COOPERATION AND EXCHANGE OF INFORMATION THROUGH PLM AT DISTRIBUTED MANUFACTURING SYSTEMS

Michal Cigánik[1], Štefan Valčuha[2], Jan Tomíček[3], Martin Vrabec[4]
[1,2] STU in Bratislava, Faculty of Mechanical Engineering, Institute of manufacturing systems, environmental technology and quality management, [3,4]CTU in Prague, Faculty of Mechanical Engineering, Department of machining, process planning and metrology,
[1]michal.ciganik@stuba.sk, [2]stefan.valcuha@stuba.sk, [3]jan.tomicek@fs.cvut.cz, [4]martin.vrabec@fs.cvut.cz

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Abstract: Globalization and development of information systems are currently the dominant factor in business. Use of the distributed manufacturing addresses the issue of maintaining or even increasing the competitiveness of the enterprise market. The development in the mechanical engineering leads to the new ways of company's cooperation and to creation of so called distributed manufacturing systems (DMS). Proposed article gives a view on a development of new methodology of DMS ontology and managing the processes within this environment such as simulation of production and innovation management.

1. INTRODUCTION

The current market environment is characterized as high turbulent and it needs permanent adaption of manufacturing systems. All influencing factors of market such as product adaption, fast innovations under the influence of new technologies, fast engineering (increase of product complexity) and global competition pressure have significant effect on the conditions of future manufacturing [1]. Turbulent environment and its influencing factors causes that only companies with flexible manufacturing systems have the ability to survive. Companies, especially small and middle sized enterprises (SMS) perceive the strong competitive pressure in terms of quality, delivery time and customer's specific requirements. Therefore they are forced to use new tools and approaches to manufacturing. Integration of companies into so called virtual organizations (VO) or distributed manufacturing systems (DMS), where the subjectivity of company's remains, is considered as one of the possible solutions [2].

The competitiveness of enterprise is influenced especially by fast response to customer requirements, flexibility, high quality, fast delivery of the product to the market with an effort to fully satisfy customer's needs. Currently in the world there is observed a growing emphasis on the integration of enterprises (especially SMEs) into the cooperative networks, and ultimately to the creation of DMS (distributed manufacturing systems). The way how to maintain growth of competitiveness and increase of innovative activities for SMEs is the creation of such associations and cooperation's in the form of DMS. The current market situation therefore leads to use of new management approaches, new methods, technologies and tools [3]. The reaction on this new situation was the development of product lifecycle management (PLM) conception. PLM represents the process of management of the whole product lifecycle from initial concept through its design, production and maintenance to its final recycling. The core of PLM lies in creation of central management of all data related to product (geometry, metadata, structure …) and technology used. It is also a scientific approach based on the tools such as CAD, CAM and PDM but it can be also considered as integration of these tools with methods, people and processes throughout all phases of product lifecycle. PLM tools can be used for automation of company's processes and so to make the management process more

effective. In other words, the PLM creates a global environment for creating and managing digital data. The main advantages of implementing PLM systems into the DMS can be considered as:

- Improving the quality and shortening time of engineering designs
- Shortening of time for searching existing data
- Shortening the time to launch a new product on the market
- Reducing the cost for designing new product
- Reducing the cost of innovation
- Reducing the cost on tools and preparations
- Reducing the number of errors in documentation

PLM is also responsible for integrating all components of the company information system into one functional unit.

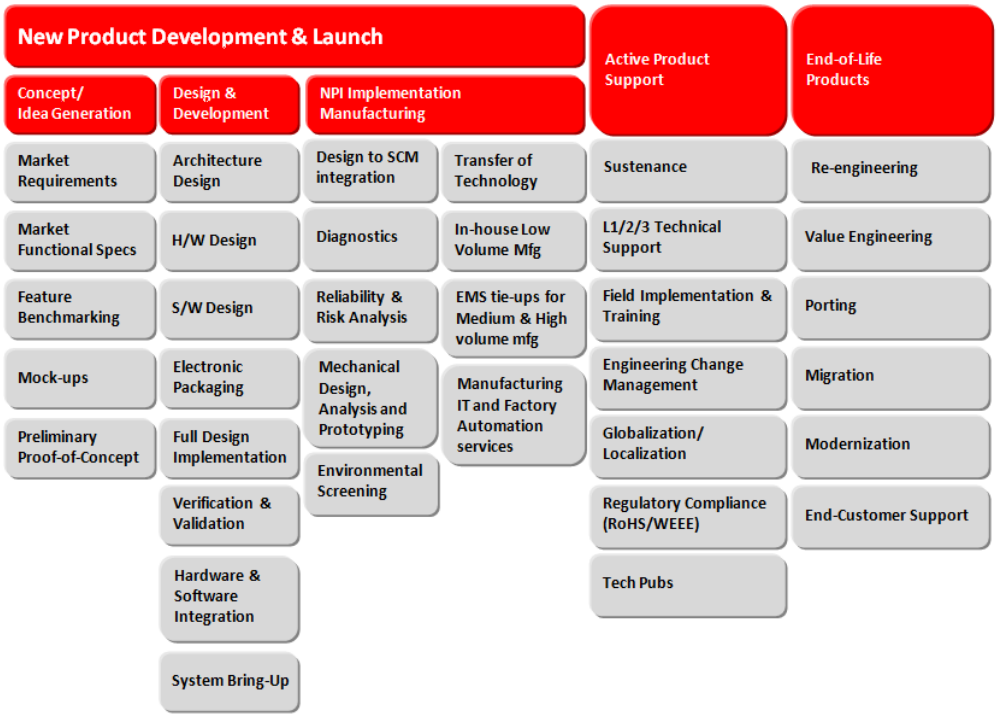

Figure 1. The basic structure of PLM [4]

Predecessor of DMS was a concept of virtual organisation (VO) accepted as a progressive form of enterprise network. Companies in comparison with traditional structure of supplier-customer relations cooperate in a stronger bond without any geographical, communications or administrative restrictions. Primary idea of VO creation is the effective development and manufacturing of complex product such as car or production machine.

Development in the last decade brought also the change of terminology where DMS is represented as a latest expression of VO. The DMS itself represents temporary connection of companies concentrated on one market opportunity. Individual participating organizations are connected via internet and they are sharing the common information system. Each organization in DMS has its own given competence and responsibility in related area.

For the need of further research it was a important to create a model DMS consisting of the Laboratory of PLM situated at the Faculty of Mechanical Engineering,

STU in Bratislava (FME), and its partner Faculty of Mechanical Engineering, CTU in Prague (CTU), as a technological workplace. The basic tool for cooperation is represented by CAD/CAM/PLM system CATIA. For cooperation purposes in DMS environment software SMARTEAM was used for product development [5]. PLM system SMARTEAM plays the role of the integration tool in DMS. Represents a modular, highly adaptable cPDM/PLM solution based on Microsoft Windows platform, used to:

- Business collaboration
- Administration and management of all product data
- Reuse of information and processes gained in the previous draft of the product

2. THEORETICAL BACKGROUNDS

PLM laboratory as a part of the Faculty of Mechanical Engineering STU in Bratislava has been for long time devoted to the issue of multi-company cooperation at DMS. Laboratory posses a hardware (laboratory with 12 workstations and server with shared database) and software equipment (CATIA V5, SMARTEAM) appropriate to address multi-company cooperation.

Currently it is significantly connected with the Department of Machining, Process Planning and Metrology, Faculty of Mechanical Engineering in Prague. This technological workplace posses except of computing equipment also production machines.

3. THE COOPERATION AT DMS (CASE STUDY)

3.1. INTENTION

The main goal was to create a model solution of DMS and to ensure data transfer and communications in this model solution from the initial component design proposal via its innovation to the experimental production at a remote workplace. CTU in Prague and ZTS VVU Košice were cooperating as partners. Possibilities to test selected means of communication and cooperation on multi-company level were created by mutual cooperation. By installing SMARTEAM license to the workstation at CTU and creating VPN connection the first variant of cooperation and communication was created. VPN provides a secure encrypted link between STU in Bratislava and CTU in Prague. This way of connection allows log in to the PLM server at FME, STU in Bratislava and possibility to download the necessary licensing and cooperation rights.

CTU acts as a workplace which can directly interfere into cooperation process as a full partner in the DMS. Although it is a geographically remote partner, using the VPN creates an idealized single-enterprise character, which means it has access to the PLM server and the date on this server. It can also on-line interfere into the process cooperation. In this way CTU replaces a missing element in product development process and covers product manufacturing issues. FME is acting as a central managing member, which provides entire data management and creates ideal conditions for DMS. It also covers the areas of administration, design and construction.

The first variant of cooperation and communication between CTU in Prague and FME STU in Bratislava was directed to the creation of two departments, which would ensure cooperation and at the same time would be located on two different, geographically distant places. This intention was fulfilled and the project for cooperation and communication on multi-company level was created. In the next phase the mechanical

component will be designed and modeled on the FME STU using the CATIA V5 system. SMARTEAM and PLM server will be used to cooperate with CTU on the design of the new part manufactured at the manufacturing department of CTU.

The entire cooperation and communication is executed via PLM server at STU in BA. During the data transmission and processing which is ensured by SMARTEAM system network between departments will be created. After design, construction and storage of component to the PLM server CTU can be connected using the internet and system SMARTEAM at PLM server to download relevant components at its local workstation. After the creation of manufacturing program at CTU the data with new information included are stored in the CHECK IN state on PLM server. After notification CTU as a manufacturing department produces component (according to program) and assembles them into final product. In this stage data on project completion will be stored through SMARTEAM. SMARTEAM enables the creation of projects, data processing, their backup and has other capabilities for the management of PLM in DMS.

The main effort is to create a model variant of cooperation in which several enterprises would be involved. It is possible to ensure cooperation by three different ways; through SMARTEAM Editor, SMARTEAM WebEditor and VPN. Use of PLM system SMARTEAM is a good choice for the creation of multi-company cooperation in DMS.

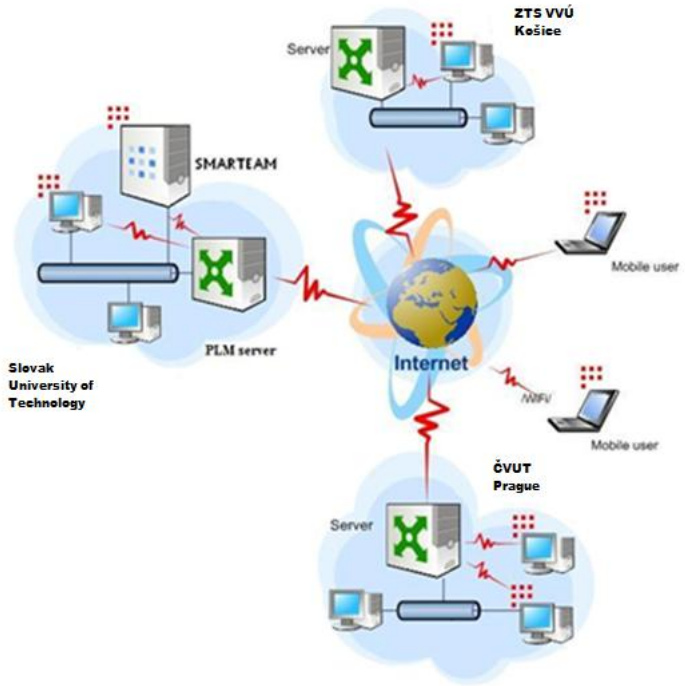

Figure 2. Communication and cooperation using the PLM system SMARTEAM

3.2. MODEL SOLUTION

The model solution describes utilization of Collaborative Product Data Management (*CPDM*) technology for decentralized product design in DMS. The solution was divided into two parts:

- design of new product
- product innovation

3.2.1 DESIGN OF NEW PRODUCT

During the first stage of problem solution the model DMS was created, consisting of managing company and two subcontractors. In the scope of model solution cooperating companies were formed by workstations located in the PLM and Innovation laboratory at the Institute of manufacturing systems, environmental technology and quality management. The workstations are permanently connected to the server of FME in BA where software licenses of CAD/CAM/PLM system CATIA V5 and database of PLM system SMARTEAM are installed.

Input parameter was design of product in DMS environment. CTU in Prague, Department of Machining, Process Planning and Metrology, which has the appropriate software and hardware equipment participated as a co-worker of model solution. The basic assumption of cooperation was the creation of model link within FME STU in Bratislava.

Basic information flow is depicted on Fig. 3. Managing company sends an assignment to individual subcontractors. After successful solution these subcontractors are sending their results (digital models, design propositions, etc.) back. If the solution results are acceptable, managing company (employee) saves them into the database (information vault). If the results are rejected, they are sent back for modification until the assignment is fulfilled.

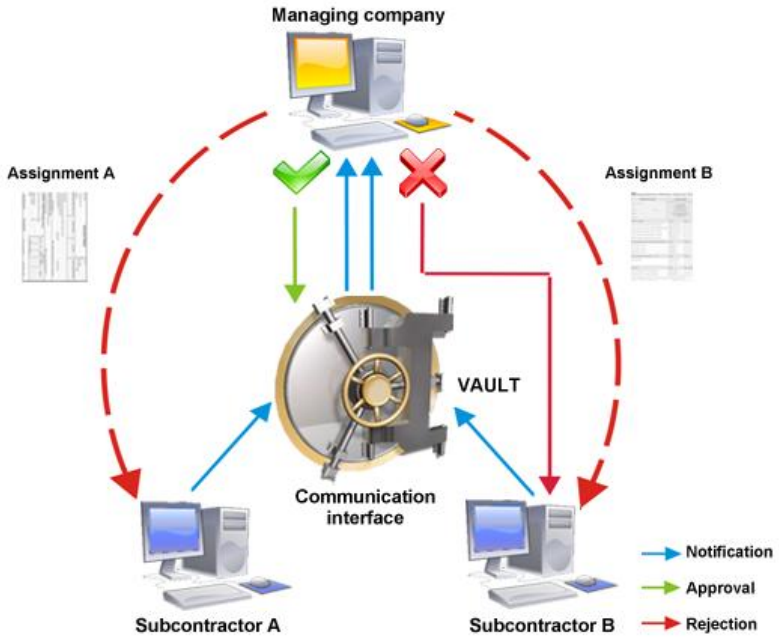

Figure 3. Model of information flow

Let us consider an attractive market opportunity of manufacturing the engineering product (computer cooler in this particular case). The company that registered this market opportunity represents the managing company which governs the entire project. The required product consists of four parts that were divided to two subgroups (aluminum components of the cooler and the fan). Regarding this situation two subcontractors should be involved in the manufacturing process. Subcontractor A represents a provider of aluminum components and subcontractor B represents the provider of the fan.

Further cooperation of the above mentioned partners was defined by workflow diagram shown in Fig. 4. The project of cooperation starts with the acceptance of market opportunity.

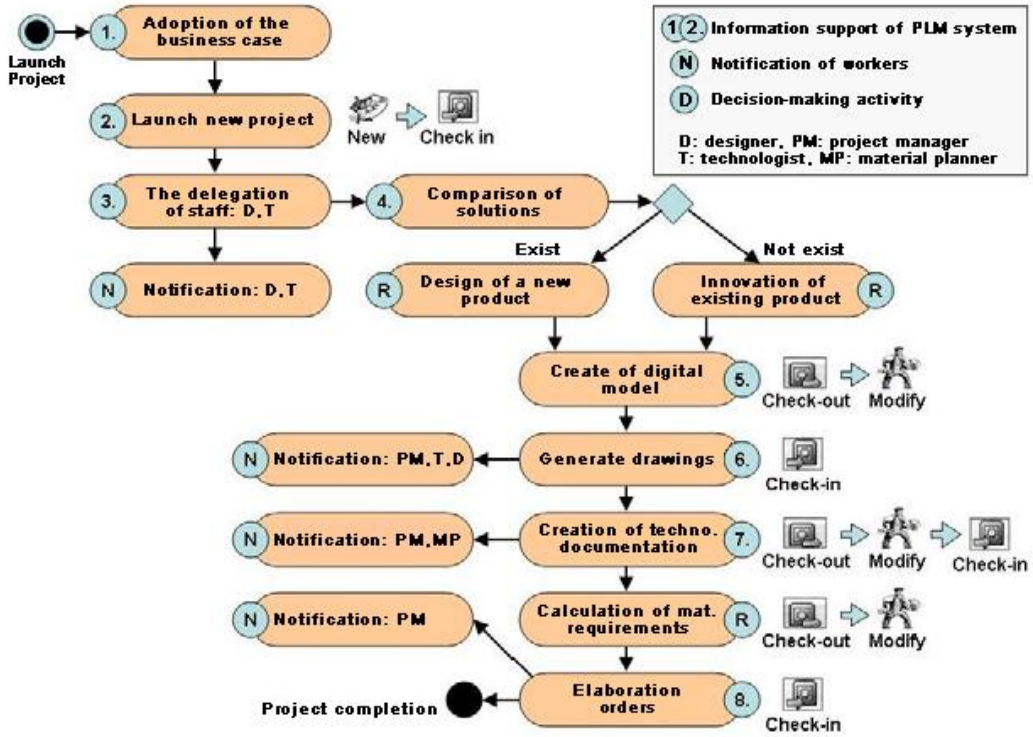

Figure 4. Work flow in DMS [6]

Project manager of the managing company enters the new project into the SMARTEAM database. Engineering designers of the subcontractor A responsible for construction of aluminum components of the cooler, completing and checking of the assembly begin their work after successful project uploading into the database. All design procedures are executed in the CAD/CAM/PLM environment of the CATIA V5 system. Final results of the designer's work are digital models in the CATPart, CATProduct and CATDrawing file formats.

Active communication between chief of design of subcontractor A and project manager of the managing company is performed during the design period. Notification by project manager is required after finalization of the project by designers of the subcontractor A. In this case notification is performed by communication through VoIP program Skype or another network communication service. After notification product manager decides whether the designed components comply with product requirements or not. If the components are fulfilling the requirements, project manager saves all the data provided by subcontractor A into the database as accepted (see Fig. 5).

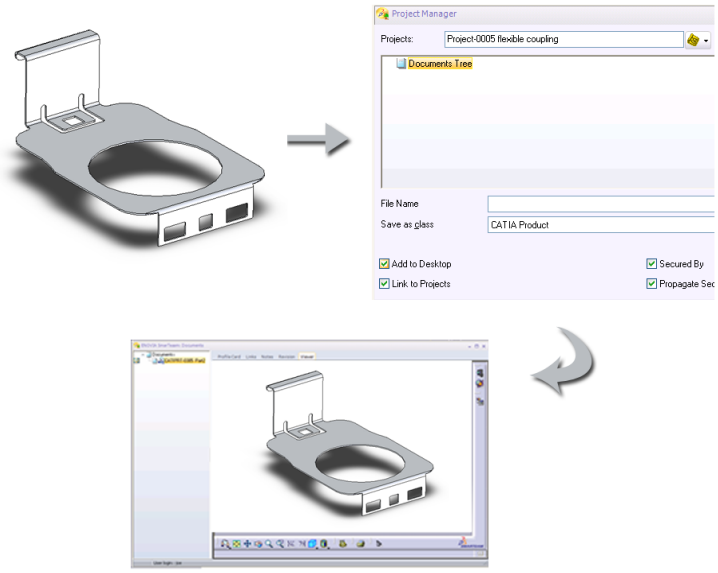

Figure 5. Save the component A into the database and its profile card

Almost identical scenario is observed with designers of the subcontractor B which is responsible for the fan (motor, propeller). These designers are again creating digital models regarding all the requirements and are continuously consulting the problems with the project manager. Notification is performed after the finishing of their work. After successful notification is the process of saving the data into database repeated.

In the next phase of the project the chief of design from the company A starts its work again, his task is to finalize the relationships between components in the assembly. Chief designer works in tight cooperation with the project manager through the selected communication services as shown in Fig. 6.

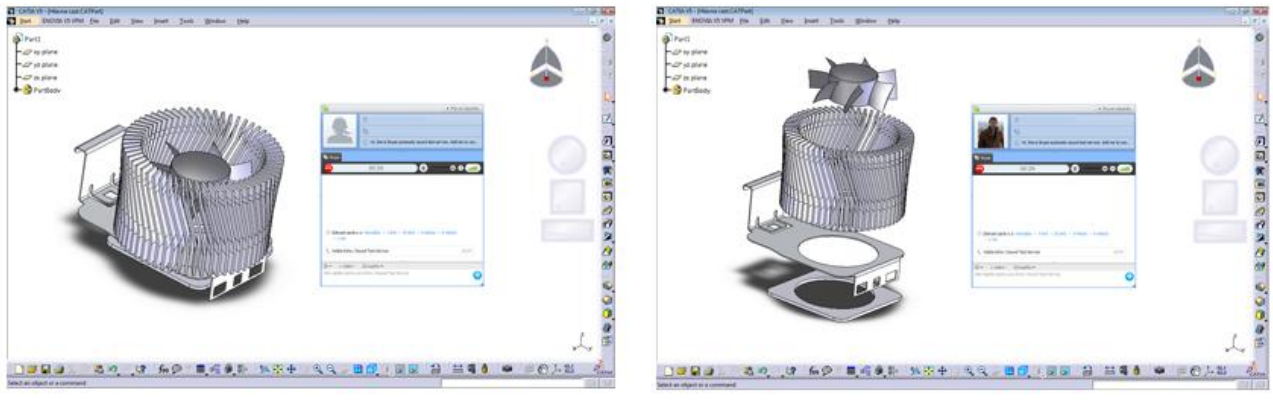

Figure 6. Communication between chef designer and project manager

Last step of the project is represented by sending the manufacturing information to company with free production capacity, then production process is optimized regarding the required amount of production (bill of material creation). Finally the production can start.

3.2.2 PRODUCT INNOVATION

The aim of second stage of model solution was product innovation with assumption of the same information flow. With this stage was presented unambiguous breaking of

geographical barriers as well as ability to share the SMARTEAM database. Basic prerequisite for the product innovation in DMS was model interconnection within FME STU. Partner from at this stage of solution, CTU in Prague, participated at innovation of our designed product. During innovation stage one can assume use of the capacities of the same company or different one. Regarding the fact that project was solved previously, it is not required to design entire assembly again but to use the data from database which reduce total solution time by 50%. In the problem presented above, the innovation can be represented by change of fan dimensions and also change of the fixed elements of the cooler. The use of knowledge management is significantly emphasized. Finally, the work of the engineering designer can be summarized as:

1. Reading of the product model from the database
2. Change of the design regarding the requirements of the customer
3. Repeated process of notification and validation as in the case of new assembly
4. Saving of the assembly into the database
5. Sending the data to Production Company
6. Manufacturing of the innovated product

4. CONCLUSIONS

The next solution period is devoted to plan the process simulation of product lifecycle from initial concept through design and simulation in the area of manufacturing to final model production. Significant area of research will be the solution of the ontology of DMS which starts with market opportunity for machinery product. Company which records this opportunity takes managing role in the DMS. After the initial analysis the following step is the selection of suitable (ideal) partners. This selection is done by comparison of input product parameters with parameters saved in the database of registered companies. For selection of ideal partners we would like to develop multi-objective algorithm. The main purpose of this algorithm is the creation of the software application to help small and middle sized enterprises find the ideal partner for cooperation in DMS.

5. ACKNOWLEDGEMENTS

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