VALIDATING COOPERATIVE SYSTEMS SIMULATION AND REMODELING FOR PUMP COVER DESIGN AND MANUFACTURING IN A VIRTUAL ENTERPRISE

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ABSTRACT

In order to integrate the manufacturing systems in virtual environment some changes must be made in manufacturing systems architecture. To support this environment, the basic infrastructure for the enterprise must to consider two main modules: The Internal Module, that represents the autonomous unit of a particular company and includes the manufacturing system, the complete structure of the company information (databases, information system etc.) and all the decision making processes;

The Cooperation Layer, which contains all the functionality for the interconnection between the company and the whole net/environment.

The aims of this paper are to propose several techniques for manufacturing systems remodeling in order to integrate them in virtual enterprise environment, and to validate those techniques by manufacturing simulation.

The main problem in this integrated environment consists in the management of connections and data exchange between the CAD-CAM-CAE systems.A solution represents a cooperative system for product design and development based on CAD-CAM-CAE techniques.

In this paper we intend to present a case study involving 3 different modules located in different places acting in the same CAD/CAM/CAE project (a pump cover).

Keywords: virtual enterprise, manufacturing systems, remodeling, simulation, cooperative systems

1. INTRODUCTION

The ability to transform a new product idea more and more rapidly and with less cost into a market-ready product has a new joined the quality and functionality of the product as a decisive competitiveness factor [1].

Companies can no longer remain competitive merely by optimizing their products. They must also be capable of:

- product data management (PDM) information (the users in an virtual enterprise shall have access to information from the process owner and other partners in a secure and controllable manner without having systems of their own);
- business contract (the exchange system shall support the definition and maintenance of contracts regulating mutual information service between partners playing different roles in the common business process);
- transparency of services (users connected to a connected partner shall be able to navigate and use exposed information in the process owner PDM system);
- project standards (for the publishing of different kinds of standards and specifications referred to in the contract between different partners in the virtual enterprise);
- push, pull, transaction (different modes of information exchange in the virtual enterprise: push to broad audience (broadcast), push to predefined audience derived or subscribed (distribution), person to person (communication), etc);
- conferencing (integration like video and audio conferencing);
- export over time (archiving of document issues, revisions or versions, will be affected by virtual enterprise requirements);
- global workflow (the exchange system shall support multi-enterprise workflow: a defined workflow shall be able to transfer itself to a partners support system);

- change management (Actors in the virtual enterprise need to exchange legacy data and migrate with other systems outside their own secure corporate boundary. In this case when the common business process applies engineering change formalism, the corresponding messages must be in scope with the exchange of information in the virtual enterprise and be supported by computer aided transactions);
- producing the product required by the customer flexibly, quickly and economically. In order to achieve collaboration between different partners in the virtual enterprise, there needs to be common processes supporting the distributed product development process [2]. Today, the new requirements are much more focused on collaborative processes that handle product definition data [1].

Virtual engineering provides a basis for collaborative engineering. Digital product data can easily be shared among engineers and designers working on the same project. Shared virtual environments can allow engineers from different locations to work together and in the same time. These environments give engineers and designers a better understanding of the product, improve quality, reduce time to market, and ensure that designs are right from the first time, reducing the need for expensive reworking later in the process. Collaboration can be extended outside a company by sharing virtual product information with suppliers and partners, creating a closer relationship in product development.

If we define VE as a temporary alliance of enterprises that come together to share skills and resources in order to attend a business opportunity and whose cooperation is supported by computer networks and adequate ICT tools and special application software, it is also necessary that we find the training tools for the human resources that will be involved in this new industrial paradigm. The applications like the one presented here may be such a tool.

In this paper we describe an intranet based approach developed by the PREMINV laboratory in the Technological Systems Engineering & Management Faculty (the University Politehnica Bucharest), using an open platform for training the students and engineers to work in the new VE environment imposed by globalization in competition and manufacturing. We have chosen a Pump Cover case study for 3 modules in CAD/CAM/CAE Catia environment as an example of collaborative working in PREMINV Virtual Enterprise (VE) Platform [8].

2. VIRTUAL ENTERPRISE PARADIGM

The goal of enterprise is today the development of systems of information exchange in support of a concurrent engineering environment. The construction industry is unique in that the actors - the designers, engineers, suppliers, manufacturers and builders – only form as a team for one project with new problems of co-ordination on each occasion. A different architecture, engineer and construction organization, a fresh virtual enterprise, is needed every time for every new project. For Concurrent Engineering innovative techniques to co-ordinate and manage information, resources and documents need to be developed to integrate successfully and reduce lead times, increase quality and keep within budget constraints. The following key issues that are essential for a successful concurrent engineering approach: distributed product and document modeling including intra and inter-model operability, conflict management, information logistics, version management, legal issues related to electronic documentation, monitoring and forecasting, cost control, etc. Rapid time-to-market is important for the competitive success of many companies for the following reasons, competitive advantage of getting to market sooner; premium prices early in life cycle, faster breakeven on development investment and lower financial risk, longer market life cycle, and greater overall profits and higher return on investment.

Today, society has changed from a closed market and closed manufacturing place to an open one. It is no longer necessary to have centralized manufacturing facilities. The functions could be distributed [4]. Design, manufacturing, production planning and marketing, service part etc. could be done in different places in a country, continent, globe, using network facilities to the exchange of information, services and goods [4]. This model allows creating, managing, sharing and reusing electronic product and process information in a collaborative environment through a product's life cycle. Such a globalization leads to a cross-cultural dialog between governments, corporations, societies and, most important, individuals. It becomes necessary to model the globalization process and use the global communication networks for a high level of interactivity in co-operative problem solving in manufacturing. In this way, information and communication technologies are the main source for maintaining global competitive advantage. The materialization of the paradigm of virtual enterprise, enabled by recent developments in information and communication technologies, requires the definition and reference architecture [6].

It is generally accepted that "virtual enterprise is a temporary alliance of enterprises that come together to share skills and resources in order to attend a business opportunity and whose cooperation is supported by computer network and adequate information and communication technologies tools and special application software" [5]. Enterprises operate as nodes in a network of suppliers, customers, engineers and other specialized service providers. Virtual Enterprise materializes by selecting skills and assets from different firms and synthesizing them into an apparently single business entity [1].

There are fundamental effects on the organization of business flows and processes, transaction costs, the creation of new business models, and changes in the boundaries of firms across sectors. All this effects are defining the new digital economy perspectives on business, products, individuals and technology. Digital economy encompasses e-business, e-commerce, and e-services as services or resources that can be accessed through people or businesses, using network technologies.

We propose a presentation about the extended enterprise as core element of manufacturing globalization, under the impact of new network technologies, which are defining the perspectives of new digital economy.Today, the portal method increases effectiveness (doing the right things) by evaluation, selection and realization of new project ideas.

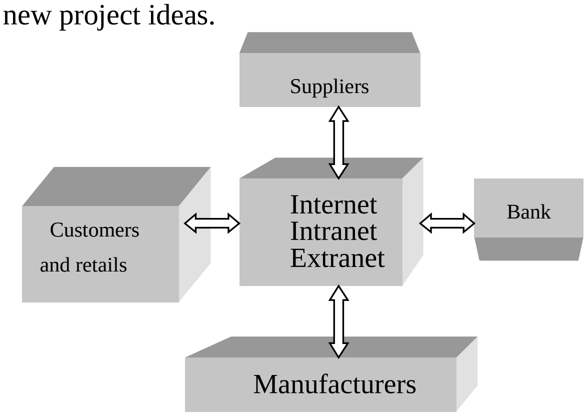

Figure 1. The exchange of information services and goods through networks

The Intranet/Extranet/Intranet based product development included methods database ensure high efficiency (doing the things right) by supporting management of selected product development projects. The portal method aims at systematic support of the innovation process in order to focus existing, but usually limited capacities in the development area on the right projects (effectiveness). It is basically a benefit-oriented method for prioritization of development projects.

For business, e-service is going to be a new way to save money, to revenue growth, and faster development model. For end-users, e-services increase productivity and simplify life, take advantage of more sophisticated and specialized services on as needed basis. At the level of production dedicated enterprises, e-services are [6]: business-to-business (B2B), intra-business (IB), and business-to-customer (B2C). [1] [4]

In a real meaning, an e-business is any business that uses Internet or Internet technologies to attract, retain and cultivate relationships with customers, streamline supply-chain, manufacturing, and procurement systems and automate corporate processes to deliver the right products and services to customers quickly and cost-effectively, also to capture, explore, analyze, and automate corporate processes information on customers and company operations in order to provide better business decisions [6]. For the future, e-services and e-business [7], as were defined, require the enterprise re-thinking and re-modeling, with the system and applications design for an efficient use of new network technologies.

The perspectives [4] of this kind of manufacturing and economy, named shortly new digital economy, we can see the product perspective (holistic product view, product life-cycle, value-network integration, etc.), business organizational perspective (new organizational form, customers and suppliers integration, collaborating organization etc.), the technology perspective (technological building blocks, infrastructures, interoperability etc.) and the individual perspective (skills, workspaces, collaborating individual, different rolls: worker, consumer, citizen). As a general requirement for an infrastructure to support virtual enterprise it can be underlined that the companies must be able to inter-operate and exchange information in real time so that they can work as a single integrated unit, although keeping their independence/autonomy. A complete redesign of an existing enterprise to converged enterprise would represent a big effort, not justifiable in market terms as companies are not replacing easily their running systems [1]. A better strategy is to try to separate the internal functionalities from the network-related ones and develop the necessary mappings to legacy systems, to correspond to the new aggregator model for modern electronic commerce.

3. THE PREMINV PLATFORM

To support this environment, the basic infrastructure for the PREMINV must to consider two main modules:

The Internal Module, that represents the autonomous unit of a particular company and includes the complete structure of the company's information (databases, information system etc.) and all the internal decision making processes;

The Cooperation Layer, which contains all the functionality's for the interconnection between the company and the whole net/environment.

This structure guarantees a standardized and targeted application of the tools and gives a description of methods to be applied within every particular development phase. Furthermore, special hyperlinks serve the illustration of presentations and software tools for the support of software application. The navigation tool can be called up by means of a common Internet browser, so that any developer in parallel to further IT applications can use it. The tool thus constitutes a knowledge store, which is easily accessible to any company member and co-operation partner, due to is platform independence. For example one typical case for co-operative process engineering would be where the company designs a product and other companies manufacture it. A publish a virtual product to a shared area where the other companies can interact and use the virtual product for creating manufacturing information, and request engineering changes. For example, a co-operative scenario is: the company 1 publish the product definition to a neutral area shared by the company 1, 2 and N. Company N request an engineering change and company 1 updates the shared area and company 2 and N are automatically notified (enterprise 2 and N are subscribes of the concerned update). A typical case [6] is that company 1 has the product in PDM system and wants to keep it there, but with the capability to publish selected information.

4. SIMULATION IN VALIDATING MANUFACTURING SYSTEMS REMODELING

For the manufacturing industry, globalization means both tougher competition and tougher customer demands. As a result, manufacturing enterprises have to reduce time-to-market, deal with shorter product life cycles and large and unpredictable changes in volume on the one hand, and respond to increased demands on price, quality and delivery times on the other hand. It is obvious that several aspects of these environmental changes put requirements on the manufacturing system to deal with this situation. As a result, firms have to restructure more frequently than ever before. This means that manufacturing systems will have to be designed and developed more frequently, in less time and with fewer resources available. The resulting manufacturing system then in turn needs to be agile or hyper-flexible.

Companies seem to lack clear guidelines for adopting simulation and increasing its level of integration with respect to the manufacturing system development process. At the same time, simulation research on integration aspects often deals with specific functional issues, such as developing various tools for integrating and connecting simulation to other systems, rather than general structural and hierarchical integration aspects as part of a methodological approach. Conversely, research that takes a holistic view

on integration of simulation into manufacturing system development is scarce, or researchers only implicitly report on how simulation in practice should be integrated.
Simulation not only is well suited to cope with the general trends in industry, but also it needs to become an important part of an integrated methodology or concept for manufacturing system development.

5. CASE STUDY

The three modules of Catia V5: Computer-aided design (CAD), computer-aided manufacturing (CAM), and computer-aided engineering (CAE) implied in this project are the technologies used for this purpose during the product cycle. Thus, to understand the role of CAD, CAM, and CAE, we need to examine the various activities and functions that must be accomplished in the design and manufacture of a product. These activities and functions are referred to as the product cycle.
The product cycle is composed of two main processes: the design process and the manufacturing process. The design process starts from customer's demands that are identified by marketing personnel and ends with a complete description of the product, usually in the form of a drawing. The manufacturing process starts from the design specifications and ends with shipping of the actual products.
Once a design has been completed, after optimization or some trade-off decisions, the design evaluation phase begins. Prototypes may be built for this purpose. The new technology called rapid prototyping is becoming popular for constructing prototypes. This technology enables the construction of a prototype by depositing layers from the bottom to the top. Thus it enables the construction of the prototype directly from its design because it requires basically the cross-sectional data of the product. If the design evaluation on the prototype indicates that the design is unsatisfactory, the process described is repeated with a new design.
When the outcome of the design evaluation is satisfactory, the design documentation is prepared. This includes the preparation of drawings, reports, and bills of materials. [9]
The manufacturing process begins with process planning, using he drawings from the design process, and it ends with the actual products. Process planning is a function that establishes which processes – and the proper parameters for the processes – are to be used. It also selects the machines that will perform the processes, such as a process to convert a piece part from a rough billet to a final form specified in the drawing. The outcome of process planning is a production plan, a materials order, and machine programming.
Other special requirements, such as design of jigs and fixtures, are also handled at this stage. The relationship of process planning to the manufacturing process is analogous to that of synthesis to the design process: It involves considerable human experience and qualitative decisions. This description implies that it would be difficult to computerize process planning. Once process planning has been completed, the actual product is produced and inspected against quality requirements. Parts that pass the quality control inspection are assembled, functionally tested, packaged, labeled, and shipped to customers.
We have described a typical product cycle. Now we will review it to show how the computers, or CAD, CAM and CAE technologies, are employed in the cycle.
Computer-aided design (CAD) is the technology concerned with the use of computer systems to assist in the creation, modification, analysis, and optimization of a design. Thus any computer program that embodies computer graphics and an application program facilitating engineering functions in the design process are classified as CAD software. In other words, CAD tools can vary from geometric tools for manipulating shapes at one extreme, to customized application programs, such as those for analysis and optimization, at the other extreme. Between these two extremes, typical tools currently available include tolerance analysis, mass property calculations, and finite-element modelling and visualization of the analysis results, to name a few.
The most basic role of CAD is to define the geometry of design a mechanical part, architectural structure, electronic circuit, building layout, and so on because the geometry of the design is essential to all the subsequent activities in the product cycle.

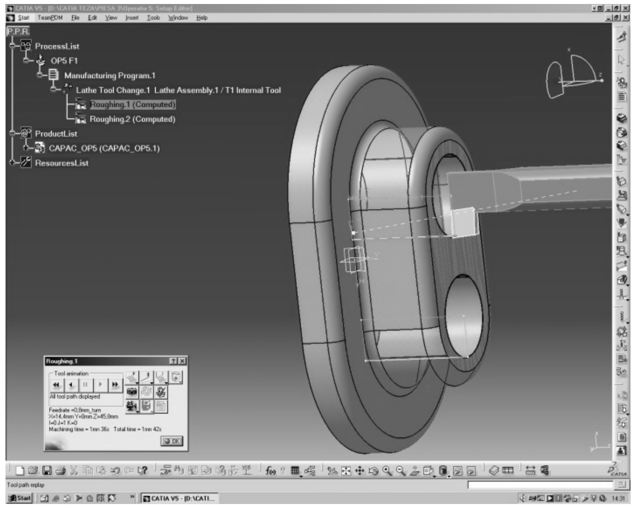

Figure 2. Pump Cover 3D Model manufacturing simulation in Catia V5 CAM Module

The geometry created by these systems can be used as a basis for per-forming other functions in CAE and CAM. This is one of the greatest benefits of CAD because it can save considerable time and reduce errors caused by otherwise having to redefine the geometry of the design from scratch every time it is needed. Therefore we can say that computer-aided drafting systems and geometric modeling systems are the most important components of CAD.

6. CONCLUSIONS

As opposed to the classical enterprise model (mono-localized), inside a Virtual Enterprise first we perceive the customers requirements and than the product design and manufacturing is started, keeping a continuous relation with the customer.

The technologies, techniques and methods used in Virtual Enterprises bring to cost, design and manufacturing time reduction, distribution time reduction and higher customers satisfaction.

In order to integrate the manufacturing systems in virtual environment some changes must be made in those systems architecture.

After material flow analysis and simulation for one part manufacturing result if it is necessary or not to design and manufacture the part in Virtual Enterprises.

For simple parts or assemblies it is sufficient a classical architecture enterprise for part design and manufacturing but for complex parts or assemblies it result the necessity of a virtual enterprise and concurrent engineering (distributed architecture).

The techniques for remodeling the manufacturing systems in order to integrate them in the virtual environment can be validated by simulating the manufacturing processes involved in such a project.

In this paper we describe a Pump Cover case study for 3 modules in CAD/CAM/CAE Catia environment as an example of collaborative working in PREMINV Virtual Enterprise (VE) Platform, an open platform for training the students and engineers to work in the new VE environment imposed by globalization in competition and manufacturing.

Data exchange problems are caused by the CAD/CAM/CAE process. Such things as dissimilar software systems, lost data, inconsistent product versions and poor communication between design, engineering, and manufacturing can impede success.

In our case study, because all 3 modules use the same software, we observed that we have fewer problems in data transfer in contrast with the case if we use different software. To use the same software is not the best solution, even in this case we can have problems with the software version and data exchange between them. A solution can be a neutral data file that will automatically detect the requested format and will modify the file accordingly without any more user intervention.

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