Research Article

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Solution of a production process with the application of simulation: A case study

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Abstract: Simulation programs are increasingly being used to solve material flow problems. These programs are primarily used for the simulation of production or transport processes. Testing of a new type of control in-process would mean stopping production and testing experiments with uncertain results. To avoid this lengthy and above all expensive way of any change, simulation programs have been used. Simulations of production processes in these programs enable better production planning and examination of bottlenecks in the production process by proposing changes, such as robots, conveyors, or also various logistics controls. The advantage is not only the fact that the production does not have to be interrupted, but also that it is possible to try many different experiments in a simulation process. The article is focused on the analysis of the production process in a selected production enterprise. After the analysis, the Tecnomatix Plant Simulation program was used for the creation of production process simulation. Results and improvements to the production process were proposed from the initial simulation with a focus on practical use.

Keywords: production, simulation, process

1 Introduction

In today's world, manufacturing companies are under increasing pressure from customers. Customers have great options in choosing the product they want to buy. They also have increasingly demanding requirements for their selected products. For companies to remain competitive with other companies, they must fully meet the wishes and needs of their customers, which means responding flexibly to modern trends. Rising competition, market globalization, low costs, available new technology, or changes in living standards, etc., present several variables which have a great impact on manufacturing enterprises today [1]. As mentioned in ref. [2], the prediction of market behavior is very helpful for a manufacturing enterprise to build efficient production systems. Authors in this publication emphasized the development of more flexible production systems which are important for the adaptation of market changes. One of the key elements or tools for the solution of the above said problems are presented by simulation. It is possible to say that simulation presents an area of production and logistics which is a well-accepted tool, for example for planning and evaluation of processes [3]. As presented in ref. [4], simulation is a well-established model-based analysis method for a lot of applications in this domain and very actual trend in production and logistics.

A simulation is a helpful tool for the understanding of production systems and also it can be able to present different types of solutions with high application in practice. Simulation helps to develop more flexible production systems and also can improve the quality of the systems and of course at lower production costs [5]. The simulation presents a very important tool of technological tools and also methods that help the successful implementation of digital production and manufacturing, for example as mentioned in ref. [6]. This is very important in today's turbulent manufacturing environment [6]. Simulation can be used for planning solutions in production environments [7], optimization of enterprise processes [8,9], and also for planning and control of production [10,11]. The use

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and application of simulation programs are deeply wedded to the simulation approach. Simulation programs are increasingly being used to solve material flow problems in companies. These programs are mainly used to simulate the production or transport process without production process disruption [12]. Testing a new type of operation during the in-process control would mean stopping production and testing experiments with uncertain results. To avoid this lengthy and, above all, expensive (due to the impossibility of production) method of any change, simulation programs have been used [13]. The simulation of production processes enables better production planning and examination of bottlenecks and problematic parts in the production by the proposal of changes, or various logistics processes [14]. The advantage is not only that the production does not have to be interrupted but also that in a simulated process it is possible to try many different experiments. These experiments simulate months or years, and with this, can be created plans for production for the next period and evaluate the benefits of a change in the course of the process [15]. But a very important part of the simulation is presentation and explanation of the simulation results. Because wrong simulation results, which are translated into wrong decision proposals with the next implementation, can imply cost with a higher magnitude than the total cost of the simulation study [16]. The aim of the case study is to model the production process in a selected production enterprise, model of weak (bottlenecks), and activities that may affect the continuity of the production activities. The case study tries to provide proposals for improvement which will bring possible solutions in the production process. The partial aims of the study were: analysis of the current state of the evaluated production enterprise, formation of the simulation for the production process, analysis of the simulation results, and proposals for improvements in the production process.

2 Analyzed data

The evaluated production enterprise has three buildings (halls), one office building, and a free-standing building, in which one of the production processes is situated (dryer of wood). There is a hack saw in the first hall (Figure 1, red line), this saw is used for round log processing. The saw is not automated, it is controlled by a worker. The round log is stored in the first hall. After the log processing, the semi-finished products are stored in a warehouse located in the first hall behind the frame saw. In-house transport among these production steps is realized by a high-lift truck. The second hall is for

the processing of semi-finished products. This involves grinding and cutting to specific lengths, according to the order form. In-house transport is provided manually. This type of transport was chosen due to the fact that there is not enough space for handling a high-lift truck or pallet equipment. The third hall involves other production steps, namely drilling, milling, and gluing to the final shape (form). There is also a surface treatment of these products. Among these steps, in-house transport is also manual. The last station in this production hall is the packaging workplace.

2.1 Production process

The evaluated enterprise has a production process divided into three halls (buildings) and a dryer located next to these halls. Figure 2 presents the production process of this enterprise and Table 1 presents the times of production steps for the evaluated production process.

Stages of production in the enterprise: pre-making phase – processing of round log and drying; making phase – trimmed and trimming of semi-finished products, cutting, drilling, milling, and gluing; finishing phase – surface treatment, packaging, and delivery.

During the analysis, some shortcomings were identified. Shortcomings were defined as – dryer because this production step is very busy with small reserve, production step gluing, surface treatment, packaging – these production steps do not work efficiently, this means that these production steps have very large downtimes.

3 Simulation model

The program Tecnomatix Plant Simulation is designed for solving problems and subsequent optimization of these problems. It is an effective tool for dynamic simulation and allows the creation of digital models of production and logistic systems and also to examine characteristics of systems and optimize their effectiveness. Using this program in the process of planning, it is possible to obtain probable results before installing the real production systems. A simulation model of the production process was created in the program Tecnomatix Plant Simulation. This program is a tool for creating discrete simulations. With the help of this program, it is possible to create virtual digital logistics or also the production process from individual parts. The program allows by its analytical tools, such

Figure 1: Layout of buildings of the production enterprise (red line – production hall, blue line – production hall, yellow line – production hall, pink building – drying chamber, green building – administrative building). Source: authors.

as analysis of obstacles, statistics, and graphs, to very quickly simulate and evaluate the system without intervention to the real process. This allows trying more variants of the problem

solution. The simulation model was created to represent a single shift operation (from 6 am to 2 pm, 8 h). Within the model, one fork-lift truck was modeled, which was set

Figure 2: Production process (scheme of the production process). Source: authors.

Table 1: Times of production steps

Time of round log processing	20 min
Drying	30 min
Trimmed and trimming of semi-finished products	20 min
Cutting	20 min
Grinding	10 min
Drilling	15 min
Milling operation	18 min
Gluing	20 min
Surface treatment	10 min
Packaging	5 min

Source: authors.

according to the actual time of work in the enterprise (every hour and a half it brings a round log for processing). Additional data that were entered into the simulation are presented in Table 1. Figure 3 presents the whole production process of the enterprise simulated in the program Tecnomatix Plant Simulation

3.1 Procedure of model creation

The next part of the study presents the process of simulation model creation in the selected program.

Production hall 1 – At the beginning of the simulation, it was needed to draw a line for the fork-lift truck. The next step was the insertion of the block “Source.” It was also necessary to create components that were inserted into the model, i.e., round log, box, etc. The procedure of model creation was as follows. The first

part was to set “container or transporter” in the folder “Mus” and they could be duplicated. In the folder “User objects” was displayed the duplicated item, which was named and set. Figure 4 presents the production hall 1 in the simulation program.

The next block Source was set so that only one high-lift truck came to the track (high-lift truck was “add” to the column MU) (Figure 5).

In the next step, an input was created. The “Source” was inserted from the work bar in the part Material Flow. To the block Source, it was necessary to add the block Buffer, between which was created a connection. This block was named a round log warehouse.

4 Simulation experiments

The simulation experiment confirms or refutes the assumptions about the behavior of the production process. Thanks to the continuous results of experiments, it is possible to constantly modify the simulation model so that the best possible solution variants are achieved. Each experiment is done under predefined conditions. After processing the simulation process in the program, shortcomings in the production process were identified. These shortcomings were the production step of the dryer and also the production processes of gluing, surface treatment, and packaging.

The last part of the study will focus on a proposal for improving the production process in the production enterprise by eliminating these bottlenecks and also minimizing employee downtime. The proposed solutions which will

Figure 3: Production process of the enterprise presented in the program Tecnomatix Plant Simulation. Source: authors.

Figure 4: Production hall 1 in the simulation program. Source: authors.

Figure 5: Set up "Source." Source: authors.

Figure 6: Utilization of devices (device 1 – processing, 2 – dryer, 3 – planning, 4 – cutting, 5 – grinding, 6 – drilling, 7 – milling operation, 8 – gluing, 9 – surface treatment, and 10 – packaging). Source: authors.

present the improvements of the production process for these bottlenecks must be better defined, which result from the simulation. With the help of simulation, it was determined that the stage of production “drying” is sufficient in the case if the enterprise will want to stay at its current capacity and will not increase its production.

If the enterprise receives more orders, the production step “drying” becomes a bottleneck. Figure 6 presents the utilization of production steps in the enterprise. The least used steps in the production enterprise are gluing, surface treatment, and packaging. Another important finding by

the simulation is the fact that some stages in the production process are blocked. The most blocked step is “grinding.”

4.1 Proposal No. 1: production process “dryer”

The enterprise wants to expand its capacity shortly and for this reason, this production stage in the production

Figure 7: Addition of the second dryer to the production process. Source: authors.

Figure 8: Utilization of devices in the stage “dryer” (1 – processing, 2 – dryer, 3 – planning, 4 – cutting, 5 – grinding, 6 – drilling, 7 – milling operation, 8 – gluing, 9 – surface treatment, and 10 – package). Source: authors.

enterprise is identified as a bottleneck. This is because it is used sufficiently with minimal reserve. This means that if the production enterprise receives more orders, this production step will lag. The solution is to build another dryer. This solution was integrated into the simulation. Figure 7 presents the changes that occurred in the simulation. Figure 8 presents the utilization of the stage “dryer” if the enterprise will have two dryers. This figure also shows that no production step in the process is not blocked (in comparison with the initial simulation, with the blocked step).

4.2 Proposal No. 2: production steps “gluing, surface treatment, and packaging”

The production steps “gluing, surface treatment, and packaging” are not sufficiently utilized. The solution for these non-effective workplaces can be their connection to the one with one employer. Figure 9 presents the application of the changes in the simulation model.

This change in the simulation model achieved that the production in the process are more work out. Staff

Figure 9: Application of the change in the simulation model. Source: authors.

Table 2: Financial costs related to staff

Production step in the process	Staff	Costs
Financial costs related to the production process (the initial simulation)		
Time for round log processing	1	850
Drying	x	1,000
Planning	1	830
Cutting	1	850
Grinding	1	860
Drilling	1	850
Milling operation	1	850
Gluing	1	850
Surface treatment	1	900
Packaging	1	850
Sum	9	8,690
Financial costs related to the production process (proposal of improvement)		
Time for round log processing	1	850
Drying	x	1,000
Planning	1	830
Cutting	1	850
Grinding	1	860
Drilling	1	850
Milling operation	1	850
Gluing, surface treatment, and packaging	1	950
Sum	7	7,040

Source: authors.

The symbol x presents that for this part of production process was not use a staff.

costs have been reduced because of the previous three employees, the enterprise needs only one who ensures the operation of all three workplaces. Table 2 presents the financial costs for the staff from the initial simulation and after the improvement proposal (Figure 10).

From Table 2 it can be seen that the staff costs have been reduced by this proposal by 1,650 € per month. Yearly, the enterprise saves by this solution 19,800 €.

5 Conclusion

The case study aimed to point out the possibilities of using computer simulation and the simulation program Tecnomatix Plant Simulation to solve problems in a selected production enterprise. A simulation was created in this program, and this reflects the current state of the evaluated production enterprise. The simulation experiment consisted of two parts. The first part was focused on the description of the current state and the second part was aimed at improving the current situation in the enterprise. Two variants of improvement and simulation were created. The results from these simulations were analyzed, and one proposal of improvement calculated the costs associated with the solution design and in the other case, the table with the financial savings after application of the proposal.

Figure 10: Utilization of devices after connection of three steps in the production enterprise (1 – processing, 2 – dryer, 3 – planning, 4 – cutting, 5 – grinding, 6 – drilling, 7 – milling operation, 8 – gluing and surface treatment, 9 – packaging). Source: authors.

The program Tecnomatix Plant Simulation is one of the most widely used software for modeling, simulation, and optimization of production and logistics processes of today's companies and enterprises. This program is mostly used by companies that deal with the automotive industry, but over time it also reaches smaller companies that deal with the industry. It is also being used in companies with smaller serial production. This program can be used in every company where it is necessary to reduce production costs, improve material flow in the production process, or increase labor productivity. In addition to the function that it is possible to optimize the existing production process without disrupting the operation of the company, this program is also suitable for designing new products. For the design of new products, the possibility of 3D visualization is built into this program. This allows the user a virtual tour of the new production. This option helps to fulfill the contractor's ideas.

After processing the simulation and subsequent analysis, it was found that the production process has two shortcomings. The first determination was the stage dryer. This operation is assessed as a bottleneck because if the enterprise wants to receive more orders shortly, then this operation would not be sufficient. Therefore, the proposed improvement was oriented to building up a second dryer. The costs that the enterprise would incur are 30,000 €. Other shortcomings in the enterprise were the operation of gluing, surface treatment, and packaging. These operations are inefficient because they are insufficiently working out.

The proposal was processed in such a way that these operations were merged and were handled by only one employee. As a result, the enterprise would save the salaries of two employees, which amounted to 1,650 € per month. The optimization of production and also logistic processes can be defined as a very important element (factor) to the success of the enterprise. The simulation that was created gives very important and accurate information that leads to planning and decision-making in the near and also in the distant future. By optimization, the enterprise can reduce costs and also increase labor productivity.

If a company intends to increase production, using the Tecnomatix Plant Simulation program, it can avoid unnecessary purchases, such as a production line or the construction of an area that is not needed at all. The simulation avoids unnecessary purchases. Nowadays, more and more companies are starting to look at the possibilities offered by the digital business. There are more and more companies in the market that deal with digital business. These companies offer their services such as optimization of production processes, logistic processes, and

also proposals for improving these processes. In addition to these services, companies have different types of software where customers can choose according to the needs and focus of the business. It can be said that digitization will continue to move forward.

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