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USING CAD SYSTEMS IN CUSTOMIZED PRODUCT DESIGN

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Abstract: *The paper will present the means of using CAD systems in customized product design. The goal is to introduce practical side of computer-aided design tools and configuration tools in creating and, if it is needed, modifying designs of customized products. To accomplish the previously stated, a link between configuration tools and CAD system is created with the intention of involving the customer in design process. All of the efforts described in the work are made in purpose of establishing an interactive process with customer and using the potentials of parametric CAD systems in shortening the time to market. Further more the creation of closed loop system between CAD and configuration tools is discussed, and all in purpose of making fast modifications in product design within the shortest period of time.*

Key Words: ***Mass Customization, Product design, Computer aided design, Closed loop system***

1. INTRODUCTION

Global market has become very demanding during the last two decades. The variety of products and the time to market are dictating a fast pace of design and manufacturing of the product. Further more response to the market changes and new customer needs has to be perfectly timed.

Traditionally designing of products was done one at a time. Two decades ago that was acceptable, but today the tables have turned. The number of variants of one product is rising, while the quantity of those variants is naturally going down. Mass production is slowly giving its ground to Mass customization, and it is in light of these changes that applying of traditional design of single products is giving its place to design of product families.

Computer-aided design systems have made revolution during the 80's and 90's in the field of product design. Using CAD meant a lot of time saved. Now with uplift of Mass customization, computers and the CAD are taking one more step in helping companies solve their burning problems. Once again using CAD systems properly can save us more time than ever.

2. PRODUCT DEFINITION

One ofthe difficulties with mass customization is that product variety increases drastically with just a few product options. This will likely stretch a company's own infrastructure, especially with regard to variety of tooling and fixtures needed to manufacture a wide range of product variants. Also, part numbers rise, adding complexity to logistics and manufacturing processes. As a result, there is increased outsourcing of significant portions of complex products such as automotives which allows more product derivatives to be built in their own facility without having to invest in expansion of their own plants.

Companies need tools to manage the product rather than product data.

- Quality Function Deployment (QFD),
- Computer-aided Design (CAD),
- Computer-aided Engineering (CAE),
- Computer-aided Manufacturing (CAM),
- Component Supplier Management (CSM),
- Design for Manufacturing/Assembly (DFMA),
- Visualization ,
- Product Data Management (PDM),
- Product Configurator (PC)

2.1 Product Configurators

Recently, a new set of design solutions, called Product Configuratiors (PC), have become significant in addressing many of the design issues related to mass customization. They are systems that create, maintain, and use electronic product models that allow complete definition of all possible product option and variation combinations, with a minimum of data entries. This capability is essential for companies offering unique configurations to satisfy specific customer needs. Configuration is "…the construction of a physical system according to specifications by selecting, parameterizing, positioning and assembling instances of suitable existing component types from a given catalog" [2]

Dispite a huge number of variation, the electronic systems with a mass customization interaction platform consist of tree main components:

- The *core configuration software* presents the possible variations and guides the user through the configuration process, asking questions or providing design options. Consistency and manufacturability are also checked at this stage.
- A feedback tool is responsible for pressenting the configuration. Feedback information for a design variant can be given as *visualization* and in other forms (e.g. price information, functionality test etc.) and is the basis for the trial-and-error learning of the user.
- *Analyzing tools* finally translate a customer specific order into lists of material, constuction plans, and work schedules. They further transmit the configuration to manufacturing or other departments.

2.2 A Procedure for Building Configurator Systems

Procedure for building configurator systems for mass customization, takes few steps as follows:

1. **Process Analysis -** Analysis of the existing specification process (AS-IS), statement of the functional requirements to the process. Design of the future specification process (TO BE). Overall definition of the product configuration system to support the process.
   Tools: flow charts, Activity Chain, Model, key numbers, problem matrix, SWOT, list of functional describing characteristics and gap analysis.
2. **Product Analysis -** Analysing products and eventually life cycle systems. Redesigning/ restructuring of products. Structuring and formalising knowledge about the products and related life cycle systems in *a product variant master*.
   Tools: List of features and product variant master.
3. **Object Oriented Analysis -** Creation of object classes and structures. Description of object classes on CRC-cards. Definition of user interface. Other requirements to the IT solution.
   Tools: Use cases, class diagrams and CRC-cards.
4. **Object Oriented Design -** Selection of configuration software. Defining and further developing the OOA-model for the selected configuration software. Requirements specification for the programming including user interface, integration to other ITsystems.
5. **Programming -** Programming the system based on the model. Testing the configuration system.
6. **Implementation -** Implementation of the product configuration system in the organisation. Traning users of the system, and further training of the people responsible for maintaining the product configuration system.
7. **Maintenance -** Maintenance and further development of the product and product related models.

3. MASS CUSTOMIZATION IN FURNITURE INDUSTRY

The main theme of this paper is the chance of improving the business of the enterprises buy introducing the concept of mass customization. Target are mostly medium and small companies who would benefit from improving their responsiveness as well as loyalty and satisfaction of their customers buy using this concept.

The work on this paper has been done in cooperation with one small enterprise which is producing industrial furniture. For the purpose of the paper one piece of furniture from their program will be used and followed trough the whole process.

First insights in the area and chance of customized products in Serbia is for the moment leading to the conclusion that the potential is there. The market of industrial furniture in Serbia is growing bigger every day and more and more small and medium enterprises are rising and getting into the market. Only those who implement new and better methods and techniques will stay in race.

4. IMPLEMENTING CAD SYSTEMS IN DESIGN OF CUSTOMIZED PRODUCTS

Nowadays is almost unthinkable to design various products without the help of modern engineering tools. Those tools can significantly reduce the time needed for developing new products and thus be highly effective. The list of software products dedicated for manufacturing and engineering design support is continually growing up and today we can talk about practically unlimited possibilities of choice. For each case of user needs structure we can select (without any problems) adequate software solutions, beginning with trivial *drafting* or NC/CNC/DNC – *programming* tools to *high-end* software solutions purposed for engineering support during the complete product life cycle. [1]

In that context, software solutions from category of Computer Aided Design tools aimed for support in 'birth of a product' (development, design and/or product modeling) occupy the dominant place and all of theoretical explanations and experiments in this paper are oriented to the main goal, which is product custimization.

User design is a particular form of product customization that allows the customer to specify the properties of a product. It has emerged as a mechanism to build brand loyalty, to fit products to the heterogeneous needs of a market, and to differentiate the offerings of a manufacturer. However, many consumers face daunting challenges in designing a product that fits their personal needs. This makes it essential for producers of customized goods and services to create user interfaces that are effective in supporting consumers in the user design process.

User design offers tantalizing potential benefits to manufacturers and consumers, including a closer match of products to user preferences, which should result in a higher willingness to pay for goods and services. There are two fundamental approaches that can be taken to user design: *parameter-based* systems and *needs-based* systems. With parameter-based systems, users directly

specify the values of design parameters of the product. With needs-based systems, users specify the relative importance of their needs, and an optimization algorithm recommends the combination of design parameters that is likely to maximize user utility. [2] In this paper we will concentrate on the parameter-based systems and give one possible solution on the example of custimizing a computer table.

4.1. Example of MC on the computer table design

The description of the whole process will be given in this section. The appearance of the computer table is shown on the Figure 1.

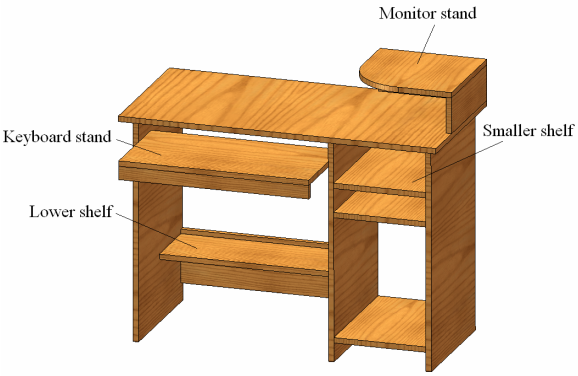

Figure 1. *Computer table*

At the beginning of the process, this picture is shown to the customer. The computer table is given in configuration with every option included. In order to achieve the custimization of the following product, several options are given and they can be selected or unselected by clicking the corresponding field in the customization form which is shown in Figure 2.

The means of customization are given through the selection of these components:

1) monitor stand
2) keyboard stand
3) lower shelf
4) number of smaller shelves on the right side of the table

As it can be seen, a desired configuration of the table can be set by simply choosing the given option. In addition to this, the picture on the top of the form is immidiately changing to show the appropiate model of the table.

Behind this form stands a complex three dimensional model which is done in SolidWorks. SolidWorks is a parasolid-based solid modeler, and utilizes a parametric feature-based approach to creating models and assemblies. Before making the complete assembly, every part of the product is developed separately as a part. After this, the next step was to create the assembly of the table.

It is important here to say that only one assembly is necessary. That assembly must contain every single option included and displayed. SolidWorks has the ability to work with configurations and design tables of parts and assemblies. Design tables are the best way to create configurations of parts. They are used to control dimension values for families of parts, and suppression states of features or parts.

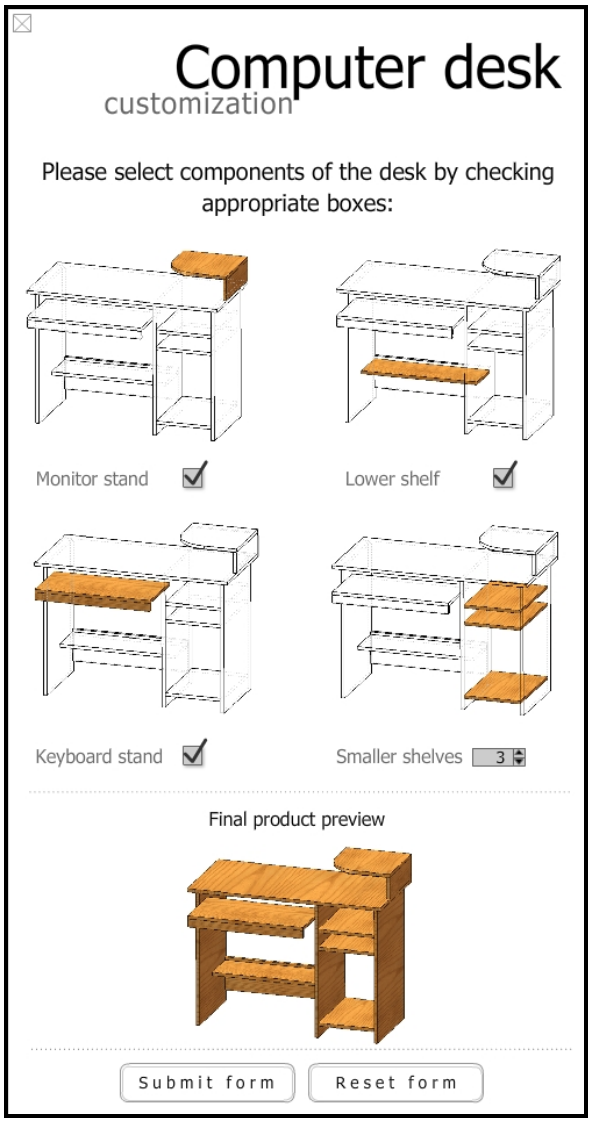

Figure 2. *Customization form*

Design tables can be used to create a family of parts from a single part design. Since the SolidWorks software is an OLE/2 application, an Excel spreadsheet is used to lay out the design table so it can be imported into the SolidWorks document. This is rather very important for us, because of the following: when the customer creates the desired appearance of his table, an exel file is generated. That file has special fields and formatings which allow SolidWorks to actually create the needed configuration. The new configuration has all the features as if it was manually created in the software. Further on, it is possible to create drawing documents and Bill of Materials which are essential for the production.

4.2. Closed loop system

Most of the attention and research on the subject of mass customization have until now been focused on the topic of configuration tools and dealing with the customers. Less attention has been given to the other side of the complete process – the manufacturing and the impact that the concept of mass customization has on manufacturers.

The main difference between the systems used in most cases and the one discussed in this paper is the closed loop system (Figure 3).

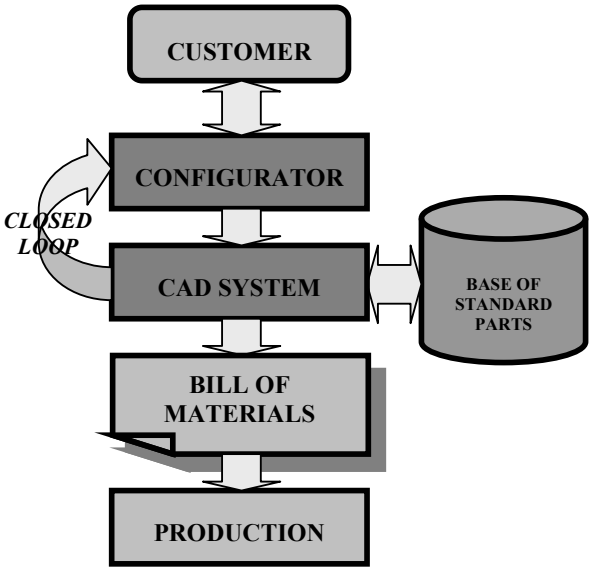

Figure 3 *Using the closed loop system*

It is nothing revolutionary from one point of view, but in the other hand it is quite different from most concepts in use. As seen from the figure the point of the closed loop is giving the response back to the customer as soon as customer has decided which configuration is best fitting. After that if not satisfied the customer can change any of given options and adapt the product over and over again.

But all configurators that are used do the same thing, they offer you the possibility to change your design, colors, dimensions and other parameters until you are satisfied, what would now be the difference. In this case the CAD system is actively interacting with configuration tools and not only used to build up the base of standard parts. The base is still there, but now being pulled from CAD system every time the customer changes his configuration. What is than the advantage of using the CAD system and why would we include, in some ways expensive, CAD software if one relatively simple configurator is doing the job? The advantage lays in other part of the shown diagram (Figure 3) and that is looking at the whole process from the manufacturers point of view.

5. CONCLUSION

Manufacturers point of view is always simplifying the production process and managing the production. In the case of mass customization putting the CAD system in between configuration tools and the production would do just that, simplify the production process.

One of the CAD systems vast possibilities is creating the bill of materials (Figure 3). The bill of materials can then be used in purposes of manufacturing. In the case of selected production program (furniture industry), the bill of materials is enough. In other cases the other modules of CAD system could be used, for example the modules which generate the NC code.

So the next step of research is the development of interface that would make the connection between CAD system and production, and in that way reaching the full capacity of the system presented in this paper.

The potential of CAD systems in implementing the mass customization concept is unquestionable. It is there, but the CAD system must be used in the right way so it could give the edge to production companies which pursue mass customization strategy in market race.

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