girmediği bu dönemde kimliklere dair bilinen özellikler, kişinin klavye olanakları doğrultusunda sınırladığı ipuçlarından ibaret olmuştur. Anonim sanal kimliklerde kimliğin sahibi doğrudan bilinmez. Metin bazlı sosyal platformlarda bir takma isim üzerinden oluşturulan kimliklerdir ve bedensel temsil yoktur (Timisi 2005: 95-98).

Web 2.0 tabanında inşa edilen sanal kimlikler ise sosyal medya kullanımı temelinde şekillenen kimliklerdir. Web 2.0, Web 1.0'dan farklıdır. Çünkü Web 2.0, insanları birbirine bağlamak, etkileşimde bulunmak, tanışmak, arkadaş edinmek ve aktif üreticiler olarak çevrimiçi içerik oluşturmakla ilgilidir (Andersen 2007). Artık yalnızca metinler, takma isimler, metin bazlı sohbetler dolaşımda değildir. Bireyler Web 1.0'dan farklı şekilde kendilerini temsil olanağına sahip olmuştur. Sosyal ağ sitelerini benzersiz kılan şey bireylerin görünür olmalarına imkân sağlamasıdır. Sosyal ağ siteleri/sosyal medya, bireylerin genel veya yarı açık bir profil oluşturmasına, bağlantılar paylaşmasına, bağlantıda olduğu diğer kullanıcıların bir listesini oluşturmasına, bağlantıda oldukları kullanıcıların yaptıklarına ve kendisinin yaptıklarının görüntülenmesine izin veren sanal bir sistemdir (Boyd ve Ellison 2008: 211). Bu sistemde iç içe geçmişlik söz konusudur. Konuyla bağlantılı olarak, sosyal medyayı modellemek üzere Velâzquez'in Las Meninas "Nedimeler" tablosundan esinlenebiliriz. Tabloda model, ressam, kral, seyirci iç içedir. Bu durum, gözetleyen ve gözetlenen ayrımını ortadan kaldırmıştır. Bizzat ressamın kendisinin dahi yansıdığı tabloda, bakan aynı zamanda bakılan olmuştur (Foucault 2001: 35-44). Sanal kimlik/profil sahibinin kendisi de tabloda olduğu gibi takipçilerle iç içedir. Kalabalık, iç içelik ve birbirlerinden haberdarlık durumu Jeffrey Rosen'in "Çıplak Kalabalık" isimli kitabında "omnipticon" olarak adlandırdığı kavramı da çağrıştırır. Omnipticon, çok sayıda kişinin çok sayıda kişiyi izlemesi anlamını içermektedir (Sprague 2007). Omnipticon kavramında olduğu gibi güncel olarak, sosyal medyada karşılıklı gözetlemeyi, takip etmeyi yoğun şekilde tecrübe etmekteyiz.

Genel bir ifadeyle; yeni medya ve özelde sosyal ağlar, klasik kitle iletişim araçlarından farklıdır. Web 2.0 teknolojisi sayesinde kullanıcılar; içerik oluşturabilmekte, diğer kullanıcılar hakkında bilgi derleyebilmekte ve onlarla karşılıklı iletişime geçebilmektedirler. İnternetin popüler olmaya başladığı 1990'ların sonunda, kullanıcıların içerik yüklemesine izin veren web siteleri ile bu olanak

başlamıştır. Süreci 2004 yılı itibariyle Facebook, 2005 yılında YouTube, 2006 yılında Twitter2, 2010 yılında Instagram izlemiştir. Güncel olarak da yeni uygulamalar ve var olan uygulamaların yeni versiyonları kullanıcıların hizmetine sunulmaya devam etmektedir.

2. Instagram'ın Aurası

Yeni uygulamalar ve uygulamalara gelen güncellemeler sosyal medya seçeneklerinin fazlalığını açıkça göstermektedir. Sosyal medya denildiğinde pek çok uygulama akla gelmekte, her uygulama farklı amaçlarla kullanılmaktadır. Sosyal medya platformları sürekli evrim halindedir. Sosyal medya çoğaldıkça, her biri insanların iletişim repertuarlarında kendi farklı konumlarını edinmektedir. Sosyal medyaya yüklenen anlamlar, sosyal medyadan beklentiler, sosyal medya kullanım amaçları, kullanıcıların bakış açıları birbirinden farklıdır. Bu sebeple genel bir sosyal medyayı tanımı yapmak ve sosyal kullanımlarını değerlendirmek, tüm uygulamalar için geçerli ortak özelliklerden bahsetmek zordur (Madianou 2015).

Sosyal medya platformları ve bu platformların pratikleri birbirinden farklıdır. Dolayısıyla sosyal medya uygulamalarında oluşturulan profillerin sunuluşu, amacı ve kurgulanışı da birbirinden farklılaşmaktadır. Sosyal medya sanal bir mekândır. Bu mekânlarda bulunan profil sahibi uygulamanın olanakları ve izinleri doğrultusunda kimliğini yönlendirmektedir. Mekânsal anlamda bir sanallıktan, sanal mekânların da kullanıcıyı yönlendirdiği bir auradan bahsetmek mümkündür. Mekânın aurası meselesine, Şentürk (2014), "Mekân, sadece mekân değildir" ifadesini kullanarak dikkat çekmiştir. Mekânlar canlıdır ve edilgen değildir. Mekânlardaki her bir yapı; belli bir dönemin ekonomik, sosyal ve siyasal süreç içindeki yaşantının, gerçekliğin, oluşumun tanıklığını ve sözcülüğünü yapmakta, dönemin aurasına ait bir mesaj içermektedir. Mekânın ekonomik, politik, ideolojik, kültürel etki gücü vardır ve psiko-sosyal anlamda yönlendiricidir. Mekanların birey üzerinde etkisi aşikardır ama burada dikkat çekilen mekânlar, fizikî mekanlârdır ve mimarî bileşimlerdir. Ancak ağ toplumlarında toplumsal ilişkiler, sanallık temelinde yürütülmektedir. Dolayısıyla mekân algısı da değişerek sanal bir özellik elde etmeye başlamıştır. Sanal mekânlar ve bu mekânlarda şekillenen toplumsal ilişkiler vardır (Ertürk 2017: 84). Mekânın aurası meselesi sosyal medyada da geçerlidir. Sosyal medya uygulamaları kişilerin sanal mekanları sayılmaktadır. Bireyler inşa ettikleri yeni kimlikleri ile sanal mekânlara katılmaktadırlar (Yurdigül ve Elitaş 2017: 146-147). Mekân sanal da olsa pratikleri, etkileri ve kimlik inşalarına yansımaları söz konusudur.

Bu çalışmada Instagram uygulamasına odaklanılmıştır. Instagram'ın aurası görsel odaklıdır. Instagram; fotoğraf, video gibi görüntü odaklı paylaşımları temel alarak sanal sosyallik olanağı sunmaktadır. Instagram'ın kullanıcıyı bir gösteri dünyasına çeken aurası, metin odaklı Twitter uygulamasıyla karşılaştırıldığında daha anlaşılır olmaktadır. Manuel Castells (2016: 20-29), İsyan ve Umut Ağları İnternet Çağında Toplumsal Hareketler (Networks of Outrage and Hope) kitabında "Ağa bağlı toplumsal hareketler'' ifadesini kullanarak, toplumsal hareketler ile Web 2.0 tabanlı yeni medyayı ilişkilendirmiştir. Arap ülkelerinde, İspanya'da, ABD'de nedenleri ve sonuçları farklılık gösterse de toplumsal hareketler ağ üzerinden gerçekleşen iş birliği ile organize olmuştur. Castells, Web 2.0 ve sosyal medya uygulamaları ile bireysel ve kurumsal hesapların bu platformları kullanarak dinamik bir şekilde etkileşimde bulunduklarını, paylaşım ve içerik ürettiklerini belirtmiştir. Castells, Mısır devriminin öne çıkmasını sağlayacak teknolojik platformun Twitter olduğunu vurgulamıştır. Aktivistler için sosyal değişimi sağlamak üzere bağlantı sosyal medya üzerinden kurulmuştur. Hatta 2011'de

[2] 2023 yılında Elon Musk'ın Twitter'ı satın almasından sonra uygulamanın güncel ismi X olmuştur.

Mısır'da gerçekleşen devrimler "Twitter devrimleri" olarak etiketlenmiştir (Dijck ve Poell 2013; Hallikainen 2015: 10). Twitter daha çok haber ve ülke gündemleri endeksli bir zeminde işlemekte, metin içeriği ile öne çıkmaktadır.

Twitter uygulamasının adaleti sağlamaya kadar varan gücüne Instagram'ın gösteriler dünyasında rastlamak pek olası değildir. Konuya Frankfurt Okulu temsilcilerinden Marcuse (1990)'nin ileri endüstri toplumunu ele aldığı "Tek Boyutlu İnsan" kitabı bağlamında da yaklaşılabilir. Marcuse, mutsuzluklar içerisinde yapay esenlikler/mutluluklar yaratan araçların varlığına dikkat çekmiştir. Bu bağlamda, yapay ihtiyaçlar sınıfına sosyal medyanın/Instagram uygulamasının girip giremeyeceği tartışılabileceği gibi; sosyal medyanın/Instagram'ın yapay bir mutluluk ve haz sağladığı da Marcuse'ci bir bakış açısıyla ifade edebilir. Şentürk (2017: 25) 'ün de internetin yapaylığına yaptığı "…günümüzde hiçbir şey göründüğü şey değil; aksine ve büyük ihtimalle gözükmediği şeydir. İnternet ise belki de olduğu gibi görünmesi bir türlü izin verilmeyen ve hayatımızda en çok yer eden bir mefhumdur" göndermesi, Instagram profillerinde öne çıkmaktadır. Çünkü Instagram'da inşa edilen sanal kimliklerde genel olarak bir kurgusallık hakimdir ve beğenilmek, onaylanmak, popüler olma kaygısıyla profiller şekillenmektedir. Web 1.0 olanaklarıyla şekillenen anonim sanal kimlikler, Instagram uygulamasının göstergelerden beslenen aurasıyla görünür kılınmış ve belli özellikler öne çıkarılarak kurgusal sanal kimliklere dönüşmüştür.

Instagram uygulamasında metinsel bir gönderinin paylaşımı dahi Twitter'da olduğu gibi yazı karakterleri üzerinden gerçekleştirilememektedir. Instagram görsel sunumları merkeze almaktadır. Instagram'ın aurası daha çok göstergeler üzerinedir. Instagram; görüntü, beden, imaj yoluyla sosyalleşme biçimini popülerleştirmiştir. Fotoğraf paylaşım sitesi olarak sosyal medyayı kullanan insanların kullanımına sunulan Instagram, kullanıcılarına üye olanların fotoğraflarına, videolarına bakma özgürlüğü tanımaktadır. Paylaşımların ortak özelliği "görsel olarak çekicilik" üzerine kurulmuştur. Instagram kullanım amacı beğenme ve beğenilme dürtüsüdür. Merak etmek ve beğenilmek insanın doğası gereği olan dürtülerdir ve bireyler bu dürtülerini oluşturdukları yeni kimlikleri/sanal kimlikleri üzerinden tatmin etmeye çalışmaktadırlar (Yurdigül ve Elitaş 2017: 129-140).

3. Sanal Kimlik İnşaları ve Kuramsal-Kavramsal Dayanaklar

İç içe geçmişliğin, kitleselliğin, kalabalığın olduğu sanal düzlemlerde kimlikler, yeniden inşa edilebilmektedir. Sosyal medyayı ve inşa ettiğimiz sanal kimlikleri nasıl belirleyeceğimiz bize bağlıdır. Sanal kimliklerimizi ya yaşamının bazı yönlerinin bir türevi ya da gerçek yaşamdan tamamen uzaklaşarak bir parodisi haline getirebilmekteyiz (Waskul ve Douglass, 1997). O halde Instagram uygulamasında "sanal kimliklerimizi nasıl inşa ettiğimiz" sorusuna verdiğimiz yanıt, kimliğin yönünü belirleyecektir. Kimliğin yönünün kadın ve erkek için aynı düzlemde olduğundan bahsetmek zordur. Kadınların ve erkeklerin sosyal medyada sanal kimlik deneyimleri ve sosyal medyaya yükledikleri anlamlar birbirinden farklılaşmaktadır. Kadınların ve erkeklerin sosyal medya deneyimlerini temellendirebileceğimiz teorilerden ve toplumsal cinsiyetin dikotomik ayrışmalarından bahsetmek mümkündür.

Niedzviecki (2019)'nin dijitalize olmuş koşullarda bir başkasına ulaşmanın, başkasının ilgisini çekmenin ve fark edilmenin arzulanmasına dikkat çekmiştir. Dijital koşulların bir parçası olan sosyal medya da başkaları içindir. Sosyal medya deneyimlerimiz; görünme, gözetleme, bilinme, onaylanma, onaylama, takip etme, takip edilme, beğenme, beğenilme, popüler olma gibi eylemler üzerinden şekillenir. Takipçilerden bağımsız bir sanal kimlik inşasından bahsetmek mümkün olmamaktadır. Sanal ağlarda kimlik oluşturmak beraberinde dış motivasyon olarak takipçi nabzını

izleme sorumluluğunu getirmiştir. Bireyler sanal kimliklerine gelen geri dönüşleri, beğenileri takip etmektedir (Ertürk 2017: 83). Foucault (2012: 95-96) gözetleyen bir bakışın gözetlenen üzerinde bir ağırlığı olduğunu vurgulamıştır. Bu anlayış takipçinin profil sahibi üzerinde etkili olduğunu anlayabilmemiz için bağlantılı bir ifadedir. Spinoza (2004: 242)'ya göre;

> "…ün ve şan denen şey yalnızca halkın sanısı ile beslenen kendinden memnun olmadır. Bu sanı ortadan kalkınca, asıl memnun olma da yani herkesçe sevilmeden ibaret yüce iyilik de kaybolur; şan ve ünü yalnız halkın sanısından çıkaran kimsenin her günkü korku ile kıvranarak kendi şöhretini korumak için çabalaması, kendini zorlaması…" dır.

Spinoza'nın şöhret üzerine yaptığı bu saptamalar, sosyal medyada takipçi beklentisi durumuna uyarlanabilmektedir. Halk, gözetleyen ya da takipçi, kimlik sahibini yönlendiren ve kimliğin varlığının ispatı için önemli olan bir detay olmaktadır. Çünkü kimlik, öteki tarafından tanınır, bilinirse geçerlidir. Sanal kimliğin de geçerliliği takipçi onayına bağlıdır.

Seçilen "Sembolik Etkileşimcilik Kuramı" Sosyal medya-takipçi ilişkisiyle ilişkilendirilebilecek ölçüde güncele uyarlanabilmektedir. Kuramın temsilcilerinden Mead'in benlik ile ilgili görüşleri, "beni-bana - The Me" ayrımı sembolik etkileşimciliğin esasıdır. Benlik bireyseldir fakat geniş anlamda toplumun bir üyesi olmayı, grup beklentilerine uygun yaşamayı gerektirir. Grup beklentileri ve topluluğun tutumunu Mead, "genelleştirilmiş öteki" şeklinde kavramsallaştırır (Ritzer ve Stepnisky 2019: 340-343). Birey üzerinde etkili olan diğerleri, genelleştirilmiş ötekidir. Genelleştirilmiş öteki, diğerleri, sosyal medyada takipçi bağlantısını yorumlayabilmemiz için önemli bir dayanaktır. Sosyal medya diğerleri içindir. Diğerlerinin/takipçinin onayını almak önemlidir. Cooley'in ayna benlik görüşünde; başkalarının bizim görünüşümüzle ilgili düşüncelerinin etkisiyle kendimizle ilgili duygularımızın geliştiği vurgusu vardır. Takipçi onayı, beğenisi ne kadar yüksek olursa ona göre birey kendine dair olumlu duygular geliştirebilmektedir. Goffman (2014)'ın "Gündelik Yaşamda Benlik Sunumu" eserinde belirttiği performans sunumları önemli bir başka detaydır. Buna göre bireyler göze girmek adına; toplumun ortak değerlerince idealize edilmiş, arzulanan izlenimi yaratma çabasındadır. Goffman, dramaturji fikirlerinde bizim kendimize mümkün olan en iyi izlenimi vermek için çabaladığımızdan bahseder. Hepimizin rol yapan artistler olduğumuzu ve izlenim yönetimi uyguladığımızı belirtir (Wallece ve Wolf 2015: 274-275,324). Goffman, bireylerin etkileşime girdiklerinde başkaları tarafından kabul edilecek olan belirli bir benlik sergilemek istediklerini varsaymıştır. İzlenim yönetimi ile bireyler sahne önünde bazı teknikler uygularlar. Teatral bir anolojiyi takip eden Goffman, insanların sahne önünde kendilerinin idealleştirilmiş bir resmini sunmaya çalıştıklarını ve bu sebeple bazı şeyleri gizlediklerini belirtmiştir (Ritzer ve Stepnisky 2019: 357-358). Kurgu; beraberinde bir senaryoyu, senaryoya uygun rolleri, seyircinin rol beklentilerini ve bu beklentileri karşılıyorsa onaylanmayı, takdiri getirir. Kurulan sanal etkileşimler, performanslar ve inşa edilen sanal kimliklerde kurgusallık hakimdir. Çünkü arzu edilen; kusur bulunmasına izin vermeden onaylanmaktır. Bu sebeple sanal kimlik sunumları gerçekten uzaklaşarak, idealize edilerek gerçekleşmektedir. Bağımsız bir gözlemci olarak; sosyal medyada bu arzuların genel olarak; kadın kullanıcılarda kusursuzlaştırılan beden üzerinden yükselmekte, erkek kimliklerinde ise ortalama bir gelire sahip olmanın ötesinde; maddi anlamda güçlü, harcamaları, geliri ile standartların üstünde kurgulanan yaşamları ile öne çıkmaktadır.

Sınırsız senaryo ve rol seçenekleri arasında dijital dünyada gerçek yaşamın etkileri altında kalmak, kimlik sunumlarında ideal olanı sergilemeye çalışmak, kurguya başvurmak, sosyal medyanın

hem özgürleştirici hem de sınırlayıcı yönüne işaret eder. Giddens'ın Yapılaşma Kuramı[3] ışığında sosyal medyayı, hem imkan tanıyan hem de bireyi sınırlandıran bir platform olarak değerlendirebiliriz. Sosyal medya, iletişim kurma ve kimliği sunma konusunda imkân tanıyan hem de bireyi sınırlandıran bir platformdur. Gerçek yaşamda benimsenen değerlerin etkisi, kişilerin sosyal medya profillerine yansımaktadır. Ancak gerçek yaşamda benimsenen değerler denildiğinde, çok çeşitli detaylar akla gelebilir. Buna çalışmada; toplumsal cinsiyetin kadın ve erkek için geliştirdikleri cinsiyet kodlarına yönelik değerler olarak bir sınır çizilmiştir. Cinsiyet kodlarından beden-maddi güç dikotomisi seçilmiştir. Toplumsal cinsiyete dair gerçek yaşamda olan dikotomilerin etkisi sosyal medyada da geçerlidir. Bu dikotomiler; gerçek yaşamda olduğu gibi sanal yaşamda da vardır. Kadını bedeniyle, fiziksel kaygılarla ve erkeği maddi gücüyle, para kazanan olma görevi yüklemesiyle sınırlayan dikotomiler, sanal kimliklerin sunulmasında etkili olmuştur. Dijital dünya özgürlükler sunar ancak gerçek yaşamdaki kabullerle de bireyi tekrar sınırlar ve yönlendirir.

Yapılaşma Kuramı kabullerine göre sosyal medya özgürlükler alanı olduğu gibi içselleştirilmiş cinsiyet rolleri tutumlarının etkisiyle kısıtlayıcıdır. Kadınlar bu cinsiyet tutumları içerisinde güzellik söylemi etkisinde kalmıştır. Güzellik söylemi, kadınlar için geçerlidir ve kadınlar üzerinde bir baskıdır. Kadının bedeni üzerinde, ataerkil ideolojinin tahakkümü, erkek egemen söylemler etkili olmuş ve kadın bedeni meta haline gelmiştir. Toplumsal cinsiyet, biyolojik cinsiyetimizin tarih ve kültürden etkilenerek sosyal kimliklerimiz haline gelmesidir. Zihin ve beden diye ikiye ayrılan toplumsal cinsiyet algısı, erkek ve kadın arasında öne sürülen dikotomilerdendir. Erkek ilki, kadın ise ikincisi ile tanımlanmaktadır. Bu dikotomiler felsefecilere dahi yansımıştır. Güzelliği doğada arayan felsefeciler için kadın doğa ile özdeştir. Jean-Jacques Rousseau'ya göre erkek, akıl yürütme yeteneği ile kamusal alandadır (Enlwistle 2014: 223-224). Cinsiyet kalıp yargılarına göre; erkek kadından fiziksel ve maddi daha güçlü olmalı dayatması söz konusudur (Dökmen 2010: 225). Buna karşın kadın ise bedeni ile özdeştir ve üreme sürecindeki rolü ile şehevi bir anlayışa sıkıştırılmıştır (Enlwistle 2014: 216-236).

Güzellik kadınlar için geçerlidir. Erkeklerde ise güçlü olmak adına iyi görünmek, daha az önemlidir. Hegemonik erkeklik izinin aranacağı genel haritada tam zamanlı bir iş sahibi olmak, erkeğin çalışarak evi geçindirmesi, onun kimliğinin ayrılmaz bir parçası olarak kabul edilmektedir. Toplumsal cinsiyet algısına göre; akıl yürütme, kamuda olma, para kazanma daha çok erkek için tanımlanmıştır. Erkeklik bazen yalnızca toplumda düzenli bir iş yaşamına sahip olma beklentisiyle de ilişkilidir. Erkek olmak, çalışan erkek olmayı başarmaktır. Kapitalist ve ataerkil ilişkilerde büyük ölçüde erkeklikle ilişkilendirilen ekonomik özerkliğe sahip olmak gerekmektedir. Evlilik üzerinden otorite sahibi olacakları bir ailenin geçimini sağlamak, erkeğe saygın bir statü sağlar ve bu en yaygın "erkeklik inşa stratejisi"dir. Sancar'a (2009: 58-64) göre, mülksüz erkeklerin kapitalist piyasada çalışacak bir iş buldukları her koşulda emeklerini satmaya razı olmalarının arkasındaki önemli nedenlerden biri ancak çalışarak (para kazanarak) sahip olabilecekleri bu "erkek ayrıcalığının" peşinden koşmalarıdır.

İçselleştirdiğimiz, öğrendiğimiz ya da kabul ettiğimiz cinsiyetlere dair kalıp yargılar, öğrendiğimiz toplumsal cinsiyete dair söylemler ve bunun yanında kabul edilmek adına ötekinin onayına duyulan ihtiyaç, takipçi beklentisi sanal kimliklerin sunulmasında ve sosyal medya deneyimlerinde etkili olan faktörlerdir.

[3] Giddens (2005: 55-58), yapının varlığını göz ardı etmez, onu "kısıtlayıcı ve mümkün kılıcı" şeklinde tanımlar. Aktörler yapının kurallarıyla kısıtlanırken bir yandan da ona sunduğu kaynaklardan faydalanır. Giddens, sosyolojide köklü bir mesele olarak gördüğü karşıtlıklardan biri olan yapı-fail düalizminin aşılması yönünde "Yapılaşma Kuramı"nı geliştirmiştir. Teori, Zıt noktalar arasında orta yolcu bir öneri sunar.Yapı kaynakları ve kurallarıyla, birey de kısıtlanışı yapıyı dönüştürme gücüyle düşünülmeli, yapı ve fail birbiriyle bağlantılı olarak ele alınmalıdır.

4. "Instagram Kullanımı Ölçüm Aracı" Ölçeğinin Uygulanması

Ölçek, online anket formuna dönüştürülmüş ve anket linki Instagram, whatsapp ve telegram uygulamaları üzerinden katılımcılara sunulmuştur. Ankete 529 kişi katılmıştır. Katılımcılardan 32 kişi Instagram kullanmadığını belirtmiştir. Çalışmanın evreni; tüm Instagram kullanıcıları gibi geniş bir alana işaret etmektedir. Aktif olarak Instagram kullanan, Instagram'da bir profile/sanal kimliğe sahip 18 yaş üzeri yetişkin bireyler çalışmanın örneklemini oluşturmaktadır. "Sosyal medya araçları içerisinden Instagram uygulamasını kullanıyor musunuz?" sorusuna hayır yanıtını veren katılımcılar, çalışmanın örneklemini temsil etmediğinden anketin devamındaki soruları görememiş ve yanıtlayamamıştır. Bu sebeple geçerli yanıt veren katılımcı sayısı 497'dir. Katılımcıların 325'i kadın, 172'si erkektir. 87 kişi 18-25, 242 kişi 25-35, 117 kişi 35-45, 39 kişi 45-55 yaş aralığında, 12 kişi ise 55 yaş ve üzeridir.

5. Veri Analizi

Araştırma sonucu elde edilen veriler bilgisayar ortamına aktarılarak Microsoft Excel paket programı ile düzenlendikten sonra SPSS (Statistical Package for Social Sciences) 29.0 paket programı ve ile analiz edilmiştir. Analizlere başlamadan önce sayısal verilerin normal dağılıma uygunluğu Kolmogorov-Smirnov, Shapiro Wilk ile Skewness (çarpıklık) ve Kurtosis (basıklık) testleri, Histogram ve Q-Q Plot grafikleri ile incelenmiştir. Yapılan analizler sonucunda verilerin normal dağılımdan geldiği sonucuna ulaşılmıştır. Kategorik veriler frekans ve yüzde değerleri ile gösterilirken sayısal veriler normallik varsayımını sağlasa da gözlem değerlerinin 30'un altında olması sebebiyle ortalama standart sapma medyan minimum ve maksimum değerleri ile gösterilmiştir. Veri analizi yapılırken, iki bağımsız grup karşılaştırması için Mann Whitney U Testi[4], demografik verinin homojenliğinin tespiti amacıyla ise Ki-Kare testi kullanılmıştır. Ölçek için istatistiksel anlamlılık düzeyi $p<0,05$ olarak kabul edilmiştir.

6. Bulgular

Tablo 1. Araştırmaya dahil edilen ölçeklere ait Cronbach Alpha katsayıları

	Cronbach's Alpha
Instagram Kullanımı Ölçümü Anketi	0,912
Sosyal Karşılaştırma	0,898
Aşırı Kullanım	0,825
Kişisel Sunum	0,726

Tablo 1'de Instagram Kullanımı Ölçümü Anketi ve alt boyutları ile Çok Yönlü Beden- Self İlişkileri Ölçeğine ait Chronbach Alfa (Güvenilirlik) sonuçları gösterilmiştir. Cronbach Alpha'ya göre bir ölçeğin güvenilir olarak kabul edilebilmesi için Alpha değerinin en az 0,70 düzeyinde olması gerekmektedir. Cronbach değeri 0,70'ten düşük olan ölçekler düşük güvenilir veya güvenilir olmayan ölçek sınıfına girmektedir. Tabloya bakıldığında değerlerin 0,7'den yüksek olduğu görülmektedir. "Instagram Kullanımı Ölçümü Anketi" ile alt boyutları ve güvenilir bulunmuştur.

[4] Mann Whitney U testi bağımsız grupların, karşılaştırılması için kullanılan bir testtir. Testin uygulanabilmesinin ön koşulu gözlemlerin birbirinden bağımsız olmasıdır. İki bağımsız ortalama arasındaki farkın anlamlı olup olmadığını test etmek için başvurulur. Bu çalışmada kadın ve erkek katılımcıların verdiği yanıtlar karşılaştırılmış ve yanıtlar arasındaki farka bakılmıştır (İslamoğlu ve Alnıaçık 2019: 481).

Tablo 2. Araştırmaya dahil edilen ölçeklere ait Skewness ve Kurtosis değerleri

	Skewness	Kurtosis
Instagram Kullanımı Ölçümü Anketi	0,254	-0,417
Sosyal Karşılaştırma	0,429	-0,419
Aşırı Kullanım	0,008	-0,763
Kişisel Sunum	0,380	-0,244

Normallik varsayımı için Skewnes ve Kurtosis değerleri incelenmiştir. Bu değerlerin -1,5 ile +1,5 aralığında olması verilerin normal dağıldığını göstermektedir (Tabachnick & Fidell, 2013). "Instagram Kullanımı Ölçümü Anketi" ve alt boyutlarının normal dağılımdan geldiği görülmektedir. Ancak analizler cinsiyete göre ayrıldığı ve değişkenlerdeki gözlem değerleri 30'un altında olduğu için parametrik olmayan testler kullanılmıştır.

Tablo 3. Katılımcılara ait demografik değişkenlerin cinsiyete göre dağılımları

	Cinsiyet					
	Kadın		Erkek			
	n	%	n	%	χ^2	p
Yaş 18-25	73	22,5%	14	8,1%	31,237	**<0,001**
25-35	167	51,4%	75	43,6%		
35-45	61	18,8%	56	32,6%		
45 ve üzeri	24	7,4%	27	15,7%		

Katılımcılara ait yaş değişkeninin cinsiyete göre dağılımı Tablo 3'te gösterilmiştir. Kadınların %51,4'ü, erkeklerin %43,6'sı 25-35 yaş aralığındadır. Yaş dağılımları kadın ve erkeklerde istatistiksel açıdan anlamlı farklılık göstermektedir (χ^2=31,23; p<0,001).

Tablo 4. Araştırmaya dahil edilen ölçekler ve alt boyutları ile cinsiyet arasındaki farklılığın analizi

		$\bar{x}$	$\sigma(s)$	Medyan	Minimum	Maximum	U	p
Instagram Kullanımı Ölçüm Anketi	Kadın	62,14	18,69	62,00	23,00	111,00	22876,5	**<0,001**
	Erkek	56,13	16,86	56,50	23,00	111,00		
Sosyal Karşılaştırma	Kadın	25,19	10,15	24,00	10,00	50,00	24575,5	**0,027**
	Erkek	22,81	8,65	23,00	10,00	50,00		
Aşırı Kullanım	Kadın	15,83	5,21	16,00	5,00	25,00	20204,5	**<0,001**
	Erkek	13,36	4,97	13,00	5,00	25,00		
Kişisel Sunum	Kadın	21,12	6,54	21,00	8,00	40,00	25247,0	0,076
	Erkek	19,95	6,18	19,00	8,00	36,00		

*$\bar{x}$=ortalama, $\sigma(s)$=standart sapma

*Mann-Whitney U Testi; p<0,05

Cinsiyet ile Instagram kullanımı ölçüm anketi arasında istatistiksel açıdan anlamlı ilişki saptanmıştır (p<0,001). Kadınların ortalama ve standart sapması 62,14±18,69 iken erkeklerin ortalama ve standart sapması 56,13±16,86'dır. Kadınların Instagram kullanımı ölçüm anketinden aldığı puan daha yüksektir. Cinsiyet ile Instagram kullanımı ölçüm anketi sosyal karşılaştırma alt boyutu arasında istatistiksel açıdan anlamlı ilişki saptanmıştır (p<0,05). Kadınların ortalama ve standart sapması 25,19±10,15 iken erkeklerin ortalama ve standart sapması 22,81±8,65'tir. Kadınların sosyal

karşılaştırması daha yüksektir. Cinsiyet ile Instagram kullanımı ölçüm anketi aşırı kullanım alt boyutu arasında istatistiksel açıdan anlamlı ilişki saptanmıştır (p<0,001). Kadınların ortalama ve standart sapması 15,83±5,21 iken erkeklerin ortalama ve standart sapması 13,36±4,97'tir. Kadınların aşırı kullanımı daha yüksektir.

Tablo 5. Instagram Kullanımı Ölçüm Anketi ve alt boyutlarının cinsiyet*yaş değişkenlerine göre farklılığının analizi

			$\bar{x}$	$\sigma(s)$	Medyan	Minimum	Maximum	U	p
Instagram Kullanımı Ölçüm Anketi	18-25	Kadın	65,95	17,36	67,00	28,00	104,00	461,5	0,567
		Erkek	62,93	16,72	66,00	41,00	93,00		
	25-35	Kadın	65,23	17,17	64,00	31,00	111,00	4862,5	**0,005**
		Erkek	58,05	15,93	59,00	27,00	96,00		
	35-45	Kadın	53,41	21,13	50,00	23,00	107,00	1650,0	0,752
		Erkek	53,77	18,48	53,00	23,00	111,00		
	45 ve üzeri	Kadın	51,29	15,64	51,00	28,00	95,00	302,5	0,685
		Erkek	52,15	14,86	48,00	28,00	75,00		
Sosyal Karşılaştırma	18-25	Kadın	27,51	10,21	28,00	10,00	48,00	471,0	0,644
		Erkek	25,64	9,16	27,00	10,00	38,00		
	25-35	Kadın	26,27	9,74	26,00	10,00	50,00	5216,0	**0,038**
		Erkek	23,27	8,41	24,00	10,00	49,00		
	35-45	Kadın	21,30	10,35	20,00	10,00	46,00	1524,0	0,314
		Erkek	22,54	9,44	22,50	10,00	50,00		
	45 ve üzeri	Kadın	20,58	8,53	20,00	10,00	46,00	306,0	0,734
		Erkek	20,67	7,14	21,00	10,00	35,00		
Aşırı Kullanım	18-25	Kadın	16,03	4,31	16,00	5,00	24,00	407,5	0,231
		Erkek	14,86	4,42	14,00	9,00	25,00		
	25-35	Kadın	17,17	4,71	17,00	5,00	25,00	4105,0	**<0,001**
		Erkek	14,08	4,93	14,00	5,00	25,00		
	35-45	Kadın	13,28	6,30	12,00	5,00	25,00	1681,0	0,883
		Erkek	12,82	5,37	12,50	5,00	25,00		
	45 ve üzeri	Kadın	12,42	4,27	12,00	5,00	21,00	297,5	0,616
		Erkek	11,70	4,06	11,00	5,00	19,00		
Kişisel Sunum	18-25	Kadın	22,41	6,59	23,00	8,00	36,00	498,5	0,885
		Erkek	22,43	6,86	22,00	12,00	36,00		
	25-35	Kadın	21,79	6,11	21,00	10,00	40,00	5654,0	0,226
		Erkek	20,71	5,82	20,00	12,00	35,00		
	35-45	Kadın	18,84	6,99	17,00	8,00	40,00	1705,5	0,989
		Erkek	18,41	6,12	18,00	8,00	36,00		
	45 ve üzeri	Kadın	18,29	6,17	16,50	10,00	34,00	273,0	0,335
		Erkek	19,78	6,45	18,00	8,00	32,00		

*$\bar{x}$=ortalama, $\sigma(s)$=standart sapma

*Mann-Whitney U Testi; p<0,05

25-35 yaş arası kadın ve erkek katılımcılar ile Instagram kullanımı ölçüm anketi arasında istatistiksel açıdan anlamlı ilişki saptanmıştır (p<0,05). 25-35 yaş arası kadınların ortalama ve standart

sapması 65,23±17,17 iken 25-35 yaş arası erkeklerin ortalama ve standart sapması 58,05±15,93'tür. 25-35 yaş arası kadınların Instagram kullanımı ölçüm anketinden aldığı puan daha yüksektir. 25-35 yaş arası kadın ve erkek katılımcılar ile Instagram kullanımı ölçüm anketi sosyal karşılaştırma alt boyutu arasında istatistiksel açıdan anlamlı ilişki saptanmıştır ($p<0,05$). 25-35 yaş arası kadınların ortalama ve standart sapması 26,27±9,74 iken 25-35 yaş arası erkeklerin ortalama ve standart sapması 23,27±8,41'dir. 25-35 yaş arası kadınların sosyal karşılaştırması daha yüksektir. 25-35 yaş arası kadın ve erkek katılımcılar ile Instagram kullanımı ölçüm anketi aşırı kullanım alt boyutu arasında istatistiksel açıdan anlamlı ilişki saptanmıştır ($p<0,001$). 25-35 yaş arası kadınların ortalama ve standart sapması 17,17±4,71 iken 25-35 yaş arası erkeklerin ortalama ve standart sapması 14,08±4,93'tür. 25-35 yaş arası kadınların aşırı kullanımı daha yüksektir.

Tablo 6. Instagram Kullanımı Ölçümü Anketinde yer alan ifadelere kadınlar tarafından verilen yanıtlara ilişkin betimsel istatistikler

	Kesinlikle Katılmıyorum		Katılmıyorum		Karasızım		Katılıyorum		Kesinlikle Katılıyorum	
Kadın	n	%	n	%	n	%	n	%	n	%
Instagram kullanırken ekonomik kaynaklarımı diğerlerinin ekonomik kaynakları ile karşılaştırırım.	97	29,8%	74	22,8%	49	15,1%	63	19,4%	42	12,9%
Instagram kullanırken sosyal hayatımı diğerlerinin sosyal hayatı ile karşılaştırırım.	93	28,6%	61	18,8%	51	15,7%	78	24,0%	42	12,9%
Diğer profillerle karşılaştırdığımda kendimi yeterince çekici bulmuyorum.	151	46,5%	73	22,5%	44	13,5%	32	9,8%	25	7,7%
Instagram kullanırken nasıl giyindiğimi diğerlerinin nasıl giyindiği ile karşılaştırırım.	101	31,1%	81	24,9%	51	15,7%	55	16,9%	37	11,4%
Diğer profillerle karşılaştırdığımda sosyal hayatımı sıkıcı buluyorum.	95	29,2%	74	22,8%	66	20,3%	49	15,1%	41	12,6%
Diğer profillerle karşılaştırdığımda ekonomik kaynaklarımın yetersiz olduğunu düşünüyorum.	85	26,2%	66	20,3%	45	13,8%	73	22,5%	56	17,2%
Diğer profillerle karşılaştırdığımda kariyerimi / eğitim hayatımı başarısız buluyorum.	146	44,9%	82	25,2%	45	13,8%	26	8,0%	26	8,0%
Diğer profillerle karşılaştırdığımda giyim tarzımı zevkli bulmuyorum.	141	43,4%	78	24,0%	56	17,2%	27	8,3%	23	7,1%
Instagram kullanırken fiziksel özelliklerimi diğerlerinin fiziksel özellikleri ile karşılaştırırım.	104	32,0%	69	21,2%	49	15,1%	63	19,4%	40	12,3%
Instagram kullanırken kariyerimi / eğitim hayatımı diğerlerinin kariyerleri / eğitim hayatları ile karşılaştırırım.	67	20,6%	62	19,1%	59	18,2%	86	26,5%	51	15,7%
Instagram'da, planladığımdan daha fazla zaman harcarım.	61	18,8%	52	16,0%	50	15,4%	93	28,6%	69	21,2%
Uykum geldiği halde Instagram'ı kullandığım oluyor.	51	15,7%	56	17,2%	35	10,8%	116	35,7%	67	20,6%

Instagram'da vakit geçirebilmek için ekstra zaman yaratırım.	101	31,1%	104	32,0%	40	12,3%	47	14,5%	33	10,2%
Can sıkıntımı gidermek için Instagram'da vakit geçiririm.	25	7,7%	27	8,3%	38	11,7%	124	38,2%	111	34,2%
Yapmam gereken işler olmasına rağmen Instagram'da zaman geçiririm	56	17,2%	61	18,8%	51	15,7%	96	29,5%	61	18,8%
Instagram'da paylaşacağım fotoğraflarda kıyafetimin ya da makyajımın nasıl olduğunun önemi yoktur.	33	10,2%	64	19,7%	52	16,0%	84	25,8%	92	28,3%
Instagram takipçilerimin, paylaştığım fotoğrafları/videoları beğenmesi benim için önemlidir.	85	26,2%	69	21,2%	54	16,6%	73	22,5%	44	13,5%
Instagram'da hangi fotoğrafı paylaşacağıma karar vermem zaman alır.	63	19,4%	57	17,5%	60	18,5%	69	21,2%	76	23,4%
İnsanların beğenmeyeceklerini düşünsem bile fotoğraflarımı Instagram'da paylaşırım.	90	27,7%	64	19,7%	61	18,8%	59	18,2%	51	15,7%
Paylaştığım fotoğraflarım yeterince beğeni almadığında moralim bozulur.	141	43,4%	77	23,7%	47	14,5%	36	11,1%	24	7,4%
Bazen fotoğraf çekmemin tek amacı Instagram'da paylaşım yapabilmek oluyor.	118	36,3%	56	17,2%	46	14,2%	59	18,2%	46	14,2%
Kendime ait fotoğrafları (selfieler, profil resimleri gibi) düzenledikten (fotoshop, filtre gibi) sonra paylaşırım.	118	36,3%	71	21,8%	53	16,3%	50	15,4%	33	10,2%
Instagram profilimi düzenli olarak güncellemek benim için önemlidir.	160	49,2%	87	26,8%	37	11,4%	20	6,2%	21	6,5%

Tablo 7. Instagram Kullanımı Ölçümü Anketinde yer alan ifadelere erkekler tarafından verilen yanıtlara ilişkin betimsel istatistikler

	Kesinlikle Katılmıyorum		Katılmıyorum		Karasızım		Katılıyorum		Kesinlikle Katılıyorum	
Erkek	n	%	n	%	n	%	n	%	n	%
Instagram kullanırken ekonomik kaynaklarımı diğerlerinin ekonomik kaynakları ile karşılaştırırım.	62	36,0%	37	21,5%	32	18,6%	27	15,7%	14	8,1%
Instagram kullanırken sosyal hayatımı diğerlerinin sosyal hayatı ile karşılaştırırım.	66	38,4%	36	20,9%	34	19,8%	23	13,4%	13	7,6%
Diğer profillerle karşılaştırdığımda kendimi yeterince çekici bulmuyorum.	69	40,1%	53	30,8%	28	16,3%	10	5,8%	12	7,0%
Instagram kullanırken nasıl giyindiğimi diğerlerinin nasıl giyindiği ile karşılaştırırım.	71	41,3%	47	27,3%	32	18,6%	11	6,4%	11	6,4%
Diğer profillerle karşılaştırdığımda sosyal hayatımı sıkıcı buluyorum.	57	33,1%	40	23,3%	41	23,8%	18	10,5%	16	9,3%

Diğer profillerle karşılaştırdığımda ekonomik kaynaklarımın yetersiz olduğunu düşünüyorum.	57	33,1%	33	19,2%	30	17,4%	27	15,7%	25	14,5%
Diğer profillerle karşılaştırdığımda kariyerimi / eğitim hayatımı başarısız buluyorum.	83	48,3%	40	23,3%	30	17,4%	7	4,1%	12	7,0%
Diğer profillerle karşılaştırdığımda giyim tarzımı zevkli bulmuyorum.	69	40,1%	44	25,6%	34	19,8%	13	7,6%	12	7,0%
Instagram kullanırken fiziksel özelliklerimi diğerlerinin fiziksel özellikleri ile karşılaştırırım.	64	37,2%	40	23,3%	39	22,7%	15	8,7%	14	8,1%
Instagram kullanırken kariyerimi / eğitim hayatımı diğerlerinin kariyerleri / eğitim hayatları ile karşılaştırırım.	49	28,5%	41	23,8%	36	20,9%	32	18,6%	14	8,1%
Instagram'da, planladığımdan daha fazla zaman harcarım.	51	29,7%	41	23,8%	26	15,1%	33	19,2%	21	12,2%
Uykum geldiği halde Instagram'ı kullandığım oluyor.	49	28,5%	33	19,2%	25	14,5%	36	20,9%	29	16,9%
Instagram'da vakit geçirebilmek için ekstra zaman yaratırım.	81	47,1%	44	25,6%	25	14,5%	12	7,0%	10	5,8%
Can sıkıntımı gidermek için Instagram'da vakit geçiririm.	21	12,2%	18	10,5%	34	19,8%	54	31,4%	45	26,2%
Yapmam gereken işler olmasına rağmen Instagram'da zaman geçiririm	59	34,3%	37	21,5%	28	16,3%	28	16,3%	20	11,6%
Instagram'da paylaşacağım fotoğraflarda kıyafetimin ya da makyajımın nasıl olduğunun önemi yoktur.	25	14,5%	35	20,3%	33	19,2%	35	20,3%	44	25,6%
Instagram takipçilerimin, paylaştığım fotoğrafları/videoları beğenmesi benim için önemlidir.	50	29,1%	30	17,4%	39	22,7%	31	18,0%	22	12,8%
Instagram'da hangi fotoğrafı paylaşacağıma karar vermem zaman alır.	47	27,3%	36	20,9%	41	23,8%	32	18,6%	16	9,3%
İnsanların beğenmeyeceklerini düşünsem bile fotoğraflarımı Instagram'da paylaşırım.	58	33,7%	30	17,4%	32	18,6%	31	18,0%	21	12,2%
Paylaştığım fotoğraflarım yeterince beğeni almadığında moralim bozulur.	68	39,5%	43	25,0%	26	15,1%	19	11,0%	16	9,3%
Bazen fotoğraf çekmemin tek amacı Instagram'da paylaşım yapabilmek oluyor.	81	47,1%	23	13,4%	23	13,4%	31	18,0%	14	8,1%
Kendime ait fotoğrafları (selfieler, profil resimleri gibi) düzenledikten (fotoshop, filtre gibi) sonra paylaşırım.	74	43,0%	38	22,1%	29	16,9%	18	10,5%	13	7,6%
Instagram profilimi düzenli olarak güncellemek benim için önemlidir.	71	41,3%	47	27,3%	25	14,5%	13	7,6%	16	9,3%

Betimsel istatistik tabloları, kadın ve erkek katılımcıların ölçekte geçen bazı ifadelere katılma oranlarını karşılaştırmak amacıyla oluşturulmuştur. Betimsel istatistik tablolarında kadınlar ve erkekler tarafından ifadeler5e verilen yanıtların oranları6 karşılaştırılmıştır. Buna göre; sosyal karşılaştırma alt ölçeğindeki ifadelere katılım oranları: "Instagram kullanırken ekonomik kaynaklarımı diğerlerinin ekonomik kaynakları ile karşılaştırırım." İfadesine kadın katılımcıların %32,3'ü, erkek katılımcıların %23,8'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Diğer profillerle karşılaştırdığımda ekonomik kaynaklarımın yetersiz olduğunu düşünüyorum." İfadesine kadın katılımcıların %39,7'si, erkek katılımcıların %30,2'si katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir.

"Instagram kullanırken sosyal hayatımı diğerlerinin sosyal hayatı ile karşılaştırırım." İfadesine kadın katılımcıların %15,3'ü, erkek katılımcıların %21'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Diğer profillerle karşılaştırdığımda sosyal hayatımı sıkıcı buluyorum." İfadesine kadın katılımcıların %27,7'si, erkek katılımcıların %19,8'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Instagram kullanırken kariyerimi / eğitim hayatımı diğerlerinin kariyerleri / eğitim hayatları ile karşılaştırırım.." İfadesine kadın katılımcıların %42,2'si, erkek katılımcıların %26,7'si katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Diğer profillerle karşılaştırdığımda kariyerimi / eğitim hayatımı başarısız buluyorum. " İfadesine kadın katılımcıların %16'sı, erkek katılımcıların %11,1'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir.

"Instagram kullanırken fiziksel özelliklerimi diğerlerinin fiziksel özellikleri ile karşılaştırırım" ifadesine kadın katılımcıların %31,7'si, erkek katılımcıların %16,8'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Diğer profillerle karşılaştırdığımda kendimi yeterince çekici bulmuyorum." İfadesine kadın katılımcıların %17,5'i, erkek katılımcıların %12,8'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Instagram kullanırken nasıl giyindiğimi diğerlerinin nasıl giyindiği ile karşılaştırırım." İfadesine kadın katılımcıların %28,3'ü, erkek katılımcıların %12,8'i katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. "Diğer profillerle karşılaştırdığımda giyim tarzımı zevkli bulmuyorum." İfadesine kadın katılımcıların %15,4'ü, erkek katılımcıların %14,6'sı katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir.

Ölçekte kişisel sunum alt ölçeğinde verilen yanıtları değerlendirildiğinde; "Instagram'da hangi fotoğrafı paylaşacağıma karar vermem zaman alır." İfadesine kadın katılımcıların %44,6'sı, erkek katılımcıların %27,9'u katılıyorum ve kesinlikle katılıyorum yanıtını; "Instagram takipçilerimin, paylaştığım fotoğrafları/videoları beğenmesi benim için önemlidir." İfadesine kadın katılımcıların %36'sı, erkek katılımcıların %30,8'i katılıyorum ve kesinlikle katılıyorum yanıtını; "Kendime ait fotoğrafları (selfieler, profil resimleri gibi) düzenledikten (fotoshop, filtre gibi) sonra paylaşırım" İfadesine de kadın katılımcıların %25,6'sı, erkek katılımcıların %18,1'i katılıyorum ve kesinlikle katılıyorum yanıtlarını vermiştir.

Değerlendirme ve Sonuç

Sosyal medya; iletişime, sosyalleşmeye, bilgi alışverişine, eğitime, ticarete, dayanışmaya kadar işlevsel anlamda kullanılabilecek bir platformdur. Sosyal medyayı Instagram özelinde değerlendirdiğimizde gösteri dünyasında olduğumuzu söyleyebiliriz. Instagram eğlence odaklıdır. Gösteriş, beden, mutluluk temaları profillerde öne çıkmaktadır. Bu temalarla kimlik sunumları gerçekleşmektedir. Gösterinin, mutluluğun, fiziksel ya da maddi iyi olma durumunun sürekliliği

[5] Çalışmanın özellikle kavramsal-kuramsal çerçevesinde değerlendirilebilecek ifadelere verilen yanıtlara odaklanılmıştır.
[6] İfadelere katılım düzeyini belirleyen katılıyorum ve kesinlikle katılıyorum seçeneklerinin işaretlenmesiyle oluşan oran yüzdeleri toplanmıştır.

mümkün olmasa da Instagram bunun aksini söyler. Herkes mutlu, güzel, eğlenceli, eğitimli, varlıklı ve iyi koşullarda yaşamaktadır. Bahsedilen bu detaylar, sanal kimliklerde kadın ve erkek kullanıcılarda farklılaşarak tecrübe edilmiştir. Çalışmada olanaklarıyla olduğu gibi kısıtlamalarıyla da sınırları olan bir Instagram uygulamasından bahsedilmiştir. Sınırlar, genelleştirilmiş ötekinin beklentileriyle ve bu beklentilere uygun bir sanal kimlik kurgusuyla şekillenir. Ötekiler takipçidir, takipçilerinin onayı alınmalıdır. Bu, sanal kimliğin bilinirliği için, onaylanmak ya da yeri gelirse popüler olup internet ünlüsü dahi olabilmek için gereklidir.

Sosyal medyada bir sanal kimlik inşası ve sunumu gerçekleşir. Kadınların ve erkeklerin sosyal medyada sanal kimlik inşa etme deneyimlerinin keşfedilmesi ekseninde "Instagram Kullanımı Ölçüm Aracı" ölçeği katılımcılara uygulanmıştır. Cinsiyet ile Instagram kullanımı arasında istatistiksel açıdan anlamlı ilişki saptanmıştır. Kadınların Instagram kullanımı ölçüm aracından, sosyal karşılaştırma ve aşırı kullanım alt ölçeklerinden aldığı puanlar, erkeklerden daha yüksek olmuştur. Öyleyse kadınlar, Instagram'da kendilerini diğer kullanıcılarla daha çok kıyaslamakta ve Instagram'da erkeklerden daha fazla vakit harcamaktadır.

Sosyal karşılaştırma alt ölçeğindeki sorulardan ipuçları toplanmıştır. "Instagram kullanırken ekonomik kaynaklarımı diğerlerinin ekonomik kaynakları ile karşılaştırırım" ve "Diğer profillerle karşılaştırdığımda ekonomik kaynaklarımın yetersiz olduğunu düşünüyorum" İfadelerine kadın katılımcılar, erkek katılımcılardan daha yüksek oranda katılıyorum ve kesinlikle katılıyorum yanıtını vermiştir. Hegemonik erkeklik -Ataerkil ilişkilerde ekonomik özerklik ve yeterlilik, kaynak sağlayıcılık rolleri normatif erkeklikle ilişkilendirilmiştir (Connell 2005)- ten beklenen sorumluluklar ve maddi güç baskısından dolayı ifadelere erkek katılımcıların daha yüksek oranda katılacağı beklenirken oranlar beklenen yönde olmamıştır. Ayrıca sosyal hayatı sıkıcı bulma, eğitimi/kariyerini karşılaştırma ve bu açıdan kendisini başarısız bulma ifadelerine de katılım oranı kadın katılımcılarda erkek katılımcılardan daha fazla olmuştur. Bu yanıtlar bir noktada kadının kendisini ekonomik anlamda yetersiz gördüğü ve sosyal anlamda da kısıtlanmış olarak hissetmeye götürdüğü yorumu yapılabilir. Dahası kadın, Instagramda daha fazla vakit harcadığından ınstagramda kendini kıyaslamaya da daha fazla yönelebilmekte ve bu sebeple yetersizlik hissine de daha fazla kapılmaktadır

Sosyal karşılaştırma alt ölçeğinden devam edildiğinde; Instagram'da fiziksel özelliklerini, nasıl giyindiğini kıyaslama ve kendisini yeterince çekici bulmama, giyim tarzını zevkli bulmama ifadelerine katılıyorum ve kesinlikle katılıyorum yanıtını veren kadınların oranı erkeklerden daha fazla olmuştur. Çok büyük farklardan bahsedilmese de genel oranlara göre; fiziksel kaygılar, fiziksel açıdan kendini diğerleriyle kıyaslama ve görüntüsünden kaygı duyma; kadınlarda erkeklerden daha fazla olmuştur. Beden üzerinden belirlenen toplumsal cinsiyet algısında güzellik söylemlerinin kadınlara yansımış olduğuna değinilmişti ve dolayısıyla bu beklenen bir sonuçtur. Güzellik kadın için geçerli olmakla birlikte kadınların bu anlamda bedenlerine yönelik kaygılanması, rejim, güzellik uygulamaları, giyim, makyaj gibi detaylarla ilgilenmesi, iyi gözükmek adına ne gerekiyorsa yapmayı göze alması idealize edilen bir kadın imgesine ulaşabilmek içindir (Firestone, 2013:163). Instagram görsellerin dolaşımda olduğu bir şölen yeri ve bu uygulamada kusursuz görseller dolaşımdadır. Dolayısıyla, güzellik söylemi kadınlar için geçerli olduğundan kadınların sosyal medyada da kendisini diğer profillerle kıyaslayıp bedensel, fiziksel anlamda ve giyim tarzı gibi imajla ilgili detaylarda yetersiz görmesi durumu şaşırtmamaktadır.

Instagram Kullanımı Ölçüm Aracı'nın Kişisel Sunum alt ölçeğinde, sosyal medyada onaylanma, beğenilme kaygısı ve beğenilmek için kusursuz görseller paylaşma açısından verilen yanıtları

değerlendirdiğimizde; “Instagram'da hangi fotoğrafı paylaşacağıma karar vermem zaman alır.” “Instagram takipçilerimin, paylaştığım fotoğrafları/videoları beğenmesi benim için önemlidir.” “Kendime ait fotoğrafları (selfieler, profil resimleri gibi) düzenledikten (fotoshop, filtre gibi) sonra paylaşırım” ifadelerine katılım oranlarında kadın ve erkekler arasında yine çok büyük bir fark olmasa da genel olarak oranlar, sosyal medya profillerinde güzellik, beden üzerinden onaylanma ve görsel kaygıların kadınlarda daha fazla olduğu görüşünü destekleyicidir. Başkaları üzerinde fiziksel olarak iyi bir izlenim bırakmaya kadınlar, erkek kullanıcılara göre daha fazla önem vermektedir. Kadın bedeni üzerinden geri dönüşler alacağını sosyal medyadan önce içselleştirmiştir.[7] Bilindik çevrenin dışında büyük bir kitleselliğin, takipçilerin karşısında kadınların gündelik yaşamda olduğu gibi sosyal medyada da bedeni üzerine söylemlerde bulunabilecek başkaları olduğunu bilmektedir. Oranlara da bu yansımıştır. Gerek kadın gerekse erkek katılımcılar için bir sosyalleşme, vakit geçirme, iletişim aracı olmakla birlikte oranlar, güzellik söylemi ve görsel kaygıların kadınlarda daha fazla olduğu görüşünü destekleyicidir

Baudrillard (2011)’ın tanımıyla yorumlayacak olursak kimlikler, sanal platformlarda simüle edilerek sergilenmektedir. Baudrillard, simüle etmeyi “Gerçek olmayan bir şeyi gerçekmiş gibi sunmak, göstermeye çalışmak” şeklinde tanımlamıştır. Kavram gizlemek değildir. Gizlemek, sahip olunan şeye sahip değilmiş gibi davranmak iken; simüle etmek ise sahip olunmayan şeye sahipmiş gibi yapmaktır. Dolayısıyla kurgusal sanal kimliklerimiz birer simüle etme eylemi kapsamındadır. Bu doğrultuda kadın bedenine yapılan dayatmalarla idealize öne çıkararak onaylanmayı beklemektedir. Fiziksel çekicilik, erkek profiller sahiplerine popülarite sağlasa dahi bu onun maddi güçlü yönünü destekleyici bir faktör olmaktadır.

Başta Instagram olmak üzere sosyal medya platformları benliğin sunumunun çeşitli versiyonlarını aynılaştıran etkide bulunmaktadırlar. Farklılık ve özgünlük öne çıkmak için elzem olarak sunulsa da belirli tipolojilere dâhil olmayan gönderilerin beğeni kazanması yahut istenen ölçüde popülarite sağlaması söz konusu olmamaktadır. Bu doğrultuda eskiden beri popülerlik kriterleri olarak değerlendirilen kadınlarda dış görünüş, erkeklerde ise güç ve zenginlik hâlihazırda en önemli etkenler olmayı sürdürmektedir.

Çalışma çerçevesinde kadınların ve erkeklerin sosyal medyada sanal kimlik inşa etme deneyimlerinin keşfedilmesine baktığımızda; yanıtlarda çok büyük bir fark olmasa da genel olarak kadınlar Instagram’ı erkeklerden daha fazla önemsemekte, Instagram’da erkeklerden daha fazla mesai harcamakta, sosyal hayatını, eğitim hayatını, kariyerini, ve fiziksel özelliklerini erkeklerden daha fazla kıyaslamakta, paylaşımlarına ve alacağı geri dönüşlere, beğenilere erkeklere oranla daha fazla önem vermektedir.

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[7] Kadının bedeni üzerine dayatmalar konusuna Bourdieu (2015) “Eril Tahakküm” eserinde değinmiştir. Kadının bedeni; başkaları için bedendir, başkalarının bakış ve konuşmalarının bir nesnesidir. Kadınların bedensel olarak idealize edileni yakalama kaygıları içinde olmakta, çekici gözükmek adına yaptıkları diyetler, kalori hesapları ile uğraşmaktadır (Giddens 2010: 138). Giddens’ın kitabında yer verdiği bu kişisel açıklamaya benzer ifadeler Bauman (2011: 66)’dan da gelmiştir. Bauman, güzellik dayatmalarına ve her gün bir yenisi eklenen estetik işlemlerine ve medikal kozmetik sloganlarına gönderme yaparak “Kadının hayatı erkeğinkine kıyasla daha da zor” der. Kadınlar, gece gündüz ameliyat ya da doğru krem gibi ardı arkası kesilmeyen yeni keşiflere çıkmak zorundadır

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REFORMS IN TYPHLOPEDAGOGIC TEACHING

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Abstract – Typhlology is the branch of research that studies how individuals with serious injuries-up to total blindness-live their lives. Typhlopedagogy is a subfield of typhlology that focuses on the instructional strategies used to educate pupils who have visual impairments. The challenge of special education in Albania is to bring Albanian pedagogy into line with the accomplishments and standards of pedagogy of developed western nations, based on the best experience and successes. The Albanian government provides free boarding for ten years straight, from preparatory to ninth grade, to kids with visual impairments. The education of pupils who lack vision, their qualifications, and life skills provide a challenge to us. An example of how a student may be integrated by moving from a special pedagogy school to a normal school is shown below.

Keywords –Emotional encounter, blindness, education, social accommodations, methodological innovation, and typo-pedagogical change.

1. INTRODUCTION

The educational and pedagogical process

Typhlopedagogy is a subfield of typhlology that focuses on the intricate processes involved in teaching and learning for visually impaired pupils. They use their knowledge to find solutions to more than 70% of the issues they face in life.

The curriculum comprises all of the courses offered at the relevant public school as well as extra courses, programs, and disciplines including writing, music education, Braille classes, outdoor orientation, etc. It's challenging to teach these pupils (typhlopedagogy).

Pupils struggle with perception, lack of knowledge, and inability to distinguish symmetry, color, and harmony-aesthetic aspects that create feelings of beauty-among other issues. A gap in the formation of aesthetic enjoyment that provides size, color, natural shapes, and appearance is caused by blindness. The instructor is compelled to fill up this knowledge gap by using oral storytelling, literary similes, and the creation of virtual pictures and visualizations. Students with total absence of vision, but who do not have other health issues, have full intellect, have sentiments, thoughts, values, morality, goals and desires for life.

To ensure that kids always feel like they belong among others, the school and the instructor must make up for the pupils' loss of sight with love, their presence, educational professionalism, spiritual affinity, and communication bridges. Naturally, this calls for a daily, demanding, and exhausting commitment as well as resources, a material foundation, civic engagement, institutional cultural awareness, and legislation that expressly states the position of visually impaired students. Albanian authorities in the fields of science, intellectualism, and social work who work with special education need to do their part to meet scientifically the commitments that remain in light of the advancements and educational standards of industrialized nations.

Typhlopedagogy, Typhlopsychology, and Typhlotechnics are some of the sub-branches of Typhology, a specific discipline, that directly affect the development of children with visual impairments. The goal of pedagogical standards in special education institutions is to help kids grow up to be free, autonomous persons who can live regular lives in the future, just like everyone else.

Children between the ages of three and five who are born blind and do not get the appropriate care fall into this category. The youngster requires a lot of information at this age. For visually challenged youngsters, receiving educational assistance at this age would be a significant step toward their intellectual future. The task of early interventions lies ahead. A pilot study is required to treat youngsters between the ages of three and five. A different analysis addressing programs, infrastructure, and financial costs is necessary for this. It is essential to bear in mind that while working with pupils who have visual impairments, we are not working with a tranquil, well-adjusted youngster. They often complain of headaches, sleep disturbances at night, exhaustion in class, fast mental tiredness, and other issues related to metabolic abnormalities. To make their lives more vibrant and active, a unique program of cultural and artistic pursuits must be implemented. Activities like play therapy, athletics, poetry, dance, and music have a positive biological influence on students' lives. According to scientific research, there seems to be a nearly two-year developmental delay in comparison to kids with normal eyesight. Students' good energies are released when they are able to perform both individually and in groups, reaching to behave freely and without worry. This impacts their desire towards leading happy lives. The hardest part of teaching is getting students to grasp topics. Since every person is different and needs to be addressed as such both pedagogically and psychologically, the job must be completed individually for every individual. An essential framework in our educational endeavors continues to be the acknowledgement of the authority that mobile analysts, or the impacted, get.

2. STRUCTURED REFLECTION

One of the modern successes in dealing with students is the development of organized reflection methods. We must work diligently to instruct them like normal students and even recognize and develop their proclivities and skills in other subjects since most pupils have a regular brain structure. The visual deprivation is overcome and the student with visual impairments is able to develop their personality normally with the help of their instructor and their combined effort. Children that get inadequate education and training become intellectually retarded. It has been noted that in terms of psychological traits, blind children adjust to their surroundings without completely realizing how they differ from others. If we are talking about a blind

child's full integration into society with all of its components, the cost of spending is enormous. There are also situations when a family isolates and fails to educate their kid for psychological or financial reasons. Given that the state has made advantageous circumstances for their education, this is unacceptable. There is still a problem with this as high school and university education continue. Today's blind students use specialized computer applications that are quite beneficial. As a result, accessing information online is now simpler. In order to provide the values that human society has developed over the ages in a variety of ways, including those who are blind, more special education services are being provided.

The primary issue for them is the relationship between the environment and the macro environment, as well as their ownership and use. The cornerstone of educational activity continues to be their adoption and perfection. to understand light and dark, to utilize computers, the Internet, books, and newspapers, as well as ordinary tools and measurement instruments. Correcting distortions in reality perception is a challenging task for the teacher-typhlopedagogue; this is the primary goal of Typhlopedagogy. One of the most challenging aspects of visualizing enormous, intangible dimensions is doing it with color. With concrete items, when the imagination is more vivid, it is different.

3. TYPHLOTECHNICS

Typhlotechnics has produced excellent results and is now highly beneficial for blind students; nevertheless, locating the suppliers and the nations that manufacture these devices—such as Braille printers and optical sound scanners—can be challenging. Students are able to mentally map places during the orientation course. In particular, pupils who were born blind need to do this. Non-visual learners use their senses of touch and hearing to manipulate and comprehend spatial information. Making mental maps of surroundings and their spaces—a process known as spatial data processing—is crucial for effective orientation and the development of movement patterns. The senses of smell, touch, and hearing are important sources of information that need mastery. The process of creating mental maps of movement is directly impacted by the activation of these senses. Dactyl maps, which are tactile and represent spatial information at tiny scales, are useful teaching aids. Similarly, technological aids such as mobile phones that have been configured provide blind students with an aural or tactile cue when a barrier is presented to them. Since these resources are pricey, not all visually impaired kids have access to them. The confidence that is instilled in him about his future employment and ability to blend in with others is quite significant. It is important to remember that instructors should steer clear of subjectivism while explaining concepts, particularly when working with younger students and in lower grades.

Instructors need to have a strong foundation in verbal explanation. Verbal teaching is based on instruction, verbal explanation, description of the phenomena or object, movement, creatures, or social interactions, all of which the teacher must be very proficient in.

Approaching the psychological service for pupils with visual impairments is crucial. Both thoughtful group work and individual therapy treatments may help people overcome a great deal of challenging spiritual issues. In order for kids to believe they have what it takes to handle rigorous coursework, we need to help them feel more confident in their own abilities. They need to be taught to accept the stigma. It is unusual, but sometimes they are taunted or insulted when others ignore or make fun of them. To skillfully, wisely, and culturally sidestep these warnings, one must have inner spiritual power. This shouldn't result in harm, retreat, or a bashful and reserved demeanor in public. More emphasis should be placed on teaching civic education students on how to treat students with physical impairments with dignity and respect, emphasizing the moral and spiritual harm that results from treating them badly. In a same vein, even for comedic purposes, it is immoral to listen to profanity, monikers, and insults in the media. A society's attitude toward human flaws and injuries is a crucial indicator of its quality and cultural level. In other instances, parents have hidden or isolated little children from their peers in an attempt to shield them from shame or ridicule—even if the children would much rather be among their friends. The topic of additional curriculum and text enhancement must be reviewed with working groups in special pedagogy programs and modules. to raise the standard of scientific typopedagogy by continuously upgrading the staff's typological instructors' qualifications. It would be a job for the future to equip schools with technological instruments like optical readers, electronic dictionaries, talking clocks, telephones, Braille machines, blood pressure and stress monitoring equipment, vocalization software, genuine pedagogical research, etc.

4. INTEGRATION IN PUBLIC SCHOOLS AS AN ELEMENT OF THE REFORM

Children with visual impairments have varying emotional experiences depending on where they are in their educational journey. We can therefore discuss his transition from preschool to school life. This is a very challenging time for the child because the specialized school is only in one city and their "migration" to a public school at a young age causes significant emotional shocks. The following factors (phenomena) contribute to the best possible coping strategies for this emotional phenomenon:

a) parental warmth,

b) The socially acceptable atmosphere, which unintentionally yet subconsciously causes the transfer of priceless spiritual energy (positive energy), which acts as a further tool and stimulus for learning,

c) The professionalism of the special education teacher, also known as the assistant teacher, who has the essential special pedagogy skills and may act as a solid support system for the kid throughout his transition from the special school to the public one.

As a result, the concept of equality within his social-natural circle is validated in the student's mind. This disproves the myth that only kids with similar clinical statuses should get an education for someone with this

kind of handicap. Its healing is the development and attainment of abilities that allow for integration and employment; it is the resuscitation of faith, hope, life security, economic independence, psychological emancipation, moral equilibrium, and life motivation. More specifically, how can the instructor help this main cycle student succeed in the learning process?

We are giving this typhlopedagogic presentation

A student who is blind attends your class. Undoubtedly, you'll go through a startling emotional encounter. The main source of my anger is my uncertainty about my ability as a teacher and how to best support this student's special education requirements so they can learn in a normal classroom. How will he behave in the classroom to meet his psychological and social needs and feel welcomed and a part of the overall educational process, just like everyone else? What obstacles and challenges do I face during learning, and how can I get beyond them? Which personalized strategy will be created just for him? What are the expectations of other students about the presentation in front of the class, the school atmosphere, the opinions of other instructors, and the student's own feelings? Things to say and things not to say while facing him. After psychomotor exams, classroom instruction, and school orientation, how will I be able to move about and how will we be able to overcome psychomotor limitations? This kid really has certain particular needs, which I have to recognize and meet for him throughout the course of the learning process. Since this is a social scenario, there are additional specific requirements for my adult child who is parentless. There are additional challenges and a different curriculum. Undoubtedly, being blind is a more severe disability. I feel as if an inner voice is waking me up from the deepest part of me. As I peruse educational materials, I come across inspiring quotes from kids who have visual impairments, such as "Never forget that I am blind; don't treat me like a blind student." According to observations of visually impaired children, the Albanian student leaves his home at the age of six, when warmth from family members is most required, to pursue his education at a specialized school in Tirana.

Here we can draw some psychological conclusions

For this pupil, the extended absence of family members creates a secondary source of drama. He feels an inner delight, a stimulant brought about by the family atmosphere, a sense of moral satisfaction, and positive reinforcement throughout the nights he spends with them and during their meetings. Every kid has an invaluable spiritual energy that is formed by their blood relatives. As a step toward our education system's inclusiveness, the transfer of students from special schools to public schools under the supervision of auxiliary teachers and with the help of special school pedagogues who possess the requisite knowledge of special pedagogy would raise the bar for this educational service. There is a lot of instructional material available for this learner. As he gets older, he understands he doesn't put a lot of strain on his family. However, the entire family—parents, siblings, sisters, friends, and relatives—makes up the educational context that justifies using this child, along with all other children, as an extra tool and catalyst for the development of visually impaired students. By doing this, we challenge the myth that children with the same clinical condition should get the same education as those with the impairment.

Regardless of the challenges and barriers they face, the naturalization of these kids in an open social setting is the only educational approach that gives them real-world experience, gives them the life skills they need to become independent and free from inferiority complexes. Four entities directly influence the education and training of visually impaired students: the family, the school, the specialized institution, and the special instructor. The remedy for it is really to acquire the competences necessary for integration and work. Reviving faith, hope, joy for life, security and hope, economic independence, psychological emancipation to form a moral balance, motivation, and the confidence that one can manage life in an appropriate manner are all crucial for the visually impaired student. The specialized physician diagnoses the clinical ailment, which may include nystagmus, color blindness, astigmatism, myopia, hypermetropia, or strabismus. The instructor considers that among the resources they should bear in mind are the usage of glasses, the amount of time needed to finish a work, enough lighting in the classroom, larger books, or Braille. The literature on typology as a branch of science and as a science itself aids the instructor in comprehending the requirements and pedagogical approach of working with this student. It is crucial to extract psychometric data and adjust the knowledge escalation that would need advancement following the test, depending on the amount of knowledge.

Strict adherence is required to the regulations that restrict the learning possibilities as well as the psychomotor and physical capacities of pupils with vision impairments. We may direct the educational process toward cultural restoration by acknowledging the obstacles. Is the social milieu and the school ready to fulfill this educational goal? The scarcity of skilled personnel across many specializations, particularly in the area of special education, need to be expanded to a large teacher pool, with particular emphasis on the Primary Cycle profile. It is better treated and more effectively rehabilitatively at this age. A kid with special needs cannot be accommodated in a packed class of more than thirty pupils. Despite the obstacles, being blind enables you to experience many spiritual delights in life.

To assimilate and not be left alone is sufficient. They need to be qualified and activated. They desire special schooling, which naturally entails more attention and a larger price tag than regular education. The aim of modern education and current pedagogy is accommodation in public schools, where it is feasible to teach the student with visual impairment. Albania is required to implement changes for a contemporary, high-quality, and inclusive education on a global scale, as are other nations and communities.

"Regular schools with an inclusive orientation are the best means to combat discriminatory attitudes, to build accepting communities, to build inclusive societies and to achieve education for all; in addition, they provide effective education for the majority of children and improve the efficiency and ultimately the cost of the entire education system." The third decade of enacting inclusive policies has begun in the most developed school systems in Europe.

Furthermore, the goal and reform in special education are spelled out in detail in international publications. "Persons with disabilities are not excluded from the general education system on the basis of disability," and they must be given "accommodation reasonable" and "necessary support" for learning, according to the UN Convention on the Rights of Persons with Disabilities, (2006).

Likewise, "ensuring that all children have access to good quality basic education" is the definition of "access to education for all" in the UNESCO Guidelines for Inclusion (2005). This entails establishing a setting in basic education programs and schools where kids are given the chance to study; The school has an obligation to provide accommodations for all students, irrespective of their physical, intellectual, social, emotional, linguistic, or any other condition, even if the UNESCO Main Program "Education for All" (2001) emphasizes the right to education for those with disabilities to inclusion. It is acknowledged that special education is important. The issue that the instructor and the school are up to this purpose therefore emerges.

A set of tasks for the assistant teacher to do in the event that a student in the class is visually impaired. Participating in the educational process and the classroom presents few challenges since, compared to other impairments, education is simpler when the initial disability is absent. When it comes to moving about and taking care of their needs, students who are deaf or hard of hearing may be very independent. However, they need a specific mode of communication, such as sign language, which keeps them apart from practically all classroom interactions. For students with intellectual disabilities, however, the process is far more complex and challenging. Teachers with specialized training in special pedagogy are needed to create an individualized learning and activity program that takes into account the student's areas of interest, type, and level of disability. Any instructor who is qualified to teach in a classroom may assist a visually impaired student who receives minimal assistance and cooperation in integrating into a normal classroom. Students without additional disabilities finish the curriculum in its entirety; they only need to modify the teaching strategies and resources, not the goals that are meant to be attained. To effectively manage a class with one or more visually impaired students, a teacher needs support from specialized institutions, an assistant teacher using modern methods, teamwork for the individual educational plan, and support from the school and the family.

In order to prevent the student with a disability from feeling alone, the instructor must set up the classroom as best they can. It is important to inform students about their intellectual capacity, limits, and possibilities as a new student. to foster a sense of respect and unity by refraining from using language that denigrates or stigmatizes the identity of the troubled kid. In this instance, the learner feels more equal, driven, and confident. In order to avoid misunderstandings that may arise from naïve and stigmatizing inquiries, the instructor has to prepare the class psychomorally beforehand. Being familiar with the surroundings is crucial since it gives the student mobility safety. Since changes impact the student's mental scheme of orientation, the classroom system must preserve the condition as long as possible. Unfamiliar and chaotic environments cause stress and fatigue in the student's memory and cause visual problems. Keep the students and tables in the proper order. Also, make sure that the students are aware of the external environment, which includes the stairs, threshold, obstacles in the school yard, etc., as well as the material tools used in the classroom, such as desks, shelves, portable air conditioners, and projection devices. It is preferable to put the visually impaired student in the first bank, unless there is a computer that has to be placed in the final bank and requires larger screen pictures or larger books. He manages the admissions and exits of the classroom as well as the computer's chalkboard via the webcam. The verbalization of the story is a continuous endeavor for the instructor dealing with visually impaired pupils. He cannot see our gestures or actions, thus in order to avoid

casting him in an unfavorable light throughout the conversation, we must explain the event as precisely as we can in words.

While we modify our teaching strategies to fit the needs of each program, we never cut the standards. He will be equal rather than favored. There won't always be a teacher to guide the student in life, therefore we must educate him how to become more independent and competent. Telling the pupil how to do this or that activity initially will provide him the chance to develop his own implementation ideas within the context. You'll be persuaded that he develops concepts and is really helpful, and in this instance, new and contemporary educational methods are being used in the classroom. When speaking with a blind student, teachers and other interlocutors should exercise caution when using phrases like "you saw it" or "Look here..." since they might cause pain and serve as a reminder of his severe restricting condition. When dealing with a kid who has visual impairments, the specific education plan is crucial. The personalized work platform that methodically organizes the instruction of the impaired learner is this educational document. This follows a structural pattern, and the instructor is not the only one who does it. The administrative, instructional, and restorative aspects are the program's main foci. A dedicated working group at the DARs is responsible for creating this initiative. The specialized institution offers a variety of technical assistance, including acoustic books, thermoform sheets, portable banks, magnifiers, larger books, Braille books, and an electroorganizer application that can be placed on a phone for communication.

CONCLUSIONS

Though there is still more work to be done in this area, social integration is a positive step toward comprehensive education.

Switch from the medical to the social model as a fresh, contemporary method of offering top-notch assistance to pupils who struggle with studying.

When working with pupils who have visual impairments, educators should read literature and learn more about typhlopedagogy.

Collaborate as a team with the committee at the school to ensure that the customized curriculum is implemented smoothly and that the learning process is evaluated.

Establish a classroom that is suitable in terms of psychology, socialization, and technology.

Work closely with the parent of the student to accomplish the skills in accordance with the curriculum's goals.

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BİR YERALTI ALTIN MADENİNDE ÜRETİM SÜRECİNDE KARŞILAŞILABİLECEK İSG PROBLEMLERİ VE ÖRNEK KAZALAR

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Abstract – Bu akademik çalışmada, Yeraltı altın madenlerinde üretim sürecinde karşılaşılabilecek İş Sağlığı ve Güvenliği (İSG) problemleri olan; Kimyasal Maruziyet, Gürültü ve Titreşim, Ergonomik Sorunlar, Fiziksel Yaralanmalar, Yetersiz Havalandırma, Göçük ve Çökme Riskleri, Gaz ve Toz Tehlikeleri, yeraltı altın madenciliği işletmelerinde sık sık karşılaşılan ve ciddi sonuçlara yol açabilen sorunlardır. İşletmeler, bu riskleri azaltmak ve işçilerin güvenliğini sağlamak için sıkı İSG politikaları ve prosedürleri uygularlar. (1)

Çalışma, bu tür bir analizin, yeraltı altın madeni tesislerinin iş güvenliğini artırmada nasıl etkili bir araç olabileceğini vurgulayarak, iş güvenliği alanında daha geniş bir farkındalık oluşturmayı amaçlamaktadır. (Külekçi,2023)

Keywords –iş güvenliği, yeraltı altın madenciliği, risk analizi

1.GİRİŞ

1.a. Yeraltı altın madenciliğinin önemi

Yeraltı altın madenciliği, altın cevherlerinin yeraltında bulunması ve çıkarılması işlemidir. Bu, altın yataklarının derinliklerine ulaşmayı gerektiren bir süreçtir. Yeraltı altın madenciliği, açık ocak madenciliği ile karşılaştırıldığında genellikle daha maliyetli ve teknik olarak zorlayıcıdır, ancak aynı zamanda çevresel etkileri daha azdır.

Yeraltı altın madenciliğinin önemi birkaç faktöre dayanır:

Verimlilik ve Verim: Yeraltı altın madenciliği, düşük kaliteli cevherleri çıkarmak için daha etkili olabilir. Açık ocak madenciliği için uygun olan cevherlerin tükenmesiyle birlikte, yeraltı madenciliği daha çeşitli ve derin yataklardan altın çıkarmayı mümkün kılarak madencilik endüstrisinin sürdürülebilirliğine katkı sağlar. (Özgenç & Kabadayı, 2019)

Çevresel Etkilerin Azaltılması: Açık ocak madenciliği genellikle toprağı, bitki örtüsünü ve su kaynaklarını ciddi şekilde etkileyebilir. Yeraltı madenciliği, yüzeydeki bu etkileri en aza indirir ve çevresel etkileri azaltır.

Güvenlik: Yeraltı madenciliği, madenciler için genellikle daha güvenli bir çalışma ortamı sunar. Ancak, bu, belirli teknik ve güvenlik protokollerinin sıkı bir şekilde uygulanmasını gerektirir.

1.b. İş Sağlığı ve Güvenliği (İSG) kavramının önemi ve madencilik sektöründeki yeri

İş Sağlığı ve Güvenliği (İSG), çalışanların sağlığını ve güvenliğini korumayı amaçlayan bir kavramdır. Bu, işyerlerindeki potansiyel tehlikelerin tanınması, değerlendirilmesi ve kontrol edilmesini içerir. İSG önemlidir çünkü çalışanların sağlığı ve güvenliği, sadece bireylerin kendileri için değil, aynı zamanda işletmeler için de kritik bir konudur. Sağlıklı ve güvenli bir çalışma ortamı sağlamak, işletmelerin sürdürülebilirliğini artırır, iş gücü verimliliğini artırır ve itibarlarını korur. (Miller & Davis, 2020)

Madencilik sektörü, İSG'nin önemi açısından özellikle dikkate değerdir çünkü madencilik faaliyetleri doğası gereği yüksek riskler içerir. Madenler genellikle derin yeraltında veya açık ocaklarda bulunur ve bu çalışma alanları potansiyel olarak tehlikeli olabilir. Madencilik faaliyetlerinin İSG önlemleri olmadan yürütülmesi, ciddi kazalara, yaralanmalara ve hatta ölümlere neden olabilir.

Madencilik sektöründeki İSG'nin yeri şu şekilde özetlenebilir:

İş Kazalarının Önlenmesi: Madencilikteki iş kazaları genellikle ciddi sonuçlara yol açabilir. İSG önlemleri, iş kazalarının önlenmesine yardımcı olur ve çalışanların güvenliğini sağlar.

Sağlık Risklerinin Azaltılması: Madencilik faaliyetleri, işçilerin solunum yolu hastalıkları, işitme kaybı ve diğer sağlık sorunları gibi çeşitli sağlık riskleriyle karşılaşmasına neden olabilir. İSG politikaları ve prosedürleri, bu tür riskleri azaltmaya yöneliktir. (Black, & Smith,2016)

Çevresel Etkilerin Yönetimi: Madencilik faaliyetleri sadece işçiler için değil, aynı zamanda çevre için de risk oluşturabilir. İSG uygulamaları, çevresel etkilerin minimize edilmesine yardımcı olabilir.

Kamu İtibarının Korunması: Maden şirketleri, iş sağlığı ve güvenliği konusundaki sorumluluklarını yerine getirerek kamuoyunun güvenini kazanır ve itibarlarını korur.

Madencilik sektöründe İSG, işletmelerin etkin bir şekilde işletilmesi ve sürdürülebilirliği için kritik bir rol oynar. Bu nedenle, maden şirketleri genellikle sıkı İSG politikaları ve prosedürleri uygular ve çalışanların eğitimi ve bilinçlendirilmesi konusunda sürekli çaba harcar. (Külekçi, 2022)

2.YERALTI ALTIN MADENİ ÜRETİM SÜRECİNİN TANIMI

Yeraltı altın madeninde kullanılan temel ekipmanlar ve bu süreçlerde işçilerin rolleri

Yeraltı altın madenciliği, karmaşık ve çeşitli ekipmanlar ve süreçler gerektirir. İşte yeraltı altın madeni işletmelerinde yaygın olarak kullanılan bazı temel ekipmanlar ve bu süreçlerde işçilerin rolleri:

Jeolojik Araştırma ve Keşif: İlk adım, maden sahasının jeolojik özelliklerinin araştırılması ve altın yataklarının keşfedilmesidir. (resim-1) Jeologlar ve jeofizikçiler, arazi çalışmaları yapar ve potansiyel altın yataklarını belirlemek için jeolojik verileri analiz ederler.

(Külekçi, Çullu, Yilmaz, 2023)

Resim – 1: Alanda jeolojik araştırma ve keşif

Delme ve Patlatma: Yeraltı altın madenciliğinin ilk aşamalarından biri, cevheri çıkarmak için kayaların delinip patlatılmasıdır. Bu, delme makineleri kullanılarak gerçekleştirilir. Delme işlemi, cevheri içeren kaya kütlesinin parçalanmasını sağlar. Daha sonra patlatma işlemi, delinmiş kaya kütlesinin dinamitle patlatılarak küçük parçalara ayrılmasını sağlar.

(Külekçi, Yılmaz, 2018)

Tünel Açma ve Galeri İnşaatı: Yeraltı madenlerinde, altın yataklarına ulaşmak için tüneller ve galeriler açılması gerekebilir. Bu süreçte tünel açma makineleri ve ekskavatörler gibi ekipmanlar kullanılır. İnşaat işçileri, madenin içindeki altyapıyı oluşturur ve işletme için gerekli altyapıyı sağlarlar. (Resim-2)

Resim – 2: Tünel açma ve galeri çalışmaları

Madencilik Ekipmanları: Yeraltı madenlerinde kullanılan çeşitli madencilik ekipmanları vardır. Bunlar arasında maden kazıcıları, yükleyiciler, taşıma arabaları ve matkap makineleri bulunur. Bu ekipmanları işçiler, madenin içindeki kaya ve cevherleri çıkarmak, taşımak ve işlemek için kullanılır. (Resim-3)

Resim -3: Yeraltında kullanılan ekipmanlar

Havalandırma Sistemleri: Yeraltı madenlerinde, havalandırma sistemi, işçilerin güvenli bir şekilde çalışabilmesi için kritik öneme sahiptir. Havalandırma sistemleri, tüneller boyunca taze hava sağlayarak gazların ve tozların uzaklaştırılmasını sağlar. Bu sistemler, işçilerin solunum sağlığını korumak için hayati öneme sahiptir. Aynı zamanda güvenlik işçileri, işçilerin güvenliğini sağlamak için gerekli güvenlik protokollerini uygular ve işçileri eğitirler.

(Külekçi, Meral, 2023)

Drenaj ve Su Yönetimi: Yeraltı madenlerinde su, önemli bir sorun olabilir. Madenin alt kısımlarında biriken suyun tahliyesi için drenaj sistemleri kullanılır. Bu sistemler, suyun maden içindeki belirli bölgelere yönlendirilmesini ve tahliyesini sağlar. Bu, madenin su altında kalmasını ve işçilerin güvenliğini tehlikeye atmasını önler. (Külekçi, 2019)

Cevher İşleme Tesisleri: Yeraltı madenlerinden çıkarılan cevherler, yüzeydeki işleme tesislerine taşınarak işlenir. Bu tesislerde cevherler öğütülür, flotasyon veya siyanürleme gibi işlemlerle altın ayrıştırılır ve nihayetinde altın konsantreleri elde edilir. (Külekçi, Vural, 2023)

3.YERALTI MADENCİLİĞİNDE İŞ SAĞLIĞI VE GÜVENLİĞİ PROBLEMLERİNİN BELİRLENMESİ

Yeraltı altın madeni üretim sürecinde İş Sağlığı ve Güvenliği (İSG) açısından karşılaşılabilecek potansiyel sorunları belirlemek için birkaç faktörü göz önünde bulundurabiliriz:

Tehlikeli Ortamlar: Yeraltı madenciliği, dar alanlar, düşük oksijen seviyeleri, toz, gazlar gibi tehlikeli ortamları içerebilir. Bu nedenle, işçilerin bu ortamlara maruz kalmasını önlemek için uygun önlemler alınmalıdır. (Külekçi, 2023)

Kazalar ve Yaralanmalar: Yeraltı madenlerinde işçiler için çeşitli fiziksel tehlikeler bulunmaktadır. Düşmeler, kaya düşmesi, ekipman arızaları gibi durumlar kazalara veya yaralanmalara yol açabilir.

Ergonomik Faktörler: Yeraltı madenciliği genellikle fiziksel olarak zorlayıcı bir iş olabilir. Ağır kaldırma, tekrarlayıcı hareketler ve uzun süreli oturma veya ayakta durma gibi durumlar işçilerin sağlığını olumsuz etkileyebilir. (Külekçi, 2023)

Toz ve Zehirli Gazlar: Madenlerde oluşan tozlar ve zehirli gazlar solunum problemlerine, cilt rahatsızlıklarına ve diğer sağlık sorunlarına neden olabilir

Gürültü ve Titreşim: Madenlerdeki ekipmanlar ve işlemler genellikle yüksek düzeyde gürültü ve titreşime neden olur. Bu, işitme kaybına ve diğer sağlık sorunlarına yol açabilir.

Güvenli Tahliye Yolları: Acil durumlarda (örneğin, yangın veya patlama durumlarında) işçilerin güvenli bir şekilde tahliye edilmesini sağlayacak uygun tahliye yollarının olması önemlidir. (Külekçi, Meral, 2023)

İşçi Eğitimi ve Bilinçlendirme: İşçilerin güvenli çalışma prosedürlerini bilmeleri ve bu prosedürlere uymaları sağlanmalıdır. Eğitim ve bilinçlendirme programları işçilerin riskleri tanımasına ve önlemleri almasına yardımcı olabilir.

Bu gibi potansiyel İSG problemlerinin belirlenmesi, risk değerlendirmesi yapılması ve uygun önlemlerin alınması gerekmektedir. Ayrıca, yerel yasal düzenlemelere ve uluslararası İSG standartlarına uygunluk da sağlanmalıdır.

Yeraltı Madenciliğine Özgü İSG Riskleri:

Dar Alanlar: Yeraltı madenciliği genellikle dar ve kısıtlı alanlarda gerçekleştirilir. Bu durum, işçilerin hareket kabiliyetini sınırlar ve acil durumlarda tahliyeyi zorlaştırabilir.

Kaya Düşmeleri: Yeraltı madenciliğinde, tavan ve duvarlardan kaya parçalarının düşme riski vardır. Bu durum işçiler için ciddi yaralanma veya ölüm riski oluşturabilir.

Gaz Birikimi: Yeraltı madenlerinde, patlayıcı veya zehirli gazların birikmesi riski vardır. Bu gazların doğru bir şekilde kontrol edilmemesi, patlama veya zehirlenme riskini artırabilir.

Oksijen Azalması: Yeraltı madenlerinde oksijen seviyelerinin düşmesi riski vardır. Bu durum işçilerin solunum problemleri yaşamasına ve bilinç kaybına neden olabilir. (Külekçi, Güvendi, 2012)

Kuyu ve Tünel Çökmesi: Yeraltı madenciliği sırasında kuyu veya tünellerin çökmesi riski vardır. Bu durum işçilerin hapsedilmesine veya yaralanmasına neden olabilir.

4. YERALTI ALTIN MADENLERİNDE MEYDANA GELEN İŞ KAZALARI

- 12.09.2020 tarihinde Kongo Demokratik Cumhuriyeti'nde yoğun yağmur yağışı üç altın madeni kuyusunun çökmesine yol açtı. Yaşanan faciada ilk bilgilere göre en az 50 kişi hayatını kaybetti. (Resim -4)

Maden çökmesinden sağ kurtulan Diwa Honoré, çukurlarda 50'den fazla madenci olduğunu söyledi. Madenlerin bulunduğu Kamituga şehri Belediye Başkanı Alexandre Bundya, "Kazıcıları ve taş taşıyıcıları sular yuttu. Motor pompalarla bir kurtarma ekibi kurbanların bedenlerini çıkarmaya geldi." dedi.

Resim – 4: Kongo Demokratik Cumhuriyeti'nde altın madeni kazası

Çöken üç maden kuyusu yaklaşık 50 metre derinliğindeydi. Doğu Kongo'daki yapay maden ocakları güvenli olmamaları ile biliniyor. Bu maden ocaklarında çocuklar ve kadınlar da çalışıyor.

- 5 Ağustos 2010 Şili'de San Jose bakır ve altın madeninde meydana gelen göçükte 33 madenci yerin 700 metre altında mahsur kalmıştı. Kazadan 17 gün sonra bir sondaj kuyusu ile işçilere ulaşılmış ve sağ oldukları tespit edilmişti. (Resim -5) Sonrasında kurtarma çalışmalarına hız verilmiş ve yüzeyden 66 cm. çapında açılacak olan sondaj kuyusu içerisinden işçilerin dışarıya çıkarılması kararı alınmıştı. Yaklaşık 4

ay süreceği tahmin edilen kurtarma çalışmaları daha kısa sürede tamamlandı. Bugün kazadan iki ay sonra 33 madenci bir kapsülle yeryüzüne çıkarılıyor.

Resim – 5 : Şili'de maden içinde göçük kazası

Madencilerin, olası kazalarda, yaşamlarını sürdürebilmeleri için tek imkân olan ve bir merdivenle acil çıkış kapısına bağlanan sığınak odalarının bulunması gerekiyor. Bu odalar ne yazık ki çok az maden ocağında bulunmakla birlikte bu maden ocağında vardı. **Böyle bir sığınak bulunmasına rağmen sığınaktan acil çıkış kapısına giden merdiven yoktu.** Dolayısıyla, kurtarma ekipleri 17 gün sonra madencilerin çıkardıkları çekiç seslerini duymamış olsalardı, erken kurtulma olanağı sağlayacak olan sığınma odasının işçiler için mezar olması içten bile değildi.

- 14.03.2024 tarihinde Avustralya'da bir altın madeninde meydana gelen çökme sonucu bir işçi hayatını kaybetti ve bir diğeri ağır yaralandı. (Resim - 6) Melbourne yakınlarındaki Ballarat'ta bulunan madende, yerin 500 metre altına düşen kayalar altında kalan iki kişiden birinin hayatını kaybettiği bildirildi. Olayın ardından diğer 29 madenci ise yakındaki güvenlik kapsülüne sığındı ve dört saat sonra tahliye edildi.

Resim - 6 : Avustralya'da madende göçme

Avustralya İşçi Sendikası, madencilerin "hava ayağı" olarak bilinen manuel bir çıkarma yöntemi uyguladıklarını belirtti. El matkabı kullanılarak kayaların delindiği bu tekniğin güvenlik endişeleri nedeniyle bazı madenlerde aşamalı olarak kaldırıldığı ifade edildi.

- Avustralya'daki Beaconsfield'de bulunan bir altın madeninde, yerin 1 kilometre kadar altında 14 gün geçiren 2 madenci 9 Mayıs 2006'da sağ salim kurtulmuştu. Kaza sırasında madenciler, kendilerini düşen kayalardan koruyan metalden bir sığınakta bulunuyordu. 5 gün madenin kaya duvarından akan sudan içen madencilere bir boru yardımıyla su ve yiyecek gönderilmişti.

SONUÇ VE TARTIŞMA

Yeraltı madencilik sektörü gibi çok tehlikeli sınıfında bulunan iş ortamlarında faaliyetler öncesinde mutlaka sağlıklı ve güvenli çalışma ortamlarının oluşturulması için risk analizleri yapılması, tüm risklerin belirlenmesi ve bu risklere karşı gerekli tedbirlerin alınarak toplu korumanın sağlanması amaçlanmaktadır. Toplu korumanın yapılamadığı takdirde ise çalışılan işe uygun kişisel koruyucu donanım kullanımının yapılarak en son başvurulması gereken bireysel koruma gerekmektedir.

Yeraltı altın madencilikte karşılaşılabilecek problemler tespit edilerek bu problemlere karşı alınabilecek öneriler sıralanmıştır:

Göçük Tehlikesi:

- Düzenli olarak yapılan jeolojik incelemelerle maden alanında tavanının sağlamlığı hakkında bilgi elde edilmelidir.
- Düzenli olarak yapılan göçük tahmin ve izleme sistemlerini oluşturan organizasyon kurulmalıdır.
- Çalışanlar, göçük tehlikesine karşı düzenli olarak eğitim verilmeli ve uygun kişisel koruyucu donanım kullandırılmalıdır.

Gaz Tehlikeleri:

- Çalışma sahasının belirli noktalarına gaz dedektörleri ve izleme ekipmanları yerleştirilmelidir.
- Çalışanlara, gaz zehirlenmeleri ve patlama tehlikesine karşın eğitim verilmelidir.
- Havalandırma sistemleri düzenli olarak kontrol edilmeli ve teknisyenler tarafından bakımları yapılmalıdır.

Fiziksel Yaralanmalar:

- Çalışanlara, güvenlik ekipmanlarını doğru kullanma ve iş yerinde güvenli davranma konularında eğitim verilmelidir.
- Ekipmanların düzenli olarak bakımı yapılmalı ve güvenli kullanımı konusunda denetimler sağlanmalıdır.
- Tehlike oluşabilecek alanlarda uygun güvenlik tedbirleri alınmalı ve işaretlemeler yapılmalıdır.

Toz Maruziyet:

- Toz solunması engellenebilmeli, engellenemiyorsa uygun solunum koruyucu ekipmanlar sağlanmalıdır.
- Tozların oluştuğu alanlarda düzenli olarak temizlik yapılmalı ve havalandırma sistemleri etkin bir şekilde çalıştırılmalıdır.
- Çalışanlar, maruz kaldıkları tozların potansiyel tehlikeleri konusunda yetkili kişilerce eğitim verilmelidir.

Bu öneriler, yeraltı altın madencilikte oluşabilecek iş sağlığı ve güvenliği problemlerine yönelik önlemler ve iyileştirmeler için bir yol haritası olmayı sağlar. İş sağlığı ve güvenliği önlemlerinin düzenli olarak belirli aralıklarla gözden geçirilmesi ve gerektiğinde belirli düzenlemeler yapılması, yeraltı altın maden işletmelerinde çalışanların sağlığını ve güvenliğini korumak için çok büyük bir öneme sahiptir.

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Re Dopant Seviyesinin $BaZrO_3$ Perovskitlerinin Mekanik, Elektronik ve Termodinamik Özellikleri Üzerine Etkisi: VASP Kullanılarak Bir DFT Çalışması

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Özet – Bu çalışmada, DFT (Yoğunluk Fonksiyonel Teorisi) tabanlı VASP (Vienna Ab-initio Simulation Package) programı kullanılarak Re dopant seviyesinin BaZrO3 perovskitlerinin mekanik, elektronik ve termodinamik özellikleri üzerindeki etkisi araştırılmıştır. Farklı Re dopant konsantrasyonları için optimize edilmiş geometriler, elastik sabitler, band aralığı, elektronik yoğunluk dağılımları, Debye sıcaklığı ve Gibbs serbest enerjisi gibi termodinamik parametreler hesaplanmıştır. Hesaplama sonuçları, Re dopant seviyesinin BaZrO3 perovskitlerinin mekanik sertliğini önemli ölçüde artırdığını, band aralığını daralttığını ve elektronik iletkenliği artırdığını göstermektedir. Termodinamik analiz, Re dopant seviyesi arttıkça Gibbs serbest enerjisinin azaldığını ortaya koymakta olup, malzemenin termal kararlılığının arttığını göstermektedir.

Anahtar Kelimeler – Perovskit, DFT, Termodinamik Özellikler, Mekanik Özellikler, Elektronik Özellikler

I. GİRİŞ

ABO_3-tipi perovskitler olarak bilinen kapsamlı üçlü oksit sınıfı, kimya mühendisliği, ısı motorları, hidrojen membranları, aktüatörler, sensörler, elektrokimyasal uygulamalar, katı oksit yakıt hücreleri ve diğer cihazlar için potansiyel bir malzeme olarak hala çok dikkat çekmektedir[1]. Her ne kadar yapısal, elastik, dielektrik ve ABO_3 tipi saf perovskitten yapılan alaşımların piezoelektrik özellikleri kristalleri önemli ölçüde ilgi görsede daha fazla çalışma hala ihtiyaç duyulmaktadır. Ayarlanabilir piezoelektrik ve dielektrik tepkileri nedeniyle, perovskitlerin katı çözeltileri, yüksek dielektrik sabit kapasitörler, ferroelektrik ince film bellek cihazları, sensörler, anahtarlar, aktüatörler, piezoelektrik sonarlar, atomik mikroskoplar, ultrason jeneratörleri, piezoelektrik motorlar, mürekkep püskürtmeli yazıcılar ve yakıt enjektörleri için büyük bir teknolojik potansiyele sahiptir[3]. Malzemelerin dış makroskopik strese karşı mekanik reaksiyonu elastik sabitler tarafından tanımlanır. Atomlar arası bağlar, mekanik kararlılık, termal gevşeme ve iç gerinim arasında sıkı bir ilişki vardır[4]. Buna ek olarak, ABO3 tipi bileşikler aynı zamanda mükemmel termal uygulamalar için önemli olan termodinamik özellikler araştırma topluluklarının büyük ilgisini çekmektedir[5].

$BaZrO_3$ (BZO) gibi zirkonat perovskitler yüksek sıcaklıklardaki (>1300 ◦C) kararlılıkları nedeniyle [6], kimyasal inertlik ve proton iletkenliği [7], düşük dielektrik kaybı ve düşük termal iletkenlik [8] gibi özellikleri nedeniyle en önemli oksit malzemelerden biridir. İnce film biriktirmede bir alt tabaka [9] veya demir bazlı süper iletkende [9], katı oksit yakıt hücrelerinde [10], sensörlerde [11] girdap sabitlemesini artırmak için nanopartiküller gibi büyük potansiyel uygulamalara sahiptir.

Bu çalışma, Zr bazlı metalik perovskitler $BaZrO_3$'ün yapısal, elektriksel, elastik ve optik yönlerini incelemek için gerçekleştirilmiştir. Bir malzemenin elektriksel özelliklerini anlamak için katı haldeki optik özelliklerini analiz etmek gerekir. Yarı harmonik Debye modeli kullanılarak, ısıl genleşme katsayısı, gruniesen parametresi, bulk modülü, hacim, ısı kapasitesi gibi termodinamik özellikler

hesaplanmıştır.

II. HESAPLAMA METOTLARI

Bu çalışmada tüm hesaplamalar VASP [12] paket yazılımı kullanılarak yapılmıştır. Elektron-elektron etkileşimindeki değiş-tokuş ve korelasyon terimleri için, genelleştirilmiş gradyan yaklaşımı (GGA) çerçevesinde Perdew ve Zunger[13] tipi fonksiyonel kullanılmıştır. Elektron-iyon etkileşimi, projektör-arttırılmış dalga (PAW) yöntemiyle, 700 eV'ye kadar olan düzlem dalgaları kullanılarak modellenmiştir. Brillouin bölgesi örneklemesi için k-nokta örgülerinin oluşturulmasında Monkhorst- Pack [14]şeması 17x17x17 olarak kullanılmıştır. Elastik özellikler zor-zorlanma[15] metoduyla hesaplanmıştır.

Fonon frekans dağılımı Phonopy kodu [16] ile elde edilmiştir.

III. SONUÇLAR VE TARTIŞMA

A. Yapısal ve Elastik Özellikler

İlk olarak, birim hücre hacmin rahatlatılmasına izin verilerek enerji minimumuna karşılık gelen örgü parametreleri VASP programı aracılığı ile ISIF = 3 kullanılarak optimizasyon işlemi ile elde edilmiştir. Daha sonra farklı örgü sabitleri için enerji değerleri hesaplanarak Murnaghan durum denklemi (EOS) kullanılarak bulk modülü ve bulk modülünün basınç değerleri hesaplanmıştır.

Tablo 1. Yapısal ve Mekanik Özellikler

Basınç (GPa)	a (Å)	B (GPa)	B'	C_{11} (GPa	C_{12} (GPa)	C_{44} (GPa)	G (GPa)	E (GPa)	ν	B/G
0	4.248	160.6	4.06	320.0	81.0	83.5	96.4	240.9	0.2499	0.600
[7]	4.226	155.9	3.90	315	73	82				
[8]	4.23	148.74	4.74							
[10]Exp	4.19	127.2								

Elastik sabitlerin hesaplamaları malzemelerin kimyasal kararlılıklarını tahmin etmek için gereklidir. Bunlar izotropik yığın ve kesme kuvveti ile ilgilidir. Bulk modülü, kristalin sertliği veya deformasyon üretmek için gereken enerjdir. Bulk modülü ne kadar yüksekse kristaldeki sertlik de o kadar yüksektir. Örgü parametresi , Bulk modülü ve elastik sabitleri değerleri literatür değerleri ile uyumludur. Elastik sabitleri değerlerine göre BaZrO3 mekaniksel olarak kararlıdır. Poisson oranı, malzemenin iç yapısının ve atomik bağlarının bir göstergesidir. Düşük Poisson oranına sahip malzemeler, daha kırılgan olma eğilimindedir. Yüksek sertlik ve düşük süneklik gösteririr. B/G oranı, malzemenin kırılganlık veya süneklik özelliğini anlamak için kullanılır. **B/G < 1.75:** Bu oran, malzemenin daha kırılgan olduğunu gösterir. Kırılgan malzemeler, çok az veya hiç plastik deformasyon göstermeden kırılır.

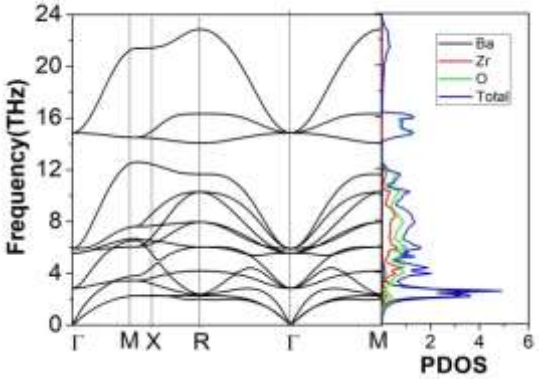
Born mekanik kararlılık kriterleri;

$$C_{11}>0,\ C_{12}>0,\ C_{44}>0,\ C_{12}>C_{44},\quad C_{11}+2C_{12}>0,\ C_{11}-C_{12}>0\ \text{'dir.} \tag{1}$$

B. Dinamik Özellikler

Kuramsal yaklaşımlardan kararlılık tespitinde en sağlıklı yöntemlerden biri de fonon dağınımı incelemesidir. Titreşim modlarının tamamının sıfırdan büyük olması bir kararlılık göstergesidir. Malzemenin dinamiksel olarak kararlılığını tespit etmek amacıyla PHONOPY programı kullanarak BaZrO3 bileşiğinin fonon frekans spektrumu hesaplandı. Bu kod, yoğunluk fonksiyonel pertürbasyon

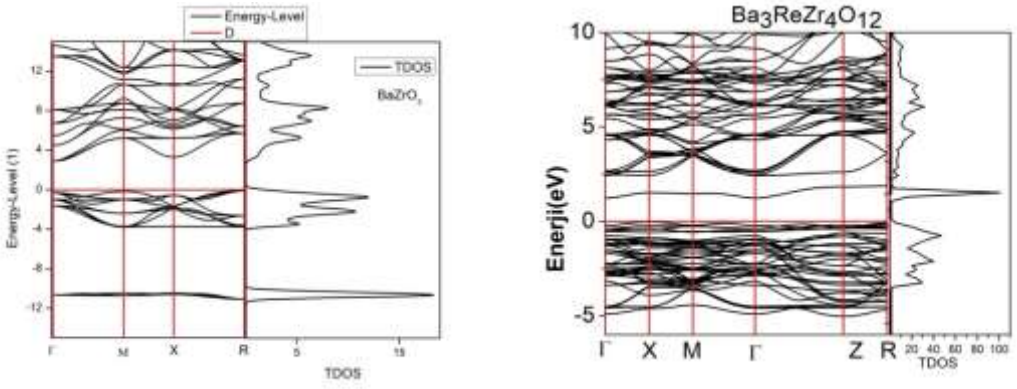
teorisini kullanarak kuvvet sabiti matrislerini ve fonon frekanslarını hesaplar. Fonon dağılım hesaplamaları için 40 atom içeren 2 × 2 × 2 süper hücre kullanıldı. Birim hücrede 5 atom olduğu için 15 toplam mod bulunur. 3 tanesi akustik 12 tanesi optikt kola aittir. Herhangi bir negatif frekans bulunmadığı için $BaZrO_3$ dinamiksel olarak kararlıdır. Düşük frekanslarda titreşimlere Ba atomlarının katkısı varken Orta frekanslarda Zr ve O, yükek frekans bölgesinde O atomundan titreşiminden katkı gelmektedir.



Şekil 2. Fonon Dispersiyon Eğrisi

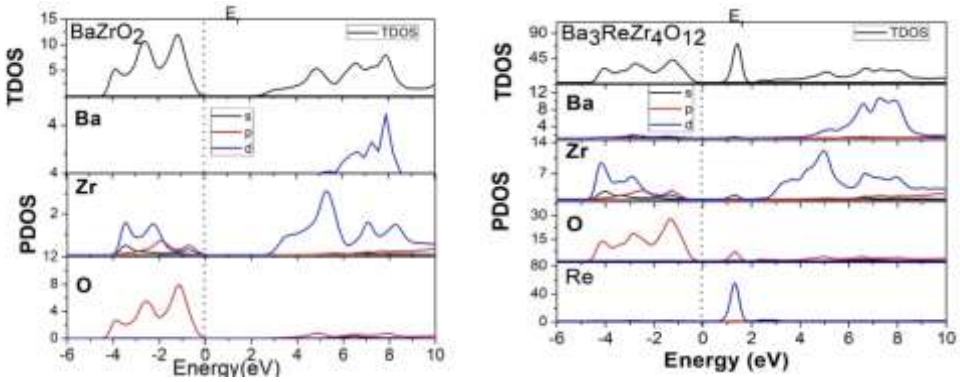
C. Elektronik Özellikler

Malzemenin elektronik özellikleri, malzemelerin kalitesi, elektrik iletkenliği, bant yapısı ve kimyasal bağlar gibi özelliklerin belirlenmesini sağlar. BaZrO3 alaşımının yüksek simetri yönü boyunca enerji bandı yapısı Şekil 3de sunulmuştur



Şekil 3. Elektronik band yapısı grafiği

Bant aralığı 1.4eV ve 1.6eV arasındaki yarı-iletkenler fotovoltaik çevrimde en uygun malzemelerdir. Elektronik band yapısı şekilde verilmiştir. $BaZrO_3$ için enerji band aralığı E_g=3.005eV olarak hesaplanmıştır. Γ- Γ simetri noktalarında doğrudan band aralığı gözlenmiştir. Referans alınan çalışmada Eg= 3.156 eV [7] olarak verilmiştir. Deneysel değer 5.3 eV dir. Bulunan farkdan dolayı düzeltme terimleri eklenerek (HSE06, mBj gibi) tekrar hesaplama yapılması gerekir. Re katkısından sonra band aralığı 1.26 eV olarak azalmıştır.

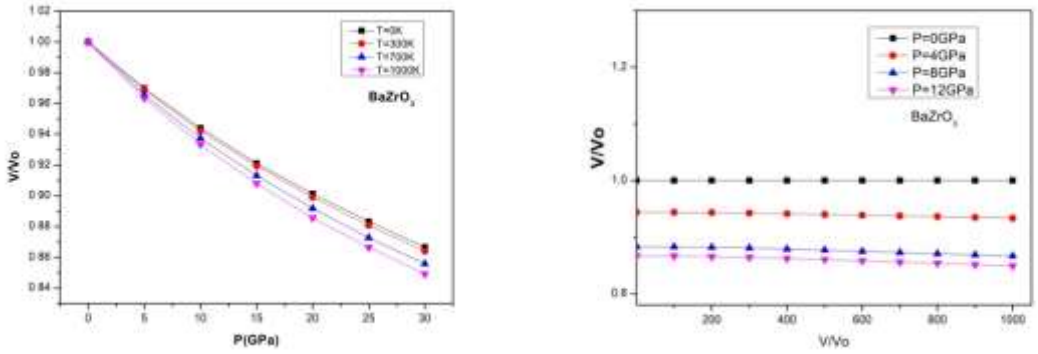


Şekil 4. Toplam ve kısmi durum yoğunluğu

Toplam ve kısmi durum yoğunlukları incelendiğinde DOS grafiklerinin band ile uyum içerisinde olduğu görülmektedir. Valans bandında düşük enerji aralığında -4 eV – 0 eV arasında O-p bandından katkı çoğunluktadır. Zr atomunun p ve d bandından da ayrıca katkı gelmektedir. İletkenlik bandında ise katkı Ba ve Zr atomlarının d bandından gelmektedir. Az miktarda O atomunun p bandından da katkı vardır. Fermi enerjisi yakınlarında valans bandında oluşan maksimum pikler termoelektrik malzemeler için uygun olan malzemelerdir. P-tipi katkılı yarıiletken olarak görülmektedir. Re atomunu bu yarıiletken bileşiğe katkı yaptıktan sonra iletkenlik bandında 1-2 eV arasında büyük bir pik görülmektedir. Bu pik Re-d bandından ve az miktarda O-p bandından gelmektedir. Ayrıca bu iki band arasında hibritleşme söz konusudur.

D. Termodinamik Özellikler

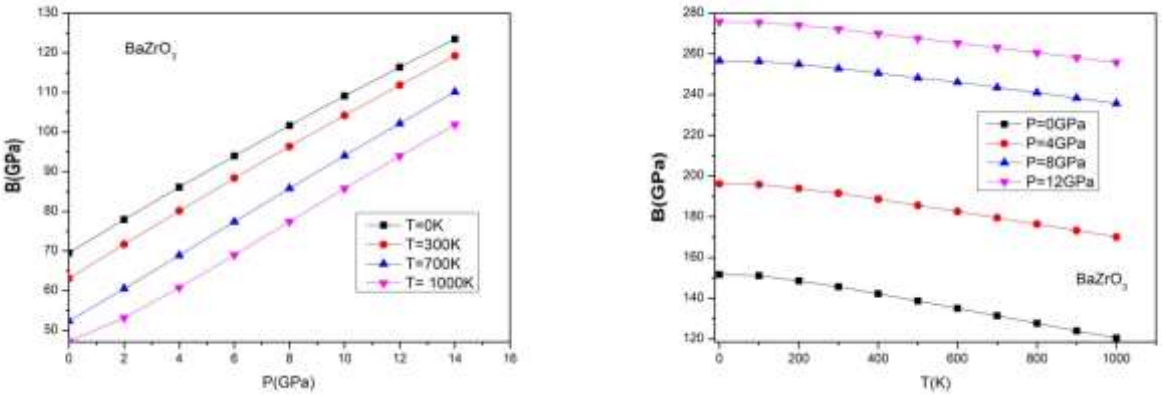
BaZrO3'ün termodinamik parametreleri üzerindeki sıcaklık ve basınç etkisini incelemek istediğimizde . Termodinamik özellikleri elde edebilmek için birim hücre hacmine karşı toplam enerji hesaplamaları gerçekleştirmek gereklidir. Termal parametreler kuasi-harmonik Debye modelinin tamamen geçerliliğini koruduğu 0-1000 K sıcaklık ve 0-30 GPa basınç aralığında belirlenmiştir. Şekil 5(a ve b)'de sırasıyla BaZrO3 için farklı sıcaklıklarda hacim ve basınç arasındaki ilişkiler ile farklı basınçlarda hacim ve sıcaklık arasındaki ilişkiler gösterilmektedir. $BaZrO_3$'ün birim hücre hacmi artan sıcaklıkla birlikte artmaktadır. Bu genişleme, katıların termal enerjiye karşı tipik tepkisidir; atomlar daha şiddetli titreşir ve daha fazla alana ihtiyaç duyar. Bunun aksine, birim hücre hacmi artan basınçla birlikte azalır. Bu sıkışma, dış basıncın atomları birbirine daha yakın itmesi ve birim hücre hacmini azaltmasıyla oluşur.



Şekil 5. için Normalize hacim (a) basınç/ ve (b) sıcaklık ile değişimi.

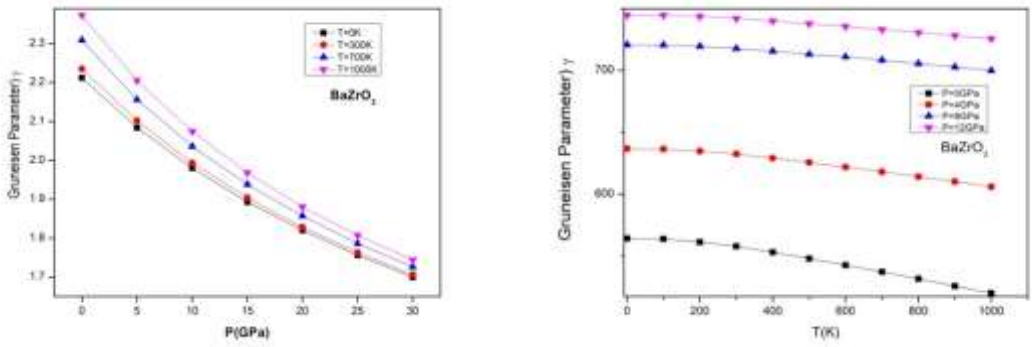
Bulk modülü, malzemenin uniform sıkıştırmaya karşı direncini ölçer. Genellikle sıcaklık arttıkça azalır, bu da malzemenin yüksek sıcaklıklarda daha sıkıştırılabilir olduğunu gösterir. Daha yüksek basınçta hacim modülü genellikle artar, bu da malzemenin daha az sıkıştırılabilir hale geldiğini gösterir. 0 K ile

100 K arasında hacim modülünün sıcaklığa göre ihmal edilebilir bir bağımlılık olduğu, ancak 100 K'ın üzerinde hacim modülünün sıcaklık ile doğrusal olarak azaldığı gözlenmiştir. Buna ek olarak, oda sıcaklığında hacim modülü $BaZr0_3$ bileşiği için sıfır basınçta 155.2 GPa değerine ulaşmaktadır. Şekil 6'da, hacim modülü (B) ile basınç (P) arasındaki ilişki çeşitli sıcaklıklarda neredeyse doğrusal olarak artmaktadır. Bu grafikten, hacim modülünün sıkıştırma altındaki hacim değişimine karşı direnci tanımlayan önemli bir parametre olduğu söylenebilir.



Şekil 6. BaZrO3 için bulk modülünün (a) farklı sıcaklıktaki basınç ve (b) farklı basınçlardaki sıcaklık ile değişimleri

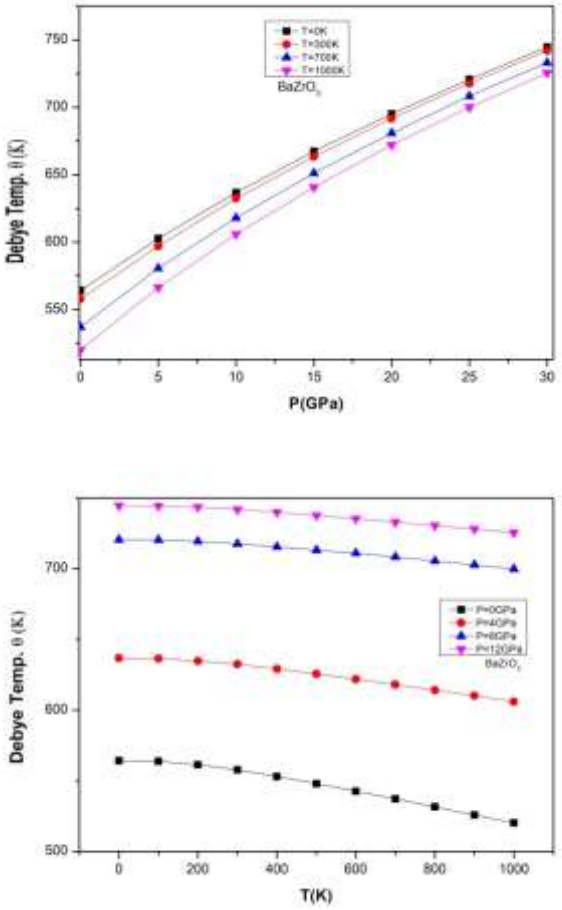
En önemli termodinamik büyüklüklerden biri olan Gruneisen parametresi, γ malzeme özellikleri olan kütle modülü, ısı kapasitesi, içsel termal iletkenlik, termal iletkenlik, sabit hacimde genleşme katsayısı ve hacim birlikte. Gruneisen parametresi sıcaklık değişimlerinin bir ürünün boyutu veya dinamikleri üzerindeki etkisini tanımlar. Gruneisen parametresi (γ), termodinamik özellikleri ve titreşen kafeslerde anharmonik korelasyonu tanımlayan önemli bir parametre ve boyutsuz bir niceliktir. γ'nin farklı basınç setlerinde sıcaklığa göre değişimleri Şekil 7(a)'da gösterilmiştir. Farklı basınçlarda γ'nin sıcaklık arttıkça yavaş yavaş arttığı, farklı sıcaklık değerlerinde ise basınç arttıkça γ'nin hızla azaldığı görülmektedir. Ancak, basıncın etkisi sıcaklığın etkisinden daha önemlidir. $BaZr0_3$ bileşiğinin γ değeri sıfır basınç ve sıcaklıkta 2.22 iken, bu değer sıfır sıcaklık ve 20 GPa'da 1.81'e düşerek kafes içindeki anharmonisitenin azalmasına neden olur. Yüksek γ değeri, bileşikte yüksek anharmonisiteye işaret eder ve bu da düşük kafes ısı iletkenliğine yol açar. Oda sıcaklığında, γ değeri sıfır basınçta 2.24'tür.



Şekil 7. Gruneisen parametresine karşı a) farklı basınçlarda sıcaklık b) BaZrO3 bileşiği için farklı sıcaklıklarda basınç ile değişimi

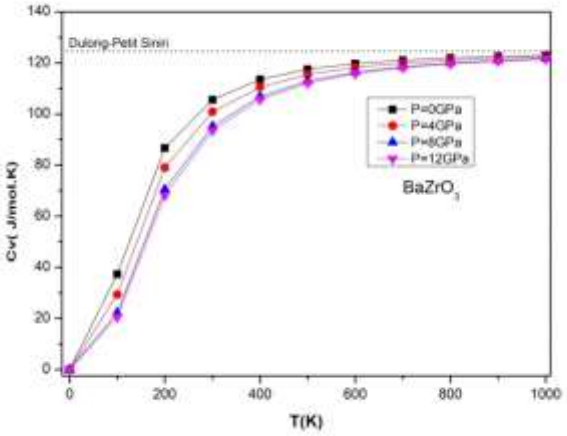
Katıların en önemli termofiziksel parametrelerinden biri olan Bir malzemenin titreşimsel tepkisini, Debye sıcaklığını (θ_D) tahmin eder, dahil olmak üzere birçok farklı fiziksel özellik ile güçlü bir şekilde ilişkilidir. erime sıcaklığı, termal genleşme katsayısı, atomlar arası bağlanma, kafes titreşimi, termal iletkenlik, elektron-fonon bağlanma sabiti ve kristalde boşluk oluşumu, süper iletken geçiş sıcaklığı ve fonona özgü

ısı. Bir malzemenin Debye sıcaklığı (θD), süper iletkenlik için gereken minimum sıcaklıktır. Debye sıcaklığı (θD), kovalent bağın kuvvetini karakterize eden termodinamik parametrelerden biridir ve malzemenin elastikiyeti ve ısı kapasitesi ile ilişkilidir. Farklı sıcaklıklarda ve farklı sıcaklıklardaki basınçta Debye sıcaklığının sıcaklık (K) ve basınça göre değişimi Şekil 8'de gösterilmiştir. θ_D, 0 – 100 K sıcaklık aralığında ihmal edilebilir bir değişiklik gösterir ve sonrasında tüm basınç setleri için sıcaklık arttıkça azalır. Açıkçası, θD daha yüksek basınçta çok yavaş azalır. Gözlemlediğimiz üzere, θ_D sabit sıcaklıkta basınç ile neredeyse doğrusal olarak artan bir değişim gösterir. Ayrıca, basıncın θ_D üzerindeki etkinin sıcaklıktan daha önemli olduğu açıktır. Hesaplanan θ_D değerinin 0 K ve 0 GPa'da 566.955 K olduğu bulunmuştur. Genellikle sıcaklık arttıkça azalır, bu da atomik titreşimlerin arttığını gösterir. Yüksek basınç altında Debye sıcaklığı artması, daha sert örgü titreşimlerini işaret eder.



Şekil 8. $BaZrO_3$ için farklı basınçlarda Debye sıcaklığının sıcaklık değişimi ve farklı sıcaklıklarda Debye sıcaklığının basınç değişimi

Sabit hacimdeki spesifik ısı (Cv), kafes titreşimi, iç enerji, faz değişimi ve malzemelerin diğer birçok fiziksel değişkeni ile ilgili başka bir termodinamik özelliktir. Farklı basınçlarda C_V'nin sıcaklığa bağlı olarak değişimi Şekil 9'da gösterilmiştir. Belirli bir basınçta, 0 K'de CV sıfırdır, bu da kafes titreşimlerinin olmadığı anlamına gelir. Başlangıçta, C_V Debye T^3 yasasını takip ederek sıcaklık artışı ile doğru orantılı olarak artar. Daha sonra ise sıcaklık ile birlikte sabit bir değişim gösterir ve tüm katı malzemelerin sergilediği davranış olan Dulong ve Petit limitine yaklaşır. Düşük basınçta, C_V değeri yüksek basınçtan daha büyüktür. Oda sıcaklığında ve 0 GPa basınçta Cv 106.98 J/mol.K olarak hesaplanmıştır.



Şekil 9. $BaZrO_3$ için farklı basınçlarda Cv'nin sıcaklıkla değişimi

IV. SONUÇ

$BaZrO_3$ alaşımının yapısal, elastik, elektronik ve titreşimsel ve termodinamik özellikleri DFT (Yoğunluk Fonksiyonel Teorisi) yöntemi ile incelenmiştir. $BaZrO_3$ bileşiği ile ilgili termodinamik nicelikler daha önce çalışılmamıştır. Yapısal ve elastik parametreler, sıfır basınçta literatür verileriyle karşılaştırılmıştır. Alaşım, sıfır basınçta sünek ve yumuşak bir özellik göstermiştir. Yüksek Debye sıcaklığı, yüksek termal iletkenlik ve güçlü kimyasal bağlanmayı temsil eder. Fonon verileri alaşımın dinamik olarak kararlı olduğunu göstermiştir.

Bu bileşiklerin termodinamik özellikleri, sabit basınçta ısı kapasitesi ve termal genleşme katsayısı, 0-1000 K sıcaklık aralığında hesaplanmıştır. Elde edilen sonuçlar, bu malzemenin kararlılık kriterlerinin iyi doğrulandığını ve mekanik kararlılıklarını doğruladığını göstermektedir. İki bileşiğin de ısı kapasitesi artan sıcaklıkla birlikte artmaktadır. Bu durum, $BaZrO_3$'ün yüksek termal kararlılığını göstermektedir. Bu çalışmanın, araştırmacıları bu heyecan verici alaşımı hem teorik hem de deneysel olarak daha detaylı incelemeye teşvik edeceğini umuyoruz.

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Multilingualism is beneficial for business. Results of a linguistic landscape research in the Eastern Slovakian-Hungarian border region.

Kornélia Hires-László, Gergely Horzsa, László Letenyei

Abstract – The issue of monolingual/multilingual inscriptions in Central Europe has been the subject of political discourses on national minorities for a long time. We, Hungarians, have mostly found it prejudicial that the language usage of public inscriptions in Slovakia, Romania, the former Yugoslavia, or more recently in Ukraine were regulated by language laws.

The politicisation of the topic rarely made it possible to dedicate enough attention to the economic aspects of multilingual inscriptions. The present study makes an attempt to remedy this deficiency: the field work on the Eastern part of the Slovakian-Hungarian border region made it measurable if multilingual inscriptions can have a tourism business significance. As a result of the study we can assert that: 1) the multilingualism of the examined ventures providing touristic services or public catering goes hand in hand with the higher prestige and the presumptive higher incomes of the businesses in question, respectively 2) in the businesses where the language of the neighbouring countries are not used, English is typically the language of communication with the foreign guests dropping in. The lack of openness towards the neighbouring language generally results in the drive back of both languages.

Keywords – Multilingualism, linguistic landscape, Slovakian-Hungarian border region

1. Introduction

The issue of monolingual/multilingual inscriptions in the Carpathian Basin has been the subject of political discourses on national minorities for a long time. We, Hungarians, have mostly found it prejudicial that the language usage of public inscriptions in Slovakia, Romania, the former Yugoslavia, or more recently in Ukraine were regulated by language laws. The politicisation of the topic rarely made it possible to dedicate enough attention to the economic aspects of multilingual inscriptions. The present study makes an attempt to remedy this deficiency: the field work on the Eastern part of the Slovakian-Hungarian border region made it measurable whether multilingual inscriptions can have a tourism business significance.

In 2018/19, Corvinus University of Budapest, the Slovakian civic association Nadácia pre Budúcnosť and Interregio Forum Association from Hungary accomplished a Slovakian-Hungarian cross-border cooperation project[1]. The project was focused on multilingualism: going beyond the usual questions of minority studies it tried to find the answer to the question whether there was a need to rethink the business practices of bilingual inscriptions, in the view of cross-border tourism, employment and last, but not the least shopping tourism. The project consisted of several waves, firstly of a needs assessment that included a linguistic landscape inquiry, then a pilot action within which the participants of the project put out 50-50 bilingual boards and 20-20 bilingual menus, also measuring the effects of the intervention of the pilot

[1] Linguistic Landscape: innovative methodologies strengthening bilingualism in the Hungarian-Slovakian border region. Supported by www.skhu.eu.

action. The introduction of a tourism brand qualifying the accessibility of the foreign language was part of the project. The present summarising document is based on all these experiences, while trying to find the answer to the question: is bilingualism beneficial for business?

2. Theoretical Framework

Linguistic landscape refers to the visibility and salience of languages on public and commercial signs in a given territory or region. (Landry & Bourhis, 1997)

It is not very popular to begin a study with a definition, as it spoils the mood of the reader to go on even before reading the actual text, yet in our case it is worthwhile to go back to the roots. For those interested in this train of thoughts, yet prefer not to read several pages of specialist literature, we hereby summarise the essence:

In the theoretical introduction below we will show that the creators of the notion of linguistic landscape simultaneously thought of two occurrences, inscriptions of public and commercial nature (both in research and language usage). Yet, the notion and the research tool was later largely used for the scientific support of the different language/minority movements, therefore primarily (almost exclusively) for the examination of public inscriptions. It follows from this that the methodology of the analysis of public inscriptions has often become more elaborate, more developed in interaction with the other issues of the literature related to minority language usage, like e.g. education, language rights etc. The examination of business-related inscriptions, more exactly: their inherent interpretation rooted in business logic, has not deepened enough.

By the time the thought of linguistic landscape research established in 1997 by the French-Canadian pair of authors reached Hungary (with a delay of more than a decade), this was primarily aimed rather at the inquiry of public inscriptions, as some sort of an issue of community language usage/language policy. As a result of an extremely rapid diffusion process the notion of linguistic landscape quickly became known in the countries of the Carpathian Basin, then all across Central Europe. During the diffusion process community language usage issues have again become more pronounced, while the analysis of commercial inscriptions (and the theoretical approach connected to them) have mostly disappeared.

The present study reaches back to the roots in the beginning of the 1990s, as it analyses business-related inscriptions in a different approach from public inscriptions, following Bourhis (1992), Leclerc (1989) and others. Instead of issues like language dominance, minority language usage or language rights, the present treatise employs notions like consumer satisfaction, language demand and offer, intermediary languages etc.

2.1. 1997–2013: The Career of the Notion of Linguistic Landscape

One of the triggers for the research started by Bourhis in 1992 was undoubtedly the specific French Canadian phenomenon simply called by Leclerc (1989) poster language fight: there had been public inscriptions both in French and in English, yet these did not only compete to get into the favour of consumers, but also promoted, as some kind of a self-advertising message, the identity, particularly the ethnic/language identity of the advertiser. 1989 had still been an offline world, where the spatial appearance of the posters reflected well the changes, the dynamics of the language identity of the regions/settlements. He formulated his research plan in 1992, and according to it there was not even necessary to address the people in order to measure the language competences (vitality) of the regions in question, rather their imprints, or in other words, the inscriptions had to be examined, as some sort of expressed preference. The result of this research was the article published in 1997, in which Landry and Bourhis (1997) came up with the notion of linguistic landscape. Both here and in their 1992 research plan they declare that a distinction must still be made between the examinations of two types of street inscriptions, i.e. *public* and *commercial* inscriptions, as the producers of the two categories are driven by different points of view, different

motivations. Whereas in the first case the viewpoints of language dominance are obviously related to some local political issue, in the case of the second one the most important viewpoint is to gain the preference of the consumer. Still, even the 1997 programme document is primarily dealing with public inscriptions, respectively the issue of language dominance.

In the perception of Szilvia Szoták the languages of the boards became interesting for the researchers especially in zones of language conflicts, like Brussels, Montreal (Monnier and the province of Québec), for instance. Conseil de la langue française 1989; Bourhis, Richard Y. 1992), Izrael (Spolsky and Cooper 1991; Shohamy, Ben-Rafael, and Barni 2010), India (Itagi et al. 2002). The researches focus both on the minority language usage of the indigenous population (Cenoz and Gorter 2006), or the language usage of immigrant communities (Collins and Slembrouck 2007), and on the emergence of English as an international language in the linguistic landscapes (Backhaus 2006; Gorter 2006; Shohamy, Ben-Rafael, and Barni 2010; Soukup 2016)

2.2. Linguistic Landscape Diffusion in Hungary

Without undervaluing the significance of similar approaches and antecedents (Szépe 1994; Szépe György 1984) the scientific community in Hungary learned about the usefulness of linguistic landscape researches through the works of Petteri Laihonen, a Finnish linguist married to a woman in Budapest. He researched Hungarian linguistic landscapes in minority areas, especially in Transylvania (Laihonen 2009), but also carried out researches in other Hungarian inhabited areas (Laihonen 2012), and analysed the theory and usefulness of language ideologies in research projects related to the Hungarian language (Laihonen 2011).

The work of the young researcher was embraced by Csilla Bartha, and they presented this "new" research area in a common publication (Csilla Bartha, Laihonen, and Tamás Péter Szabó 2013), respectively at a conference in 2013, organised by the Research Institute for Linguistics of the Hungarian Academy of Sciences, entitled "Linguistic Landscape in Theory and Practice". Unfortunately the volume of the conference never came out, but still, the conference had a relative influence on the domestic community of linguists and beyond them, in two respects: on the one hand it stepped over disciplinary boundaries (opening up towards Sociology, Anthropology etc.) and on the other hand linguistic landscape became interesting outside the borders of Hungary, too, for the intellectuals of the neighbouring countries. In the beginning of the 2010s linguistic landscape researches were primarily held together in Sub-Carpathia by István Csernicskó (1998, 2013), in Transylvania by István Horváth and Erika Tódor (Horváth and Tódor 2011). The Termini Hungarian Linguistic Research Network systematically mapped minority linguistic landscapes in the neighbouring countries, including Austria (Szilvia Szoták 2016) the countries of the Balkan Peninsula, and – approaching our own area of inquiry – the border regions of Slovakia and Hungary (Gizella Szabómihály 2009; Bauko 2018; Károly Presinszky, 2018). The topic unfolded: our knowledge about linguistic landscapes is enriched today by quite a number of collection volumes dealing with linguistic landscapes (Erika-Mária Tódor, Enikő Tankó, and Zsuzsanna Dégi 2018; Anita Márku and Kornélia Hires-László 2015). Researchers belonging to the Hungarian minorities are undoubtedly leading the research of the topic, although we are also aware today of many researches started by Romanian, Slovakian researchers.

2.3. Business Anthropological Approach

The approach of the present research is different from most of the above-mentioned literature (appearing in volumes of collections), insofar as these embed linguistic landscape research into the context of minority studies or linguistic sciences, while we apply the approach of business anthropology. By this the inquiry returns to the original raising of the issue in the beginning of the 1990s, making the distinction between commercial and public inscriptions.

If our approach were an inquiry of a purely business nature, i.e. embedded in marketing sciences, then we should ask in connection with bilingual inscriptions questions like e.g. 1) What is the product? 2) What is the target group? How can the target group be segmented from a linguistic point of view? 3) How does the

message help in reaching the target group? 4) What is the aim of the marketing message? For example: does it help in selling, or is it meant to enhance the comfort of the consumer?

I see a few important differences between the business anthropological and the purely business-related approach, which also play a role in the present inquiry. The difference that I see the most important is the viewpoint of reflexivity as borrowed from cultural anthropology. While according to the approach of business studies the behaviour of economic operators can be deduced from the expectation of profit maximisation, we, anthropologists, want to understand the thinking of economic operators, because we believe that their behaviour is shaped by their thoughts and opinions. In the case of bilingual inscriptions therefore, the question is not simply whether a board helps to reach a given target group or its consumer satisfaction, but rather what the entrepreneur that places it out thinks about it, what are the points of view he takes into consideration when placing the board out or when changing an existing board into a bilingual one, and what are the mechanisms used later on to put the board out. Thus, our main research questions sound like this:

- What language usage consumer groups can be distinguished according to local respondents?
- According to the respondent, is bi- or multilingualism beneficial to business?
  and (whether or not),
- By what mechanisms this effect appears?
- Finally, how are the inscriptions put out?

As the authors of the present study are also Hungarian researchers from Hungary or one of the neighbouring countries, our preliminary knowledge / pieces of specialist literature reading also belong to the area of minority studies/ language rights. However, we could not use minority studies viewpoints in the present inquiry, because it was oriented to the tourists and visitors travelling to and from the two countries. For instance, at one of the intervention locations of the project, in the town of Sárospatak in Hungary, there is in fact no Slovakian minority at all, thus one cannot talk about minority language usage. Still, because of the increasing Slovakian tourist traffic, the management of the town expressly asked us to put out inscriptions at tourist locations within the framework of the present project in two languages, Hungarian and Slovakian. The minority studies literature framework could not have provided a basis for the needs and impact assessment of this intervention – but business science, more precisely business anthropology could.

Concerning self-reflection we also find it important to elucidate our own preliminary opinion related to research and bilingual boards. In the discussion we will thoroughly deal with the attitudes related to language usage of the field workers participating in the research, and we also included their feelings in the inquiry. We do not believe in scientific dispassionateness, as science is cultivated by humans, which is not a problem, but one must get straight the viewpoint based on which a certain opinion is formed. Therefore, we wanted to make our expectations clear from the very beginning, to straighten out what we think of bilingual notes in Slovakia and Hungary.

2.4. Our Preliminary Expectations Regarding the Field

An anthropological field work could not be complete without the presentation of the field. In our case “field” means the boards and inscriptions of the Eastern Slovakian-Hungarian border region. In order to understand the current practice, I feel it is important to offer a wider, panoramic view of the area in question.

Running over the countries of the Balkan Peninsula from South to North one can observe so many countries, so many customs, and that bilingual practices differ from one country to another. In Greece, for instance, where the knowledge of the Greek alphabet is not universal among foreign visitors arriving here, most of the inscriptions can also be read in English. Beside the different form of writing, this can obviously also be explained by the former British dominance. The situation in neighbouring Bulgaria or Serbia is similar, the knowledge of Cyrillic is not obvious for the visitors coming from other countries, therefore bilingual inscriptions, more precisely monolingual ones, but written in two different alphabets are a general practice (latinica, cirillica in Serbian). Interestingly, although Albanians use the Latin alphabet, most inscriptions of

public interest are explained (e.g.: Kentar/Center), because (according to the locals) Albanian is not a language that can be understood by others. In addition to those, there are other minority language inscriptions, too, e.g. in multi-ethnic Vojvodina one can find inscriptions in Serbian Cyrillic/ Latin/ Hungarian/ German/ Croatian language. In Romania extra care is taken to use the same character type and size, typographical appearance for the different languages (although the language of the state always comes first).

One might think that the Hungarian and Slovakian practices are similar, but that is not the case. As opposed to Albanian or Greek for instance, none of these two languages consider themselves small or incomprehensible to the degree that English labelling would be necessary. In the case of Hungarian this is anachronistic, as even the malls beside larger cities can only be found by the drivers following monolingual (Hungarian) signs. The expression (bevásárlóközpont = shopping mall) is obviously meaningless for a foreigner, albeit a pictogram featuring a shopping cart sometimes solves the dilemma. One of my personal favourite of the signs that are unintelligible for foreigners is located at a roundabout in Nyírbátor, where an exit is marked by the word "Országhatár" (National boundary).

As far as minority language usage is concerned, the official (public) practice mostly limits minority signs to town signs in both countries, yet, as opposed to the Romanian system, these signs are not the same size as the one in the official language of the state, but located under the main sign, in a smaller size and in a different colour (white, against a green background in Hungary and blue background in Slovakia), as some kind of an explanatory note with the name of the place in the language of the minority to favour the dummies. Based on all this, at the beginning of our field work we had the feeling that the protection of the mother tongue is far more important in both countries than smooth communication with visiting foreigners or the positive discrimination of minority language usage.

Yet, during the field work we were surprised to discover that in the case of business signs mother tongue dominance does not prevail in everyday life. Multilingualism is pronouncedly significant, especially in what the presence of English is concerned –, something that cannot be explained by official, national language policy or semi-colonial past as it was the case in Albania or Greece.

3. THE COURSE OF RESEARCH

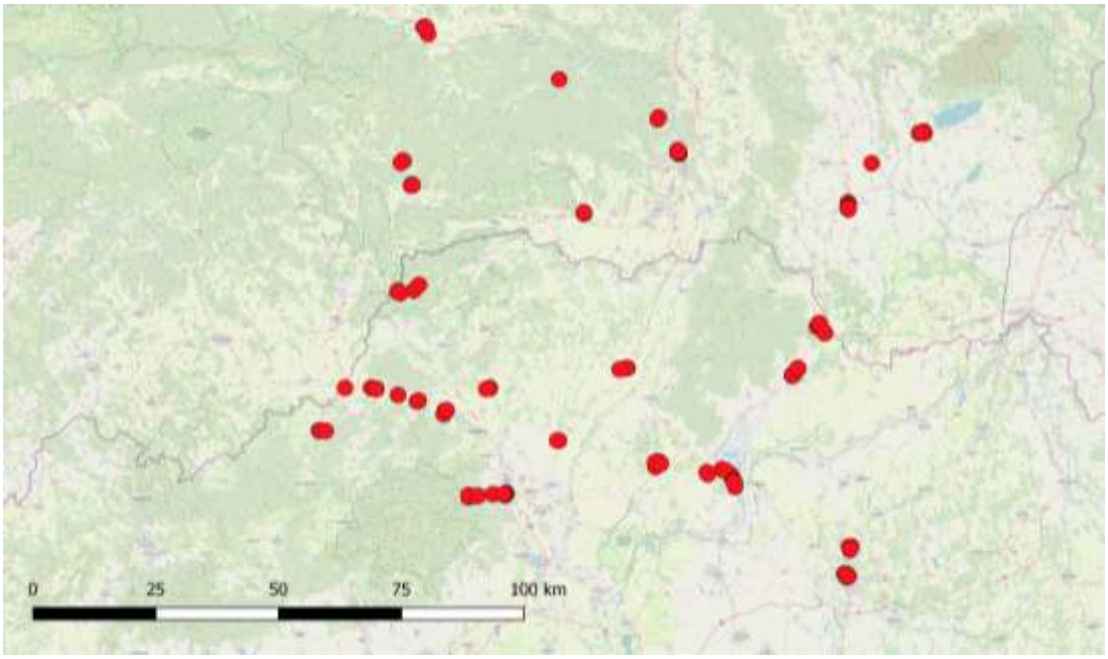
Methodology and Sampling

In the course of our linguistic landscape research we employed field work tools among the hosts, accommodation service providers and tourism-related businesses of the Hungarian-Slovakian border region. The question might arise in the minds of the readers why personal field work was necessary in the first place, why wasn't enough to observe the linguistic landscape from the Google Street View application, perhaps collecting statistics with an adequate search engine. To answer that, we must point out that in addition to the mechanical recording of outside (street) signs, pollsters carried out other important tasks, such as the following:

1. Pollsters first examined, took pictures of, and interpreted external (i.e. frontal, shop-window) signs; this was the part of their work that could have also been carried out by an online engine.
2. Then they entered the business locations and examined the inscriptions in the interior, e.g. price lists, also from the perspective of multilingualism.
3. After that, they started a conversation with the attending personnel, within which they carried out partaking observations: attempted to speak various foreign languages in different places. There were native Hungarian, Ukrainian-Slovakian and Russian speakers among the field-workers.
4. They asked permission to take a few photographs inside the place, then

5. If it was possible, they also asked a simple needs assessment questionnaire, within the framework of a structured interview.
6. Finally, after their visit, pollsters recorded their impressions about the place, including quasi-hard data like the estimated area of the establishment and such difficult phenomena as the prestige of the location.

Field-work was carried out mostly in the Eastern part of the border region, in the Northern and Eastern areas of Borsod-Abaúj-Zemplén County (the districts of Putnok, Edelény, Szikszó, Encs, Gömrő, Sátoraljaújhely, Sárospatak, Tokaj, Szerencs), the Western and Eastern parts of the district of Kassa/Košice (the subregions of Gölnicbánya/Gelnica, Igló/Spišská Nová Ves, Rozsnyó/Rožňava, Nagymihály/Michalovce, Szobránc/Sobrance, Tőketerebes/Trebišov), respectively in the larger towns of the region. Between the 21st and the 31st of June 2018, we visited a total number of 231 businesses in seven turns, 90 in Slovakia and 141 on the Hungarian side of the border region.



In the case of both countries we focused on tourism within the sectors of the economy, and on appearing multilingualism as an economic resource. In the case of the regions, towns, traveller destinations visited by tourists we primarily attempted to map the usage of various languages within service providing units. When assembling our research plan, we strived to cover the examined region from an area and settlement size perspective, although we could not achieve territorial representativeness, and the applied qualitative methodology did not require that, either. Our goal was not to get a picture of the region regarding written multilingualism that could be generalised for touristic enterprises, but rather to obtain valid data in a first research of this nature about the principles that guide the appearance of multilingual inscriptions in the inside and outside spaces of the businesses visible for the tourists, and especially to see to what degree the hope for economic gain is a defining factor for the ventures.

Apart from this research the project also included a pilot intervention (the placement of bilingual boards, menus). Project results are spectacular, mainly in Sárospatak, where 25-25 bilingual inscriptions were placed concentrated, at the lido and at town tourist destinations. 50 boards were put out in Slovakia, too, but on a much larger geographic area. A data survey was simultaneously conducted on a sample of 280 people, basically to assess the efficiency of the placement. The results, where it was possible, were taken into consideration when writing the present study.

Sample Distribution

Figure 1 summarises the different business types in the sample, and their distribution according to country and settlement type. As some of the businesses could be categorised into several types at the same time, the sum of the quantities in the picture exceeds by 42 the effective number of the businesses visited. If we only consider the real number, we can say that 6 of the visited Slovakian businesses were located in rural areas, 60 in small towns, and 24 in larger cities, with more than 100,000 inhabitants. In Hungary these values are in the same order of succession 15, 78 and 48. 141 businesses in Hungary were included in the sample, whereas only two-thirds of that number in Slovakia, i.e. 90 businesses. The difference is explained by a circumstance that was discovered also during the field research, namely that there were less businesses of a touristic relevance on the Slovakian side, and the volume of tourism was generally lower here, which made it more difficult on the Northern side of the border to find businesses adequate from the point of view of research sampling.

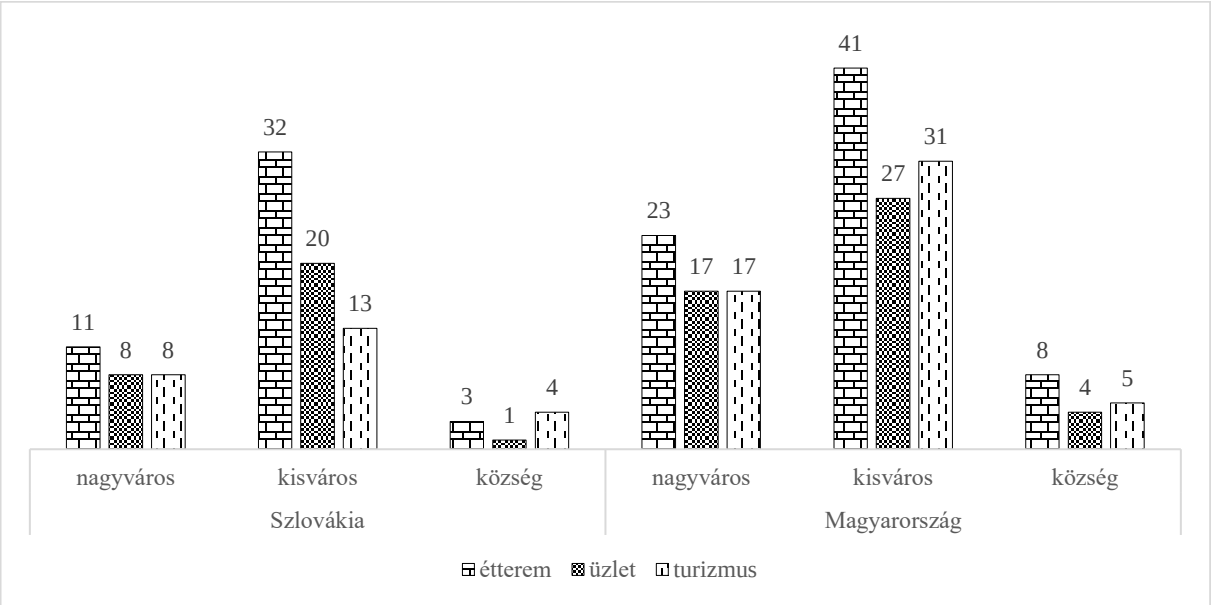
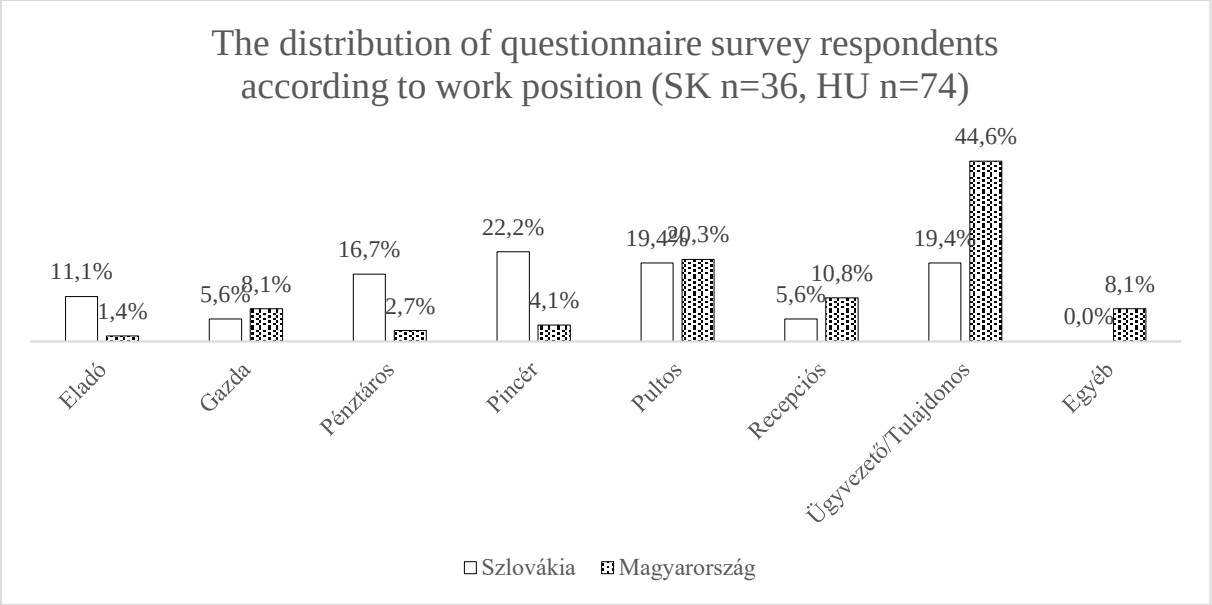


Figure 1. Types of commercial entities visited according to country and settlement type (n=231, some businesses could be included into several categories)

[**Az ábra feliratai/Translation of the words in the figure:**
nagyváros = large city; kisváros = small town; község = village;
Szlovákia = Slovakia; Magyarország = Hungary;
étterem = restaurant; üzlet = shop; turizmus = tourism]

After mapping the external language of the businesses, the inner examination of the business followed, respectively, before that, the questionnaire survey addressed to the employee of the venture, provided that he/she was willing to take part in the survey. Of the employees working in the 231 businesses almost half, 49 percent, or 113 people expressed their consent to participate in the survey, and 92 people, i.e. 40 percent agreed to allow for the documentation of indoor space language usage. The rate of refusal was somewhat higher on the Slovakian side of the border region than on the Hungarian side: rejection to participate in the survey was 41 percent in Slovakia and almost 54 percent in Hungary, and 69, respectively 55 percent regarding the permission to take photographs inside the establishments. In spite of that, one third of the Slovakian businesses and 53 percent of the Hungarian ones agreed to allow the documentation of the language use of their indoor spaces.

During the survey data gathering we generally succeeded to address individuals in higher positions in Hungary as compared to the ones in Slovakia, where the majority of the respondents were cashiers, waiters, bartenders or sales clerks, and the proportion of managers and owners in the sample was only one fifth. On Hungarian territory the same rate was almost 45 percent. Only the ratio of bartenders and information clerks was balanced in the two samples, 20 percent were employed in such positions both in Hungary and in Slovakia. Partly due to the differences in position, the age of the respondents was also somewhat different in the two countries. Although the year of birth was not asked directly, the field operators divided the respondents in three categories depending on their age (young: below 30, middle aged: between 30-60, and elderly: over 60 years of age). Only one person of the latter category was included in the entire sample. The proportion of the young people among the respondents was 37 percent in Slovakia, and only 20 percent in Hungary. Differences were much more significant from a gender perspective: while 80 percent of the respondents in Hungary were male, the share of male respondents was only 31 percent in Slovakia. Taking into consideration the fact that the units of the observation were not individual employees, but the businesses themselves, these differences are not very relevant from the perspective of the findings of our research.



[**Az ábra feliratai/Translation of the words in the figure:**
Eladó = Shop Assistant; Gazda = Farmer; Pénztáros = Cashier; Pultos = Bartender; Recepciós = Receptionist; Ügyvezető/ Tulajdonos = Manager/ Owner; Egyéb = Other
Szlovákia = Slovakia; Magyarország = Hungary]

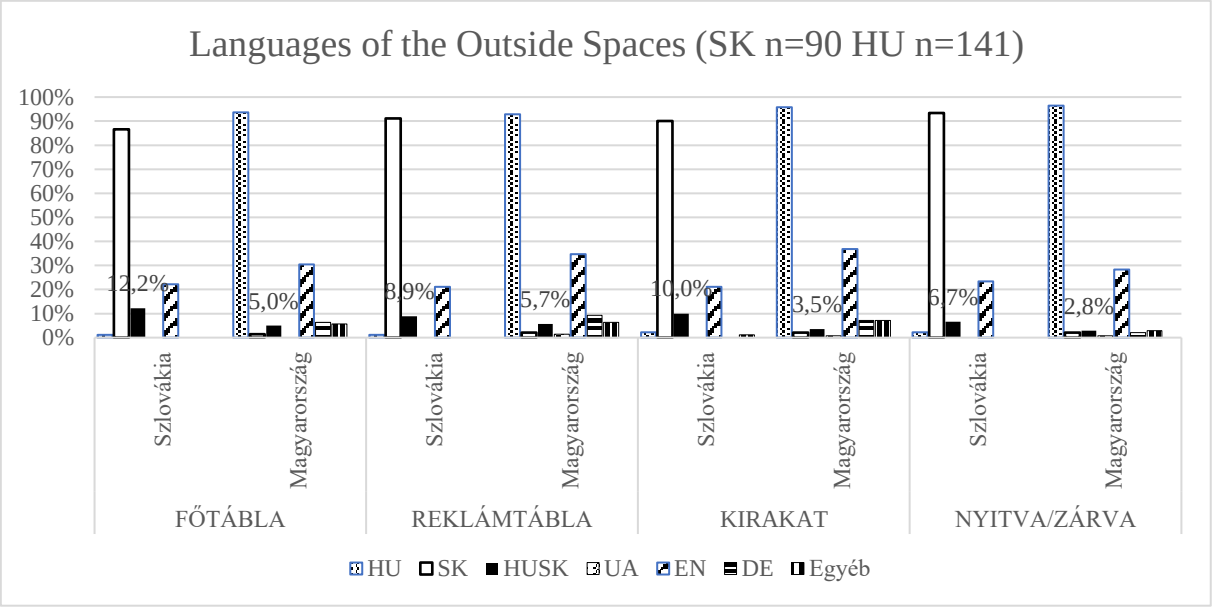
Results

LANGUAGES OF OUTSIDE SPACES

Regarding the outside languages of the businesses, field workers recorded the language in which the name of the business appeared, the languages of the incidentally appearing other signs, mottos, inscriptions besides the main advertising sign or board. We made a separate record about the languages used in the shop-window, or more precisely: of all the texts appearing in the shop-window, respectively in what language(s) the information appeared on the sign of the opening hours. Possible languages that could be recorded were Hungarian, Slovakian, Ukrainian, English and German. Expressly Slovakian-Hungarian bilingual notes were encoded as a separate category during the field work (in this case neither the Hungarian, nor the Slovakian language was indicated independently). It was also possible to note down other languages; most frequently this meant the languages of the national cuisines represented by the restaurants – e.g. Italian in the shop-windows of pizzerias and ice cream parlours, coffee-shops. It is

important to underline that we took no notice of the size and appearance of the various texts in different languages.

Regarding the languages of the outside spaces it can be said that bilingual Hungarian-Slovakian inscriptions appeared far less frequently than expected, and this statement is true for both the Hungarian and the Slovakian side of the border region. Bilingual inscriptions appeared most frequently on the main boards, the sign on which the name of the business was shown, both in Slovakia and Hungary, but even so their share was only around 12 percent in Slovakia. Hungary performed even worse in this respect, here only 5 percent of the inscriptions were bilingual (Hungarian-Slovakian). This difference can also be explained by the presence of the Hungarian minority in the case of Slovakia, and within that, the businesses owned by persons belonging to that minority, thus we wish to underline that multilingual inscriptions are not primarily or necessarily placed out of business policy considerations. The proportion of English language inscriptions in Hungary exceeded the ratio found in Slovakia, their proportion could be even six times higher than that of the Slovakian-Hungarian bilingual inscriptions. Slovakia leaves Hungary behind also in the bilingualism of the other signs; in the case of advertising boards by 3 percent, its advantage being almost 7 percent in the case of shop-windows, 4 percent regarding the information notes about the opening hours.



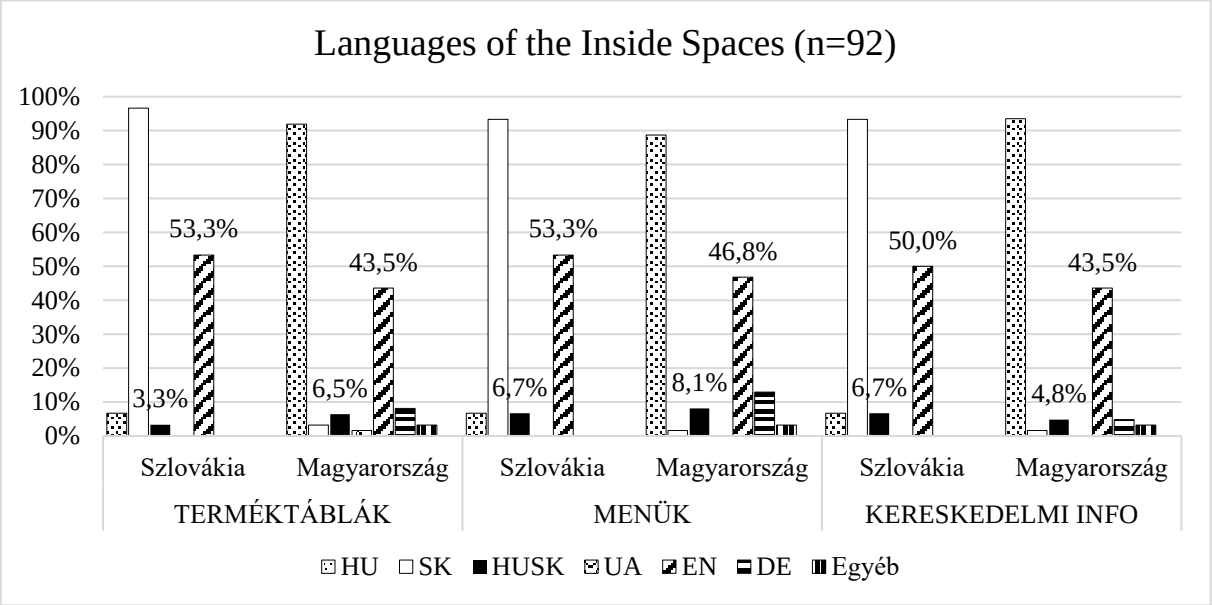
[**Az ábra feliratai/Translation of the words in the figure:**
Szlovákia = Slovakia; Magyarország = Hungary
FŐTÁBLA = MAIN BOARD; REKLÁMTÁBLA = ADVERTISING BOARD; KIRAKAT = SHOP WINDOW; NYITVA/ZÁRVA = OPENING HOURS
Egyéb = Other]

LANGUAGES OF INSIDE SPACES

Field workers were allowed to map the language usage of the inside spaces of a total number of 92 businesses, of which 30 in Slovakia and 62 in Hungary. Besides producing a photo documentation of the inner spaces of commercial buildings, the language usage of three categories of inscriptions was expressly recorded. One such category were the different product signs, inscriptions meant to help visitors in getting informed about the particularities and prices of the services and products sold – these could be price labels on the shelves in the case of shops, or the board with the prices of the services in the case of restaurants, hotels or other touristic organisations. The other recorded data referred to the language of the menus: in quite a number of restaurants the products do not appear in different languages on the large boards, yet menus are translated into multiple languages, which is a relevant factor largely for the restaurants and buffets, but the catering parts of other touristic services also belong here. The third category were any other

kind of commercial information boards, and the direction signs within the establishment that did not fall into the previous two categories, in other words were not related to direct services (various advertising boards, and the boards and inscriptions serving inside orientation).

The differences between the businesses located in Slovakia and Hungary with respect to their inside spaces turned out to be far less significant than in the case of outside inscriptions. Regarding bilingual Slovakian-Hungarian inscriptions the businesses in Slovakia underperform and the ones in Hungary outperform as compared to the outside signs. In this respect indoor service and products boards in Hungary are twice as likely to include information in Slovakian besides the information in Hungarian, while in the case of menus we found an advantage of a little bit over 1 percent in the examined businesses. Regarding the boards containing additional information the businesses in Slovakia had an advantage of 2 percent. Generally speaking 7-8 percent of the menus, 3-7 percent of the product labels, and 5-7 percent of the other information notes contain simultaneous Hungarian and Slovakian inscriptions. In comparison with outside inscriptions, the usage of the English language inside the businesses is strikingly popular both in the case of Hungary and Slovakia. In both countries, in the case of all three indoor inscription types the proportion of information also appearing in English is between 40-50 percent, while in the case of the businesses on the Hungarian side of the Slovakian-Hungarian border region, in menus for instance even the use of German was one and a half times more frequent than Slovakian.

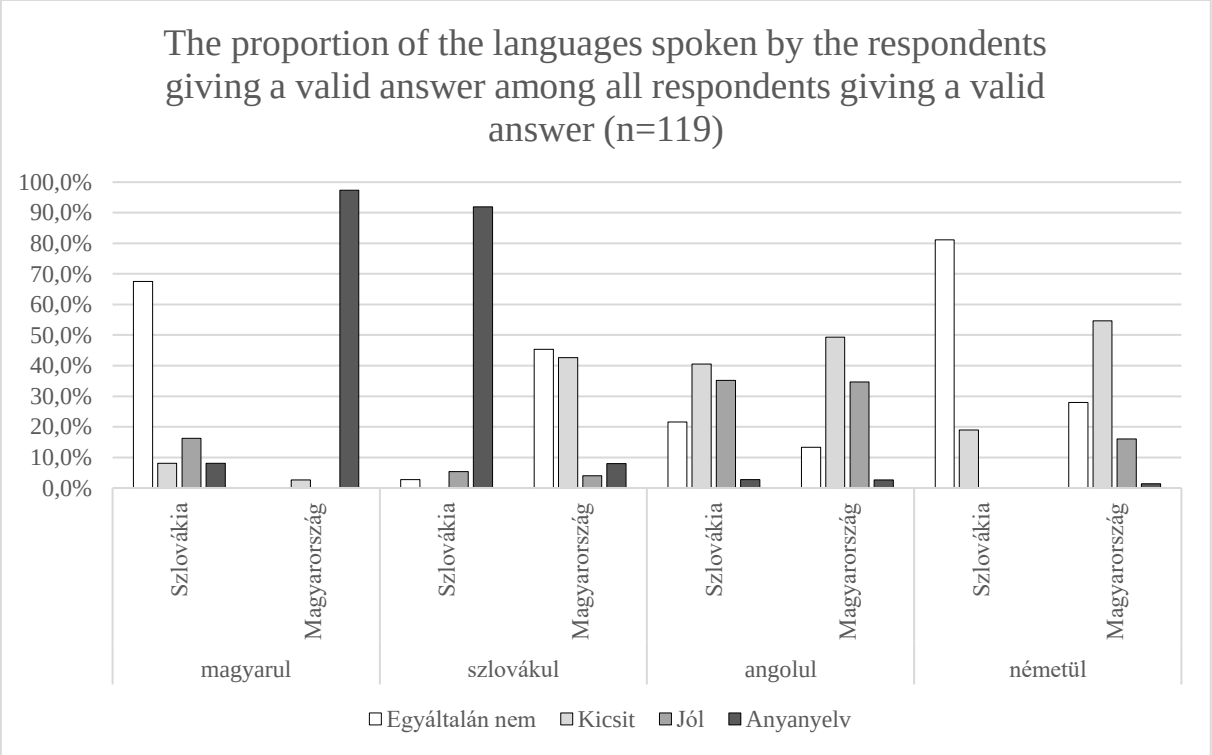


[**Az ábra feliratai/Translation of the words in the figure:**
Szlovákia = Slovakia; Magyarország = Hungary
TERMÉKTÁBLÁK = PRODUCT LABELS; MENÜK = MENUS; KERESKEDELMI INFO = COMMERCIAL INFO;
Egyéb = Other]

SPOKEN LANGUAGES

During the field research we asked the employees working in the business establishments about their language knowledge and their levels of competency in the given languages. Referring to their knowledge of the languages concerned, respondents could choose from a four-grade scale, where 1 meant no knowledge at all, 2 mid-level language competency, 3 speaking the language fluently, and 4 that the given language was their mother tongue, or that their language competency was on the level of a native speaker. We asked about language skills about a total of 5 languages, these were the Hungarian, Slovakian, English, German and Ukrainian – the latter is not listed. Generally, about 70 percent of all the respondents giving a valid response (53 people) in Slovakia spoke no Hungarian at all, while about 40 percent of all those with a valid response in Hungary (66 people) declared that they spoke a little Slovakian. This is particularly

remarkable, and we had not expected this scale of language knowledge. It can thus generally be said that mutual language knowledge is comparable in the two countries, adding up to more than one third – almost one half of the respondents, although the level of Hungarian language knowledge in Slovakia among those speaking Hungarian is higher, than the level of Slovakian knowledge among the Hungarians that speak this language. This level of language competency can also be considered a touristic potential for the region. Still, English language knowledge is more frequent: two thirds of the respondents in Slovakia, and more than 80 percent in Hungary declared that they spoke at least a little bit of English. Concerning German language competencies, the respondents in Hungary got well ahead of their Slovak partners: only a little bit more than one quarter said that they knew no German at all, whereas in Slovakia this proportion exceeded 80 percent.



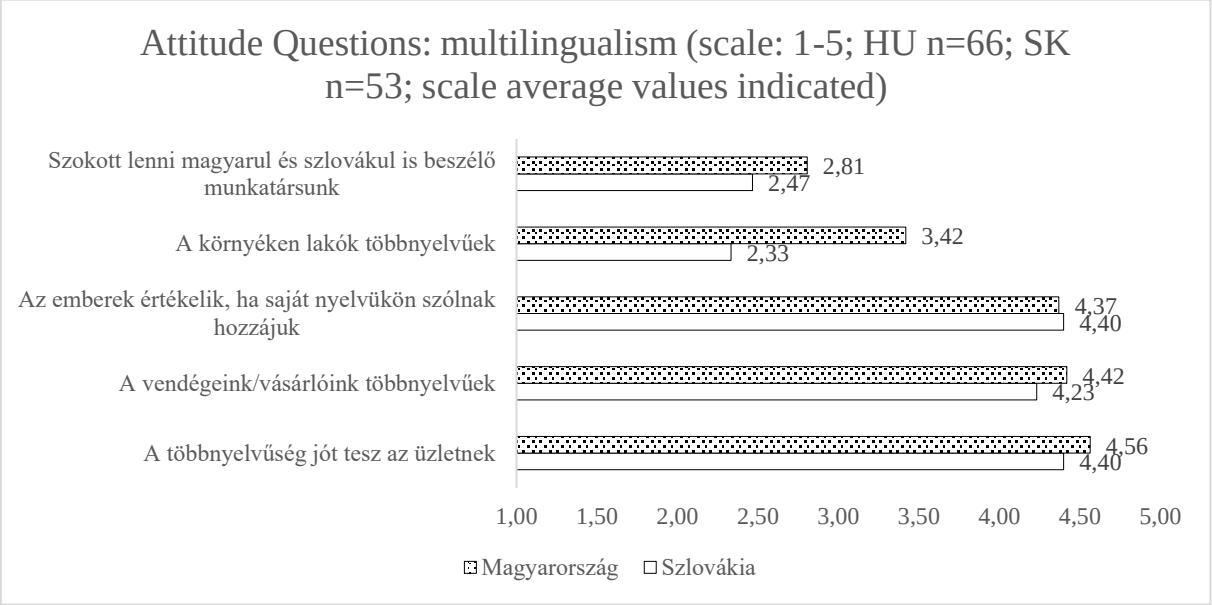
[**Az ábra feliratai/Translation of the words in the figure:**
Szlovákia = Slovakia; Magyarország = Hungary
magyarul = Hungarian; szlovákul = Slovakian; angolul = English; németül = German
Egyáltalán nem = At all; Kicsit = A little; Jól = Well; Anyanyelv = Mother tongue]

ATTITUDES

In a further group of questions for the inquired employees and business owners we formulated statements regarding language usage, asking them to mark on a five-grade scale how much they agreed. The first two and the fourth statement referred more to information about business operation, while the other two could be considered attitude questions. Although we had earlier measured similar level mutual language competencies among the respondents of the Slovakian and Hungarian businesses, Hungarian respondents gave a higher-than-average value to the statement that they usually had both Hungarian and Slovakian speaking colleagues. At the same time, this higher-than-average value was due to the higher number of neutral standpoints, as when the distribution of the answers was analysed more in-depth, we discovered that 27 percent of the Slovakian respondents had chosen 4 or 5 (agree or agree completely), whereas only 13 percent of the Hungarians. The number of neutral standpoints in the case of the Hungarian respondents (44 percent on the Hungarian side, and only 24 on the Slovakian) can also be explained with lower level language competency, a fact that had already been established among our respondents: it may well be that

they adopted a neutral standpoint because a beginners' level language knowledge was neither considered Slovakian language competency nor the total lack of it.

The second standpoint was asked in connection with the statement that local residents living in the area are multilingual. Interestingly, Slovakians generally disagreed more with that than the Hungarian respondents, although the presence of the Hungarian minority was stronger in Slovakia, than that of the Slovak minority on the Hungarian side of the border. In Hungary, 44 percent of the respondents agreed with the statement (at least to a degree of 4), while in Slovakia the proportion of agreement was only 13.5 percent, with not a single respondent agreeing completely. The question might have been formulated somewhat ambiguously, as our intention was to refer to the language usage of the population of a given region, rather than the mono- or multilingualism of certain individuals – the differences could also be coming from this, and the interpretation differences between the Hungarian and the Slovakian translations of the statement: the respondents in Slovakia may have understood that the question was referring to individuals, and they did not consider the persons speaking Hungarian but not Slovakian as multilingual. In spite of this, the multilingualism of the buyers was valued equally high on both sides of the border. Only 4 percent of the respondents on the Hungarian side, and 19 percent on the Slovakian side disagreed partially or totally (1-2 grades on the scale) with the statement that their guests/ buyers were multilingual.



[**Az ábra feliratai/Translation of the words in the figure:**
Szokott lenni magyarul és szlovákul is beszélő munkatársunk = We usually have both Hungarian and Slovakian speaking colleagues;
A környéken lakók többnyelvűek = The people living in the area are multilingual;
Az emberek értékelik, ha saját nyelvükön szólnak hozzájuk = People appreciate when they are addressed in their own language;
A vendégeink/ vásárlóink többnyelvűek = Our guests/ buyers are multilingual;
A többnyelvűség jót tesz az üzletnek = Multilingualism is beneficial for business;
Szlovákia = Slovakia; Magyarország = Hungary]

The two attitude questions, the most interesting ones from the perspective of our topic in the questions series, referred to the view of the respondents on the issue whether the buyers appreciated being addressed in their own languages, respectively whether multilingual solutions were beneficial for business. Although we received quite high average scale grade values for the former question, too, the latter brought even higher averages. Almost three quarters of the respondents on the Hungarian side, and more than half on the Slovakian side totally agreed with the statement that multilingualism was beneficial for business. Generally speaking, the statement was "at least" agreed by 89 percent of respondents in Slovakia, and 83 percent in

Hungary. The proportion of neutral answers among the respondents was 8-9 percent, and only one person gave a value below 3 in the entire sample.

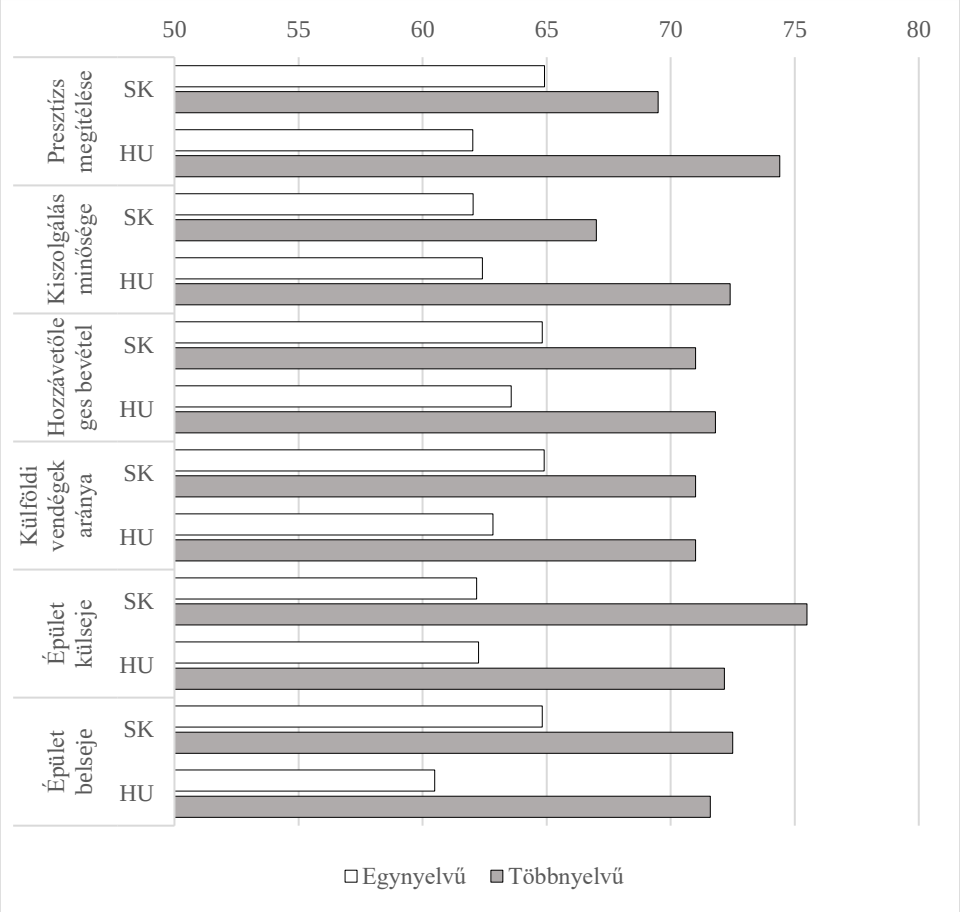
When we cross-checked these results with the situation observed in connection with the inside and outside space language usage, we could see that in the places *where the main inscription was bilingual Slovakian-Hungarian, 100% of the respondents totally agreed with the statement*. Among the interrogated employees of the businesses with only a Slovakian language main inscription, the proportion of total agreement was lower, of only 57 percent, and among the respondents working in businesses with only a Hungarian language main inscription it was 69 percent. Similar results were obtained in connection with the mono- or bilingualism of the menus.

Relevant foreign language usage except for the Slovakian and the Hungarian was only found in the English language inscriptions, especially in the case of menus. If we examined to what extent was the positive appreciation about the business value of multilingualism incidental with the use of the English language on menu cards, we observed that in the places where the products or services also appeared in English on the menu, 84 percent of the respondents completely agreed with the statement. Based on this, multilingualism could generally mean Slovakian-Hungarian bilingualism, or the use of the domestic language and English, albeit the greater part of the respondents also totally agreed that the use of the language of the guests could be important. Generally speaking, based on the above facts, a question worthy of further analysis can be formulated, namely that if business opportunities are recognised by the employees in multilingualism, then why the use of multilingual solutions in the region continues to remain so scarce?

PRESTIGE

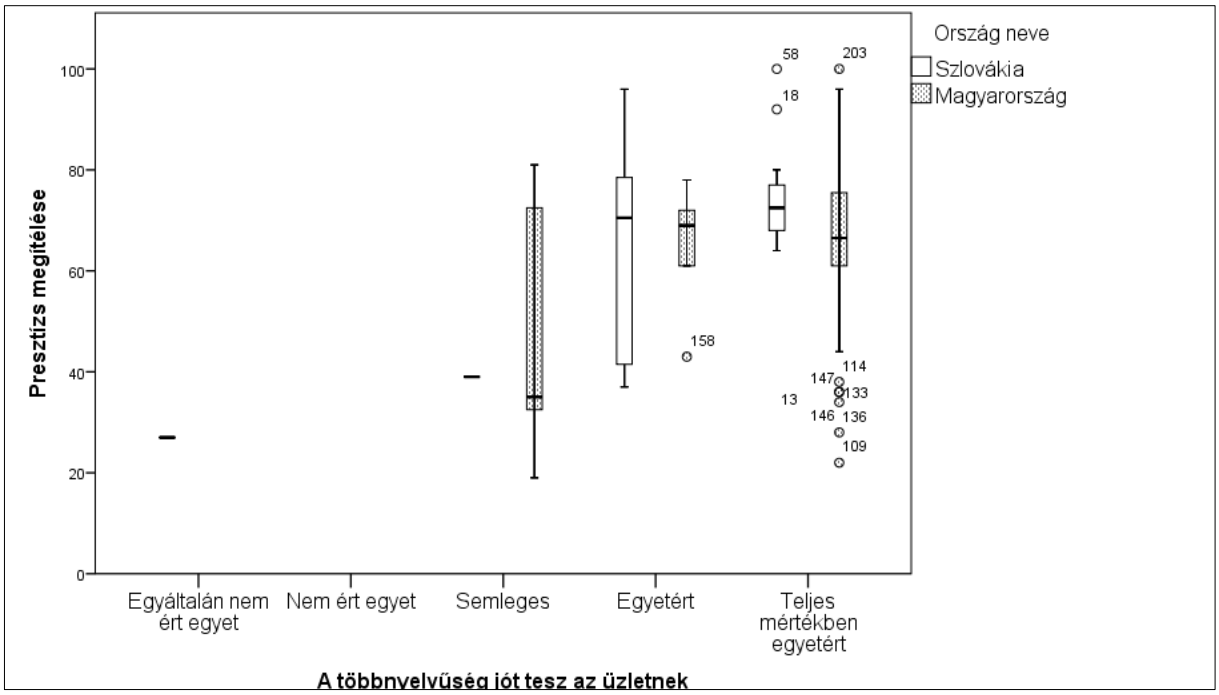
No questions about the exact turnover or returns of the businesses had been asked during the research. Besides methodological and ethical considerations, the counter-argument was that comparing businesses differing in status, size and type would not have any purpose, and it would be difficult to decide on that ground which of them was better off or worse “in comparison with themselves”. Yet field operators recorded on a 100-grade scale their impressions about the incomes, and especially the prestige of the given visited venture. By examining variable average values and deviations we can conclude that, independently of the country of residence, the businesses where respondents had a more neutral standpoint in relation with the beneficial nature of multilingualism for the business, seemed to be of a much lower prestige than those where the respondents recognised the business opportunities inherent in multilingualism better than that.

The results are summarised by the graph below:



[**Az ábra feliratai/Translation of the words in the figure:**
Presztízs megítélése = Prestige appreciation; Kiszolgálás minősége = Service quality; Hozzávetőleges bevétel = Approximate income; Külföldi vendégek aránya = Ratio of foreign guests; Épület külseje = Building exterior; Épület belseje = Building interior;
Egynyelvű = Monolingual; Többnyelvű = Multilingual]

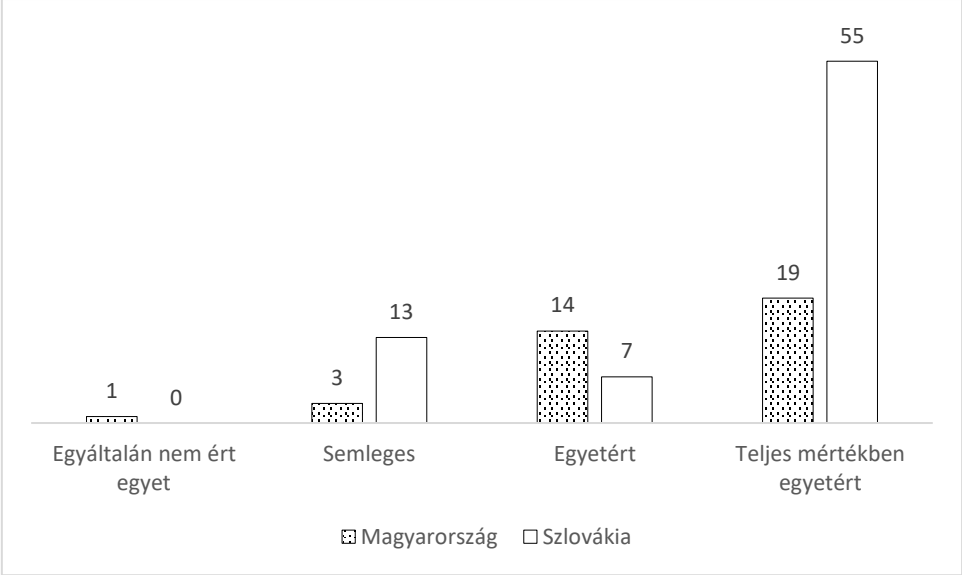
The prestige of the places where an English language service list or menu was also available was valued higher by an average of 15 points on the 100-grade list (56, respectively 71 points), while the prestige difference between the businesses with only monolingual and with Slovakian-Hungarian bilingual menus or outside inscriptions was 12-12 points in favour of the bilingual ones, (although their number in the sample of 92 elements, including the evaluation of the inner space, was merely 6). Generally, we cannot establish cause-effect relations based on the data, in other words it cannot be determined unambiguously whether higher prestige brings about the recognition of the importance of multilingualism, or multilingual solutions by themselves can raise the prestige of a given place. At any rate, it can be formulated as a conclusion, or a hypothesis to be tested further that multilingualism seems to be incidental with prestige.



[**Az ábra feliratai/Translation of the words in the figure:**
Ország neve = Name of country
Szlovákia = Slovakia
Magyarország = Hungary
Presztízs megítélése = Prestige appreciation
Egyáltalán nem ért egyet = Totally disagree; Nem ért egyet = Disagree; Semleges = Neutral; Egyetért = Agree; Teljes mértékben egyetért = Totally agree]

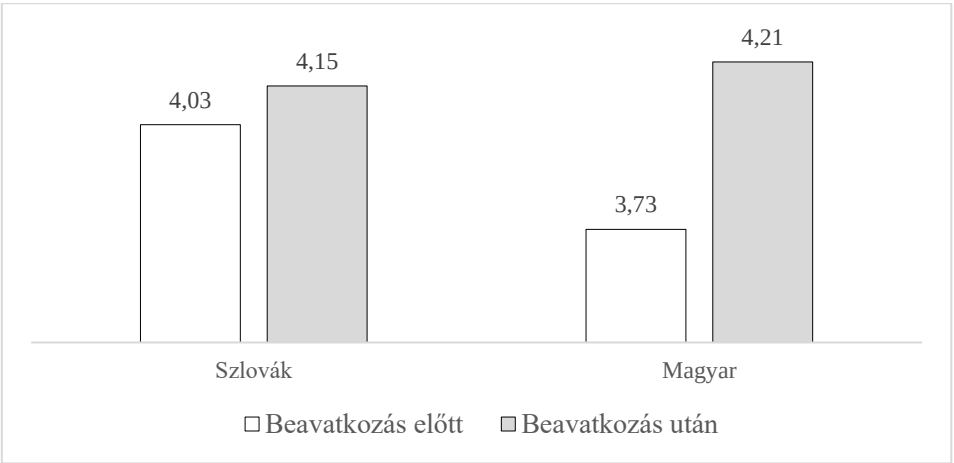
It can also be, of course that both factors (multilingualism and prestige) are determined by a third, external factor, the presence of foreign guests. Cause-effect relationships can again be outlined in two different ways: places with a higher prestige attract foreigners, respectively the presence of foreigners indirectly elevates the prestige of the business. We consider that the significance of the latter must not be underestimated. At any rate, it can be said as a general result that the more the respondents agreed with the statement that "our guests are multilingual", the higher our field-workers valued the prestige of a given business. Average prestige values reached 27, 27, 54, 62, 69 percent, as the degree of agreement with the statement grew.

Multilingualism and higher prestige therefore go together, and this, by all means, brings about business advantages – we thought. But what did the entrepreneurs think about that? In order to obtain an answer to the question, we asked the representatives of the businesses, within the framework of the same linguistic landscape research. The question was wilfully formulated simply: Is, in your view, bilingualism beneficial to business?



[**Az ábra feliratai/Translation of the words in the figure:**
Egyáltalán nem ért egyet = Totally disagree; Semleges = Neutral;
Egyetért = Agree; Teljes mértékben egyetért = Totally agree;
Magyarország = Hungary; Szlovákia = Slovakia]

As it can be observed on the figure, the stakeholders (employees and managers of accommodation services providing, catering, tourism enterprises) mostly strongly agreed that multilingualism was beneficial for business. There is one notable Hungarian respondent however, who affirmed that bilingualism would not improve his business. We searched in our database, what kind of undertaking it was. It turned out, that the explanation had nothing to do with xenophobia: the venture was a catering establishment in a village with no significant Slovakian minority or tourism. In a third approach, as in connection with the interventions of the pilot project we asked 280 local passers-by about their opinions regarding the inscription boards that we had put out, in the mean time we also asked them this question, too. The sample was not representative for the population but only regarding the inscriptions put out:



[**Az ábra feliratai/Translation of the words in the figure:**
szlovák = Slovakian; magyar = Hungarian;
Beavatkozás előtt = Prior to the intervention; Beavatkozás után = After the intervention]

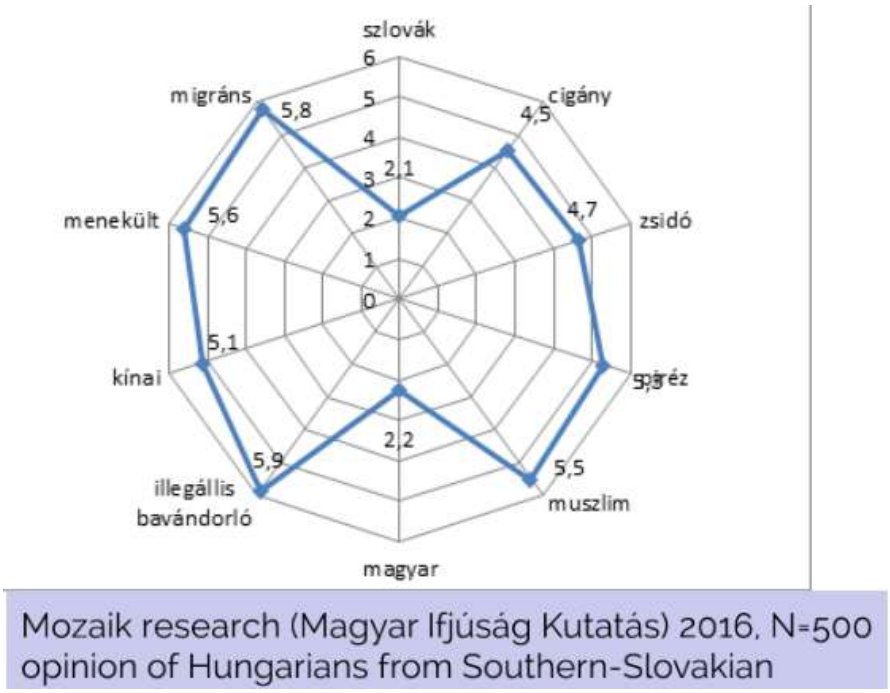
Passers-by were addressed twice by the pollsters, before and after the boards were placed. As it can be seen of the figure, people generally agreed that bilingual inscriptions are beneficial for business (average values of 4.03 and 3.73 in Slovakia and in Hungary); yet, if they also had the chance to see such a bilingual sign,

then based on their own impressions, this positive opinion becomes a lot stronger (values of 4.15 and 4.21). It follows from this, that the visitors, inhabitants and entrepreneurs of the border region truly value bilingual signs, provided that these exist in the first place.

Xenophobia

Our research was focused on this: Can bilingual inscriptions help the growth of cross-border tourism, and if yes, through what mechanisms? In order to examine this question we had to address another question first: could it damage the prospects of a commercial venture if, in addition to Hungarian, it also allowed the Slovakian language to appear in its business communication in Hungary (and vice versa). This issue in fact reaches back to the question of nationalism, respectively xenophobia (the fear or hatred of things that are foreign or strange, i.e. in the present case the negative feelings of two linguistic/ ethnic groups against each other). If there was significant xenophobia (nationalism) in a region, then it would be understandable if an entrepreneur in the tourism industry, like e.g. the owner of a restaurant, feared that by the public display of the language of the neighbouring state, he may lose his domestic consumer circle, or a part of it.

The nationalism and xenophobia researches in the region carried out on large samples mostly report the steady decrease of the mutual aversion of the Slovakian and Hungarian communities against each other, especially since the accession of both countries to the EU. Passenger traffic between the two countries has been dynamically increasing specifically since the opening of the Schengen borders, which could have contributed to the strengthening of good personal experiences. The data of a 2016 research focused on the youth of the Hungarian speaking minority in Slovakia are particularly meaningful:



Source: MOZAIK, Magyar Ifjúság Kutatás 2016

[**Az ábra feliratai/ Translation of the words in the figure:** szlovák = Slovakian; cigány = Gypsy; zsidó = Jewish; piréz = Piréz (a fictitious community); muszlim = muslim; magyar = Hungarian; illegális bevándorló = illegal immigrant; kínai = Chinese; menekült = refugee; migráns = migrant]

http://www.ujnemzedek.hu/sites/default/files/atoms/files/magyar_ifjusag_kutatas_2016_gyorsjelentes_a_karpat-medencei_fiatalokrol.pdf

It can be seen on the figure that, xenophobia (or perhaps the distrust) among the Hungarian youth in Slovakia is generally quite high against everyone, including the "Piréz" ethnic group, which is a fictitious people, used as a control variable. However, there are two ethnic groups that are judged positively, their own group (i.e. the Hungarians from Slovakia), and the Slovakian one. The positive message of the research results from the perspective of our own research is, that based on these macro-data Slovakian – Hungarian relations from a business point of view are not influenced negatively by bilingual inscriptions: in our

example the restaurant owner is not going to lose clients as a result of the placement of bilingual inscriptions.

During our research we examined the evolution of verbal communication by *participative observation*: how is the foreign language, the language of the other country used verbally? Our surveyors, among who there had been native Slovakians, Ukrainians, Russians and Hungarians, took the surveys in groups of two. Their task was to initiate conversation in the language of the other country wherever it was possible. In a *self-reflexive* way, our pollsters also described their feelings regarding the communication situations in their field reports. It turned out from these reports that this task had been extremely burdensome, because of the following feelings:

- They were frequently afraid that they will not be understood (when speaking Slovakian in Hungary and vice versa)
- Even more frequently they recounted that they felt it was somehow rude, or even insulting to use another language than Slovakian in Slovakia (and vice versa), in spite of the fact that they spoke that, too, or at least one of them spoke it. For them it would have been natural that if one of them could speak the local country language, then he/she should be the speaker (or act as an interpreter).
- On the other hand they also found it frustrating to speak bad Hungarian or bad Slovakian, therefore no matter which language they talked, it was always the surveyor with that mother tongue who communicated at the given place, respectively, if they changed the language, the other surveyor took over.
- However, they were not afraid that they would be affronted because of speaking one language or the other. The Russian surveyor recounted such feelings, respectively it appeared sporadically in some of the pollsters, but it was not justified.

In contrast with their own feelings, the surveyors could not know the feelings of their respondents, they could only observe their behaviour. Still, their observations are interesting: they took notice that the shop-keeper/ waiter etc. was heartily ready to speak the foreign language both on the Hungarian and the Slovakian side, if they spoke it fluently, almost perfectly. Many respondents said (according to the field reports) that they knew the other language, but not well enough, and they did not want to be ridiculed. They frequently understood it, but were not able to answer in the foreign language. Generally: it was observed that when someone only spoke a little in the language of the foreign country, they were more reluctant to use it. Instead of using a broken Slovakian or a broken Hungarian they often used broken English, which was spoken well by only a few. It seems that in this region speaking a broken English is less frustrating than using the local languages.

4. Summary

The present study was written based on the research results of a Slovakian-Hungarian cross-border project dealing with bilingualism. The target groups of the project had been enterprises in the area of tourism, accommodation service provision, hosting, and the research question referred to how Slovakia could be made more comfortable from a language perspective for the Hungarian guests arriving there and vice versa. Within the framework of the project a linguistic landscape research was carried out, encompassing a number of 100-100 ventures from the target group, completed by participative observation and a series of qualitative interviews, respectively by a pilot intervention (the placement of bilingual signs, menus), in connection with which a data collection was executed from 280 people, basically to measure the efficiency of the sign placements.

Xenophobia

Based on our participative observation we found that verbal communication in the language of the other country is often difficult. The reason for that is not xenophobia (anti-Slovakian and anti-Hungarian feelings are disappearing), but other types of fears, frustrations: I will not be understood, I will be considered impolite, and I will become ridiculous. Our conclusions are similar to those that were based on the inscriptions: if the two countries do not take effort to strengthen the language of the neighbouring country, their citizens will probably primarily communicate in English among themselves.

It can cause concern that no general cultural patterns have formed for multilingual business communication, which can be the reason of confusion and frustrations both in buyers and sellers. Once for instance, a Catalan acquaintance of mine in Barcelona explained to me that in this multilingual city the main rule is that communication is always adjusted to the language of the buyer: if in a shop we ask for anything in Catalan, Spanish or English, the vendor will try to answer in that language. Here, in the Eastern Slovakian-Hungarian border region, there are no such simple rules.

Multilingualism does not do harm to business. Based on specialist literature, it seems that there is no significant Slovakian/ Hungarian xenophobia, therefore it is unlikely that many would turn up their noses seeing a bilingual sign or two in any of the two countries; and participative observation also showed that while verbal communication in a foreign language may be difficult, it is not doing harm to business. But does bilingualism good for it? Is it realistic to expect business profit from the placement of bilingual inscriptions at tourist destinations?

Is bilingualism beneficial to business?

The business value of bilingualism was assessed based on two data surveys. The first one was the feeling of the surveyors: during their field work they recorded their impressions about the places visited, according to several perspectives, among which there had been more obvious ones (e.g. the estimated surface of the establishment in square meters), and more flexible impressions (e.g. how high the prestige of the place was). As it was shown in the analysing chapter, multilingual places performed better than monolingual ones, without exception: they attracted more foreign visitors, provided better services, suggested higher prestige etc. This result is not surprising; if we reverse the statement: newer, more modern, fancy places in our places are mostly also multilingual.

The difference between monolingual (provincial, countrified) and multilingual (fancy, modern, fashionable) feelings by all means brings about business advantages – we thought. But what do the entrepreneurs think about that? In order to obtain an answer to the question, we asked the representatives of the businesses, respectively the audience of the bilingual signs that we had placed out. The question was wilfully formulated simply: Is, in your view, bilingualism beneficial to business??

The stakeholders (employees/ managers of accommodation services providing, catering, tourist enterprises) mostly strongly agreed that multilingualism was beneficial for business. Measured on a five-grade scale the statement received 4.56 (in Hungary) respectively 4.4 (in Slovakia), iskolából ismert kifejezéssel élve négyötöd. In the places where there were bilingual signs, 100% of the respondent stakeholders totally agreed (grade 5) with the statement.

In a third approach, as in connection with the interventions of the pilot project (i.e. the placement of the inscriptions) we asked 280 local passers-by about their opinions regarding the inscription boards that we had put out, and in the mean time we also asked them this question, too. Men in the street (to use a journalist's expression for the result of this non-representative sampling method) agreed anyway that

bilingual signs are beneficial for business (by average scores of 4.03 and 3.73 in Slovakia and Hungary); but when they even saw such a bilingual sign, this positive opinion became even more strikingly marked (values of 4.15 and 4.21). It follows from that, that the visitors, inhabitants and entrepreneurs of the border region truly appreciate bilingual signs – provided that these are there.

What we did not expect

The surveys had three surprising, unexpected observations.

The first unexpected observation was that there was no de facto bilingualism (i.e.: Slovakian-Hungarian bilingualism) in the region. It seems that our earlier feelings, field visits have deceived us: based on the representative sample, it looks like in the Eastern Slovakian-Hungarian border region, at main tourist, accommodation, catering locations the proportion of HU/SK bilingual inscriptions barely reaches 5%. The less than 5% proportion of HU/SK bilingual business inscriptions is lower not only than the proportions of HU/SK tourism oriented towards the countries, not to say the border region, but occasionally and sometimes it is even lower than the proportion of the local Hungarian population in Slovakia/ Slovakian population in Hungary.

The second observation that we were not prepared to in advance, relates to a non-verbal communication channel: money. The two countries use different currencies; Hungarian Forints are used in Hungary, and Euros are in circulation in Slovakia. Besides language, feelings of comfort can also be improved by the acceptance of one's currency, as equal in rank with the local currency, appearing on menus, signs. We created a new notion to express that in a similar way to mother tongue: mother currency. The mother currency is the currency that is the most familiar one to me in my thinking, by which I can best feel the value of the numbers, and I can immediately tell about something whether it is too expensive, or too cheap for me. In our South-Eastern Slovakian sample the percentage in which prices appeared in Forints in writing (in shop windows, on menus or indoor inscriptions) was around zero, while in Hungary prices appeared in Euros, too, in a significant proportion (24%). However, we cannot say more about that for now: an exciting issue, raising several other research subjects.

Our third unexpected observation is related to the outstandingly high ratio of English language inscriptions: we found a 25% proportion of English language signs (in outdoor inscriptions). The high proportion is not justified either by historic traditions (the region had never been a British colony, and there had never been significant cultural linkages between Central European and Anglo-Saxon countries), or the influx of English language tourists in the area.

The expansion of the English language was also confirmed by the results of participative observation. We thought that we had thoroughly prepared ourselves before our surveys, when we succeeded to recruit surveyors from Sub-Carpathia, whose native languages were either Hungarian, Slovakian, Ukrainian or Russian. We encouraged the surveyors to use their mother tongues as a foreign language in communication situations (especially Slovakian in Hungary and vice versa). Yet in reality, communication was not carried on in broken Slovakian or broken Hungarian, but rather in broken English. There were several reasons for that – see later. What can be inferred, however, is the following: both countries do a lot to protect and promote their own mother tongues. Yet, if they fail to take steps to protect the language of their neighbour, too, then the inhabitants of the two countries will sooner or later begin to communicate with each other in English.

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ELEKTİRİKLİ ARAÇLARIN AKTARMA ORGANLARININ ENERJİ VERİMLİLİĞİ İNCELENMESİ

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Özet – Bu çalışma içerisinde elektrikli araçların güç aktarma organındaki enerji verimliliğinin ne derece gerekli olduğu ve elektrikli araçlarda kullanılan şanzıman tiplerinin çalışma prensipleri anlatılıp, enerji tüketimleri kapsamlı bir şekilde literatür değerlendirmesi ile kıyaslanmaya çalışılmıştır. Günümüzde mevcut elektrikli araçlarda sıkça kullanılan sabit aktarım oranlı şanzımana alternatif olabilecek şanzıman tipleri incelenmiştir. İncelemeler sonucunda elektrikli araçlarda şanzıman kullanımının zaruri olmadığı fakat tavsiye edilen şanzıman tiplerinin kullanımında enerji tüketimi açısından ciddi tasarruf sağladığı görülmüştür Gelecek çalışmalarda elektrikli araçların güç aktarım sisteminde şanzıman kullanımıyla alakalı olarak, enerji tüketiminin değerlendirmesi, maliyet hesabı yapılması ve bahsedilen diğer hususların üzerinde durulması gerekmektedir. Bu sayede geliştirilecek şanzıman tipleri elektrikli araçların enerji tüketimlerini çok daha ekonomik bir seviyeye getirecektir.

Anahtar Kelimeler–Elektrikli Araç, Enerji Tüketimi, Şanzıman

1. GİRİŞ

Seraların azaltılmasına ilişkin mevzuatın arttırılması gazlar ve daha sürdürülebilir enerji kaynaklarına geçiş, Elektrikli Araçlar (EV'ler) umut verici çözümler olarak görülmekte ve pazara daha hızlı tanıtılmaktadır. Elektrikli araçlar sayesinde hem hava kirliliği hem de gürültü kirliliği azalacaktır. [1], [2], [3],. Şu anda EV'ların sınırlayıcı özelliği, esas olarak pil teknolojisi sınırlamaları nedeniyle kısa menzilleridir. Elektrikli Araçların (EV) müşterilere ve çevreye uzun vadeli faydalarına rağmen, başlangıç maliyeti ve şarj başına yetersiz sürüş menzili, büyük ölçekli ticarileştirmenin önünde önemli engel teşkil etmektedir. [4] Elektrikli araçların büyük çoğunluğunda değiştirilebilir çok vitesli bir şanzımanla donatılmamıştır. İçten yanmalı motorların aksine, elektrik motorları sıfır devirden itibaren maksimum torka sahiptir, bu da tahrik sistemi sıfır devirden itibaren maksimum çekme gücüne ulaştığı için kalkışta maksimum hızlanmaya izin verir. Tersine, maksimum hız aralığında, elektrik motorları genellikle maksimum güce sahiptir ve bu da teorik olarak yüksek hızlara izin verir. Elektrik motorları belirli bir hızda farklı yüklerde farklı verimliliklere sahiptir. Bu nedenle,

motoru optimum hız aralığında tutmak ve böylece daha yüksek verimlilik ve aracın ilgili menzilini garanti etmek için bir dişli kutusu kullanılabilir**.**

Bir şanzıman kullanarak aracın sürülebilirliğini iyileştirmek de mümkündür. Özellikle elektrokimyasal pillerin enerji yoğunluğu bakımından fosil yakıtlarla kıyaslanabilir olmadığı durumlarda, güç aktarım mekanizması verimliliğini artırmak için mümkün olan her yolu takip etmek gerekir[5].

Her ne kadar elektrikli araçlarda şanzıman kullanılmadığı yönünde düşünce olmasına rağmen düşünülenin aksine elektrikli araçların büyük çoğunluğunda en az bir tane aktarım sağlayan şanzıman bulunmaktadır. Elektrikli araçlardaki şanzımanın sayısı, eleman yerleşim metoduna göre değişmektedir, her tekerlek için bağımsız yerleşim yapıldığında şanzıman sayısı dörde kadar çıkabilir.

Elektrikli araçlarda şanzıman kullanımı ihtiyacına bakıldığında, ortaya çıkan durumda elektrik motorunun tork bölgelerine ve enerji kullanım verimliliğine dikkat edilmesi gerektiği görülmektedir. Elektrik motorlarının da fosil yakıtlı motorlar gibi verim bölgeleri vardır ve motorun çalışma noktası yüksek verimli bölgelerde tutulduğunda enerji tüketim verimliliği artmakta, motor boyutları küçülebilmekte ve bataryadan çekilen enerji miktarı azalmaktadır. Büyük kapasiteye sahip bataryalı araçlarda batarya, hem toplam maliyetin hem de ağırlığın maksimum seviyeyi oluşturduğundan dolayı şanzıman, maliyet artırıcı bir eleman olmasına rağmen daha küçük batarya kullanılmasını gerektiğinden hem genel araç maliyeti azalmakta hem de ortaya daha hafif bir araç yapısı çıkmaktadır. [6]

Elektrikli araçlara (EV) çok hızlı şanzımanların uygulanması, motorun çalışma verimliliğini artırmayı ve sürüş performansını iyileştirmeyi amaçlamaktadır. [7] EV'ların enerji tüketimini azaltmak için Bottiglione tarafından sonsuz değişken bir şanzıman önerilmiştir [8]. Dinamik ve ekonomik performansı artırmak için optimize edilmiş iki vitesli otomatik şanzıman, elektrikli ticari minibüse entegre edilmiştir. Bir EV'da dört vitesli DCT eklemenin etkileri bir İngiliz şirketi tarafından test edilmiştir [9],[10]. Bunlar, EV'da çok hızlı şanzıman eklemenin geliştirilmiş ekonomisini değerlendiren mevcut literatürün bir kısmını oluşturmaktadır. Hem iki hızlı DCT'nin hem de basitleştirilmiş CVT'nin genel güç aktarma organı verimliliğini artırabileceğini (%7-%15 döngülere bağlı olarak), akü enerjisinden tasarruf sağlayabileceğini (%2,6-%14,4 döngülere bağlı olarak) birkaç subjektif oranı ve EV'nin kısa bir karşılaştırmasını göstermiştir. [17], [12]

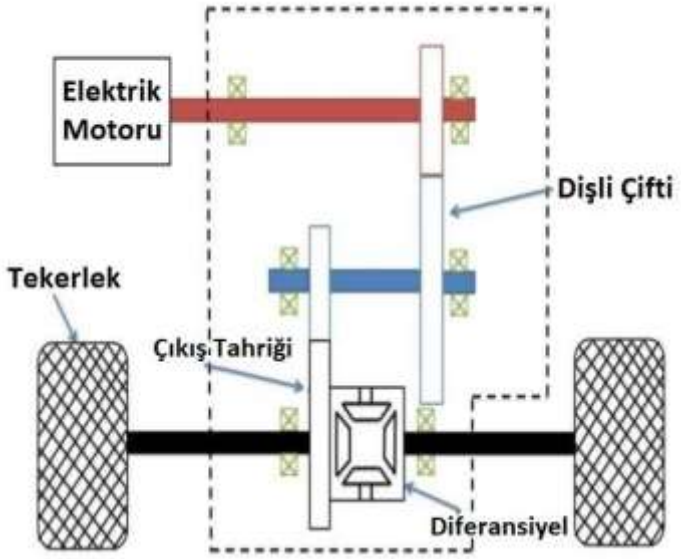
Burada her şanzıman modelinin aynı etkide ekonomik yarar sağlamasının mümkün olmadığı da unutulmamalıdır. Bu çalışmada, elektrikli araçların motor verimliliğini artırmak ve enerji tüketimini azaltmak için EV modellerinde yaygınlaşması mümkün olan şanzıman tiplerinin incelenmesi amaçlanmıştır.

2.VİTES KUTUSU ÇEŞİTLERİ

2.1. **Sabit Oranlı Tek Rediksiyonlı Şanzıman**

Yeni nesil modern elektrikli araçlar (EV'lar), elektrikli makinenin içten yanmalı motora göre geliştirilmiş yeteneklerinin bir sonucu olarak sabit oranlı şanzımanla donatılmıştır. [15] Sabit oranlı şanzımanda, aktarım oranı araca ve sürücüye alternatif sunmayan, bir veya birden fazla kademeli tek vitesli bir şanzıman türüdür. Bu şanzımanlar "Redüktör" olarak adlandırılır ve maliyet bakımından uygun fiyatlı olduğundan keyifli bir sürüş sağlamaktadır. Bu tip redüktörlerde sadece bir dişli çifti kullanılır.şanzıman ve aracın hızı sabittir.[16]

Elektrik motorlarının olağanüstü dinamik performansı ve maliyet kontrolü nedeniyle sabit oranlı tek redüksiyon (SR) şanzımanlar elektrikli araçlar (EV'ler) için gereklidir, Çoğu EV'de çok vitesli şanzıman yerine uygulanır; örn. Chevrolet Bolt, Volkswagen, e-Golf, Nissan Leaf, BYD e6 ve hatta Tesla Model S. Elektrikli olduğu için motor çok geniş bir çalışma aralığına ve daha yüksek verimli güç kaynağına sahiptir. [17]



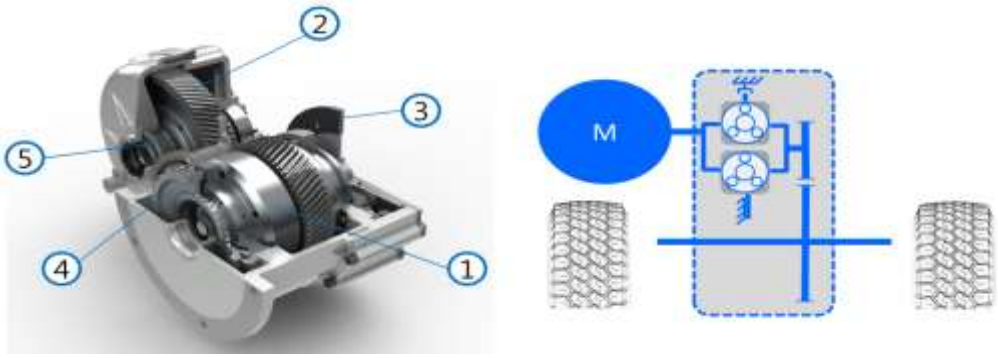
Şekil 3. Sabit Oranlı Aktarım Görseli [13], [24].

Şekil 3, bir sabit oran ve bir nihai tahrik oranı içeren tipik bir tek hızlı aktarma organını göstermektedir. Ek olarak, motor ters dönüş yeteneğine sahip olduğundan, tüm EV'lerde ters şaft ortadan kaldırılmıştır. [15].

2.2 İKİ VİTESLİ PLANET DİŞLİ ŞANZIMAN

İki vitesli şanzıman elektirikli araçta kullanılan çok hızlı iletim sistemidir. Bu şanzımanda bileşik planet dişlinin iki serbestlik derecesi sistemde iki farklı dişli oranı elde edilebilmektedir. [25] Şanzıman bileşik planet dişlilerden oluşur. Çift pinyonlu planet dişli seti, tek pinyonlu planet dişli seti ve diferansiyel dişlisinden oluşur.

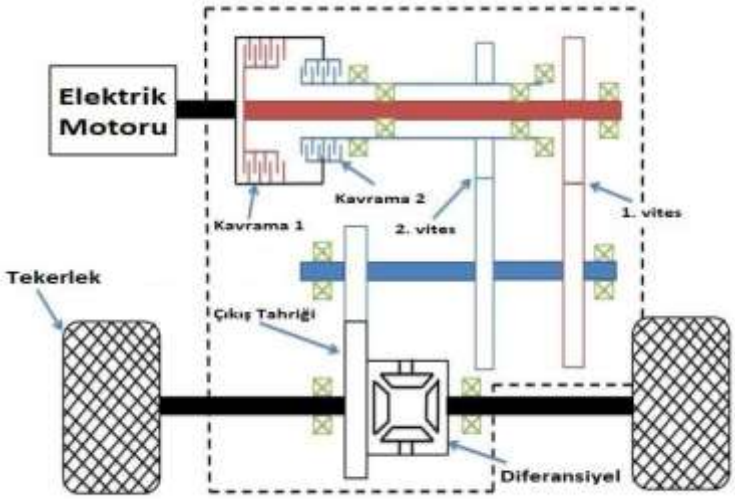
Şekil 5.’ de birinci ve ikinci planet setlerine ait görseller görülmektedir. Birinci ve ikinci planet dişli setlerinin dış boyutlarının aynı olması ve ikinci planet sisteminde aktarım oranının daha düşük olması için daha küçük taşıyıcı kullanımından dolayı ikinci planet sistemindeki halka dişli yüzeyinin daha geniş imal edildiği düşünülmektedir. Yüksek hızlı araçların çoğunluğunda yalnızca iki hızlı şanzıman kullanılır. Bunlar Porsche Tycan vb. [26] , [27]



Şekil -5: İki planet dişli şanzıman. 1 – İki entegre planet dişli setleri, 2 - Tek kademeli nihai tahrik, 3 - Kontrollü kuru sürtünme freni, 4 - Seçilebilir tırnaklı kavrama, 5 - Diferansiyel dişlisi [28].

2.3 İKİ VİTESLİ ÇİFT KAVRAMALI DCT (DUAL CLUTCH TRANSMİSSİON) ŞANZIMAN

Motor ile şanzıman arasına monte edilmiş ortak bir tambur sistemine sahip iki kavrama kullanan çift kavramalı şanzımanlar (DCT), tek kavramalı versiyonun eksikliklerini giderir. Motorun giriş miline takılan ortak bir tambur ile iki kavramanın sürtünme plakaları doğrudan birinci ve ikinci dişlilere bağımsız olarak bağlanmıştır.. Bu iki hızlı DCT aktarma organının benzersizliği, debriyajın vites değiştirmesi için kesintisiz debriyajın avantajından faydalanmaktadır ve sadece iki hız eklenmesiyle senkronizörün karmaşıklığı ve kontrolü ortadan kalkmıştır. Bu nedenle vites değişimi yalnızca çift kavramalı kontrolü ile gerçekleştirilir. Sonuç olarak, vites değiştirme kalitesi ve sürüş konforu tek rediksiyonluya kıyasla önemli ölçüde iyileştirilmiştir, böylece DCT'ler EV'larin güç aktarma organlarındaki uygulamalara çok uygun hale gelmiştir. [24]



Şekil 9. İki vitesli çift kavramalı şanzıman [13], [24].

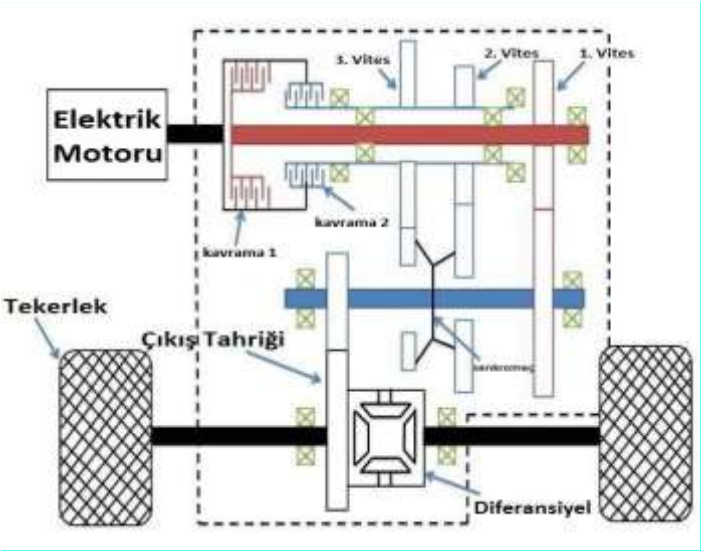
Şekil 9'da EV'lar için önden çekişli iki hızlı DCT tabanlı güç aktarma organının yapısını göstermektedir. Motor, kavramalar, transmisyon dişli takımı, diferansiyel ve tekerleklere giden çıkış milinden oluşur. DCT güç aktarım sisteminin benzersiz özelliği, kavramaların uygulanması ve dişli düzeninin düzenlenmesidir. İki vitesli şanzımanda yalnızca iki dişli çifti ve bir nihai tahrik dişlisi bulunan bu şanzıman, nispeten basit bir şanzımandır ve senkromeç mekanizmalarını kullanarak alternatif vitesleri devreye sokmaya gerek yoktur. Sadece iki vites oranı için vites değiştirme işlemi yalnızca çift kavrama kontrolüyle gerçekleştirilir. Ayrıca motorun ters dönebilme özelliği sayesinde ters mil ortadan kaldırılabilmektedir. Kısacası, iki vitesli çift kavramalı şanzımanla donatılmış EV aktarma organları nispeten basittir. [24], [30].

DCT çift kavramalı şanzıman, kavramaların kaymasının kontrol edilmesi sayesinde çekişi çok az kesintiye uğratarak torku bir kavramadan diğerine aktarma yeteneğine sahiptir. [15]. İki kavrama alternatif olarak devreye girer ve vites değiştirme sırasında tork kesintisini ortadan kaldırmak için biri diğeri ayrılmadan önce ön devreye girer [31]. İki hızlı DCT model tasarımının kalbi, iki kavramanın giriş miline bağlı ortak bir tambura sahip olmasıdır.Motor ve sürtünme plakaları bağımsız olarak sırasıyla 1. ve 2. dişliye bağlanır. [31], [32].

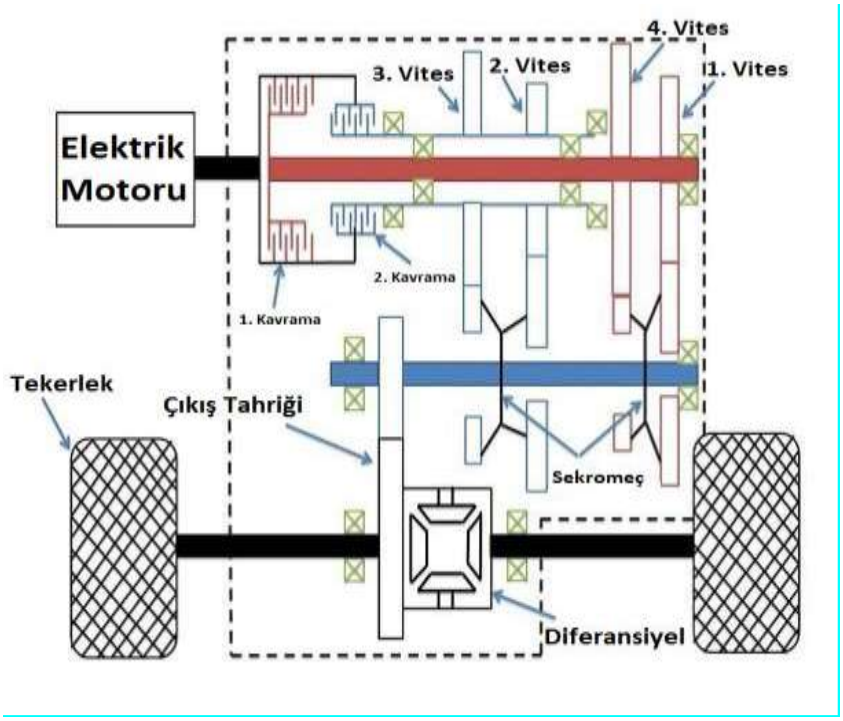
iki kavramanın kullanılması tork kesintisinin üstesinden gelerek tork aktarımını kolaylaştırır. İki vitesli şanzıman, düşük devirde daha yüksek tekerlek torku sağlar, dolayısıyla elektrik motorunun durma torku daha düşük olabilir ve bu da motorun daha küçük olmasına neden olabilir. [13]. Küresel verimlilik sürüş menzilinin artmasına yol açan artışlar, ve ayrıca hızlanma ve tırmanma kabiliyeti da artırır. Son olarak, ikinci bir vitesin varlığı hız olarak üstün bir araç olmasına olanak tanır [28], [33]. Yalnızca iki hız olduğundan, her kavrama her hıza doğrudan bağlanır, dolayısıyla bir senkronizatöre ve onun kontrolüne gerek yoktur. Ekstra dişli seti ve

kavramaların verimlilik ve toplam kütle üzerinde olumsuz etkisi vardır [15]. DCT şanzımanda ikinci aktarım oranı birinci aktarım oranının verimliliğinin azalmaya başladığı noktada devreye girmesi yüksek verimlilik bandında kalma süresini uzatmaktadır. Şekil 10'da bu durum görsel olarak da ifade edilmektedir.

Aşağıdaki Şekil 11'deki üç vitesli kavramalı şanzıman gösterilmektedir. Bu şanzımanın daha uygun aktarım oranları sayesinde ortalama motor çalışma verimliliğini biraz daha yükseltir ancak iletimdeki artan enerji kaybı nedeniyle iki vitesli sistem kadar verimli değildir [34].



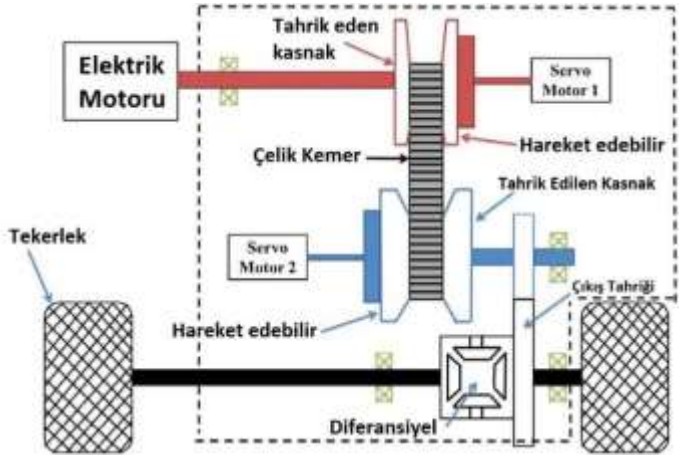
Aşağıdaki Şekil 12'de Dört vitesli çift kavramalı şanzıman gösterilmektedir. Bu şanzımanda vites sayısı dörde çıktığından, en uygun oranın belirlenebilmesi için daha fazla aktarım oranı kullanılarak motor çalışma devir aralığı daraltılabilmektedir, fakat motor verimliliğinin artırılmasıyla elde edilen enerji tasarrufu, iletimdeki kayıpla tamamıyla kaybedilmektedir. Maliyet yönünden üç ve dört vitesli şanzımanlar ile donatılmış araçlar, ilave bileşenlerin maliyeti nedeniyle iki vitesliden doğal olarak daha pahalıdır ve buna ek olarak, üç vitesli çift kavramalı şanzımanın üretim ve kontrol gereksinimi iki vitesli çift kavramalı şanzımandan çok daha fazladır [34].



Şekil 12. Dört vitesli çift kavramalı şanzıman [13], [24].

2.4. SÜREKLİ DEĞİŞKEN ŞANZIMAN (CVT)

Bir CVT (Sürekli değişken şanzıman), Şekil (14)'de gösterildiği gibi dişli oranının minimumdan maksimuma kadar sürekli olarak değişmesini sağlamak için konik diskler ve bir kayış veya zincir kullanır. Genellikle bir CVT, iki değişken çaplı kasnağı birbirine bağlayan çelik bir kayışa sahiptir; aktarım oranı Kasnak çapındaki ayarlamayla birlikte değişir ve mümkün olan en iyi hızın elde edilmesini sağlar tüm araç sürüş menzili daha yüksek motor verimliliği sağlar [17].



Şekil 14. Sürekli değişken şanzıman şematik gösterimi [13], [24].

CVT’nin V-kayışı tipinde dişliler yerine giriş ve çıkış millerinde sürtünme konisi yüzeyleri kullanır. Ayrıca örneğin toroidal varyatörler, hidrostatik varyatörler veya zincir varyatörler de vardır.

Elektrikli araçlara yönelik CVT'ler, İYM'lere yönelik geleneksel CVT'lerden önemli ölçüde farklı değildir. Temel fark, çok fazla torka sahip olmayan ancak yüksek hızlara ulaşan daha küçük motorların kullanılmasına izin vermek için önemli ölçüde daha yüksek hızlar için üretilmesi gerektiğidir. Bir başka seçenek de vites öncesi redüksiyon dişlisi kullanmaktır. Bu durumda İYM ile aynı varyatör kullanılabilir, ancak kavramada hem varyatörde hem de dişlide iki kat verimlilik kaybı olur.

Maksimum güç ve hız açısından CVT, şanzımansız veya iki vitesli şanzımanlı elektrikli araçlara kıyasla yüksek değerlere ulaşılmasını sağlar. Bir diğer avantajı da, kontrolör neredeyse her vites oranını (ekipmanın tasarımıyla belirlenen belirli bir aralık dahilinde) elde edebildiğinden, motoru her zaman en yüksek verimlilik bandında kullanma yeteneğidir.

Ancak, verimlilik açısından şanzımanın kendisinin olumsuz yönleri vardır. Temelde sürtünmeli bir güç aktarımı olduğundan, kayma meydana gelebilir ve bu da güç kaybına, aşırı ısınmaya ve hasara neden olabilir. Aynı zamanda CVT'lerin üretimi nispeten karmaşık ve pahalıdır.

Bu tür bir şanzımana örnek olarak Bosch'un CVT4EV'si verilebilir, Bosch, şanzımanın otomobillerin arazide hızlı sürüşüne ve hatta bir arabayı veya diğer otomobilleri çekme kabiliyetine izin vereceğini belirtmektedir. [13]

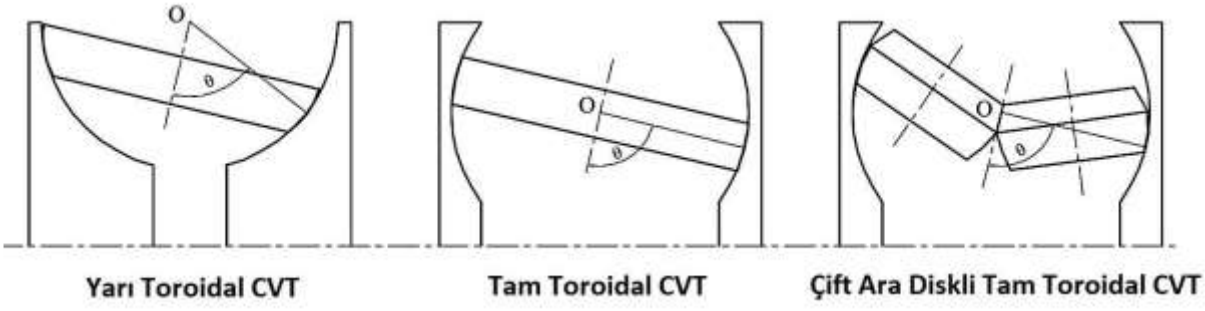
Sabit oranlı tipik bir dişli kutusuyla karşılaştırıldığında CVT, motorun çok daha uzun bir süre boyunca en yüksek verimlilik noktalarında çalışmasını sağlayabilir. Dişli oranını ayarlamak için birlikte veya ayrı hareket eden konik diskler ile kayış veya zincir arasındaki sürtünme nedeniyle CVT' lerde önemli güç kaybı vardır [24].

Konik diskleri yerinde tutmak için onlara baskı uygulamak için de güç gerekir ve zincir veya kayış, içten yanmalı motorlu bir araç için bir duraktan başlamak gibi bazı durumlarda kayarak daha fazla kayba neden olabilir. Düzgün çalışma, tork kesintisinin olmaması ve çekiş makinesini geniş bir hız aralığında çalıştırabilme yeteneği, birçok araştırmacının EV uygulamaları için CVT'leri araştırması için yeterli motivasyon olmuştur [12], [24] [40], [41], [42].

CVT' nin en büyük dezavantajı, geleneksel dişli şanzımana kıyasla düşük verimliliktir. İYM'li araçlarda kullanılan geleneksel CVT' nin verimliliği %85'tir ancak EV’ ler ile daha basit bir yapı elde edilebilir, yani tork konvertörüne ihtiyaç duyulmaz, dolayısıyla %90'lık bir verimlilik elde edilebilir. [24].

CVT' nin uygulanmasıyla elektrik motoru performansında ve enerji verimliliğinde elde edilen iyileşme, şanzımanın zayıf verimliliği nedeniyle dengelenebilir CVT araçlarda çekiş motoru, içten yanmalı motor veya elektrik motoru ideal çalışma noktasında çalışabilmektedir. Seri üretim araçlarında kullanılan CVT teknolojisi neredeyse her durumda ana bileşenin değiştirici olduğu kasnak aktarımıdır. Başka bir CVT konfigürasyonu toroidal değiştiricidir. Değişken dişli oranına sürtünme dişlilerinin döndürülmesiyle ulaşılır.

Toroidal CVT' de gücün aktarılması ara disklerin giriş ve çıkış diskleri ile temas yarıçaplarını değiştirerek çevrim oranının arttırılması ya da azaltılması ilkesine dayanır. Şekil 15' de gösterildiği gibi tam, yarım ve çift ara diskli olmak üzere 3 tipi bulunmaktadır. İsimlendirmede giriş ve çıkış disklerinin birleştirildiğinde bir tam daire oluşuyorsa tam toroidal, yarım daire oluşuyorsa yarı toroidal ismi verilmektedir [43].



Şekil 15. Toroidal CVT türleri [43].

CVT' lerin genel karakteristik özellikleri söz konusu olduğunda, hareketin temas ve sürtünme ile iç içe olmasından dolayı CVT' nin verimliliği diğer şanzımanların gerisinde kalmaktadır. Verimliliği azaltan genel kayıplara hidrolik pompa güç kaybı, varyatör tork kaybı, tork konvertörü güç kaybı örnek olarak gösterilebilir. CVT' lerin ilk versiyonlarında giriş gücünde %30' dan fazla kayıp olmasına rağmen elektrikli varyatör kontrolü ve optimize edilmiş kayış basınç kontrol stratejileri sayesinde verim %70' in altından % 83 – 89 civarına yükseltilmiştir [5],[17]. Verim konusu şanzımanın içyapısındaki duruma göre değişirken kullanıldığı kombinasyona göre de değişkenlik göstermektedir. CVT' ler tork konvertörü kullanılmaksızın içten yanmalı motorlarla kullanıldıklarında % 85, elektrik motorlarıyla kullanıldıklarında % 90 verim elde edilebilmektedir [17],[44].

Temas ve sürtünmenin hüküm sürdüğü diğer bir durum ise kasnaklardaki esneklik ve boşluk durumudur. Bu durum, tahrik oranını, tork kapasitesini ve kayma davranışını ciddi oranda etkilemektedir [45],[46]. Boşluğun alınması için tahrik edilen tarafa ön gerilim yayı eklenmektedir. Ön gerilimi artırmak, vites değişiminin daha yüksek hızda yapılmasını sağlarken, ön gerilimi azaltmak daha düşük bir hızda vites değiştirilmesine izin

vermektedir. Yetersiz ön yükleme yapıldığında kayma oluşmasına, aşırı ön yükleme ise kayışta aşınmaya sebebiyet vermektedir. [47].

Ön yüklemenin uygun bir değere ayarlanmasının ardından aktarım oranı aralığının seçimi konusu gelmektedir. CVT için mümkün olduğunca geniş aktarım oranı aralığı istenir fakat bu durum maliyet artışına sebep olur. Bu yüzden aktarım oranı aralığı hesaplanırken performans ve maliyet dengelenmelidir. [6].

CVT' yi diğer şanzıman modelleri ile kıyasladığımızda karşımıza her teknolojinin karakteristik olarak avantaj ve dezavantaja sahip olduğu çıkmaktadır. Söz konusu kıyaslama manuel şanzıman ile yapıldığında CVT' nin sınırsız dişli oranı sağladığı fakat manuel şanzımana göre düşük verimliliğe sahip olduğu fark edilmektedir. Diğer yandan manuel şanzıman, sınırlı dişli oranı sağlayıp ve kavrama kayıplarına sahipken CVT' ye göre daha verimlidir [40]. Aynı karşılaştırma 2 vitesli DCT ile CVT arasında yapıldığında ise 2 vitesli DCT' ye sahip araçların daha çok maddi ekonomi sağladığı, tork konvertörsüz CVT' ye sahip araçların ise daha iyi sürüş deneyimi sunduğu görülmektedir [6], [17].

CVT kullanımının motorda gereken tepe tokunu azalttığını ve böylece elektrik motorunun boyutlarının küçültülebilmesinin mümkün olduğu belirtilmektedir. Boyut küçültülmesi motorun, motor sürücüsünün ve diğer güç elemanlarının ağırlıksal olarak hafiflemesi anlamına da gelmektedir. Bu şekilde diğer sistemlere göre daha düşük enerji tüketimi sağlanmış olmaktadır. Yüksek performans elde edilebilmesi için sistem tasarımı yapılan bir çalışmada [17], güçlü motor ile kombine edilmiş bir CVT' nin tek vitesli sisteme kıyasla daha verimli olduğu ortaya çıkmıştır. Diğer yandan performanstan feragat ederek tüketim açısından ekonomik bir motor ile basitleştirilmiş CVT kombinesinin ekonomik tasarruf sağladığı belirtilmektedir.

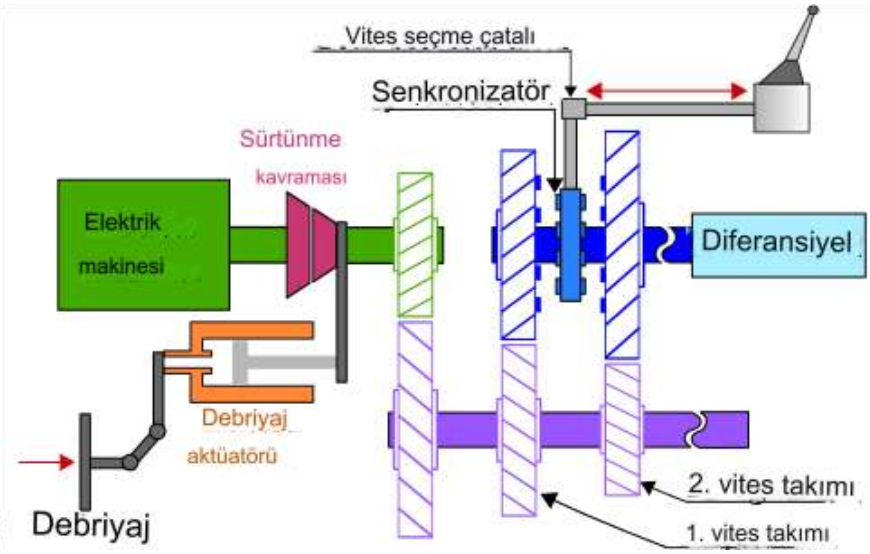
Elektrikli araç modelinin motor etkinliğini artırmak ve enerji tüketimini azaltmak için yapılan bir çalışmada [17], iki vitesli çift kavramalı ve tork konvertörsüz CVT kullanılmıştır. Çalışma sonuçlarında tork konvertörsüz CVT' nin ECE, LA-92 ve HWFET sürüş çevrimlerinde konvertörlü haline kıyasla daha verimli bir çalışma gerçekleştirdiği görülmüştür. Ayrıca 2 vitesli DCT ve CVT 'nin tek vitesli şanzımana göre daha iyi ekonomik ve dinamik performansa, daha kısa ivmelenme süresine, daha yüksek son sürate sahip oldukları ortaya koyulmuştur.

Başka bir çalışmada ise göreceli olarak pahalı olmayan bir indüksiyon motoru ile bir CVT eşleştirmesi yapılarak batarya elektrikli aracın genel verimliliğini artırmak amaçlanmıştır. Çalışmada karşılaştırma yapılacak iki araçlardan bir tanesi kompakt araç olması için BMW Mini E, diğeri ise spor bir araç olması için Tesla Roadster olarak tasarlanmıştır. Çalışma sonuçlarında CVT, araçların sabit aktarımlı tek vitesli hallerine göre kıyaslandığında kompakt araçta % 1,3, spor araçta % 9,15 ' lik verim iyileşmesi sağlamıştır[48].

Hibrit enerji depolama sistemi ve CVT kullanılan bir diğer çalışmada [6], Volkswagen e-golf araç modeli baz alınarak CVT nin ek enerji tüketimine rağmen genel enerji tüketiminin FTP-75 e göre % 4,8, HWFET e göre % 10,9 oranlarında azaltıldığı görülmüştür. Aynı zamanda hibrit enerji depolama sistemi ile günlük 50 km sürüş değeri dikkate alındığında yıllık batarya kapasite kaybının CVT kullanımında tek vites kullanımına göre % 14,5 daha iyi bir olduğu ortaya koyulmuştur.

2.5. MANUEL ŞANZIMAN (MT)

Klasik dişli kutusu, Şekil 16'da gösterildiği gibidir. Sürücü tarafından Motorun bağlantısını kesen ana debriyajın devreye girmesiyle, Sürücü vitesleri bir kolla manüel olarak değiştirir ve dişli kutusundan sürücü vitese geçtiğinde vites kolu, senkronizatör mekanik olarak vitesi hizalar. Dönen diferansiyel ile dişlilerin hızı tekerleklere aktarılmaktadır [49]. İYM ile çalışan bazı araçlar EV' lara dönüştürülen sistemlerde basitlik açısından stok MT kullanılır [51]. MT' lar güvenilir, düşük maliyetli ve az bakım gerektirirken, EV' lerin üretiminde nadiren kullanılırlar, çünkü sürüş kalitesi, sistem verimliliği ve debriyaj ömrü güçlü bir şekilde sürücünün vites kutusunu nasıl kullandığından etkilenmektedir [50].

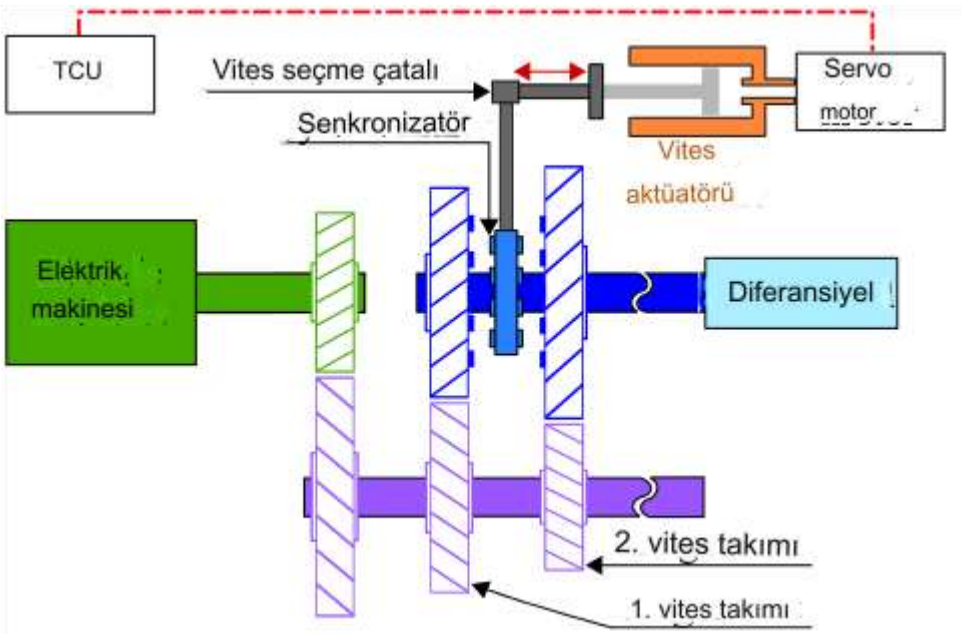


Şekil 16. Manuel şanzıman (MT)

2.6. OTOMATİK MANUEL ŞANZIMAN (AMT)

Şekil 17'de gösterildiği gibi AMT, elektrohidrolik veya elektromekanik aktüatörlerin senkronizörlere geçtiği ve vites değiştirdiği MT' nin bir çeşididir [49]. İYM' li araçlar için AMT bir debriyaj içerecektir ancak motor hızı ve torku hassas bir şekilde kontrol edilebildiğinden EV' ler için bu gerekli değildir. Vites değiştirme, Şekil 17'de gösterildiği gibi bir şanzıman kontrol ünitesi (TCU) tarafından otomatik olarak kontrol edilir. Motor torku sıfıra ayarlanır, senkronizör devreden çıkarılır, motor hızı yeni vitese göre ayarlanır ve

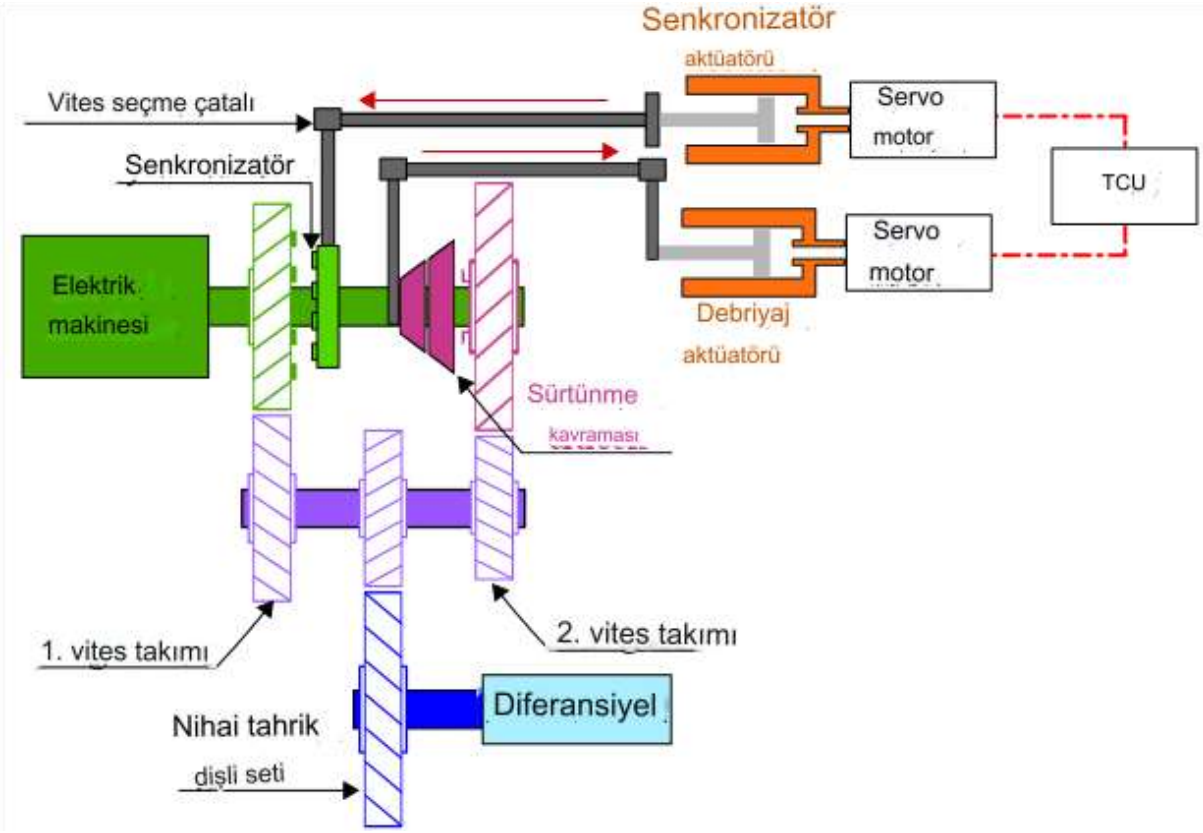
senkronizör yeniden devreye alınır. Bu işlem sırasında tork kesintiye uğrar ve viteslerin tamamen yumuşak bir şekilde değişmesi önlenir. Bir girdap akımı tork bypass kavraması uygulanarak, yumuşak vites değiştirme elde edilebilir, bu da AMT' yi elektrikli çekiş sistemleri için daha uygun hale getirir. Her ne kadar AMT içten yanmalı motorla çalışan araçlarda hiçbir zaman geniş bir kullanım alanı bulamamış olsa da [39], düşük üretim ve bakım maliyeti, basitliği, uygulama kolaylığı ve verimliliği nedeniyle EV uygulamaları için umut verici bir adaydır.



Şekil 17. debriyajsız otomatikleştirilmiş şanzıman (AMT)

2.7. TERS OTOMATİKLEŞTİRİLMİŞ MANUEL ŞANZIMAN (I-AMT)

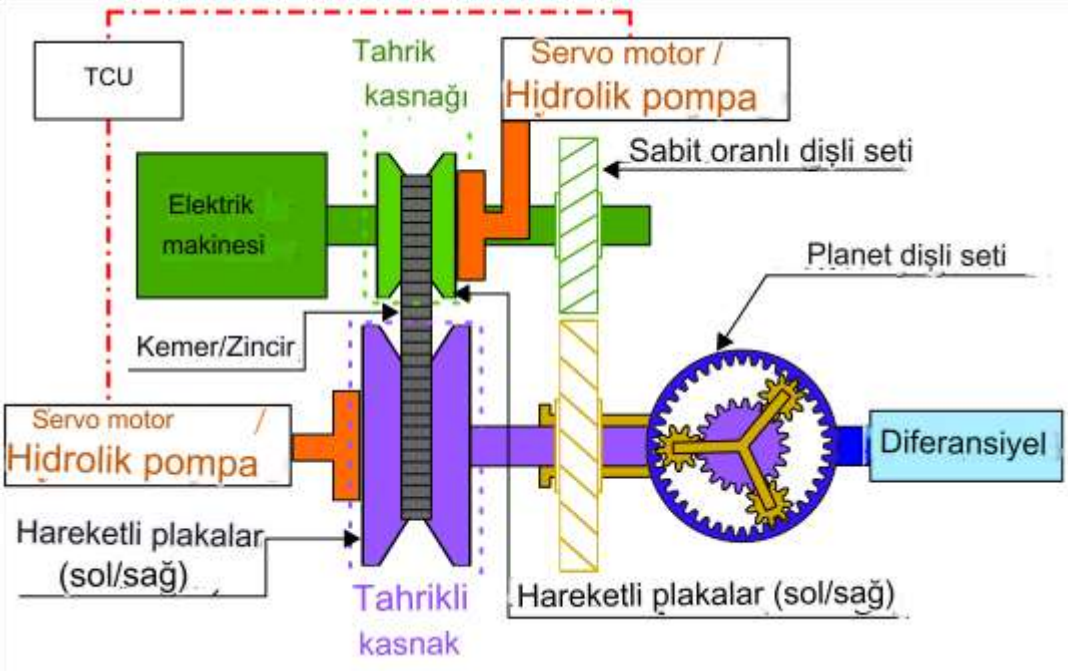
Bir I-AMT, Şekil 18'de gösterildiği gibi bir senkronizatör yerine ikinci vitesi bağlamak için bir kavrama içermesi dışında AMT' ye çok benzemektedir. Birinci vites senkromeç tarafından devreye alınır veya devre dışı bırakılır ve güç, debriyaj kullanılarak harmanlanır. EV' ler için önerildiği gibi, bu yeni düzen, geleneksel AMT' ye kıyasla vites değiştirme sırasında tork kesintisini yaklaşık %50 azaltır. Geliştirilmiş kontrollerle torku tamamen telafi etmek ve kesintisiz vites değiştirmeyi gerçekleştirmek mümkün olabilir [52].



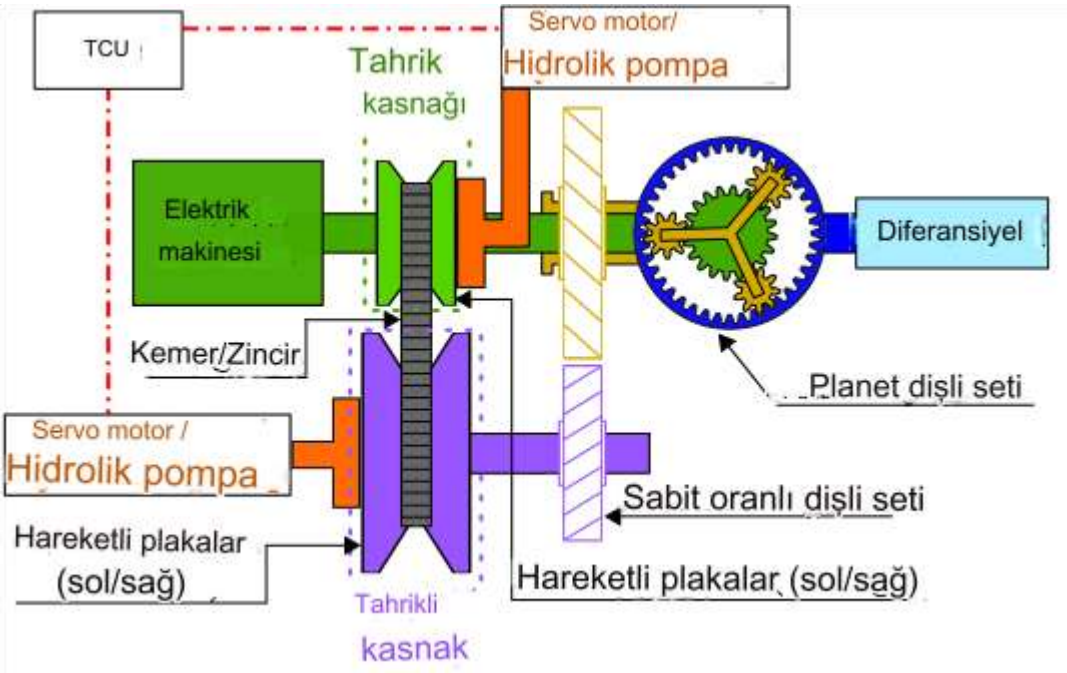
Şekil 18. İki vitesli ters otomatikleştirilmiş manuel şanzıman (I-AMT)

2.8. SONSUZ DEĞİŞKEN ŞANZIMAN (IVT)

Bir CVT' nin en düşük dişli oranı, sabit bir oran ve bir planet dişli takımı eklenerek sıfıra veya hatta negatife düşürülebilir, giriş hızlarının çıkış hızlarına oranının sonsuz olabildiği bir şanzımandır [53]. Planet dişli takımı, seri konfigürasyon için doğrudan motor miline (Şekil 19) veya paralel konfigürasyon için sabit oranlı dişli takımının çıkışına (Şekil 20) bağlanabilir. IVT ile elde edilebilen dişli oranları aralığı, dişli kutusu kinematik denklemlerinde açıklandığı gibi CVT, sabit ve planet dişli oranlarının bir fonksiyonudur [53]. IVT' nin ana çekiciliği, düşük oranın sıfır olabilmesidir, bu da bir IYM' un CVT için gerekli olduğu gibi debriyaj olmadan rölantide çalışmasına izin verir [54]. Elektrikli makineler sıfır hızda tam tork üretebildiğinden, EV uygulamaları için IVT' nin CVT' ye göre önemli bir faydası yoktur.



Şekil 19. Seri sonsuz değişken şanzıman (IVT)



Şekil 20. Paralel sonsuz değişken şanzıman (IVT)

BULGU VE TARTIŞMA

Çok vitesli dişli kutuları akademik literatürde kapsamlı bir şekilde araştırılmış ve Tablo V'te ticari olarak üretilen çok vitesli şanzımanlar gösterilmiştir. Üreticiler ve araştırmacılar genellikle çok vitesli dişli kutularının aktarma organlarının enerji tüketimini azaltacağını ve performansı artıracağını iddia etmektedir. Debriyajsız AMT'ler ve DCT'ler en umut verici ve yaygın olarak kullanılan teknolojilerdir, ancak EV'ler için CVT'ler de geliştirilme aşamasındadır. I-AMT'ler, IVT'ler ve MGT'ler, araştırma literatüründe araştırılmış olmalarına rağmen, muhtemelen artan karmaşıklıkları ve potansiyel olarak daha düşük verimlilikleri nedeniyle henüz herhangi bir endüstriyel uygulamada yer bulamamışlardır. Çeşitli ticari çok vitesli şanzımanların araştırma aşamasındaki enerji verimliliği ve çekiş sistemleri için iddia edilen faydaları bu bölümde özetlenmiştir.

Ticari olarak geliştirilen çok vitesli şanzıman tiplerine İlişkin Sonuçlar

Aşağıdaki Tablo V'te özetlendiği gibi birçok farklı Ekipman ve otomobil üreticisi çok vitesli dişli kutuları geliştirmiştir. Altı hıza kadar dişli kutuları geliştirilmiş ve hatta Bosch yakın zamanda EV'ler için bir CVT ürünü duyurmuştur. Tabloda listelenen vites kutularının yaklaşık yarısı binek araçlara yöneliktir. Gkn / Bmw I8, Schaeffler Ag/ Audi E-Tron ve Porsche Taycan Bu araçlar halihazırda üretimde olan vites kutularıdır, performans odaklı elektrikli araçların hızlanmasını ve en yüksek hızını iyileştirmek için kullanılıyor. Formula E yarış serisi araçlarda ayrıca serinin 2014 yılındaki başlangıcından bu yana hızlanmayı, azami hızı ve verimliliği artırmak için 2 ile 5 vites arasında vites kutuları kullanılmıştır. Listelenen diğer binek araç vites kutuları verimliliği artırmayı amaçlamaktadır ve %5 ila 18 arasında verimlilik artışı hedeflenmektedir.

ÜRETİCİ /KULLANICI FİRMA	ŞANZIMAN TİPİ	ARAÇ SEGMENTİ	ŞANZIMAN FAYDALARI	REFERANS
GKN/BMW İ8	2 VİTESLİ	BİNEK SPOR ARAÇ	Geliştirilmiş Hızlanma Ve Azami Hız	Https://Www.Gknautomotive.Com/ Gkn Develops Two-Speed Eaxle; İn Production On Bmw İ8 - Green Car Congress," *Green Car Congress*, Https://Www.Greencarcongress.Com Https://Www.Gknautomotive.Com/En/Systems-And-Solutions/Electric/Modular-Electric-Drive-Systems/
PORCHE TAYCAN	2 VİTESLİ DCT	MAKAM VE SPOR ARAÇ	Geliştirilmiş Hızlanma Ve Azami Hız	D. Tracy, "An Extremely Detailed Look At The Porsche Taycan's Engineering Designed To Take On Tesla," Jalopnik, Jun.

				Https://Jalopnik.Com/An-Extremely-Detailed-Look-At-The-Porsche-Taycans-Engin-1837802533 Https://Www.Porsche.Com/İnternational/Models/Taycan/Taycan-Models/Taycan-Turbo/#Technical-Data-Y1afl1-2025
BOSCH	CVT4EV	ORTA-BÜYÜK TİCARİ VE SPOR ARABA	Geliştirilmiş Dinamik Performans Ve Enerji Verimliliği %4 Verimlilik Kazancı	Bosch İntroducing Cvt For Electric Vehicles: Cvt4ev," *Green Car Congress*. Https://Www.Greencarcongress.Com Https://Www.Bosch-Mobility.Com/En/Solutions/Transmission-Technology/Transmission-Cvt4ev/
HEWLAND/ FORMULA E (FIA)	2 İLE 5 VİTES	YARIŞ ARACI	Geliştirilmiş Dinamik Performas Enerji Verimliliği %15-%40 Verimlilik Kazancı	Motorsport.Com, "The Technology Gains That Have Transformed Formula E," *Insideevs*. Https://İnsideevs.Com/News/342347/The-Technology-Gains-That-Have-Transformed-Formula-E/ Https://Www.Fiaformulae.Com/En/News/487147/Formula-Es-Cutting-Edge-Electric-Race-Car-Gen3-Explained Https://Powertrain.Hewland.Com/Case-Study/Singer-Performance-Automotive-İce/
MERCEDES BENZ	2 VİTES OTOMATİK	HAFİFİ İLE ORTA HİZMET TİCARİ KAMYON	Geliştirilmiş Dinamik Performans Ve Enerji Verimliliği	Https://Www.Mercedes Benz.Com.Tr/Passengercars/Models/Electric.Html?Subgroup=See-All&Filters=Electrıc&Group=All&View=Bodytype Https://Www.Mercedes-Benz-Trucks.Com/Tr_Tr/Emobility/World/Emobility.Html
TAHRİK SİSTEMİ TASARIMI / MSYS	3 VİTESLİ	BİNEK ARAÇ	Enerji Verimliliği %10-%15	Https://Greenmotion.Co.Uk/News/Drive-System-Design-Develops-New-Electric-Car-Powertrain New 3-Speed Ev Powertrain To Offer 10-15% İmprovement İn Ev Range - Green Car Congress," *Green Car Congress*, https://www.greencarcongress.com/2014/02/20140219-dsd.html
EATON	2, 4, 6 VİTESLİ AMT	TİCARİ KAMYON OTOBÜS	Geliştirilmiş Hızlanma, Azami Hız, Tırmanma Kabiliyeti Ve Enerji Verimliliği	Eaton 2-, 4-, 6-Speed AMT Commercial Vehicles Improved Acceleration, Top Speed, Gradeability, And Energy Efficiency

ZF	2 VİTESLİ	BİNEK ARAÇ	Enerji Verimliliği *%5*	Https://Jalopnik.Com/Heres-Zfs-New-Two-Speed-Transmission-For-Electric-Cars-1836428183
BORGWARNER / EGEARDRİVE	3 VİTESLİ DCT	ORTA HİZMET TİCARİ FİLO KAMYONU/ MİNİBÜSÜ	Geliştirilmiş Dinamik Performans Ve Enerji Verimliliği	Https://Www.Borgwarner.Com/Technologies/Ev-Transmissions
AUDİ E-TRON / SCHAEFFLER	2 VİTESLİ DCT	MAKAM VE SPOR ARAÇ	Geliştirilmiş Hızlanma Ve Azami Hız	https://www.schaeffler.com.tr/tr/products-and-solutions/otomotiv/%C5%9Fanz%C4%B1man_sistemleri/ https://www.audiusa.com/us/web/en/ev-hub/e-tron-technology.html

Aralarında Mercedes-Benz, Eaton, BorgWarner'de bulunduğu üreticiler, kamyonetler, kamyonlar ve otobüsler gibi orta ve ağır hizmet tipi elektrikli araçlar için vites kutuları geliştirmiştir. Bu çok ağır araçlar için çok vitesli dişli kutuları, hızlanmak için gereken yüksek torku sağlayabilir ve aynı zamanda %15'e kadar verimlilik artışı da sağlayabilir. AISIN ve Denso, Hewland Engineering Ltd, OC Oerlikon Corp. AG, Ricardo Plc, Schaeffler AG ve Xtrac Ltd.'nin ortak girişimi olan Blue Nexus da dahil olmak üzere diğer üreticiler de elektrikli araçlar için çok vitesli dişli kutuları araştırma ve geliştirmeleri devam etmektedir.

SONUÇ

Bu çalışma içerisinde elektrikli araçların güç aktarma organındaki enerji verimliliğinin ne derece gerekli olduğu ve elektrikli araçlarda kullanılan şanzıman tiplerinin çalışma prensipleri anlatılıp, enerji tüketimleri kapsamlı bir şekilde literatür değerlendirmesi ile kıyaslanmaya çalışılmıştır.

Elektrikli araçlar, enerji kaynağı olarak bataryalarda depolanan elektrik enerjisini kullanır ve motor tahrik sistemleri, bataryanın çıkış gücünü tekerlekler için dönme enerjisine dönüştürerek elektrikli aracın çalışmasını sağlar. Bu nedenle otomotiv endüstrisi yoğun bir şekilde batarya teknolojisini güvence altına almaya odaklanmakta ve bu da elektrikli araç şanzımanlarının araştırma ve geliştirme hızını yavaşlatmaktadır.

Elektrikli araçlarda batarya kapasitesinin artırılmasıyla menzil artışı sağlanabiliyor ancak boyut, ağırlık ve maliyet bunun sınırlarını belirlemektedir. Elektrikli araç performansını artırmanın bir başka yolu da aracın enerji verimliliğini artırmak olacaktır. Elektrikli araçların temel bileşeni çekiş motorudur ve onun mümkün olan en iyi verimlilikte çalışmasına izin vermek, elektrikli araçların enerji verimliliğini artırmanın bir yolu olacaktır. Bir aracın genel çalışma verimliliği, aktarma organlarının verimliliğine ve alt bileşenlerine

bağlıdır. Ancak bu verimlilikler aynı zamanda aracın sürüş çevrimlerini gerçekleştirirken aracın normal çalışması sırasında güç aktarım sisteminin çalıştırıldığı durumlara da bağlıdır.

İçten yanmalı motorlar birden fazla vitese sahiptir ve doğru hızda doğru miktarda güç sağlamak için çok hızlı şanzımanlar gerektirir; çünkü maksimum tork yalnızca motor belirli bir devir sayısına ulaştığında motorun durması önlenir. Buna karşılık elektrikli araçlar, elektrik motorlarının özellikleri nedeniyle çalışma anında maksimum tork uygulayabilir ve içten yanmalı motorlara kıyasla 2-3 kat daha yüksek dönüş aralığında çalışabilirler. Elektrikli araçların, eşdeğer içten yanmalı motorlu araçlara göre daha hızlı hızlanma sağlayabilmesinin nedeni, tahrik motoruna elektrik enerjisi sağlandığı anda maksimum tork üretmesi ve vites değiştirme süresine gerek olmamasıdır. Günümüzdeki elektrikli araçlarda kullanılan şanzımanlar arasında tek vitesli şanzımanlar, çok vitesli dişli şanzımanlar, Sürekli Değişken Şanzımanlar (CVT), ve planet dişli şanzımanlar bulunur.

İncelenen şanzıman türlerine bakıldığında hemen hemen tüm şanzıman tipleri günümüzdeki elektrikli araçlarının büyük çoğunluğunda bulunan tek vitesli şanzımana göre daha uzun menzil, daha ekonomik enerji tüketimi ve daha dinamik performans sağlamaktadır. Buna karşın şu anki piyasa koşullarında isimleri duyulmaya başlanan araç modellerine bakıldığında ise üretici firmaların aldığı kararın üretim kolaylığı ve maliyetten yana olduğu görülmektedir.

Bununla birlikte, birçok elektrikli araç, içten yanmalı motorlu araçlara kıyasla genellikle daha düşük bir azami hıza ve yüksek hızlarda daha düşük verimliliğe sahip sabit dişli oranlı tek vitesli şanzımanlar kullanır; bu, şehir içi sürüşe kıyasla avantaj, yüksek hızlı sürüş için bir dezavantajdır. Bu nedenle elektrikli araçların verimliliğinin artırılması için elektrikli araçlara yönelik şanzımanların gerekli olduğu savunulmaktadır. İçten yanmalı motorlu araçlarda olduğu gibi, yüksek hızlı sürüş sırasında verimliliği artırmak için elektrik motorunun dönüş hızını azaltmak gerekir. Ancak şanzımanla donatılmış seri üretimde olan elektrikli araç modellerini bulmak günümüzde zor ve kurulumu planlı modeller yaygın değildir. Ayrıca elektrikli araçlar için aktif olarak şanzıman geliştiren üretici firmalarıda bulmak kolay değildir.

Üreticilerden birkaçı çok vitesli şanzıman ürününü duyurmuş olsa da, şu anda birden fazla dişli oranına sahip bazı firmalar araç üretmektedir; BMW i8, Audi E-Tron ve Porsche Taycan. Bu firmaların asıl amacı enerji verimlilikten ziyade hızlanmayı iyileştirmek amacıyla çok vitesli şanzıman kullanmaktadır. Mevcut araştırmaların büyük bir kısmı çok vitesli şanzıman sistemlerin nasıl tasarlanacağı, modelleneceği ve kontrol edileceği konusunda fikir verirken, çok vitesli şanzıman sistemleri ile tek hızlı şanzıman sistemlerini karşılaştıran daha fazla çalışmaya ihtiyaç vardır. Ayrıca elektrik makinesi, invertör ve dişli kutusu tasarımlarını birlikte optimize eden çalışmalar çok daha iyi bir sonuç sağlayacaktır.

Gelecekte çok vitesli şanzımanlar, batarya paketinden mümkün olduğunca fazla menzil elde etmeyi amaçlayan ve daha yüksek hacimli, daha düşük maliyetli elektrikli araçlarda da yer bulabilir. Çok vitesli dişli kutuları, bataryalı elektrikli araçların verimliliğini ve performansını artırmak için önemli bir potansiyele sahiptir. Birden fazla vitese sahip olmak, elektrikli çekiş makinesinin ve invertörün daha verimli bir bölgede çalışmasını sağlar. Akademisyen ve üreticilerin yaptığı araştırmalara göre, aktarma organlarının verimliliğinde yüzde birkaç ile yüzde on beş veya daha fazla iyileştirme olduğunu belirtmiştir.

İnceleme sonucunda en son literatür çoğunlukla motorun verimliliğini ve sürüş koşullarını (çok hızlı ayrık şanzıman ve CVT için) dikkate alarak dişli oranlarının optimize edilmesine, çeşitli sürüş çevrimleri için vites değiştirme stratejisinin optimize edilmesine (çok hızlı ayrık şanzıman, CVT ve çok motorlu konfigürasyon için) odaklanmaktadır.

Literatürde var olan şanzıman çalışmaları hem günümüz hem de gelecekteki batarya elektrikli araçlarda hem ekonomik hem de dinamik performans açısından umut vadetmektedir.

Gelecek çalışmalarda elektrikli araçların güç aktarım sisteminde şanzıman kullanımıyla alakalı olarak, enerji tüketiminin değerlendirmesi, maliyet hesabı yapılması ve yukarıda bahsedilen diğer hususların üzerinde durulması gerekmektedir. Bu sayede geliştirilecek şanzıman tipleri elektrikli araçların enerji tüketimlerini çok daha ekonomik bir seviyeye getirecektir.

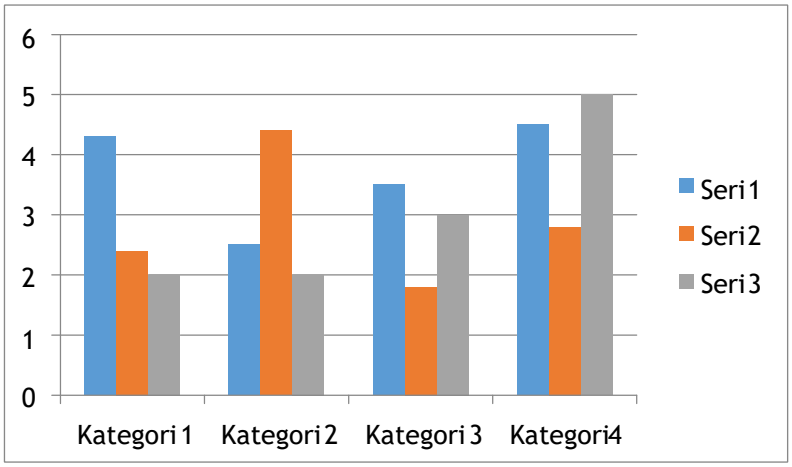


Figure 1. Title of the Figure

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Küresel Uluslararası Ticaret Eğilimleri Bağlamında Türkiye'nin Dış Ticareti

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Özet – Teknik ilerlemeler, düzenleyici değişimler ve ekonomik entegrasyon sonucunda küresel ticaret ortamı büyük ölçüde değişmiştir. Bu çalışma, Türkiye'nin dış ticaret politikasının birçok bileşenini ve bunların ülkenin ekonomik büyüme ve kalkınması üzerindeki etkilerini incelemektedir. Araştırma, Dünya Bankası ve Dünya Ticaret Örgütü gibi uluslararası veritabanlarından elde edilen ticaret istatistiklerinin nicel veri analizi ile politika analizleri ve uzman görüşmelerine dayalı nitel değerlendirmeleri birleştiren karma yöntem yaklaşımını benimsemektedir. Analiz dönemi, 2000'lerin başlarından günümüze kadar uzanmakta olup, 2008 finansal krizi ve son COVID-19 salgını gibi önemli küresel ticaret olaylarının etkilerini kapsamaktadır. Bulgulara göre, küresel eğilimler Türkiye'nin dış ticareti üzerinde önemli bir etkiye sahip olmuştur. Özellikle Avrupa Birliği ile olan gümrük birliği ve serbest ticaret anlaşmaları, Türkiye'nin ticaret politikası ve ekonomik entegrasyonu üzerinde büyük bir etki yaratmıştır. Küresel ekonomik belirsizliklere yanıt olarak, Türkiye geleneksel pazarların ötesinde ticaret ortaklıklarını genişletmiştir. Asya, Afrika ve Latin Amerika'daki gelişmekte olan ekonomiler, Avrupa pazarlarına bağımlılıktan uzaklaşmayı gösteren stratejik bir hamle ile önemli ticaret ortakları haline gelmiştir. Ticaret lojistiği ve gümrük prosedürlerinde dijital teknolojinin uygulanması, Türkiye'nin ticaret verimliliğini artırmıştır. E-ticaret ve dijital ticaret platformları, özellikle küçük ve orta ölçekli işletmeler için yeni pazarlar açmıştır. 2008 finansal krizi ve COVID-19 salgını, Türkiye'nin ticaret dinamikleri üzerinde önemli bir etkiye sahip olmuştur. Finansal kriz, ticaret hacimlerinde geçici bir düşüşe neden olmuştur. Türkiye'nin uluslararası ticaret politikaları, küresel ticaret sorunları karşısında dirençli ve uyumlu olduğunu göstermiştir. Ülkenin bölgesel ticaret anlaşmalarına stratejik katılımı, ticaret ortaklarının çeşitlendirilmesi ve teknolojik ilerlemelerin benimsenmesi, Türkiye'yi küresel ticaret arenasında dinamik bir oyuncu olarak konumlandırmıştır.

Anahtar Kelimeler – Küresel Ticaret, Ekonomik Bütünlük, Dış Ticaret, Türkiye.

I. GİRİŞ

Türkiye, coğrafi konumu, ekonomik potansiyeli ve ticaret hacmi ile uluslararası ticaret sahnesinde önemli bir aktördür. Ülkenin dış ticareti, ihracat ve ithalat arasındaki denge, ticaret ortakları ve ticaret politikaları gibi birçok bileşeni içermektedir. Türkiye, tarih boyunca İpek Yolu gibi ticaret yollarının kesişim noktasında yer almış ve bu stratejik konumu sayesinde ticarette önemli bir rol oynamıştır. Modern dönemde, Türkiye'nin dış ticaret politikaları, ekonomik büyüme, kalkınma ve küresel entegrasyon hedeflerine hizmet etmektedir.

Türkiye'nin dış ticaret yapısı, son yıllarda önemli değişimler göstermiştir. Ülke, tekstil, otomotiv, elektronik, gıda ve tarım ürünleri gibi çeşitli sektörlerde güçlü ihracat kapasitesine sahiptir. İhracat pazarları arasında Avrupa Birliği ülkeleri, Orta Doğu, Asya, Afrika ve Amerika kıtası bulunmaktadır. İthalatta ise enerji, hammadde ve yüksek teknoloji ürünleri öne çıkmaktadır. Türkiye'nin dış ticaret hacmi, küresel ekonomik koşullara ve iç piyasadaki gelişmelere bağlı olarak dalgalanmalar göstermektedir.

Küresel ticaret, dünya ekonomisinin büyümesi ve gelişmesi için hayati öneme sahiptir. Ülkeler arasındaki ticaret, kaynakların daha verimli kullanılmasını sağlar, ekonomik işbirliğini artırır ve küresel refahı destekler. Küresel ticaretin artması, aynı zamanda teknolojik yeniliklerin ve bilgi transferinin hızlanmasına katkıda bulunur. Serbest ticaret anlaşmaları, gümrük birliği ve bölgesel entegrasyon girişimleri, küresel ticaretin kolaylaştırılmasında önemli araçlardır [1].

Türkiye, küresel ticaret ağının önemli bir parçasıdır. Ülke, Gümrük Birliği anlaşmasıyla Avrupa Birliği pazarına erişim sağlamış ve çeşitli serbest ticaret anlaşmaları ile ticaret ortaklarını çeşitlendirmiştir. Türkiye'nin dünya ticaretindeki yeri, ihracat ve ithalat hacmi, ticaret politikaları ve ekonomik işbirlikleriyle belirlenmektedir. Özellikle, Türkiye'nin dış ticaretinde Avrupa Birliği'nin payı büyük olmakla birlikte, Asya, Afrika ve Latin Amerika gibi gelişmekte olan pazarlarla olan ticaret ilişkileri de giderek artmaktadır [2].

Küresel ticaret dinamikleri, Türkiye'nin ticaret politikalarını ve stratejilerini doğrudan etkilemektedir. Küresel ekonomik krizler, ticaret savaşları, teknolojik yenilikler ve dijital ticaretin yükselişi gibi faktörler, Türkiye'nin dış ticaret politikalarında değişikliklere yol açmıştır. Örneğin, 2008 finansal krizi ve COVID-19 salgını, küresel ticaret hacminde önemli düşüşlere neden olmuş ve Türkiye'nin ticaret politikalarını gözden geçirmesine yol açmıştır [3].

Bu çalışmanın amacı, küresel ticaret eğilimleri bağlamında Türkiye'nin dış ticaret politikasının çeşitli bileşenlerini ve bunların ülkenin ekonomik büyüme ve kalkınması üzerindeki etkilerini incelemektir. Çalışma, Türkiye'nin dış ticaret stratejilerini, ticaret ortaklıklarını ve küresel ticaret dinamiklerine uyumunu analiz etmeyi hedeflemektedir.

Araştırma Soruları:

1. Küresel ticaret eğilimleri, Türkiye'nin dış ticaret politikalarını nasıl etkilemektedir?
2. Türkiye'nin başlıca ticaret ortakları kimlerdir ve bu ortaklıkların ekonomik etkileri nelerdir?
3. Dijital teknolojilerin ve e-ticaret platformlarının Türkiye'nin dış ticaret verimliliği üzerindeki etkileri nelerdir?
4. Türkiye'nin bölgesel entegrasyon çabaları ve serbest ticaret anlaşmaları, dış ticaret hacmini nasıl etkilemiştir?
5. Küresel ekonomik krizler ve belirsizlikler, Türkiye'nin dış ticaret dinamiklerini nasıl etkilemiştir?

Bu araştırma soruları, Türkiye'nin küresel ticaret ağındaki yerini, ticaret politikalarının etkinliğini ve gelecekteki ticaret stratejilerini anlamak için kritik öneme sahiptir. Araştırmanın bulguları, politika yapıcılar ve akademisyenler için değerli bilgiler sunarak, Türkiye'nin küresel ticaret sahnesindeki rolünü güçlendirmesine katkıda bulunacaktır.

II. LİTERATÜR TARAMASI

A. Uluslararası Ticaret Teorileri ve Modelleri

Uluslararası ticaret teorileri, ülkeler arasındaki ticaretin nedenlerini ve sonuçlarını anlamak için geliştirilmiştir. Bu teoriler, ticaretin ekonomik büyüme, refah ve kaynakların verimli kullanımı üzerindeki etkilerini açıklamaya çalışır.

Mutlak Üstünlük Teorisi: Adam Smith tarafından geliştirilen bu teori, bir ülkenin belirli bir malı diğer ülkelere göre daha verimli üretebildiği durumlarda ticaretin faydalı olduğunu savunur. Bu durumda, ülkeler mutlak üstünlüğe sahip oldukları malları üretir ve ticaret yaparlar [4].

Karşılaştırmalı Üstünlük Teorisi: David Ricardo tarafından geliştirilen bu teori, bir ülkenin diğer ülkelere göre daha düşük fırsat maliyeti ile üretebildiği malları üretip ihraç etmesi gerektiğini belirtir. Karşılaştırmalı üstünlük, uluslararası ticaretin temel dinamiklerinden biridir ve ülkeler arasındaki ticaretin faydalarını açıklar [5].

Heckscher-Ohlin Teorisi: Bu teori, bir ülkenin ticaret yaparken nispeten bol olan üretim faktörlerini kullanarak üretim yapacağını savunur. Heckscher ve Ohlin, ticaretin faktör donanımı ve faktör fiyatları üzerindeki etkilerini analiz eder [6].

Yeni Ticaret Teorisi: 1980'lerde Paul Krugman tarafından geliştirilen bu teori, ölçek ekonomileri ve pazar yapılarının uluslararası ticaretteki rolünü vurgular. Yeni ticaret teorisi, tekelleşmiş rekabet ve ürün çeşitliliği gibi unsurları dikkate alarak, ticaretin dinamiklerini açıklar [7].

B. *Küresel Ticaret Eğilimleri ve Dinamikleri*

Küresel ticaret, son yıllarda önemli değişiklikler ve gelişmeler göstermiştir. Bu değişiklikler, küresel ticaretin dinamiklerini ve eğilimlerini şekillendiren çeşitli faktörlerle ilişkilidir.

Küresel ticaretin artması, serbest ticaret anlaşmaları ve ekonomik entegrasyon süreçleriyle desteklenmektedir. NAFTA, Avrupa Birliği ve Asya-Pasifik Ekonomik İşbirliği gibi bölgesel ticaret blokları, ticaretin serbestleşmesini ve ekonomik entegrasyonu teşvik etmektedir [8].

Ticaret politikaları ve koruma önlemleri, küresel ticaretin dinamiklerini etkileyen önemli faktörlerdir. Ticaret savaşları, tarife ve tarife dışı engeller, ticaret akışlarını ve küresel ekonomik dengeleri değiştirmektedir. Özellikle ABD-Çin ticaret savaşı, küresel ticaret üzerinde ciddi etkiler yaratmıştır [9].

Dijital ticaret ve e-ticaretin yükselişi, küresel ticaretin dinamiklerini önemli ölçüde değiştirmiştir. Dijital platformlar, küçük ve orta ölçekli işletmelerin uluslararası pazarlara erişimini kolaylaştırmakta ve ticaretin hızını artırmaktadır. Ayrıca, dijital teknolojiler, ticaret lojistiği ve gümrük prosedürlerinde verimliliği artırmaktadır [10].

Küresel ekonomik krizler, ticaret hacimlerinde ve ticaret politikalarında önemli değişikliklere yol açmaktadır. 2008 finansal krizi ve COVID-19 salgını, küresel ticaret hacminde düşüşlere neden olmuş ve ticaret politikalarını yeniden şekillendirmiştir. Bu krizler, tedarik zincirlerinde aksamalara ve ticaret akışlarında dalgalanmalara yol açmıştır [3].

C. *Türkiye'nin Dış Ticareti Üzerine Mevcut Araştırmalar ve Bulgular*

Türkiye'nin dış ticareti üzerine yapılan araştırmalar, ülkenin ticaret politikalarının ve stratejilerinin küresel ticaret dinamiklerine uyumunu incelemektedir.

Türkiye'nin Ticaret Politikaları: Türkiye, dış ticaret politikalarını küresel ticaret eğilimlerine uyumlu hale getirmek için çeşitli stratejiler geliştirmiştir. Gümrük Birliği anlaşması ve serbest ticaret anlaşmaları, Türkiye'nin ticaret hacmini artırmış ve ekonomik entegrasyonunu sağlamıştır. Ayrıca, dijital ticaret ve e-ticaretin yükselişi, Türkiye'nin dış ticaret verimliliğini artırmıştır [11].

İhracat ve İthalat Dinamikleri: Türkiye'nin ihracat ve ithalat yapısı, ekonomik büyüme ve kalkınma hedeflerine hizmet etmektedir. İhracatında tekstil, otomotiv, elektronik ve tarım ürünleri öne çıkarken, ithalatında enerji, hammadde ve yüksek teknoloji ürünleri önemli bir yer tutmaktadır. Türkiye'nin başlıca ticaret ortakları arasında Avrupa Birliği ülkeleri, Orta Doğu, Asya, Afrika ve Amerika kıtası bulunmaktadır [2].

Ticaretin Ekonomik Büyüme Üzerindeki Etkisi: Araştırmalar, Türkiye'nin dış ticaretinin ekonomik büyüme ve kalkınma üzerindeki olumlu etkilerini vurgulamaktadır. Ticaretin artırılması, sanayi üretimini ve istihdamı desteklemekte, ekonomik büyümeyi hızlandırmaktadır. Ayrıca, ticaretin teknoloji transferi ve yenilikçilik üzerindeki etkileri de önemli bir araştırma konusu olarak öne çıkmaktadır.

D. *Literatürdeki Ana Tartışmalar ve Boşluklar*

Literatürde, Türkiye'nin dış ticareti ve küresel ticaret dinamikleri üzerine yapılan araştırmalar çeşitli tartışmaları ve boşlukları içermektedir.

Ticaret Politikalarının Etkinliği: Türkiye'nin ticaret politikalarının etkinliği ve bu politikaların küresel ticaret dinamiklerine uyumu konusunda farklı görüşler bulunmaktadır. Bazı araştırmacılar, Türkiye'nin ticaret politikalarının ekonomik büyüme ve kalkınma üzerindeki olumlu etkilerini vurgularken, diğerleri bu politikaların yetersizliklerine dikkat çekmektedir [12].

Dijital Ticaretin Rolü: Dijital ticaretin Türkiye'nin dış ticareti üzerindeki etkileri konusunda daha fazla araştırmaya ihtiyaç vardır. Dijital teknolojilerin ticaret lojistiği, gümrük prosedürleri ve ticaret verimliliği üzerindeki etkileri, henüz tam olarak anlaşılmamıştır [10].

Ticaretin Sosyal ve Çevresel Etkileri: Türkiye'nin dış ticaretinin sosyal ve çevresel etkileri üzerine yapılan araştırmalar sınırlıdır. Ticaretin çevresel sürdürülebilirlik, işgücü hakları ve sosyal eşitsizlikler üzerindeki etkileri, daha fazla araştırma gerektiren önemli konulardır.

Sonuç olarak, Türkiye'nin dış ticareti ve küresel ticaret dinamikleri üzerine yapılan mevcut araştırmalar, önemli bulgular ve tartışmalar sunmaktadır. Ancak, literatürdeki bazı boşluklar, bu konuların daha derinlemesine incelenmesi gerektiğini göstermektedir. Bu çalışma, Türkiye'nin dış ticaret politikalarının

ve stratejilerinin küresel ticaret dinamiklerine uyumunu ve bu uyumun ekonomik büyüme ve kalkınma üzerindeki etkilerini anlamak için önemli bir katkı sağlayacaktır.

III. KÜRESEL TİCARET EĞİLİMLERİ

A. *Küresel Ticaretin Son Yıllardaki Gelişimi ve Eğilimleri*

Son yıllarda, küresel ticaret dinamikleri ve eğilimleri önemli değişiklikler göstermiştir. Küresel ticaret hacmi, çeşitli ekonomik, politik ve teknolojik faktörlerin etkisiyle dalgalanmalar yaşamıştır. Küresel finansal krizler, politik belirsizlikler ve teknolojik yenilikler, ticaret akışlarını ve ticaret politikalarını etkilemiştir.

2008 yılında yaşanan küresel finansal kriz, dünya ticaret hacminde önemli bir düşüşe neden olmuş, ancak sonraki yıllarda kademeli bir toparlanma gözlenmiştir [13]. 2010'lu yılların ortalarına kadar küresel ticaret hacmi artış göstermiş, ancak 2018'den itibaren ABD-Çin ticaret savaşı gibi ticaret anlaşmazlıkları ve korumacılık politikaları nedeniyle yeniden baskı altına girmiştir [9].

COVID-19 salgını, küresel ticaretin son yıllardaki gelişimini derinden etkilemiştir. Pandemi, tedarik zincirlerinde ciddi aksamalara neden olmuş, uluslararası ticaret akışlarını kesintiye uğratmış ve dünya ticaret hacminde belirgin bir düşüşe yol açmıştır [3]. Ancak, aşıların yaygınlaşması ve ekonomik faaliyetlerin yeniden başlamasıyla birlikte, küresel ticaret hacminde toparlanma işaretleri görülmektedir.

B. *Serbest Ticaret Anlaşmaları ve Ekonomik Entegrasyon Süreçleri*

Serbest ticaret anlaşmaları (STA) ve ekonomik entegrasyon süreçleri, küresel ticaretin büyümesini ve gelişimini destekleyen önemli araçlardır. STA'lar, ticaretin serbestleştirilmesi, tarife ve tarife dışı engellerin kaldırılması yoluyla ticaret hacmini artırmayı amaçlar. Ekonomik entegrasyon ise, ülkeler arasında daha derin ekonomik işbirliği ve entegrasyon süreçlerini içerir.

NAFTA ve USMCA: Kuzey Amerika Serbest Ticaret Anlaşması (NAFTA), 1994 yılında ABD, Kanada ve Meksika arasında imzalanmış ve bu ülkeler arasındaki ticaret hacmini önemli ölçüde artırmıştır. 2020 yılında NAFTA, ABD-Meksika-Kanada Anlaşması (USMCA) ile yenilenmiş ve güncellenmiştir [14].

Avrupa Birliği: Avrupa Birliği (AB), dünya üzerindeki en kapsamlı ekonomik entegrasyon süreçlerinden birini temsil eder. AB üyesi ülkeler arasında serbest ticaret, ortak tarım politikaları ve ekonomik entegrasyon sağlanmıştır. AB'nin genişleme süreçleri ve yeni serbest ticaret anlaşmaları, ticaret hacmini ve ekonomik işbirliğini artırmıştır [15].

Asya-Pasifik Ekonomik İşbirliği (APEC): APEC, Asya-Pasifik bölgesindeki 21 ülkenin ekonomik işbirliğini ve ticaret serbestleştirmesini teşvik eden bir forumdur. APEC üyeleri arasında ticaret hacmi önemli ölçüde artmış ve ekonomik entegrasyon süreçleri desteklenmiştir [16].

C. *Ticaret Savaşları, Korumacılık ve Diğer Engelleyici Faktörler*

Küresel ticaret, ticaret savaşları, korumacılık politikaları ve diğer engelleyici faktörler nedeniyle zaman zaman ciddi zorluklarla karşı karşıya kalmaktadır. Ticaret savaşları, ülkeler arasında tarifelerin artırılması, ticaret engellerinin koyulması ve ekonomik yaptırımların uygulanması gibi düşmanca ticaret politikalarını içerir.

ABD-Çin Ticaret Savaşı: 2018 yılında başlayan ABD-Çin ticaret savaşı, küresel ticaretin dinamiklerini önemli ölçüde etkilemiştir. ABD, Çin'den ithal edilen çeşitli ürünlere yüksek tarifeler uygulamış ve Çin de misilleme olarak ABD ürünlerine benzer önlemler almıştır. Bu ticaret savaşı, dünya ticaret hacminde belirsizlikler yaratmış ve ticaret akışlarını olumsuz etkilemiştir [9].

Korumacılık Politikaları: Korumacılık, ülkelerin yerli sanayilerini yabancı rekabetten korumak amacıyla ticaret engelleri koymasıdır. Tarife ve tarife dışı engeller, ithalat kotaları ve sübvansiyonlar, korumacılık politikalarının örnekleridir. Bu politikalar, ticaret akışlarını kısıtlamakta ve küresel ticaretin serbestleşmesini engellemektedir [17].

Diğer Engelleyici Faktörler: Küresel ticareti etkileyen diğer engelleyici faktörler arasında jeopolitik riskler, doğal afetler, siyasi belirsizlikler ve düzenleyici değişiklikler yer almaktadır. Bu faktörler, ticaret akışlarında aksamalara neden olabilir ve ticaret politikalarının yeniden şekillendirilmesini gerektirebilir.

D. *Dijital Ticaret ve E-Ticaretin Yükselişi*

Dijital ticaret ve e-ticaretin yükselişi, küresel ticaret dinamiklerinde devrim niteliğinde değişikliklere yol açmıştır. Dijital ticaret, elektronik ticaret platformları, dijital ödeme sistemleri ve dijital lojistik çözümlerini içerir.

E-Ticaretin Gelişimi: E-ticaret, internetin yaygınlaşması ve dijital teknolojilerin gelişmesiyle hızla büyümüştür. Küresel e-ticaret platformları, küçük ve orta ölçekli işletmelerin (KOBİ) uluslararası pazarlara erişimini kolaylaştırmış ve ticaretin hızını artırmıştır. Özellikle Amazon, Alibaba ve eBay gibi platformlar, küresel ticaret hacminde önemli bir paya sahiptir [10].

Dijital Lojistik ve Gümrük Prosedürleri: Dijital teknolojiler, ticaret lojistiği ve gümrük prosedürlerinde verimliliği artırmıştır. Dijital izleme sistemleri, otomatik gümrük işlemleri ve dijital belgeler, ticaret sürecini hızlandırmakta ve maliyetleri düşürmektedir. Bu yenilikler, küresel ticaretin daha akıcı ve verimli bir şekilde gerçekleşmesini sağlamaktadır [3].

Pandemi ve Dijital Ticaret: COVID-19 salgını, dijital ticaretin önemini daha da artırmıştır. Fiziksel mağazaların kapanması ve sosyal mesafe önlemleri, tüketicileri online alışverişe yönlendirmiştir. Bu durum, e-ticaret hacminde büyük bir artışa yol açmış ve dijital ticaretin gelecekteki büyüme potansiyelini göstermiştir [3].

Küresel ticaret, son yıllarda önemli değişiklikler ve gelişmeler göstermiştir. Serbest ticaret anlaşmaları ve ekonomik entegrasyon süreçleri, küresel ticaretin büyümesini ve gelişimini desteklerken, ticaret savaşları ve korumacılık politikaları ticaret akışlarını olumsuz etkilemektedir. Dijital ticaret ve e-ticaretin yükselişi, ticaretin dinamiklerinde devrim niteliğinde değişikliklere yol açmış ve küresel ticaretin hızını ve verimliliğini artırmıştır. Türkiye, bu küresel ticaret eğilimlerine uyum sağlamak ve dış ticaret hacmini artırmak için çeşitli stratejiler geliştirmektedir. Türkiye'nin küresel ticaret sahnesindeki rolü, bu eğilimler ve dinamikler bağlamında şekillenmektedir.

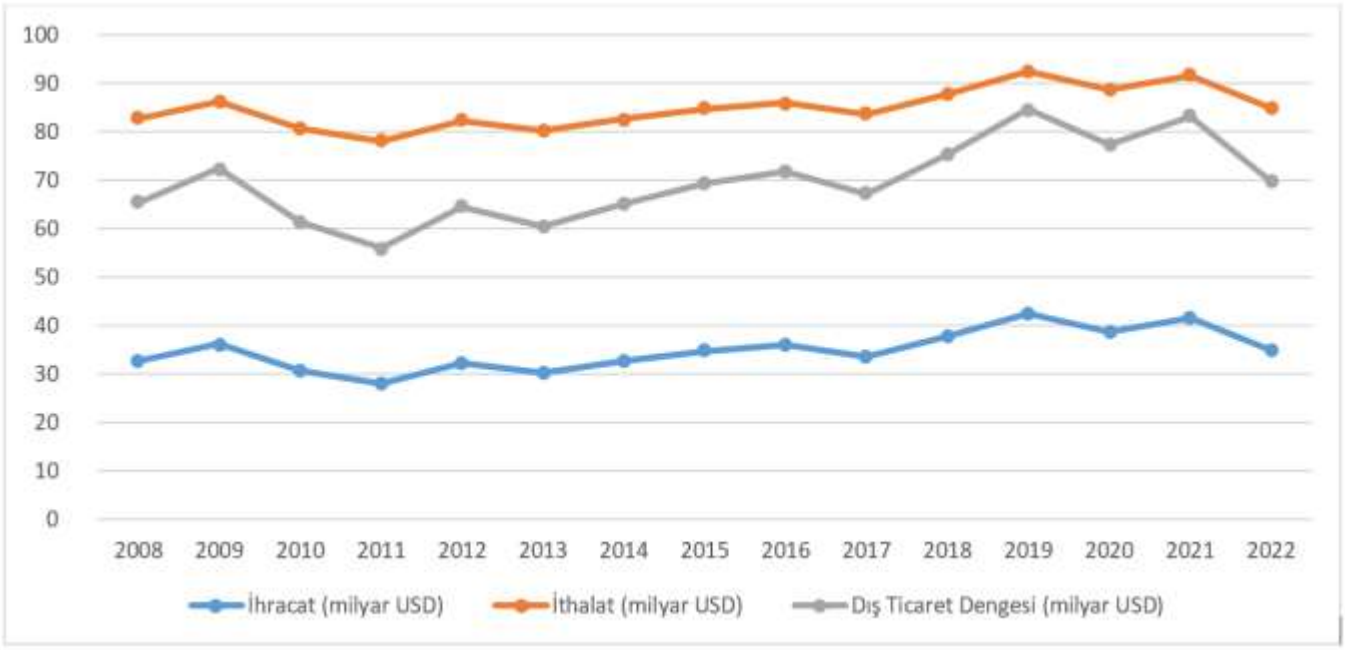
IV. TÜRKİYE'NİN DIŞ TİCARETİ

A. *Türkiye'nin İhracat ve İthalat Yapısının Analizi*

Türkiye'nin dış ticareti, son yıllarda önemli gelişmeler göstermiş ve ülkenin ekonomik büyüme ve kalkınmasına katkıda bulunmuştur. Türkiye'nin ihracat ve ithalat yapısı, çeşitli sektörlerdeki üretim kapasitesi ve küresel ticaret dinamiklerine göre şekillenmektedir.

İhracat: Türkiye'nin ihracatında öne çıkan sektörler arasında otomotiv, tekstil ve hazır giyim, elektronik, makine ve teçhizat, tarım ve gıda ürünleri bulunmaktadır. 2021 yılında Türkiye'nin toplam ihracatı 225 milyar dolar seviyesine ulaşmıştır [18]. Otomotiv sektörü, toplam ihracatın yaklaşık %20'sini oluşturarak, Türkiye'nin en büyük ihracat kalemlerinden biridir. Tekstil ve hazır giyim sektörü ise toplam ihracatın %15'ini oluşturmakta ve Türkiye'nin geleneksel ihracat sektörlerinden biri olarak öne çıkmaktadır.

İthalat: Türkiye'nin ithalatında ise enerji, hammadde, ara mallar ve yüksek teknoloji ürünleri önemli bir yer tutmaktadır. 2021 yılında Türkiye'nin toplam ithalatı 271 milyar dolar seviyesinde gerçekleşmiştir [18]. Enerji ithalatı, toplam ithalatın yaklaşık %20'sini oluşturarak en büyük kalemi temsil etmektedir. Bu durum, Türkiye'nin enerji ithalatına bağımlılığını göstermektedir. Ayrıca, makine ve ekipman, kimyasal ürünler ve elektronik ürünler de Türkiye'nin ithalatında önemli paya sahiptir.

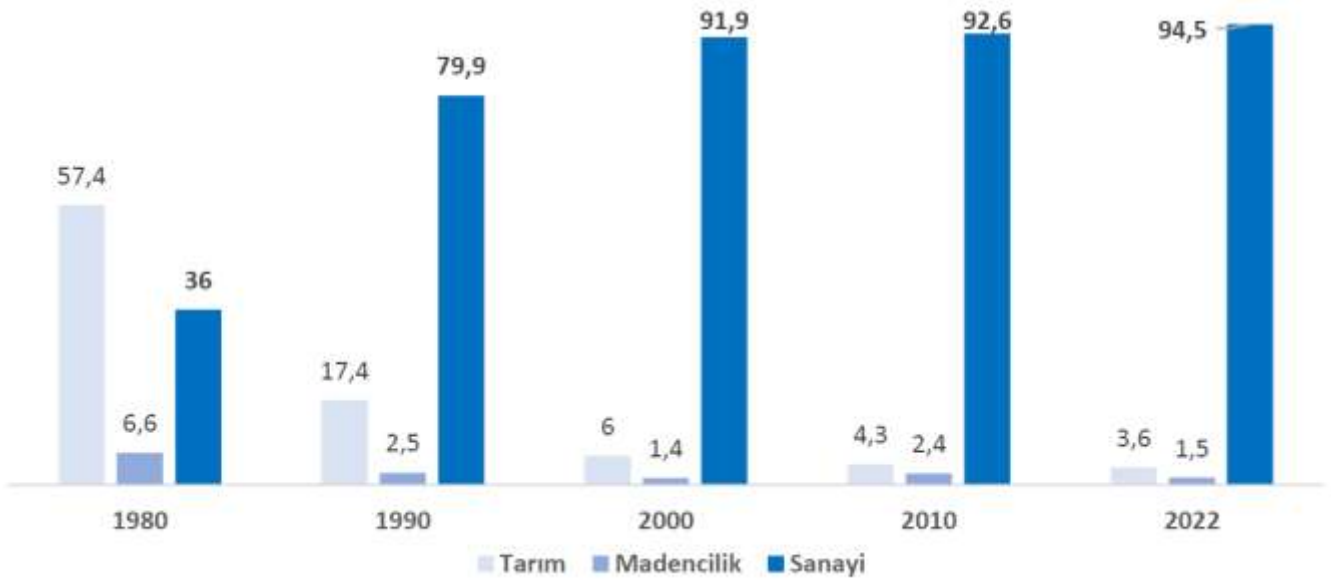


Şekil 1. Türkiye'nin 2008-2022 Yılları Arasında Döneme Ait İthalat, İhracat ve Dış Ticaret Dengesi

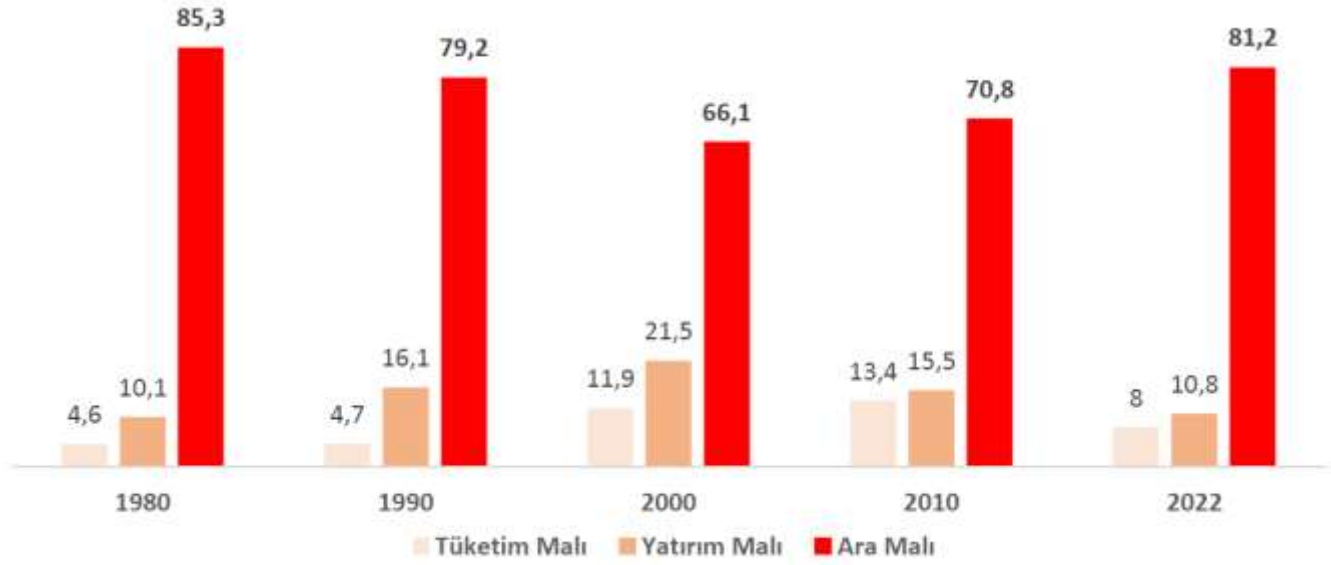
Tablo 1. Türkiye Dış Ticareti Verileri (2000-2023)

	İhracat Değer Bin $	İhracat Değişim %	İthalat Değer Bin $	İthalat Değişim %	Denge Bin $	Hacim Değer Bin $	Karşılama Oranı %
2000	27.774.906	4,5	54.502.821	34,0	-26.727.914	82.277.727	51,0
2001	31.334.216	12,8	41.399.083	-24,0	-10.064.867	72.733.299	75,7
2002	36.059.089	15,1	51.553.797	24,5	-15.494.708	87.612.886	69,9
2003	47.252.836	31,0	69.339.692	34,5	-22.086.856	116.592.528	68,1
2004	63.167.153	33,7	97.539.766	40,7	-34.372.613	160.706.919	64,8
2005	73.476.408	16,3	116.774.151	19,7	-43.297.743	190.250.559	62,9
2006	85.534.676	16,4	139.576.174	19,5	-54.041.499	225.110.850	61,3
2007	107.271.750	25,4	170.062.715	21,8	-62.790.965	277.334.464	63,1
2008	132.027.196	23,1	201.963.574	18,8	-69.936.378	333.990.770	65,4
2009	102.142.613	-22,6	140.928.421	-30,2	-38.785.809	243.071.034	72,5
2010	113.883.219	11,5	185.544.332	31,7	-71.661.113	299.427.551	61,4
2011	134.906.869	18,5	240.841.676	29,8	105.934.807	375.748.545	56,0
2012	152.461.737	13,0	236.545.141	-1,8	-84.083.404	389.006.877	64,5
2013	161.480.915	-0,4	260.822.803	6,4	-99.341.888	422.303.718	61.9
2014	166.504.862	3,1	251.142.429	-3,7	-84.637.567	417.647.291	66,3
2015	150.982.114	-9,3	213.619.211	-14,9	-62.637.098	364.601.325	70,7
2016	149.246.999	-1,1	202.189.242	-5,4	-52.942.243	351.436.241	73,8
2017	164.494.619	10,2	238.715.128	18,1	-74.220.509	403.209.747	68,9
2018	177.168.756	7,7	231.152.483	-3,2	-53.983.726	408.321.239	76,6
2019	180.832.722	2,1	210.345.203	-9,0	-29.512.481	391.177.924	86,0
2020	169.637.755	-6,2	219.516.807	4,4	-49.879.052	389.154.562	77,3
2021	225.214.458	32,8	271.425.553	23,6	-46.211.095	496.640.011	83,0
2022	254.169.748	12,9	363.710.575	34,0	109.540.827	617.880.323	69,9
2023/10	209.903.888		303.820.801		-93.916.913	513.724.689	69,1

Kaynak: TÜİK (2023)



Şekil 2. İhracatın Mal Gruplarına Göre Dağılımı (%)



Şekil 3. İthalatın Mal Gruplarına Göre Dağılımı (%)

B. *Türkiye'nin Başlıca Ticaret Ortakları ve Ticaret Hacmi*

Türkiye, küresel ticaret ağında birçok ülke ile ticaret ilişkileri geliştirmiştir. Türkiye'nin başlıca ticaret ortakları arasında Avrupa Birliği ülkeleri, Çin, Rusya, ABD ve Orta Doğu ülkeleri bulunmaktadır.

Avrupa Birliği (AB), Türkiye'nin en büyük ticaret ortağıdır. Türkiye'nin toplam ihracatının yaklaşık %42'si AB ülkelerine yapılmaktadır. Almanya, İtalya, Fransa ve İspanya, Türkiye'nin en önemli ticaret ortakları arasında yer almaktadır [19]. AB ile Gümrük Birliği anlaşması, Türkiye'nin AB pazarına erişimini kolaylaştırmış ve ticaret hacmini artırmıştır.

Çin, Türkiye'nin en büyük ithalat ortaklarından biridir. Türkiye'nin Çin'den yaptığı ithalat, toplam ithalatın %12'sini oluşturmaktadır. Çin'den ithal edilen ürünler arasında elektronik ürünler, makine ve ekipman, tekstil ve kimyasal ürünler bulunmaktadır [18].

Rusya, Türkiye'nin önemli enerji tedarikçilerinden biridir. Türkiye'nin Rusya'dan yaptığı ithalatın büyük kısmını enerji ürünleri, özellikle doğalgaz ve petrol oluşturmaktadır. Ayrıca, Rusya'ya yapılan ihracatta tarım ve gıda ürünleri öne çıkmaktadır [18].

ABD, Türkiye'nin hem ihracat hem de ithalatında önemli bir ticaret ortağıdır. Türkiye, ABD'ye otomotiv, tekstil ve makine ürünleri ihraç ederken, ABD'den makine ve ekipman, kimyasal ürünler ve hava taşıtları ithal etmektedir [18].

Türkiye, Orta Doğu ülkeleri ile de yoğun ticaret ilişkilerine sahiptir. Suudi Arabistan, Birleşik Arap Emirlikleri ve Irak, Türkiye'nin önemli ticaret ortakları arasında yer almaktadır. Bu ülkelere yapılan ihracatta tarım, gıda ve inşaat malzemeleri öne çıkmaktadır [18].

C. Sektörel Dağılım: Tarım, Sanayi ve Hizmet Sektörleri

Türkiye'nin dış ticaretinde sektörel dağılım, tarım, sanayi ve hizmet sektörleri arasında dengeli bir şekilde dağılmaktadır.

Tarım sektörü, toplam ihracatın yaklaşık %10'unu oluşturmaktadır. İhraç edilen başlıca tarım ürünleri arasında fındık, meyve, sebze, buğday ve zeytinyağı bulunmaktadır. Türkiye, dünya fındık üretiminde lider konumdadır ve bu ürünün büyük kısmını ihraç etmektedir [22].

Sanayi sektörü, Türkiye'nin ihracatında en büyük paya sahiptir. Otomotiv, tekstil, elektronik, makine ve kimya sanayii, Türkiye'nin sanayi ihracatının ana unsurlarıdır. Otomotiv sektörü, özellikle Avrupa pazarına yapılan ihracatta önemli bir yere sahiptir. Tekstil ve hazır giyim sektörü ise Türkiye'nin geleneksel ihracat kalemleri arasında yer almaktadır [18].

Hizmet sektörü, Türkiye'nin dış ticaretinde giderek artan bir öneme sahiptir. Turizm, taşımacılık, inşaat hizmetleri ve sağlık turizmi, hizmet ihracatının önemli bileşenleridir. Türkiye, özellikle turizm sektöründe büyük bir potansiyele sahip olup, yıllık milyonlarca turist çekmektedir. Bu durum, hizmet ihracatının artmasına katkı sağlamaktadır [20].

D. Türkiye'nin Serbest Ticaret Anlaşmaları ve Bölgesel Entegrasyon Çabaları

Türkiye, küresel ticaret ağında yerini güçlendirmek ve ticaret hacmini artırmak amacıyla birçok serbest ticaret anlaşması (STA) ve bölgesel entegrasyon girişimlerinde bulunmaktadır.

Gümrük Birliği: Türkiye, 1996 yılında Avrupa Birliği ile Gümrük Birliği anlaşması imzalamış ve bu anlaşma, Türkiye'nin AB pazarına erişimini kolaylaştırmıştır. Gümrük Birliği, Türkiye'nin AB ülkelerine ihracatını artırmış ve ekonomik entegrasyonunu sağlamıştır [19].

Serbest Ticaret Anlaşmaları (STA): Türkiye, çeşitli ülkeler ve bölgelerle STA imzalamıştır. Güney Kore, Singapur, Malezya, EFTA ülkeleri ve Gürcistan, Türkiye'nin STA imzaladığı ülkeler arasında yer almaktadır. Bu anlaşmalar, Türkiye'nin ticaret hacmini artırmış ve yeni pazarlara erişimini sağlamıştır [24].

Bölgesel Entegrasyon Çabaları: Türkiye, bölgesel entegrasyon çabalarına da önem vermektedir. Karadeniz Ekonomik İşbirliği Örgütü (KEİ), Ekonomik İşbirliği Teşkilatı (EİT) ve Türk Konseyi gibi bölgesel işbirliği platformları, Türkiye'nin bölgesel ticaret entegrasyonunu desteklemektedir. Bu platformlar aracılığıyla Türkiye, komşu ülkeler ve bölge ülkeleri ile ticaret hacmini artırmaktadır [21].

Türkiye'nin dış ticareti, ihracat ve ithalat yapısı, başlıca ticaret ortakları, sektörel dağılım ve serbest ticaret anlaşmaları ile bölgesel entegrasyon çabaları bağlamında incelendiğinde, ülkenin küresel ticaret ağındaki stratejik rolü ve ticaret hacmindeki artışlar belirginleşmektedir. Türkiye, çeşitli sektörlerdeki ihracat kapasitesi, önemli ticaret ortakları ve küresel ticaret dinamiklerine uyum sağlama yeteneği ile dış ticaretini geliştirmeye devam etmektedir. Bu çalışma, Türkiye'nin dış ticaret politikalarını ve stratejilerini anlamak için kapsamlı bir analiz sunmaktadır.

V. KÜRESEL EĞİLİMLERİN TÜRKİYE'NİN DIŞ TİCARETİNE ETKİSİ

A. Küresel Ticaret Politikalarının Türkiye Üzerindeki Etkileri

Küresel ticaret politikaları, ülkeler arasındaki ticaret akışlarını ve ekonomik ilişkileri şekillendirir. Türkiye, küresel ticaret sisteminin bir parçası olarak, bu politikaların etkilerini doğrudan yaşamaktadır. Serbest ticaret anlaşmaları, gümrük birliği ve bölgesel ticaret blokları, Türkiye'nin ticaret politikalarını ve ekonomik stratejilerini belirlemede kritik rol oynamaktadır.

Serbest Ticaret Anlaşmaları (STA): Türkiye, birçok ülke ve bölge ile serbest ticaret anlaşmaları imzalamıştır. Bu anlaşmalar, Türkiye'nin ihracatını artırmakta ve yeni pazar fırsatları yaratmaktadır.

Örneğin, Güney Kore ile imzalanan STA, iki ülke arasındaki ticaret hacmini önemli ölçüde artırmış ve Türkiye'nin Asya pazarlarına erişimini kolaylaştırmıştır [24].

Gümrük Birliği: Türkiye'nin Avrupa Birliği (AB) ile olan Gümrük Birliği anlaşması, ülkenin dış ticaretinde önemli bir yer tutmaktadır. Bu anlaşma, Türkiye'nin AB pazarına gümrüksüz erişimini sağlamakta ve ticaret hacmini artırmaktadır. 1996 yılında yürürlüğe giren bu anlaşma, Türkiye'nin ihracatını büyük ölçüde artırmış ve ekonomik entegrasyonunu sağlamıştır [19].

Bölgesel Ticaret Blokları: Türkiye, aynı zamanda çeşitli bölgesel ticaret blokları ile işbirliği yapmaktadır. Karadeniz Ekonomik İşbirliği Örgütü (KEİ) ve Ekonomik İşbirliği Teşkilatı (EİT) gibi platformlar, Türkiye'nin komşu ülkelerle ticaret ilişkilerini güçlendirmektedir. Bu işbirlikleri, Türkiye'nin bölgesel ticaret hacmini artırmakta ve ekonomik işbirliğini teşvik etmektedir [21].

B. Türkiye'nin Ticaret Politikalarının Küresel Eğilimlerle Uyumu

Türkiye, küresel ticaret eğilimlerine uyum sağlamak ve rekabet gücünü artırmak amacıyla çeşitli ticaret politikaları geliştirmiştir. Bu politikalar, Türkiye'nin dış ticaret hacmini artırmakta ve küresel ticaret ağındaki konumunu güçlendirmektedir.

İhracat Teşvikleri: Türkiye, ihracatı teşvik etmek amacıyla çeşitli destek programları ve teşvikler sunmaktadır. Eximbank kredileri, ihracatçı firmalara finansal destek sağlamakta ve uluslararası pazarlara erişimlerini kolaylaştırmaktadır. Ayrıca, ihracatçı firmalara vergi indirimleri ve gümrük muafiyetleri gibi teşvikler de sunulmaktadır [11].

Dış Ticaret Stratejileri: Türkiye, dış ticaret stratejilerini küresel ticaret eğilimlerine uyumlu hale getirmek için sürekli olarak güncellemektedir. Dijital ticaretin yükselişi, Türkiye'nin ticaret politikalarının önemli bir bileşeni haline gelmiştir. Dijital ticaret platformları ve e-ticaret çözümleri, Türkiye'nin ihracat verimliliğini artırmakta ve yeni pazar fırsatları yaratmaktadır [10].

Yeşil Ticaret Politikaları: Küresel ticaretin sürdürülebilirlik trendlerine uyum sağlamak amacıyla, Türkiye yeşil ticaret politikaları geliştirmektedir. Yenilenebilir enerji, çevre dostu üretim ve sürdürülebilir tarım gibi alanlarda yapılan yatırımlar, Türkiye'nin yeşil ticaret kapasitesini artırmakta ve uluslararası rekabet gücünü pekiştirmektedir [3].

C. Dijital Ticaretin Türkiye'nin Dış Ticaretine Etkisi

Dijital ticaret, son yıllarda küresel ticaretin dinamiklerinde önemli değişiklikler yaratmış ve Türkiye'nin dış ticaretine de önemli etkilerde bulunmuştur. Dijital teknolojiler, ticaret süreçlerini hızlandırmakta ve maliyetleri düşürmektedir.

E-Ticaretin Yükselişi: E-ticaret platformları, Türkiye'nin ihracat kapasitesini artırmakta ve küçük ve orta ölçekli işletmelerin (KOBİ) uluslararası pazarlara erişimini kolaylaştırmaktadır. Türkiye, Alibaba, Amazon ve eBay gibi küresel e-ticaret platformlarında aktif olarak yer almakta ve bu platformlar aracılığıyla ürünlerini dünya çapında pazarlamaktadır [10].

Dijital Lojistik Çözümleri: Dijital lojistik çözümleri, Türkiye'nin ticaret süreçlerini optimize etmektedir. Otomatik gümrük işlemleri, dijital izleme sistemleri ve elektronik belgeler, ticaretin hızını ve verimliliğini artırmaktadır. Bu yenilikler, Türkiye'nin dış ticaret operasyonlarını daha akıcı ve maliyet etkin hale getirmektedir [3].

Pandemi ve Dijital Ticaret: COVID-19 salgını, dijital ticaretin önemini daha da artırmıştır. Pandemi sürecinde fiziksel mağazaların kapanması ve sosyal mesafe önlemleri, tüketicileri online alışverişe yönlendirmiştir. Bu durum, Türkiye'nin e-ticaret hacminde büyük bir artışa yol açmış ve dijital ticaretin gelecekteki büyüme potansiyelini göstermiştir [3].

D. Koruma Politikaları ve Ticaret Savaşlarının Türkiye Üzerindeki Etkileri

Koruma politikaları ve ticaret savaşları, küresel ticaretin serbestleşmesini engelleyen ve ticaret akışlarını olumsuz etkileyen faktörlerdir. Türkiye, bu tür politikaların ve anlaşmazlıkların etkilerini doğrudan yaşamaktadır.

ABD-Çin Ticaret Savaşı: ABD-Çin ticaret savaşı, küresel ticaret dinamiklerinde belirsizlikler yaratmış ve ticaret akışlarını etkilemiştir. Türkiye, bu ticaret savaşının dolaylı etkilerini yaşamaktadır. Özellikle,

Çin'in ABD'ye ihracatında yaşanan düşüş, Çin'in diğer pazar arayışlarını artırmış ve Türkiye ile Çin arasındaki ticaret hacmini etkilemiştir [9].

Koruma Politikalarının Etkileri: Türkiye, koruma politikalarının etkilerini en aza indirmek amacıyla çeşitli stratejiler geliştirmiştir. Tarife ve tarife dışı engellerin artması, Türkiye'nin ihracat maliyetlerini artırmakta ve rekabet gücünü olumsuz etkilemektedir. Bu nedenle, Türkiye, serbest ticaret anlaşmaları ve bölgesel entegrasyon çabaları ile koruma politikalarının etkilerini dengelemeye çalışmaktadır [17].

Ticaret Engelleri ile Mücadele: Türkiye, uluslararası ticaret anlaşmazlıklarını çözmek ve ticaret engelleri ile mücadele etmek için Dünya Ticaret Örgütü (DTÖ) gibi uluslararası platformlarda aktif rol oynamaktadır. Türkiye, ticaret anlaşmazlıklarının çözümünde diplomatik ve hukuki yolları kullanarak, ticaret akışlarını koruma çabalarını sürdürmektedir [11].

Küresel ticaret politikaları, dijital ticaretin yükselişi, koruma politikaları ve ticaret savaşları, Türkiye'nin dış ticaret dinamiklerinde önemli değişikliklere yol açmıştır. Türkiye, küresel ticaret eğilimlerine uyum sağlamak amacıyla çeşitli stratejiler ve politikalar geliştirmiştir. Serbest ticaret anlaşmaları, dijital ticaret çözümleri ve yeşil ticaret politikaları, Türkiye'nin küresel ticaret ağındaki konumunu güçlendirmektedir. Ancak, koruma politikaları ve ticaret savaşları gibi engelleyici faktörler, Türkiye'nin dış ticaret hacmini ve rekabet gücünü olumsuz etkileyebilmektedir. Bu nedenle, Türkiye'nin dış ticaret politikaları, küresel ticaret dinamiklerine uyum sağlamak ve ticaret engelleri ile mücadele etmek için sürekli olarak güncellenmelidir.

VI. VAKA ÇALIŞMALARI VE ÖRNEKLER

A. Türkiye'nin Belirli Sektörlerdeki Başarı Öyküleri ve Zorluklar

Türkiye, çeşitli sektörlerdeki başarı öyküleri ve zorlukları ile dikkat çekmektedir. Bu sektörler arasında otomotiv, tekstil ve hazır giyim, tarım ve gıda, elektronik ve turizm öne çıkmaktadır.

Otomotiv Sektörü: Türkiye, otomotiv sektöründe büyük bir başarı öyküsüne sahiptir. Türkiye, Avrupa'nın en büyük ticari araç üreticilerinden biridir ve dünya çapında birçok büyük otomotiv markası için üretim yapmaktadır. 2021 yılında Türkiye'nin otomotiv ihracatı 29 milyar dolar seviyesine ulaşmıştır [18]. Ancak, sektörde yaşanan küresel tedarik zinciri sorunları ve çip krizi gibi zorluklar, üretim ve ihracat süreçlerini etkilemektedir.

Tekstil ve Hazır Giyim: Türkiye, tekstil ve hazır giyim sektöründe de önemli bir ihracatçı konumundadır. Türkiye'nin tekstil ihracatı, kaliteli üretim ve hızlı teslimat avantajları ile öne çıkmaktadır. 2021 yılında tekstil ve hazır giyim ihracatı 20 milyar dolar seviyesinde gerçekleşmiştir [18]. Ancak, küresel rekabetin artması ve maliyetlerin yükselmesi, sektördeki önemli zorluklardır.

Tarım ve Gıda: Türkiye, tarım ve gıda ürünlerinde büyük bir ihracat potansiyeline sahiptir. Özellikle fındık, zeytinyağı, meyve ve sebze ihracatında önemli başarılar elde edilmiştir. Türkiye, dünya fındık üretiminde lider konumdadır ve bu ürünün büyük kısmını ihraç etmektedir [22]. Ancak, iklim değişikliği ve tarımsal üretimde yaşanan verimlilik sorunları, sektördeki zorluklar arasında yer almaktadır.

Elektronik Sektörü: Elektronik ve beyaz eşya sektöründe de Türkiye önemli bir üretim ve ihracat merkezi konumundadır. Türkiye, dünya çapında tanınan birçok beyaz eşya markası için üretim yapmaktadır. 2021 yılında elektronik ve beyaz eşya ihracatı 10 milyar dolar seviyesine ulaşmıştır [18]. Ancak, sektörde yaşanan teknolojik yenilikler ve rekabet baskısı, üretim süreçlerini zorlaştırmaktadır.

Turizm: Türkiye, turizm sektöründe büyük bir potansiyele sahiptir. Türkiye, tarihi ve kültürel zenginlikleri, doğal güzellikleri ve modern turizm altyapısı ile dünya çapında milyonlarca turisti çekmektedir. 2019 yılında Türkiye, 45 milyon turist ağırlayarak turizm gelirlerinde önemli bir artış sağlamıştır [20]. Ancak, COVID-19 salgını, turizm sektöründe ciddi zorluklara yol açmış ve turist sayısında büyük düşüşlere neden olmuştur.

B. İhracat Stratejilerinin Başarılı Örnekleri

Türkiye, ihracat stratejilerini geliştirmek ve küresel pazarlarda rekabet gücünü artırmak amacıyla çeşitli başarılı stratejiler uygulamaktadır.

Markalaşma ve Katma Değerli Ürünler: Türkiye, ihracatta markalaşma ve katma değerli ürünlere odaklanmaktadır. Türk ihracatçılar, ürünlerini uluslararası pazarlarda tanıtmak ve marka bilinirliğini

artırmak için yoğun çaba sarf etmektedir. Özellikle tekstil ve hazır giyim sektöründe, Türk markaları dünya çapında tanınmaktadır [23].

Yenilikçilik ve Ar-Ge: Türkiye, ihracatta yenilikçilik ve Ar-Ge çalışmalarına büyük önem vermektedir. Türkiye İhracatçılar Meclisi (TİM) ve diğer ilgili kurumlar, ihracatçı firmaların yenilikçi ürünler geliştirmesi ve Ar-Ge faaliyetlerini artırması için çeşitli destekler sunmaktadır. Bu strateji, özellikle teknoloji ve elektronik sektörlerinde başarılı sonuçlar doğurmuştur [23].

Yeni Pazar Arayışları: Türkiye, ihracatta yeni pazar arayışlarına büyük önem vermektedir. Geleneksel Avrupa pazarlarının yanı sıra, Asya, Afrika ve Latin Amerika gibi gelişmekte olan pazarlara yönelik ihracat stratejileri geliştirilmiştir. Bu strateji, Türkiye'nin ihracat hacmini artırmış ve pazar çeşitliliğini sağlamıştır [24].

E-Ticaret ve Dijital Ticaret: Dijital ticaretin yükselişi, Türkiye'nin ihracat stratejilerinde önemli bir rol oynamaktadır. Türkiye, e-ticaret platformları aracılığıyla uluslararası pazarlara erişimi kolaylaştırmakta ve ihracat hacmini artırmaktadır. Özellikle KOBİ'ler için dijital ticaret çözümleri geliştirilmiştir [10].

C. Türkiye'nin Ticaret Politikalarının Bölgesel ve Küresel Etkileri

Türkiye'nin ticaret politikaları, bölgesel ve küresel düzeyde önemli etkilere sahiptir. Bu politikalar, Türkiye'nin ekonomik entegrasyonunu artırmakta ve küresel ticaret ağındaki konumunu güçlendirmektedir.

Bölgesel Ticaret Anlaşmaları: Türkiye, çeşitli bölgesel ticaret anlaşmaları ve işbirliği platformları aracılığıyla bölgesel ticaret hacmini artırmaktadır. Karadeniz Ekonomik İşbirliği Örgütü (KEİ) ve Ekonomik İşbirliği Teşkilatı (EİT) gibi platformlar, Türkiye'nin komşu ülkelerle ticaret ilişkilerini güçlendirmektedir. Bu işbirlikleri, bölgesel ekonomik entegrasyonu artırmakta ve ticaret hacmini genişletmektedir [21].

Gümrük Birliği ve Serbest Ticaret Anlaşmaları: Türkiye'nin Avrupa Birliği ile olan Gümrük Birliği anlaşması, ülkenin AB pazarına erişimini kolaylaştırmış ve ticaret hacmini artırmıştır. Ayrıca, Türkiye, Güney Kore, Singapur, Malezya, EFTA ülkeleri ve Gürcistan gibi ülkelerle serbest ticaret anlaşmaları imzalamıştır. Bu anlaşmalar, Türkiye'nin küresel ticaret ağındaki konumunu güçlendirmekte ve ihracat hacmini artırmaktadır [19].

Küresel Ticaret Politikalarına Uyumu: Türkiye, küresel ticaret politikalarına uyum sağlamak amacıyla sürekli olarak ticaret stratejilerini güncellemektedir. Dünya Ticaret Örgütü (DTÖ) kurallarına uyum sağlamak ve uluslararası ticaret anlaşmazlıklarını çözmek için diplomatik ve hukuki yolları kullanmaktadır. Bu çabalar, Türkiye'nin küresel ticaret sistemine entegrasyonunu sağlamaktadır [11].

Türkiye, çeşitli sektörlerdeki başarı öyküleri ve zorluklar, ihracat stratejilerinin başarılı örnekleri ve ticaret politikalarının bölgesel ve küresel etkileri bağlamında incelendiğinde, küresel ticaret ağındaki stratejik rolünü ve ticaret hacmindeki artışları ortaya koymaktadır. Türkiye, otomotiv, tekstil, tarım, elektronik ve turizm gibi sektörlerde önemli başarılar elde etmiş ve küresel rekabet gücünü artırmıştır. İhracat stratejilerinde markalaşma, yenilikçilik, yeni pazar arayışları ve dijital ticaret çözümleri gibi stratejiler, Türkiye'nin ihracat hacmini ve pazar çeşitliliğini artırmıştır. Bölgesel ticaret anlaşmaları ve küresel ticaret politikalarına uyum sağlama çabaları, Türkiye'nin ticaret politikalarının bölgesel ve küresel etkilerini güçlendirmektedir.

VII. TARTIŞMA

A. Vaka Çalışmaları ve Genel Analiz Bulgularının Sentezi

Bu çalışmada ele alınan vaka çalışmaları, Türkiye'nin çeşitli sektörlerdeki başarılarını ve karşılaştığı zorlukları ayrıntılı olarak incelemiştir. Otomotiv, tekstil ve hazır giyim, tarım ve gıda, elektronik ve turizm gibi sektörlerdeki örnekler, Türkiye'nin küresel ticaret ağındaki stratejik konumunu ve rekabet gücünü ortaya koymaktadır.

Otomotiv Sektörü: Türkiye, Avrupa'nın en büyük ticari araç üreticilerinden biri olarak otomotiv sektöründe önemli bir başarı elde etmiştir. 2021 yılında 29 milyar dolarlık ihracat hacmine ulaşan sektör,

küresel tedarik zinciri sorunlarına rağmen büyümeye devam etmektedir [18]. Ancak, çip krizi ve diğer tedarik zinciri aksaklıkları, sektörün karşılaştığı başlıca zorluklar arasında yer almaktadır.

Tekstil ve Hazır Giyim: Türkiye'nin tekstil ve hazır giyim sektörü, kaliteli üretim ve hızlı teslimat avantajlarıyla küresel pazarlarda önemli bir yer edinmiştir. 2021 yılında 20 milyar dolarlık ihracat hacmine ulaşan sektör, artan küresel rekabet ve maliyet baskılarına rağmen büyümeye devam etmektedir [18].

Tarım ve Gıda: Türkiye, tarım ve gıda ürünlerinde büyük bir ihracat potansiyeline sahiptir. Fındık, zeytinyağı, meyve ve sebze ihracatında önemli başarılar elde edilmiştir. Ancak, iklim değişikliği ve tarımsal verimlilik sorunları, sektörün karşılaştığı önemli zorluklardır [22].

Elektronik ve Beyaz Eşya: Elektronik ve beyaz eşya sektöründe Türkiye, dünya çapında tanınan birçok marka için üretim yapmaktadır. 2021 yılında 10 milyar dolarlık ihracat hacmine ulaşan sektör, teknolojik yenilikler ve rekabet baskıları ile karşı karşıyadır [18].

Turizm: Turizm sektörü, Türkiye'nin hizmet ihracatında önemli bir yere sahiptir. 2019 yılında 45 milyon turist ağırlayan Türkiye, turizm gelirlerinde büyük bir artış sağlamıştır [20]. Ancak, COVID-19 salgını, turizm sektöründe ciddi düşüşlere neden olmuştur.

B. Sonuçların Mevcut Teoriler ve Çerçeveler Bağlamında Yorumlanması

Uluslararası ticaret teorileri ve modelleri, Türkiye'nin dış ticaret performansını ve stratejilerini anlamak için önemli bir çerçeve sunmaktadır. Adam Smith'in Mutlak Üstünlük Teorisi ve David Ricardo'nun Karşılaştırmalı Üstünlük Teorisi, Türkiye'nin belirli sektörlerdeki rekabet avantajlarını ve ticaret stratejilerini açıklamaktadır [4], [5].

Karşılaştırmalı Üstünlük: Türkiye, tekstil ve hazır giyim, tarım ve gıda ürünleri gibi sektörlerde karşılaştırmalı üstünlüğe sahiptir. Bu sektörlerdeki düşük üretim maliyetleri ve yüksek kalite, Türkiye'nin küresel pazarlardaki rekabet gücünü artırmaktadır. Heckscher-Ohlin Teorisi, Türkiye'nin emek yoğun sektörlerdeki üstünlüğünü ve doğal kaynaklara dayalı tarım ürünlerindeki başarısını açıklamaktadır [6].

Yeni Ticaret Teorisi: Paul Krugman tarafından geliştirilen Yeni Ticaret Teorisi, Türkiye'nin ölçek ekonomileri ve ürün çeşitliliği sayesinde küresel ticarette nasıl rekabet edebileceğini açıklamaktadır. Otomotiv ve elektronik gibi sektörlerdeki büyük üretim kapasitesi ve marka çeşitliliği, Türkiye'nin küresel ticaretteki yerini sağlamlaştırmaktadır [7].

C. Türkiye'nin Dış Ticaret Politikalarının Gelecekteki Yönelimleri

Türkiye'nin dış ticaret politikaları, küresel ticaret dinamiklerine uyum sağlamak ve rekabet gücünü artırmak amacıyla sürekli olarak güncellenmektedir. Gelecekteki yönelimler, dijital ticaretin yükselişi, yeşil ticaret politikaları ve yeni pazar arayışları üzerine odaklanmaktadır.

Dijital Ticaret ve E-Ticaret: Dijital ticaretin önemi, COVID-19 salgını ile daha da artmıştır. Türkiye, dijital ticaret çözümleri ve e-ticaret platformları aracılığıyla ihracat hacmini artırmayı hedeflemektedir. Dijital ticaret, özellikle KOBİ'ler için yeni pazar fırsatları yaratmakta ve uluslararası rekabet gücünü artırmaktadır [10].

Yeşil Ticaret Politikaları: Küresel sürdürülebilirlik trendlerine uyum sağlamak amacıyla, Türkiye yeşil ticaret politikalarını geliştirmektedir. Yenilenebilir enerji, çevre dostu üretim ve sürdürülebilir tarım gibi alanlarda yapılan yatırımlar, Türkiye'nin yeşil ticaret kapasitesini artırmakta ve uluslararası rekabet gücünü pekiştirmektedir [3].

Yeni Pazar Arayışları: Türkiye, geleneksel Avrupa pazarlarının yanı sıra, Asya, Afrika ve Latin Amerika gibi gelişmekte olan pazarlara yönelik ihracat stratejilerini genişletmektedir. Bu strateji, Türkiye'nin ihracat hacmini artırmakta ve pazar çeşitliliğini sağlamaktadır [24].

Bölgesel Entegrasyon Çabaları: Türkiye, bölgesel entegrasyon çabalarını artırarak komşu ülkelerle ticaret ilişkilerini güçlendirmeyi hedeflemektedir. Karadeniz Ekonomik İşbirliği Örgütü (KEİ), Ekonomik İşbirliği Teşkilatı (EİT) ve Türk Konseyi gibi platformlar, Türkiye'nin bölgesel ticaret entegrasyonunu desteklemektedir [21].

Sonuç olarak, Türkiye'nin dış ticaret politikaları ve stratejileri, küresel ticaret dinamiklerine uyum sağlamak ve rekabet gücünü artırmak amacıyla sürekli olarak güncellenmektedir. Dijital ticaretin yükselişi, yeşil ticaret politikaları ve yeni pazar arayışları, Türkiye'nin gelecekteki dış ticaret politikalarının ana

yönelimleri olacaktır. Bu stratejiler, Türkiye'nin küresel ticaret ağındaki konumunu güçlendirecek ve ekonomik büyümesine katkı sağlayacaktır.

VIII. SONUÇ

Bu çalışma, Türkiye'nin dış ticaretini küresel ticaret eğilimleri bağlamında analiz ederek, ülkenin çeşitli sektörlerdeki başarılarını ve karşılaştığı zorlukları ortaya koymuştur. Türkiye'nin dış ticaret yapısı, ihracat ve ithalat dinamikleri, sektörel dağılım ve ticaret politikaları incelenmiştir. Temel bulgular şu şekilde özetlenebilir:

İhracat ve İthalat Yapısı: Türkiye'nin ihracatında otomotiv, tekstil ve hazır giyim, tarım ve gıda, elektronik ve beyaz eşya gibi sektörler öne çıkmaktadır. İthalatta ise enerji, makine ve ekipman, kimyasal ürünler ve yüksek teknoloji ürünleri önemli bir yer tutmaktadır.

Ticaret Ortakları: Türkiye'nin başlıca ticaret ortakları arasında Avrupa Birliği, Çin, Rusya, ABD ve Orta Doğu ülkeleri bulunmaktadır. Bu ülkelerle olan ticaret ilişkileri, Türkiye'nin dış ticaret hacmini büyük ölçüde etkilemektedir.

Sektörel Başarılar ve Zorluklar: Türkiye, otomotiv, tekstil, tarım ve gıda, elektronik ve turizm gibi sektörlerde önemli başarılar elde etmiştir. Ancak, küresel tedarik zinciri sorunları, çip krizi, iklim değişikliği ve COVID-19 salgını gibi zorluklar, bu sektörlerdeki büyümeyi olumsuz etkilemektedir.

Dijital Ticaretin Rolü: Dijital ticaret ve e-ticaret, Türkiye'nin ihracat kapasitesini artırmakta ve uluslararası pazarlara erişimini kolaylaştırmaktadır. Dijital ticaret çözümleri, ticaret süreçlerini hızlandırmakta ve maliyetleri düşürmektedir.

Ticaret Politikalarının Bölgesel ve Küresel Etkileri: Türkiye, serbest ticaret anlaşmaları ve bölgesel entegrasyon çabaları ile ticaret hacmini artırmakta ve ekonomik entegrasyonunu sağlamaktadır. Gümrük Birliği ve çeşitli STA'lar, Türkiye'nin küresel ticaret ağındaki konumunu güçlendirmektedir.

Bu bulgular, Türkiye'nin dış ticaret stratejilerinin ve politikalarının, küresel ticaret dinamiklerine uyum sağlamak ve rekabet gücünü artırmak amacıyla sürekli olarak güncellenmesi gerektiğini göstermektedir.

Politikacılar İçin Öneriler:

Dijital Ticaret Stratejileri: Dijital ticaretin yükselişi, Türkiye'nin ihracat kapasitesini artırmak için önemli bir fırsattır. Politikacılar, dijital ticaret altyapısını güçlendirmeli ve KOBİ'lerin uluslararası pazarlara erişimini kolaylaştıran politikalar geliştirmelidir.

Yeşil Ticaret Politikaları: Sürdürülebilirlik trendlerine uyum sağlamak amacıyla, yenilenebilir enerji, çevre dostu üretim ve sürdürülebilir tarım gibi alanlarda yatırımlar artırılmalıdır. Bu politikalar, Türkiye'nin yeşil ticaret kapasitesini artıracak ve uluslararası rekabet gücünü pekiştirecektir.

Ticaret Engelleri ile Mücadele: Koruma politikaları ve ticaret savaşlarının etkilerini en aza indirmek için serbest ticaret anlaşmaları ve bölgesel entegrasyon çabaları güçlendirilmelidir. Ayrıca, Dünya Ticaret Örgütü gibi uluslararası platformlarda aktif rol alınarak, ticaret anlaşmazlıklarının çözümüne katkıda bulunulmalıdır.

Gelecek Araştırmalar İçin Öneriler:

Küresel Ticaret Dinamikleri: Küresel ticaret dinamiklerinin Türkiye'nin dış ticareti üzerindeki uzun vadeli etkilerini inceleyen araştırmalar yapılmalıdır. Bu çalışmalar, küresel ekonomik krizler, ticaret savaşları ve dijital ticaretin Türkiye'nin dış ticaret performansına etkilerini anlamak için önemlidir.

Ticaret ve İstihdam: Türkiye'nin dış ticaret politikalarının istihdam üzerindeki etkilerini inceleyen araştırmalar artırılmalıdır. İhracatın ve ithalatın istihdam yaratma potansiyeli, ekonomik büyüme ve kalkınma hedefleri açısından kritik öneme sahiptir.

Bölgesel Ticaret Anlaşmaları: Bölgesel ticaret anlaşmalarının Türkiye'nin ekonomik entegrasyonu üzerindeki etkilerini analiz eden çalışmalar yapılmalıdır. Bu araştırmalar, Türkiye'nin bölgesel işbirliği stratejilerini ve ticaret hacmini artırmak için atılması gereken adımları belirleyecektir.

Sonuç olarak, Türkiye'nin dış ticaret politikaları ve stratejileri, küresel ticaret dinamiklerine uyum sağlamak ve rekabet gücünü artırmak amacıyla sürekli olarak güncellenmelidir. Dijital ticaretin yükselişi, yeşil ticaret politikaları ve yeni pazar arayışları, Türkiye'nin gelecekteki dış ticaret politikalarının ana yönelimleri olacaktır. Bu stratejiler, Türkiye'nin küresel ticaret ağındaki konumunu güçlendirecek ve ekonomik büyümesine katkı sağlayacaktır.

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CuBZr Bileşiğinin Fiziksel Özelliklerine Dair İlk İlkeler Çalışması

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Özet **–** Heusler alaşımlarının spintronik, manyetik tünel bağlantıları, şekil hafıza etkisi, elektro-optik ve opto-elektronik cihazlar gibi birçok alanda geniş bir kullanım alanı bulunmaktadır. Bu alanlarda kullanılan Heusler alaşımlarının kullanım alanları arasında sensörler, manyetoresistörler, fotovoltaik dedektörler ve ışık yayan diyotlar bulunmaktadır. Heusler alaşımları, optik ve elektronik özellikleri geliştirilmiş yeni malzemelerin arayışında önemli bir rol oynamaktadır. Bu malzemelerin ayarlanabilir bant aralığı, büyük manyetizasyon ve yüksek Curie sıcaklığı (Tc) gibi özellikleri, araştırmacıların dikkatini çekmektedir. Bu çalışma, Yarı- Heusler CuBZr bileşiğinin temel fiziksel özelliklerini anlamayı ve analiz etmeyi amaçlamaktadır. Vienna Ab-initio Simülasyon Paketi (VASP) kullanılarak, bu malzemenin yapısal, elastik, elektronik, optik ve titreşimsel özellikleri incelenmiştir. Elde edilen sonuçlar, CuBZr bileşiğinin mekanik ve dinamik olarak kararlı olduğunu göstermektedir, bu da çeşitli uygulamalar için uygun olduğunu önermektedir. CuBZr bileşiğinin incelenmesi, literatürdeki boşlukları doldurmak, gelecekteki deneysel çalışmalara rehberlik etmek ve bu alandaki araştırmaların temelini oluşturmak için katkı sağlayabilir. Bu araştırma, enerji sektöründe daha sürdürülebilir ve verimli çözümlerin geliştirilmesine katkıda bulunabilir.

Anahtar Kelimeler – Half Heusler, DFT, Termodinamik Özellikler, Mekanik Özellikler, Optik Özellikler

I.GİRİŞ

Heusler alaşımları, süper iletkenlik, elektronik endüstrisi ve yüksek termoelektrik güç cihazlarındaki şaşırtıcı özellikleri nedeniyle bilim adamları ve araştırmacılar tarafından büyük ilgi görmüştür. Heusler alaşımının ilginç olgusu, manyetik olmayan elementlerden oluşması, ancak birleşik alaşımın manyetik özellikler göstermesidir. Heusler alaşımları, yarı Heusler alaşımları ve tam Heusler alaşımları olmak üzere iki kategoriye ayrılır. Yarı Heusler bileşikleri, elektronik, manyetik ve termoelektrik özellikleri nedeniyle malzeme bilimi ve mühendisliği alanında büyük ilgi gören önemli bileşiklerdir. Bu bileşikler genellikle XYZ formülünde ifade edilir, burada X ve Y geçiş metalleri veya nadir toprak elementleri, Z ise genellikle p-blok elementidir[1]. CuBZr, bu tür yarı-Heusler bileşiklerinden biridir ve özellikle yarıiletken özellikleriyle öne çıkar.

Yarı- Heusler bileşikleri, tamamen dolu bir d-bandı ve kısmen dolu bir p-bandı ile karakterize edilirler ve bu yapı, onların elektriksel, optik ve termal özelliklerini belirler. CuBZr bileşiği, yüksek sıcaklık kararlılığı, kimyasal dayanıklılık ve ayarlanabilir elektronik özellikler gibi avantajları ile dikkat çekmektedir. Bu nedenle, CuBZr'nin yapısal, elastik, elektronik, optik ve titreşimsel özelliklerinin detaylı bir şekilde incelenmesi, bu malzemenin potansiyel uygulama alanlarını belirlemek için kritiktir.

Bu çalışmada, CuBZr bileşiğinin yapısal, elastik, elektronik ve optik özellikleri yoğunluk fonksiyonel teorisi (DFT) yöntemi kullanılarak araştırılmıştır. DFT, kuantum mekaniksel hesaplamalar için güçlü bir araç olup, malzemelerin temel özelliklerini tahmin etmede yüksek doğruluğa sahiptir. Bu yöntem, CuBZr'nin farklı fiziksel özelliklerini anlamak ve gelecekteki uygulamalarda kullanılabilirliğini değerlendirmek için kullanılmıştır.

Yapısal analizler, CuBZr bileşiğinin kristal yapısını ve mekanik kararlılığını belirlemek için gerçekleştirilmiştir. Elastik özellikler, malzemenin mekanik dayanıklılığını ve deformasyonlara karşı direncini değerlendirirken, elektronik özellikler yarıiletken davranışını ve bant yapısını anlamak için incelenmiştir. Optik özellikler ise malzemenin ışık ile etkileşimini ve potansiyel optoelektronik uygulamalarını değerlendirmek için analiz edilmiştir. Son olarak, titreşimsel özellikler, malzemenin fonon spektrumunu ve termal kararlılığını belirlemek için araştırılmıştır.

Bu kapsamlı analizler sonucunda, CuBZr bileşiğinin yapısal, elastik, elektronik ve optik özellikleri detaylı bir şekilde ortaya konulmuş ve bu özelliklerin malzemenin potansiyel uygulama alanlarına olan etkisi tartışılmıştır. Bu çalışma, CuBZr'nin ileri teknoloji uygulamalarında kullanılabilirliğine dair önemli bilgiler sunmaktadır ve gelecekteki araştırmalara temel oluşturmaktadır.

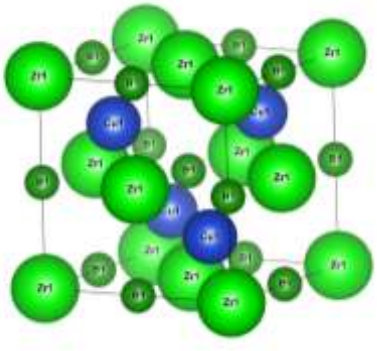
II.MATERYAL VE YÖNTEM

Yarı-Heusler alaşımı CuBZr'nin yapısal, elastik, elektronik, ve optik özellikleri, Kohn-Sham denklemini çözmek için VASP[2] paket programı ile düzlem dalga sözde-potansiyel yöntemi kullanılarak araştırılmıştır. PBE tipi [3] genelleştirilmiş gradyan yaklaşımı ile norm koruyucu psödopotansiyel, değişim-korelasyon fonksiyonlarının çözümünü hesaplamak için değerlik elektronlarının, iç elektronların ve çekirdeklerin etkileşimini ölçmek için kullanılmıştır. Dalga fonksiyonunun yakınsaması için 700 eV mertebesinde kinetik enerji kesiti seçilmiştir. Brillouin bölgesinin entegrasyonu için 16 × 16 × 16 k-noktası ölçüm mertebesinde Monkhrost-Pack [4] sistemi kullanılmıştır. Kristal yapı hesaplamaları Birch-Murnaghan'ın durum denklemini [5] içermektedir. Titreşim özellikleri yoğunluk fonksiyonel pertürbasyon teorisi (DFPT) [6] uygulanarak incelenmiştir. Üç dinamik matrisin bulunması için 2 × 2 x 2 mertebesinde süper hücre kullanılmıştır. Titreşimsel özellikleri analiz etmek için fonon dispersiyon eğrileri ve frekansları PHONOPY kodu[6] kullanılarak hesaplanmıştır. Elastik sabitler, zor-zorlanma yöntemi ile belirlenmiştir.

III.BULGULAR VE TARTIŞMA

A. *Yapısal ve Elastik Özellikler*

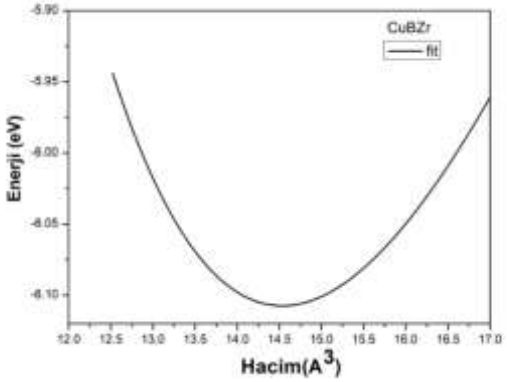
CuBZr, Şekil 1'de gösterilen ve VESTA 3D programında oluşturulan F43m (No. 216) uzay grubuna sahip yüz merkezli kübik (fcc), MgAgAs tipi bir yapıdan oluşur. Birim hücre, sırasıyla (0.25, 0.25, 0.25), (0.5, 0.5, 0.5) ve (0.0, 0.0, 0.0), Whyckoff [7] pozisyonlarında bulunan Cu, B ve Zr atomları ile üç atom içerir.



Şekil 1. Birim Hücre

Birim hücrenin hacim değişimine karşı toplam enerji değişimlerinin diyagramı yapısal kararlılık hakkında bilgi verir. CuBZr bileşiğinin yapısal ve mekanik özellikleri, enerji-hacim grafiği (Şekil 2) ve kristal yapısı (Şekil 1) kullanılarak belirlenmiştir. Şekil 2 Murnaghan [5] Durum Denklemine göre hesaplanan CuBZr için hacmin (E-V) bir fonksiyonu olarak optimize edilmiş enerjiyi göstermektedir Enerji-hacim grafiği,

CuBZr bileşiğinin kararlı bir kristal yapıya sahip olduğunu göstermektedir. Kristal yapısının belirlenmesi, bileşiğin potansiyel uygulamaları için önemlidir.



Şekil 2. Enerji-Hacim Eğrisi

CuBZr bileşiğinin yapısal parametreleri, örgü parametreleri (a_0), bulk modülü (B), B′ bulk modülünün birinci dereceden basınç türevi, Tablo 1'de sunulmuştur. Örgü sabiti 5.66 Å dır. Literatürdeki değerle tamamen aynı sonuç elde edilmiştir[8]. Yapısal özelliklerin yanı sıra, mekanik özellikler de malzemenin dayanıklılığı ve endüstriyel uygulamalarda kullanılabilirliği açısından kritik öneme sahiptir. CuBZr'nin mekanik özellikleri, Bulk modülü (B), Shear modülü (G), Young modülü (E), Poisson oranı (ν), ve Bulk/Shear modülü oranı (B/G) gibi parametrelerle değerlendirilmiştir. Bu parametreler, malzemenin çeşitli mekanik streslere karşı nasıl tepki vereceğini belirler. Mühendislik uygulamalarında kullanılacak malzemelerin gerilme ve şekil değiştirme etkisi altındaki tepkileri çok önemlidir. Malzemelerin elastik sabitleri mekanik özelliklerin anahtarıdır. Dolayısıyla sertlik, süneklik, kimyasal bağ yapısı, plastisite, anizotropi, ses hızları, Debye sıcaklığı, erime sıcaklığı gibi birçok bilgiye bu elastik sabitler ile ulaşılmaktadır[9]. Kübik sistem, uygun kafes bozulmaları kullanılarak hesaplanan C_{11}, C_{12} ve C_{44} olmak üzere üç bağımsız elastik sabite sahiptir.

Tablo 1: Yapısal ve Mekanik Özellikler

Basınç (GPa)	**a (Å)**	**B (GPa)**	**B'**	**C_{11} (GPa**	**C_{22} (GPa)**	**C_{44} (GPa)**	**G (GPa)**	**E (GPa)**	**ν**	**G/B**
0	5.66	147.52	4.06	199.2	123.3	39.9	39	107.5	0.3793	0.264
[8]	5.66									

CuBZr bileşiğinin mekanik kararlılığı, kübik kristaller için beş kriter(Born kararlılık kriterleri [10])

(C11>0, C44>0, C11>C12, C11+2C12>0, C12<B<C11) (1)

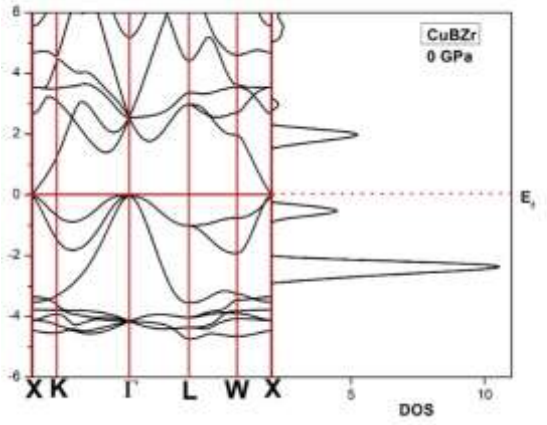
ile kontrol edilir. Tablo 2'de görüldüğü bu bileşik mekanik olarak kararlıdır. Bir malzemenin Bulk modülü B, sertliğinin ve kırılmaya karşı direncinin bir ölçüsüdür. Kayma modülü G, stres altında plastik deformasyona karşı direncin bir ölçüsüdür. Young modülü (E), çekme gerilmesinin çekme gerinimine oranı olarak tanımlanabilir. Bu değerler Tablo 2'de gösterilmektedir. Tablo 1'den görüldüğü gibi CuBZr için hespalanan Bulk modülü 147.52GPa. Bu değerler, CuBZr'nin yüksek elastik modüllere sahip olduğunu ve

mekanik olarak kararlı bir malzeme olduğunu göstermektedir. Yüksek Bulk modülü, malzemenin sıkıştırılabilirliğinin düşük olduğunu ve yapısal stabilitesinin yüksek olduğunu gösterir. Shear modülü ve Young modülü, malzemenin deformasyona karşı dirençli olduğunu ve yüksek mukavemet özelliklerine sahip olduğunu gösterir. Poisson oranı ise malzemenin elastik deformasyon sırasında nasıl davrandığını belirler; 0.3793 değeri, CuBZr'nin elastik deformasyonlar sırasında hacimsel değişikliklere karşı duyarlı olduğunu gösterir. Bulk modülünün kayma modülüne oranı olarak bilinen Paugh oranı, malzemenin kovent/iyonik durumu hakkında bilgi verir. G/B değerleri Tablo 1'te verilmiştir. Sıklıkla, kovalent bir malzeme için G/B yaklaşık 1,1 iken iyonik bir malzeme için G/B <0,6'dır[11]. Bu G/B değerleri dikkate alındığında CuBZr iyonik karakterli malzemelerdir. Öte yandan, G/B değeri malzemenin sünek/kırılgan özelliğinin değerlendirilmesinde belirleyici unsurlardan biridir. Bu oran 0.6dan küçük ise sünek davranış, aksi takdirde gevrek davranış sergiler. CuBZr bileşiği sünek davranış sergilediği görülmektedir. Poisson oranı (ν) malzemenin sünek/kırılgan olup olmadığını belirleyen ikinci bir parametredir. Bu Poisson oranında malzemenin sünek olması için kritik değer 0.260'dir[12]. CuBZr bileşiği Tablo 1'te gösterildiği gibi 0,26'dan büyük ν değerine sahiptir dolayısıyla sünek yapıya sahiptir.

Bu yapısal ve mekanik analizler, CuBZr bileşiğinin endüstriyel ve teknolojik uygulamalarda kullanılabilirliği hakkında önemli bilgiler sağlamaktadır. Özellikle, yüksek mekanik dayanıklılık ve stabilite özellikleri, bu malzemenin çeşitli mühendislik uygulamalarında kullanılmasını mümkün kılmaktadır. Bu özellikler, CuBZr'nin elektronik cihazlar, termoelektrik jeneratörler ve yapısal bileşenler gibi geniş bir uygulama yelpazesinde kullanılabilmesini sağlar.

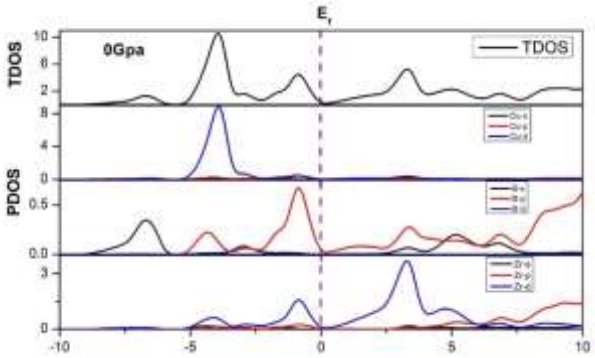
B. *Elektronik Özellikler*

Herhangi bir malzemenin elektronik özellikleri, malzemenin doğası hakkında bilgi verir. Elektronik özelliklerin hassasiyeti, bileşiğin fiziksel özelliklerinin çok hassas olmasına neden olur. Elektronik bant grafikleri ve durum yoğunluğu grafikleri, bir malzemenin elektronik özelliklerini analiz etmek için kullanılır.Araştırılan bileşiğin özellikleri hakkında fikir vermek için elektronik enerji durumların toplam, atomik ve yörünge yoğunluklarının yanı sıra bant yapıları da göz önünde bulundurularak hesaplandı. CuBZr bileşiğinin elektronik yapısını ve faz kararlılığını araştırmak için yüksek simetri yönü(X K G L W X) boyunca enerji bandı yapısı, toplam elektronik durum yoğunluğu ile birlikte Şekil 3'te verilmiştir. Şekil 3a'da görüldüğü gibi, CuBZr bileşiğinin valans bandının maksimumu X noktasında ve minimum iletim bandı X noktasındadır. Fermi seviyesi 0 ev olarak ayarlanmıştır. Fermi seviyesinde valans bandı ile iletim bandı arasında örtüşme olmadığından, doğrudan 0.37 eV band aralığına sahip bir yarı iletkendir.



Şekil 3. Elektronik band grafiği

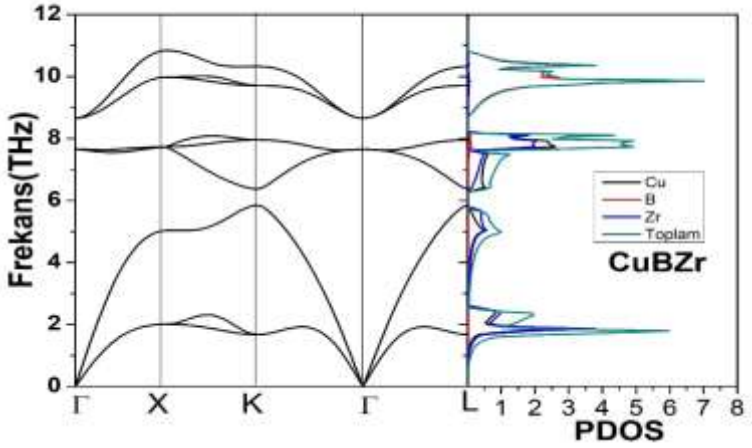
Durum yoğunluğu (Density of States, DOS) grafikleri, belirli bir enerji seviyesinde mevcut olan elektronik durumların sayısını gösterir. Toplam ve kısmi DOS grafikleri, bir malzemenin elektronik yapılarına dair detaylı bilgi sağlar. CuBZr bileşiklerinin kısmi DOS'ları da Şekil 4'te gösterilmiştir. Kısmi DOS, farklı atomların veya orbitallerin katkılarını ayırt etmeye yarar Bu grafikler, belirli enerji seviyelerinde hangi atomların veya orbitallerin daha fazla katkı sağladığını belirlemek için kullanılır. Bu bilgileri kullanarak, bir malzemenin elektriksel iletkenliği, optik özellikleri ve diğer elektronik özellikleri hakkında kapsamlı bir analiz yapılabilir. Şekil 4 'e göre valan bandın -8 ve -5 aralığındaki düşük enerji bölgesinde B atomunun s orbitalinden katkı gelmektedir. Oysa, -5 ve -2 eV aralığında Cu- d ve B-p katkısı baskınken -2 ve Fermi enerjsi arasında katkı Ba-p ve Zr-d orbitallerinden gelmektefir. İletkenlik bandı için ise B-p ve Zr-d katksı baskındır.



Şekil 4. Toplam ve kısmi durum yoğunluğu

C. *Titreşimsel Özellikler*

Fonon dispersiyon eğrisi, Brillouin bölgesindeki farklı simetri yönlerinde hesaplanmıştır. Bu eğride, x ekseni dalga vektörü (k) ve y ekseni ise frekansı (ω) temsil eder. Genellikle en düşük frekanslı modlar akustik modlar olarak adlandırılırken, daha yüksek frekanslı modlar optik modlar olarak adlandırılır. Şekil 5 de CuBZr alaşımı için fonon dispersiyon eğrisi ve kısmi fonon yoğunluk durumu (PDOS) gösterilmektedir.



Şekil 5. Fonon Dispersiyon Eğrisi

Fonon frekansları 2x2x2 süper hücre yaklaşımı ile Phonopy kodu[8] kullanılarak elde edilmiştir. CuBZr bileşiği için ilkel hücresinde üç atom bulunduğundan, herhangi bir dalga vektörü için dokuz fonon modu vardır. Bu fonon modlarından üçü akustik, diğer altı mod ise optiktir. CuBZr için belirlenen fonon dağılım

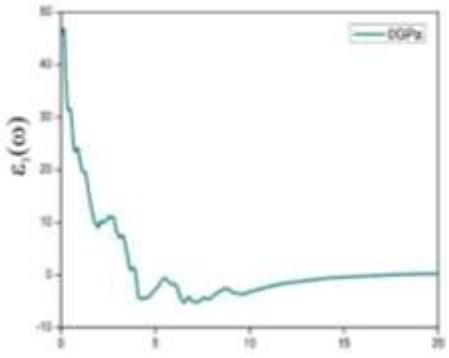
eğrileri negatif fonon frekansı olmadığından, MgAgAs yapısında dinamik olarak kararlı olduğunu göstermektedir. Şekil CuBZr alaşımı için, optik modlar 5 THz'in üstünde başlayarak daha karmaşık bir yapıya sahiptirler. Bu modlar, farklı atomların (Cu, B, Zr) kafes içinde birbirine göre hareketlerini ifade eder. Fonon yoğunluk durumu (PDOS) grafiği, her bir atom türü (Cu, B, Zr) için fononların katkılarını göstermektedir. Optik ve akustik modlar arasında var olan bant boşlukları triatomik yapıdan (atomik kütlelerdeki farklılık) kaynaklanmaktadır. Düşük frekanslarda, Zr tomundan çoğunlukla olmak üzere Cu dan,orta frekanslarda Cu coğunlukta olmak üzere ve Zr katkısı da mevcuttur. Yüksek frekanslarda ise B atomundan katkı gelmektedir.

D. Optik Özellikler

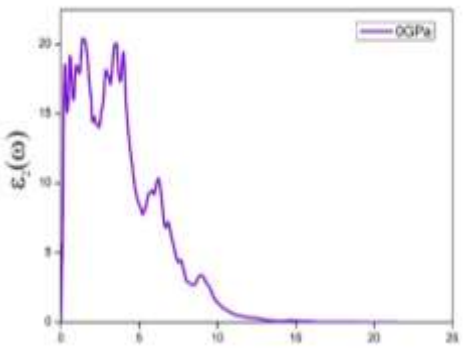
CuBZr bileşiğinin optik davranışları, optik özellikleri belirlenerek 0-20 eV aralığında analiz edilmiştir. Optik özellikler yarı iletken malzemeler için çok önemlidir, elektronik bant yapısı ve optik özellikler arasındaki ilişkiyi açıklar5. Ayrıca, yarı iletken malzemelerin optik özelliklerinde, çok düşük frekanslarda metal benzeri davranış gözlenirken, çok yüksek frekanslarda yalıtkan bir davranış sergiler31; bu da optik özelliklerin gelen foton enerjisindeki değişikliklerle incelenmesini gerektirir. Kırılma indisi, sönme katsayısı, yansıtma, iletkenlik ve soğurma katsayısı gibi optik özellikler dielektrik fonksiyonundan elde edilebilir[9]. Karmaşık dielektrik fonksiyon şu şekilde tanımlanır[10]:

$$\varepsilon(\omega)= \varepsilon_1(\omega)+i\varepsilon_2(\omega) \qquad (2)$$

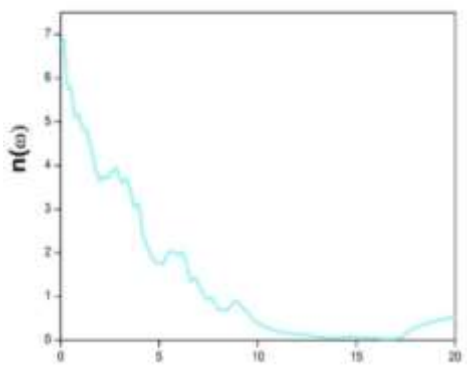
CuBZr için hesaplanan dielektrik fonksiyonunun reel ve sanal kısımlarının 0 ila 20 eV aralığındaki foton enerjisine göre ayrı bir grafiğini sunmaktadır (değişim noktası odaklanmıştır). Malzemenin metalik bir dielektriğe geçiş yaptığı frekans plazma frekansı (ωp) olarak adlandırılır ve dielektrik fonksiyonun reel kısmının $\varepsilon_1(0) = 47$. Negatif $\varepsilon_1(\omega)$ değerleri CuBZr'nin görünür ve UV bölgelerinde metalik davranışını gösterir. Bu nedenle, bu bileşiğin farklı frekans bölgelerinde optik filtrelerde veya ekranlama cihazlarında kullanımları vardır. $\varepsilon_1(\omega)$ değerleri IR ve görünür bölgelerde enerji emiliminin yüksek olduğunu gösterirken, Görünür bölgeden UV bölgesine geçerken değerler minimuma düşmektedir. Sanal dielektrik fonksiyonu $\varepsilon_2(\omega)$ için ana pikler 1.5 eV de gözlenmektedir. ε_2'deki (ω) pikler görünür bölgede ve IR'de dalgalı bir özellik gösterir. Pozitif $\varepsilon_2(\omega)$ değerleri optik soğurma bölgelerini gösterir.



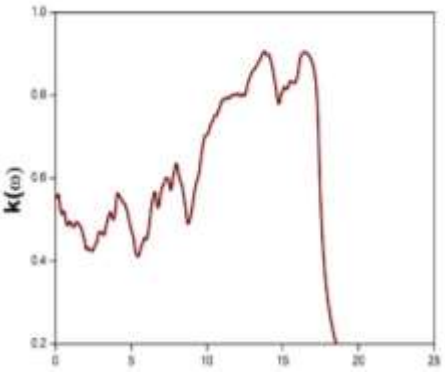
Şekil 6. Reel Dielektrik Sabiti



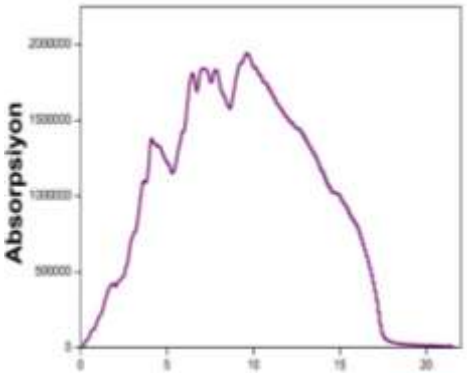
Şekil 7. Sanal Dielektrik Sabiti



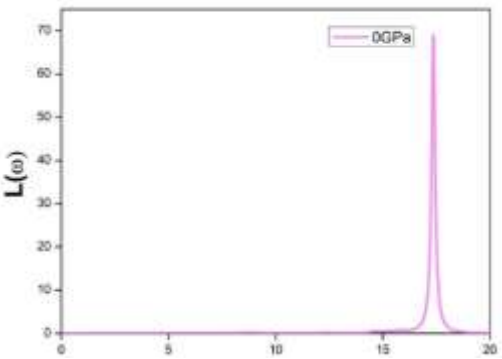
Şekil 8 Kırılma indisi



Şekil 9. Sönüm Katsayısı



Şekil 10. Absorpsiyon



Şekil 11. Enerji Kayıp Fonksiyonu

III.SONUÇLAR

GGA-PBE yaklaşımı, CuBZr Yarı- Heusler yarı-iletken CuBZr bileşiğinin ilk prensip hesaplamalarını değerlendirmek için kullanılmıştır. Hesaplanan temel hal özellikleri, elektronik bant yapısı, optik, elastik sabitler ve ilgili özellikler literatür ile uyumludur. CuBZr bileşiği, elektronik bant yapısına uygun olarak doğrudan bir bant aralığı sergilemektedir. Bu bileşik, elastik özelliklerinden de anlaşılacağı üzere sünek ve mekanik olarak kararlıdır. Çeşitli optik özellikler de 0 eV ile 20 eV arasındaki geniş bir enerji aralığında incelenmiştir. CuBZr 'nin UV enerji aralığında absorpsiyon sergilediği bulunmuştur. Bu özelliklerinden dolayı, bu bileşik uygulama için uygun olabilir. Bu sonuçlar ayrıca yarı-iletkenler, optik ve mühendislik malzemeleri alanlarında yeni malzemeler araştıran araştırmacılar için değerli bilgiler verebilir.

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Endüstri 4.0 ile Tarımsal Sulama Yönetiminde Dijital Dönüşüm ve Yazılım Çözümleri

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Özet **-** Endüstri 4.0, üretim süreçlerini daha akıllı, verimli ve esnek hale getirerek, işletmelerin rekabet gücünü artırmakta, sürdürülebilirlik hedeflerine ulaşmalarına katkıda bulunmakta, sağladığı yeniliklerle büyük bir dönüşümü temsil etmektedir. Bu dönüşüm, nesnelerin interneti (IOT), siber fiziksel sistemler (CPS), büyük veri analitiği, yapay zekâ (AI) ve robotik gibi ileri teknolojileri içermektedir.

Dijital dönüşümle birlikte tarımsal üretimde verimliliği artırmak ve kaynakları daha etkin bir şekilde kullanmak amacıyla, akıllı tarım uygulamaları ve sulama alanında birçok yazılım ve teknoloji geliştirilmektedir. Tarımsal sulamada kullanılan otomasyon, planlama, projelendirme, analiz ve öngörü yazılımları, çiftçilere ve tarım işletmelerine modern çözümler sunarak, su kullanımını optimize etmekte ve verimliliği artırmaktadır.

Bu bildiride, Ag Studio, AquaSpy, CropX, Cyber Rain, DIDAS, DOMIS, Edyn, FarmConnect, GreenIQ, Hortau, Hydrawise, IRRICAD PRO, Irrigation Advisor, Irrigation Business Software, Irrigation Insight, Livn, Manna Irrigation Intelligence, NETCAD, NETPRO, Observant, Rachio, Rain Machine, RainCAD, Rubbicon's Farmconnect, Senninger, Smart Farm Systems, Sprinkl, Spruce, St8-Wifi Timer, Tevatronic, WaterBee, WeatherTRAK ve Zilker gibi yazılımların işlevleri, avantajları ve dezavantajları ele alınarak, tarımsal sulama alanında karşılaşılan sorunlara yönelik çözümler sunulmuştur. Ayrıca, mevcut yazılımların eksik yönleri belirlenerek, bu alanda ihtiyaç duyulan gelişmeler ve yazılımların geliştirilmesi gereken yönleri incelenmiştir. Ayrıca, akıllı tarım ve sulama yönetiminde teknolojik yeniliklerin önemi vurgulanmış ve gelecekte bu alanda yapılabilecek iyileştirmelere dair öneriler sunulmuştur.

Anahtar Kelimeler – Endüstri 4.0, Sulama, Yazılım, Akıllı Tarım, Teknoloji

I. GİRİŞ

Endüstri 4.0, üretim süreçlerinde dijitalleşme ve otomasyonu ön plana çıkaran bir dönüşümdür. Bu dönüşüm, işletmelerin operasyonlarını optimize etmelerine, maliyetleri düşürmelerine ve daha yüksek kaliteli ürünler üretmelerine olanak tanır. Endüstri 4.0 [1], talebe göre hızla değişebilen üretim hatları oluşturulmasını sağlar. Böylece ürün çeşitliliği artırılır ve müşteri taleplerine daha hızlı yanıt verilmesi sağlanır. IOT sensörleri ve büyük veri analitiği, makinelerin durumu hakkında sürekli bilgi sağlar. Bu sayede arızalar önceden tespit edilerek kesintisiz üretim sağlanabilir. Tüketici taleplerine göre özelleştirilmiş ürünler üretmek mümkün hale gelir. Bu da müşteri memnuniyetini artırır ve rekabet avantajını da beraberinde getirir. Endüstri 4.0, yalnızca üretim sektörünü değil, aynı zamanda sağlık, lojistik ve tarım gibi diğer sektörleri de etkileyerek daha verimli ve sürdürülebilir çözümler sunar. Bu dönüşüm, geleceğin endüstriyel manzarasını şekillendirirken, aynı zamanda yeni iş modelleri ve fırsatlar oluşturmaktadır.

Tarım sektöründe dijital teknolojilerin kullanımı, verimliliği artırmak ve kaynakların daha etkin kullanımını sağlamak amacıyla giderek önem kazanmaktadır [2]. Geleneksel tarım yöntemleri, iklim değişikliği, nüfus artışı ve sınırlı doğal kaynaklar gibi zorluklarla karşı karşıya kalırken, dijital teknolojiler tarımın sürdürülebilirliğini ve verimliliğini artırmak için yenilikçi çözümler sunar. Bu teknolojiler, tarımın her aşamasında uygulanarak üretim süreçlerini optimize eder ve çiftçilere önemli avantajlar sağlar. Akıllı tarım uygulamaları [3], tarımsal üretimdeki sürdürülebilirliği sağlamak için nesnelerin interneti (IOT), büyük veri, veri analitiği, yapay zekâ, otomasyon ve robotik sistemler gibi teknolojilerden faydalanmaktadır. Sulama yönetiminde bu teknolojilerin kullanımı, su kaynaklarının etkin yönetimi açısından kritik bir rol oynamaktadır. Akıllı sulama sistemleri, sensörlerden elde edilen verileri ve diğer çevresel koşulları analiz ederek bitkilerin su ihtiyaçlarını belirler ve bu doğrultuda sulama yapar. Otomatik sulama sistemleri, suyun sadece gerektiği miktarda ve zamanda kullanılmasıyla su tasarrufu sağlar. Bu, su kaynaklarının korunmasına ve tarımsal sürdürülebilirliğin artırılmasına yardımcı olur.

Bu çalışma, tarımsal sulama yazılımlarının işlevlerini, avantajlarını ve dezavantajlarını incelemeyi ve bu yazılımların tarım sektöründeki rolünü analiz etmeyi amaçlamaktadır. Sulama yazılımlarının tarım sektöründe nasıl bir değişim yarattığını anlamak ve gelecekteki araştırmalara ışık tutacak yeni bakış açıları sunmayı hedeflemektedir. Bu çalışmada, Ag Studio, AquaSpy, CropX gibi yazılımların işlevleri ve sağladıkları faydalar detaylı bir şekilde ele alınmış ve bu yazılımların tarımsal sulama süreçlerinde nasıl bir dönüşüm sağladığı incelenmiştir. Materyal ve metot kısmında yazılımlarının işlevleri, avantajları, dezavantajları ve geliştirilmesi gereken yönler sunulmuştur.

II. MATERYAL VE YÖNTEM

2 .1 MATERYAL

Bu çalışmada, tarımsal sulama yazılımlarının değerlendirilmesi için çeşitli veri kaynakları ve metodolojiler kullanılmıştır. Araştırmanın materyal kısmı şu şekilde özetlenebilir:

2.1.1 Yazılımlar ve Teknolojiler:

Tarımsal sulama için bu çalışmada; Ag Studio, AquaSpy, CropX, Cyber Rain, DIDAS, DOMIS, Edyn, FarmConnect, Hortau, Hydrawise, IRRICAD PRO, Irrigation Advisor,Irrigation Insight, Manna Irrigation Intelligence, Rain Machine, Senninger, WaterBee, isimli yazılımlar ve teknolojiler incelenmiştir. Bu yazılımlar otomatik sulama amacıyla kullanılan ve yaygın olarak tercih edilen yazılımlardır. Her bir yazılım ve teknolojiye ait avantaj ve dezavantajlar incelenmiş ve geliştirilmesi gereken yönleri sunulmuştur.

2.1.2 Veri Kaynakları:

Tarımsal sulama yazılımlarının işlevleri, avantajları ve dezavantajları hakkında mevcut literatürdeki çalışmalar ve web siteleri incelenmiştir. Üreticilerin ve kullanıcıların yorumları da dikkate alınmıştır.

2.1.3 Değerlendirme Kriterleri:

Bu çalışmada, ilgili yazılım ve teknolojilerin karşılaştırması için aşağıdaki değerlendirme kriterleri belirlenmiştir:

- Yazılımların sağladığı özellikler ve sundukları teknolojik yenilikler.
- Yazılımların kullanıcı dostu olup olmadığı ve kullanıcı geri bildirimleri.
- Sulama yönetiminde sağlanan verimlilik artışı ve su tasarrufu.
- Yazılımların maliyeti ve küçük ölçekli çiftçiler için erişilebilirlik.
- Yazılımların sağladığı teknik destek ve diğer tarımsal sistemlerle entegrasyon kabiliyeti.

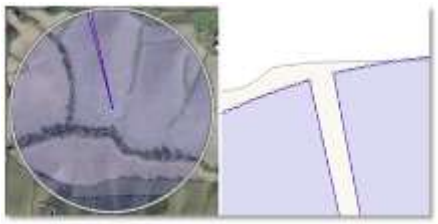
2.1.3 Analiz Yöntemleri:

Farklı yazılımların işlevleri, avantajları ve dezavantajları karşılaştırılmıştır. Her bir yazılımın güçlü ve zayıf yönleri belirlenmiş ve önerilerde bulunulmuştur.

2.2 METOT

2.2 Sulama Yönetiminde Yazılım Çözümleri

2.2.1 Ag Studio: Tarımsal veri yönetimi ve analiz platformudur [4]. Temel olarak, toprak nemini, bitki sağlığını, hava durumunu ve diğer önemli verileri izleyerek çiftçilere sulama yönetimi, planı, öneriler ve raporlar sunar. Çiftçinin ihtiyaçlarına göre verileri daha iyi anlamalarına ve karar almalarına yardımcı olur. Center pivot üzerine kurulmuş bir yazılımdır (Şekil 2.1.1).



Şekil 2.2.1. Pivot görüntüsü

Dezavantajları:

- Yazılım ve donanımın maliyetinin yüksek olmasından dolayı küçük ölçekli çiftçiler için erişilebilirlik sorunu yaratır.
- İnternet bağlantısının olmadığı veya zayıf olduğu bölgelerde Ag Studio'nun performansında düşüş yaşanabilir. Bu, veri alışverişi sorunlarına neden olabilir.

Geliştirilmesi Gereken Yönler:

- Ag Studio'nun maliyetinin düşürülmesi, yazılımın daha geniş bir kullanıcı kitlesine ulaşmasını sağlayabilir.

- Zayıf internet bağlantısı olan bölgelerde performansın artırılması ve veri alışverişi sorunlarının giderilmesi gerekmektedir.
- Veri analizi ve öngörü yeteneklerini daha da geliştirerek çiftçilere daha ileri düzeyde analizler sunabilir. Bu, kullanıcıların tarım yönetimini daha etkin bir şekilde yapmalarını sağlayabilir

2.2.2 AquaSpy: Bulut tabanlı, nesnelerin interneti (IOT) ile haberleşebilen, tarımsal sulama yönetimini optimize etmek için geliştirilmiş bir yazılım ve donanım platformudur [5]. Toprak altı sensörlerini kullanarak toprak nemini, sıcaklığını ve tuzluluk seviyesini ölçer ve bu verileri gerçek zamanlı olarak çiftçilere sunar. Veri analizi ve algoritmalar kullanılarak sulama ihtiyacı belirlenir ve suyun daha verimli kullanılması sağlanır. Mobil uygulama üzerinden de erişim sağlanabilir. 16 ülkede faaliyet gösteren AquaSpy, küresel çapta mahsul çiftçilerini desteklemeye, sulama ve besin kararlarındaki riskleri ve tahminleri ortadan kaldırmalarına yardımcı olmaya kendini adamıştır. AquaSpy prob sensörleri, her beş dakikada bir toprağın 12 katmanının tamamına elektrik sinyalleri gönderir. Daha sonra AgSpy akıllı algoritmaları bu sinyalleri eyleme dönüştürerek çiftçinin karar verebilmesi için anlaşılması kolay, veri odaklı grafikler ve görüntüler sunar (Şekil 2.2.2).

Şekil 2.2.2. AquaSpy prob sensörü ve sinyallerin grafiksel görüntüsü

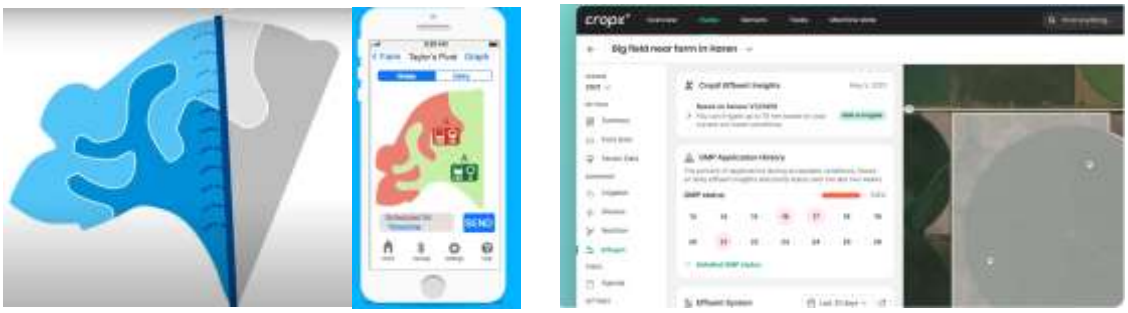
Dezavantajları:

- Kurulum ve kullanım sürecinde teknik bilgi gerektirebilir, bu da bazı kullanıcılar için zorlayıcı olabilir.
- Tam işlevsellik için sürekli internet bağlantısı gerekebilir, bu da bağlantı sorunları yaşanan bölgelerde sıkıntı yaratabilir.

Geliştirilmesi Gereken Yönler:

- Kullanıcıların yazılımı daha etkin kullanabilmeleri için kapsamlı çevrimiçi ve yerinde eğitim programları geliştirilebilir. Web seminerleri, video eğitimler ve kılavuzlar bu konuda yardımcı olabilir.
- Teknik destek ekibi genişletilerek kullanıcıların karşılaştığı sorunlara daha hızlı ve etkili çözümler sunabilmek için 7/24 destek hizmetleri, yerel temsilciler ve hızlı yanıt süreleri önemli olabilir.
- İnternet bağlantısının sınırlı olduğu alanlar için offline modda çalışabilen özellikler geliştirilebilir. Bu, kullanıcıların internet bağlantısı olmadan da veri toplayıp analiz yapabilmelerini sağlar.
- Kullanıcı verilerinin nasıl toplandığı, kullanıldığı ve korunduğu konusunda daha şeffaf gizlilik politikaları sunulabilir. Kullanıcıların verilerinin güvende olduğundan emin olmaları sağlanmalıdır.
- AquaSpy'nin API'ları geliştirerek üçüncü parti uygulamaların entegrasyonu kolaylaştırılabilir. Bu, daha fazla özelleştirme ve genişletilebilirlik sunar.
- Farklı dillerde hizmet sunularak küresel kullanıcı kitlesine daha iyi hizmet verilebilir. Kullanıcıların ana dillerinde destek almaları sağlanmalıdır.
- Daha büyük veri setlerinin analiz edilebilmesi ve bu verilerden daha derin öngörüler elde edilmesi için büyük veri analitiği kullanılabilir. Daha kapsamlı analizler ve öngörüler sunulabilir.

2.2.3 CropX: Yapay zekâ ve makine öğrenimini kullanarak toprak nemini, sıcaklığı ve bitki sağlığını izleyen sensörler, çiftçilere sulama ihtiyaçlarını belirleme konusunda gerçek zamanlı bilgi sunar [6]. Bu veriler, CropX platformunda analiz edilir ve kullanıcıya sulama planları, öneriler ve raporlar sağlanır. Bir veya binlerce alanı aynı kontrol panelinden yönetebilme yeteneği sunar (Şekil 1.2.3).



Şekil 2.2.3. CropX kontrol paneli

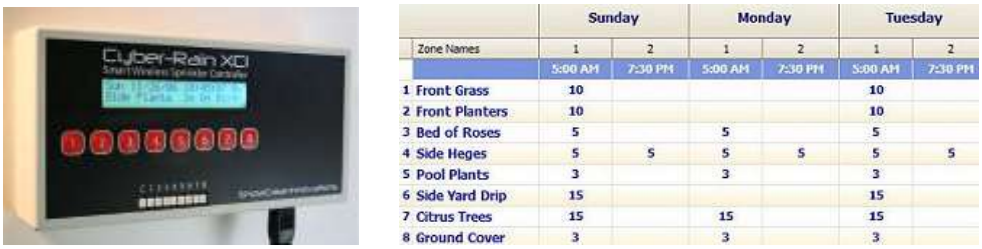
Dezavantajları:

- Bazı coğrafi bölgelerde veri toplama ve analiz hizmetleri yeterince kapsamlı değildir.
- Farklı tarım sistemlerine ve coğrafi bölgelere uyum sağlayabilen daha esnek ve özelleştirilebilir bir uygulama olmalıdır.

Geliştirilmesi Gereken Yönler:

- Mobil uygulamanın daha işlevsel hale getirilmesi ve saha içindeki kullanıcıların ihtiyaçlarını daha iyi karşılaması sağlanabilir.
- Daha gelişmiş veri analizi ve yapay zekâ teknikleri ile daha isabetli ve öngörülebilir sulama planları oluşturulabilir.

2.2.4 Cyber Rain: IOT (Nesnelerin İnterneti) teknolojisi ve bulut tabanlı veri analitiği kullanarak, kullanıcıların sulama sistemlerini uzaktan izlemelerine ve kontrol etmelerine olanak tanır [7]. Bu özellik, çiftçilere ve tarım işletme sahiplerine büyük bir operasyonel esneklik sağlar. Sensörler aracılığıyla toprak nemini, hava durumunu ve bitki ihtiyaçlarını izler, bu verileri analiz ederek sulama süreçlerini otomatik olarak ayarlar veya kullanıcıya öneriler sunar. Kullanıcı dostu arayüz, çiftçilerin ve tarım işletme sahiplerinin yazılımı etkili bir şekilde kullanmalarını kolaylaştırır ve kullanımı daha verimli hale getirir (Şekil 2.2.4). Cyber Rain, farklı tarım teknolojileri ve sistemleriyle entegre olabilir.



Şekil 2.2.4. Cyber Rain Cihazı ve yazılımı

Dezavantajları:

- Her kontrol sistemi en fazla 8 bölgeyi yönetebilir. Bölge sayısı daha da arttırılabilir.

- Verilerin görselleştirmesi yapılmamaktadır. Bir arayüz ile verilerin grafiksel olarak gösterimi sağlanabilir.

Geliştirilmesi Gereken Yönler:

- Gelecekteki sulama ihtiyaçlarını tahmin edebilen ve optimize edebilen daha gelişmiş veri analiz ve öngörü yetenekleri sunulmalıdır. Bu, kullanıcıların daha akıllı sulama kararları almasına olanak tanır
- Farklı tarım sistemleri ve teknolojilerle entegrasyon kapasitesi artırılmalıdır. API entegrasyonları ve uyumlu veri alışverişi protokolleri geliştirilmelidir.
- Daha güvenilir ve stabil internet bağlantısı gereksinimleri azaltılmalıdır. Veri alışverişi için alternatif yöntemler veya düşük bant genişliği gerektiren seçenekler sunulabilir.

2.2.5 DIDAS: Damla sulama sistemlerinin tasarımı ve sulama planlaması için geliştirilmiş bir yazılım paketidir [8]. Farklı toprak türleri ve buharlaşma koşulları altında çeşitli bitkilerin su kullanım verimliliğini optimize etmek amacıyla sulama sistemlerinin geometrik özelliklerini değerlendirir, sulama programlarını optimize eder ve sulama verimliliğini artırır. Kullanıcı dostu arayüzü ile hem uygulayıcılara hem de akademisyenlere sulama tasarımı ve planlamasında karar desteği sağlar (Şekil 2.2.5).

Şekil 2.2.5. DIDAS yazılımı

Dezavantajları:

- DIDAS, bitki büyümesini veya verimini değerlendirmez, sadece su kullanım verimliliğini analiz eder.
- Yağmurla beslenen mahsul üretiminde veya ek sulama durumlarında kullanılamaz, yalnızca düzenli sulama programlarına uygundur.
- Program, daha çeşitli sulama stratejilerine uyum sağlamada sınırlı kalabilir, bu da farklı tarımsal uygulamalar için eksikliği yaratır.
- Yazılım sadece Microsoft Windows işletim sisteminde çalışmaktadır, bu da farklı işletim sistemlerini kullanan kullanıcılar için erişilebilirliği sınırlar.

Geliştirilmesi Gereken Yönler:

- DIDAS'a bitki büyümesi ve verim değerlendirme özelliklerinin eklenmesi, sulama verimliliğinin daha bütüncül bir şekilde analiz edilmesine olanak sağlayabilir.
- Yazılımın yağmurla beslenen mahsul üretimi ve ek sulama uygulamaları için de kullanılabilir hale getirilmesi, daha geniş bir tarımsal uygulama yelpazesi sunar.
- Daha çeşitli sulama stratejileri ve yöntemleri (örneğin, karık sulama, yağmurlama sulama) için destek sağlanması, programın esnekliğini ve kullanım alanını artırır.
- Yazılımın farklı işletim sistemlerinde (örneğin, macOS, Linux) çalışabilen sürümlerinin geliştirilmesi, daha geniş bir kullanıcı kitlesine ulaşılmasını sağlar.

- Yazılımın düzenli olarak güncellenmesi ve kullanıcı desteğinin artırılması, programın güvenilirliğini ve performansını sürekli kılar.

2.2.6 DOMIS: Tarım ve diğer sektörlerde suyun verimli kullanımını sağlamak amacıyla damla, yağmurlama ve mikro yağmurlama sulama sistemlerinin tasarımını yapan bir karar destek sistemidir. Sistem, su mevcudiyeti, mahsul türü, toprak tipi ve iklim koşulları gibi faktörleri dikkate alarak, kullanıcıya interaktif rehberlik sunar. DOMIS [9], sulama sistemlerinin detaylı maliyet hesaplamalarını yapar ve ekonomik fizibilitesini değerlendirir. Ayrıca boru yerleşimi, su ihtiyacı tahmini, su uygulama oranları, sürtünme kaybı analizleri, pompa boyutlandırması ve toplam sulama süresi gibi sulama sisteminin tüm bileşenlerinin tasarım adımlarını destekler ve bu süreçte kullanıcıya rehberlik eder (Şekil 2.2.6). Sistem ayrıca, bölgesel iklim verileri, toprak özellikleri, mahsul bilgileri ve su kalitesi gibi çeşitli verileri de içerir.

Şekil 2.2.6. DOMIS Sulama planlaması

Dezavantajları:

- Detaylı ve doğru tasarım yapabilmek için geniş çaplı veri girişi gerektirir. Bu verilerin toplanması ve doğru bir şekilde sisteme girilmesi zaman alıcı ve maliyetli olabilir.
- DOMIS, bilgisayar destekli bir sistem olduğundan, teknolojik altyapıya ve bilgiye sahip olmayan kullanıcılar için erişim ve kullanım zorluğu yaratabilir.
- Sistem, belirli bölgesel veya yerel koşullara özgü verileri ve özellikleri tam olarak kapsayamayabilir, bu da her durumda en uygun çözümü sunamayabileceği anlamına gelir.

Geliştirilmesi Gereken Yönler:

- Kullanıcıların sistemi daha kolay anlaması ve kullanabilmesi için gereksiz karmaşıklıklar azaltılmalıdır. Veri toplama ve giriş sürecindeki zaman ve çaba gereksinimini azaltabilir.
- Kullanıcıların farklı bölgesel veya yerel koşullara göre özelleştirilmiş tasarımlar yapabilmesi için sistem daha esnek hale getirilmelidir. Farklı mahsul tipleri, toprak özellikleri ve sulama ihtiyaçlarına göre çeşitli seçenekler sunulmalıdır.
- Sistemdeki hesaplama süreçleri optimize edilmeli ve daha hızlı yanıt süreleri sağlanmalıdır. Büyük veri setleriyle çalışırken performansın düşmesi önlenmelidir.
- Kullanıcıların sistemi etkin bir şekilde kullanabilmesi için eğitim materyalleri ve kullanıcı desteği güçlendirilmelidir. Kullanıcıların sistemden maksimum faydayı sağlamaları için sürekli eğitim ve teknik destek sağlanmalıdır.

2.2.7 Edyn: Bahçedeki bitkilerin sulama ihtiyacını akıllıca yönetmek için tasarlanmış bir sulama kontrol sistemi olarak işlev görür. Topraktan zararsız bir elektrik sinyali geçirerek toprak nemini, asitliğini ve verimliliğini ölçer [10]. Bu verileri, Edyn'in veri tabanlarına ve topluluğun diğer üyelerinin verilerine dayanarak analiz eder. Güneş enerjisiyle çalışan sensörler sayesinde, WiFi bağlantısıyla Edyn Cloud'a veri gönderir ve uygulama üzerinden kullanıcılara anlık olarak toprak besin içeriği, nem düzeyi, ışık yoğunluğu, sıcaklık ve pH gibi bilgileri sağlar. Bu sayede bitkiler yalnızca ihtiyaç duydukları zaman sulanır, su tasarrufu sağlanır ve bitkilerin sağlıklı büyümesi desteklenir (Şekil 2.2.7).

Şekil 2.2.7. Edyn sensörü

Dezavantajları:

- Sistem, internet bağlantısı ve Edyn Cloud'a erişim gerektirir. Bu nedenle internet kesintileri veya sorunları durumunda sistemin performansı etkilenebilir.
- Akıllı sulama sistemleri genellikle diğer geleneksel sulama yöntemlerine göre daha yüksek maliyetlidir. Yüksek başlangıç maliyeti olabilir ve kurulum için profesyonel yardım gerekebilir.
- Sensörlerin ve cihazların doğru çalışabilmesi için düzenli olarak güç kaynağına ve güneş ışığına ihtiyaç vardır. Teknolojiye bağımlılık, sistemde arızalar veya bakım gereksinimleri ortaya çıkabilir.
- Akıllı cihazların ve bulut hizmetlerinin kullanılması, veri güvenliği endişelerine yol açabilir. Kullanıcı verilerinin korunması ve gizliliği önemlidir

Geliştirilmesi Gereken Yönler:

- Sistemlerin topladığı verilerin daha derinlemesine analiz edilmesi ve kullanıcılar için anlamlı hale getirilmesi önemlidir. Makine öğrenimi ve yapay zekâ algoritmalarının daha etkin kullanılmasıyla, toprak nem, pH düzeyleri gibi parametrelerin tahmin edilmesi ve optimize edilmesi sağlanabilir.
- Sensörlerin hassasiyetinin artırılması ve daha dayanıklı malzemeler kullanılarak donanımın güvenilirliğinin artırılması gerekmektedir. Özellikle açık hava koşullarına dayanıklı, su ve gübre gibi kimyasallara karşı dirençli sensörlerin geliştirilmesi önemlidir.
- Güneş enerjisi veya pil kullanımıyla çalışan sistemlerin enerji verimliliği daha da artırılabilir. Daha düşük güç tüketimi sağlayacak teknolojik yeniliklerle, sistemlerin daha uzun süre kesintisiz çalışması sağlanabilir.
- Farklı sulama yöntemleri, toprak tipleri ve bitki türleri için uyumlu ve esnek sistemlerin tasarlanması gerekmektedir. Sistemlerin diğer akıllı ev cihazlarıyla entegrasyonu da kullanıcı deneyimini iyileştirebilir.

2.2.8 FarmConnect: Tarımın İnterneti, çiftliklerdeki akıllı sensörler ve IOT cihazlarını bir araya getirerek, çiftçilere sulama yönetimi ve tarla verilerinin analizini kolaylaştıran bir çözüm sunar [11].

AgPod adlı güçlü çiftlik içi IOT ağ geçidi, saha sensörleri ve mikro iklim istasyonları gibi entegre cihazlar aracılığıyla toplanan verileri işleyerek, kullanıcıların bitkilerin su ihtiyaçlarını belirlemelerine ve sulama planlamalarını optimize etmelerine olanak tanır. Bu sistem, FarmConnect yazılımı üzerinden (Şekil2.2.8) sağlanan bulut tabanlı hizmetlerle veri analitiği yaparak, çiftlik yönetimini dijitalleştirir ve tarımsal üretkenliği artırmayı hedefler.

Şekil 2.2.8. Farm Connect yazılımı

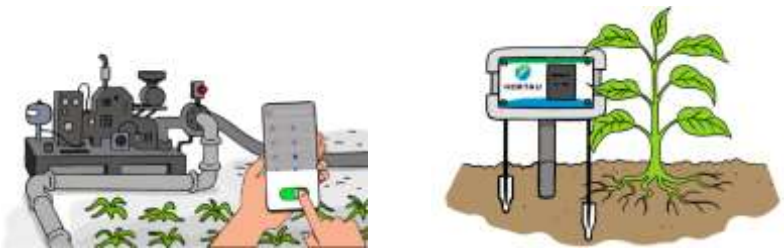
Dezavantajları:

- Sensörlerin doğru kalibre edilmemesi veya veri analizinde yaşanan hatalar gibi teknik sorunlar da performansı etkileyebilir. Bu nedenle, sistem kurulumu ve bakımı konusunda iyi bir teknik destek ve eğitim gereklidir.

Geliştirilmesi Gereken Yönler:

- İnternet erişimi gibi altyapı gereksinimlerini karşılamak için alt yapı geliştirilebilir ve kullanıcıların teknik destek alabilecekleri güvenilir bir sistem sağlanabilir.
- Farklı IOT cihazları ve platformlar arasında uyumluluk sağlamak ve entegrasyonu kolaylaştırarak çiftçilerin mevcut sistemlerine entegrasyonu ve veri paylaşımı artırılabilir.

2.2.9 Hortau: Tarım sektöründe su yönetimi konusunda uzmanlaşmış bir şirkettir. İleri düzeydeki IoT ve veri analitiği çözümleri ile çiftçilere, hassas sulama yapma imkânı sağlar. Gerçek zamanlı toprak nem, su gerginliği ve hava durumu verilerini kullanarak çiftçilere bilgi sağlar ve bu bilgiler doğrultusunda sulama kararları almalarına yardımcı olur. Hortau'nun sunduğu mobil platform sayesinde [12], çiftçiler su kullanımını optimize edebilir, verimliliği artırabilir ve tarım faaliyetlerini daha sürdürülebilir hale getirebilirler. Ayrıca, uzaktan erişim ve otomatik sulama kontrolü gibi özelliklerle işletmelerine kolaylık ve verimlilik kazandırır (Şekil 2.2.9)



Şekil 2.2.9. Hortau uzaktan kontrol sistemi

Dezavantajları:

- Sulama süreçlerinin tamamen otomasyonu, kullanıcıların teknolojiye bağımlılığını artırabilir ve geleneksel sulama yöntemlerine göre daha fazla eğitim ve teknik destek gerektirebilir.
- İnternet bağlantısına dayalı sistemlerde yaşanabilecek güç kesintileri veya bağlantı sorunları, sulama planlarının ve veri alımının aksamasına neden olabilir.

Geliştirilmesi Gereken Yönler:

- Daha gelişmiş veri analitiği ve öngörücü bakım özellikleri eklenerek, sistemlerin daha önce oluşabilecek sorunları tespit etmesi ve kullanıcıya öneriler sunması sağlanabilir.

2.2.10 Hydrawise: Wi-Fi üzerinden kontrol edilebilen akıllı bir yağmurlama denetleyicisi sağlayan bir sistemdir [13]. Kullanıcılar, web tarayıcıları veya Hydrawise mobil uygulamaları aracılığıyla dünya genelinden yağmurlama sistemlerini izleyebilir ve yönetebilirler. Dokunmatik ekranlı kontrol cihazları ile kolay kurulum ve programlama sağlanırken, sezgisel arayüzü sayesinde kullanıcılar, sulama programlarını anlamak ve özelleştirmek konusunda kolaylık yaşarlar. Profesyonel donanım desteği ile akış ölçerler, yağmur sensörleri ve ana vanalar gibi çeşitli donanımları destekleyerek eski veya yeni yağmurlama sistemlerinin entegrasyonunu sağlar (Şekil 2.2.10)

Şekil 2.2.10. Hydrawise donanımı

Dezavantajları:

- Bazı kullanıcılar için teknolojiye hızlı adapte olamama veya teknik zorluklar cihazın kullanımını karmaşık hale getirebilir.
- Cihazın bulut tabanlı olması ve kullanıcı verilerinin internet üzerinden aktarılması, veri güvenliği endişelerine yol açabilir.

Geliştirilmesi Gereken Yönler:

- Kullanıcı arayüzünün daha sezgisel hale getirilmesi ve kullanıcıların daha kolay şekilde sulama programları oluşturmasına olanak tanınabilir.
- Daha fazla sulama bileşeni ve sensörü ile uyumlu hale getirilerek sistem çeşitliliğinin artırılması ve kullanıcıların sistemlerini daha esnek bir şekilde yapılandırabilmesi sağlanabilir.
- Daha düşük güç tüketimi ile enerji verimliliği artırılarak uzun pil ömrü sunulabilir.
- Kullanıcıların yaşadıkları sorunlara hızlı yanıt verilerek iyi bir müşteri destek hizmeti sunulabilir.

2.2.11 IRRICAD PRO: Büyük sulama sistemleri üzerinde çalışan profesyonel tasarımcılar için güçlü ve kullanıcı dostu bir araçtır [14]. Hızlı, doğru ve kullanımı kolay özellikleri ile yüksek kaliteli tasarımlar üretmek için idealdir. Tasarım ve maliyet raporlarını kolayca derler. Sistem bileşenlerinin kolay girişi için özel yapılmış arayüz ekranı bulunmaktadır (Şekil 2.2.11).

Şekil 2.2.11. Irricad Pro yazılımı

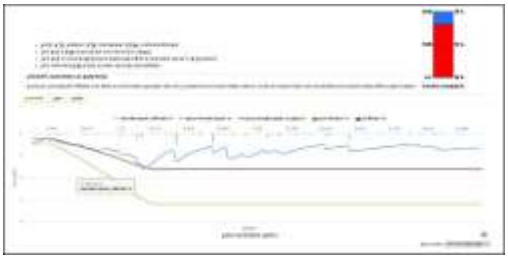
Dezavantajları:

- Profesyonel bir tasarım yazılımı olması nedeniyle IRRICAD Pro'nun maliyeti yüksek olabilir. Küçük işletmeler veya bireysel kullanıcılar için erişilebilir olmayabilir.
- Yazılımın çalıştırılabilmesi için gereken sistem gereksinimleri yüksek olabilir. Bu da bazı kullanıcılar için ek donanım veya yazılım yükseltmeleri gerektirebilir.
- Karmaşık yazılımlar genellikle sürekli güncelleme ve teknik destek gerektirir. Bu hizmetlerin maliyeti ve kullanılabilirliği, kullanıcı deneyimini etkileyebilir.
- Profesyonel tasarım yazılımları genellikle gelişmiş özelliklere sahip olmasına rağmen, kullanıcı arayüzü karmaşıklığı bazı kullanıcılar için kullanımı zorlaştırabilir

Geliştirilmesi Gereken Yönler:

- Yazılımın daha hızlı çalışması ve büyük ölçekli tasarımlar üzerinde daha etkin bir şekilde işlem yapabilmesi için performans iyileştirmeleri yapılmalıdır. Bu, kullanıcıların daha verimli çalışmasını sağlayabilir.
- Farklı veri formatlarını ve entegrasyonları destekleyerek, kullanıcıların farklı platformlarla ve sistemlerle sorunsuz bir şekilde çalışması sağlanabilir.
- Kullanıcıların yazılımdan maksimum verim alabilmeleri için eğitim ve teknik destek imkanları genişletilmelidir. Kullanıcıların yazılımı etkin bir şekilde kullanabilmeleri için sürekli destek sağlanmalı ve kullanıcı topluluğuyla etkileşim artırılmalıdır.

2.2.12 IRRICAD ADVISOR: Çiftçiler, danışmanlar veya araştırmacılar, farklı toprak tipleri, iklim koşulları ve sulama uygulamalarıyla mahsul verimini maksimize etmeyi ve aşırı sulamayı minimuma indirmeyi hızlı ve kolay bir şekilde sağlayabilirler [15]. WISE yazılımıyla, mahsulün sulama ihtiyaçlarını özetleyen detaylı programlar sunar ve bu sonuçları tablo ve grafikler halinde sunarak kullanıcıların kolayca anlamasını sağlar (Şekil 2.2.12). Sonuçlar, Excel dosyası olarak dışa aktarılabilir veya doğrudan arayüzden yazdırılabilir.



Şekil 2.2.12. Irricad Advisor

Dezavantajları:

- Doğru sulama planlaması için güvenilir hava istasyonu ve toprak verisi sağlamaya bağlıdır. Veri eksikliği veya hatalı veri girişi, tahminlerin doğruluğunu etkileyebilir.
- Uygulamanın verimliliği, kullanıldığı bölgenin iklim ve toprak koşullarına göre değişebilir. Her bölge için optimize edilmemiş uygulamalar, beklenen verimi sağlamayabilir.

Geliştirilmesi Gereken Yönler:

- Hava istasyonu ve toprak verilerinin doğruluğu, sulama planlamasının temelidir. Yazılımın bu verileri güvenilir bir şekilde işleyebilmesi ve kullanıcıya doğru tahminler sunabilmesi kritik önem taşır.
- Farklı mahsul türleri, toprak tipleri ve iklim koşulları için özelleştirilmiş sulama programlarının oluşturulabilmesi önemlidir. Yazılımın çeşitli senaryolara uyum sağlayabilmesi ve esneklik sunabilmesi gerekmektedir.
- Çiftçilerin veya danışmanların saha içinde veya dışında mobil cihazlar üzerinden erişebilmeleri ve yazılımı kullanabilmeleri önemlidir. Mobil uyumlu bir uygulama, kullanıcıların verilere her zaman erişebilmesini sağlar.

2.2.13 Irrigation Insight: Sulama Insight programı, yüksek çözünürlüklü hava tahmini verilerini kullanarak tarımsal sulama yönetimine entegre çözümler geliştirip, çevresel, sosyal ve ekonomik faydaları arttırmaya odaklanan bir araştırma girişimidir [16].

2.2.14 Manna Irrigation Intelligence: Bulut tabanlı yazılım çözümü sunarak [17], yetiştiriciler ve şirketlere sulama süreçlerini ve mahsul büyümesini izleme imkânı sağlar (2.2.14). Uydu tabanlı yapısı sayesinde geniş alanlarda kolayca uygulanabilir, donanım gereksinimlerini ortadan kaldırır ve çalışmaların ölçeklendirilmesini sağlar.

Şekil 2.2.14 Bulut tabanlı yazılımı

2.2.15 Rain Machine: Akıllı bir Wi-Fi yağmurlama sistemi sunarak su tasarrufu sağlar [18]. Sistem, her bölgenin özelliklerini kullanarak su hacmini hesaplar; bölge alanı, yağmurlama başlığı ve evapotranspirasyon (bitki ve topraktan buharlaşma) gibi faktörleri dikkate alarak sulama ihtiyacını belirler. Küresel kapsama alanına sahip olan RainMachine, çeşitli hava durumu hizmetleri aracılığıyla çalışır. Kullanıcılar, akıllı telefonlarını veya web tarayıcılarını kullanarak sistemi uzaktan kontrol edebilir ve programlayabilir, böylece doğal kaynakları etkin bir şekilde yönetebilirler.

2.2.16 Senninger: Çiftçilere daha verimli su uygulamaları sağlamak için çalışmaktadır. Senninger'in ürünleri [19], tarım alanlarında suyun daha etkin kullanılmasını ve mahsul verimliliğinin artırılmasını hedefler. Ayrıca, basınç düzenleyiciler ve Wobbler teknolojisi gibi yenilikçi ürünlerle su ve enerji tasarrufu sağlayarak sürdürülebilir sulama çözümleri sunar (Şekil 2.2.16).

Şekil 1.2.16. Senninger sulama çözümleri

2.2.17 WaterBee: Çevresel faktörleri izleyen modüler akıllı sensörlerden oluşan bir sistemdir. Toprak nemini, mahsul gelişimini ve diğer önemli parametreleri sürekli olarak takip eder. Sensörlerden gelen veriler, ZigBee kablosuz ağı üzerinden merkezi bir web servisine iletilir ve oradan da GPRS ağ geçidi aracılığıyla kullanıcıya ulaştırılır. Bu veriler, akıllı yazılım paketi tarafından analiz edilir, modeller oluşturulur ve çiftçilere özel sulama tavsiyeleri sunmak için kullanılır. Kullanıcılar, bu verilere akıllı telefon veya tabletleri üzerinden erişebilen kullanıcı dostu bir uygulama aracılığıyla ulaşırlar. WaterBee [20], su tasarrufunu artırır, işletme maliyetlerini düşürür ve bitki sağlığını ile mahsul verimini optimize etmeye yardımcı olur. Ayrıca kolay kurulum ve esneklik sağlayarak değişen koşullara hızlıca uyum sağlayabilir.

Burada belirtilen yazılımlar dışında da incelenen ve kullanılan çok sayıda yazılım bulunmaktadır ve hepsi sulama konusunda benzer çözümler sunmaktadır. Akıllı sulama sistemleri sayesinde, suyun sadece gerektiği miktarda ve zamanda kullanılması sağlanır, bu da su tasarrufunu ve bitki sağlığını maksimize eder. Böylece, tarımsal üretimde sürdürülebilirlik artırılırken, su kaynaklarının korunması ve maliyetlerin düşürülmesi de mümkün hale gelir. Bu yazılımlar, çiftçilerin karar alma süreçlerini kolaylaştırarak, tarımda daha bilinçli ve verimli uygulamaların hayata geçirilmesine olanak tanır. Tarım teknolojilerinin sürekli gelişmesiyle birlikte, sulama yazılımlarının çeşitliliği ve yetenekleri de artmakta, çiftçilere daha fazla seçenek ve esneklik sunulmaktadır.

III. BULGULAR

3.1. Yazılımların Fonksiyonelliği

Yazılımlar, toprak nem seviyesini izleyerek sulama zamanlamasını optimize etmektedir. Bu, su tasarrufu ve verimlilik artışı sağlamaktadır. Otomatik kontrol sistemleri, hava durumu verileri ile entegre çalışarak suyun etkin kullanılmasını sağlamaktadır. Sulama sistemlerinin projelendirilmesi ve planlanması için kapsamlı tasarım araçları sunulmaktadır.

3.2. Kullanıcı Deneyimi ve Kullanılabilirlik

Yazılımlar, kullanıcı dostu arayüzleri ile kullanıcıların işlemlerini kolaylaştırmaktadır. Mobil uygulamalar, kullanıcıların sulama sistemlerini her yerden yönetmelerine olanak tanımaktadır.

3.3. Performans ve Entegrasyon

Yazılımlar, tarımsal verileri gerçek zamanlı ve yüksek doğrulukta işlemektedir. Tek bir platformda toplanmasını ve yönetilmesini sağlamaktadır.

3.4. Maliyet ve Destek

Yazılımlar, maliyet açısından farklılık göstermektedir; düşük maliyetli çözümler küçük ve orta ölçekli işletmeler için cazip bulunmaktadır. Yazılımların sağladığı teknik destek ve eğitim olanakları, kullanıcı memnuniyetini artırmaktadır.

3.5. Kullanıcı Geri Bildirimleri

Kullanıcılar, yazılımların verimlilik artışı ve su tasarrufu sağlamasından memnundur. Kurulum ve ilk ayarların karmaşıklığı ve bazı yazılımların yüksek maliyetleri, kullanıcılar tarafından dile getirilmiştir.

3.6. İyileştirme Önerileri

Yazılımların daha kullanıcı dostu hale getirilmesi, kurulumu kolaylaştırılması ve maliyetlerin düşürülmesi önerilmektedir. Yazılımların performansının uzun vadede izlenmesi ve sürekli iyileştirilmesi gerekmektedir. Farklı iklim ve toprak koşullarına uygun yazılımlar geliştirilmelidir.

Bu bulgular, tarımsal sulama yazılımlarının mevcut durumunu ve gelecekte yapılabilecek iyileştirmeleri ortaya koymaktadır. Yazılımların sağladığı teknolojik avantajlar, tarım sektöründe dijital dönüşümün önemini ve bu alandaki potansiyel yenilikleri vurgulamaktadır.

IV. TARTIŞMA

Bu çalışmanın bulguları, tarımsal sulama yazılımlarının sunduğu yenilikçi çözümler ve tarım sektörüne katkıları açısından önemli sonuçlar ortaya koymuştur. Hem mevcut literatürle uyumlu hem de yeni perspektifler sunarak tarımsal sulama yönetiminin geleceği için ipuçları sağlamaktadır.

Çalışma, yazılımların kullanıcı dostu hale getirilmesi, maliyetlerin düşürülmesi ve küçük ölçekli işletmeler için erişilebilir çözümler sunulması gerektiğini göstermektedir. Gelecek araştırmalar, bu eksikliklerin giderilmesine yönelik yeni yazılımların geliştirilmesine odaklanmalıdır. Ayrıca, farklı iklim ve toprak koşullarına uygun yazılımların performansının uzun vadede izlenmesi gerekmektedir.

Bu çalışmada incelenen yazılımlar ve kullanıcı geri bildirimlerinin sayısı sınırlıdır. Gelecek çalışmalar, daha geniş bir örneklem üzerinden daha fazla yazılımı değerlendirerek kapsamlı sonuçlar elde etmelidir. Ayrıca, farklı bölgelerdeki uygulamalarla yazılımların performansının karşılaştırılması, daha genel geçer sonuçlar sağlayacaktır.

Sonuç olarak, bu çalışmanın bulguları, tarımsal sulama yönetiminde dijital dönüşümün önemini ve yazılımların sağladığı faydaları vurgulamaktadır. Yenilikçi çözümler, tarım sektöründe verimliliği artırmakta ve su kaynaklarının sürdürülebilir kullanımına katkı sağlamaktadır. Gelecekte yapılacak araştırmalar ve geliştirmeler, bu alanda daha etkin ve kullanıcı dostu çözümler sunarak teknolojik ilerlemeyi hızlandıracaktır.

V. SONUÇLAR

Bu çalışmada, tarımsal sulama alanında kullanılan yazılım ve teknolojilerin işlevleri, avantajları ve dezavantajları incelenmiş, bu yazılımların tarımsal sulama yönetiminde sağladığı katkılar değerlendirilmiştir. Çalışma sonucunda elde edilen başlıca sonuçlar aşağıda sunulmuştur.

- Toprak nem sensörleri ve veri analitiği kullanan yazılımlar, sulama zamanlamasını optimize ederek su tasarrufu sağlamış ve verimliliği artırmıştır. Bu teknolojiler, su kaynaklarının daha etkin kullanılmasını mümkün kılmıştır.
- Otomatik sulama kontrol sistemleri, hava durumu verileri ile entegre çalışarak sulama süreçlerinin otomatik olarak yönetilmesini sağlamış ve su israfını önlemiştir. Bu sistemler, kullanıcıların uzaktan erişim ve kontrol imkanlarını artırmıştır.

- Sulama sistemlerinin projelendirilmesi ve planlanması için kullanılan yazılımlar, mühendisler ve tarım uzmanları tarafından sulama sistemlerinin doğru ve verimli bir şekilde tasarlanmasına katkıda bulunmuştur.
- Kullanıcı dostu arayüzler ve mobil uygulama entegrasyonları, kullanıcıların sulama sistemlerini kolayca yönetmelerini ve anlık bilgilere erişmelerini sağlamıştır. Bu özellikler, çiftçilerin teknolojiye adaptasyonunu kolaylaştırmıştır.
- Yazılımların yüksek doğrulukta veri işleme ve hızlı analiz yetenekleri, tarımsal verilerin gerçek zamanlı olarak işlenmesine olanak tanımış ve sulama süreçlerinin daha verimli yönetilmesini sağlamıştır. Ayrıca, çeşitli tarımsal sistemlerle entegrasyon kabiliyeti, tarım işletmelerinin operasyonel verimliliğini artırmıştır.
- Yazılımların maliyetleri ve sağladığı teknik destek, kullanıcı memnuniyeti ve yazılım kullanımını etkilemiştir. Düşük maliyetli çözümler, küçük ve orta ölçekli tarım işletmeleri için cazip bulunmuş, yüksek maliyetli yazılımlar ise büyük ölçekli işletmeler için daha uygun olmuştur.
- Yazılımların daha kullanıcı dostu hale getirilmesi, maliyetlerin düşürülmesi ve küçük ölçekli işletmeler için erişilebilir çözümler sunulması gerekmektedir. Gelecekteki araştırmalar, bu eksikliklerin giderilmesine ve farklı iklim ve toprak koşullarına uygun yazılımların geliştirilmesine odaklanmalıdır.

Bu sonuçlar, tarımsal sulama yönetiminde kullanılan yazılımların sağladığı teknolojik avantajlar ve kullanım kolaylıkları ile tarım sektöründe dijital dönüşümün önemini vurgulamaktadır. Yazılımların sağladığı yenilikçi çözümler, tarım sektöründe verimliliği artırmakta ve su kaynaklarının sürdürülebilir kullanımına katkı sağlamaktadır.

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Study of electrical resistivity of hafnium in the wide temperature range using classical and quantum mechanical methods

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Özet - Bu çalışma, Bloch-Gruneisen yaklaşımını kullanarak geniş bir sıcaklık aralığında hafniyum öz direncinin analitik ve deneysel hesaplama sonuçlarını sunmaktadır. Hafniyumun önemli uygulamalara sahip olmasına rağmen, genellikle doğada zirkonyum ile birlikte bulunduğunu ve kimyasal benzerlikleri nedeniyle iki elementi ayırmanın zor olabileceğini dikkate alınması önemlidir. Hafniyuma olan talep genellikle onun nükleer teknolojilerdeki, yarıiletken endüstrisindeki ve yüksek performanslı malzemelerdeki rolünden kaynaklanmaktadır. Hafniyum malzemesinin teknolojide önemli uygulamaları olduğu göz önüne alınarak öz direncinin sıcaklığa bağlı değişimi istatistiksel fiziğin klasik ve kuantum mekaniksel yaklaşımları kullanılarak incelenmiştir. Sonuç olarak, yüksek düzeyde hassaslık olduğu ve önerilen yöntem yalnızca basit algoritmik hesaplamalar gerektirir ve yakınsama tatmin edicidir.

Anahtar Kelimeler: Hafniyum, Bloch-Gruneisen yaklaşımı, Debye sıcaklığı, özdirenç

I. Giriş

Hafniyum, sembolü (Hf) ve atom numarası 72 olan kimyasal bir elementtir. Hafniyum, 1923 yılında sırasıyla Hollandalı ve Macar kimyagerler Dirk Coster ve George de Hevesy tarafından keşfedildi. Atom numarası 72 olan tahmin edilen elementin varlığı için numuneleri analiz ederken zirkonyum cevherlerinde hafniyum buldular [1-3]. Periyodik tablodaki geçiş metali grubunun bir parçası olan parlak, gümüşi gri bir metaldir. İşte hafniyum hakkında bazı önemli gerçekler. Hafniyum doğada serbestçe bulunmaz. Genellikle zirkonyum mineralleri ile kombinasyon halinde bulunur ve sıklıkla zirkon (zirkonyum silikat) cevherlerinden çıkarılır. Hafniyum, yüksek erime noktasına sahip, ağır, yumuşak bir metaldir ve zirkonyumunkine benzer bir yoğunluğa sahiptir. Oksijen ve nitrojene karşı yüksek afinitesi vardır ve daha fazla korozyonu önleyen koruyucu bir oksit tabakası oluşturur. Elektrik elektronik endüstride geniş uygulama alanına sahiptir [3-5]. Hafniyum, nötronları absorbe edebilme özelliğinden dolayı nükleer reaktörler için kontrol çubuklarının üretiminde kullanılmaktadır. Bileşikleri, yüksek erime noktasına sahip oldukları ve yüksek sıcaklıklara dayanabildikleri için bazı özel seramiklerde kullanılır. Hafniyum ayrıca bazı alaşımlarda mekanik ve korozyona dayanıklılık özelliklerini geliştirmek için de kullanılır. Hafniyumun en önemli uygulamalarından biri nükleer endüstridir. Hafniyum, nötronları güçlü bir şekilde emer, bu da onu kontrol çubuklarında ve nükleer reaktörlerin diğer bileşenlerinde faydalı kılar. Hafniyum ayrıca bazı nötron emici alaşımların üretiminde de kullanılır. Hafniyum dioksit (HfO2), modern yarıiletken cihazların üretiminde kullanılarak, güç tüketiminin azaltılmasına ve elektronik devrelerde performansın artırılmasına yardımcı olur [6-10].

Hafniyumun sıklıkla zirkonyum ile birlikte bulunduğunu ve bu iki elementin kimyasal benzerliklerinden dolayı ayrılmasının teknik olarak zor olduğunu belirtmekte fayda var. Hafniyum metal bir element olduğundan yüksek termal iletkenliğe ve elektrik iletkenliğe sahiptir. Hafniyum, standart

sıcaklık ve basınçta parlak bir katıdır ve yüksek erime sıcaklığına sahiptir. Hafniyum diğer bazı metallerle karşılaştırıldığında doğada nispeten azdır ve üretimi genellikle zirkonyum talebine ve çeşitli uygulamalarına bağlıdır. Bu çalışmada hafniyumun özdirencinin sıcaklığa göre değişmesi klasik ve kuantum mekaniksel yaklaşımlar kullanılarak incelenmiştir. Alınan sonuçlar literatürle karşılaştırılarak doğruluğu incelenmiştir.

2. Elektriksel direnç için klasik ve kuantum mekaniksel yaklaşım

İletken metallerin sıcaklığı arttığında elektronların kristal örgülerle çarpışma sayısı artacağından özdirenci de artar. Klasik termodinamiğe göre özdirencin sıcaklığa göre değişmesi,

$$\rho(T) = \rho_0[1 + \alpha(T - T_0)] \quad (1)$$

formülüne göre belirlenir. Burada α, özdirencin sıcaklık katsayısı, T_0 sabit referans sıcaklığı, ρ_0, T_0sıcaklıktaki özdirençtir.

Materyallerin özdirencinin sıcaklığa göre değişmesini incelemenin en iyi yöntemlerinden birisi de Bloch-Gruneisen yöntemidir. Debye modeli kullanılarak önerilen Bloch-Gruneisen yaklaşımına göre özdirencin sıcaklığa göre değişmesi aşağıdaki formüle göre hesaplanır [10-11]:

$$\rho(T) = \rho_0 + (n-1)\rho'\theta_D \left(\frac{T}{\theta_D}\right)^n J_n\left(\frac{T}{\theta_D}\right) \quad (2)$$

burada ρ_0 ve ρ' sırasıyla residual (artık) özdirenç ve sıcaklık özdirenç katsayısıdır. Hafniyum metali için $\rho_0 = 1\mu\Omega.cm$ Formül (1)'de n değişeni iletkenler için $n = 5$ değerini alır. Formülden görüldüğü gibi özdirenci hesaplamak için (1) ifadesindeki $J_5\left(\frac{T}{\theta_D}\right)$ Bloch-Gruneisen fonksiyonun hassas hesaplanması gerekir. Bu çalışmada hesaplamalarda $J_5\left(\frac{T}{\theta_D}\right)$ Bloch-Gruneisen fonksiyonu için aşağıdaki analitik ifade kullanılmıştır [12]:

$$J_5\left(\frac{T}{\theta_D}\right) = 120\zeta(5) - \sum_{k=1}^{\infty} e^{-ky}\left(y^5 + \frac{5y^4}{k} + \frac{20y^3}{k^2} + \frac{60y^2}{k^3} + \frac{120y}{k^4} + \frac{120}{k^5}\right. \quad (3)$$

Burada $y = \frac{T}{\theta_D}$ ve $\zeta(p)$ Riemann zeta fonksiyonu olup aşağıdaki gibi tanımlanır:

$$\zeta(p) = \sum_{k=1}^{\infty} k^{-p} \quad (4)$$

Bu çalışmada önerilen yaklaşımlar geniş sıcaklık aralığında geçerli olup hafniyumun iletkenliğini de ayrıntılı olarak inceleme imkânı sağlamaktadır. Hafniyumun özdirencinin sıcaklığın farkı değerlerinde hesaplama ve kaynak sonuçlar karşılaştırmalı olarak Tablo 1'de verilmiştir.

3. Tartışma ve sonuçlar

Hafniyum günümü teknolojilerde geniş kullanım alanına sahiptir. Bu çalışmada Hafniyumun özdirencinin sıcaklığın farklı aralıklarında değişmesi Bloch-Gruneisen ve klasik yaklaşıma göre karşılaştırmalı olarak incelenmiştir. Hesaplama sonuçları sıcaklığın farklı değerlerinde Tablo 1'de verilmiştir. Alınan sonuçlara göre önerilen yöntem genel olup sıcaklığın tüm aralıklarında doğru sonuçlar vermektedir.

Tablo 1. Hafniyumun özdirencinin sıcaklığa göre değişmesinin karşılaştırmalı sonuçları ($\theta_D = 484K, \rho_0 = 1\ \mu\Omega.cm, \rho' = 0.127\ \mu\Omega.cm, \alpha = 0.004K^{-1}$)

$T\ (K)$	Kaynak [13]	Denklem (1)	Denklem (2)
250	27.36	27.39	26.97
300	34.03	34.01	34.09
350	40.96	40.62	41.05
400	48.08	47.24	47.88
500	63.10	60.47	61.31
550	70.88	67.08	67.93
600	78.52	73.70	74.51
650	86.00	81.32	81.06
800	106.9	100.16	100.56
1000	128.3	126.63	126.36

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Study of specific heat capacities of aluminum boron nitride ($AlBN_2$) using Einstein-Debye approximation

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Özet **-** Bu çalışmada, alüminyum bor nitrürün spesifik ısı kapasitelerinin değerlendirilmesi için etkili ve doğru Einstein-Debye yaklaşımı sunulmaktadır. Alüminyum bor nitrürün, özellikle yüksek sıcaklıktaki performansı ve termal özelliklerinin bilinmesini gerektiren çeşitli endüstriyel uygulamalarda onu değerli kılan termal, elektriksel ve mekanik özelliklerin benzersiz bir kombinasyon oluşturmasıdır. Araştırmalar nitrür bileşiklerinin geniş bant aralıklı yarıiletken özelliklere sahip olduğunu göstermektedir. Bu tür malzemelerin özgül ısı kapasitesi, termodinamik özelliklerin değerlendirilmesinde ve sistem tasarımında önemli bir parametredir. Bu nedenle, geniş bant aralıklı yarı iletkenler olarak nitrür yarıiletkenler uzun süredir büyük ilgi ve araştırma ilgisi çekmektedir. Özetle, önerilen yönteme göre inceleme ve sonuçlar, önerilen yöntemin genel ve kararlı olduğunu gösterdi. Sayısal örnekler, önerilen yöntemin mükemmel etkililiğe ve doğruluğa sahip olduğunu göstermektedir.

Anahtar Kelimeler: Alüminyum bor nitrür, Einstein-Debye yaklaşımı, Debye sıcaklığı, Einstein sıcaklığı

I. Giriş

$AlBN_2$ moleküler yapılı madde alüminyum (Al), bor (B) ve nitrojenden (N) oluşan bir bileşik olan alüminyum bor nitrürü ifade eder. Alüminyum bor nitrür, onu çeşitli uygulamalarda faydalı kılan ilginç özelliklere sahip bir seramik malzemedir ve yarıiletken özelliğine sahiptir. Alüminyum bor nitrürün önemli uygulamalarını aşağıdaki gibi özetleye biliriz [4-7]. Termal Yönetim: Alüminyum bor nitrürün mükemmel termal iletkenliği, onu yüksek sıcaklıktaki ortamlarda termal yönetim malzemesi olarak kullanıma uygun hale getirir. Isıyı verimli bir şekilde dağıtmak için genellikle elektronik cihazlarda, LED aydınlatmada ve güç elektroniklerinde soğutucu malzeme olarak kullanılır. Yalıtım alanında: Alüminyum bor nitrür, yüksek ısı iletkenliği ile birlikte mükemmel elektrik yalıtım özelliklerine sahiptir. Hem termal yönetimin hem de elektriksel izolasyonun gerekli olduğu elektrikli bileşenler ve sistemlerde yalıtım malzemesi olarak kullanılabilir. Yüksek Sıcaklık Bileşenleri: Yüksek termal stabilitesi ve termal şoka karşı direnci nedeniyle alüminyum bor nitrür, fırınlar ve reaktörler için potalar, ısıtma elemanları ve refrakter astarlar gibi yüksek sıcaklık bileşenlerinin üretiminde kullanılmaktadır. Seramik Matris Kompozitleri (CMC'ler): Alüminyum bor nitrür, mekanik özelliklerini, termal iletkenliğini ve aşınma direncini arttırmak için seramik matrisli kompozitlere dahil edilebilir. Bu kompozitler havacılık, otomotiv ve hafif, yüksek performanslı malzemelerin gerekli olduğu diğer endüstrilerde uygulama alanı bulmaktadır. Alüminyum bor nitrür kaplamalar, korozyona, aşınmaya ve kimyasal saldırılara karşı koruma sağlamak için çeşitli alt katmanlara uygulanabilir. Bu kaplamalar otomotiv, havacılık ve elektronik gibi endüstrilerde bileşenlerin ömrünü ve performansını uzatmak için kullanılır. Elektronik Ambalaj: Alüminyum bor nitrür, entegre devreler, LED'ler ve diğer elektronik cihazlar için termal yönetim, elektrik yalıtımı ve mekanik destek sağlamak amacıyla elektronik ambalajlarda kullanılır. Genel olarak alüminyum bor nitrür, özellikle yüksek sıcaklık performansı ve termal yönetim gerektirenler olmak üzere çok çeşitli endüstriyel uygulamalarda değerli kılan termal, elektriksel ve mekanik özelliklerin benzersiz bir kombinasyonunu sunar [4-11].

Endüstri alanında önemli uygulamaları olan Alüminyum bor nitrür maddesinin termodinamik özelliklerinin hassas hesaplanması çok önemlidir. Bu çalışmada hafniyum Alüminyum bor nitrür bileşiğinin C_p ve C_V öz ısı miktarları geniş sıcaklık aralığında Einstein-Debye modeli kullanılarak incelenmiştir. Alınan sonuçlar kaynaklardaki farklı yaklaşımlarla karşılaştırılasından görüldüğü kadarıyla uygulanan yöntem daha genel olup geniş sıcaklık arasında hassas sonuçlar vermektedir.

2. Hafniyum oksidin Einstein-Debye modeline göre incelenmesi

Bu çalışmada öz ısı miktarının hesaplamasında aşağıdaki formüller kullanılmıştır [1, 2]:

$$C_P(T) = C_V(T)\left(1+\frac{A_0 T}{T_m}C_V(T)\right), \quad (1)$$

$$C_V(T) = 3N_A k_B M(T,\theta_D,\theta_E) \ , \quad (2)$$

burada $A_0 = 5.1x10^{-3} J^{-1}K\,mol$, T mutlak sıçaklık, T_m erime sıçaklığı, N_A Avogadro sayısır, k_B the Boltzmann sabiti, θ_D Debye sıçaklığı and θ_E is the Einstein sıcaklığıdır. (2) formülünde $M(T,\theta_D,\theta_E)$ fonksiyonu aşağıdaki formüle göre hesaplanır:

$$M(T,\theta_D,\theta_E) = L_V(T,\theta_D) + (s-1)A(T,\theta_E), \quad (3)$$

burada s bir örgüdeki atom sayısıdır. $L_V(T,\theta_D)$ fonksiyonu ise:

$$L_V(T,\theta_D) = (n+1)D_n\left(1,\frac{\theta_D}{T}\right) - \frac{\theta_D}{T}\frac{n}{e^{\frac{\theta_D}{T}}-1}. \quad (4)$$

tanımlanır. Burada $D_n(\beta,x)$ Debye fonksiyonudur:

$$D_n(\beta,\mathrm{x}) = \frac{n}{x^n}\int_0^x \frac{t^n}{(e^t-1)^\beta}dt \ . \quad (5)$$

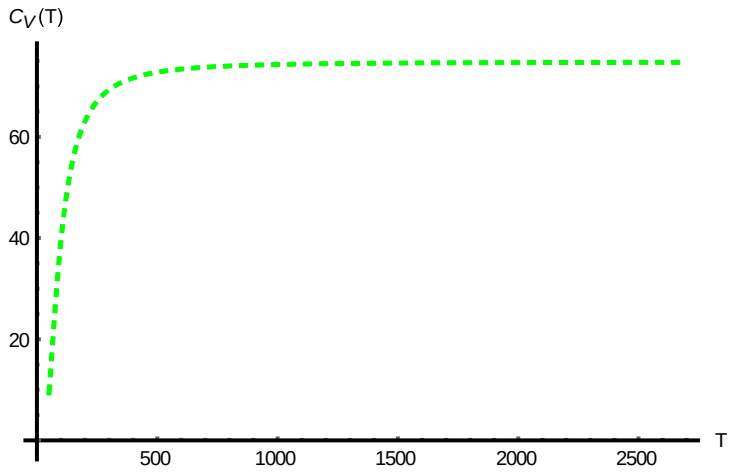
$A(T,\theta_E)$ fonksiyonu ise aşağıdaki formüle göre hesaplanır:

$$A(T,\theta_E) = \left[\frac{\theta_E}{2T}\frac{1}{\sinh\left(\frac{\theta_E}{2T}\right)}\right]^2 . \quad (6)$$

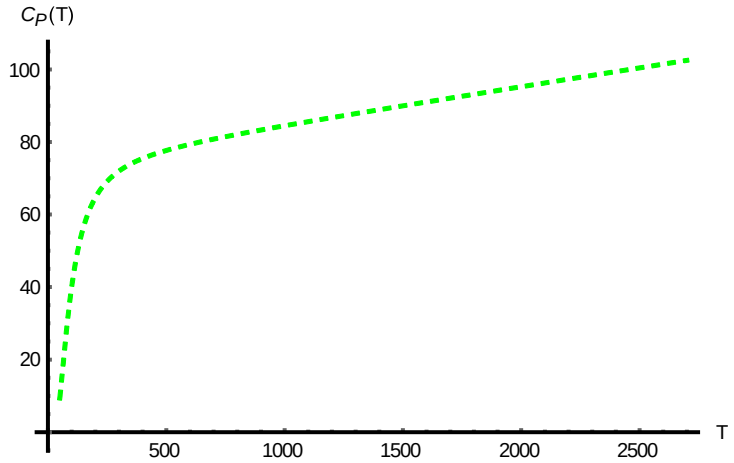
Burada Debye fonksiyonu $D_n(\beta,x)$ yakın zamanda yapılan çalışmadaki formüle göre hesaplanır [3]. Bu çalışmada geniş sıcaklık aralığında Alüminyum bor nitrür maddesinin ısı kapasiteleri Einstein-Debye yaklaşımı kullanılarak incelenmiştir.

3. Tartışma ve sonuçlar

Alüminyum bor nitrür maddesi yapısına göre seramik özelliklerine sahiptir. Bu çalışmada Alüminyum bor nitrür maddesinin ısı kapasitelerinin sıcaklığa göre değişmesi incelenmiştir. Hesaplama sonuçları yakın zamanda Alüminyum bor nitrür maddesinin termodinamik özelliklerinin hesaplanmasına önemli katkılar sağlayan kaynak [11]'de verilen sonuçlarla karşılaştırılmıştır. Hesaplama sonuçlarının kaynaklardaki verilerle karşılaştırması Şekil 1 ve 2'de verilmiştir. Şekillerdeki sonuçlar geniş sıcaklık aralığında kaynaklardaki verilerle uyum içerisindedir.



Şekil 1. Alüminyum bor nitrür maddesinin C_p ısı kapasitesinin sıcaklığa göre değişmesinin sonuçları ($\theta_D = 395K, \theta_E = 280K, T_m = 2770\ K$)



Şekil 2. Alüminyum bor nitrür maddesinin C_V ısı kapasitesinin sıcaklığa göre değişmesinin sonuçları ($\theta_D = 395K, \theta_E = 280K, T_m = 2770K$)

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