

MODIFICATION OF PRODUCTION PROCESS STRUCTURE AND OPTIMIZATION OF MATERIAL FLOW FOR SELECTED TYPES OF COMPONENTS COMPUTER SIMULATION MEANS

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Material flow optimizing is a process of finding an ideal level of material continuous movement at minimum cost, time consumption, energy, resources, employees or other criteria, such as length of transport distances, transport volume per time unit, size, capacity, capacity transport unit, transportation costs, use of loading space (volume), duration of transport and so on. The article describes the optimization of material flow in production of two types of components implemented in our partner company Regada, Ltd. Presov. Creating a computer model of current state of monitored process according to basic characteristics showed the unsuitability of this solution. The problem was solved through design and subsequent verification of several alternatives. First alternative was examined by use of technological equipment for the operation. Subsequently, production process was simplified and replacement operations paths were created. The following three alternatives simulate combination of these paths with original paths.

KEYWORDS

material flow, optimization, simulate, production

1 INTRODUCTION

Currently, due to huge progress in computer technology a wide range of different simulation programs is offered. Computer simulation has become an essential part of research in any field of science. Computer simulations facilitates the decision making process and significantly affects the economic costs of company. In field of engineering, simulation is used to optimize production processes, operations and individual actions during production. Simulation enables to test planned procedures for the company, without any attempt to compromise its equipment and assets. The mission is to detect problems before actual implementation in the production process. Simulation divides production process into smaller parts and optimizes them in regard to utilization of individual machines. By simulation is understood an experimenting with a computer model of a real production system. The aim is to optimize the production process. The simulation is possible to use in synchronization of material flows. The first step is to build a simulation model of production system. On created model

various experiments are subsequently carried out in order to find the best solution respectively the most satisfactory one. Obtained results need to be correctly interpreted and then applied to real system. Simulation is an experimental method that uses a computer model of the system instead of real one. Simulation model allows implement and test highly complex processes in short time that actually lasts relatively long time (days, weeks). [Panda 2016a]

Currently the market offers many good simulation products aimed to systems simulating. It depends on customer requirements, for which software he decides. Selection of the appropriate simulation software has certain criteria. It depends on the desired result. Using simulation program is smooth, if consumers choose the right simulation program that is most appropriate for the operation. In case that company did not choose the right program, the simulation is ineffective.

As simulation software to solve the specific question FACTOR/AIM was chosen, which allows quick use of alternative solutions and compare them with each other; without disrupting the system and real process. System offers the possibility to analyze dynamic context of observed systems and illustrate them. It can also quickly investigate narrow spaces, time flow, give investment decisions and drew attention to errors in planning. System also enables the improvement of corporate strategy and assessment of the further company reorganization. Program FACTOR/AIM offers graphical and text output. From text output (report) offers a choice of messages from input and output data. [Prislupcak 2016]

The article describes creation of a computer simulation for solving the problem of use of machines in real production process in REGADA Company, Ltd. The aim was to find a suitable form of production process and optimize material flow of work rhythm for each device by simulating the basic model. In order to have an appropriate result, it was necessary to create several alternatives from which right solution for change and adjustment of production process was selected.

2 CHARACTERISTICS OF THE EXAMINED PRODUCTION PROCESS

2.1 Product

Two types of products in ten dimensional rows enter production process. They are products of WAFER and LUG type. Operation time for each dimensional line is the same for both types. Annual production batch of pieces is different. Quantity of annual production batch is presented in Table (Tab. 1).

Table 1. Quantity of annual production batch

Type	pcs/year	Type	pcs/year
W 25	550	L 25	300
W 32	500	L 32	300
W 40	2 500	L 40	1 200
W 50	6 500	L 50	3 600
W 65	4 500	L 65	4 200
W 80	8 500	L 80	3 500
W 100	8 500	L 100	4 000
W 125	3 000	L 125	1 500
W 150	6 500	L 150	3 200
W 200	4 500	L 200	2 400

As semi-finished products we used aluminium castings. Manufactured product is shown in Fig. 1.



Figure 1. Manufactured product W 100

2.2 Manufacturing process

Manufacturing process is a set of activities that are mutually dependent. Their interactions will transform input materials to products with desired properties for its function. Monitored production process consists of three operations for each component.

Table 2. Machining times

Dimension	1. operation [min]	2. operation [min]	3. operation [min]
25	6	4	12
32	6	4	12
40	6	5	13
50	7	5	14
65	8	6	15
80	8	7	16
100	9	8	18
125	10	8	19
150	11	9	20
200	12	10	23

Production process is shown in flowchart in Fig. 2. It describes the pathways of components and machines that are required for production of specified size range.

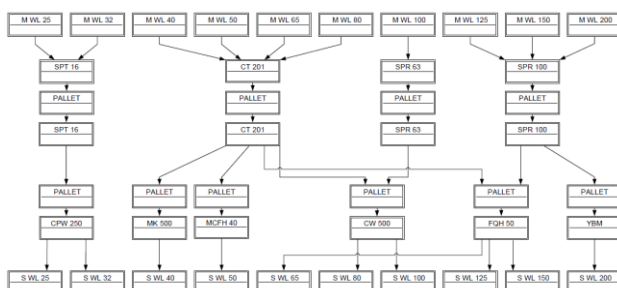


Figure 2. Flowchart of production process

Flowchart contains multiple objects. They are entry stores, machines, buffer stores and outlet stores.

M WL xx – The input store for a given size range of both types.

S WL xx – Outlet store for a given size range of both types.

PALLET – Buffer store (storing box).

SPT 16 – NC turning machine for machining flange and shaft components up to diameter 200 mm and length 500 mm.

CT 201 – CNC lathe for machining flange and shaft components up to diameter of 360 mm and length 400 mm.

SPR 63 – NC lathe for machining flange and shaft components up to diameter of 470 mm and length 250 mm.

SPR 100 – NC lathe for machining flange and shaft components up to diameter of 550 mm and length 250 mm.

CPW 250 – CNC machining centre with 360° rotary table and tool magazine for 20 tools. Maximum rotary diameter is 380 mm. It is used for drilling, threading, milling aluminium and brass.

MK 500 – CNC machining centre with 360°/1° rotary table and tool magazine for 24/64 tools. Maximum rotary diameter is 500 mm. It is used for drilling, threading and milling.

MCFH 40 – NC machining centre with 360°/1° rotary table and tool magazine for 21 tools. Maximum rotary diameter is 500 mm. It is used for drilling, threading and milling.

FQH 50 – CNC machining centre with 360°/1° rotary table and tool magazine for 30 tools. Maximum rotary diameter is 700 mm. It is used for drilling, threading and milling.

YBM – CNC machining centre with 360° rotary table and tool magazine for 54 tools. Maximum rotary diameter is 500 mm. It is used for drilling, threading and milling.

3 PROPOSAL OF MANUFACTURING PROCESS SIMULATION MODEL FOR A CONSTRUCTION NODE

3.1 Simulation of the basic model

Simulation of the basic model based on flowchart of production process is shown in Fig. 2. It simulates the production of all parts types. POOL element is positioned behind each machine as technological pallet for machined parts, instead of WIP element (buffer store). POOL element as opposed to WIP element allows to view the number of accumulating parts during simulation running. Simulation model is shown in Fig. 3.

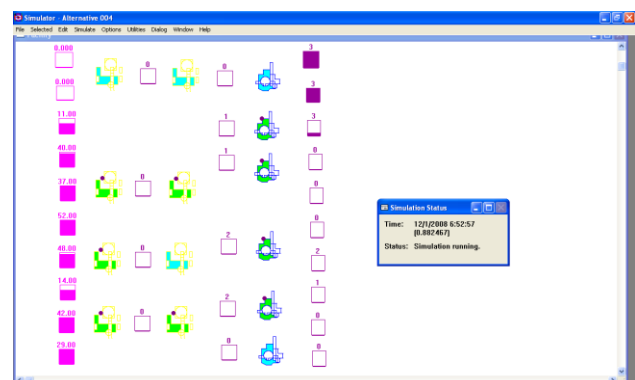


Figure 3. Simulation of the basic model

Machine utilization obtained by created simulation is shown on graph (Fig. 4). Due to simulation of whole production process by all kinds and dimensional series in production of annual batch resulted in a large difference between utilization percentage of individual machines. Machines SPT 16 and CPW 250 were used the least because only parts L 25, W 25,

L 32, W 32 were machined there, which production represents the least number of pieces in shortest operation time. After finishing its work in simulation, machines stayed inactive until the end of simulation, even in the case, that it was possible to perform other operations there. MK 500 centre was used more; even only parts L 40 and W 40 were machined. This effect was caused by longer operating times and especially greater quantity of pieces. Highest values were achieved on machines FQH 50 and CW 500.

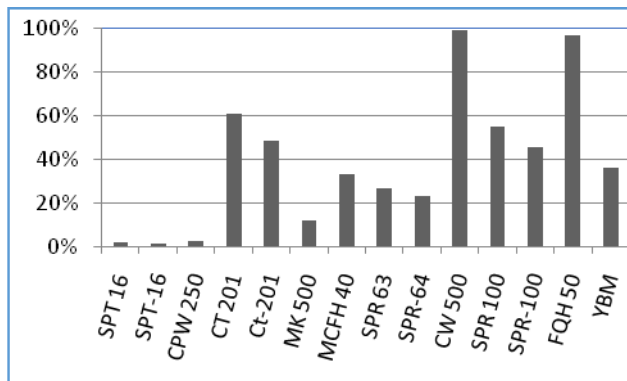


Figure 4. Machine utilization graph obtained by simulating basic model [%]

This simulation was made for one machine of each type. Because of uneven usage of machine it is considered to use a multiple machines for one operation.

3.2 Alternative pathways

Based on simulation of basic model we came to realization that this layout of machines leads to wide differences of their use. Machines producing components in smaller batches stayed unused compared with machines on which components produced in larger batches and with a longer operation time. Machines which completed their work were kept available, but no more parts were created. Production of components may not be strictly realised on those machines which were defined with the picture in flowchart (Fig. 2). After consultation with the company the manufacturing process was modified and alternative replacement was created for parts entering into this process. Modified flowchart is shown in Fig. 5.

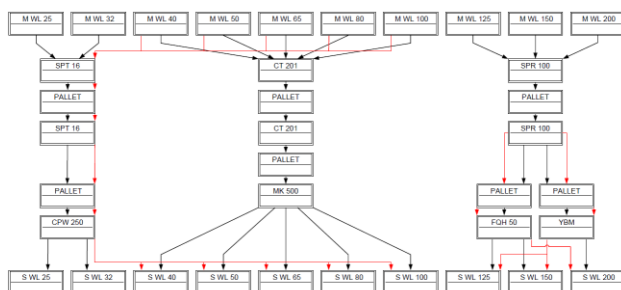


Figure 5. Flowchart of the alternative replacement pathways

Simulation of modified model was divided into three alternatives. First alternative is simulating components manufacturing process from dimensional range 25 to 100. Second alternative is simulating components manufacturing process from dimensional range 125 to 200. Third alternative with the possibility of part replacement pathways is

a combination of two previous alternatives, which simulates the course of production of all types of parts.

The first alternative with the possibility of replacement pathways

As mentioned above, first alternative with part replacement pathway possibility simulates production of dimensional range from 25 to 100. Function Setup/Operation, is used here, which allows to define time required for sorting the machine. Sorting time of 30 minutes is defined for lathes and 45 minutes for machining centres. Flowchart is shown in Fig. 6.

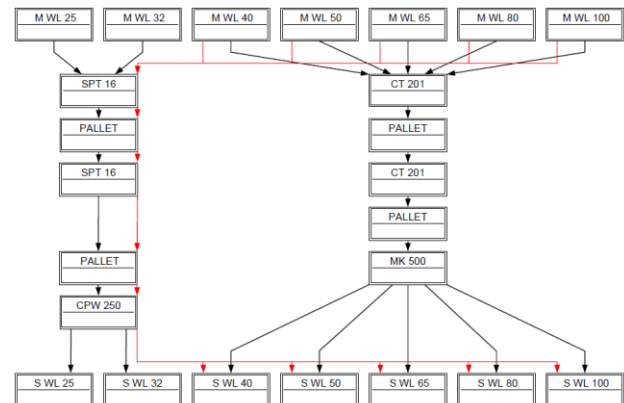


Figure 6. Flowchart of first alternative with possibility of replacement pathways

On alternative pathway are moving only three types of components (W 50, W, 80 and W 100). From W 50 90% are moving by alternative pathway from total number of pieces in the batch. From W 80 and W 100 type it is 100 %. To machine SPT 16 POOL element was added, which is required to accumulate a component intended to replace the pathway. In process plan two ways, by which components can be moved, are defined. Branching the process plan is made by using Probabilistic Select tool. This feature allows specifying a fixed percentage of pieces from batch to continue on alternate pathway. The simulation model is shown in Fig. 7.

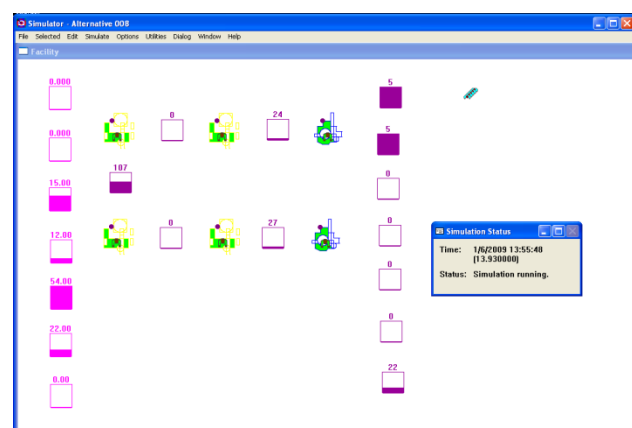


Figure 7. The simulation model of first alternative with possibility of replacement pathways

Percentage of machine utilization is shown on graph in Fig. 8. The graph shows that use of the first group SPT 16, SPT-16 and CPW 250 is very similar to use of second group CT 201, CT-201 and MK 500. Machining centres are used much more than turning machines because of their longer time required for third operation.

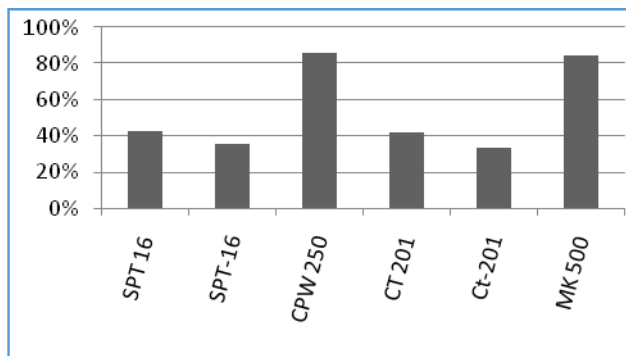


Figure 8. Machine utilization graph in [%] of first alternative with possibility of replacement pathways

Second alternative with the possibility of replacement pathways

Second alternative with possibility of replacement pathways simulates the production of second part of manufacturing process. In this alternative parts from dimensional size range 125 to 200 are machined. The use of alternative pathways comes with the third operation, which decides on which machining centre they will be machined. Flowchart of second alternative is shown in Fig. 9.

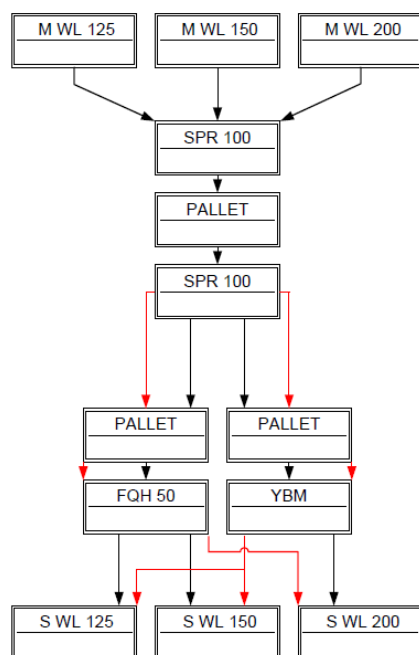


Figure 9. Second alternative with possibility of replacement pathways

Branching of process plan was carried out similarly as in previous case. In this case it was not necessary to add another POOL element as before, because each processing centre has its own, due to accumulation of components. In this alternative L 125, W 125 and W 200 parts are moving on pathways. For type L 125 it is 100 % from batch, W 125 is 100 % from batch and W 200 is 27 % from batch. Simulation model is shown in Fig. 10.

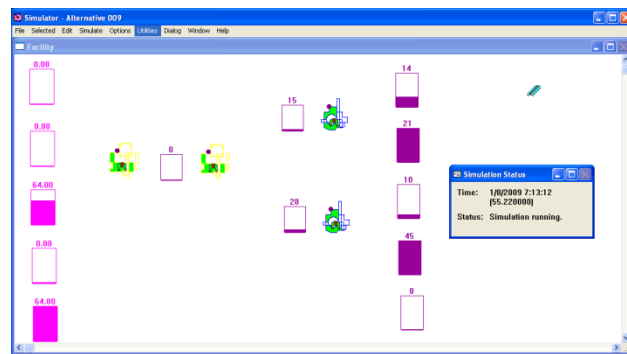


Figure 10. Simulation model of second alternative with possibility of replacement pathways

Percentage of machine utilization is shown in the diagram (Fig. 11). In this case, lathes were used more than in previous option and therefore that all parts had to go through these machines. Process plans are branched to processing centres. They are therefore used a little less.

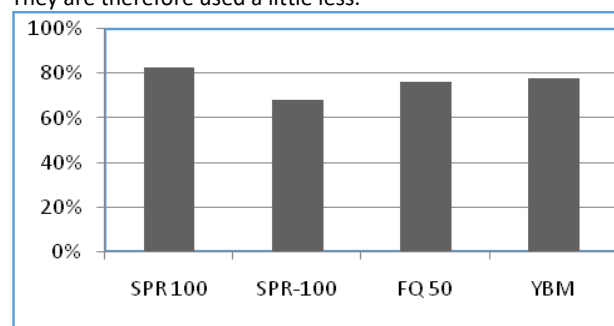


Figure 11. Machine utilization graph in [%] of second alternative with possibility of replacement pathways

Third alternative with possibility of replacement pathways

Third alternative with possibility of replacement pathways is a combination of two previous alternatives. The third alternative simulates production of all types of parts and examines the overall impact of alternative parts pathways for the entire production process. Alternative pathways stayed unchanged. Flowchart is shown in Fig. 5. This alternative of replacement pathway is designed for moving parts: W 50, W 80, W 100, L 125, W 125 a W 200.

Alternative simulation model is shown in Fig. 12. On the model you can see machine division into two groups. First group is based on first alternative with possibility of replacement pathways and second group is based on second alternative. Following two groups are not interconnected together with other pathways. Branching of the process plan was carried out similarly as in the previous case.

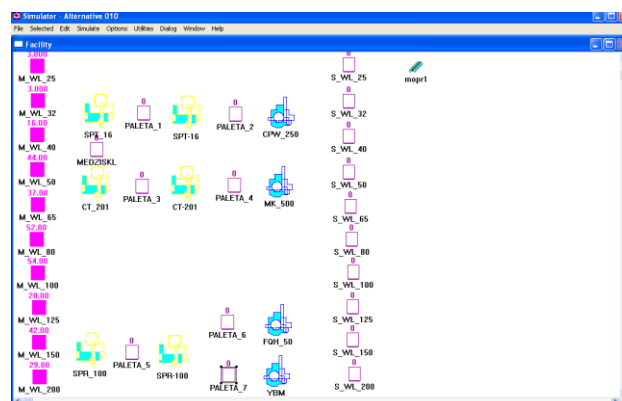


Figure 12. Simulation model of third alternative with possibility of replacement pathways

Percentage of machine utilization is shown in diagram (Fig. 13). This alternative is a combination of previous two alternatives, as previously mentioned, which can also be seen in the similarity of the graphs. Factory/AIM software calculates machine utilization from total simulation time. Machining centre CPW 250 and MK 500 finish its work as the last. Second group of machines will complete its work a little earlier than the first one. Therefore, their use compared to other alternative of replacement pathways is reduced.

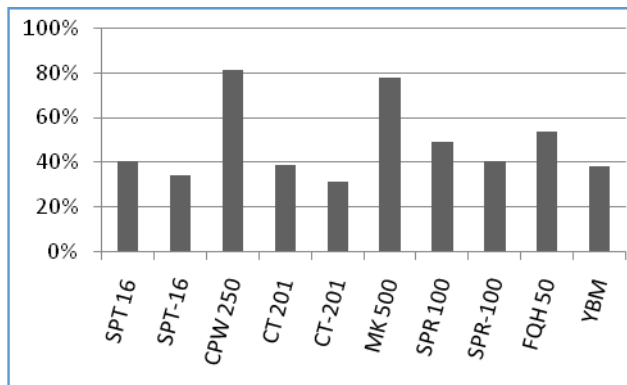


Figure 13. Machine utilization graph in [%] of third alternative with possibility of replacement pathways

In previous alternatives possibilities of shortening time of production and increase in machine utilization were examined. In simulation process, parts are moved in order to reach the end point as soon as possible. Picture (Fig. 14) shows the continuity of operation and time course as it appeared at production process of flow chart in Fig. 5 without alternative pathways and with one component in one batch for each type of WAFER dimensional range. Others parts must wait for third operation for a time while machining centre is released. This effect is could be observed during simulation as an accumulation of parts for POOL element before third operation on machining centre. Also in the diagram we can see that first and the second operation are completed before end of first operation is executed on component, that first operation is attached to complete first part of the previous operation.

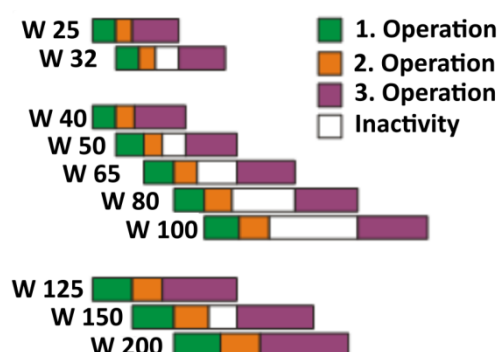


Figure 14. Time course of operations and its continuity in production process

3.3 Options for removing difference of using lathes

First option of removing this difference is use two machines for first operation. During first operation carried out on two parts at same time, in-process container at second lathe will enter two components at once, it ensures uninterrupted operation of second machine due to lack of workpieces.

Second option is a delayed start of second machine, so that the in-process container accumulate a sufficient number of

components, due to need of both machines ended its work with a time difference equal to the time required for the second operation.

Third option is to increase the number of machines for first operation. Machine for the second operation could start its work immediately after first part delivery.

4 CONCLUSION

The article deals with problem of total time shortening of production and use of machine in real production process. The aim was to optimize material flow of work rhythm of each device. Initial proposal process has proven ineffective. Various uses of individual machines from the total simulation time (from start of the operation on first piece up to last operation on last piece) are shown on graph (Fig. 4). Due to finding unequal utilization of several machines replacement tracks of material flows for the possibility of combined machine for the production of several types of components was designed. Proposed alternative pathways are shown in Fig. 5. Because machine utilization has increased, total production time was also reduced.

Possibility of replacement pathway has its importance in machine failure, which allows redirecting the production to another machine. The possibility of shortening time required for production is by use of multiple machines. By examining the production process problem with use of machine for second operation occurred. This was caused by a shorter time of second operation duration. It was found that operation time difference can be eliminated in three ways:

- 1) using two machine sets for first operation,
- 2) delaying run of second machine,
- 3) increasing the number of machines for the first operation.

The most favourable solution for machinery manufacturing process layout appears to be cell arrangement with replacement pathways of material flow according to flowchart Fig. 5 which cell should include lathe for first operation (or two machines), lathe for second operation and machining centre for third. In this solution it is also necessary to ensure duplication of jigs and tools for each types and size range. For lathes sorting time of 30 minutes and for machining centres 45 minutes was set. The handling time has been neglected after consultation with company because only machine utilization was monitored. Accidental faults were not simulated.

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