ANALYSIS OF MANUFACTURING SYSTEMS WITH USE OF SIMULATION SOFTWARE

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Abstract: *Knowledge gained from the Digital factory field needs to be expanded and further disseminated. The use of the Digital factory concept is mainly in laboratory conditions. It is essential for new knowledge to be made it more accessible for further experiments and for acquiring new knowledge for faster and easier deployment. The visualization of machines, devices, and entire manufacturing systems allows for almost faultless design of such systems. It is an expense saving and time-efficient solution. The article represents an experiment aimed at exploring simulation methods used in design and development of production systems by use of simulation digital tool. Comparison of the results obtained by examining the simulation model and real model will be made for acquisition of deviation between virtual model and real model. The task of optimization is, in this case, to create an optimal timetable for individual production lines by increasing flexibility and lowering costs, with prediction that the conditions are met and all orders will be made on time, minimize downtime, reduce production of waste and consider the efficient use of electricity.*

Keywords: SIMULATION, MANUFACTURING, TECNOMATIX,

1. Introduction

Among the current priorities in the field of production is the effort to shorten product cycle cycles, to increase the usability of production systems and to reduce the complexity of products, which requires changes in the technical preparation of production as well as in the realization of production. Optimizing these and other areas is geared to the main goal of increasing efficiency, saving costs, increasing productivity. Maintaining the right to maintain high quality and production stability is a matter of course. The scope and scope of workplace optimization is given by sufficient flexibility, which is achieved using appropriate technologies already at the design of the workplace itself. With increasing demands for production efficiency, reliability and the quickest start-up, an important part of the design of production and assembly lines is the computer simulation.

Empirical experience confirms that the most expensive decisions to change production and products are those that arrive late in the last stages of product development and the process of putting products and production systems into operation. It can be stated that any change introduced into production needs to be prepared and reliably tested in all aspects of production in the early stages of the design and development of production systems. Testing the production process in production systems is one way of preventing late changes in production systems. Simulation methods, as well as the virtual introduction of production systems into the digital enterprise concept, are a tool that verifies the functionality of the individual models together with the systems and verifies the functionality of the elements of automation technology in the early stages of product development and manufacturing processes. The current way of introducing new production systems has its drawbacks, and by means of new software tools for simulation and modeling of process systems, the time needed for the preparation and deployment of real systems will be shortened and thus considerable savings will be saved. Start of production or the introduction of new production, the production line is time-consuming. With these tools, there is a significant reduction in the start-up time of production. The virtualization of production systems by virtue of the future of technology and the "Industry 4.0" concept.

Computer simulation enables virtual verification of plans and assembly lines before the start of production, thus helping to mitigate risks, whether in terms of cost or real-world safety. It is a comprehensive tool that can verify the feasibility of the assembly process by controlling the reachability and eliminating possible collisions. This process is performed by simulating the whole assembly procedures of the product and the required tools and their interaction. Using computer simulation, it is possible to design the most optimal way of these processes and to incorporate all the necessary means necessary for the planned production process. The main advantages of computer simulations include, in particular, the possibility of early detection of errors in the design phase and optimization of production, the possibility of making analyzes of the feasibility of a given solution or examining ergonomics of manual works.

2. Literature analysis

At present, a large part of the production is realized in medium and small-lot or piece production. Many ranges of flexible assembly of manufacturing machines and handling equipment from production cells to flexible production systems (hereinafter referred to as PVS) are designed for these production series. The efficiency of the work of such flexible clusters of production and handling technology does not achieve the efficiency of mass production. The lower efficiency is particularly evident in the higher percentile of bypass and non-production times due to the frequent change in production. As a result, the Lean Manufacturing requirement has grown in recent years, i.e. the slimming of production strategies and the design of products and equipment itself. These requirements will need to be implemented in new production strategies, product design support and production facilities. [1]

CAx technologies have become self-evident in the design process of manufacturing systems and processes. These technologies make it possible to streamline the process of designing and designing production systems with a view to improving quality through virtual simulation and testing of individual kinematic patterns. However, these kinematic models need to be integrated and integrated into the process control itself within the simulation. On the basis of the analysis, it can be stated that the process of decontamination of the production system and its processes is often lengthy and not always predefined solutions are right. This process is demanding, costly and increases the total time needed to complete the project. The big advantage for the implementation of this process is the ability to use new technologies that allow engineers to build a complete production equipment and also they realized processes in an interactive virtual 3D environment, which are implemented as complete mechanical, electrical, hydraulic and pneumatic systems and include the production process the process into operation weeks or months before building a real production system. By creating a simulation model in a virtual environment within the Industry 4.0 concept, it is possible to simultaneously control and monitor material flow that can be tested and optimized by means of simulation tools. The expected benefit of using virtual simulation tools is to shorten the time to redeploy production systems to operational status at the planning stage. The author (Lee Ch.G. and Park S.C., 2014) addresses the idea of linking the virtual model of a production system with a real-time control system to achieve virtualization of systems. [2]

Based on the information from published works by authors (G. Kovács and S. Kot, 2017; Hoffmann et al, 2010; Reinhart, G. and

Wunsch, G., 2007,) it is possible to conclude that simulation tools have high application in the design and the design of new production systems, but it is important to evaluate methodologies interaction between platforms, a new production system in the simulation environment and verification of production equipment in a real environment and compare the simulation model with the real environment of the production system. [3, 4, 10]

Innovating current solutions emphasizes the development of fully integrated and interoperable manufacturing systems that can respond in real time to conditions and requirements changing in real time. [5]

Simulation software enables simulation of all activities from product creation, manufacturing processes, production planning, operational management, component manufacturing, inspection, assembly, packaging to shipping, to reduce material and energy demands, increase work productivity, reduce inventory, shorten ongoing development and production times, increase time and power utilization of production facilities, and increase product quality. The potential of using simulation software is high. To select the software, you need to have a clear idea of the usability and suitability of the selected software, and it is necessary to correctly define the criteria and the objective of the project.

Problems and Errors Detected During Simulation:

• large transport points,

• small storage capacity,

• Insufficient storage capacity,

• excess or shortage of workers,

• poor layout of workplaces,

• downtime.

• high caries,

• Insufficient maintenance,

• Unusable workplaces during breaks,

• Verification of functionality, reliability and performance,

• poorly planned progress of individual operations in the project.

There are models that are built for single use only (eg when analyzing processes to confirm the correctness of our hypotheses). Next are the models whose use is repeated. These are, therefore, simulation models of production and logistics systems that are still available to the user. Such models are used, for example, to verify the availability of system capacities, production plans, and the number of workers depending on the plan. An important part of the reuse of the model is its updating. The user not only changes the production plan but needs to constantly update the basic process data in the simulation model (eg machine failure, cycle times, sorting times). Today's simulation software can communicate with different databases or spreadsheet editors. Therefore, process data can be maintained in MS Excel spreadsheets or automatically downloaded from the enterprise information system. This greatly reduces the simulation model user's expertise. Although the construction of the model is performed by an expert, it can also be used by a scheduler in the production, and may not be able to control the programming language. [6]

2.1 Tecnomatix Plant simulation

Tecnomatix Plant Simulation of workplaces and assembly systems helps in planning new systems or improving current systems. It is also often used in decision-making processes such as return of investment, cost of planned changes, project confirmation, production process analysis, and so on. Simulation in assembly systems facilitates the design phase and enhances the smoothness of project design and execution through its outputs. At present, simulations are up to 99% accurate. Of course, it depends on the input parameters and the validity of the model.

Benefits of simulation:

• testing innovative strategies in risk-free virtual environments,

• maximum use of production resources,

• reducing investment risk through rapid simulation,

• optimizing the size of systems and storage space,

• rapid identification of sources of problems in logistics and production spheres,

• 20-60% reduction in inventory due to system size,

• 5 - 20% reduction in investment costs for the new system,

• reduction of capacities for personnel and handling equipment,

• quickly achieve positive results and identify impacts [7].

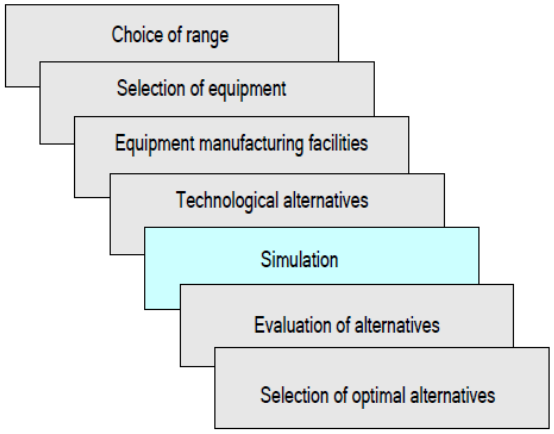

Fig.1 *Integration of simulation in designing of production cells [11]*

2.2 Tecnomatix Process Simulate

It is a comprehensive tool that can verify the feasibility of the production or assembly process and eliminate possible collisions. This process is carried out by simulating the entire assembly or production procedures of the product and the required tools and their interaction. Its task is to design the most optimal solution of the processes and to involve all the necessary means necessary for the planning of the production process. [8]

Main functions:

- 3D simulation.
- static and dynamic detection of collisions,
- 2D and 3D view,
- 3D measurement,
- scanning operations
- planned assembly operation.
- 3D geometry and kinematics. [7]

Process Simulation is the solution to minimize the risk of changes in the production and launch of new production system. It allows to verify the plans from design concept to start of production. It helps allay these risks. Ability to use 3D data makes easier virtual validation, optimization and commissioning of production processes. This results in faster launches and better production quality. Tecnomatix - Process Simulation can verify the feasibility of the assembly process by verifying reachability of the robot or human, and collisions between moving devices or between

man and machine. This is done by simulating complete assembly sequence of the products and their working tools. Tools such as measurement and detection of collisions allows detailed control and optimization of assembly processes. The software is fully integrated with the platform Teamcenter. Technology can be reused and can verify the production processes. Makes easier simulation of assembly processes, human operations and mechanical methods of tools, devices and robots [7, 8].

Advantages:

- reduce the risk in the production system,
- shortening the planning of new production systems,
- reduce the cost of change thanks to the early detection of errors,
- analysis of ergonomic process.
- choice of the best production variant[7].

3. The example of Tecnomatix application

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

Research question:

How does the impact / insufficiency of information gained from simulation with respect to real-process operation?

In this study, the proposed digital model is used to represent the production and transport system. Dynamic simulation data can be used to verify the layout of individual production machines, conveyors, industrial robots and to determine the working range of the workers.

In addition, it is possible to verify the selection of the industrial robot and to verify its working range. It is necessary to verify the collisions and the reach of the industrial arm. From Fig.1 "Collision warning of industrial robotic arm with CNC milling machine doors" it is obvious that a collision state arises. It is necessary to review the time sequence of the event and at the same time to change the choice of the industrial robot due to the inaccessibility of the robotic arm.

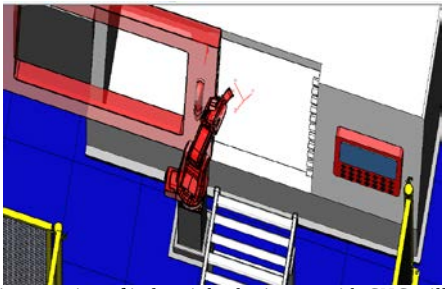

Fig.2 *Collision warning of industrial robotic arm with CNC milling machine doors*

Among other things, I know to gain the load characteristics and speed characteristics of the industrial robot joints. In figure 2, "Joint value", it is possible to see the characteristics of the rotation of individual joints in relation to time, where it is possible to check the applicability of the range of joints. We can use the information to make it easier for the production system to be put into real operation.

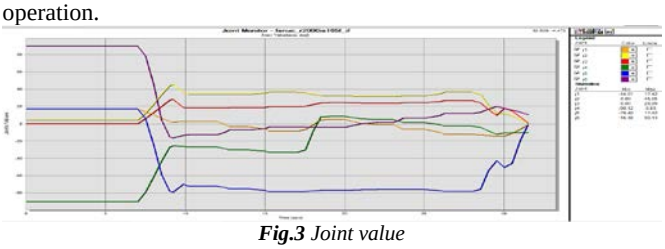

Fig.3 *Joint value*

4. Results and discussion

Simulation is suitable tool for experimenting with the structure of work and modernization of the production system. Simulation allows detection and the subsequently reducing collision situations in the design of the production system in the digital space and the help to find unfeasible and dangerous situation.

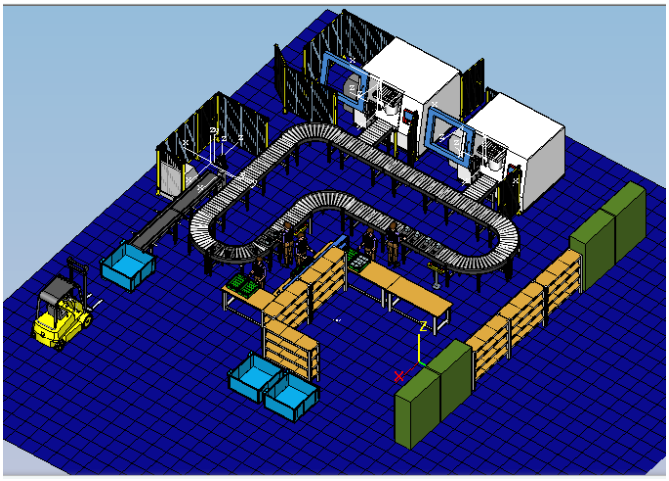

Fig.4 *Designed production system*

Same production system made in Tecnomatix Plant simulation can be analyzed for bottlenecks or throughput, labor time management, conveyor usage etc. On figure below is shown 3D model visualized in Tecnomatix Plant Simulation software.

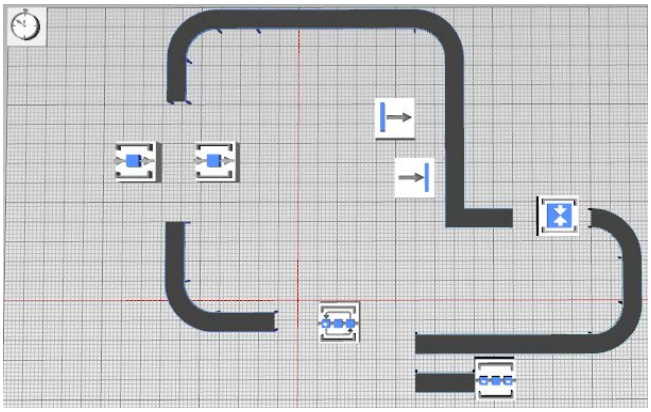

Fig.5 *Designed production system in Tecnomatix Plant Simulation (3D view)*

By analyzing this model, we can get resource statistics about each station. Based on that production line stations can be managed or time management on stations can be adjusted.

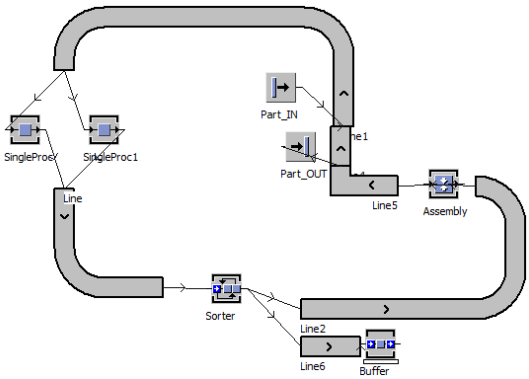

Fig.6 *Designed production system in Tecnomatix Plant Simulation (2D view)*

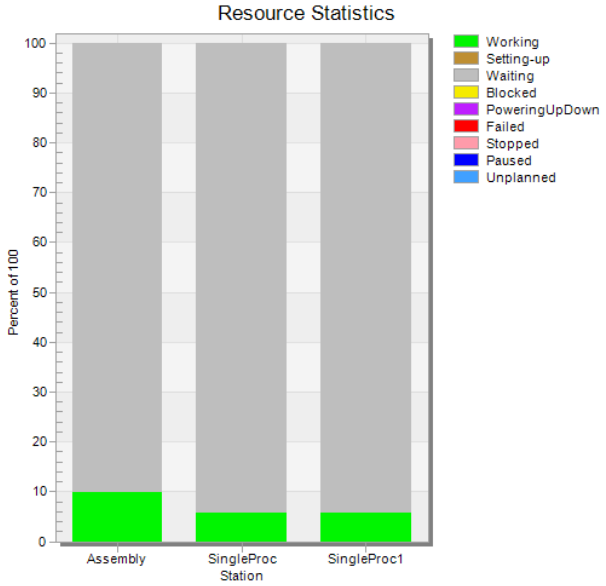

***Fig. 7** Resource statistics before implementation of changes*

Between figure seven and eight we can see difference in productivity of stations. In figure eight is much better productivity and working time on stations because of adjustments to model based on simulation results.

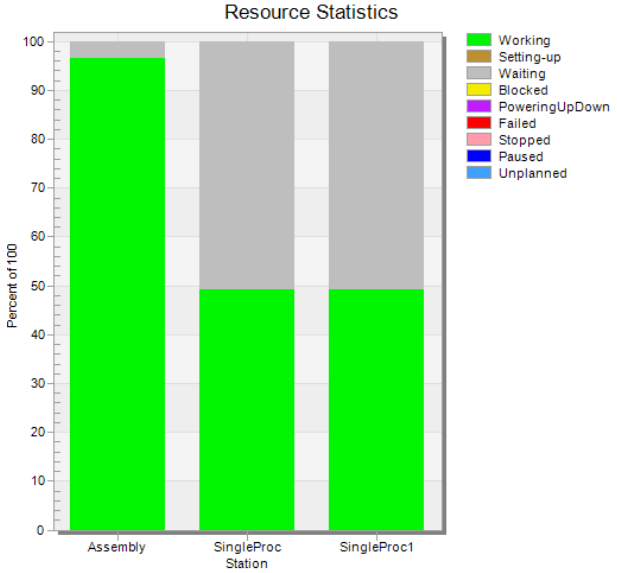

***Fig. 8** Resource statistics after implementation of changes*

5. Conclusion

The use of simulation tools in the design and implementation of production systems is highly sought after by the professional public and in the field of design and design of production systems and by the automatic service, and the results of the research will be expected from the point of view of the transfer. The creation and more frequent introduction of simulations of various processes in manufacturing, logistics or other industries is an integral part of the Digital Factory concept, which falls under the Industry 4.0 strategy. Simulation facilitates decision making when designing new and optimizing existing production systems.

Simulation methods are used for evaluation different aspects of production systems or subsystems. Repeatability is important and 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 [9].

Production planning ensures the efficient use of material resources, production capacities of the company and external cooperation with a view to meeting the deadline by the customer in the required quantity and quality. Data is very important for production planning. These are input data, which are usually output from the majority of processes in individual departments, which are then joined and evaluated. Further research in this field is the possibility of integrating available information from the simulation model to automate the generation of mechanisms and the automatic selection of production facilities or decision-making solutions.

Software solutions allow you to create simulations across the range of tasks from simple object availability testing within the robot workspace to virtual plant simulation including process, production, logistics, product, and more.

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