KNOWLEDGE ENGINEERING AND MANAGEMENT IN LASER AND HIGH INFORMATION TECHNOLOGIES

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ABSTRACT

This paper deals with the knowledge acquiring, engineering and management methodology in Global manufacturing environment applying laser and high information technologies and seeking cost minimization. Developed methodology is imposed to solve mentioned problems and it is based on the framework with concurrent procedures of new product virtual and rapid prototyping and also process forecasting at the early business engineering stage. Information flows and logistics considerations as knowledge, facts and rules among new products and processes developers, suppliers, producers, partners and customers that are located apart within great distances for definition an optimum business alternative have been used. An appropriate study case for an estimation of the proposed methodology is provided. The proposed research is being implemented both in industry and university education process.

Keywords: Knowledge engineering and management

1. INTRODUCTION

Global manufacturing (GM) environment is characterized by increased product diversity and greatly reduced product life cycle. The emphasis on improved industrial productivity at the reduced cost in high product variety has been appeared when economy world from national business to global marketplaces is turned. New product developers, producers, suppliers, and customers are located apart within great distances. At the beginning of GM era, a lot of industrial production moved from the USA, Western Europe, Australia, and Japan to developing countries in South-East Asia and Eastern Europe. There are many small and medium enterprises (SMEs) producing various products, their parts and components according to the orders of customers. Industrial productivity, unfortunately, is limited by the short integration and co-operation of new product and manufacturing system designers and developers in modern manufacturing environment. It can be increased by newest laser,

information and other high technologies. Logistics developments of information flows applying knowledge engineering and management can speed up the designing procedure of new product and process or even production plant. These developments have to be guided by the changes in managing the way of thinking, decision-making and the organizational structure of company. In most cases these requirements can satisfy Hybrid Manufacturing System (HMS) that consists of humans, machines and computers. HMS has objective to increase the manufacturing flexibility, agility and lean production applying concurrent engineering, knowledge base and expert systems. In this research the logistics knowledge of information flows oriented to human resources and knowledge management in manufacturing area applying laser and other high tehnologies is considered. These factors have the decisive role increasing the efficiency and effectiveness of a manufacturing enterprise through the integration and implementation of laser and high information technologies and human skills. The objective of this paper is creation of integrated product and process development framework and appropriate interfaces with knowledge acquiring, engineering and management methodology in discriminating manufacturing area using logistics information flows and appropriate data bases (DB).

2. FRAMEWORK OF INTEGRATED PRODUCT AND PROCESS DESIGN

The ability of knowledge engineering and management is competitive criteria of integrated activity in GM environment increasing productivity. Productivity depends on relation between created value and its incurred cost. Manufacturing cost minimization often is main factor that could increase productivity. Integrated, concurrent design of products and their related processes, including manufacture and support is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and logistics and customer requirements Walker [1]. Integrated approach of product and process design obliges developers to apply novelties of technologies and engineering logistics Blanchard [2], in particular, methodology of Design for parameter X (DFX) Boothroyd et al. [3], which are decisive factors of manufacturing cost minimization. During past 20 years the methodology of DFX has achieved new advantages in the product design procedure Huang and Mak [4]. Numerous research publications deal with the principal approaches of manufacturing cost estimation and definition at the early product design stage. Shah and Rogers [5] developed assembly-modeling system applying product

feature-based design. Hundal [6] considers the systematic mechanical design with cost and management perspective, Leibl et al. [7] developed feature-based cost estimation method of new product design and manufacturing as a main starting point with appropriate data bases for cost estimation and forecasting. Bargelis et al. [8] proposed an intelligent functional model for costs minimization in HMS, which uses knowledge base with process planning rules and also product design features knowledge with appropriate parameters.

2.1 Methodology and framework structure

The methodology created in this paper is modeling of the information-based system definition Ayyub [9]. This definition is based on the observations and considerations done at the GM environment in mechanical and mechatronics products industry. There are so many small and medium enterprises (SMEs) applying laser, information and other high technologies, in particular different CNC machines for parts fabrication. The observations of different mechanical products and processes design methods, applied operations, manufacturing cost, and product delivery time on the interactions among these elements and the expected behavior have been modeled. The causal models have been used in the form of mathematical equations for the achievements of the paper research objective.

Developed framework of integrated product and process design (Fig. 1) is based on the classification of products, processes and design features, which mainly influence on product functionality and manufacturability. Framework foresees at the product conception stage general methods, guidelines and good practice of different processes with laser, information and other high technologies. Classification helps to specify a deeper knowledge of various DFX peculiarities to separate product classes and their appropriate processes. Framework consists of three parts: product development, process development and production. The aim of first framework part is generation of some product virtual prototyping (VP) alternatives widely employing collaborative design methodology, when DFX manner and good practice is emphasized. Main task is how to learn and motivate designers for manufacturability knowledge. Next step of this framework part is estimation of developed alternatives and selection of optimum product 3D CAD model. The product PP prototype for VP optimum alternative selection sometimes is necessary. The rapid prototyping (RP) and rapid tooling (RT) methodology for this task is better to use. The second framework part is process development that has a task to generate several alternatives applying laser, information and

other high technologies. The best pilot product alternative as an initial data of this framework stage and Computer aided process planning (CAPP) system is used. CAPP generates some

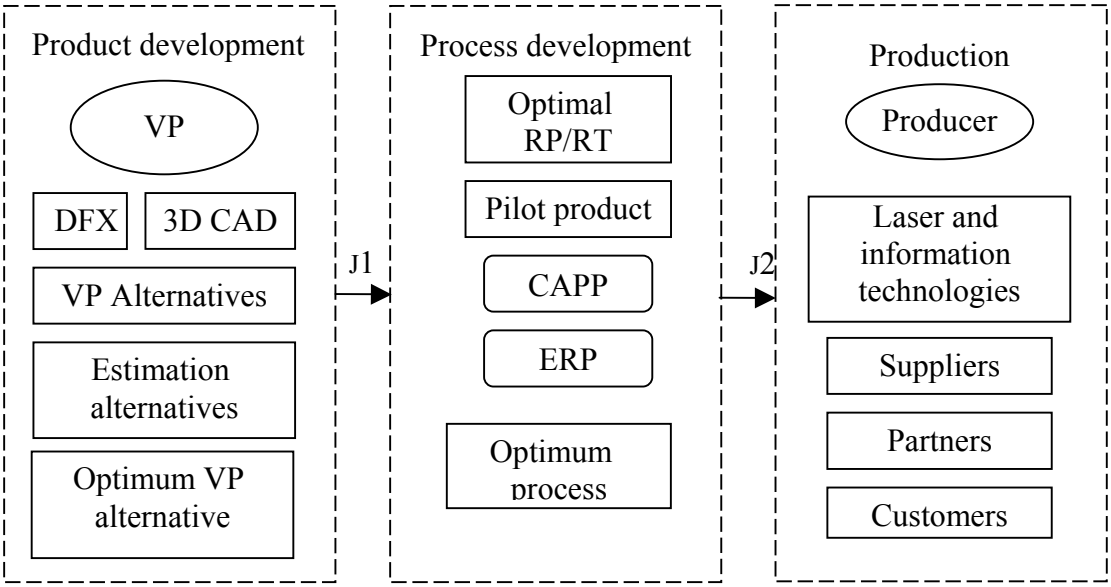

Fig. 1 Framework of integrated product and process design structure

Alternatives of process and Enterprise resources planning (ERP) data for each alternative are defined. According to these data the optimum process for developed product is defined. Third framework part appoints producer, which is able to win order for manufacturing developed product applying laser, information and other high technologies. Latter technologies have biggest chances to produce product with highest quality, minimum cost and fast delivery time to customer. All three framework parts can be applied concurrently in different companies and even countries, i.e. newest information and communication technologies have steadied automatic data exchange inside and outside of each framework part applying developed interfaces *J1* and *J2*. Developed framework is suitable to GM environment, which is characterized with wide differentiation of customers, products and processes developers, partners and suppliers, which are located apart in different companies and countries. The logistic information flows among participators of new product developers and producers finding best decision have been developed and considered.

2.2 Generation of the logistics information flows

The structure of logistics information flows inside and outside of framework is presented on the Fig. 2. Information flow *F1* presents the colaboration among the customers and new product developers and even producers. Product idea can be generated by customers and users

or new product developers. The virtual forums, discussions and negotiations among partners for this aim often are arranged and appropriate software and techniques are applied. Product

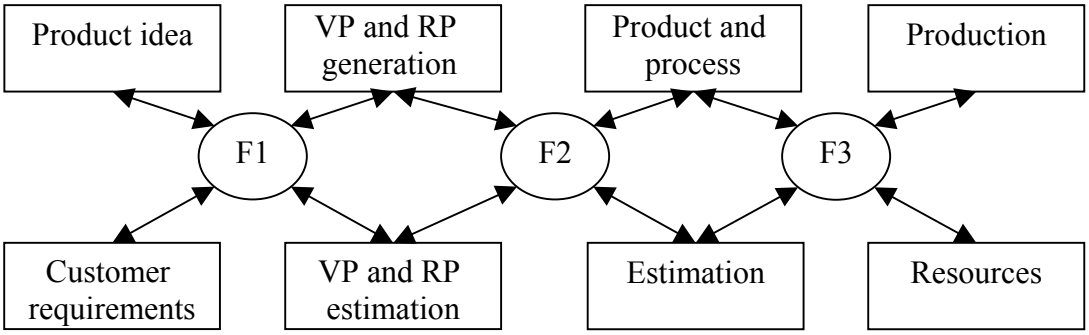

Fig. 2 Information flows inside and outside of framework

physical prototype (PP) made by rapid prototyping technique also is sending in parallel to various fears and exibitions for new product consideration in market. VP and PP developments according to the DFX methodology are carried out and product quality and manufacturing cost are checked. Remarks and notes from exibitions, forums and negotiations by information flow *F1* are sistematized and thoroughly analized and considered. The customer requirements are emphasized in this stage and suitable corections of product design are made if necessary. Concurrently the interactions among information flows *F1* and *F2* are warranted by standard information and communication technologies (ICT). The aim of interactions is consideration and estimation of final product design and optimal batch process.

Information flow *F2* contains analysis of part attributes and design features collecting data for optimal process development. The interfaces for sharing information among product 3D CAD model, RP/RT model and CAPP system have been used. Several process alternatives and manufacturing resources data are generated and estimated. Each step of process development procedure by customer requirements is checked and finaly the possible alternatives of processes are formed. Information flow *F3* for selection optimal producer is applied. There are data base (DB) of potencial producers which are able to win order. Producer ability by experience of use laser, information and other high technologies and proposition of minimal manufacturing resources is defined. The geographical location of producer and logistics possibilities of delivery production to customer often has decisive and important stress to winner. Manufacturing cost forecasting model Bargelis and Rimasauskas [10] as estimation criterion of producer chance to win order in advance is used. Product quality, delivery time to customer and manufacturing cost value are main parameters of order winners. Thorough work in each part of integrated product and process development

framework applying consecutive optimization scheme (Fig. 3) must be applied. The research by appropriate results was checked and discussed.

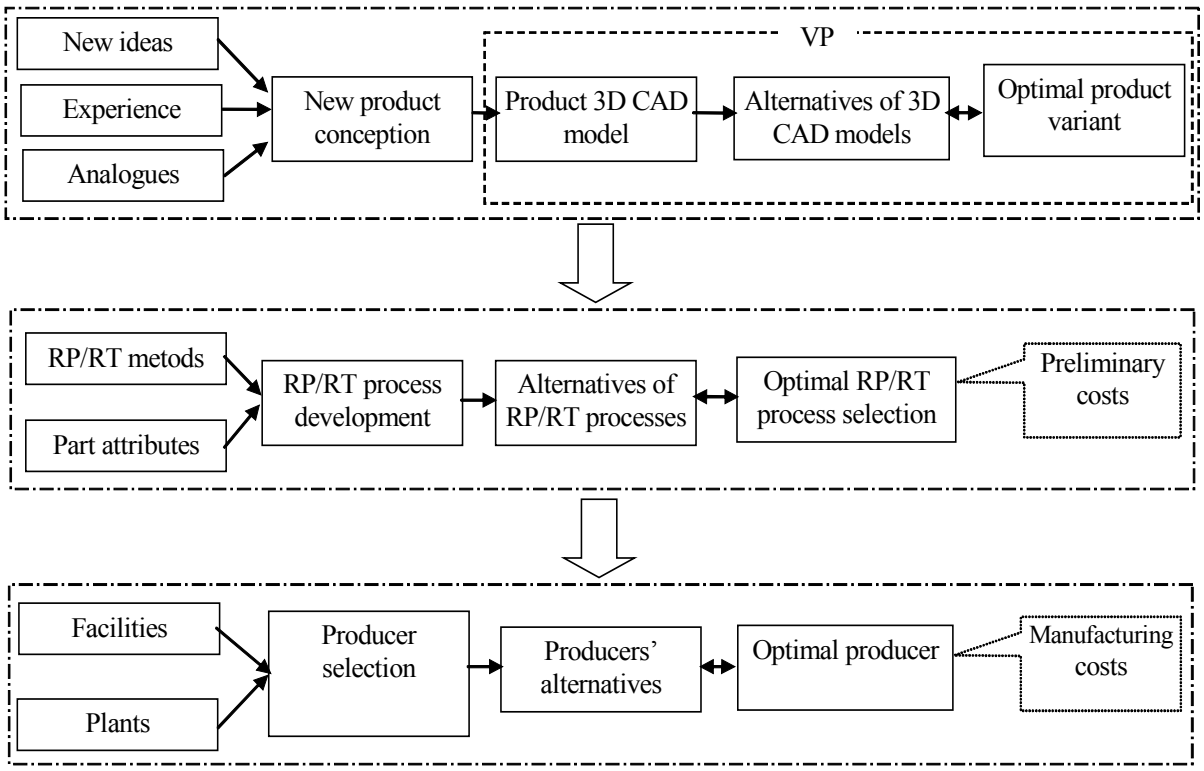

Fig. 3 Consecutive optimization scheme of product and process design

3. RESULTS AND DISCUSSIONS

The research results of this paper present integrated product and process development in regional Baltic Sea information logistic network applying consecutive optimization scheme presented in Fig. 3. This consideration of the selection cheapest and dependable producer of mechanical products also has been taken into account. There are examined solid mechanical and sheet metal design products. First stage of consecutive optimization scheme examines the VP of new products alternatives and selects optimal product's VP variant. The appropriate aim function is developed and applied. Second stage is related with physical product prototype development. RP laser and other high technologies for solid products and sheet metal prototypes are used. These prototypes in customer organizations are tested and corresponding corrections or re-designs are proposed. Third framework stage for optimal producer selection is devoted. The process quotation forecasting software Bargelis and

Rimasauskas [10] to fall into rank of potential producers is exploited. Order winners are those who are proposing lower cost and better delivery reliability.

Regional Baltic Sea logistics network as a part of Global customers, developers, suppliers, producers and consumers' network is developed and illustrated in Fig. 4. The countries of considered logistics information flows network into separate positions have been classified. Sweden and Denmark are main customers and developers of mechanical products while their consumers are in Germany, Netherlands and United Kingdom. Lithuania and Poland as producers' countries of mentioned mechanical products have been selected in this investigation. Historically is ordered that both mentioned countries are as potential producers of various mechanical products only because their entering in market has been late and at the current moment they are not able to develop competitive products. The reason is a high risky of finding appropriate market niches and competitive new products when huge investments are necessary for this deal. Local businessmen afraid to do this and external investitures always have so many proposals in Global market. On the other hand they firstly are looking to invest and outsource their production in China and other countries of South-East Asia. Fortunately, not all products are available to produce and finally assemble there, because many logistics and transportation cost, and other problem exist. Suppliers of raw materials in mentioned countries also in Russia and Ukraine are located. Complicated material profiles, high properties steel and plastics also complicated components in high technology countries are produced while low carbon steel sheets, tubes, bars and strips are supplied from Russia, Ukraine, China and India. Latter materials are very important seeking the minimal manufacturing cost though quality problems sometimes could arise.

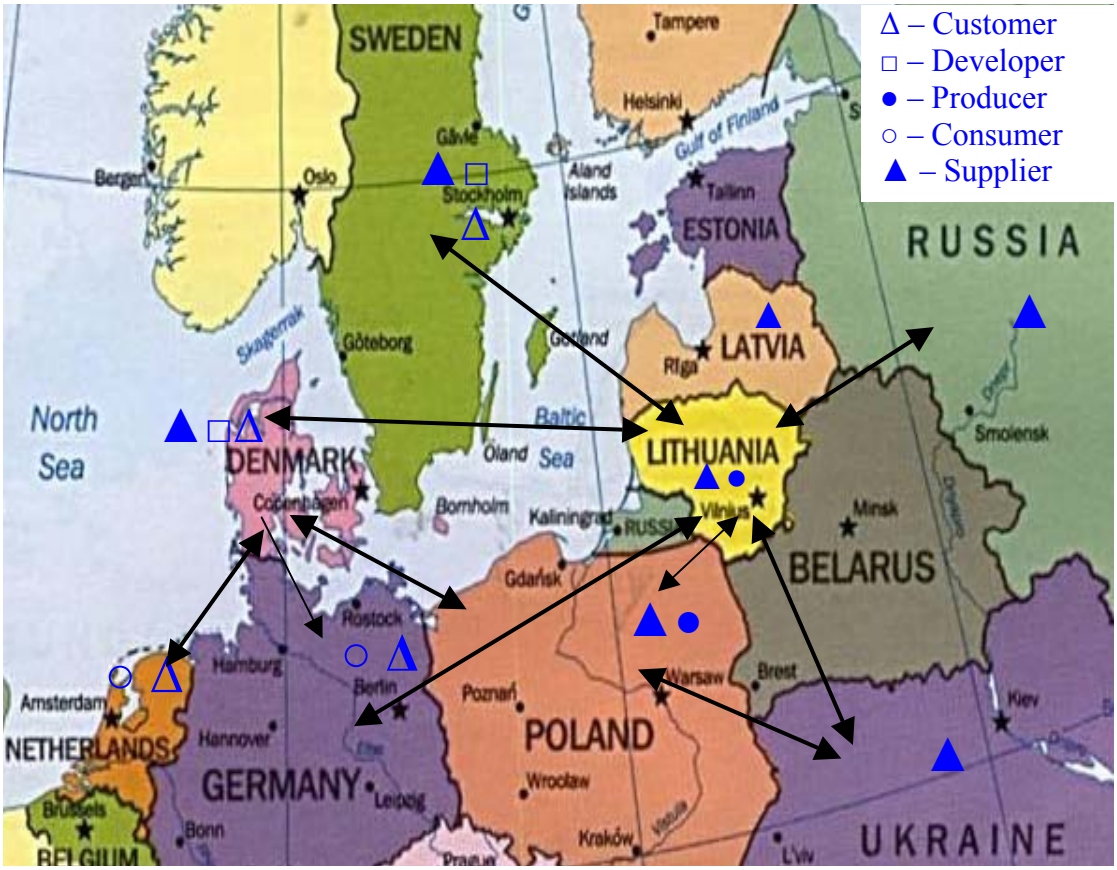

Fig. 4 Regional Baltic Sea logistic network as a part of Global customer's, developers, suppliers, producers and consumers network

4. CONCLUSION

Developed framework of integrated product and process design was successfully used in created regional Baltic Sea logistics information network managing optimal manufacturing knowledge in different countries and companies for competitive business implementation.

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