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Optimization of Manufacturing Processes on the Platform of PLM Systems

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Abstract The aim of this paper is to highlight the current trends in the development of tools for support of the manufacturing systems designing (creation). Current approaches of digital representations of real manufacturing, which show the manufacturing processes in a virtual environment, have strong potential to improve the quality of the final projects. The term PLM (Product Lifecycle Management) environment in the design process called comprehensive solution to the management of all product data, process changes associated with the product structure and product configurations and product development projects and has subsequently production projects. Modeling and simulation is a powerful innovative tool. Virtual / Digital Commissioning represents modern methods of a set of tools for programming of control systems, manufacturing systems and lines using a realistic virtual environment.

Keywords: *manufacturing, FMS, designing, CAD, PLM*

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1. Introduction

One, but not the only single method of competitiveness of engineering company is a product modifiability its manufacturing systems enabling dynamic response to changes in market. It is closely linked with the design and reconfiguration of its manufacturing structure, based on the principles of modularity and the using of modular design of multifunctional elements and technological units of manufacturing technology. [1]

The role of designers is in limited time to draught in form of project documentation the configuration of manufacturing process that will be realizable in frame of optimal economical conditions, requested time and shop floor area and to able to meet the dynamically changing market demands [2,3].

The project of new manufacturing system requires system solution of set of design, technological, spatial and organizational factors (selection of manufacturing devices, material flow optimization, layout ... lead-time, production bottlenecks, ...), leading to optimal processing factory configuration. The effectiveness of its operation in real terms depends on the level of mutual synchronization capability, anticipating and eliminating effects of these factors on the production characteristics of the manufacturing system.

The road to the final project documentation taking into account synergies between these factors guaranteeing compliance with the projected goals and achieved practice results, almost always leads to significant complexity and variation of solutions. Capacity to build of innovative, competitive manufacturing in limited time is therefore one of the most difficult problems in the life cycle of the company. It requires the application of adequate computer, information and software support of modern CAx systems capable of applying standardized design practices, the use of corporate knowledge, solutions of "good practice" etc.

Quality has become the critical issue. Philip B. Crosby, a prominent representative of the theory of quality, defines quality as compliance with the requirements. It is therefore essential that customer requirements are well identified. Quality costs are generally caused by the action involved (in) quality are not made correctly the first time (if they were, it would create a quality product, and the quality was actually free because the cost of poor quality fell away). P. B. Crosby argued that money actually does not increase the price of the goods, on the contrary, it decreases. S P. B. Crosby is also associated Rule 1 - 10 - 100, according to which no matter where and when you notice respectively eliminate errors. Therefore, it is always better to keep quality from the outset, as means to rectify shortcomings.

Quality, in this context, is everything about the product and its associated manufacturing organization. Some suggest that, traditionally, quality is available but for a higher price. High quality has become a pre-existing condition for acceptable product performance. Any quality initiative must begin with the product and that product's design. Hence in the development and designing process is the Concurrent Engineering Design philosophy used. The Concurrent Engineering design process provides a

stable, repeatable process which increased accuracy is achieved in a shorter time with less variation.

2. Design and Integration

The term PLM (Product Lifecycle Management) is in frame of the designing process called complex solution for management of all product data; process changes associated with the product structure and product configurations and product development projects [4,5,6].

The PLM thus manages and supports all information of the entire product lifecycle. PLM is not a one product, it is a set of systems of CAD, CAM, CAE, including PDM, support of CAAP, simulation of manufacturing over to communication with customers and subcontractors [7,8,9,10].

By abbreviation PLM is also called a strategic business approach that uses a consistent set of business applications to support collaborative designing, management, transmission and use of product information in so-called extended enterprise from product design to disposal, integrating people, processes, business applications and information, with the emphasis on knowledge management.

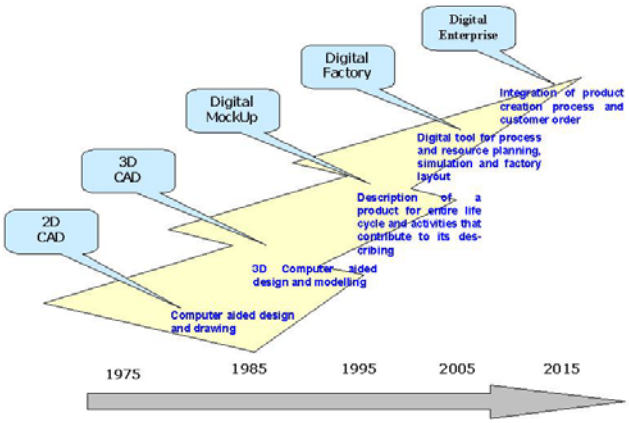

Figure 1. Development stages for the digital designing and manufacturing

Sometimes the term PLM from marketing purposes narrows to the integration of CAD systems and project data management PDM (Product Data Management). Therefore, for example, Autodesk avoids to this not exact definition and promote so-called "integrated design process". In any case, it is about capture of trend of virtual prototyping and knowledge sharing using new technologies [11,12,13,14,15].

3. Why to Visualize

Current tools CAx for designing provide a complex representation of the final product. These data can be advantageously used in subsequent steps for planning and design of technological processes of production in a virtual environment. This solution, better known as the "Digital Factory" is a complex representation of the real manufacturing which shows the manufacturing processes in a virtual environment. It is used mainly for process of planning, simulation and optimization of production processes of complex products (cars, trains, planes, boats ...), using these software tools, it is possible to plan and manage the life cycle of the product. In essence, this concept includes the business processes of the enterprise (design - production) into complex systems, in which in short time is needed to solve the problems of optimal design, eliminate potential waste and other.

The whole concept of the so-called "Digital Factory" covers several areas, most notably of which are based on digital models of complex product: the implementation of digital planning of manufacturing processes, verification of digital manufacturing and production support. The basic idea is to identify problems and solve them in computer model - even before they happen in real environment. The concept of the Digital Factory focuses on the planning, simulation and validation of production processes, ergonomics and simulation of manufacturing systems (Figure 1).

Once you have planned various processes is necessary to determine whether the plan corresponds to the real possibilities of work or production systems. Verification is used for simulation (depending on the nature of the problem is continuous or discontinuous), after planning provide tools for modeling manufacturing processes a sequence of operations, their time and resources consumed by these operations. During the planning process can be introduced erroneous data, these can be determined by reference simulation. E.g. using continuous simulation can also check the manual installation times. Planner at scaling down some time assembling the kit, using simulation tools can accurately simulate the assembly and then compare the results with the plan.

With the method of a continuous simulation are verified rather smaller and shorter operations at one post, and the like. With the method of discrete simulation are verified production lines and manufacturing systems. Particular stocks at work, transport efficiency, as stocks and the like are verified.

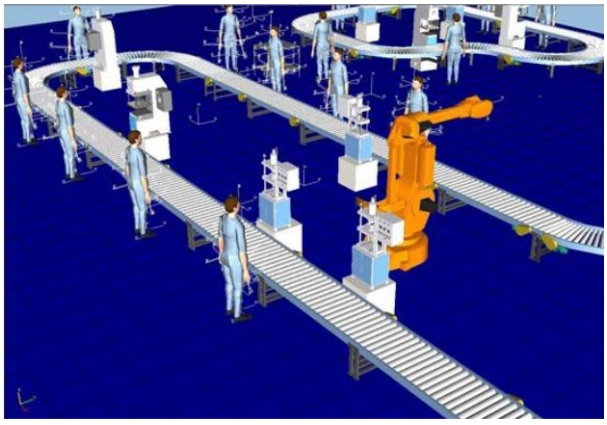

Figure 2. Designing of manufacturing layout in modular engineering software tool Tecnomatix Process Designer

The advantage of application of the Digital Factory tools is optimalization of the space arrangement of manufacturing systems and other different technological devices, the possibility of time simulation of manufacturing without the need for prototyping and analysis of production systems in order to identify bottlenecks or the possibility of a virtual view to the production hall.

Modules for manufacturing systems designing allow to designers concurrent design and analysis directly in a 3D graphic environment. So way can be verified e.g.

reachability objects by robots or manipulators, synchronization and collision of moving parts in space (which is eg. a particularly difficult task when using multiple robots for welding bodies and in similar applications). From the spatial arrangement of the manufacturing system can then check collisions with the existing buildings, technological infrastructure or building or contrariwise, the digital model as a basis for the building projects.

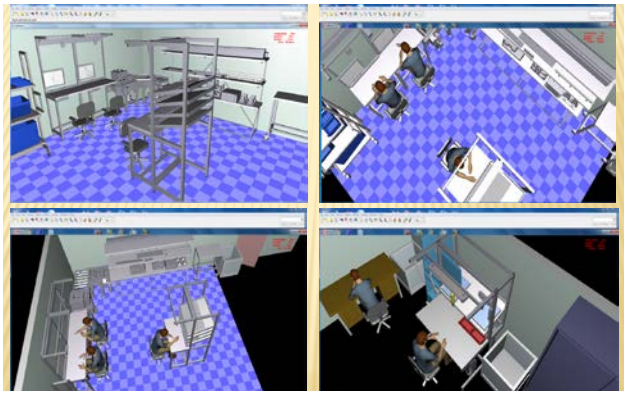

Figure 3. Designing of laboratory layout in modular engineering software tool Tecnomatix Process Designer

In Figure 2 and Figure 3 are examples environment for layout designing. Process Designer enables you to plan your assembly or work processes in a 3D collaborative environment. It gives possibility quickly and easily to compare multiple alternative scenarios and select the most optimal process, define the assembly sequence, choose the required tools and create the plant, line or station layout using an intuitive and configurable user interface. Perform line balancing by optimizing the assignment of processes to stations or workers, and have clear visibility of active and passive resources. In addition, so type of tools enable to generate customized reports and various types of process documentation, including electronic work instructions, bills of materials and management reviews and directly connect this step of designing to simulation and optimization of manufacturing process [16].

In Figure 4 and Figure 5 are examples environment for simulation made in software Tecnomatix Process Simulate from Siemens PLM. Of course, modeling everything and at any price has no meaning. Modeling makes sense only if it provides a basis for sound decision-making, in many cases it is possible to use simplified models or can be used to correct the results of the calculation and the like. If we have models of manufacturing systems, it is advantageously use for next steps of designing process.

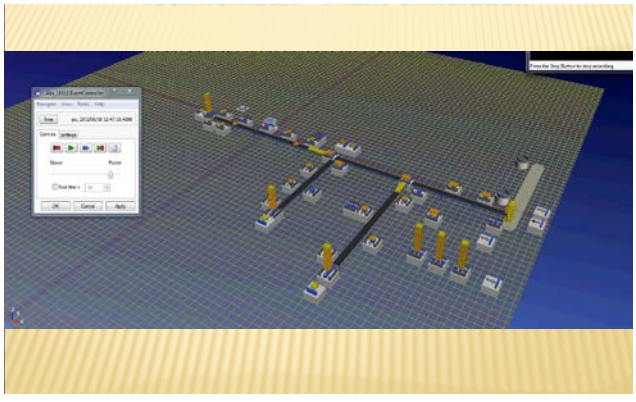

Figure 4. Simulation of assembly process in modular engineering software tool Tecnomatix Process Simulate

The modern product range of Siemens PLM Software or Dassault Systèmes include a number of software tools for different areas of production, which can be interconnected in precise digital modeling, simulation and 3D spatial visualization. These tools to enable industrial companies to use in practice the concept of digital factory, plan and design production, design, verify and optimize processes and production resources in the digital environment.

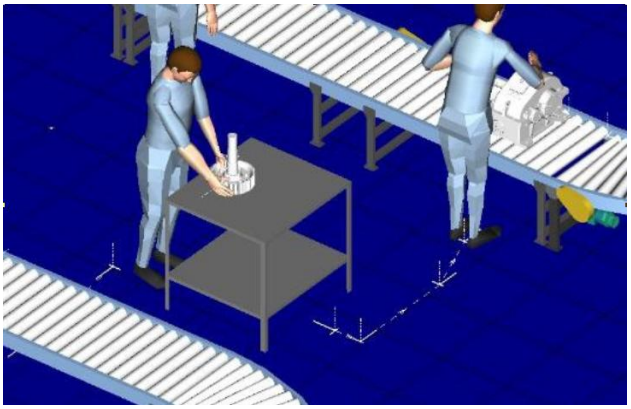

Figure 5. Simulation of humans from point of view ergonomics using Tecnomatix Process Simulate

Digitization allows faster and more accurately prepare processes, while simulation and optimization of the development phase to ensure that the produced flawless product right the first time, without making any real factory in additional costly and time-consuming changes. This will limit the defects, which might otherwise occur during start up of production.

Virtual environment made in precise digital modeling make possible not only to optimize designing automation systems but to debug PLC/industrial computers programming too.

4. Virtual Commissioning

One of the topics in the digital factory is the Virtual Commissioning. The commissioning of the automated system is an important phase in the engineering, which makes visible whether the systems and components are planned, designed, produced and installed correctly according to the user requirements. However, this phase has been known as time-consuming and cost-consuming in practice and can be improved by Virtual Commissioning.

Advanced sophisticated and highly automated and flexible manufacturing systems are all controlled by programmable logic controller (PLC) or industrial control systems programs that include sophisticated tooling, robots, transfer lines and other safety equipment. [16] Industrial programming allows manufactures to alter production lines without having to completely retool the entire facility. However, whenever changes are made, engineers still have to stop the production for an extended period of time while they debug the PLC programs against live equipment. Present state of the art is that the simulation of the system components is frequently used and the simulation is used without integration of automation devices and components, for example without PLCs (Programmable Logic Controller).

Virtual commissioning (Digital commissioning) is a modern method and set of tools for programming of control systems, manufacturing systems and lines using a realistic virtual environment. Toolkit for virtual commissioning created using digital models of manufacturing systems and allows debugging code for each PLC (Programmable Logic Controller) before they are actually installed. The solution allows you to select the appropriate resources management, design and debug the system of automated control directly on a virtual model of the production system.

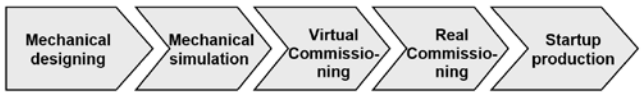

Figure 6. The designing stages in the production with Virtual Commissioning

The focus of digital factory is the digital processing of product development and production planning based on the existing CAx data with a seamless workflow in PLM (product lifecycle management). Digital simulation methods and technologies are used to secure the planning results, to optimize the process and to respond more quickly to the changes than before. In this way the product qualities are improved. Another benefit is the reduction of the planning time as well as the overall project duration. Key features include:

- Possibility of verifying program code without having been present real device
- Visual verification process, which is controlled by the PLC code before integration,
- Verify a number of scenarios in a controlled manner "what if?"
- Virtual production testing and identification of conditions which involve the failure of the program
- Use or create libraries of mechatronic devices
- Manual generation for manufacturing system operation.

To test the PLC-program before the real commissioning, the Virtual Commissioning can be applied. It serves as a smooth transition between digital and real factory. In the case of Virtual Commissioning, the physical plant, which consists of mechatronic components, is simulated with the virtual model. This simulated system is connected to the real controller (PLC) via simple connection or real industrial communication systems. The goal is to approximate the behavior of the simulated system to that of the real physical plant by connecting the commissioned PLC to the real plant without changes. Therefore the development and test of automation systems can be done parallel to the electric and mechatronic development. In the case of the real commissioning, the connection can be switched to the real system again.

Tools for virtual commissioning are the latest trend in expansion of the design process of production control in one phase and consistent applying the concept of digital factory. With virtual commissioning solutions it is possible to debug PLC codes on a virtual environment before downloading them to real equipment. By simulating and validating automation equipment virtually, it is possible to confirm that they will work as expected and significantly reduce system startup time.

5. Conclusions

The complexity of tracing and maintaining a competitive advantage in global markets requires a new level of agility new product development. Many manufacturers use advanced robotics and networked, collaborative machines and sensors to create an organized integration of networks with direct connection to the broader value chain. We believe that this value chain also needs to include a link that delivers a significant advantage over traditional models: the intelligent product-to-production platform. Solution for product lifecycle management (PLM) and manufacturing execution system (MES) integration directly links product requirements, design and manufacturing information to your shop floor execution systems. PLM-MES integration allows you to continuously respond to shifting demands by distributing your latest product designs and assembly methods to a more connected, more efficient and more effective production value chain, assuring complete visibility between manufacturing and engineering domains. Present innovations in digital manufacturing solutions and tools are directed to extension for integration of manufacturing production with manufacturing execution system and big data solutions for production quality. Intelligent product-to-production platform can be answer to increasing of speed of technological change, shifting consumer demands and competitive pressure.

As PLM is primarily focused to designing processes, it is very closely related to integrated management systems (IMS). Quality, Environmental, and Safety management systems are often combined and managed as an IMS. These systems are not separate systems that are later joined together, rather they are integrated with linkages so that similar processes are seamlessly managed and executed without duplication.

The package of PLM tools is relative large-scale software system that functionality is focused primarily on the needs of key customers (automotive, aerospace, etc.). As their production is based on co-operation with a high number of subcontractors, it is necessary to integrate data across PLM structure so-called “extended enterprise”. It can therefore be expected trends (as with ERP) solutions of customization to the needs of "small" customers or clients from other sectors of the economy, such as the machine.

It is planned to increase support for a broader inclusion of social communication in business information systems, thus PLM. Social networks are a rapidly growing service that transforms the socialization processes and ways of working and it attaches considerable potential. From corporate social network, for example, expects that in the framework of enhanced cooperation company would have a qualitative improvement in innovation and new forms of communication could help get "customer view".

Currently, presented new features of tools that may be included within the concept of PLM, are mainly focused on the productivity of the designing process. Besides strengthening collaborative designing, the great attention is paid to the efficient use of corporate knowledge (for example implementation of designing templates). With regard to design of complex (mechatronic) engineering and technical systems operated in global business

environment, the necessity of knowledge about designing theory is more and more important.

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