Future of the Manufacturing Systems

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Abstract: This article describes basic information about future of manufacturing systems. In the introductory section there are described trends that will create future concept of manufacturing systems. These trends are also described. Currently existing, advanced software solutions allow to faster accurate data and information exchange, facilitate planning and monitoring during manufacturing processes. The article provides also problems of current manufacturing lines via core characteristics of reconfigurability and their application to particular problems of designing and optimization of manufacturing configuration. Based on these characteristics was created a methodology for the designing of the reconfigurable manufacturing line configuration.

1 Manufacturing systems

Today's manufacturing systems are characterized by options and features to process any type of the components, parts, pre-established production processes and customer requirements. An essential feature of the production system is flexibility. And aspects, which characterize them are [6]:

- Continuous exposure and adaptation to change manufacturing operations.
- Completion and assembly of product requires no longer complete big deliveries of parts of same type. Individual components in specific order are required in deliveries, corresponding to composition of products. This helps not to form too large stocks in workplace or in stock.

The new generation of production is all about production systems that can think independently, as well as persons who individually control car. Manufacturers today are seeking efficiencies in production, and the ability to deliver a broader mix of customized products to their customers. They know that staying competitive will require operational processes and production lines to be integrated and adaptable in order to enable fast configuration changes and reduce lead times. And all of that needs to occur without compromising an inch on safety or quality. This is a problem that companies will have to deal with in the future.

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1.1 Future of the manufacturing systems

Many literatures refer to scenario future of manufacturing systems as a "self-organized production processes for highly customizable products." They liken it to global recovery of manufacturing industry, which may be driven by government funds, market forces and technology megatrends. As industrial technology grows increasingly pervasive, wave of automation and digitization is being labelled “Industry 4.0,” as in the fourth industrial revolution and appearance of the manufacturing systems are starting to change [12]. These changes in different areas, complemented by the possibility of using new technologies / megatrends, could described:

- **Product research and development**: A look at how artificial intelligence is helping to materials science, and how to use augmented and virtual reality in everyday work.
- **Resource Planning & Sourcing**: On-demand decentralized manufacturing and blockchain projects are working on the complexities of integrating suppliers.
- **Labour Augmentation & Management**: Augmented reality, wearables, and exoskeletons are augmenting human capabilities on the factory floor [1].
- **Machining, Production & Assembly** [4]: Modular equipment and custom machines like 3D printers are enabling manufacturers to handle greater demand for variety. The use and development of 3D printers may allow the gradual removal of surplus warehouses in the future.
- **Quality Assurance**: A development of technologies of the computer vision which will be possible to find imperfections or find solution how the software and blockchain technologies will be able to more quickly identify problems (and implement recalls).
- **Warehousing**: New demand could bring “lights-out” and eco-friendly environment warehouses, with the help of robotics and vision tracking.
- **Transport & Supply Chain Management** [3]: Telematics, Internet of things, autonomous vehicles will bring greater efficiency and granularity for manufacturers delivering their products.
- **Production planning**: Computer simulation, reconfigurability, Internet of things, sensors, and so on.

As it is possible to see in these examples, new technologies are prone to hybridization, and that process will be augmented by the further inter-combination of emerging technologies. The next evolutional stage of digital transformation will be marked by larger crossovers between information and communication technology, including aspects of artificial intelligence and operation technology. Such integration of technologies is becoming an integral part of machines, appliances and common goods and ushers in the promotes the growth of the phenomenon of intelligent things. Key technology that drives these changes is the Internet of Things, computer simulation, agent-based modelling and reconfigurability.

The following subchapters describe the use of the listed trends in production systems.

1.1.1 Internet of Things

IoT (the commonly used acronym for Internet of things) broadly refers to a network of devices and sensors capable of capturing and communicating data with one another. The possibilities of the Internet of Things are gradually changing the future of manufacturing systems. The sensors in the system enable the collection of granular data, for example, from assets like machinery – energy consumption, heat levels, uptime/downtime – or the tracking of goods in transit.

The data capture enabled by IoT primarily drives greater overall efficiency by helping to optimize each phase of the production process. Whether it's general day-to-day operations, the health of machinery, or reducing energy consumption, information collected by IoT devices supports better decision-making and quick alerts when something is going wrong.

1.1.2 Computer simulation

A computer simulation is the usage of a computer for the imitation of a real-world process or system. The dynamic responses of one system are represented by the behaviour of another system, which is largely modelled on the former [10]. A simulation requires a model, or a mathematical description of the real system. This is in the form of computer programs, which encompass the key characteristics or behaviours of the selected manufacturing system. Here, the model is basically a representation of the system and the simulation process is known to depict the operation of the system in time [11].

1.1.3 Agent based Modelling

An agent-based model (the commonly used acronym is ABM) is one of a class of computational models for simulating the actions and interactions of autonomous agents (both individual and collective entities such as organizations or groups) with a view to assessing their effects on the system as a whole. It combines elements of game theory, complex systems, emergence, computational sociology, multi-agent systems, and evolutionary programming. [5]

Particularly within ecology, ABMs are also called individual-based models, and individuals may be simpler than fully autonomous agents within ABMs. A review of recent literature on individual-based models, agent-based models, and multiagent systems shows that ABMs are used on non-computing related scientific domains including biology, healthcare, hospitals and manufacturing. Agent-based modelling is related to, but distinct from, the concept of multi-agent systems or multi-agent simulation in that the goal of ABM is to search for explanatory insight into the collective behaviour of agents obeying simple rules, typically in natural systems, rather than in designing agents or solving specific practical or engineering problems [7].

1.1.4 Reconfigurability

Reconfigurability is a new approach that enables cost-effective production of products and rapid response to market changes. Reconfigurable production system represents an adaptive system capable of adjusting its production capacity to demand fluctuations and adapting its functions to produce new products. Reconfigurable production system is designed to quickly change the structure of hardware and software elements within a selected product family [8]. Such manufacturing systems are designed as modular, using reconfigurable manufacturing machines and equipment. They often work on a plug and produce approach that allows very fast integration and use of the latest technologies.

It is also possible to say that it is a system that is capable of dynamically adapting the production system configuration to meet production demand. Their structure can be described as a concept similar to a modular production system. [9]

In the second chapter the usage of characteristics of the reconfigurability in designing of manufacturing lines is described. Such an approach contributes to better design of production systems in the future, when these trends are fully utilized in everyday work. The disadvantage of their implementation is high investment, whose payback period is uncertain. Utilizing agent modelling or reconfigurability characteristics will allow to see hidden problems through detailed visualization and accurate results. This possibility can be achieved by linking computer simulation with a database systems and detailed 3D visualizations, that can be used in the simulation software by exporting from CAD software solutions.

2 Designing Manufacturing Lines Via Characteristics of the Reconfigurability

Increasing number of components and their possible variations in the product significantly effects on the overall structure of the production system. As a result of these changes, it is necessary to take into account a number of factors and criteria in the design manufacturing process itself so that the optimal result is achieved. The current proposal of manufacturing lines has a comprehensive structure and it is difficult problems for many enterprises [1]. For the design of production lines is needed to consider many options and objectives for optimal result. The aforementioned problems from the change in the line configuration could be partly removed by the following methodology which takes into account future possible changes in production facilities due to the change in the portfolio of manufactured products.

At the Department of Industrial Engineering, a dissertation thesis was elaborated in which the methodology for designing manufacturing lines through the characteristics of reconfigurability is described, the methodology is shown in Figure 1.

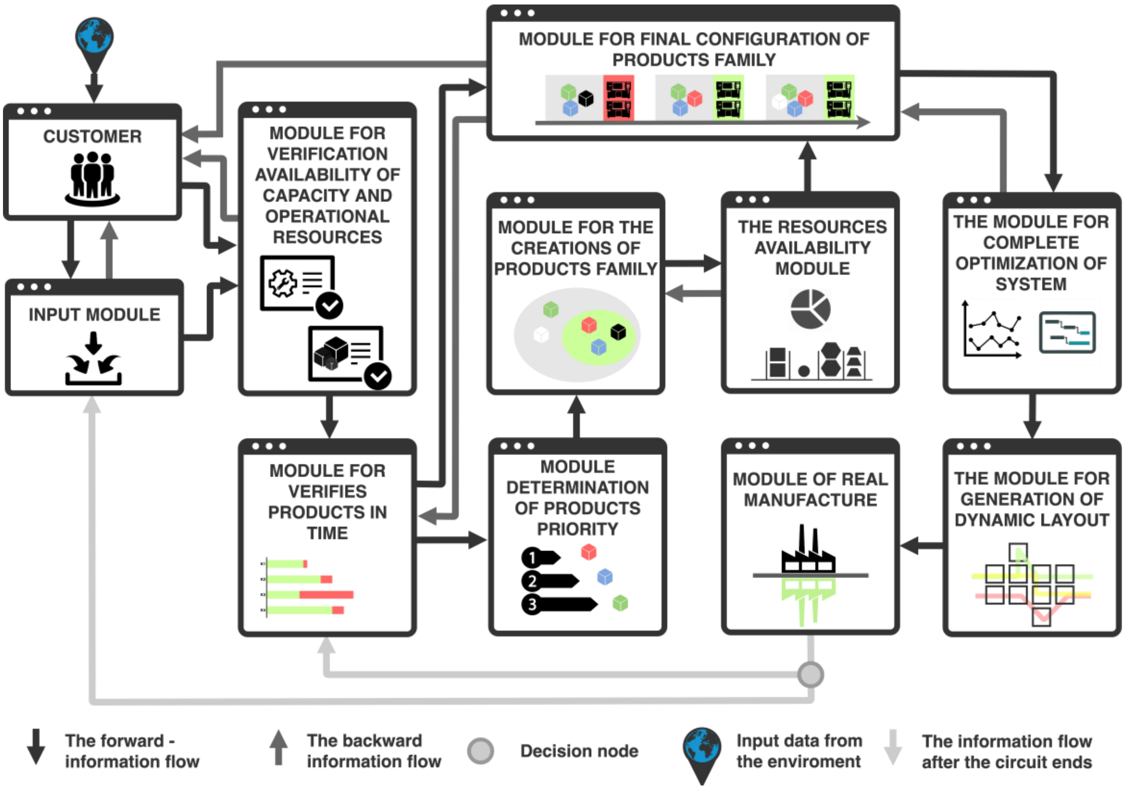

Figure 1 - The block diagram of a methodology for designing manufacturing lines via characteristics of reconfigurability (Source: Second author - Ing. Vladimír Vavrík)

Methodology applies individual basic characteristics to create a new approach to designing current systems. The basic characteristics of reconfigurable manufacturing systems used in this methodology are customization, scalability, convertibility, modularity, integrability, and diagnosability.

In this methodology are described a module for designing manufacturing lines via characteristics of reconfigurability:

- **The first module – CUSTOMER** – the customer order is an entry point in a real environment of manufacture. In this module is the sales department represented by input data which are generated in a predetermined range. This data is sent on the next module.
- **The next module – INPUT MODULE** – his primary function is the storage of input parameters. These parameters are updating in the

case if the new product family was created or changed. Each change is sent the customer for approval. If the customer agrees with the changes of the parameters, the module adjusts it.

- **MODULE FOR VERIFICATION AVAILABILITY OF CAPACITY AND OPERATIONAL RESOURCES – The first examination of processability** - The part for the verification availability of capacity resources compares the count of required machines with the count of machines in the designed system. The initial count of machines in the designed system depends on many factors. For example, the expected size of the factory, the extent of investment for building, prediction for the future selling of products, etc. The second part compares the types of operations assigned for a particular product with the type of operations which can be done in the designed system. When the designed system can produce each type of operation on the assigned product. Then the product is possibly made in the designed system. If the particular product does not fulfil defined requirements of capacity and operational, it is necessary to inform the customer. The customer must change product parameters because the product will not be made. The other ways are to add new functions and increase the capacity of the designed system for an not processable product, but only if the product will order in regular.
- **MODULE FOR VERIFIES PRODUCTS IN TIME – The module which contains verification rules** - The parameter of a short time then can indicate product processability for the actual defined products. When a family of products does not contain all products defined by customers, the remaining products must be verified via this short time producing parameter.
- **MODULE DETERMINATION OF PRODUCTS PRIORITY – The last module for verification defined product** - The function of this module is the analysis of the similarity between products, according to time for manufacturing and the similarity of product operations. The result of this module is a sequence for assigning products to the products family.
- **MODULE FOR THE CREATIONS OF PRODUCTS FAMILY – The main part of the methodology** - The firstly part contains methods for clustering products to each other and defining input parameters for the determination count of machines for this group. The function of the second part this module is, therefore, determination of the count of needed machines for created cluster.

  Then, the count of machines this cluster is tested by simulation. The simulation model is created as parametric, that means, that every new cluster is possible to simulate with his count of machines and other parameters.

The count of the machines is suitable if all the production volume will manufacture in simulation on defined time. When the count of the machines is not suitable, then it increases the correction coefficient in defined height.

The next function of this part is that the machines determined for a group of products will assign toward real machines in a defined system. The final family of products is created on the base of adding and replacing products into groups, where the final group fulfil all condition.

- **MODULE FOR FINAL CONFIGURATION OF PRODUCTS FAMILY – The conditions are verified in this module**. This module verifies two conditions. Firstly, the counts of assign machine are lower or equal the counts of machines needed for a family of products. When the result of this condition is "lower", then the last adding product will be replacing. However, if the result of these conditions is "equal", we apply the second condition. The counts of machines needed for a family of products is lower or equal the count of all machines in the system. When the result of this condition is "lower", then we can add a new product into the group of products.

The last three modules in the block diagram are only a vision for additional continuing of this methodology. The modules contain a vision for the design of a complex system based on describing the methodology, simulation and using the multiagent logistic system. The described methodology can be used as a base for complex systems for design and optimization of new generation reconfigurable manufacturing lines.

3 Conclusion

Manufacturing is main driver of economic growth, attract investment, the incentive for innovation and job creation in high value.

All points on turn and developments that are happening now are building blocks for future manufacturing systems. Question is what happens when even trends (IoT, computer simulation, agent-based modelling, reconfigurability) described in this article, will be fully implemented in production and work with them starts to be routine. One of the new system concepts that can be the starting point for solving multiple problem areas of the future are reconfigurable manufacturing systems [2]. Therefore, the solution of the problems of current production systems can be a gradual implementation of these characteristics into the present systems. In this article was also introduced the methodology for designing production lines via characteristics of reconfigurability. In this article was elaborately describe each module this methodology and recommendation for the next research in this area.

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