Optimization of the production process using virtual model of a workspace

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Abstract. Optimization of the production process is an element of the design cycle consisting of: problem definition, modelling, simulation, optimization and implementation. Without the use of simulation techniques, the only thing which could be achieved is larger or smaller improvement of the process, not the optimization (i.e., the best result it is possible to get for the conditions under which the process works). Optimization is generally management actions that are ultimately bring savings in time, resources, and raw materials and improve the performance of a specific process. It does not matter whether it is a service or manufacturing process. Optimizing the savings generated by improving and increasing the efficiency of the processes. Optimization consists primarily of organizational activities that require very little investment, or rely solely on the changing organization of work. Modern companies operating in a market economy shows a significant increase in interest in modern methods of production management and services. This trend is due to the high competitiveness among companies that want to achieve success are forced to continually modify the ways to manage and flexible response to changing demand. Modern methods of production management, not only imply a stable position of the company in the sector, but also influence the improvement of health and safety within the company and contribute to the implementation of more efficient rules for standardization work in the company. This is why in the paper is presented the application of such developed environment like Siemens NX to create the virtual model of a production system and to simulate as well as optimize its work. The analyzed system is the robotized workcell consisting of: machine tools, industrial robots, conveyors, auxiliary equipment and buffers. In the program could be defined the control program realizing the main task in the virtual workcell. It is possible, using this tool, to optimize both the object trajectory and the cooperation process.

1. Introduction
Optimization process is a sequence of action that leads to selection of the best solution from a set of available alternatives. Taking into account a wide range of problems considered with production management one could define the optimization process as determination the values of parameters that characterize the given production process to adjust its course without violation previously specified constraints. From this point of view the process optimization is related with the lean production approach. The last is directed to iterative elimination of all process elements that violate its main requirements. In this iterative process could be distinguished three sub-processes [1] of elimination (in their Japanese forms):
- muda (waste elimination);
- mura (unevenness elimination);
- muri (overburden elimination).

The muda process is considered with elimination the seven wastes determined with the acronym TIMWOOD. Particular letters mean the next wastes: T- wastes in transportation (product damage), I - wastes in inventory (not used material that do not bring a profit), M - wastes in motion (not products damage), W - wastes considered with waiting, O - wastes considered with over-processing (product should fulfil customer requirements an do not exceed them), O - wastes considered with over-production (production of larger number of products than is required by the customer) and finally D - wastes caused by defects (considered with products and process and required additional work). The mura process is considered with establishing a smooth production cycle. For large production system it is realized using the JIT philosophy. It leads to higher productivity at lower storage capacity. Finally the muri process is directed to standardization of parts and processes. By simplification it allows increasing the productivity and quality levels. In figure 1 is presented an overview of an optimization process including Japanese approach to lean production. Concluding it should be stated that lean production is centered on making only actions that add value and on reducing everything else. The value adding action, from the perspective of the customer for whom the product or service is designed, is any action that the customer could be able to determine as necessary and valuable.

![Diagram of process optimization](image)

**Figure 1.** Scheme of process optimization.

In the figure 1 are presented additional elements considered with the optimization process. For the system of a production process it was distinguished three main elements: equipment created this system, procedures linking equipment to realize a production flow and control system supervising functioning of two previous elements.

During the optimization process should be taken into account three designing parameters: geometry, material and assembly method. The geometry parameter is consider with determining the form of process elements using a system of the CAD/CAE class [2,3,4]. This process is added with more specifies analysis like dynamic one or strength one [5,6,7]. The second factor is considered with material optimization. This is particularly important for some types of manufacturing systems [8,9,10]. At least the last factor is considered with assembly method and proper assembly parameters that influence the characteristic of a product.

2. The life-cycle approach in the optimizing process

The second problem, related with process optimization issue, is the life-cycle of a technical mean [11]. Optimization criteria must include requirements considered with all possible stages of this cycle. It
must be stated that the life-cycle is a complex scheme that presents sequence of different forms of a product “life”, what is shown in figure 2. Three main periods could be distinguished in the product life-cycle: construction creation phase, material “existence” one and liquidation one.

![Diagram of the life-cycle of a technical mean](image)

**Figure 2.** Scheme of the life-cycle of a technical mean [11].

One of the most susceptible phase of the whole technical mean life-cycle is the creation phase. Mistakes made at this phase are the most serious and costs of their fixing are the highest. So it is very important to conduct that phase carefully and, on the other hand, quickly according to a market demand. The other phases do not influence the costs of the whole technical mean life-cycle so much.

Therefore taking into account costs considered with product elaboration it should be stated that computer tools allow decreasing them in different stages of the technical mean life-cycle. One of techniques, applied for time and costs decreasing, is simulation. Modern computer systems of the CAE class allow designing complex technical means [12] and conduct complicated engineering analysis including simulations tests.

3. Simulation of a virtual workcell as the tool for process optimization

The elaborated problem was considered with designing a virtual production system, in the form of a workcell, to analyze the problem of production system optimization. The scheme of the analyzed system is presented in figure 3. The system consists of a lathe, a milling machine and a robot. The robot is also responsible for controlling the production process in this model workcell. Optimization
process is conducted using outer computer on which optimizing procedures are implemented. In figure 4 is presented the virtual model of a lathe. This model is equipped with a virtual controller allowing executing programs written in the G-code.

![Figure 3. Scheme of the analyzed production system.](image)

![Figure 4. Virtual model of a lathe.](image)
In a similar way is developed the virtual model of a milling machine. It also allows the implementation of procedures stored in the G-code. The sequence of transport operations, realized in the presented virtual manufacturing system, is supervised by the robot controller. The purpose of this research is to develop a protocol of cooperation of indicated equipment and of data exchange to make possible the optimizing process of the working workcell on the basis of past experience. Nowadays was accomplished tests considered with cooperation of mentioned devices.

![Virtual model of a milling machine](image)

**Figure 5.** Virtual model of a milling machine.

The whole workcell could be controlled using supervising program that run programs controlling particular devices. It is possible to use virtual sensors which allows simulating a real flow of control signals in a real control system.

### 4. Conclusions

The presented approach of production system optimizing using a virtual environment of a production system is only the transitional stage to the fully automated production system that could optimize itself. To realize this task one should applied visualization systems [13,14] that could help to supervising the system work. It is also needed to implement algorithm of artificial intelligence to speed up the calculation processes and to work around the problem of the global optimum.

The element of future research should be also the problem of linking and analysis of data from external sensors [15,16] for the implementation in procedures performed in virtual reality. Thus, it is possibility to make more real the operating conditions of virtual devices. These devices may be any real controllers or and sensors of any type. [17,18]. It should be also noted that the important role, in further work, will play control programs basing on algorithms of artificial intelligence [19,20]. They allow creating the environment of production systems, as intelligent and adaptive.

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