

# STABILISATION OF PRODUCTION LINES BY USING OF SIMULATION STUDY METHODOLOGY

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**Abstract:** *Modern business conditions have forced manufacturing companies that want to achieve and maintain their competitive abilities in the global market on a permanent optimization of the working parameters and the internal organization of production systems. Continuous increasing of production capacity along with simultaneously reducing of production costs and maintains quality of the product at least the same level can be achieved by this way. One of methodologies that allow simulation of complex production/transportation processes is the simulation study, by whose usage is possible to provide a satisfactory description and efficient optimization of dynamic phenomena within the production systems. In this paper is presented implementation of simulation study methodology on real production line for production of automotive parts, with code label "Ring 1".*

**KEYWORDS:** MATERIAL FLOWS, QUEUING, SIMULATION EXPERIMENT, SIMULATION STUDY, BALANCING

### 1. INTRODUCTION

The basic goal of any manufacturing system is the achievement of anticipated production quantity and quality on time. Consequently the planning and operating of production systems are constantly targeted to reduce production costs in order to increase the overall effectiveness and achieve an appropriate level of competitiveness at the market. Existing production systems are increasingly faced with the complex logistical and organizational problems by implementing modern technologies with the aim to reduce production costs. From the viewpoint of material flows within the production, above mentioned problems are primarily related to the deviation appearance of the scheduled from the actual capacity of production/transportation lines. Additionally, a frequent phenomena that occurs in the production are:

- bottlenecks, i.e. the imbalance between the particular production and transportation operations;
- lower level of utilization degree for production-transportation lines than was planned;
- planned storage capacity and buffers does not match to the actual needs;
- significant differences between the theoretical and the planned production capacity, with no valid information and specific knowledge about dependencies related to production - transportation capacity.

To resolve above mentioned issues simulations methods based on analysis of discrete events are even more in usage. Application of those methods allows the better analysis of complex manufacturing processes. In practice it is often not given careful attention to the problems of compliance between production and transportation capacities, as well as to the significant impact of random events (e.g. malfunctions), which cause an inadequate level of balance within the production line. In addition, in most cases decisions on whether applied systems of material flows and transport resources was appropriately selected, are carried out by application of the methods for the analysis of material flows, which do not take into account the dynamics and stochastic phenomena that occur in production systems at the real conditions. In relation to this, for many production systems there are not enough necessary knowledge about certain internal production-transportation processes, which usually results in the occurrence of unnecessary costs in the production process. Large part in those costs causes disproportion of production operations and internal transportation equipment. It should be emphasized that the imbalance between production and internal transportation operations is not always an indicator of the inadequate working parameters of internal transportation system. Often occur the problems of inappropriate equipment used in the processes of internal transportation, which

must also be taken into account when considering all above mentioned issues.

### 2. SIMULATION STUDY

#### 2.1. Simulation

In general, it can be said, that every complex system or phenomenon, i.e. processes that contain stochastic, nonlinear or time variable, often can not be describe by a set of deterministic mathematical expressions or equations, and they are usually analysed by modelling and simulating. The term simulation stems from the Latin word "simulare" that means "imitation", which is essentially the main goal of the simulation execution, [1] and [2].

Simulation models are used for insight access into behaviour of a virtual or real existing production system, which otherwise could not be achieved by conventional scientific methods, and thus becomes an acceptable device for analysis and design of production systems, [1].

#### 2.2. Simulation study methodology

Performing of simulations with the aim to describe the processes within the production systems is characterized by expression simulation study and defined by Guideline VDI 3633, [1]:

„ Simulation study is a project for systems testing supported by simulation model. (...) Simulation studies may include several simulation experiments, which at the other hand can be made up from several simulation passes. “

According to this definition, simulation study consists of the following phases, [3]:

- 1<sup>st</sup> defining problems, objectives and tasks;
- 2<sup>nd</sup> collecting and processing the input data;
- 3<sup>rd</sup> logical descriptions of the observed process;
- 4<sup>th</sup> validation and verification of simulation models;
- 5<sup>th</sup> simulation experiments;
- 6<sup>th</sup> analysis of the gained results.

### 3. PRODUCTION BALANCING

In this paper are considered the problems and possible solutions for balancing of manufacturing line for production of automotive parts, with code label "Ring 1". Detail information about considered topic can be found in the literature states [3].

### 3.1. Production line „RING 1“

Production line "Ring 1" is suitable for the analysis of material flows by using of simulation studies from the following reasons:

- serial production,
- technological process is structured,
- production process takes place over a longer period of time,
- has a wide variety of production equipment with different degree of the human work share,
- production is segmented into independent production units that are technologically separated from other production units,
- the customer request, reducing of production costs for 5% on an annual level, and
- despite to the good production results achieved in the previous period, the global market requires a continuing activity to reducing of production costs, which would result in increasing of company profit at the end.

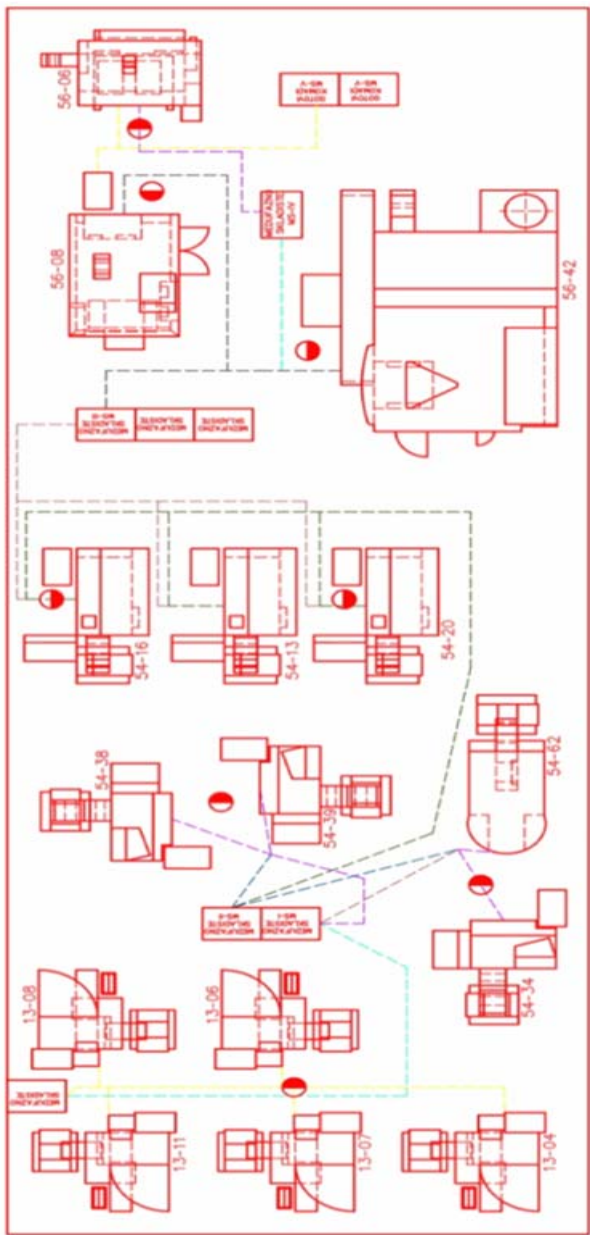


Figure 1 Layout of the equipment in production line „RING 1“

In Figure 1 is shown the layout of production equipment, production line, "Ring 1". On the production line five machining operations are running with different degree of automation, which

requires different engagement level of workforce. Transport process is carried out piece by piece in the workplace, while transports between the various operations are done by wheelbarrow for transferring of Kanban pallets that contains sixty parts. Weekly program of individual production segments within the manufacturing line, "Ring 1" is shown by table 1.

Working place	Weekly working period	
	day	shifts
13-04; 13-06; 13-07; 13-08; 13-11	7	3
54-34; 54-62	7	3
54-38; 54-39	5-6	3
54-16; 54-16	7	3
54-13	5-6	3
56-42	7	3
56-08	5-6	3
56-06	6	3

Table 1 Weekly working plan for production line „Ring 1”

### 3.2. Modelling of production line „RING 1“

The first step of the production line "Ring 1" modelling is acquisition and processing of data about processing time, tool change time, durability of tools, time cyclic controls, quantitative interval for cyclic controls, etc. A random sample method was used for the data acquisition, while the acquired data are processed according to corresponding statistical methods. Analyzed processes are described by 23 variables that behave according to certain statistical distributions.

Software Plant Simulation 8.1 was used as a simulation tool for describing of observed process. The software, is based on a methodology for processing of discrete events, and owns a rich base of ready made facilities for modelling. An additional advantage of this simulation tool is possession of specially created programming language SimTalk that allows modelling of additional non-standard processes and phenomena in manufacturing systems.

The following data were used for creation of manufacturing line "Ring 1" simulation model:

- for creation of a logical model - flow map of technological materials at production line, "Ring 1", [3];
- for parametric definition of valid parameters and model values – statistic parameters of processes within production line „Ring 1“.

As a result of the modelling of processes within production line, "Ring 1" a complex simulation model is got. In addition to standard software elements from software database obtained model integrates a number of solutions and the logic flow process based on the usage of the programmed routine, Table 2.

Construction elements	Values
Number of objects	612
Working generators and brokers for operation control	7
Subroutine	64
Number of software lines	2633
Number of global software variables	163
Number of tables for data extraction	37
Number of elements for data acquisition (diagrams, histograms, tables)	21

Table 2. Construction parameters of simulation model for production line „Ring 1“

Taking into account the authentic values for verification assessment of simulation model (medians and average values of observed data) satisfactory maximal percentage difference between simulation model and real systems was obtained (6.44% respectively 5.9%).

### 3.3. Simulation experiments

Analysis for product line is consisted of two processes:

1. Determination of the characteristics for existing production lines, e.g. whether there are bottlenecks in the system and to what extent;
2. Balancing of production lines based on observed deficiencies.

Two simulation experiments by the following scenarios are used for determination of existing production equipment characteristics:

- I. First scenario - completely empty system in the reference time was observed (if accumulation of pallets is occurred, it can be concluded that there are bottlenecks);
- II. Second scenario – in each buffer of the observed production system 60 Kanban pallets is located (if imbalance of Kanban pallets within the production line buffers after the reference time appears, that can be defined as the degree of system unbalance).

Results for first scenario are presented on Figure 2. It can be concluded on the basis of obtained data that in observed production line there are bottlenecks, but it is unknown to what extent and which production entities are reasons for this.

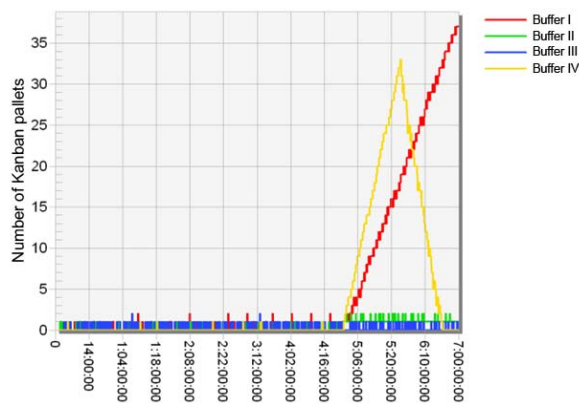


Figure 2 Buffers availability of production line „Ring 1“

Values of unbalance degree are obtained on the basis of data analysis for second scenario, Table 3. Analysis of annexes in Table 3 leads to the conclusion that certain capacity reserves existing in operations 2 and 3, while in operation 4 is bottleneck caused by excessive capacity of operation 3.

Operation			
I	2	3	4
	-2,41		14,82
	-12,54		
Available for weekly working hours including scheduled work breaks			
	-18,13		19,8
	-7,98		

Table 3 Degree of unbalancing for production line „Ring 1“

In order to balance the obtained manufacturing system it is necessary to reorganize the operations 2 and 3 on the following way. Operations 2 and 3 are jointed together and one operator will serve parallel both processing machines, figure 3. This means investment in two new machines for operation 2 and replacing the existing one. On the other hand production costs of observed manufacturing line will be reduced through the decreasing of two shift positions, respectively seven workers, or roughly 56.000,00 € per year. All those changes made reengineering of observed manufacturing line on presented postulates cost efficiently.

On the basis of the previously described scenario new simulation experiment is conducted, and summary of balancing effects for the production line "Ring 1" are shown in Table 4. At the

same time on figure 4 are presented the dynamics of the queuing in production line buffers during simulation experiments 2 and 3 of observed production line. Initial states of all buffers capacity are presented by dashed lines, while the full lines present the states of all buffers capacity after balancing process.

It should be noted that the production capacity of the production line has not changed, but a flow of material is balanced, which directly resulted in the reducing of production costs through reduction of jobs and increased performance of production equipment.

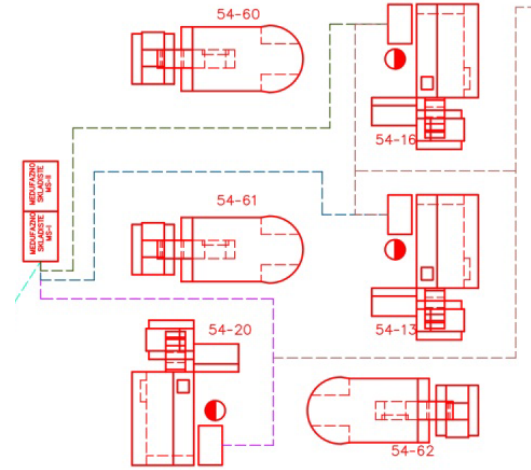


Figure 3 Operation 2-3 on production line „Ring 1“

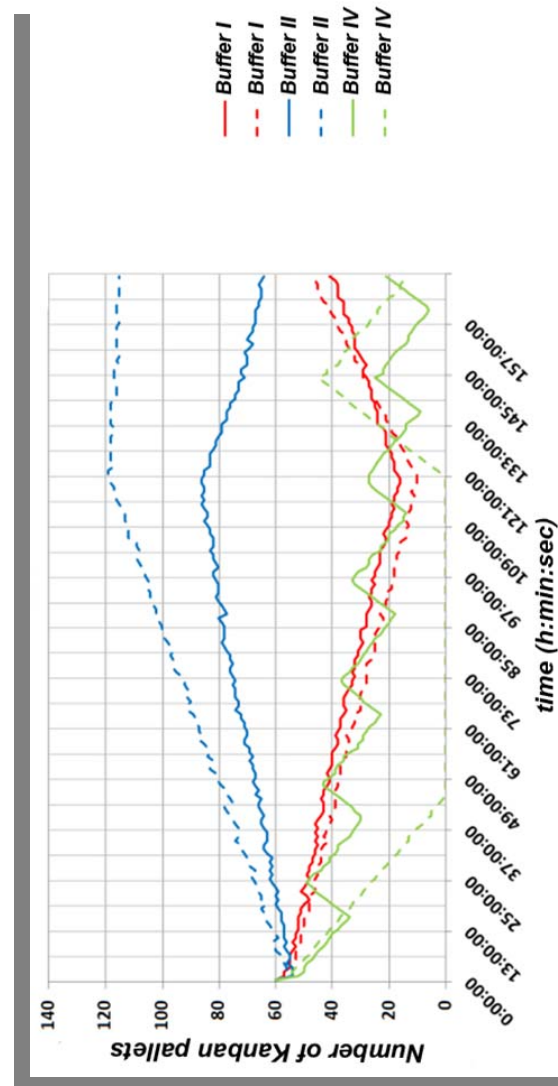


Figure 4 The dynamics of the queuing during simulation experiments 2 and 3 of production line "Ring 1"

Operation	1	3	4
Simulation experiment No. 2	-14,95		14,28
Simulation experiment No. 3	-4,4		2,73
Difference N2-N3	-10,55		11,55
For available weekly working time with scheduled work breaks			
Simulation experiment No. 2	-26,11		19,8
Simulation experiment No. 3	-15,24		10,91
Difference N2-N3	-10,87		8,89

Table 4 Degree of in balancing between simulation experiments 2 and 3 at production lines "Ring 1"

#### 4. CONCLUSION

Implementation of simulation study represents the only acceptable solution because of the fact that conventional methods for balancing of material flows do not have the possibility to take into account the dynamic nature of processes which taking a place in modern production systems. On the other hand implementation of the simulation studies for an analysis of production systems is complex and time-consuming process, whose result largely depends on the quality of input data, the level of model details, and competences of workers who create and perform simulation studies. Results obtained by the implementation of simulation studies are comprehensive and give a very clear picture of interaction between the processes within observed production systems. This kind of data structure, gained by accomplished simulation studies, represents a solid basis for detailed planning, analysis and optimization of material flows within the production systems. A good example that fully confirms previous observations is presented by implementation of simulation study on the production line, "Ring 1", where balancing of the material flows within the observed production system for is done approximately 20% by application of simulation studies.

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