TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 58, Issue II, June, 2015

ON USING PARAMETRIC MODELING IN FURNITURE DESIGN

Zsolt BUNA, Ionuț BADIU, Arnold ÉLES

Abstract: *Every company wants to maximize their profit by different means. This paper presents a parametric design approach which reduces the time for product development in the furniture industry. Computer Aided Design software is used to generate different parametrized three dimensional models of furniture using design tables made in Microsoft Excel files for data input. In the article there are conducted two case studies for this procedure in which two CAD applications, SolidWorks 2014 and CATIA V5, are analyzed in terms of user interface, necessary steps and the differences in using design tables to achieve the desired results.*
Key words: *Design table, parametric design, furniture design, Excel, CATIA V5, SolidWorks 2014.*

1. INTRODUCTION

The furniture industry is always searching for ways to improve competitiveness [1] and, at least in Romania, it has been an early adopter and a constant user of Computer Aided Design (CAD) solutions. At the beginning, computer aided design software were working only in two dimensions, but in time, with their development to three dimensional modeling, new features were added such as parametric modeling and design tables.

For example, Barros et al., in [2], have used CAD software in the development and the design of furniture, where a parametric model was developed to create the best cost efficient and structurally resistant chair. Also, in [3], Pan and Wang have developed an algorithm to reuse existing 3D models for furniture design. The authors also compared their software to SolidWorks 2008 and Autodesk Inventor Professional 2010, where they used design tables to modify their models.

Parametric modeling and design tables are used to reduce the time needed to create different versions of the same products or three dimensional models. Usually, with a design table the entry data can be in form of numbers (dimensions, angles or number of some features) or Boolean operators for different features (existence of some particular features).

Parametric design is usually used in the CAD software applications in form of *Tool Boxes*, where 3D models of screws, nuts, bolts and other assembling elements can be generated using the applications' interface.

Parametric design was successfully used also in different fields of studies like digital archaeology, where ceramic vessels were parameterized [4] or where a database of construction elements was created [5]. In both cases the starting point was a parameterized three-dimensional model.

Using design tables in the furniture industry to implement parametric design is useful when a large order is needed to be fulfilled with different sizes of the same model of furniture, as it reduces work time and possibility of error.

2. METHODOLOGY

Every manufacturing process should have its entry data based on the consumers' or buyers' needs. Because of this, the customers are the starting point of this methodology.

The design table, which is a Microsoft Excel document (some applications can also use Notepad), is a friendly interface for non-experienced users with CAD software

applications. It can represent the bridge between the average computer user and the CAD software. The values in the table can be introduced with ease, without the help of a CAD engineer.

With the use of design tables, most, if not all elements of a 3D model can be parametrized [6]: dimensions, tolerances, relationships among them, base or split parts, product configurations, materials, colors, or the number, position and existence of components themselves. Since design tables modify the content of assemblies and components, the technical drawings are automatically modified accordingly and the new products can be manufactured immediately.

The methodology of using design tables is illustrated in Figure 1.

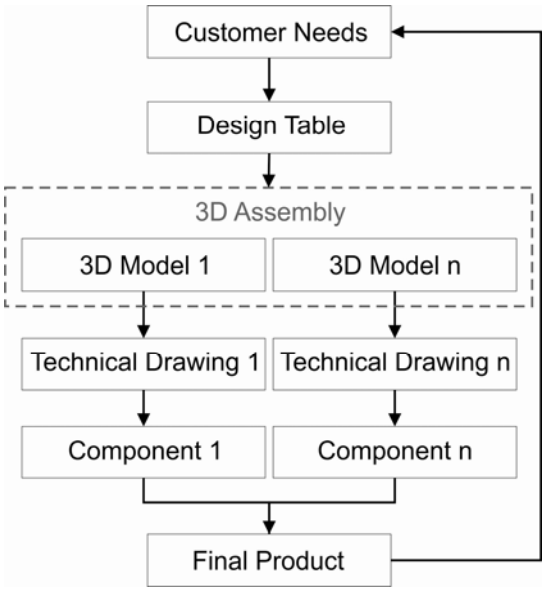

Fig. 1: General methodology of using design tables.

3. CASE STUDY

As a case study, the authors have chosen the closet type furniture with several shelves and two doors. The same piece of furniture was modeled and parameterized both in SolidWorks 2014 and in CATIA V5 for a comprehensive comparison of the two software platforms, which are actually form two product lines of the same software house.

3.1. Parameterization in SolidWorks 2014

Firstly, the tridimensional model needs to be modeled, this means that all the components need to be designed and assembled into an assembly file. The first model will be created using standard dimension, which will be modified lately using the design table.

In the design of the components all the holes (for fastening elements and for other elements) and cut-outs must be created and fully constrained within their sketches.

The methodology of using design tables in SolidWorks 2014 application software can be seen in Figure 2.

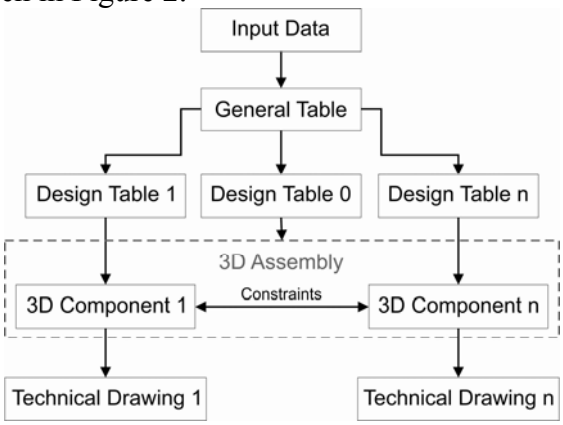

Fig. 2: Methodology of using parametric design in SolidWorks 2014.

As it can be seen in the above methodology, a *general table* must be created in SolidWorks, from which all the design tables for components and assemblies can be generated with their input values. Using a general table to introduce all the input data may be useful, given the fact that it may be sent to the customers in order for them to fill in the table.

Figure 3 illustrates the tridimensional model of the furniture designed in SolidWorks.

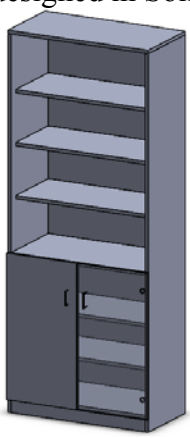

Fig. 3: The 3D model in SolidWorks.

While designing the components of the 3D model of the furniture, the designer has to take in consideration the different constraints that must be achieved in the assembly. Since the assembly will be modified trough the Excel document, some constraints (between the component and the assembly) have to be created inside the components. As an example, the back of the closet is constrained to the sides of the assemblies – side and top of the closet, as presented in Figure 4.

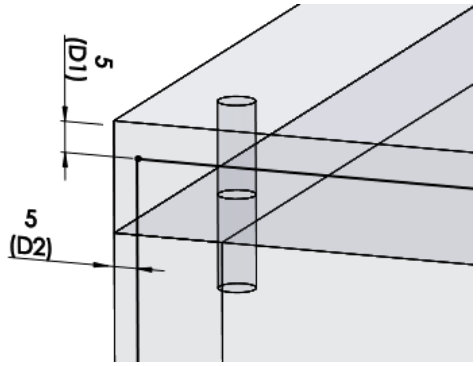

Fig. 4: Constraints between components and assembly created inside the component.

In some cases in SolidWorks, constraints cannot be created between components in an assembly. In these cases, the dimensions must be introduced from the design tables. Also, some calculations can be made using equations in the general design table, and the results can be linked to the individual design tables of the components. This approach is useful when some automatic dimensions need to be calculated, like an average distance, the distance between components or an offset.

The general design table can be seen in Figure 5.

Dimensions of the closet

Feature	Height	Width	Depth	Number of interior shelves	Distance between interior shelves	Number of exterior shelves	Distance between exterior shelves	Height of the doors
Value	2000	800	400	2	230	3	300	775

Fig. 5: The general design table of the 3D model.

Figure 6 illustrates the design table layout for the side of the closet. The dimensions can be renamed for an easier identification of the features.

Design Table for: Side

	Height@Sketch1	D1@Exterior shelves	D3@Exterior shelves	D5@Sketch4	D1@Interior shelves	D3@Interior shelves	D5@Sketch2	D3@Sketch3
First Instance	2000	3	300	300	2	230	230	757

Fig. 6: Design table layout.

The same layout is used for the rest of the components which have to be modified through the design table.

By modifying the design table (see Figure 7 in which there are shown the modified values), the 3D model is automatically modified as shown in Figure 8.

Dimensions of the closet

Feature	Height	Width	Depth	Number of interior shelves	Distance between interior shelves	Number of exterior shelves	Distance between exterior shelves	Height of the doors
Value	1600	800	400	2	120	4	230	400

Fig. 7: Modified dimensions of the 3D model.

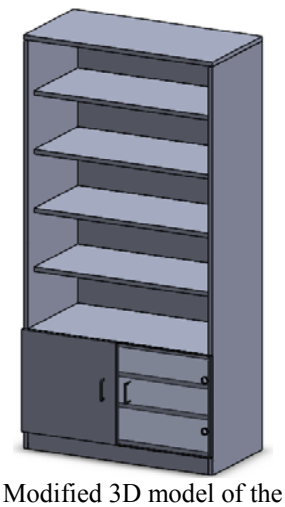

Fig. 8: Modified 3D model of the closet.

3.2. Parameterization in CATIA V5

A major advantage of parameterization in the design software CATIA compared to SolidWorks lies in the possibility to create and manage parameters using a single general Excel spreadsheet, for which the methodology of using parametric design, as shown in Figure 9, is somewhat easier and faster to apply. The general design table takes into account the different constraints created between components and the assembly, in the event that some values are changed. Equal distances between components or offset distances are calculated based on equations.

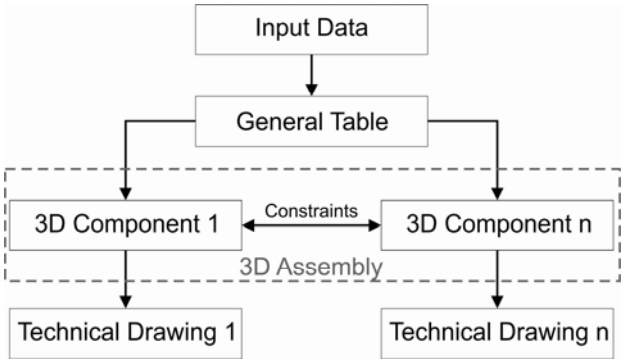

Fig. 9: Methodology of using parametric design in CATIA V5 R21.

After the 3D modeling and assembling of the furniture model (Figure 10), the Excel table is actually created by inserting parameters of one's choice, in order to be easily changed, as shown in Figure 11. Entering all parameters in the table would be a waste of information that might confuse the users.

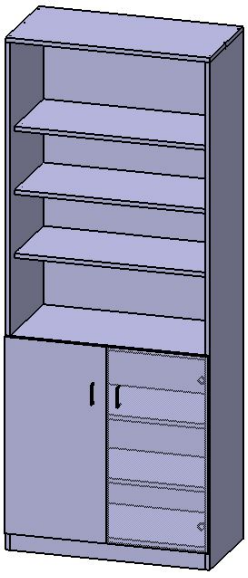

Fig. 10: The 3D model in CATIA.

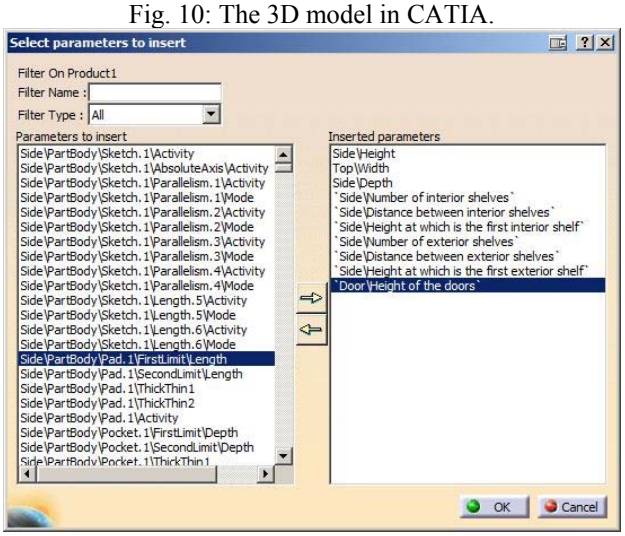

Fig. 11: Selection of parameters that are to be included in the general Excel table.

Just as in SolidWorks, in CATIA there is a possibility to change the name of the parameters for a better understanding of the table by the designers.

The general design table can be seen in Figure 12.

Side\Height (mm)	Top\Width (mm)	Side\Depth (mm)	`Side\Number of interior shelves`	`Side\Distance between interior shelves` (mm)	`Side\Height at which is the first interior shelf` (mm)	`Side\Number of exterior shelves`	`Side\Distance between exterior shelves` (mm)	`Side\Height at which is the first exterior shelf` (mm)	`Door\Height of the doors` (mm)
2000	800	400	2	250	209	3	250	300	775

Fig. 12: The general design table of the 3D model.

By entering new values in a design table for parameters that are to be changed (Figure 13), the 3D model will undergo changes as shown in Figure 14.

Side\Height (mm)	Top\Width (mm)	Side\Depth (mm)	`Side\Number of interior shelves`	`Side\Distance between interior shelves` (mm)	`Side\Height at which is the first interior shelf` (mm)	`Side\Number of exterior shelves`	`Side\Distance between exterior shelves` (mm)	`Side\Height at which is the first exterior shelf` (mm)	`Door\Height of the doors` (mm)
1600	800	400	2	120	140	4	250	230	400

Fig. 13: Modified dimensions of the 3D model.

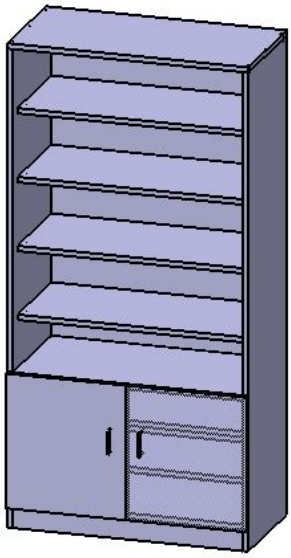

Fig. 14: Modified 3D model of the closet.

4. CONCLUSION

An efficient approach for rapid assembly design is presented in this paper. Also, the study focuses on testing and comparing two design software packages in terms of design table application. The two software have a similar profile and are part of the same company, albeit for different markets.

The parameterization process of components that can be implemented using design tables can significantly increase the productivity of a company. This is very useful for furniture manufacturers which must respond quickly to the demands of the customers in trying to keep ahead of their competitors.

It is important to know that one may create parameterized design tables in both applications mentioned in this paper. The differences highlighted regarding the creation and uses of the two tables are rather few. Indeed, there is a great advantage regarding CATIA software since it requires the creation of only one general design table, whereas SolidWorks requires an individual table for each component, as well as a general one. This advantage makes modeling in CATIA easier. A major downside of SolidWorks is that it requires a general table and individual tables for each component of an assembly and the links between these Excel documents have to be constantly updated by opening them, otherwise the tables can use cached values.

It should be specified that both alternatives for parameterization are viable solutions that can be applied in the furniture industry and provide good results in terms of accuracy and processing time. One drawback for the CATIA software is its significantly higher license price compared to SolidWorks.

5. ACKNOWLEDGEMENT AND DISCLAIMER

This paper has benefited from the support of the project “Research for the development and implementation into production of innovative furniture”, contract no. 12 P01 001 13 C3, beneficiary Smart Furniture SRL Cluj-Napoca, partner Technical University of Cluj-Napoca. The project is part of the Competitiveness Pole 12 P01 001 “Transylvanian Furniture Cluster” financed through the Sectorial Operational Program “Increase of Economic Competitiveness 2007-2013” by the European Regional Development Fund.

This publication reflects only the views of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

6. REFERENCES

[1] Cicala, I.R., Dragomir, D., Dragomir, M., *Determining the critical success factors of a romanian furniture manufacturer, as part of a strategic planning initiative*, Review of Management and Economic Engineering, Vol. 12, No. 1 (47), 2013, ISSN 1583-624X , pp: 149-164.

[2] Barros, M., Duarte, J.P., and Chaparro, B.M., *Integrated Generative Design Tools for the Mass Customization of Furniture*, in Design Computing and Cognition '12, J.S. Gero, Editor, 2014, Springer Netherlands, pp: 285-300.

[3] Pan, W. and Wang, Y., *Rapid assembly design for solid furniture modeling*, in Proceedings - Workshop on Digital Media and Digital Content Management, DMDCM 2011, 2011, pp: 279-283.

[4] Neamțu, C., Badiu, I., Pupeză, P., Ghinea, R., *Using CATIA V5 for developing a parametric database for pottery*, Quality-Access to Success, Vol. 13, S5, 2012, ISSN 1582-2559, pp: 509-512.

[5] Buna, Z., Comes, R., Badiu, I., *Parameterized database creation for construction elements of monuments*, Journal of Ancient History and Archaeology, Vol. 1, No. 2, 2014, ISSN-2360-266X, pp: 92-98.

[6] Dassault Systèmes, Configurations/Design Table Configurations, in SolidWorks 2014 Help, 2014.

Despre utilizarea modelării parametrice în proiectarea mobilei

Rezumat: Orice companie doreşte să-şi maximizeze profitul prin diferite mijloace. Această lucrare prezintă o abordare privind proiectarea parametrizată care reduce timpul necesar dezvoltării de produs în industria mobilei. Software CAD este folosit pentru a genera modele tri-dimensionale parametrizate de mobilier folosind instrumentul design table realizat în fişiere Microsoft Excel pentru introducerea datelor. În cadrul articolului sunt realizate două studii de caz pentru această procedură în care două aplicaţii CAD, SolidWorks 2014 şi CATIA V5, sunt analizate în ceea ce priveşte interfaţa utilizator, paşii necesari şi diferenţele în utilizarea instrumentului design table pentru a obţine rezultatele dorite.

Zsolt BUNA, eng. phd student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, zsolt.buna@muri.utcluj.ro, tel. no. +4 0754 643 601.

Ionuţ BADIU, eng. phd student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, ionut.badiu@muri.utcluj.ro.

Arnold ÉLES, eng. phd student, Technical University of Cluj-Napoca, Department of Design Engineering and Robotics, eles_arnold@yahoo.com.