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CONCEPT OF THE SYSTEM FOR DESIGN AND OPTIMIZATION OF CONFIGURATIONS IN NEW GENERATION OF MANUFACTURING SYSTEMS

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Abstract
Conventional methods for the rapid design of new production systems are no longer sufficient, therefore new mathematical models must be designed to reach actual requirements. By using these mathematical models, we can design new supporting systems, that can reduce time needed for design of final solution. Concurrently these models must be based on the relevant parameters by which we can evaluate the generated solutions and thereby to improve the final solution. Improvement in this case means finding solution that can meet given requirements and offers us cost-effective outcomes too. This article deals with the design and optimization of reconfigurable manufacturing systems with support of the widening classical simulation methods by new approaches. We have briefly focused on the concept design that will support the rapid reconfigurability. Using presented approach and other technologies of reconfigurability it will be possible to build rapidly such production system that will be able to adjust its production capacity due to fluctuations in demand and to adapt its functions to the new products.

Key Words: Manufacturing, Reconfiguration, Configuration, System.

Introduction

Due to global competition, manufacturing companies face the constantly unpredictable changes in the market environment. This is connected with the need of rapid placement of the product on the market of various volumes and variants.Each company is currently trying to produce as many products as possible, so they increase utilization of available machines and equipment to the maximum. It is required to take into account the quality of products and the need to reduce production costs (Rakyta, 2015).

If production companies want to stay competitive, they must be able to design production systems that will produce high quality products at the low level of expended costs. Such production systems must be able torespondrapidly to ongoing changes in the market and user needs. Responsiveness refers to the change rate in business objectives and to production of new products.

It is often very difficult to optimize such complex system, because the service processes are very diverse, rugged and ensure continuity of the main production process (Krajčovič, 2014).

Reconfigurability is a new technology that is responsible for cost-effective and also quick response to changing market conditions. According to Herčko (2015) machines, equipment, warehouses and production lines will be connected in the future factories, to form common cyber-physical systems and thus will support fast implementation of the system reconfigurability. Conventional methods are not sufficient for the rapid design of new production systems, therefore new mathematical models must be designed to reach actual requirements. By using these mathematical models we can design new supporting systems, that can reduce time needed for design of final solution. Concurrently these models must be based on the relevant parameters by which we can evaluate the generated solutions and thereby to improve the final solution. Improvement in this case means finding solution that can meet given requirements and offers us cost-effective outcomes too.

Summarization of Acquired Knowledge and its Critical Evaluation

Based on exploring wide range of publications we came to the conclusion that many solutions already exist and they are closely linked to reconfigurability. Most of them deal with device and hardware solutions that offer the ability of quick change. But at present there is no solution that deals with quick design of production system. Such solution has not been discussed very deeply yet, therefore we have decided to approach to the design of such solution.

The designed solution differs from the existing methods and models in offering a unique process of generating manufacturing configurations. It will also offer optimization of generated solutions in such way that the configuration is economically efficient and meets all relevant requirements. Such solution can serve for the designers of production systems as design and analysis tool to support the design of production systems. Designed solution also evaluates generated configurations so it significantly shortens the time it takes to design a new production system. Such solution uses the principle, based on reconfigurability. Mathematical model used in the designed methodology will use various methods such as cluster analysis and mathematical combinatorics. The mathematical model can serve to the construction of the real system.

System for Supporting the Design and Optimization of Configurations in New Generation of Manufacturing Systems

The designed methodology of the system is based on customer requirements. If these requirements are not indicated clearly, then it is not possible to generate potential solutions. It depends on customer what is to be produced, in what quantities and at what terms. This information must enter the input module of designed system, where inputs are defined. The module must deal directly with the customer what and how much will be produced.

The input module must be connected to the capacity calculations module. After identification of required production components capacity calculations module would calculate the required number of machines that can meet the defined requirements.

Data entering mentioned module have to enter into the manufacturing configuration generator module which should generate all possible configurations that are appropriate for different parameters.

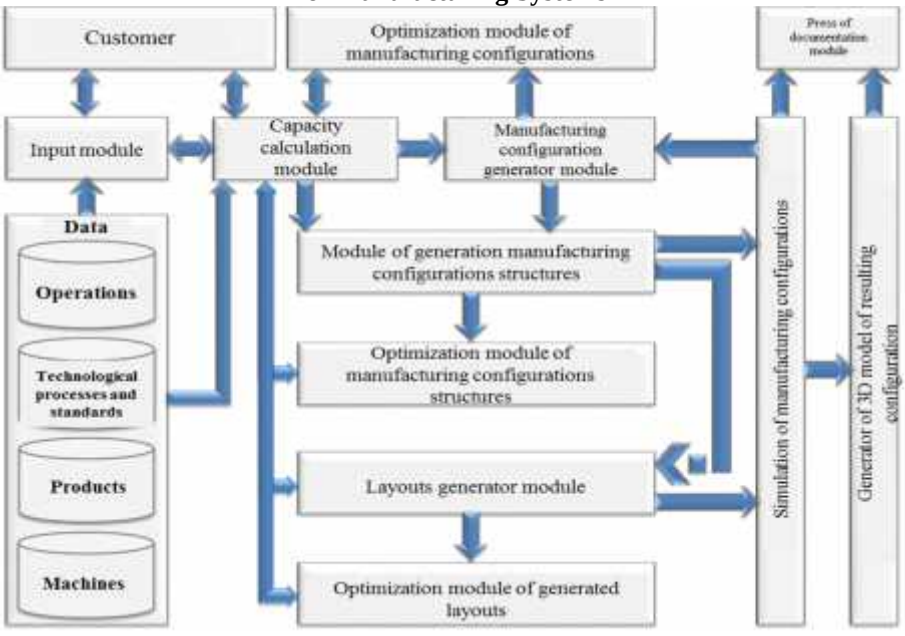
After generating all possible configurations, data must enter from the generator ofmanufacturing configurations module to the optimization module of manufacturing configuration, where the configuration that meets defined target is chosen. These parameters must be generated in the capacity calculations module and the input module. Reduction of the number of configurations will not only provide a smaller number of configurations, but in the next steps will also significantly reduce the consumption of computing power of hardware thatrealize calculations.

From generator of manufacturing configuration module we can within reduced number of production configuration transfer the output parameters to the module of generationmanufacturing configurations structures, which receives data from the capacity calculations module and input module. The task of the module is to generate different structures of production configurations and assign them relevant parameters.

Unless production configurations structures are generated, their output parameters have to enter to the module of optimization manufacturing configurations structures. Role of the module is to assign and remove machines according to defined requirements based on capacity calculations module and input module.

Output parameters from the generator of production configurations structures module must be subsequently transferred to the configurations of module for optimization of production structures. Generated structures of production configurations are rejected or recieved here. Process of rejecting / receiving is based on the comparison of evaluation and target parameters. The evaluation parameters are associated with the generated structures and target parameters are based on objectives which are given in the capacity calculations module and also in the input module.

Fig.1: The Concept of the System for Supporting the Design and Optimization of Configurations in New Generation of Manufacturing Systems



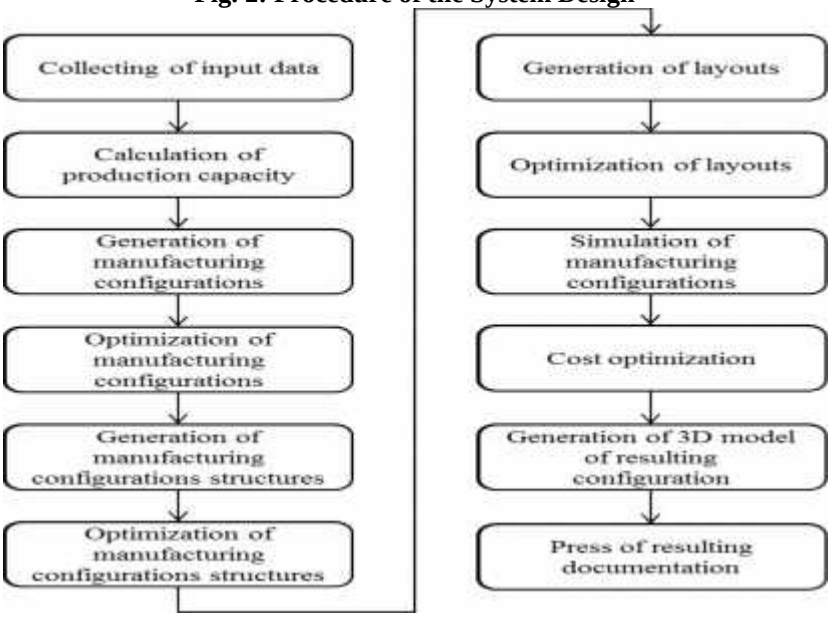
(Source: Author)

Figure 1 shows the schema of the system consisting of modules and links between them. Links represent transfer of parameters between the modules. They are necessary for ensuring correct operation of the individual modules. Role of the system is generating the most appropriate configuration from the objectives point of view. Objectives are directly defined by the customer. Such system would offer a rapid response to the changing customer requirements, which are based on changes in the production program, the production mix and volume. Based on the generated configurations we can generate and optimize their layout, where we have to take into account the restrictions on the work zones.

Procedure of the System Design

In the first part of the design it needs to be addressed the issue of input data collection to perform the necessary analyzes such as cluster analysis and customer evaluation of produced modules. Using these approaches, we can identify what we can produce. In another part it is necessary to focus on capacity calculations which can quantify, based on the input data, how many machines will be needed. Then we can identify all possible production configurations that can be assembled with precisely calculated number of machines. Then we can choose the most suitable configuration that best meets given objectives. In the next section we can deal with generation of production configurations structures. Based on predefined criteria (throughput time, cycle-times, production costs and time of orders delivery) we can optimize the structures of production configurations. Based on the generated configurations we can generate and optimize their layout, where we have to take into account the restrictions on the work zones. But it is necessary to consider the fact that in this case we must consider the limitation, that is defined by the minimum dimensions of the work area based on the working conditions of the machine (manipulation zone of the machine, reach of the machine, etc.). Then we can minimize the requirements on transport, so that we start to group machines until they touch each other. It must be noted that for each machine is defined working zone, which is generated randomly. By simulation of the final production configuration, we can verify the correctness of the designed solution and also we can get more detailed results that were not reflected in the designed solution, such as times for material-handling, times for picking and storing material, waiting, etc. At the same time we can verify the reliability of the production configuration when faults appear and other unconsidered conditions that may occur in production within the proposed configuration. If we are able to check the proposed production configuration, we could proceed to generation of a 3D model of the final configuration.3D library of machines should be prepared within the given solution. This library could be used in case we know dimensions of the machines footprint. Based on the identification values of footprints which were used in generating layout, we can identify which particular 3D model of the machine belongs to individual footprints.Documentation for the final configuration should serve for the summarization of the resulting data received from the generated solutions. The documentation should include following information for the designed configuration: profit which can be achieved, production costs which will by generated, volume of production which can be produced in the given delivery date, what is the throughput like, what are the dimensions of final configuration, distances between workplaces, working zones within the configuration, reliability of the production configuration and so on. For better visualization it would be appropriate if documentation includes also the 3D model of final configuration. Using 3D model will be helpful for production systems designer in the process of design new production system.

Fig. 2: Procedure of the System Design



(Source: Author)

Conclusion

Functionality of the designed solution using mathematical models can be verified by a computer simulation. Dependencies can be examined based on a simulation model to which we can assign the output parameters from the designed solution. Inter-comparison of outputs offers us verification of the designed solution accuracy.

When offered this solution to the practice it is possible to reduce time for the design of new system without much knowledge in the computer simulations. This solution may be also useful for decision support when receiving the most appropriate configuration due to changes in the production program, production mix and production volume.

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