

ANALYSIS OF APPROACHES TO THE MATERIAL FLOW IN THE PRODUCTION PROCESS WITH THE USE OF SIMULATION

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ABSTRACT

Simulation in the production process represents the implementation of processes in real-time and space. Current trends are heading towards the implementation and expansion of various types of automated delivery systems in many industrial enterprises. These efforts are supported by requirements to increase reliability, reduce operating costs and time as well as meet operational schedules. The present article pays attention to the use of simulations, which are supporting tools in ensuring the operation of the production process,

focusing on the evaluation and planning of the material flow. The first part of the paper presents a theoretical description of problems in the area of application of simulation tools in the production process with a subsequent focus on material flow analysis. The core of the paper presents a description of the analysis of approaches to material flow assessment, using supportive simulation tools in line with the ideas of business digitization. At the end of the article, the overall evaluation and summary of the issue are described.

Keywords: simulation, material flow, production process, analysis

INTRODUCTION

The use of simulations in the real world brings time, material and realization savings. Simulations of production and distribution processes are used to optimize throughput, reduce deficiencies and minimize work in the manufacturing process. Simulation is a representation of how a system or process works. Through simulation, the model can be implanted with unlimited variations and create complex scenarios. These capabilities allow you to analyze and understand how individual elements integrate and influence the simulated environment.

The simulation in the approach of the production process and production system is, in the subset, the use of software to produce computer models of production systems that are analyzed with subsequent retrieval of important information. At present, a simulation is a valuable tool used in evaluating the production process as a whole. The simulation can be used to

predict the performance of an existing or planned system and to compare alternative solutions for a particular project problem (Baron, Panda, Pollak, & Cmorej, 2017). Some reasons to use simulations (Hroncová, et al., 2019):

- the system under study is so complex that there is no suitable mathematical method and problem formulation;
- the system under investigation changes its properties too slowly or too quickly,
- the system under investigation could cause a disaster to itself or its surroundings in a poorly chosen experiment, and the danger of such an experiment cannot be predicted in advance,
- the system under investigation is difficult or even impossible to manipulate (economic systems),

therefore it cannot be experimented or is too expensive.

By means of simulation methods it is possible to comprehensively capture dynamic (with time variables) and stochastic (random) errors in the system, the possibility to experiment if it would not be possible in reality for various reasons (cost, danger, slowness, lack of real system) under controllable changing conditions. Wider practical deployment of simulation into the production process was possible only with the development of computer technology in the 1990s because of the need to work with large volumes of 2D and 3D data, preferably in real-time, both in the creation of simulation models, preparation of experiments, and subsequent evaluation (Buchmeister, Palcic, & Ojstersek, 2019).

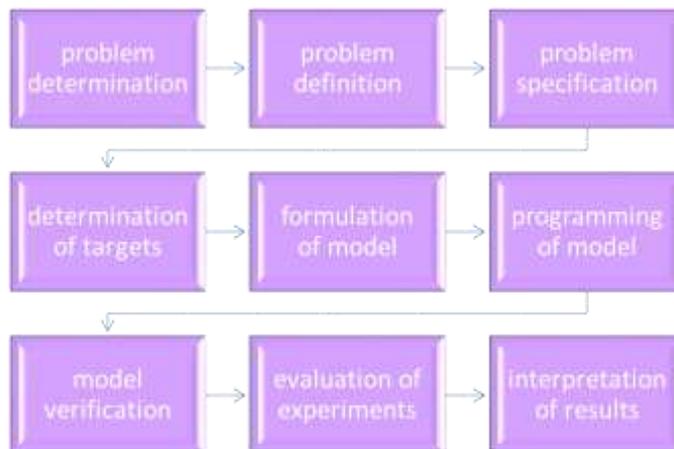


Figure 1. Implementation of simulation in the production process.

The most important goal of manufacturing simulation is to understand the change of the whole system due to some local changes. It is easy to understand the difference caused by changes in the local system, but it is very difficult or impossible to assess the impact of this change on the whole system. The simulation gives us some measure of this impact. The objectives of the production process or its

factors that can be obtained by simulation analysis are (Behunova, Behun, & Knapcikova, 2018):

- parts produced per unit of time,
- time spent in the system by section,
- time spent in queue parts,
- time spent in transit from one place to another,
- timely deliveries,
- build inventory,

- inventory in process,
- percentage of machines and workers.
-

The basic principle of simulation is to simplify the real system by creating a simulation model describing the specific properties of the real system that are the subject of the simulation. Simulation experiments will be implemented after the authentication and validation of the simulation model. The results of these experiments will improve the possibilities of various simulated systems and verify their impact on the modelled system. The results of the experiments are re-applied to the real system to improve its properties.

The main methods of using digital factory technology are computer simulations supported by experts. Simulation systems offer comprehensive solutions for the analysis of manufacturing processes implemented in manufacturing companies. The scope of application covers the whole production process from design and preparation of production, production and planning of installation of machines to assembly and sale of finished products. One of the most used methods from production system designers is discrete event simulation. This type of simulation allows you to evaluate system performance statistically and probably reproduce the interactions of all its components over a specified period of time. In some cases, modelling production systems requires a continuous simulation approach. These are cases in which the conditions of the system change, such as the movement of liquids in oil refineries or chemical plants. Since continuous simulations cannot be modelled using digital computers, they do so use small discrete steps. This is a useful feature because there are many instances where both continuous and discrete simulation, called hybrid simulation, that is needed in many industries, must be combined (Čep, Brychta, Janásek, Petrů, & Zlámal, 2013).

At present, a large number of specialists deal with the issue of material flow in production. For example, Michlowicz and Smolinska present the

example of Witness simulation software for use to improve flow continuity in the production process. They analysed the availability, processing time, number of operators, etc. and determined the highest productivity in the examined system (Michlowicz & Smolinska, 2019). Authors Kodym et al. described the optimization of material flow using simulation software. In this study, the creation of a new assembly workplace simulation model with automatic identification via barcoding is presented (Kodym, Čujan, Turek, & Mikušová, 2019). In further research, the issue of assembly line optimization was described. Authors Hamzas et al. presented the investigation of current state model and two independent proposals in real conditions of manufacturing production. They used Witness simulation software and CAE diagram. On the basis of results, they provided the recommendations for elimination of bottleneck and reduction of production time (Hamzas, Bareduan, Bahari, Zakaria, & Zakaria, 2019). Simulation of material flow is possible to use not only in the engineering industry. The research of Lopez-Davalos presents the simulation of material flow operations in the aerospace factory. The results of this research describe the main problems causing blockages and other non-value activities (Lopez-Davalos, Liaqat, Hutabarat, Tiwari, & Tiwari, 2018). The issue of material flow analyzes was described by authors: Duplakova et al., 2018; Centobelli, Cerchione, Murino, & Gallo, 2016; Uriarte, Ng, Zúñiga, & Moris, 2017; Popa et al., 2018; Seewaldt, Nagel, Geckler, & Bracht, 2017; Drastich, 2017, etc.

SIMULATION AND MATERIAL FLOW IN THE MANUFACTURING PROCESS

Most organizations that implement simulation tools in manufacturing processes and systems use commercial software products to manipulate materials. The two most common criteria for selecting simulation software are the flexibility of

modelling (the ability to model any system regardless of its complexity or uniqueness) and a simple work environment. The simulation language is a software package and is of a general nature (in terms of the applications it can solve) and the simulation model itself is done by "programming". The main advantage of a good simulation language is the flexibility of modelling. The main disadvantage is that programming expertise is needed. A production simulation language is one where particular modelling constructs are oriented to production or material handling. Over the past five to ten years, there has been considerable interest in simulation software that is easier to use, which largely means reducing the amount of programming needed to build the model. The main disadvantage of simulators is that they are not as flexible as language simulations because they do not allow full layout (Mikušová et al., 2018).

There are five different types of models that are used in different simulation programs:

- Simulation of tasks
- Standardized situation simulation
- Virtual reality simulation
- Process-based simulation
- Simulation of complex tasks in processes

The above-mentioned types of models can be applied to the tasks related to the material flow of the production process. Material flow in the enterprise is a system that needs to be directed and managed. In order to do this, the material flow must first be analyzed according to the determined parameters. For the analysis itself to make sense, it is necessary to use specific quantities related to the material flow - the number of goods, length of travel and time, speed of movement, travel speed and acceleration, size of goods flow, the intensity of loading, frequency of loading, goods, handling, transport, network complexity, number of interruptions (related to production and storage

functions), number of reverse flows and number of changes (Sadílek, 2011).

The material flow is structured according to how the movement of the centre of gravity of the material in space and time is realized. A distinction is made between the continuous and discontinuous material flow. Continuous material flow is a material movement in which matter occurs at the material flow points to be examined and has no initial or final boundary. Discontinuous material flow is a material movement in which an alternating state occurs at the examined points of the material flow, i. j. the presence and absence of matter, having an initial and final boundary (Lehocká, Hlavatý, & Hloch, 2016).

The material flow is divided into three parts. The first part is the information flow. It is the flow of information in a written or spoken form that is necessary to manage all logistics activities in an enterprise. It includes the flow of information relating to the material flow of individual technological processes of the company. The second part is the cash flow. This is a cash flow that is realized between individual market players. Cash flow is the most important part of being and operating a business in the market. The last part is the flow of material that passes from the supplier to the customer and undergoes a number of operations during the production of the material to the finished product. The material flow begins already during the extraction of the raw material. The third part represents a key role in the implementation of simulation in the production process (Lehocka et al., 2016).

ANALYSIS OF APPROACHES WITH THE USE OF SIMULATION

A large number of companies are trying to optimize material flows using primarily classical methods. These methods are very successful, but care must be taken to use them correctly in the industry, otherwise, it may have the opposite consequences for the business. Therefore, computer simulations that are able to

estimate the future behaviour of the production system are used today to optimize production process flows. An overview of the simulation tools used to address material flows in the production process is described briefly below.

Plant Simulation

The software enables simulation and optimization of production and logistics systems and their processes (figure 2). Use this software to optimize material flow, resource utilization and logistics for all levels of company planning, from global

facilities to local workshops to production lines. In the freely assembled object library, all basic Plant Simulation building objects are clearly stored. Each user can compose them graphically and interactively with individual objects. These include (Tecnomatix Plant Simulation, 2019):

- Integrated neural networks,
- Factor analysis,
- Experiment control,
- Automatic optimization of system parameters,
- Sequencing.

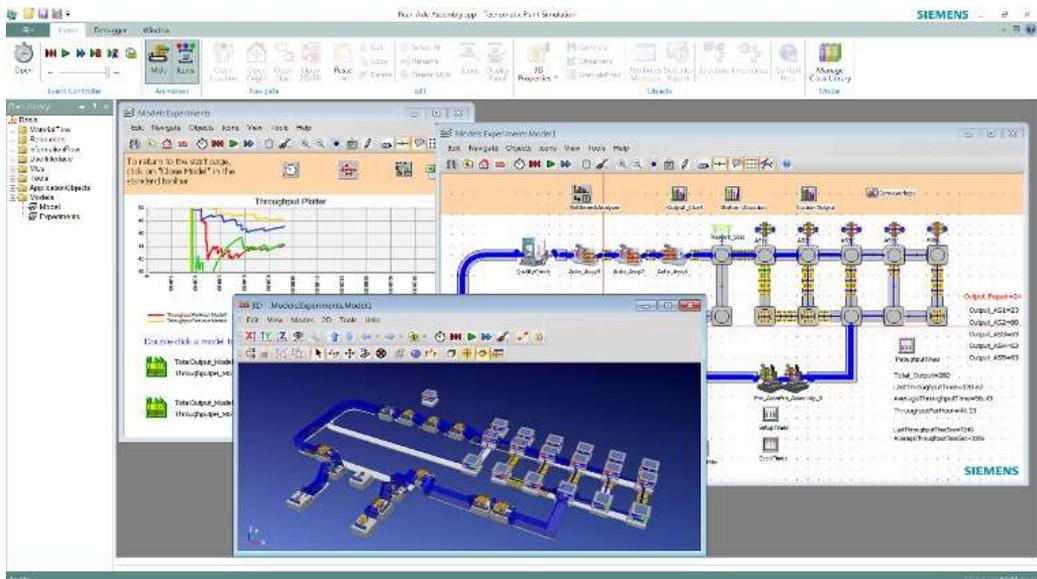


Figure 2. Working environment – Plant Simulation (Tecnomatix Plant Simulation, 2019).

Arena

This software is the most widely used integrated graphical simulation tool for discrete systems that models, designs, visualizes and performs statistical analyzes. Arena Simulation (figure 3) allows you to (Arena, 2019):

- Production management (production process evaluation, capacity planning, JIT, ERP, Six Sigma, stockpile optimization, etc.),

- Packaging (arrangement of conveyors, the efficiency of packaging equipment, machines, palletizing equipment, etc.),
- Logistics chain management - analysis of transport variants, expedition, inventory control.

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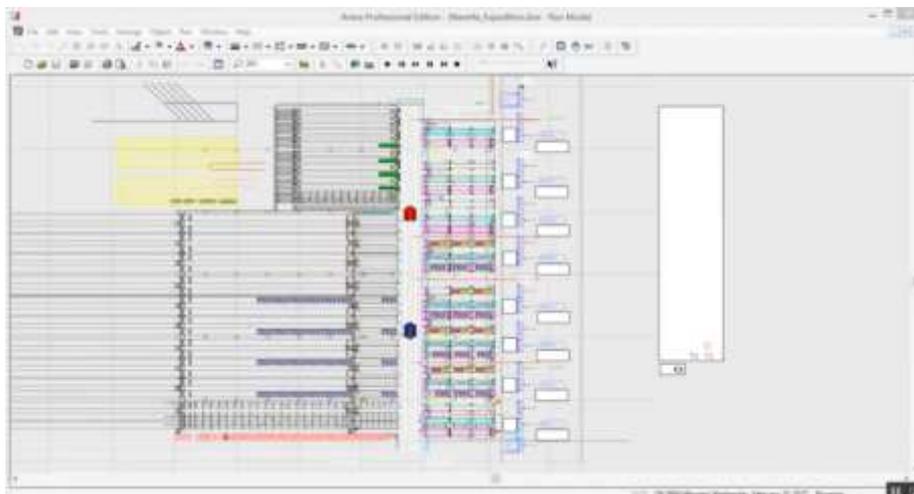


Figure 3. Working environment – Arena (Arena, 2019).

Simul8

Simul8 (figure 4) is a cost-effective and easy-to-use simulation software that helps you to give quick answers to various questions related to eg. financial and production processes, information flows, logistics systems and supply chains. Simul8 is well-suited for all industries, from the automotive industry to the food industry,

banking, government and healthcare. Simulations can be created in Simul8 using five basic elements. These symbols are placed on the bar and can be used with the desired properties such as processing time, buffer size, etc. The visual logic of Simul8 is based on an event-oriented structured language that can be used to construct an accurate simulation model (Simul8, 2019).

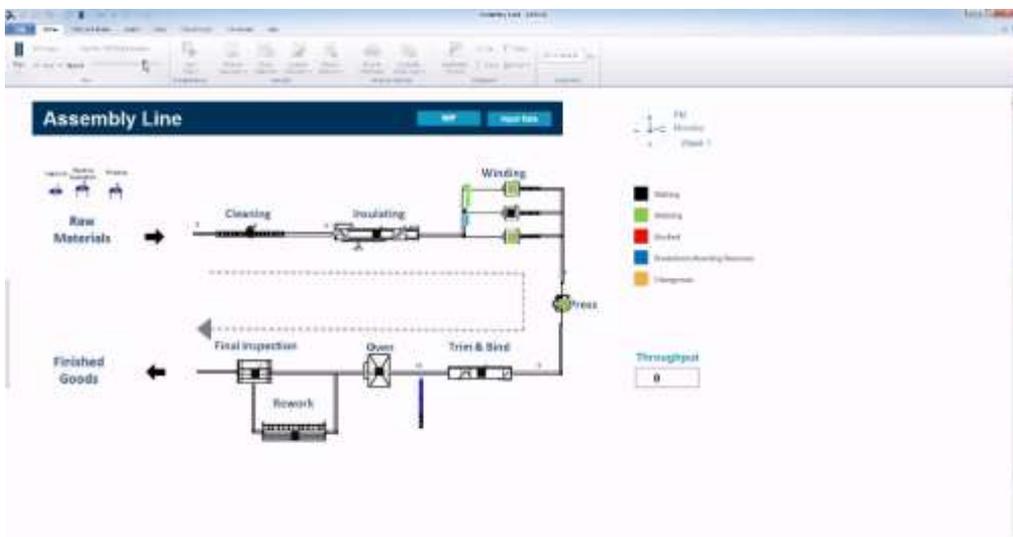


Figure 4. Working environment – Simul8 (Simul8, 2019).

AutoMod

Simulation software AutoMod (Figure 5) provides a variety of deployment options. These range from production process modelling, warehouse simulation, supplier-customer relationships, to online binding/emulation. The base system includes a process system, Simulator, DTrace, ACE, IGES and the ability to import SDX. The following modules are

available as building blocks (Applied smart factory, 2019):

- AS / RS (warehouse technology),
- Conveyor,
- Kinematics,
- Pathmover,
- Bridge Crane,
- Power and Free (overhead crane),
- Tanks and Pipes,
- AutoTruck.

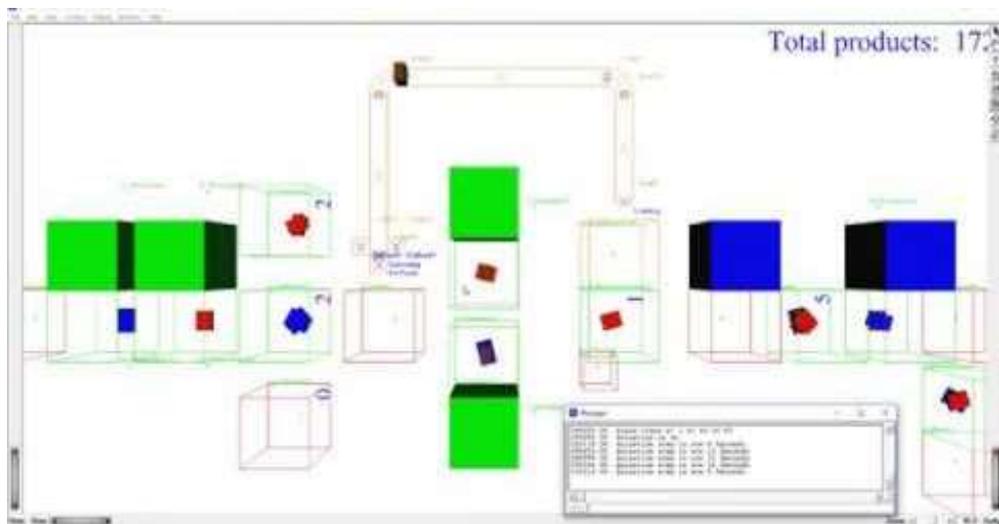


Figure 5. Working environment – AutoMod (Applied smartfactory, 2019).

Witness

This standard interactive simulation software (figure 6) is often used to plan and optimize production, logistics and services. It is used in universities and also provides wide use in practice. The witness is mainly used in (Witness, 2019):

- implementation of modern management methods,
- optimization of capital investment,
- capacity planning,

- identification of bottlenecks in production,
- optimization of production batches,
- verification of manufacturing processes,
- distribution of production units
- reduction of work in progress
- quality monitoring
- optimization of logistics processes and services

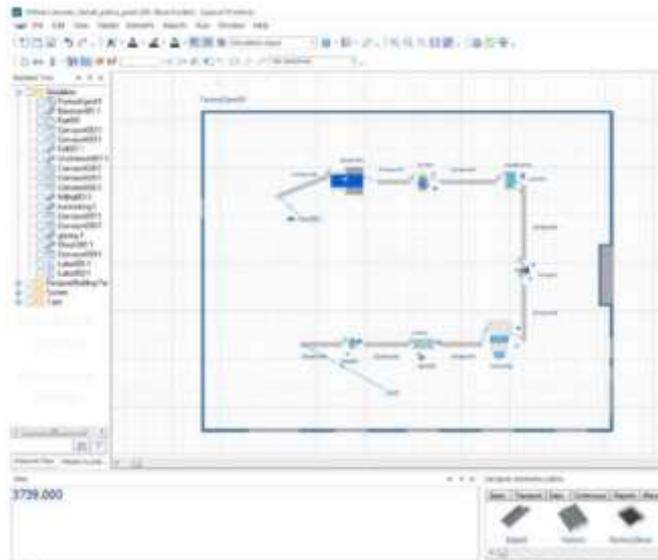


Figure 6. Working environment – Witness (Witness, 2019).

CONCLUSIONS

The manufacturing process currently uses a large number of support tools that work in conjunction with the concept of creating a digital enterprise. These tools allow each manufacturing company to complete an overview of the current state of production, but can also predict future developments. The simulation has been a part of almost all manufacturing companies that implement it in various production parts for several years. One of them is the transfer of material flow in production. The present paper gave an insight into approaches to material flows in the production process using simulations. He created a comprehensive overview of the issues raised and created the basis for future solutions to research tasks, as the simulation is a daily part of the life of a manufacturing company.

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