Application of Simulation Software in the Production Process of Milled Parts

Darina Dupláková, Monika Telišková, Jozef Török, Dušan Paulišin, Jaroslav Birčák

Faculty of Manufacturing Technologies with a seat in Presov, Technical University of Kosice, Sturova 31, 080 01 Presov, Slovakia

***Abstract* – In the present, simulation programs are very widespread tool in designing of new systems, improving the existing systems, etc. The simulation software is possible to apply in various sectors, e.g. production, logistics or the field of various services. This article is focused on the application of Witness – simulation software in the manufacturing process. The introduction of this article is focused on short description of simulation issue in the manufacturing processes. The last part of the introduction is focused on description of Witness simulation software. The material and method section describes the manufacturing process (material flow) from which the simulation model is created and subsequently optimized. The final part of this article provides overview of the results from suggested optimization.**

***Keywords* – Simulation, optimization, production process, Witness.**

1. Introduction

Simulation presents an experimental method where the studied object is substituted with its simulation model and all the experiments and tests are realized with that model in order to obtain the information and conclusions about the original system. The principle of simulation lies in the fact that there is a simulation model of real system created in computer environment. Then it is possible to realize different experiments [1].

DOI: 10.18421/SAR12-02
https://dx.doi.org/10.18421/SAR12-02

Corresponding author: Darina Dupláková,
Faculty of Manufacturing Technologies with a seat in Presov, Technical University of Kosice, Slovakia
Email: darina.duplakova@tuke.sk

Received: 22 May 2018.
Accepted: 16 June 2018.
Published: 25 June 2018.

Simulation can be applied to the various aspects of business, technology and science. Focus in this article is on the manufacturing operations. Simulation models of manufacturing system can be used for the following objectives [2]:

- Configuring labour-resources in an intensive assembly process.
- Determining throughput capability of a manufacturing cell, an assembly line, or a production system.
- Determining the needed number of automated guided vehicles in a complex material handling systems.
- Determining the size and resources in a complex automated storage and retrieval system.
- Determining the best ordering policies for an inventory control system.
- Determining buffer sizes for work-in-progress in an assembly line.
- Validating the outcomes of material requirement planning.

These applications have several advantages and disadvantages. In the following table there are presented a few examples of advantages and disadvantages of simulation.

Table 1. Advantages and disadvantages of simulation software [3]

Advantages	Disadvantages
Experiments with time (cycle/mean/lead) possible	A model is only an abstract simplified representation of reality
New situations can be explored	Time-consuming
Problems can be detected before they reach the shop-floor	Sometimes hard to analyse the results
Possible to try alternatives without heavy machine investment	Hard to determine the level of detail for simulation model
Good knowledge of the system can be gained	Expensive software and hardware needed

The basic simulation procedure is presented in the following figure.

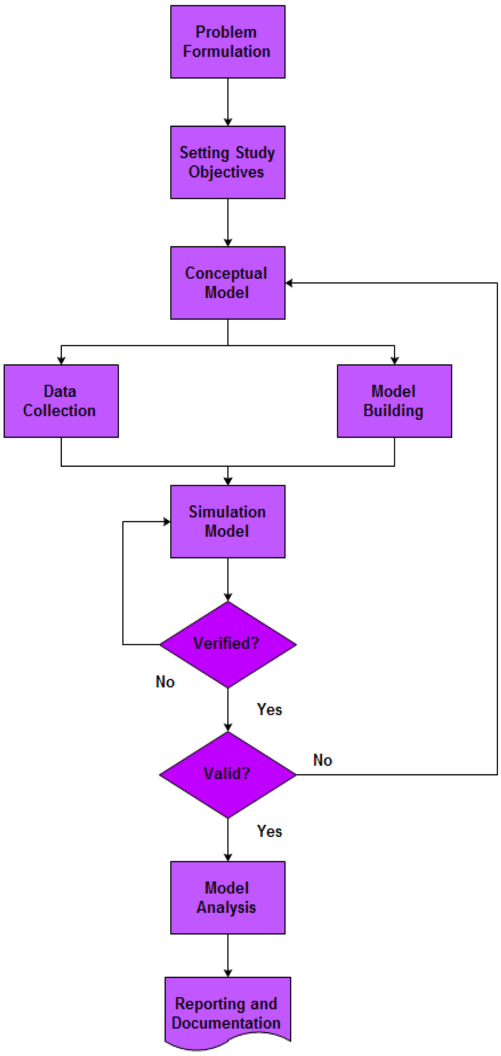

Figure 1. Simulation procedure [3]

Various types of simulation programs are used for realization of the simulation [4]. The simulation software is reliable tool for obtaining information about the progress and the results of the manufacturing process [5]. They provide large quantity of data to help the manufacturing company decide quickly and correctly on any problems. The most famous simulation tools used in industry are:

- Delmia – creation, scheduling and management of production processes.
- Tecnomatix Plant Simulation - simulation, visualization, analysis and optimization of production systems, material flow, resource utilization and logistics processes.
- Flexsim - computer simulation, analysis, visualization and optimization – from the manufacturing up to the delivery.
- Spar – simulation of operation, efficiency of system, production costs, scheduling, optimization and logistical model.
- Simul8 – reduction of waiting time, optimization and more efficiency of machine utilization, identification and elimination of bottlenecks.
- Arena – documenting, visualizing and previewing of the processes.
- Dosimis – verification and analysis of manufacturing process in the automotive industry
- Witness – computer simulation of the working environment and simulation of the consequences of different decisions in the field of production, logistics and services.

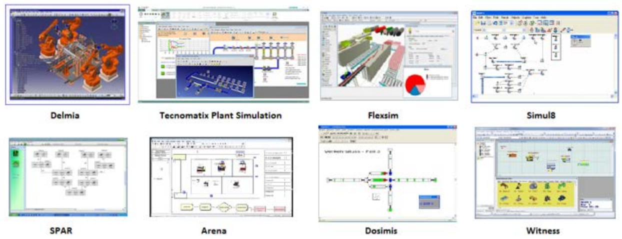

Figure 2. Simulation software used in practice

In manufacturing plants, there is often used the simulation software called Witness. It is used for simulation of manufacturing, service and logistics processes. In the Witness, the simulation model consists of a collection of elements, actions, rules and tools. Modeling elements are categorized as follows [2]:

- *Graphical elements*: enhance the presentation of the model and the supply information; the basic graphical elements are pie charts, time series and histograms
- *Logical elements*: files, shifts, distributions, attributes, variables, functions
- *Physical elements*: parts, fluids, conveyors, vehicles, track, carries, pipes, paths, tanks, buffers, processors, machines

The basic working environment (Figure 3.) consists of these parts:

- Tool bars
- Element tree
- Layout window
- Designer elements
- Simulation time

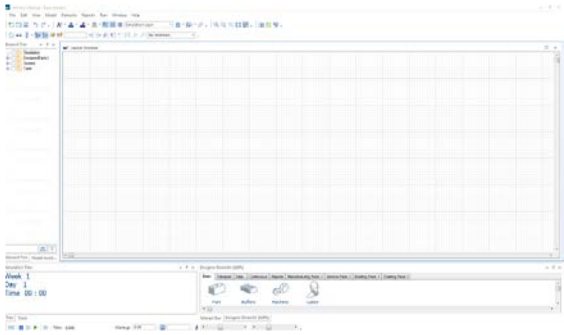

Figure 3. The environment of simulation software – Witness

In Witness simulation software, the creation and evaluation of model entails the following tasks:

- Define the model elements required (parts, machines, labour, etc.).
- Display those elements on the screen.
- Provides the details of system operational logic.
- Run the simulation.
- Generate and evaluate the results.
- Provide the solution.

2. Material and Method

In the following part of this article, described is the application of simulation software Witness in the practice. This section provides the input data of manufacturing process and then represents the created model and in the last part displays the model after optimization.

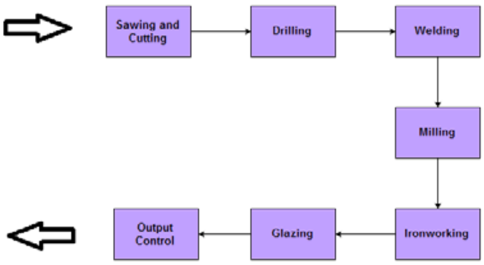

Figure 4. Material flow of production process

Simulation model of production process was created on the basis of material flow scheme (Figure 4.). The input data (production time and time of transport between operations) are presented in the following table (Table 2.).

Table 2. Input data

Production process	Time [s]
Storage	-
Transfer of material	17
Sawing + Cutting	36
Transfer of material	4
Drilling	11
Transfer of material	4
Welding	13
Transfer of material	7
Milling	9
Transfer of material	8
Ironworking	6
Transfer of material	8
Glazing	20
Transfer of material	7
Output control	8
Transfer of material	17
Shipping	-
Total production time	179

From the above mentioned data, the basic simulation model was created (one piece of a part). This model provides the verification of the correctness of the model creation against the real production process. The created model is presented in the following figure.

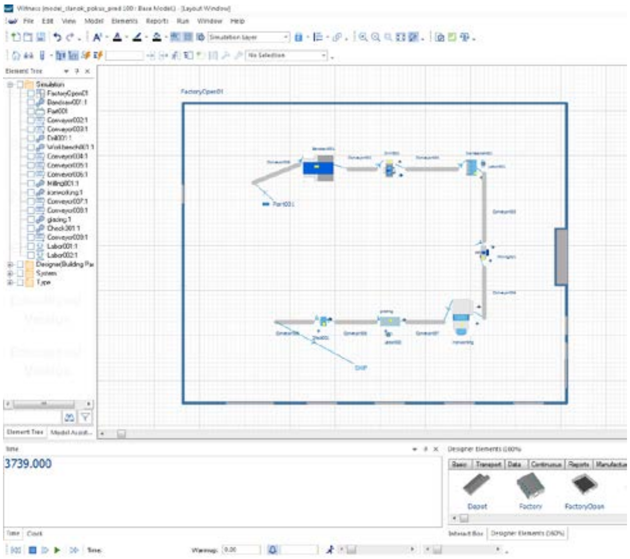

Figure 5. Model of production process - Witness 2D

Then, the simulation model was modified for the quantity of material entering the production process based on real production data. In the further models, the production batch was defined – 10 and 100 pieces according to the kind of produced model.

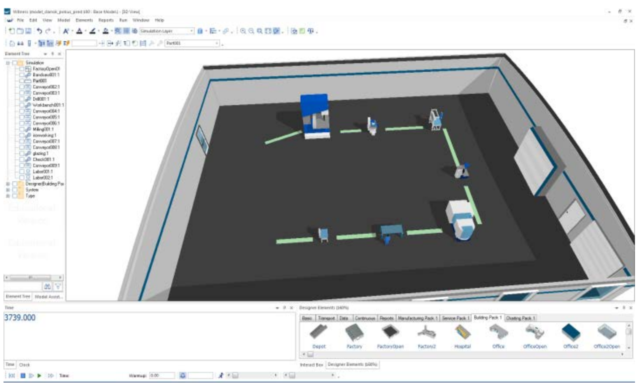

Figure 6. Model of production process - Witness 3D

Due to the disproportionately increasing production process length, the optimization was realized in the workplace. The optimization of the workplace consists in the exchange of sawing and cutting machine used for two machines performing these operations separately. After this change, the production times were also adjusted, the sewing operation took 21 seconds and the cutting operation was 15 seconds. A conveyor was also inserted between the machines performing these operations, after which the blank was moved for 4 seconds. The following figure shows a new production process model completed with the production machine.

Figure 7. Model of production process after the optimization – Witness 3D

After the individual models were created, the simulation of the production process for individual production batches was carried out. The following part describes and evaluates individual results achieved in given simulation by numerical and graphical interpretation.

3. Results

After the simulations were performed, the overall results for the individual production batches (presented in the following figures and Table 3.) were generated by the simulation tool. Machine busy and total production time was evaluated.

Figure 8. Report by on shift time - Busy

In the previous figure, the graphical interpretation shows that after the optimization, an increase at the production batch of 10 pieces even at a production batch of 100 pieces in the capacity of the individual machines was recorded.

During the evaluation of realised simulation from the point of view of production time, it is also possible to see a reduction in production time after splitting the cutting operation into two production machines at higher production rates. In the production of 10 pieces, the production time was reduced by 26.25% and in the production of 100 pcs the proposed optimization to reduce the production times was up to 31.59%. The numerical results and their graphical interpretation are listed below.

Table 3. Evaluation table

	Total production time before optimization	Total production time after optimization	Percentage of difference in production time before and after optimizations
10 pieces	499	368	26.25%
100 pieces	3739	2558	31.59%

The following figure provides the graphical interpretation of results recorded in the evaluation table (Table 3.).

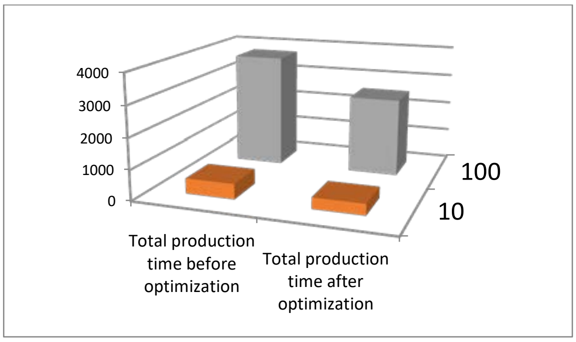

Figure 9. Evaluation bar

From the above results it can be stated that the applied simulation of the change of the machines had a positive advantage in terms of machine utilization and reduction of production times.

4. Conclusion

In today's digital world, simulation software has an irreplaceable place. Simulation method is possible to apply into the various fields, including engineering for optimization of material flow, cost, prediction of model quality, design of objects, etc. [6-9] Presented article was focused on the application of Witness simulation software in the production process. The results of the individual simulation show that after the production process has been lowered by the new machine, the overall production times have been reduced and also the efficiency of the individual machines has increased. From the technical point of view, this proposal has a positive impact on practice but it is necessary to study this issue in terms of economic efficiency. The issue of economic efficiency is the subject of further research.

Acknowledgements

Presented article was supported by research grant VEGA 1/0492/16.

References

[1]. Kočiško, M., Novák-Marcinčin, J., Baron, P., & Dobránsky, J. (2012). Utilization of progressive simulation software for optimization of production systems in the area of small and medium companies. *Tehnički vjesnik*, *19*(4), 983-986.

[2]. Al-Aomar, R., Williams, E. J., & Ulgen, O. M. (2015). *Process simulation using witness*. John Wiley & Sons.

[3]. Klingstam, P., & Gullander, P. (1999). Overview of simulation tools for computer-aided production engineering. *Computers in industry*, *38*(2), 173-186.

[4]. M. Čuma, P. Szentivanyi, & J. Török. (2014). Simulation of machining process and its associated effects, *CA Systems in Production Planning*., *15*(1), 17-20.

[5]. Zajac, J., Beraxa, P., Michalík, P., Botko, F., & Pollák, M. (2016). Simulation of Weld Elbows Hot Forming Process. *International Journal of Modeling and Optimization*, *6*(2), 77.

[6]. L. Knapčíková. (2008). *Plastics and their use*. FVT PO.

[7]. Michalik, P., Zajac, J., Hatala, M., Duplák, J., & Mitaľ, D. (2016). Comparison of programming production of thin walled parts using different CAM systems. *MM Science journal*, 10, 1056-1059.

[8]. Micko, M., Botko, F., Hatala, M., Radchenko, S., & Radic, P. (2016). Prediction Model of Surface Quality after Plasma Cutting of Steel S355. *Scientific Bulletin Series C: Fascicle Mechanics, Tribology, Machine Manufacturing Technology*, 30, 63.

[9]. Sedlák, J., Glváč, A., & Czán, A. (2018). Design of stirling engine operating at low temperature difference. In *MATEC Web of Conferences* (Vol. 157, p. 04003). EDP Sciences.