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Optimization of production orders input to manufacturing system

Creating database of simulation models to support the teaching

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***Abstract*—This article is part of a project *Creating database of simulation models to support the teaching of subjects: Modeling and simulation of production systems (GMV, GMV-A) and Production Planning and control (GPR, GPR-A)* supported by Science Fund of FME 2014. The folowing arcticle is part of simulation models database designed for educational purposes. It describes practical use of line production system computer simulation. The aim of simulation is to find optimal distribution of production orders input to manufacturing system. Simulation is a noninvasive method by which can be monitored and analyzed the behavior of real system or system in level of design. This means that it is possible to examine the effect of changes in the production system without consequences, which should have their application to the real system. In this article is described the definition of simulation model to which are performed experiments. The experimental results can be applied in practice for streamlining operation of the production system.**

***Keywords*—computer simulation, simulation model, normal distribution, optimization, local minimum**

I. Introduction

Making the right decision about the direction of the manufacturing process development is one of the key factors of companies success. Competition pressure and customer demands increasing are forcing companies to constantly innovate, improve and overtake the competition. How easy should decisions making have been if the company's management knew in advance what would be the impact of that decision,and how it would be reflected in future? How to be exact in predicting the future isn't possible of course. As the previous modern technology allows, is based on current and historical data and with relevant tools to test the development of the facts. One of the most useful tools for this purpose is discrete simulation. [1]

Possibilities to use manufacturing processes simulation are numerous, because complicated production systems, which have probabilistic and dynamic behavior are the rule rather than the exception.[2] Generally, there are many methods for increasing the efficiency of discrete manufacturing. In the case of discrete manufacturing systems may be the majority of methods complicated, resource intensive (eg. money and time) and such methods can often fail.[3] Computer simulation is one of the methods helping managers to predict system behavior when internal and external conditions changes, optimize business processes according to specified criteria (profit, cost, reliability) and compare proposed alternatives of studied process organization with each other.[1]

II. Simulation as tool for production streamlining

The solution is to use computer simulation, which allows the imitation of process or system in the real world over time. Simulation involves the generating and observation of artificial history of the system. On this basis it is possible to draw conclusions of the operational properties of the real system, which is represented by the simulations. With use of simulation software is discrete simulation model designed.

Discrete events model can be defined as one in which the state variables change only at the discrete points in time when an event occurs. The model represents the dynamic characteristics of the physical system. The simulation model has two advantages. First, model allows to create a variety of different technical or logistic solutions. On the following alternatives can be examined, modified and evaluated the process conditions and other parameters without having to change the current production system. It also means that there are not losses caused by damage of semiproduct or production equipment. The second advantage is that the model shows (with a certain degree of reliability) behavior and state of processes in the future. Based on the outputs of the simulation model (its alternatives) can be analyzed the behavior of the current, or even non-existing production system, can be detected its bottlenecks, increased production rate of system, optimized resources utilization and so on. Testing of alternatives and evaluation of behavior on real system is in all respects inconvenient and often dangerous and probability of equipment or manufactured product damage is too high.

III. Practical application of simulation approach

It is said even potatoes can't be scraped with a spoon, for efficient processing of the simulation model is necessary to use the quality simulation tool. For model implementation was used simulation software Plant Simulation of Siemens company, which provides components and modules for easier work with the model. One of such modules for processing experimental study, Experiment Manager, was used for this simulation study. Experiment Manager allows

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to determine in a short period of time how the change of variables and its combination affects parameters of the production system. Below in this text is described practical use of computer simulation. The aim of simulation is to find the optimal distribution of production orders input to the production system. In the case study is examined the effect of changes of requirements input distribution for the length of the queue at the resource with the highest utilization.

IV. Simulation model description

The following text describes the layout and components of the initial simulation model.

A. Machine Tools

Simulation model layout of line production system contains 5 machining tools (Fig. 1). Some machining tools are intended for production orders with specific requirements for processing. Machining tools 1, 2 and 3 are used to perform operations required by production orders type A. Machining tool 5 processes only production orders type B. Operation time on machining tool 5 is the shortest, i.e. from 1.5 to 2.5 minutes according to the normal distribution. Machining tool 4 allows to process all production orders, as well as machining tools 1, 2 and 3 the operation time is 3 to 5 minutes.

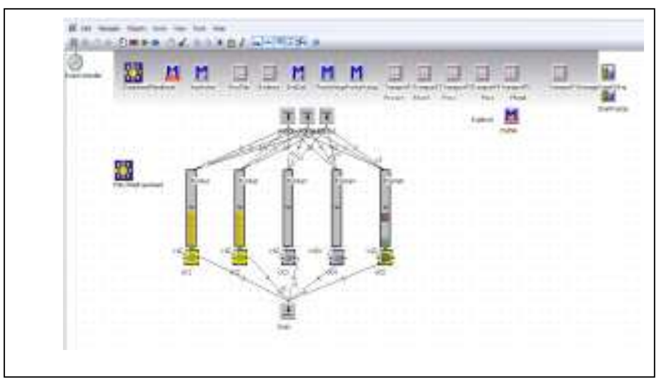


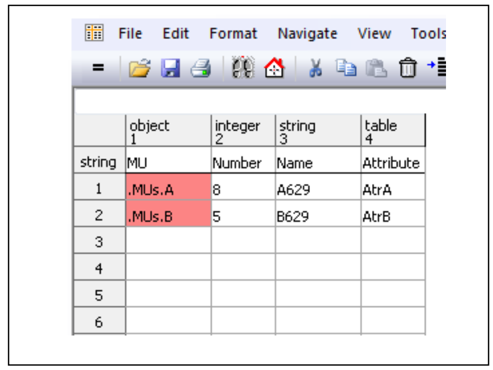
Figure 1. Simulation model layout of line production system.

B. Lines

There is a line in front of each machining tool. If, however, line reaches its maximum capacity of 6 products, is another machining tool putting into service. This doesn't concern a machining tool 5 for the production orders of type B that operate regardless of the length of queues in other lines.

C. Semi-products

As it already mentioned above, three types of machining tools for production orders with different requirements are modelled. Therefore, it was necessary to define two types of semi-products, namely type A and type B. These are entering simulation model according to the production table (Fig. 2). The sequence of production orders follows the rule "Cyclical Sequence", i.e. production orders enters production in fixed sequence that is defined in the production table (8 parts of type A and 5 parts of type B). This sequence periodically repeats.



	object 1	integer 2	string 3	table 4
string	MU	Number	Name	Attribute
1	.MUs.A	8	A629	AtrA
2	.MUs.B	5	B629	AtrB
3				
4				
5				
6				

Figure 2. Production table defines sequence of production orders input

D. Production orders input distribution

The number of production orders in a manufacturing system during shift changes, therefore this is included into the model. In the period from 9 a.m. to 11 a.m. enters into production a small number of production orders. In the initial alternative of the model is probability of orders input included using the normal distribution (Figure 3) with median 3 minutes and variance 10 seconds (the variance is the same for the entire shift). In the period from 11 a.m. to 15 p.m. enters production greater number of orders, with a distribution with median of 2 minutes and during period from 15 p.m. to 22 p.m. is necessary to process the highest number of production orders, i.e. with normal distribution with median 1 minute.

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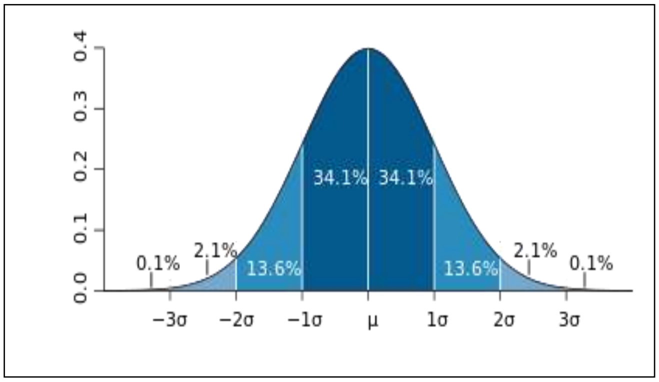

Figure 3. Normal distribution density [4]

One of the reasons to use computer simulation to optimize the processes is the ability to answer "What if" questions. In this case study, the following questions arise: What if the distribution of the enter of orders to production during work shifts changes? What impact will this change have on the number of production orders served? Which organizational changes are necessary in the production system to optimize number of production orders? These questions can be answered by the above mentioned Experiment Manager.

V. *Simulation experiment*

To implement a simulation experiment was used software module for processing experiments Experiment manager. The experiment investigates the effect of changes in the distribution of production orders enters during shift on total production. The aim of the experiment is to find the optimal distribution. Figure 4 shows the definition of the experiment. For a particular experiment, it is possible to define the input and output parameters, values of the experiment, the number of observations of each experiment, etc.

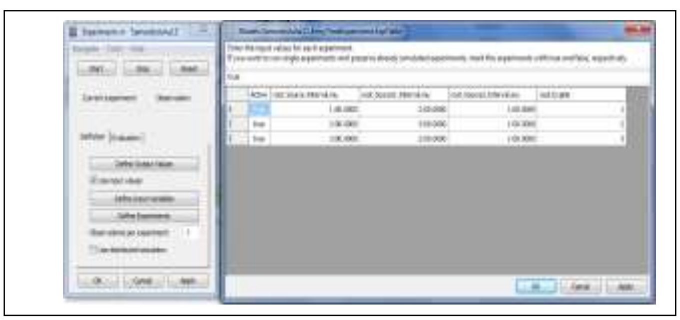

Figure 4. Module Experiment Manager and experiment definition

For the purpose of case study were defined three experiments of production orders enters distribution. The first experiment may represent a large increase of orders, which will raise the number of requests for processing. During the morning and afternoon shifts enter production orders with median 1 minute. Over lunch, the number of production orders fall slightly, the mean value is set to 2 minutes. The second experiment defines a number of requirements to be processed with a median of 2 minutes in the morning shift, 3 minutes at noon and in the afternoon it is necessary to serve the greatest number of production orders with median of 1 minute. The third experiment presents a situation in the usual working day, as defined above (initial simulation model).

VI. *Results of simulation experiment*

The aim of the experiment was to find the effect of distribution of the production orders enter in the manufactirung system on total production. By experiments with simulation model was found that the highest number of processed production orders, 589, shows the experiment 1 with lowest mean values of the inputs. Logically, the result of this experiment, which corresponds to the high utilization of the production system, can be assumed. It is interesting to notice the results of the other two experiments with similar values of normal distribution. For experiment 2 is the number of processed production orders 486 and 508 production orders for third experiment (Fig. 5).

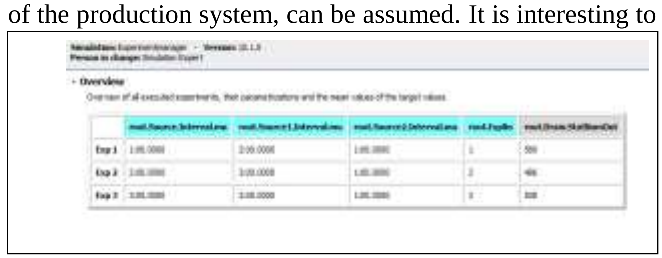

Figure 5. Table with parameters of individual experiments and their results

As seen in Figure 6, which shows a graphical representation of the experiment results, it was found local minimum corresponding to the result of experiment 2.

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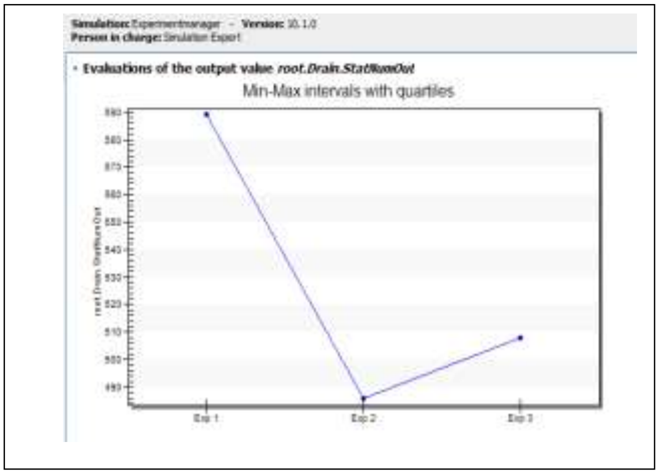

Figure 6. Graphical representation of experiment results

It was also examined average value of production order waiting time in the busiest queue number 1. Figure 7 shows this value which is 7.5 minutes. Results of this analysis confirm the finding of local minimum corresponding to input parameters of experiment 2.

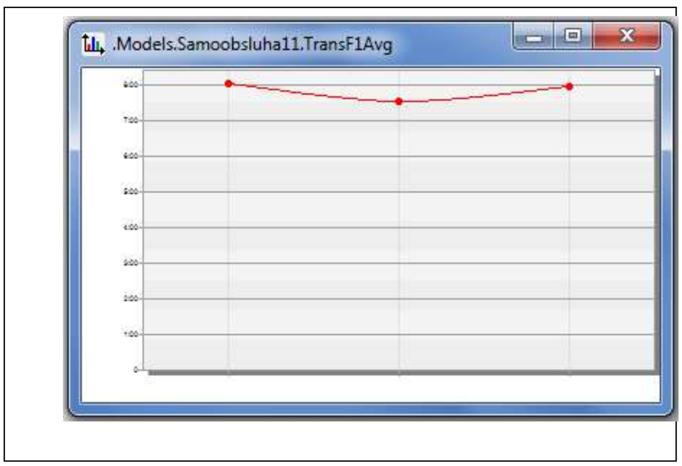

Figure 7. Graphic representation of the average waiting time in queue 1 relative to the individual experiments.

VII. *Conclusion*

By simulation of line production system, experimenting with model and its results analysis was found that the distribution of production orders input affects the total production and the waiting time in the queue. It was found the local minimum of processes production orders. It means that it is possible to make changes in the organization of production, which will increase total production.

Case study described in this article can be analogously converted to other production systems. Using computer simulations can be designed several alternatives for the simulation model.It can be selected the optimal alternative and changes applied to the manufacturing process and thus make it more effective. Following this path, a computer simulation is able to strengthen company´s position on the market and contribute to its competitiveness.

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