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IMPORTANCE OF MATERIAL OPTIMIZATION FOR BUSINESS

Barbara Barilová [1], Dominika Popovičová [2]

Abstract: *The subject of This paper focuses on the analysis of the behaviour of logistics systems within the material flow and the importance of its optimization. The main task of the paper is to define the factors that affect the flow of material, identify the elements that make it up and describe the model of operational records, which is necessary for optimization. As part of saving production costs, it will focus on calculating the optimal production batch, which will ensure the efficient operation of the company and at the same time preserving the environment.*

Keywords: Material flow; Manufacturing process; Product; Optimization; Economic Evaluation.

1 INTRODUCTION

Due to the rapid growth of the number of companies and thus rapidly growing competition, the era of globalization is very important for companies to constantly increase their competitive advantage in the market. The European Union has undergone various changes in the economy caused by the changing political environment. This fact necessitated a change in the management and direction of operational and economic processes. We can observe big changes especially in the process of material circulation. Circulation does not only mean a material connection between production and consumption, but also a material connection in one's own production. Differentiation from the competition is therefore the most important goal of manufacturing companies. Differentiation can lie in better products, technologies or innovations. However, it is especially important to pay attention to the effective management and improvement of processes in the material flow. This is a key point for any business, as it can reduce the negative impact on the environment and at the same time increase its efficiency and performance [3][12].

European waste management policy has set the objective of preventing the generation of waste. Waste generation currently appears to be stable in manufacturing industries in EEA countries 18. However, the acceding countries have seen a significant increase in production from the basic metals industry as well as from food production. The amount of construction and demolition waste is still growing. We can say that this growth is closely linked to economic growth. Recently, waste streams have also begun to emerge as a result of the implementation of measures to improve the environment in other areas, such as flue gas treatment residues and sewage sludge from sewage treatment plants [3].

One of the other very important goals of the European Union in the field of waste policy is to obtain high-quality resources from waste in as large a quantity as possible and thus contribute to the circular economy. The European Green Agreement was created to protect human health and the planet. The reason for its creation is the effort to create a healthier, more efficient, more modern and especially more competitive policy. This strategy has set a very ambitious and bold goal of zero environmental pollution.

The European Union has developed the Waste Framework Directive, which provides the EU's legal framework for waste management. A "waste hierarchy" has been introduced, meaning the introduction of a waste management preference order, which helps to categorize waste based on the need for different specific treatment approaches. To this end, the EU has created a number of laws that address these types of waste The way production factories handle waste can have a significant impact on their environmental impact. To prevent harmful effects, the company can influence its activities related to the extraction of primary raw materials and also the transformation of primary raw materials in production processes [3][8].

2 OBJECT AND METHODS

This paper focuses on the analysis of the behaviour of logistics systems within the material flow and the importance of its optimization. The main task of the paper is to define the factors that affect the flow of material, identify the elements that make it up and describe the model of operational records, which is necessary for optimization. As part of saving production costs, it will focus on calculating the optimal production batch, which will ensure the efficient operation of the company and at the same time preserve the environment.

The paper focuses on secondary research of literature, theoretical knowledge gained from the literature. To achieve the goal, several theoretical methods were used, which were used in the form of general methods such as synthesis, analysis, induction, deduction and comparison. Figures were used to clarify the interpretation of theoretical knowledge.

3 GROWTH IN PRODUCER PRICES OF INDUSTRIAL PRODUCERS

Year-on-year growth in producer prices in the euro area and throughout the European Union (EU) reached a new record in April 2022. This signals that inflationary pressures in Europe, which are already very high, have not yet peaked. And it will strengthen the arguments for the ECB to start raising interest rates faster. According to Eurostat, the Industrial Producer Price Index (IPPI) rose 1.2% month on month in the euro area and 1.3% in the EU in April. Its growth rate slowed from 5.3% in March in the euro area and 5.4% in the EU. Year-on-year, industrial producer prices in the euro area rose by 37.2% in April 2022, by 37% across the Union, which is a new record high. Eurostat further stated that in the euro area the prices of intermediate goods increased the most in April, by 3.8%, followed by non-durable goods (2.7%) and capital and durable goods (both by 1%), while energy prices fell by 1.2%. Prices in non-energy industry increased by 2.6%. In the EU, prices of intermediate goods rose by 3.9%, non-durable goods by 2.8% and capital goods and durable goods by 1% month on month in April, while they fell by 1.1% in energy. Prices in EU non-energy industry rose by 2.7%. Among the EU countries that provided Eurostat with data for April, the largest month-on-month declines in industrial producer prices were recorded in Ireland (-16.4%), Romania (-3.2%), Portugal (-2.2%) and Italy (-0.3%). On the contrary, the sharpest increases were reported by Slovakia (9.3%), Luxembourg (6%) and Bulgaria (4.1%). In a year-on-year comparison, energy prices in the euro area rose the most in April 2022, by 99.2%. At the same time, intermediate goods prices increased by 25.1%, non-durable goods by 11.2%, durable goods by 8.5% and capital products by 7.2%. Prices in industry excluding energy rose by 15.6%. In the EU, energy prices increased by 97.2% year-on-year, intermediate goods by 25.4%, non-durable goods by 12%, durable goods by 9.1% and capital goods by 7.5%. Prices in industry without energy increased by 16.1%. Year-on-year, industrial producer prices rose in all Member States in April, with the highest year-on-year increases recorded in Denmark and Ireland (both 62.3%), Romania (60.4%) and Belgium (52.7%). April prices of industrial products by 49.3% year on year. In Slovakia, industrial product prices rose by 49.3% year on year in April [2].

Figure 1 EU-EA-19 Industrial producer prices, total, domestic and non-domestic market 2010 - 2022
Source: ec.europa.eu, 2022

This is also one of the reasons why companies should do more than ever to streamline their production. It is optimization that will help the company save costs and mitigate the impact of production on the environment.

3.1 Material flow evaluation system

Material flow analysis is a major task for handling material flow properly. Factors that need to be considered while analysing are the type, quantity, weight, shape, volume and also the dimensions of the material. Obtaining all this information and evaluating it affects the way the goods are handled [7].

A material flow can be considered as a system if it has these seven characteristics:

- Function, resp. Setting the goal of the system,
- Inputs or definition of input items and information, which are subsequently transformed into the final products of the system,
- Product of the system,
- Sequence of processes in the system or chronology of steps that will ensure the transformation of input items into final products,
- The environment that must be taken into account when solving all systems,

- Transport, handling and storage equipment and elements used in material handling,
- Method or the form in which employees carry out specific activities arising from their responsibilities [13].

The method of material handling is significantly influenced by its type, quantity, weight, volume and also size. All these attributes also affect its packaging, storage, transport and handling. Material flow analysis makes sense when we can observe quantities: quantity of goods, length and time of travel, speed of movement, cruising speed, size of goods flow, intensity of goods flow, frequency of freight, change of intensity of goods flow, handling, transport, network complexity and also the number of interruptions related to production and storage, the number of backflows and the number of changes [13].

Factors that affect the circulation of material flow intensity [9]:

- The process of increasing the diversity of elements of the production process through the process of diversification and corresponding trends that affect intensity and material consumption.
- The raw material base of the national economy and its territorial distribution.
- Irregular production rhythm.
- Long-term fluctuations in material flow requirements, flows.
- Level of supplier-customer relations, selection or designation of a supplier for selected materials, evaluation of completeness and readiness of deliveries.
- Level of organization management and assessment of material and technical equipment.

Material flow consists of two basic groups of elements [9]:

- Passive elements of material flow (material, raw materials, semi-finished products, products)
- Active elements of material flow (transport-handling and storage operations).

The flow of all types of work items of a passive nature in the company forms a material flow. These include [9]:

- Raw materials and basic material.
- Products in progress.
- Final or finished products.
- Waste.
- Purchased products and semi-finished products.
- Auxiliary material (lubricants, cleaning supplies).
- Spare parts.
- Packaging.
- Non-durable goods.

The most important basis of logistics and overall material flow management is the system approach. The subject of the efforts of logistics experts should not only be the optimization of sub-areas, but also the optimization of activities in the system as a whole [11]. Material flow is formed by a unique structure of performed activities, which can be considered as active elements of material flow. Material flow consists of five basic operations:

1. Technological operations - changing the shape, composition or connection of objects into the required form. The result is a product that can be machined, shaped, chemically or thermally treated, assembled or, conversely, disassembled.
2. Control operations - checking the quantity or quality of materials and products produced or operations performed.
3. Transport operations - ensuring the movement or relocation of work items in any direction. The movement represents e.g. lifting, turning, lowering, transport between workplaces, etc .;
4. Warehousing - this is the planning of the storage of work items in the entrance warehouses, production intermediate warehouses or sales warehouses.
5. Delay - unplanned storage of a work item, which results in waiting for the next operation in the material flow.

Technological and control operations represent the actual production of the product, transport operations, storage and warehousing. Non-technological material flow operations are collectively referred to as material handling. These are operations such as: transport, storage, retention and control [9].
In order to be able to create a material flow model, we must have sufficient information that we obtain by performing operational production records. The process of making operational records consists of [9]:

1. Recording the actual course of the production process.

2. Provided data:
   - Actual discharged quantities of products.
   - Dates of implementation of individual operations and products.
   - Consumption of labor and material.
   - Deviations, failures, and their causes.

3. Activities connected with ensuring production records:
   - Breakdown of production documents.
   - Own recording and processing of data on the actual course of the production process.

4. System of production documentation:
   - Technical documents (drawing, bill of

materials, technological procedures ...).
- Documents for managing the course of work (work tickets, guides, term tickets ..).
- Collection documents (expenses).
- Handover documents (transfer ticket).

5. System of initial documentation:

- Guide.
- Worksheet.
- Handover ticket.
- Material issue.

3.2 Optimization of material flow

When handling the material, the needs, performance objectives as well as the functional specification of the proposed methods should be identified in the first instance. Due to the need to obtain this data, it is first necessary to create a quality and well-thought-out plan. This plan should define the nature of the material (what), its movement (when, where) and also the way (how). It is important that the plan captures the strategic goals and needs of the organization and should also include the design of material handling processes and methods [11].

Figure 2 Material handling process. Source: Own processing

The production batch represents the quantity of products that are put into production and the quantity of products removed from production. A material or semi-finished product is used to produce the production batch. Based on the calculations, we determine the minimum size of the benefit, which will ensure cost coverage and profit generation. Methods, tables, formulas, or graphs are used for these calculations. In the graph below, we can track the number of products on the x-axis and observe the cost per product on the y-axis. Storage costs may also be expressed in absolute terms per unit of production per year. The formula is adjusted accordingly [5].

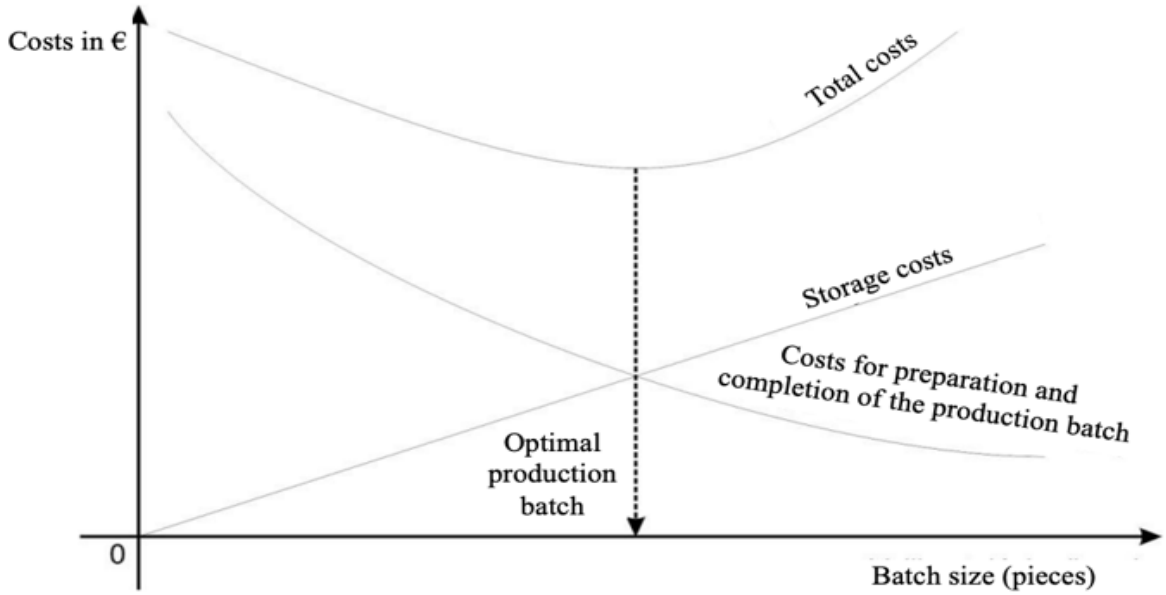

Figure 3 Optimization in material flow. Source [5]

It follows that part of the cost with the size of the production batch can fall or rise. We can say that the total average cost per product first decreases to the point until they reach a minimum, then they have an increasing tendency. The goal is to get to the point that ensures the most favorable conditions, ie the optimal production batch [14].

3.3 Calculation of the optimal production batch in absolute value

In practice, the optimal size of the production batch is further adjusted, for example, according to the size of the transport equipment, storage areas, handling equipment.

$$dvopt = \frac{\sqrt{2 * Sc * Ppv}}{\sqrt{Uc * As * t}}$$

Where:

Sc	*setup costs - preparation and completion*
Uc	*unit cost*
As	*annual storage, maintenance and interest costs*
t	*period for producing production volume Q*

Ppv *planned production volume*

Material flow optimization should ensure that the optimal costs for the movement of material and information in a given material flow are achieved, as well as the flows that follow it. The success of this process depends on the methodological procedures, consisting in the allocation of production units, warehouses and also on the technical and information equipment. The individual activities must be carried out chronologically within the optimization of the material flow, taking into account the spatial context, the intensity and frequency of the material flow, ecological and other conditions. As part of optimization in manufacturing companies, modern logistics concepts, such as of warehousing and supply within the production process are used [13][14].

The coordination of the performance of material functions, consisting of management of the material flow and the provision of the communication network and all the resulting problems, is the goal of the material management itself. (Leenders and Fearon, 1993). In the field of materials management, it is important to carry out four basic activities:

1. Anticipation of material requirements.
2. Identification of resources and acquisition of materials,
3. Transport and introduction of material into the company.
4. Monitoring the condition of material as a current asset [6].

Materials management involves a total of a large number of logistics activities. Items that are subject to material management are future finished products, raw materials, parts and components that need to be further processed or arranged before they reach the end customer. Purchasing and procurement, production management, transport of materials to and within the company, warehousing, management of the management information system, inventory planning and management, and waste disposal are integral parts of material management [6].

There are many reasons to use material flow analysis and planning. Poorly optimized material flows cost time and money. This is where a good material flow analysis can reveal many weaknesses and untapped potential. Companies face many challenges. Thoughtful material flow planning and intralogistics can prevent the growing complexity that leads to supply problems, which is then difficult to keep under control. As a result, it leads to delays in the production process [10].

The inventory of the situation as part of the material flow analysis reveals bottlenecks that cause cost increases. Waste transport systems are often purchased at a time when obstacles are apparent. However, instead of an expensive investment, it is often sufficient to assess capacity utilization in new means of transport, control the transport system differently or adjust work schedules. Material flow analysis helps to reveal this potential. In this process, it is very important that planning is comprehensive. The better the planning, the better the delivery in the production process. The basis of material flow optimization is a systematic analysis of material flows. The best solution would be to visualize processes and create transparency [14].

3.4 Productivity in material flow

Productivity is a measure that expresses how well resources are used in product creation. We calculate it as the value of outputs, as the final products of the process, divided by inputs, all production factors, such as wages, equipment prices, technology, material, capital, energy, etc. Labor productivity evaluates the total personnel costs per employee, such as training, apprenticeships, employee remuneration, etc. Labor efficiency is generally expressed in terms of the level of labor productivity. Total productivity. We calculate it as the ratio of the total inputs from the process to all outputs. The ratio determines how and where the change needs to be made [5]:

$$x = \frac{(Fp*Sp)+(Pp*Pwp*Sp)+Oi}{Lc+Mc+Ci+Ec+Tc+Dc+Ac+Tc+Qc}$$

Where:

Fp *finished products*
Sp *selling price*
Pp *products in progress*
Pwp *percentage of work in progress*
Sp *selling price*
Oi *other income*
Lc *labor costs*
Mc *material costs*
Ci *capital inputs*
Ec *energy consumption*
Tc *technology costs*
Dc *development costs*
Ac *administrative costs*
Tc *training costs*
Qc *quality costs*

4 RESULTS AND DISCUSION

Process flow (PFA) and material flow (MFA) analysis is a fundamental and therefore a key aspect in developing a material handling strategy. These analyzes help to map, control and evaluate all flows within the organization. The aim is to find out how the parts flow from the suppliers to the warehouses and from them to the place of use. It is important to find out how we can streamline processes so that the customer gets the product faster, but so that the whole process is more controlled at the same time. These findings will help ensure a better and more efficient production process, reduce waste and reduce production costs. Performing this analysis helps to save time and avoid situations that adversely affect the performance and profitability of the company. An unfavorable situation can be, for example, the lack of missing parts or

materials, which will cause longer delivery times. This adversely affects not only customers who do not receive their products on time, but also employees who may leave as a result of frustration or be fired. Material flow analysis also focuses on the cause of missing items and allows to track downtime, which helps allocate production resources where they can be used in multiple departments. The difference between the formal and informal performance of a material flow analysis lies in the technology used to perform it. Informal analysis consists of tracking emails, writing in spreadsheets or constantly monitoring the phone, which is quite time consuming and not very consistent. A much better solution is to formally track aspects of the material flow through cloud solutions. It is these solutions that are the key to identifying problems and subsequently identifying solutions that will solve the situation. The cloud system software solutions are easily integrated into supply chain systems. The implementation of these systems streamlines communication, so that every article in production has up-to-date information. Automation and built-in workflows monitor request status and are configured to handle different types of processes [13].

This simplifies requirements processing and provides a real-time view of production activities. The advantage of cloud software, and therefore of artificial intelligence, is that it ensures that the information needed to make informed decisions and perform detailed analyzes is shared and monitored. In addition, it evaluates reports on the causes of process failures and documents the daily statistics that we can build on in the future. The processes are therefore documented in detail, automated and easy to repeat. Thanks to the generated metrics, we can regularly analyze processes and identify various improvements. Data collection drives automated process improvement and, based on information, can identify potential problems, which means they can be captured and investigated in a timely manner. Updating systems after implementing changes in the production process is big advantage. This consists of ensuring a high level of information, which represents the elimination of stress resulting from the limited availability of information about the status of individual items needed for the production process. This contributes to a significant reduction in urgent requests for reported incidents. By implementing this system, the company builds resilience to various risks and optimizes its costs [1].

5 CONCLUSION

Internal material flow analysis considers all flows of goods and materials involved in the production chain - from the points of receipt and storage of goods to the production and dispensing of goods. As part of the material flow analysis, costs are assigned to each material flow in order to reveal cost drivers and bottlenecks during the optimization process. The goal of material flow analysis is to uncover and eliminate bottlenecks and weak points in material flows, through a targeted improvement of transport processes the company. It is about it is about shortening delivery times, improving production processes and synchronisation, increasing flexibility and cost reduction. Material flow optimization should be a standard procedure for every company nowadays. Material flow planning is to be seen in the context of the overall tasks of the company and includes the planning and design of the internal material flows within the closed production facilities and buildings. For this reason, all operational areas from goods receipt to goods issue are analysed. Holistic material flow planning covers a wide range of tasks and is an excellent basis for plant planning with simulation software. The aim of planning is to optimise the material flow in intralogistics. In this way, a more precise coordination of material and goods inventories or a reduction of space requirements in logistics can be achieved. In addition, the aim is to achieve the highest possible profitability, i.e. to improve the company's operating and investment costs (in advance through production planning). Process flexibility and stability are also increased. The analysis can often unlock hidden potential, for example in the areas of transport, warehousing and logistics process [4].

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AUTHORS ADDRESSES

[1] Ing. Barbara Barílová

University of Economics in Bratislava, Faculty of Commerce, Department of Marketing, Dolnozemská cesta 1, 85235 Bratislava, Slovakia

E-mail: barilovab@gmail.com

[2] Ing. Dominika Popovičová

University of Economics in Bratislava, Faculty of Commerce, Department of Marketing, Dolnozemská cesta 1, 85235 Bratislava, Slovakia

E-mail: dominika.popovicoca@euba.sk