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SIMULATION OF PRODUCTION SYSTEMS AS THE EFFECTIVE TOOL OF EFFICIENCY INCREASING

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Abstract: *Continuously increasing and escalating demands and threats related to the operation of production systems require from the production companies continual concentration, fast and correct decisions in order to consolidate and improve its market position and achieve the maximum profit. There are many resources and possibilities to increasing efficiency, respectively maximize the utilization of the production system. For the purpose of this article we have chosen as the optimal variant even more applied term simulation, because its application greatly contributes to the overall improvement of the business competitiveness.*

Keywords: Production system, simulation, simulation of production systems, digital factory.

1 INTRODUCTION

Promote and encourage the development, respectively productivity growth and competitiveness must be under conditions of maximum current turbulent and difficult market environment, the primary goal of any business. It is forced to continuously improve and adapt to the requirements of such hard competition, respectively meet the expectations and needs of its customers. The basis of this success lies in the proper and effective implementation of production systems. It is available many tools and possibilities of increasing efficiency of the operations. In this paper was chosen as the best variant in practice increasingly even more used tool that is called simulation.

2 PRODUCTION SYSTEM

Bösenberg and Metzen define it as a "complex system related to the organizational structure and man in the centre. The elements of this system are procedures, work principles, new organizational structures, strategies describing the main work tasks, scientific methods and principles of industrial engineering as well as a number of pragmatic tools for all employees [1]."

In short, the production system is a system that is based, respectively is resulting from the transformation of inputs into the products, e.g. desired outputs.

The implementation of this transformation takes place through its various subsystems. Fig. 1 shows that production system consists of these five components [5, 12]:

- Workplaces: they carry the added value; there are production resources, i.e. machinery, auxiliary equipment and assembly lines.
- Material flow: through the material flow it is ensured respectively is secured the proper management, handling and transport of the semi-product between operations/workplaces, as well as the material flow is related to the storage questions.
- Information flow: it has to be also analysed the information flow and proposed the possible options for processing, transmission and storage in a particular production system.
- Service and service provision: this is related to the ensuring of the maintenance and supply in the production system.
- Employees: in the production system this managing, respectively central component. Their decisions and management decide how efficiently the business will implement its plans and objectives.

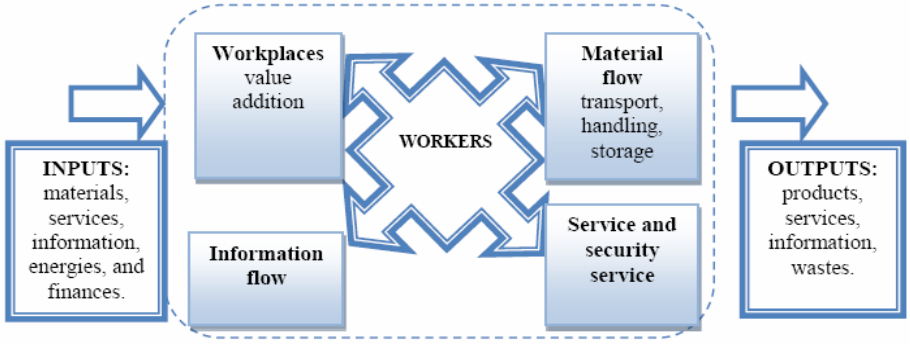


Fig. 1 Production System and its basic subsystems [1, 7]

An important step to achieve respectively ensures effective production is to find the best way to realize the plans. It is the production system, which implements the production itself. There isn´t one hundred percent accurate and guaranteed instruction to obtain the optimum that would ensure long-term stability and error-free operation. However in practice, it is necessary to address with the requirements for production systems that are placed on it. These are summarized and shown in Fig 2 [4].

Each production system consists of a set of subsystems, namely the management, technological and handling subsystems.

Structure of production system, respectively elements that make system are summarized in Table 1, where we talk about structural composition of the production system [4].

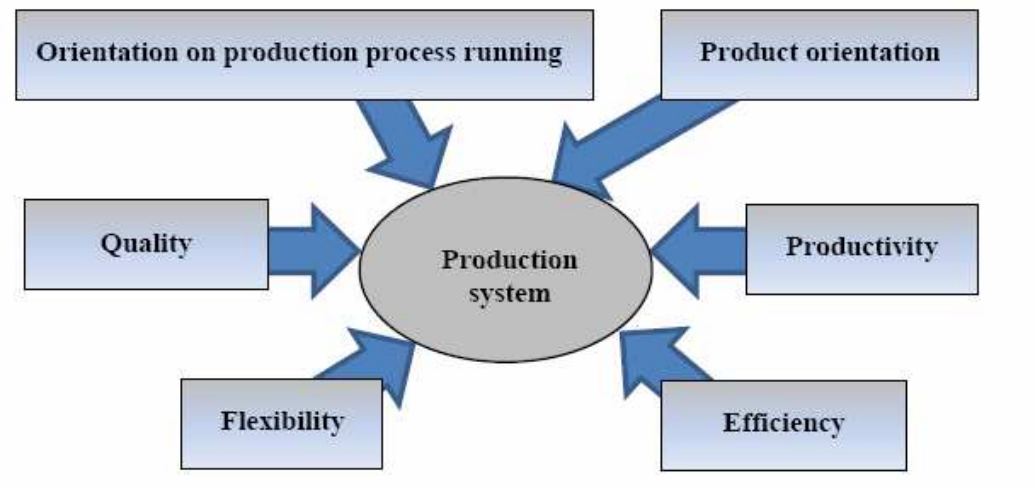


Fig. 2 Requirements required by the production system [7]

Table 1 Structural composition of the production system [prepared by 5]

1.Technological subsystem	• Input and output elements of the project, • Production machinery and technological equipment, • Elements of the waste output, • Control system.
2.Subsystem of technical inspection	• Equipment for semi-operation control of products, equipment for postoperative control of products • Equipment for control of material preparation, • Equipment for control of preparation aids.
3.Subsystem of technological process management	• Determination of operations on technological workplace, • Managing information for technological workplaces, • Information for preparation, information for technological process management.
4.Subsystem of material and production aids preparation	• Transport and handling, • Division of material, • Working of base areas, • Treatment of tools, • Maintenance and repair of production equipment; • Filing of technical documentation.
5. Subsystem of transport, handling and storage	• Transportation of production objects, • Transportation of production aids, • Traffic circle of waste.
6.Subsystem of production process management	• Detailed operational planning - operation schedules, capacity balancing, • Direct management of the production process.
7.Subsystem of technical services production	• Maintenance and repair of mechanical knots, technological workplaces, technical inspection, transport and handling equipment, • Maintenance and repair of electrical equipment.

3 SIMULATION OF PRODUCTION SYSTEMS

Centre of the success of any company is to build high-class and maximum efficiency reporting production system that would be the result of the number of correct decisions. The computer simulation is one of the key tools/techniques for their successful achievement, so the simulation is, "experimental production business" on the computer. We assign it to the so-called statistical test methods. The application possibilities of this support instrument replace the real system with simulation model. It allows us, as its users, pre-verified and reflects behaviour of real, possibly even only planned production system, than look into the future and capture any deficiencies in advance, respectively prior to the implementation of the project in order to thus avoid an increase in expenses associated with solution of problems during operation [8].

Dahl understood simulation as "a research technique that consists in studying of dynamic system, which is replaced by a simulator, with which we realize experiments with the goal to gain information about the original system [8]."Graphical illustration of the simulation principle is shown in Fig. 3.

Each model of production system consists of a set of objects and we distinguish three specific types. The first of these are stationary elements of the system, also called static, that still exist and carry on its activities/functions. These elements are such as machinery, equipment etc. Another group called dynamic elements places the various transporters and tools, that the production aids, which are used only for a specific time. This means that these elements somewhere enter into the system, then are machined, respectively moving between workplaces and then leave the system. The last group consists of objects that are linked with the environment; they are, for example, customers, suppliers and so on. [3].

Purpose, respectively the importance of simulation arises from the [14]:

- effort to ensure and achieve optimal organizational structure,
- changes in various technological and business processes,
- recovery of the production program, respectively its restructuring,
- Optimization requirements of the entire production system.

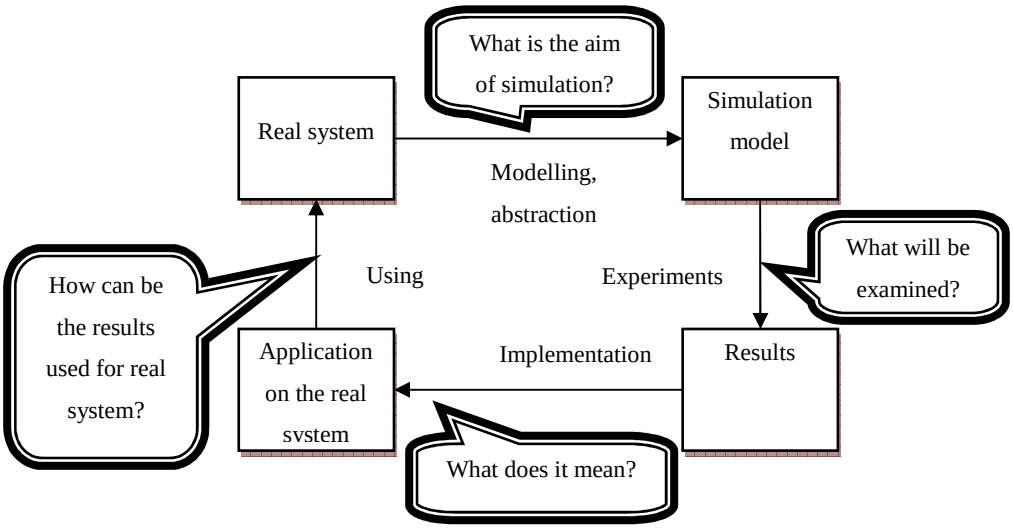
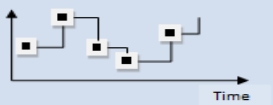
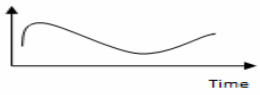
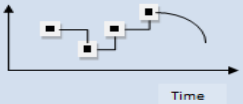


Fig. 3 The principle of using computer simulation [13]

Table 2 Types of simulation [7, 12]

Type of simulation	Characteristics	Graphical representation
Discrete simulation	It is also called event-oriented simulation. We take into account only those time points, respectively events, where there is a change of state variables of the system.	
Continuous simulation	The values of state variables are changed continuously in a given time period and are determined by the solution of differential equations describing the behaviour of the simulated system in a very short time steps.	
Combined simulation	It is a combination of discrete and continuous simulation.	

simulations, which are categorized according to the principles applied by the compilation of actual simulation model [12].

One of the basic assumptions of creating a successful simulation is to ensure that the achieved results represent respectively bring a higher value than the inputs that have been expended on realization of the actual creation of simulation. The simulation is purposeful only in the event, if the benefits of its application are higher than its costs [8, 12].

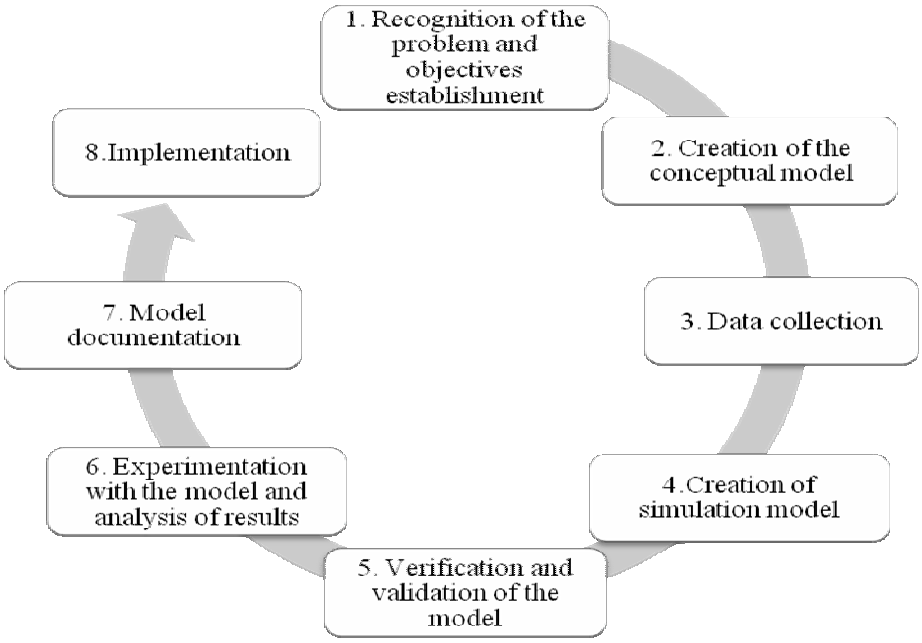


Fig. 4 Stages of simulation study [9]

The sequence of steps, respectively stages of the simulation study is illustrated on the Fig 4 [9].

If we want to begin with the creation of a specific simulation model of the production system and then performing experiments with this simulation model, it is important to determine the purpose and priorities of the simulation itself, that is exactly what we want to achieve with the application and under what conditions. It is also necessary to pay attention to the data and information collection that will serve as inputs for modelling. We mean the facts that monitor, respectively evaluate the status and work and also activity of production equipment together with their characteristics (capacity, spatial distribution, etc.) that help us, respectively allow specifying all details within solved project. After creation of the model, the next step is verification and validation. These two terms are characterized as control processes through which we can ascertain whether it fulfils all the requirements for the process, while verification focuses on verification the suitability of the product due to the specified needs. On the other side validation is the correctness verification due to real requirements.

If the model is verified and validated, the next step is the experimentation, documentation and implementation of achievements, respectively solutions [7, 9].Utilization of simulation is summarized in the Table 3 [3].

Table 3 Utilization of simulation [3]

Simulation allows	Simulation doesn´t allow
• solve analytically unsolvable tasks • examine the dynamics of the system • time and spatial comparison • detection of new facts • decision support at various stages of decision-making • improvement of the system • cost saving in various areas of the business	• replace human in decision-making • complete production management • correct data with an incorrect parameters • automatic optimization of the system • result without goal definition

Areas of simulation application are summarized in Table 4.

Table 4 Areas of simulation application [11]

Production	• implementation of modern managerial methods • capacity planning • identification of bottlenecks in production • optimization of production batches, • verification of production techniques • verification of layout proposals
Logistics	• analysis of material handling • analysis of resource utilization • distribution chains modelling • analysis of production costs
Technology	• analysis of change impact • design and verification of logic of material and information flows • integration of new elements into the system
Services	• analysis of the service times • optimization of the manpower utilization • layout of service departments • analysis of information and documents flow • rationalization of the branch network

Simulation is helpful in solving the problems such as [9, 10, 16]:

- What type and quantity of production equipment must be ensured, i.e. machinery, auxiliary equipment, tools, etc. for operation of the particular production?
- How to organize the workplace, respectively how to solve zonal and spatial relationships?
- How to effectively solve the problems of material and information flows?
- Where are the bottlenecks in production, and which are the main risks of the project?
- What duration, respectively how much time is necessary to ensure the realization of the production?
- How will the system react in the case of unpredictable changes, respectively faults?

It is very important to decide for the right simulation software, because there are a lot of possible solutions. How? The answer is found in Table 5, which shows a procedure of simulation software selection in three steps [13].

Table 5 Procedure of simulation software selection [7, 15]

1. step = basic selection	**2. step = short list**	**3. step = final selection**
Application areas (production, material flows, distribution, organization)	Simulation concept (Petri nets, simulation language, etc.)	Characteristics (Modelling elements, random functions, statistics, animations, etc.)
Users (computer specialist, designer, planner, sporadic user)	Service (Model creation, statistical analysis, presentation options, etc.)	Support (Hotline, maintenance, documentation, etc.)
Financial opportunities (hardware, software, training)	Market position (Number of installations, application areas, branches, etc.)	Environment (Interactivity, error detection, etc.)

4 DIGITAL FACTORY

The future is associated with continuous progress and development of industrial markets, where the complexity and turbulence of this environment is affected by the unexpected and hardly predictable changes. In this time "Digital Factory" (Digitalefabrik, E - Plant, E - Factory, etc.), is increasingly used term", while the most visible development, respectively progress was recorded in Germany (Siemens). It provides a strong competitive advantage and solutions for the design and management of production systems. Digital Factory is therefore compared with the concept of the future (4th industrial revolution).

We can easily say that this concept is a digital view on the real business, with which is provided how the real system will react and how it can adapt to changes on the basis of realized experiments. The most frequently is used in the phase of production system design and it is possible to observe the operation on the computer before the implementation phase. It is suitable in the cases, where is important to increase production, minimize the costs and maximize the utilization respectively production efficiency [13, 14].

Summarization o the results in Table 6 agencies CIMdata survey we can see the conditions of the introduction of digital production along with the percentage.

Table 6 Results of survey of digital production introduction [7]

Expectations from the digital production introduction	Percentage
cost savings through better resources utilization	30%
cost savings achieved through optimization of the material flows	35%
reduction the number of machines, tools and workplaces	40%
total growth of production outputs	15%
time reduction of introduction new products on the market	30%

5 CONCLUSION

Today, constantly changing customer requirements are forcing companies to control increasingly complex production processes. This is reflected in the mounting number of product functions and variants required by end-users as well as in rising demands concerning quality, flexibility, service time and the desired level of service.

To optimize these systems, simulation studies are often conducted. Simulation can be used to improve processes as well as to identify problems at an early stage. Simulation of production systems is the computer-based modelling of a real production system. Simulation allows organizations in the production industry to analyse and experiment with their processes in a virtual setting, reducing the time and cost requirements associated with physical testing.

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