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IMPACT OF COMPUTER AIDED ASSEMBLY TECHNOLOGIES AND SIMULATION IN PRODUCTION PLANNING

Doc. Ing. Václav Š. [1], PhD., Ing. Lecký Š. [2]
Faculty of Materials Science and Technology in Trnava – Slovak University of Technology[1,2], the Slovak Republic
stefan.vaclav@stuba.sk[1], simon.lecky@stuba.sk[2]

Abstract: *Planning and simulation in assembly processes and whole production systems by computer aided systems is currently an advantage of big major companies. However, computer aided technologies in field of planning and simulation of production systems and assembly systems are future of every one company if they want to remain competitive. Computer aided systems in assembly and simulation of production processes help to save time thus financial resources needed for planning and optimization of every production systems and sub-systems. This kind of computer aided systems are helping to eliminate errors in production processes and assembly systems before they can happen in reality. This paper deals with possibilities of improvement in production process planning by use of appropriate software. In this case we will use Tecnomatix Plant Simulation by SIEMENS company which. Use of this software is aimed for planning and optimizing of production systems with high level of complexity.*

Keywords: PLANNING, SIMULATION, COMPUTER AIDED ASSEMBLY, SIMULATION IN ASSEMBLY, PRODUCTION PLANNING, ASSEMBLY PLANNING, ASSEMBLY TECHNOLOGIES

1. Introduction

Based on competition in international production network we can see that pressure on improving effectiveness of production systems is increasing. International logistic networks need connected logistic concept. These need can be managed only with use of appropriate tools of digital factory in context of product lifecycle management. That enables that output data can be used as base support for cooperation between different departments. It also offers everyday relevant data for every one user who need them. Simulation of complete material flow with all important activities like production, storage and transport activities is key component of digital factory in industry. Lowering the storage capacities by 20-60% and increasing of throughput of existing production system by 15-20% is possible in real life projects. "The purpose of running simulations varies from strategic to tactical up to operational goals" [1].

From strategic point of view users answers the questions like which production plants in which countries are the best for future production of new product with regard on factors like logistic solutions, working efficiency, downtimes, flexibility, storage resources etc. All of this is considered by users for next few years. In this context user evaluate also flexibility of production system. Statistic data is a topic which is becoming more important in present [1].

From tactical point of view is simulation executed for 1-3 months in average to analyze required resources, lot sizes and optimize the sequence of orders [1].

"For simulation on operational level, data are imported about the current status of production equipment and the status of work in progress to execute a forward simulation till the end of the current shift." [1] In this case is aim of the simulation to check final output of work shift and find out if in process we can find some downtimes or accumulated material etc. [1].

In every case user use simulation so they can evaluate new production process or evaluate existing production system. Usually the values acquired by simulation of production process are the main factor in company decision making. So, the user has to be sure that results and statistic data are correct. There are several random processes in real production systems like technical availabilities, arrival time of product, process times of work activities etc. Stochastic processes play important role in simulation of throughput of production. "Therefore, Plant Simulation provides a whole range of easy-to-use tools to analyze models with stochastic processes, to calculate distributions for sample values, to manage simulation experiments, and to determine optimized system parameters [1]." Besides, result of simulation is based on imported data and how precise is virtual model opposite to the existing real production system. When assembly processes, workers with profiles or storage logic, transport systems with controls, production process becomes highly complex. "Plant Simulation provides all necessary functionality to model, analyze, and maintain large and complex systems in an efficient way. Key features like object orientation and inheritance allow users to develop, exchange/reuse, and maintain their own objects and libraries to increase modeling efficiency. The unique Plant Simulation optimization capabilities support users to optimize multiple system parameters at once like the number of transporters, monorail carriers, buffer/storage capacities, etc., taking into account multiple evaluation criteria like reduced stock, increased utilization, increased throughput, etc [1]." Based on precise modeling properties and statistic analysis we can usually get precision of results in throughput at least 99% in real life projects. Return of investment into the simulation software is almost always right after first project. Visualization of project in 3D enables interesting 3D presentation of system behavior. We can basically simulate virtual reality in 3D [1].

In Product lifecycle management scheme is simulation and planning right after concept and right before development stage. PLM is the business activity of managing, in the most effective way, a company´s products all the way across their lifecycles; from the very first idea of a product all the way through until it is retired and disposed of [8].

PLM is the management system for the company´s products. It manages, in an integrated way, all of a company´s parts and products, and the product portfolio. It manage the whole range, from individual part through individual product to the entire portfolio of products [8].

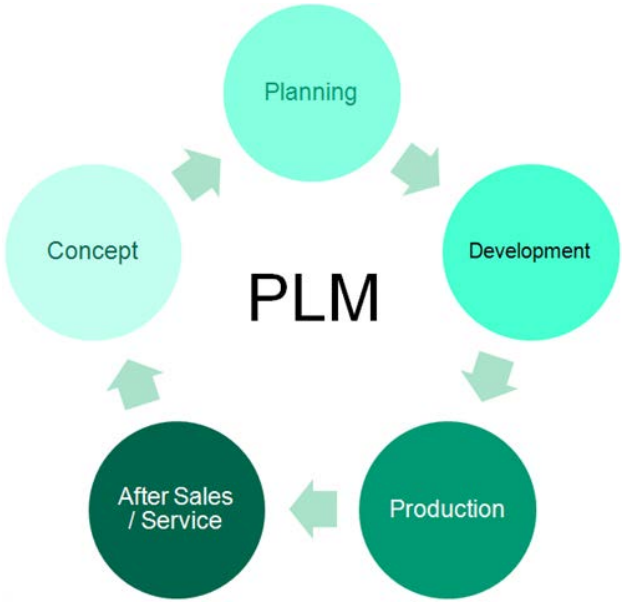

Fig. 1 *Product lifecycle management scheme* [9]

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2. Literature analysis

Simulation technology is important tool for planning and implementing of complex technical systems like production and assembly systems. Trends in economy are shortening of planning cycles, and that involves:

- increase of product complexity,
- increase of quality,
- increase of flexibility – shorter product lifecycles of products,
- lower storage capacities,
- increase of competitiveness[1].

Simulation is used where simple methods do not produce useful results[1].

In present exist a lot of simulation software in field of production (more than 100). Prices of this kind of software solutions depends on computer platform, computing power and complexity of use, usually between 2 000 and 200 000 USD. Cost of simulation projects in specialized companies are approximately between 30 000 and 100 000 USD. Even with large numbers like this we always must have in mind that profit is bigger than costs most of the time [7].

Usual main improvements:

- elimination of unnecessary over-dimension of production sub-systems (machines, storage, transport machines etc.)
- elimination of wrong design of production (wrong management, wrong design of material flow or information flow, blocking etc.)

The most used software in market with simulation software are:

- WITNESS (Lanner),
- Tecnomatix Plant Simulation (SIEMENS),
- Quest (Delmia),
- Enterprise Dynamics (Incontrol Enterprise Dynamics),
- ProModel [7].

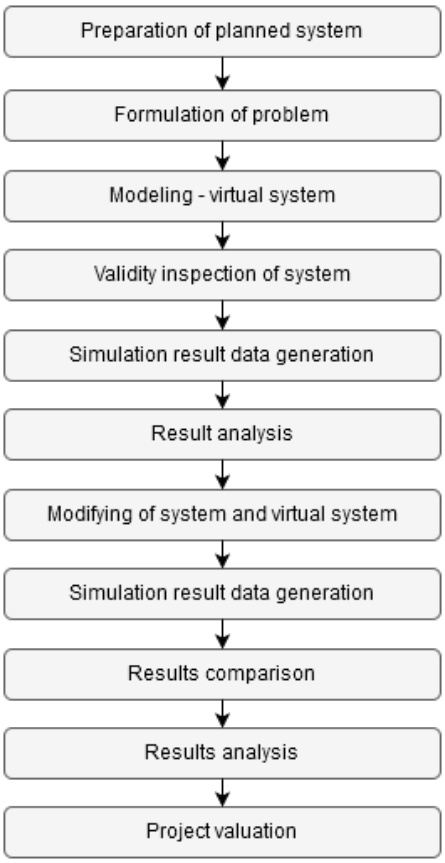

Fig. 2. *Simulation process of planned system*

3. Tecnomatix Plant Simulation

Software that will be used for creation of an example application - Tecnomatix Plant Simulation.

Tecnomatix Plant Simulation (TPS) is tool for designing and optimizing of production systems. On base of simulation is capable to answer the question "what if?". It can simulate future scenarios in stage of planning. TPS contains analytic tools like statistics, graphs and diagrams which are the reason why results are measurable and relevant. Results obtained by this process have information needed for quick and right decisions in first stages of planning, and they are shortening technological process planning time. Simulations made by TPS disposing by real values by which user can experiment and plan without stopping the production [2].

Advantages:

- testing of innovative strategies in no risk virtual environment,
- maximal usage of production resources,
- lowering the investment risk with help of quick simulation,
- size optimization of systems and storage place,
- quick identification of problems in logistics and production,
- lowering of storage capacities by 20-60% based on size of system,
- lowering the investment costs for new system by 5-20%,
- lowering the employees capacities and manipulation technology,
- quick accomplishment of positive results and identification of effect [2].

4. The example of Tecnomatix Plant Simulation application

At first we need to define what kind of research question we are going to solve by simulation.

Research question:

What are the bottlenecks of production system and how to increase throughput of production process and assembly sub-process?

In this example we introduce digital model which define production system with assembly sub-system. This model is designed in Tecnomatix Plant Simulation software from SIEMENS company. It is production where are needed these technologies:

- cold forming,
- CNC milling,
- polishing,
- drilling,
- assembly,
- quality control.

For assembly is made its own sub-system of four assembly workstations which are simulated as sub-simulation connected to main simulation of production system.

Individual workstations need to have their own time management done by user. Every machine or workstation have chance of defective work. Because of this user needs to set up workstations and machines with certain percentage of defective work outputs. Input into the system is in form of palettes by 10 pieces and simulation interval is 5 days which is one working week.

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Time management of workstations:

Table 1. Time management of workstations

Work station	Time (min)
Raw material	10
Cold forming	5
Milling	20
Polishing	10
Drilling	5
Assembly	See table number 2
Quality control	5
Packaging	1

Table 2.Time management of assembly line

Assembly station	Time (min)
Assembly station 1	10
Assembly station 2	15
Assembly station 3	10
Assembly station 4	6

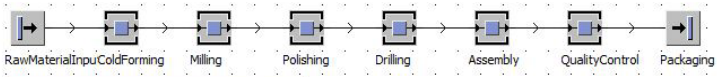

Fig. 3. *Base model of production system*

After designing of base model of production system for simulation was found out that CNC milling workstation is halted by material flowing from cold forming workstation. It was because that CNC milling workstation had longest time interval. Problem was partially solved by adding new CNC milling workstation and one buffer for material.

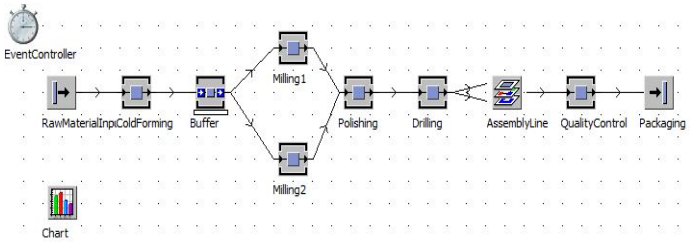

Fig. 4 *Customized base model of production system*

Sub-system of assembly was also designed as a system with four assembly workstations and two inputs of material and one output. Material is flowing from drilling workstation and after assembly sub-process is done, continues to quality control workstation.

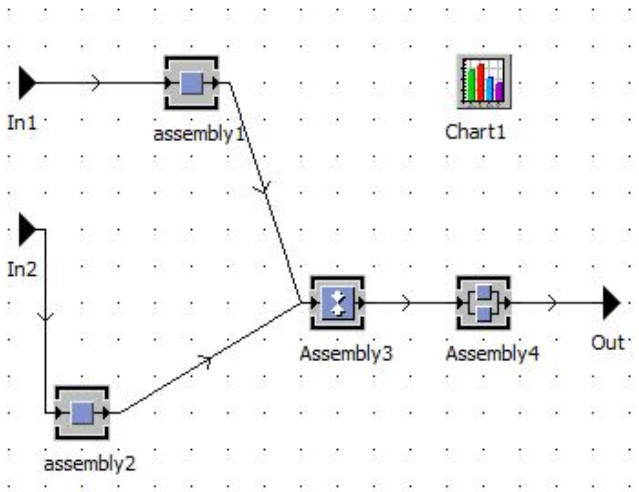

Fig. 5. *Design of assembly line as sub-system of production system*

5. Results and discussion

Customized model of production process was tested and statistical data was generated for each one of the workstations. After that data were compared with statistical data of base model production system.

In base model as you can see in figure number 5 were workstations cold forming, drilling and quality control below value 30% of working status. Workstation polishing was working on 50% and workstation CNC milling was working on 100% because of time management in this workstation. Because milling was the longest procedure, material halted the workstation and buffer was blocked on 70%.

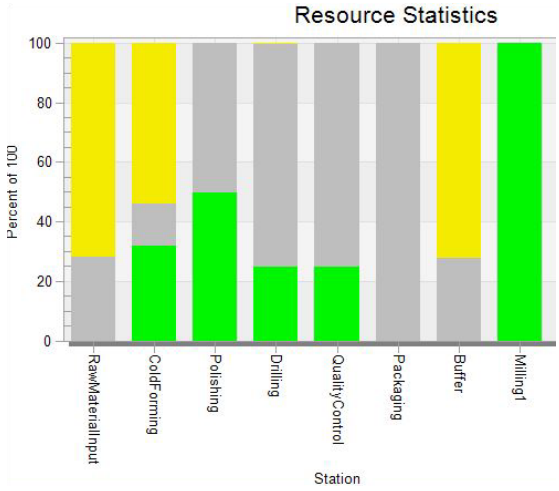

Fig. 6 *Resource statistics of base model*

Legend:

After customization of base model were statistical data changed like you can see in figure number 6. Station of polishing working status changed from 50% to 98% and workstation was blocked only on 2%. Same values were in CNC milling workstations. Workstation cold forming, drilling and quality control increased their working status up to 50%. Buffer was not blocked (0%) thus material was not halting the CNC milling workstations. On the raw material input and output (packaging) is blocking 0%.

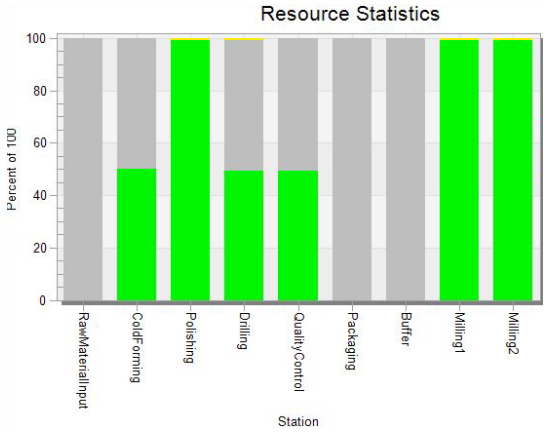

Fig. 7 *Resource statistics of customized model*

Statistic data of assembly sub-system were almost the same as before customization in workstations assembly3 and assembly4.

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They changed minimally. But assembly1 and assembly2 workstations increased their working status by 10%. Blocking is minimal on every one workstation.

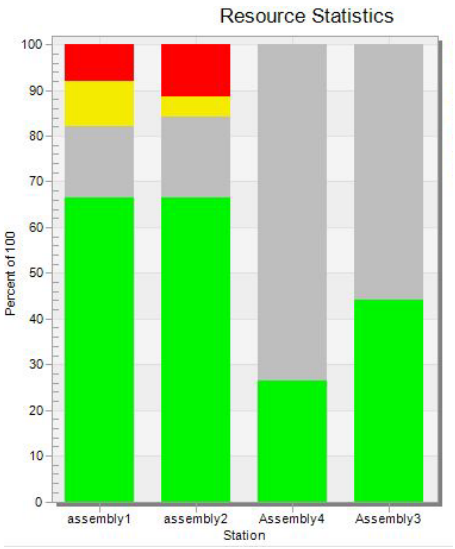

Fig. 8. *Resource statistics of sub-system (assembly model)*

Research question was how to increase throughput and eliminate bottlenecks of production system. As we can see in table number 3, base model has throughput 357 and customized production system model has throughput 711. That is increase by 1,9915 multiple.

Table. 3.

	Base model	Customized model
Priechodnosť	357	711

6. Conclusion

Computer simulations which use IT tools became necessary activity which supports design of new production systems and logistic systems or even already existing systems [3]. Simulation methods are used for evaluation different aspects of production systems. Repeatability is basic attribute of computer simulation. Because of exact values and parameters which have their own values assigned to them can be the same process executed many times. In real life this is not possible [5].

Computer simulation warrants with help of IT tools optimization of work and effectivity of whole production system, assembly lines and individual logistic processes. Digital models of logistic systems help companies simulate/test without disrupting the workflow in real production system. Because of testing of different scenarios is possible to choose the best possible alternative of system. This way are effectivity, quality and low production costs guaranteed [4].

Different types of simulation as for example discrete tasks can be applicated in digital models into the different planning activities at different levels of whole production system. Combination of simulations and optimization techniques can improve development of product and planning process of production system [6].

This paper deals with implementation of Tecnomatix Plant Simulation software from company SIEMENS to computer designing of production process. Executed simulations of designed production process showed in example that production system has flaws and bottlenecks. Because of that there was a place for improvements in designed production system with support of selected measures. With simulation we can experiment with different properties and different adjustments of model. It is users choice if it is necessary to change base model structure or just properties of production model. CNC milling machine workstation has working status 98% and blocking status 2%. That wouldn't be a problem if material didn't halt and group before this workstation in buffer. This problem was solved by adding second CNC milling workstation into the virtual model of production system. This solution increase throughput of production system from 357 to 711 (simulated throughput with solution is 1,9915 times the initial throughput of production system).

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