THE SIMULATION OF MATERIAL FLOW OF CUSTOM PRODUCTION OF TREATMENT MACHINES FOR MINING ACTIVITIES

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Abstract

The aim of the contribution is to introduce the project and to point out the possibilities of using computer simulation for the needs of more effective production logistics. Like many other tools and methods, logistics also greatly contributes to maintaining the company's competitiveness and resilience to external factors such as the crisis, inflation, falling demand, and so on. One of the key methods for maintaining balance is material planning. The most significant group, which, at the same time, forms the most relevant part of the material flow are raw and other materials and corporate work in progress and finished products. The aim is to analyse the material flow of the production process and then create a simulation to determine the length of production and identify the bottleneck. In order to get a better idea of the production process, a simulation model was developed in selected software tools as a project of custom production of treatment machines for mining activities. The impulse to start production is given by the customer, where every completed order is immediately dispatched to the customer. The order with the highest frequency in the production program of the company is used to create the material flow. The order consists of 6 machines, but the aim is to determine the length of the production of 1 machine and identify the bottleneck of the production process by simulation.

Keywords: Project, logistics, production, simulation model, efficiency

1. INTRODUCTION

Currently, it is a very important auxiliary means of production logistics computing in the form of various simulation programs that are able to harmonize material and information flow, allow for detailed analysis and monitoring of production design, integrate an optimal system of material flow, plan and manage production [1]. Through simulation and simulation programs in production logistics, it is possible to mimic the real system using a creep model, to conduct experiments on the created simulation model in a simulation environment and to apply the results, findings and outputs of the simulation to a real production system, whether newly designed or existing [2]. The material flow is analysed in a plant engaged in custom manufacturing of processing machines for mining activities. The plant operates with the PULL system, where each completed order is immediately dispatched to the customer. The order with the highest frequency in the production program of the company is used to create the material flow. The order consists of 6 machines, but the aim is to determine the length of production of 1 machine and identify the bottleneck of the production process by simulation [3,4].

2. METHODS

2.1. Analysis and visualization of material flow of production process

The aim of the paper was to analyse the material flow of the production process and then create a simulation in order to determine the length of production and identify the bottleneck [5]. Therefore, a formalized process flow diagram has been developed following an on-site production review [6]. The diagram shows the general production process with all possible flows. It is suitable for all kinds of products for the company. The forming process can take place in 2 types of machines. The first type is forming bending presses that bend the sheets into the desired shapes and at given angles. The second bending process is used to create arches, semi-arches, pipes, funnels, cylinders [2]. Both fall under forming due to changes in a sheet shape. For each type of plant owns two machines. The packaging process is mainly to mean placing machines on a means of transport. Wooden prisms are used to separate them. In the case of dispatch of spare parts, packing is carried out as usual [2]. The parts are placed on pallets and fixed with plastic straps, sometimes foil is also used. Atypical spare parts require pallets with specified dimensions. The plant creates these pallets itself. A warehouse of finished products is more of a concept than a reserved place. In most cases, the products are shipped immediately. The maximum delay is waiting for the completion of the order or the rest of the machines and parts included in the order. The finished machines are stored in this assembly shop during this waiting. The starting point for creating the simulation is the knowledge of material flow, therefore, a formalized scheme of the production process is needed. Based on this scheme, the individual activities in the production process, as well as their sequence based on the technological process, are determined [2].

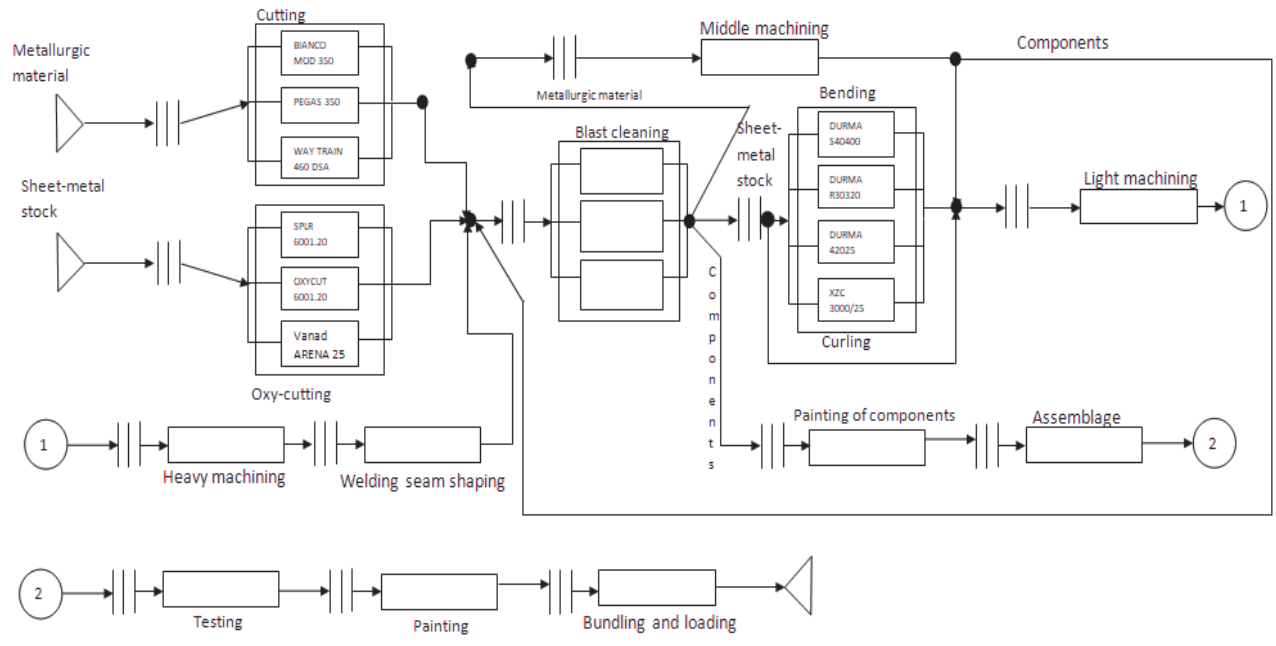

Figure 1 The formalized production process diagram

Production starts with the stocking of basic materials [2]. Sheets and dense material are required for this type of machine. Subsequently, the dimensions of the inputs are adjusted to the desired sizes. The plates are cut in 3 bats and the dense material is cut with 3 saws. Material with modified dimensions is subjected to surface blasting. After surface treatment, 2 flows are formed. The first flow consists of dense material, which continues to the middle machining centre where the threads are drilled, grinding edges. Then this material is split and 25 pieces of it are reprocessed and enter the assembly where it waits for the remaining parts needed for assembly of the machine. The remainder of the material is fused together with the sheets before being easily machined. The second flow consists of sheets, which are further divided into 2 groups. The 1st group has to be bent after surface treatment. This group includes 70 % of metal sheets. The 2nd group consisting of the remainder of the plates skipping bending. Prior to the easy machining, these groups and the flow of metallurgical material are joined into 1 flow and enter there, where they are attached to each other by spot welding. Subsequently, the pieces are welded together in a heavy machining shop and the coarse weldments are machined. The pieces thus formed are surface-treated and enter the assembly. Before assembly, hard-to-reach areas of parts that arise after assembly are sprayed with paint. After the paint has dried, all parts are assembled into 1 machine and the drive element is added. Each machine passes a two-hour test. After passing the test, the machine is sprayed with paint. Each coating has a specified thickness. The last step is loading the machine onto the vehicle. Since orders consist of several machines, previously made machines are waiting for the last in the designated places in the assembly hall. When loading, wooden prisms and artificial straps are used to separate the machines from each other, thus preventing damage to the coating during transport [6].

2.2. The production process simulation

Simulation is a research method where we replace the object of study with a model. We make experiments on the created model with the intention to accumulate and later use information about the real system [7,8]. Simulation is a method of approximate determination because its outputs are probabilistic and serve for statistical estimation. it is necessary to distinguish the simulation time, which is the length of the simulation on the computer and the simulated time that corresponds to the duration of the real system. In this case, the simulation time will be governed by the variable time flow method [9]. This method is based on jumps in time to various events in the system, such as the beginning or end of an operation. The simulation program EXTENDSIM 9 is used for the simulation. Before creating a model, the basic parameters that must be entered in blocks must be determined [10]. The titles and priorities of individual materials or groups of materials are diversified and the behaviour of items in the pre-activity series. The rules for the distribution of flows and the duration of the activities will be defined, as shown in **Table 1.**

Table 1 Time allocation of individual activities

Activity	Duration [min.]	Duration (beam) [min.]
Cutting	7±2	
Oxy-cutting	9±5	
Blast cleaning	8±2	
Bending	60±10	
Middle machining	15,90,50	
Tacking	45±15	120
Welding	40±10	500
Welding seam shaping		150
Painting of components	8,15,10	
Assemblage	720	
Testing	120	
Painting	210	
Bundling and loading	20±5	

3. RESULTS

3.1. Evaluation of the simulation

When evaluating the simulation, it is necessary to take into account that the last phase does not start until the previous phases have been completed [11]. The marked block represents the point at which the parts accumulate. The following blocks are inactive until 51 parts have accumulated in the previous block. After 50 attempts have been simulated, the production interval of 1 machine per order is determined. The lower limit of the interval is 3,800 minutes and the upper limit is 4,100 minutes [2].

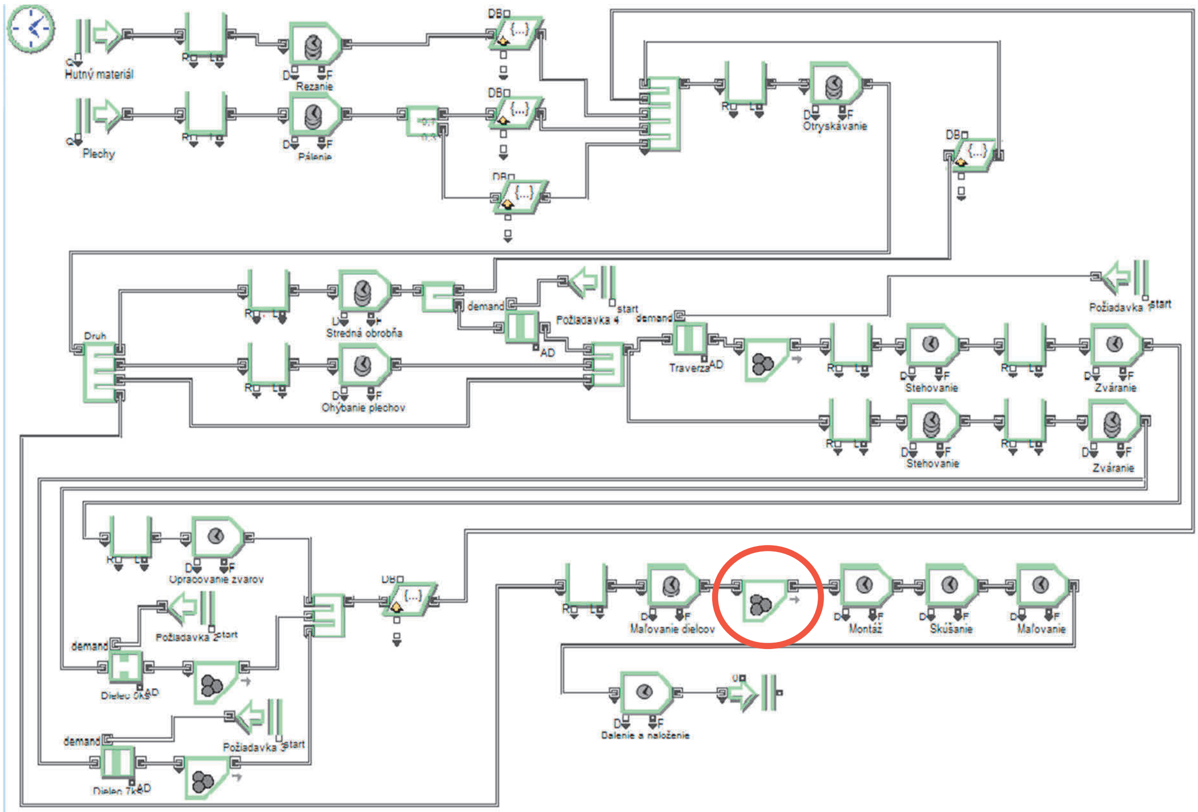

Figure 3 Simulation model of production process

The statistical results presented in **Table 2** show that the bending process represents a bottleneck in the entire production process [2,12].

Table 2 Statistical results from simulation

Block	Occupancy of activity	Occupancy of queue	Maximal queue length [pcs]	Time of first event [min.]	Time of last event [min.]
Cutting	2.64 %	2.53 %	30	0	124
Oxy-cutting	8.96 %	8.79 %	84	0	387
Blast cleaning	14.5 %	11.92 %	46	4	2825
Bending	15.52 %	14.57 %	33	17	649
Middle machining	64.6 %	63.22 %	72	15	2709
Tacking	20.11 %	6.45 %	20	352	2786
Welding	16.14 %	0.56 %	3	426	2820
Painting of components	6.95 %	1.12 %	2	411	2838
Final phase	6.33 %	-	0	2838	3899

4. CONCLUSION

In **Figure 4**, we observe a rapid increase in the number of requests in a row as a function of time and a slow decline in the curve. This behaviour clearly shows that the bending operation does not manage to meet its requirements. **Figure 5** shows the capacity utilization of bending machines that operate without reserves, which is not suitable for ensuring continuous operation. This activity requires the addition of another machine to partially smooth out a number of requirements [2].

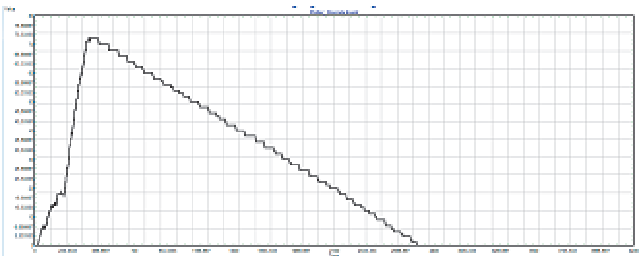

Figure 4 Size dependence of the series of bending over time

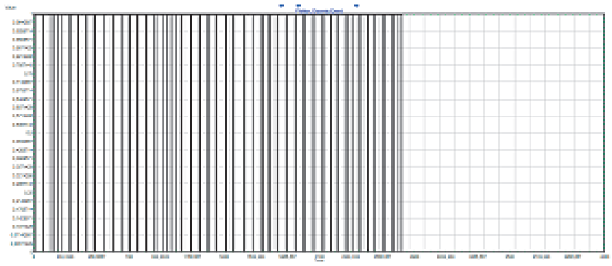

Figure 5 Dependence of machine occupancy of the bending process over time

Another operation to pay attention to is blasting. This operation will serve most requests. Its row size in **Figure 6** maintains approximately the same value over a given period of time. In **Figure 7** we observe continuous work without reserves. Based on these graphs, the activity is referred to as overloaded, and a suitable remedy is the addition of a blasting machine to speed up the handling of requirements [2].

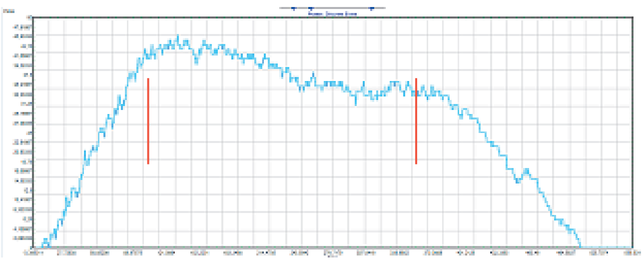

Figure 6 Dependence on the size of the blasting process series over time

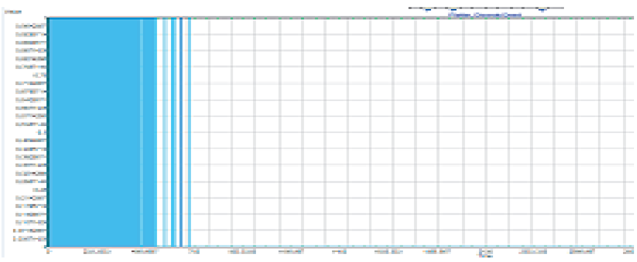

Figure 7 Dependence of machine occupancy of the blasting process over time

Production logistics has its application within the logical ordering of production and production process, as it is able to unify the purchase, distribution, connection of production and assembly processes by means of appropriately selected supporting tools and means by handling, storage, and transport [13]. Nowadays, computer technology in the form of various simulation programs, which are able to harmonize material and information flow, enable detailed analysis and monitoring of production design, integrate optimal material flow system, plan and manage production, is a very important tool for production logistics [14]. Through simulation and simulation programs in production logistics, it is possible to mimic the real system using a creep model, to conduct experiments on the created simulation model in a simulation environment and to apply the results, findings and outputs of the simulation to a real production system, whether newly designed or existing. Due to strict cost monitoring within each production process and logistics management, it is necessary to verify the possibilities of various planned systems and system changes, to look for innovative and at the same time successful and economical solutions [13,15]. It should be stressed that the requirements for changes in technological or organizational measures still entail certain risks. It is through simulation programs that these risks can be reduced, reduced or eliminated by the fact that simulation programs are capable of modelling the work environment and simulating the consequences of various decisions within production processes [16]. As a result of applying the simulation and using a suitably selected simulation program, you are more confident that the proposed solution is right for the organization, even before the actual implementation in actual conditions.

ACKNOWLEDGEMENTS

"The submitted work is a part of KEGA Project 006TUKE-4/2019 "Transfer of knowledge from the field of logistics into the preparation of innovative teaching materials for selected study units of the newly accredited study program" Commercial logistics." and a part of the project VEGA 1/0317/19,

"Research and development of new smart solutions based on principles of the Industry 4.0, logistics, 3D modeling and simulation for production streamline in the mining and building industry", funded by the Scientific Grant Agency of the Ministry of Education, science, research and sport of the Slovak Republic and the Slovak Academy of Sciences."

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