Design and Manufacturing of Organic Shape Furniture

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Abstract – Wooden furniture of organic shapes was mostly handmade in the past, each piece was almost unique, since the manufacturing processes did not allow repeatability and larger quantity production of the same products. Today, modern 3D modelling software leads to completely different prospective in wooden furniture design and production. It enables modelling of any kind of shape, based on ideas, natural shapes, even 3D scanned existing shapes, etc. Furthermore, prototypes can be 3D printed. This enables that visual presentation of designed form is made in real. Based on the printed forms virtual models can be improved leading to the final sophisticated model. Additionally, during design process the best construction details can be made to improve material efficiency and manufacturing time. Final product can be than made on CNC machines, enabling reproduction of the same product of desired shape in chosen quantities.

furniture design / 3D modelling / tectonic of timber architecture

1. INTRODUCTION

1.1. Organic design

Organic architecture is a philosophy of architecture which promotes harmony between human habitation and the natural world through design approaches so sympathetic and well integrated with its site, that buildings, furnishings, and surroundings become part of a unified, interrelated composition. Organic architecture is a term Frank Lloyd Wright used to describe his approach to architectural design. The philosophy grew from the ideas of Frank Lloyd Wright's mentor, Louis Sullivan, who believed that "form follows function." Wright argued that "form and function are one." PEARSON (2001) describes organic design as design inspired by nature and sustainability, health, conserving, and diverse, unfold, like an organism, from the seed within. It follows the flows and is flexible and adaptable. It also satisfies social, physical, and spiritual needs, grows out of the site" and is unique. It celebrates the spirit of youth, play and surprise and expresses the rhythm of music and the power of dance. The art of deploying construction technology in such a way that it forms an integral component of the design and actively helps to shape it is what KENNETH FRAMPTON (1995) defines as tectonics.

With the inspiration coming from the wood itself is the aim to offer a wide selection of live edge wood furniture boasting organic shapes and natural flaws that add to the innate beauty and sensory experience. The easy machinability of wood makes it an ideal material for digitally controlled processing. For this reason, the timber industry is well equipped with such machinery, and timber is taking on the status of a high-tech material (BURI – WEINAND, 2011, 2012) (*Figure 1*).

Figure 1. The tectonics of timber architecture in the digital age (folding, bending, weaving)

1.2. The tectonics of digitally designed timber furniture: the organic forms in wood

It is possible to show how parametric design tools can be created that are specifically tailored to timber and its material properties. Tectonics – the interplay of architectural expression, efficiency and the construction of support timber structures – is one of the focuses of our research and teaching at the Department of Wood Science and Technology at the University of Ljubljana.

New wood based materials (liquefied wood, modified wood, densified wood) and processing technologies along with the new possibilities for depicting and calculating support structures play an important role here. The aim is an efficient interlinking of design and construction that integrates the architectural, support-structure-related and production requirements, leading to sustainable and high-quality solutions (*Figure 2*).

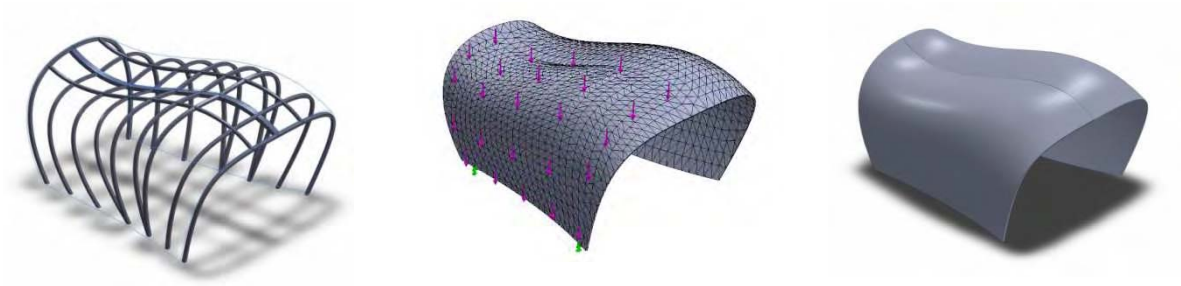

Figure 2. The tectonics of timber architecture as reflected in its production conditions

1.3. Furniture and production conditions

The life cycles of products are becoming increasingly shorter, leading to an increasing need for intensified development of new products or updating the existing ones. Computer-aided manufacturing (CAM), in which computer-aided design (CAD) and computer numerically controlled (CNC) machining are integrated for the production of parts, became a viable option for the woodworking industry in the 1980s (WIEDENBECK – PARSONS, 2010) and is one of the possibilities for reducing design and development time for new products. In modern furniture industry, CNC working centres are widely used, especially when high quality of product and flexibility of manufacturing process are expected (GAWRONSKI, 2012).

The new technologies have had great effect on the professions devoted to three-dimensional design work. Processes like modelling, performing basic stress and deformation analysis, and even the production of rapid prototypes can be currently done by a single designer without any need for a range of specialist. Therefore, an experienced designer can be more effectively involved in any design decision. Virtual simulation of product enables designing of optimal design solutions (MIJOVIĆ *et al.,* 2006).

2. CASE STUDY

The information dictating the form of a work piece, which the human previously provided through a one-time machine setting, is now directly integrated into the machine. The information flow from the control program is variable, meaning that components of various shapes can be manufactured without any time losses in production.

The idea of the case study was to design wooden sitting element / chair based on existing organic shape. The basic form for design was simple river stone (*Figure 3*). The aim of this study was to use available modern 3D modelling software to model the furniture (prototype) and make it with CNC router.

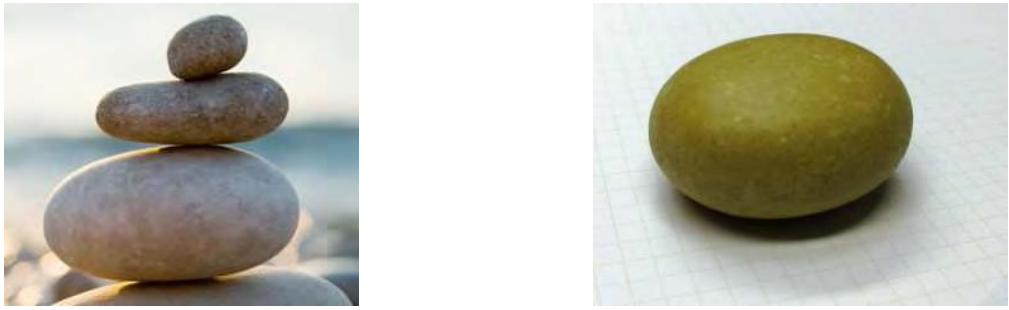

Figure 3. Simple river stone

First the photo of river stone was taken from each side (top, front and left view). The photos were then imported into SolidWorks software, which was used to model our stone. SolidWorks 3D CAD solutions enable quick transformation of new ideas into great products. SolidWorks solutions cover all aspects of product development process with a seamless, integrated workflow-design, verification, sustainable design, communication and data management. Designers and engineers can span multiple disciplines with ease, shortening the design cycle, increasing productivity and delivering innovative products to market faster. Silhouette of the stone was drawn based on these photos (*Figure 4*).

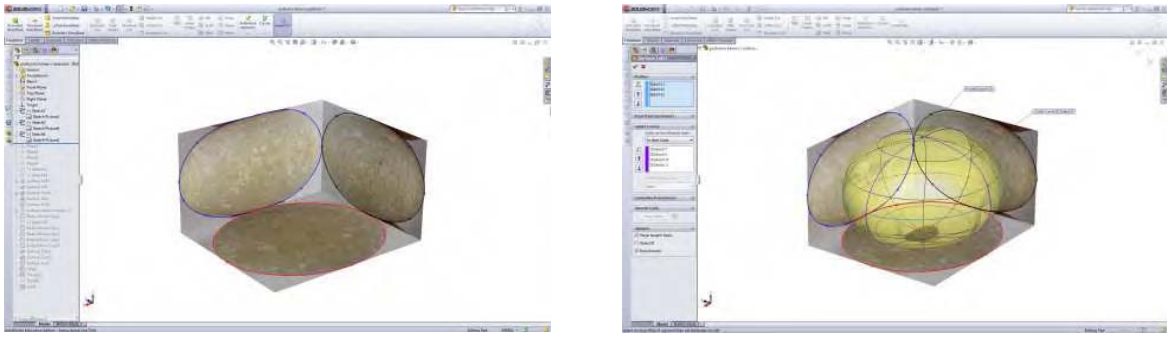

Figure 4. Silhouette of the stone (modelling with SolidWorks)

The model of the stone was then made with Surface loft. This was initial, base form, which was the starting point for further design of furniture. Several models were then made with different seating surfaces and dimensions. Bottom part of stone was flattened to ensure stability of stone. Also upper part of stone - a seat was ergonomically designed to fit the contours of the body (*Figure 5*).

Figure 5. Different model designs

For better visualisation of selected models 3D printing technique was used to make rapid prototypes. "Experience rapid prototyping" enables design team members, users and clients to gain first-hand appreciation of existing or future conditions through active engagement with prototypes. We illustrate the value of such prototypes in four critical design activities:

understanding existing experiences, exploring design ideas, in communicating design concepts and to improve the information required to successfully market a new design.
3D printer ZPrinter 450 was used to make models of selected shapes (*Figure 6*).

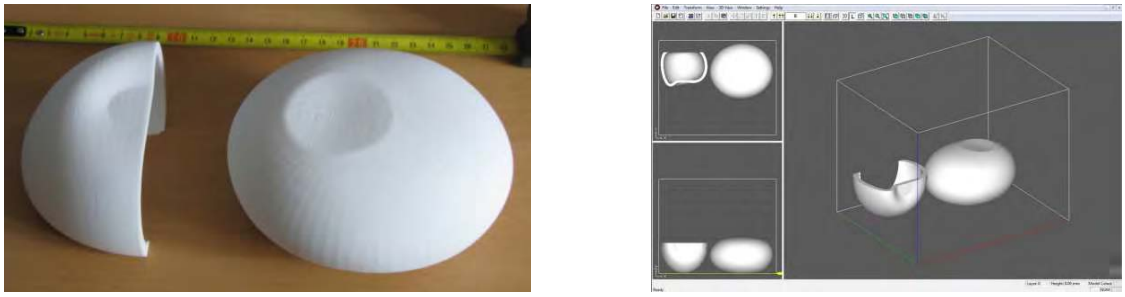

Figure 6. 3D printed prototype M 1:5

For final production the most efficient process was tried to find. It was decided that CNC router will be used to carve the surface of the furniture.
Choice between several options was made - to make it from larger block of wood- half of the stone, or to slice the model to several slices and curve each slice individually and then assemble these slices into final product (*Figure 7*).

Figure 7. Sliced model

It was determined to make model from larger blocks of wood - half of stone, because that was easier for machine operator- only two longer CNC programs had to be made (one for each half) instead of several short programs for each thin slice of product. The main cost for production of the stone was CNC machining so reduction of time for CNC machining was tried.

Also optimisation of material efficiency was needed, and first idea was to made solid block of wood by bonding lamellas. This could be easier to do, but a lot of material would be wasted and also the product would be much heavier. So it was decided to make frame of wood, which than was bonded into block, so that the block was hollow (*Figure 8*). This reduced the material consumption and also made the product lighter. So the volume of used wood was only 0.12 m^3.

Figure 8. Frames of wood bonded into block

Selected finished 3d model was than exported from SolidWorks to AlphaCAM software, which was used to make a program for CNC router. 5-axis CNC machining centre was used to carve product.

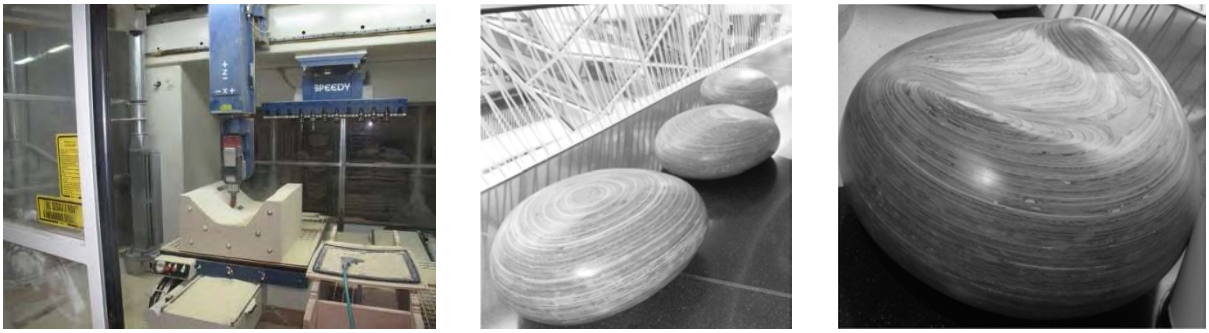

Figure 9. 5-axis CNC machining centre and products

3. CONCLUSIONS

An efficient interlinking of design and construction that integrates the architectural, support-structure-related and production requirements, is leading to sustainable and high-quality solutions. New organic design is a manifesto for wooden furniture of organic shapes in a way that is both aesthetically pleasing and kinder to the environment. It illuminates key themes of organic architects, their sources of inspiration, the roots and concepts behind the style, and the environmental challenges to be met.

Today there is a response to a new age of information and ecology; architects and designers are seeking to change the relationship between products and the natural environment. Students can also experience prototyping's impact on design, working exactly like professional designers and engineers. This project gave them the rigorous ground-level education they need to develop strong backgrounds in science and engineering. They extended existing 3D modelling knowledge with technologies like 3D printing and CNC routing.

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