THE USE OF FLEXSIM SIMULATION SOFTWARE FOR DEFINING COSTS OF A GRADUAL SHAFT PRODUCTION PROCESS

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Abstract

The article presents a method of defining costs of a gradual shaft production process using FlexSim simulation software. One of the key concepts used in the article is a computer simulation, which is necessary for the efficient and quick implementation of this type of research. The objective of the article was to determine the costs of the production process at a given size of the production lot and to present the possibilities of FlexSim software. To create a computer simulation, first a product that will be produced must be chosen. Then, the positions on the program's working field are selected and placed. The next step is to set the parameters of the machines or positions, and finally to perform a simulation. Conducted simulation showed, that the biggest costs are generated by lathes and milling machines, while the lowest - by quality control station. Thanks to the experiment, it is possible to determine how to reorganize the production process in a way enabling cost minimization. Moreover, it has been demonstrated that computer simulation allows to illustrate the virtual production process with the lack of risks associated with the real process, as well as it enables analysis of individual results and subsequent optimization.

Keywords: Computer simulation, FlexSim, flexible simulation, costs, production, gradual shaft

1. INTRODUCTION

Nowadays, the quality of services is of the primary importance for customers. High quality products, low price or quick delivery are just a few of the many features that characterize the demand for a given product, also in the machine industry. Production enterprises, in order to adapt to those standards, strive to meet the conditions set by buyers. It is a logical and conscious operation of enterprises. If the manufactured item is cheap and of high-quality, the company will automatically gain a desired reputation. Today, thanks to the development of technology, we have a number of tools allowing for virtual production planning. One of the tools used to solve these problems is the so-called computer simulation [1,2,3].

2. APPLICATION OF COMPUTER SMULATIONS IN PRODUCTION PROCESSES

The production process is the entirety of intentional activities, that lead to gradually occurring changes in the subject of work, thanks to which, successively, similarity to the intended product can be observed [4]. As a consequence, if all necessary elements have been generated, a previously designed product or group of products is obtained, assuming that they can be changed if necessary. The production process is carried out according to certain rules at a given time. It should be implemented in order to maximize production efficiency [5]. Due to numerous changes during the production process, such as the change in the number of pieces of the produced product, accurate planning of the production process seems to be difficult. The complexity of the production process causes the successful companies today to use methods that make it possible to control their work. One of the best tools to solve such problems is the so-called computer simulation [6].

Simulation modelling allows to organize all complex production operations in the right order, which translates into the correct course of the process, and finally the efficiency of production. Computer simulation allows for a wide range of activities related to production planning. Computer simulations can be used in production

processes implemented in real-time, i.e. current production, but also to simulate a process or production stage that can be used in the future [7].

In order for the simulation modelling process to proceed properly, specific information, that directly affects the production process, should be entered into the simulation software [1]. That includes:

- type of production flow,
- plan for the deployment of production sites,
- stockpile management,
- assessment of the amount of input materials,
- production plan,
- supply management.

Input of the necessary data into the software allows for a real reflection of the given production process [8].

3. COMPUTER SIMULATION OF THE GRADUAL SHAFT PRODUCTION PROCESS

The aim of simulation modelling was to determine the costs of the production process, at a given size of the production lot. The analysed production process was a production of gradual shafts, carried out in the number of 100 pieces. The shaft is a part of the machine, most often in the shape of a cylinder, rotating around its own axis together with the elements mounted on it, used to transfer the torque. Elements of the shaft are tenons on which there is contact with other elements, free surfaces, i.e. transition surfaces, rings and flanges, i.e. support surfaces for elements mounted on shafts, a movable pivot, i.e. a fixed element, sliding during work, and resting spigots, which are not movable during work. Shafts are usually made of carbon steel, alloy steels or spheroidal cast irons.

In computer simulation, it is of crucial importance to perform certain activities in a chronological manner. At the outset of the experiment, elements that participate in the production process had to be chosen and arranged in the work area in a logical way, in order to maintain the continuity of production (**Figure 1**).

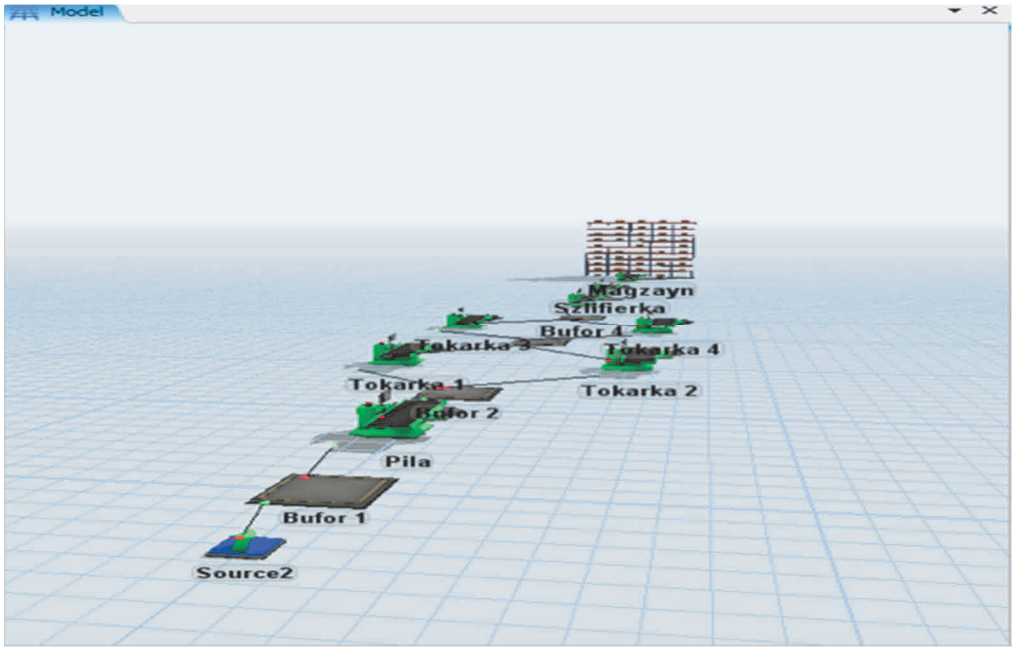

Figure 1 The arrangement of devices on the working area in the FlexSim program [own study]

The next step was to define parameters characterizing the work of the given elements, i.e. time and cost (**Table 1 and 2**).

Table 1 Duration of the operation in production process [own study]

Operation number	Operation	Work station	Duration (h)
10	Cutting	Saw	0.07
20	Rough turning	Lathe	0.8
30	Shape turning	Lathe	0.62
40	Groove milling	Miller	0.48
50	Grinding	Grinder	0.12
60	Quality control	Quality control	0.02

Table 2 Production costs at the given work station [own study]

No.	Work station	Number of stations	Costs at the station (PLN)
1	Saw	1	30
2	Lathe	4	50
3	Miller	1	50
4	Grinder	1	40
5	Quality control	1	25

The final and most important stage of the computer simulation was to achieve the goal of defining the costs of the production process. For this purpose, simulations of the manufacturing process were implemented using previously determined parameters.

3.1. Results analysis

After the simulation, a dialog window with results was obtained (**Figure 2**).

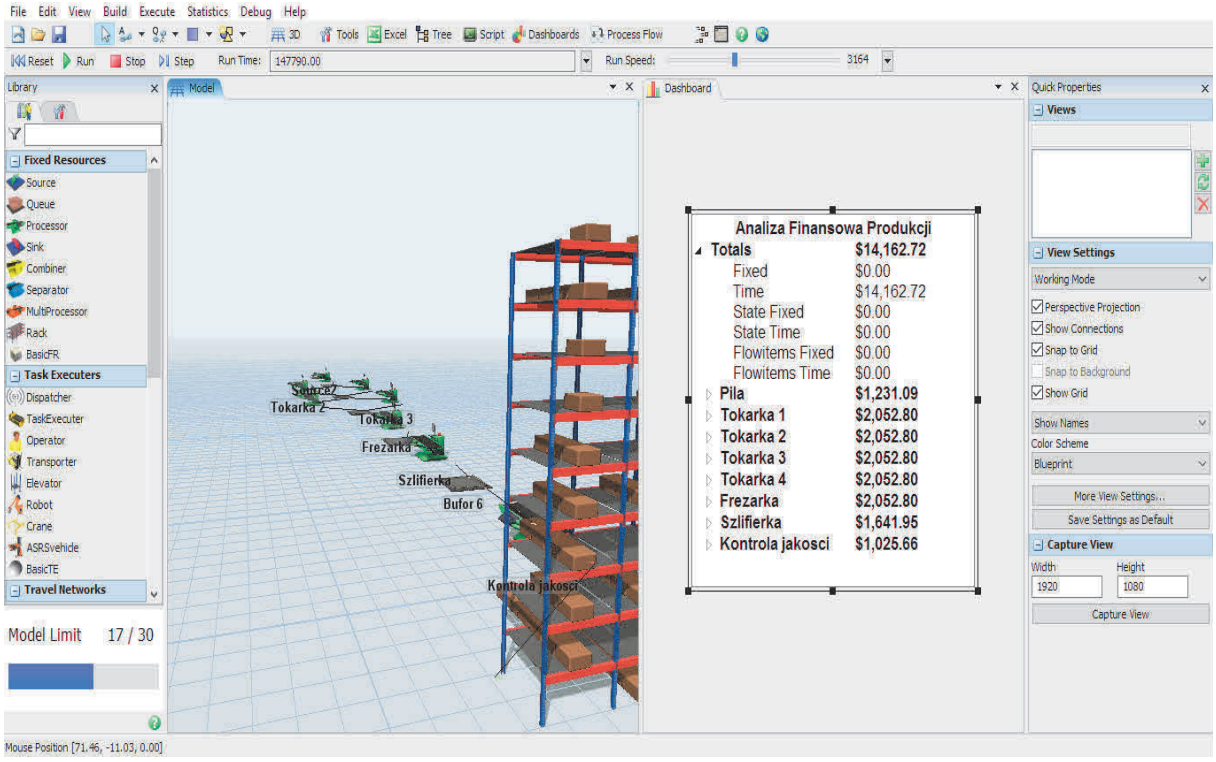

Figure 2 Financial analysis of production [own study]

As the **Figure 2** shows, the software does not only calculate the total cost of production, but also costs produced by each device. This is useful in further production analysis, if, for example, there is a need to cut costs at a particular position, at the expense of extending the production process time or vice versa. The total production cost according to the simulation is 14,162.72 $. Analysing the above results, it was noticed that the biggest costs are generated by lathes along with the milling machine. The lowest on the other hand are generated by the quality control position. If the company would like to economize the production process, it should focus on lathes and consider whether instead of 4, it could use 3 of them. In order to verify it, another simulation shall be carried out based on changed parameters and later both simulations must be compared to see which option is more profitable.

4. CONCLUSION

Results of the simulation, accordingly to the primary assumption, are mapped to the existing objects. The obtained results give values comparable to those found on real objects. FlexSim software is a great and easy-to-use tool that allows to perform computer simulations effectively. It makes it possible to track the production process in real time, which is helpful in illustrating what can be improved at a given stage. The simulation process is quicker than real one, which gives the opportunity to simulate various variants of the production process and determine the costs of their implementation. Thanks to the simulation carried out in the FlexSim program, one could answer a number of questions or make decisions that may otherwise be too costy or risky in the real production process. In summary, the program gives an opportunity to ask an important question "what would happen if" and to evaluate solutions to potential problems in order to see if they are likely to succeed. It could be a base for designers who can optimize the processes on the basis of the conducted simulations. The tests carried out on the model given the expected results. That confirms the correctness of the operation of the created models.

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