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DESIGN AND EVALUATION OF METAL CONSTRUCTION MANUFACTURING SYSTEM

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1. Introduction

Open market and competition battle in steel manufacturing systems forced many producers to improve their production and quality. Company in which we have done research represents typically medium order processing type of manufacturing systems. It produces steel constructions, atmosphere and pressure vessels and hausings of reduction gears. Steel constructions, which were neglible production segment in the past, are now main product. Regarding large local spread of some manufacturing departments, the company whishes to redesign the existed manufacturing system. The main problem is in the large distances of internal transport and consequently the appearance of bottle necks. Usually are production companies so complex, that it becomes harder to describe the behavior of those systems mathematically. Considering the second factor "uncertainty" grows up such task even more difficult [Potrc 1999]. Therefore we have used in our numerical experiments discrete event simulations, with the objective of analyzing the current state and critical places in manufacturing departments. Based on the results of the simulation a proposal for the redesign of current production system has been made**.**

2. Problem definition and the aim of process simulations

The main object of our process simulations was analysing the performance of the current production system. Because of the limited financial founds the company does not wishes to change the technological characteristics in the current production process. Therefore we have focused ourselves on the current production state and transportation devices with the objective of redesign with new optimal settings of production system and internal transport. With the previous analyse of current production organization the large spread of individual production departments has been establish, which influences on the enlargement of throughput times for certain products. Therefore we have followed the material flow and analysed the throughput times (t_{pr}). They represent the time from acceptance the row material in the production system, till the storage of finished goods [Polajnar 1993]. With the help of the throughput coefficient K_{pri} we can compare the throughput times:

$$K_{pri}=\frac{t_{pri}}{t_{1i}} \quad (> 1) \tag{1}$$

i – index, which indicates the family of products
t_{1i} – the middle normative time for family of products

Based on the material flow, the following objectives were determined:

- To become aware of the systems performance in the current production system,
- To implement these changes in a simulation model and analyze the new performance resulting from this new configuration,
- To recommend changes in the production system, based on the process simulations.

Performing current activities we found out possible reserves for reduction the production costs. Using the computer process simulations of metal construction manufacturing systems, we have establish redesign of current production system which makes possible growth of the production effectivity.

3. Simulation process

Regarding the problem demands we have decided to analyze the material flow of the current production process. It presents four main production types of products in where the dominate production are steel constructions. Redesign of the current production process has been established because of large spread of some production segments. This is especially evident for the sandblasting and colouring, which are placed far of each other. Because of complexity in treated production system we have used dicrete event simulations. Simulation software Taylor ED was used in our simulation process. Taylor ED software enables simulation of material flow in production system and contains a library of modelling objects. [Taylor 2000]

Simulation of the production system is the use of a model (not necessarily a computer model) to conduct experiments which, by interface, convey an understanding of the behaviour of the system modelled. Computer modelling is the programming of a computer to produce a system surrogate having variables whose values over time are determined by the same lows of dynamic as the variables of a real-world or hypothesized system. [Goog and others 1995] Simulation in manufacturing and logistics makes it possible to considerably improve the design and optimization of the process without actually having to perform these in reality. The foundation of a good simulation model are appropriate and authentic data. None of the physical systems totally coincidence with the computer model because of complexity and uncertainty. A discrete simulation model is stripped of all extras and is nothing more than a system of queues and operating points which are connected to each other. Each element has input and output channels, which are connected to other elements in the model and therefore assured the material flow. Most elements have parameter interface that pops up after double clicking the element. The numbers of fields that appear at almost every element are [Taylor 2000]:

- **Capacity** defines the maximum number of products that are allowed inside an element. It is typically used on elements that can contain more than one product, like queues, multiservers, and transporters and so on.
- **Cycle time** is used to determine the time delay before the product is sent out again. This can be manual or machine operation time, service time, load and unload time and so on.
- **Input strategy** dictates the channel through which this element will receive its next products.
- **Send to** define the output channel number through which products are sent out of an element.
- **Trigger on entry, exit** is executed when an atom enters or lives the current element.

The purpose of experimenting with process simulations is to discover something unknown or to test a hypothesis. It can yield a greater understanding of the potential consequences associated with different courses of action. Understanding these consequences can help ensure wise decision. Testing alternatives through simulations is a logical approach for reducing the uncertainty. The experience gained from simulations can help avoid uncertainty and costly ventures. [Goog and others 1995]

3.1 Characteristics and the problems of the current state

The simulation model of the current state (Figure 1) has been established through the imitation of the real productin system. In the model we have limited ourselves on the separate production departments.

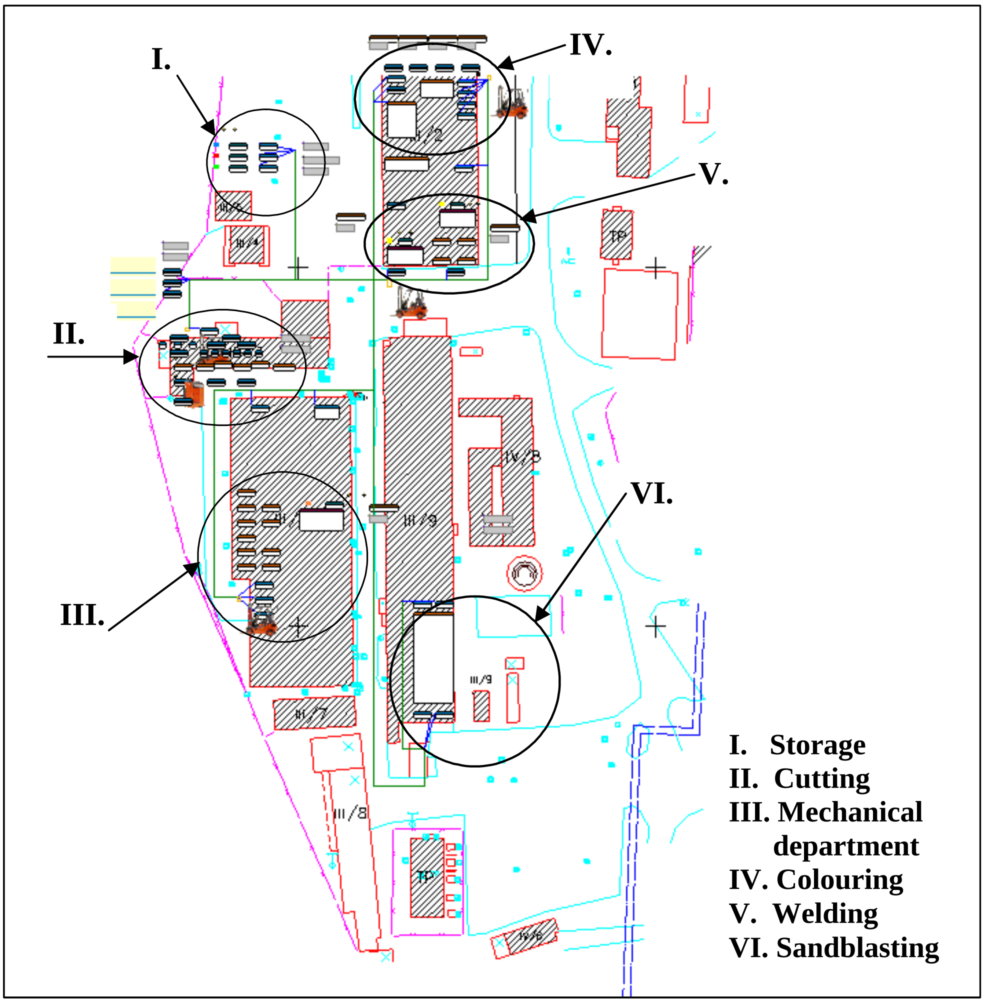

Figure 1. Simulation model of the current state

Our model represents six production departments: warehouse, cutting department, mechanical department, welding department, sandblasting department and coloring department. Production departments represents source, queue and buffers, working places and transportation. Products came in the simulation model at a certain arrival rate, wait in a queue until the working place is free. Working place means places where products change their properties, after they are serviced. Transportation paths represent connections between working places and queues. According to the Figure 1, we can clearly notice how the production departments are spread between each other which are particularly obviously for sandblasting and coloring departments.
The technology which was identical for both simulations models was used during the simulation study. Every product group in the production system has a unique material flow which does not comprehend with the flows of other product groups. According to previous conditions, quantity of products and local distribution of some production departments we have build the current simulation model. The first step after building a model was verification with the real production system.

Every single simulation has been defined with the same boundary condition as the previous one. We must emphasis, that the computer software Taylor II has builded numerous generators of the random numbers, through them we obtain numerical results which are similar to reality. Because of the random arrival of material, random time between failures and time to repair and the use of the statistical distribution for cycle times no simulation is identical to other. Therfore the results of the simulation study are always located in the interval and newer as the accuracy fixed number.

3.2 Simulation model of the new solution

According to demands of minimalisation of renuval costs the new solution for the location of the coloring department has been made. The same technological characteristics of the current production system were applayed in the new simulation model. The new model represents the reduction of logistics costs for the product group of steel constructions but in the same time the logistics costs increases for the other product groups. The positive effect on the whole production system has been founded out with the new simulation model.

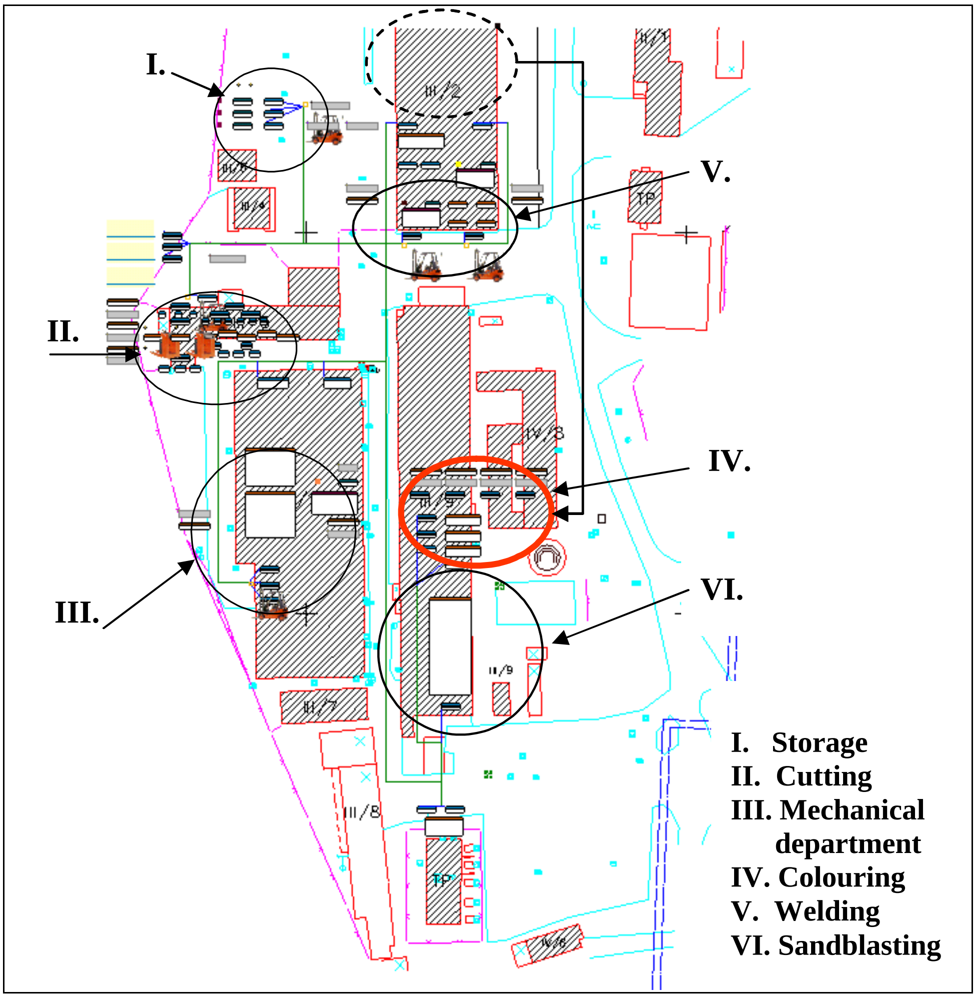

Figure 2. Simulation model of the new state

4. Simulation results of redesign in the production system

Better examination of the performance has been accomplished with the process simulation of the current and the new model. On the next figures the comparison of the throughput times of the current and new state simulation is presented.

Curves, which represent the distribution of the throughput times for the production of steel constructions, are shown in the figure 3a. We can notice that the throughput times are lower up to 28 % in the new model according to current state. The reason for reduction of throughput times is reposition of the colouring department near to sandblasting. Thus the long transportation to colouring department is not more necessary and we gain on the logistics costs.

Curves, which represent the distribution of the throughput times for the product group housings of reduction gears, are shown in the figure 3b. Generally we can summarize that the throughput times are approximately the same, because the transport ruts are not essentialy changed.

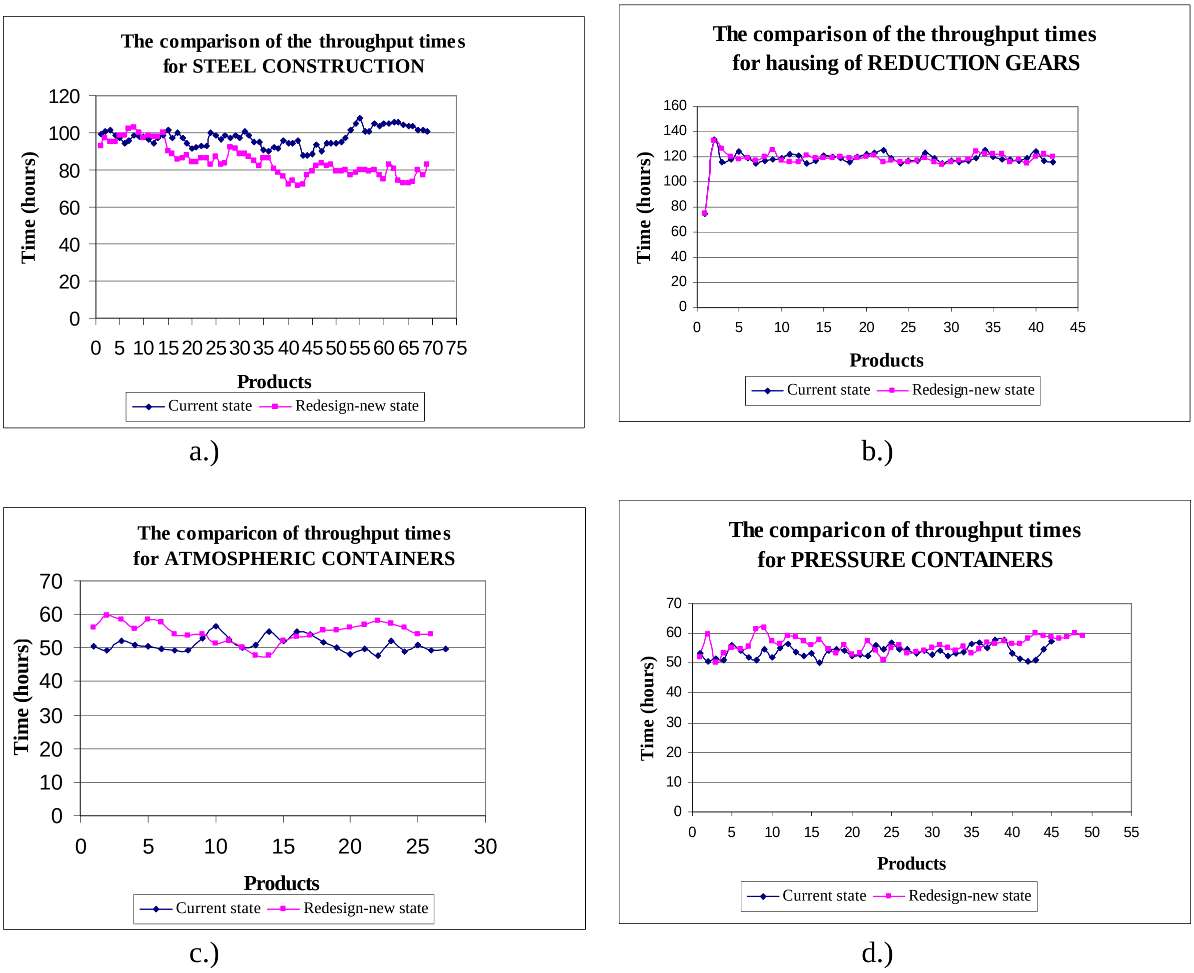

Figure 3. The comparison for the throughput times for a.) production of steel constructions, b.) hausings of reduction gears, c.) atmospheric containers (vessels) and d.) pressure containers

Curves, which represent the distribution of the throughput times for the product group atmosphere and pressure vessels (containers), are shown in the figure 3b and 3d. We can notice that in some cases the curves are touching and splitting each other. But in general the throughput times for those two prduct groups are in new production configuration higher up to 17 %. The increase of logistics costs for vessels depend on the longer transportation routs for product groups containers to the new location of coloring department.

5. Conclusion

According to changes in the market the production of steel constructions become the most important part of the whole production assortment (steel construction, atmospheric and pressure containers and housing of reduction gears). Two simulation models have been established considering the current technological capability and with regard to minimal logistics costs. The first model analysis and verifies the current state of the production process. The new model represents one of the possible solutions for the new configuration of the production system. Reduced logistics costs of the product group steel constructions has been indicated during the simulation of the new model. In the same time the logistics costs of products atmospheric and pressure containers has increased. During the simulation study the essential reduction of total logistics costs has been establish.

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