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A New Era in Furniture Production: 3d Printer

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Abstract

At the technology fair held in Germany in 2011, "Industry 4.0" has been on the agenda of the world since it was first mentioned. In some sources it is referred to as the 4th Industrial Revolution. 3d printing technology can also be covered under industry 4.0. 3D printing technology is used in many different sectors, including the furniture industry. When looking at the furniture industry, mass production is still carried out with traditional methods. While it is used especially in prototype production, it is also used in obtaining the final product today. Within the scope of the study, the production possibilities of the whole furniture, only some parts or only the fasteners with 3D printing were examined through examples. Looking at the examples and examining these areas, it is seen that 3d printing technology provides freedom in design. It makes it possible to produce complex geometries. It is possible to obtain the product designed on the computer by eliminating the cost of mold in production. 3D printing of the entire furniture with today's technology is challenging in terms of the capacity of the printers. Costs will decrease gradually as the printing area becomes more widespread. It is predicted that the samples made in this area will increase gradually.

Keywords: 3d printer, furniture design, furniture production, industry 4.0, interior architecture

1. Introduction

Three-dimensional (3D) printing was first invented in 1984 by Charles Hull. This technique was used in its early days to create prototypes and concept models. As technology evolves, when it is used in the field of furniture design, it is used to produce finished products used in interior design, from lighting products to tables and chairs. The use of 3D printing provides freedom in design, faster product development and lower cost production (Saad, 2016).

3D printing technology, defined as a product of the digital age, is used in furniture, household goods and even indoor interface design and production. By enabling the participation of the user, it can enable the design to be changed quickly and to create a personalized interior.

3D printing technology has spread to many different sectors, including the furniture industry. Furniture is still produced in mass production using traditional methods. However, 3d printing has become useful as a new design and application method in the market. 3d printing is not yet an alternative for mass production furniture. For example, the printing of plastic stools cannot yet rival the normal mold production process. But it is an excellent tool for producing high-end furniture. Such furniture is produced in limited quantities and complex geometries are made easier to produce. High-end furniture was developed by designers seeking innovation and seeking new geometries. This process results in designs that are difficult or even impossible to produce with molds. 3d printing offers more freedom to easily produce complex shapes (Gregurić, 2020).

Although 3D printing technology is mainly developed as a tool for prototyping, it gradually plays a more active role in production processes. As technology improves, it has become possible to manufacture even tools and molds used for traditional production with 3D printers. It has become both possible and economical to produce the final products. With the advent of personal 3d printers, it has made progress towards a point where production directly becomes possible at home (Rayna & Striukova, 2016).

2. Examination of the Subject Through Examples

Within the scope of the study, the use of 3d printers in furniture design has been examined through examples. All or some parts of the furniture can be produced with 3d printers. In some examples, it seems that only 3D printers are used in the fasteners.

2.1 3D Printing the Whole Furniture

Under this heading, examples of all pieces of furniture, all of which are produced with 3D printers, are examined.

2.1.1 Nagami

Combining innovative materials and the most advanced production methods, the color transition accentuated in these chairs defines the relationship between traditional and present. Shown in Fig. 1, Bow and Rise have been printed with a pellet-extruder employing raw plastic particles rather than a filament. The chosen plastic is PLA, a nontoxic, biodegradable material from renewable sources such as corn-starch (Nagami, 2020).

Figure 1: Nagami Chairs

Source: (Nagami, 2020).

2.1.2 The Ocke Series

BigRep is a German company specializing in FDM 3d printers, which allows large volumes to be printed very precisely. Shown in Fig. 2 The Ocke Series designed by industrial designer Beatrice Müller working at this company consisting of chairs and sofas, which are produced with 3D printing.

This series was originally created by the designer to show what BigRep's ONE 3D printer can do. This printer has a build volume of 1 m^3. The situation that the designer also draws attention to provides more design freedom with 3d printing, while creating interesting concepts and end products. Another feature of these furniture is that they are printed without using support materials (Bigrep, 2020).

Figure 2: The Ocke Series

Source: (Bigrep, 2020).

2.1.3 3DSystem's Lounger

This furniture was created by Janne Kyttanen, who works as a 3D printing expert at 3DSystems. This furniture has an incredibly intricate mesh design. It is not possible to produce with traditional methods. It was created using 3DSystem's ProX 950, an industrial, large volume SLA 3D printer. Kyttanen's design enabled it to be printed with as little material as possible while maintaining the strength of the sunbed. The single-print design used only 2.5 liters of resin, which translates to 6000 layers. It measures 1.5 meters in length and weighs only 2.5 kilograms. According to its designer, the lounger can support a maximum weight of 100 kilograms. Shown in Fig. 3, the 3D printed lounger was made as a demonstration of what can be achieved using the ProX 950 3D printer (All3dp, 2019).

Figure 3: 3DSystem's Lounger Source: (All3dp, 2019)

2.1.4 Philips Hue Luminaires

Philips introduced 3D printed fixtures in 2014. This product, which has a smart Led lighting system, has a structure that allows it to be controlled via mobile devices. Designed in collaboration with Philips, WertelOberfell and Strand + Hvass design studios. It aims to draw attention to a new design freedom by defending the idea that everything can be produced with 3D printing. Philips Hue is to use its additional production potential to create truly amazing light sculptures that will work with smart bulbs shown in Fig. 4.

The inspiration for the designs was taken from nature and mathematics. Turning it into something real required an SLS 3D printer and some nylon. The price for the pendant and table lamp costs very high. While expensive, the price reflects the work and effort that was put into the design by famous design studios (Philips Hue Luminaires, 2019).

Figure 4: Philips Hue Luminaires

Source: (Philips Hue Luminaires, 2019)

2.1.5 The Batoidea Chair

Batoidea was designed by Peter Donders as an exceptional example of design and technology. He created a timeless furniture by pushing the boundaries of the design. Shown in Fig. 5 has a fluid and airy structure. The sand mold technique created with 3d printing used to produce the inner core of Ferrari engines was used in the production of this furniture (PeterDonders, 2020).

Figure 5: The Batoidea Chair

Source: (PeterDonders, 2020)

2.2 3D Printing Only Furniture Joints

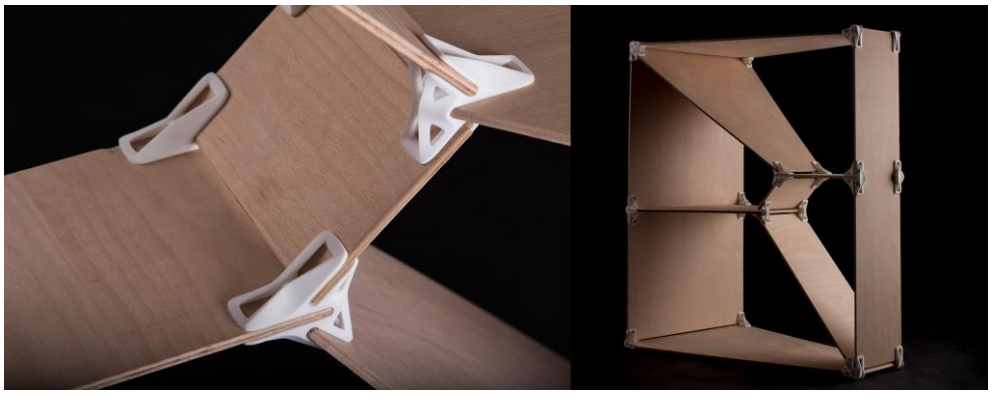
Under this heading, examples of furniture joints which are produced with 3D printers, are examined.

2.2.1 Printtobuild

The Printobuild project was carried out by Gellért Ollé. Since 3D printers are now cheaper and more useful than ever, they say that printed objects can no longer be just prototypes, but the last product we can use. At this stage, he argues that the designer's task is to design printable models. Printing all the furniture with a 3D printer is an unnecessary waste of material, instead we only need to press the joints where we can connect large parts. It emphasizes that joints are the most practical and the most difficult part in an object. Thus, modular products are created.

In Figure 7, the design of the product was realized with the Rhinoceros program. First, he made some test pieces to find the best way to fix the connections on the plywood. After that, he designed the final form using everything needed, and this phase took about 3 months. It takes about seven hours to print each joint with ABS material, but this time depends on the type of 3D printer used (Ollé, 2020).

Figure 7: Printtobuild



Source: (Ollé, 2020).

2.2.2 Suple

The gt2P design studio has researched and experienced parametric design and digital production and developed two projects: “Suple” and “Cracked”. It explores the systematization of geometric, natural or artificial events and creates productive algorithms that can control the form and function. Thus, it has managed to create standard methodologies for non-standard solutions. "Suple" is a furniture fixing system with a single connecting piece of several legs. This joint is made of aluminum and bronze using traditional techniques after 3D printing patterns. A silicone mold is formed (negatives) with this 3D printing. Then 3D printing is removed from the inside and filled with wax (positive). In Figure 8, the 3b printed fastener is shown on the left. The one seen on the right is the main part formed by metal casting (Suple Series, 2020).

Figure 8: Suple

Source: (Suple Series, 2020)

2.2.3 The Titanium-Tawa Table

The Titanium-Tawa Table should be considered as a strong competitor to the production of today's furniture is a multi-leveled lounge table made from hand crafted New Zealand Tawa wood and 3D printed titanium. The piece consists of three separate smaller tables, each with just one leg, supported by a titanium frame which connects the tables at necessary points to make it structurally sound. Each smaller table would not stand without the titanium frame that supports them.The wooden components are crafted by Nigel Cotterill, then 3D scanned and converted into digital files. Those files are used to design the titanium frame and connectors. Those models are then 3D printed and fixed to the wooden components. The Titanium-Tawa Table is a project that exploring potential relationships between hand craft and additive manufacturing (Lounge Table, 2019).

Figure 9: The Titanium-Tawa Table

Source: (Lounge Table, 2019)

2.2.4 The Joint Table by Tong Jin (TJ) Kim

Joint is a corner piece for furniture, created using a 3D printer. This joinery providing a simple way to build own furniture. It is a furniture solution that can meet different user needs and can be customized. Anyone can create their own furniture by taking the desired size of foot and table parts. (Designers, 2020).

Figure 10: The Joint Table

Source: (Designers, 2020)

2.2.5 Hybrid Carpentry

Looking at the art of carpentry is based on shredding and jointing. What can be done in traditional woodworking is limited by the capabilities of the machine. In Hybrid Carpentry, the joints that allow unlimited connection are made of Nylon-12 with SLS technique. This example shows that products with a level of complexity that are very difficult to obtain with traditional skills and tools can be produced. It also supports the potential to improve carpentry (Magrisso & Zoran, 2019). Traditional woodworking is bounded by machinery affordances and craftsmanship. Solid wood joints require high skill and converge into tangent or parallel structures of two elements. Using generative design and 3D printing of plastic wood joinery, they propes new design horizons for contemporary carpentry (Hybrid Carpentry, 2020).

Figure 11: Hybrid Carpentry

Source: (Hybrid Carpentry, 2020).

2.3 3D Printing Some Furniture Parts

Under this heading, examples of some pieces of furniture are produced with 3D printers, are examined.

2.3.1 Model No Furniture

The purpose of the design team is to produce tables, seating elements and decors that can be customized according to personal preferences or purchased and used as is. Parameters such as size, shape, color, material or curvature are customization options.

Another feature of the company is that they attach great importance to recycling. They have created an initiative that allows customers to return products to them to ensure that they are processed to the end of their life, including recycling or reuse. Model No. tries to show that everyone can create elegant and customized furniture that fits perfectly into the home or office style without contributing to environmentally friendly manufacturing practices (Model No, 2020).

Figure 12: Model No Furniture

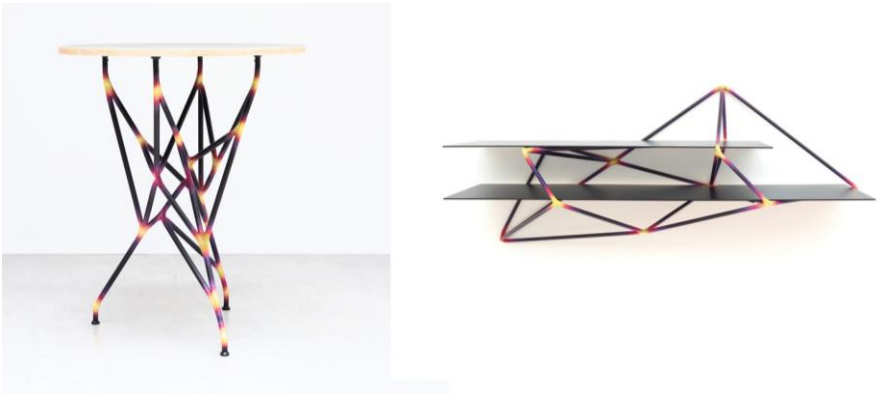
Source: (Model No, 2020)

2.3.2 MULTITHREAD

The design of each piece of MULTITHREAD furniture begins with a set of horizontal surfaces positioned in the space of a table top, a shelf, and a desk. Thin connecting bars support these surfaces. The custom software then analyzes the forces and stresses passing through the surfaces. The final form and colour of every joint is a direct representation of the energy it supports.

The pieces are printed in 3D by SLM (Selective Laser Melting), a metal printing technology. These are then handed to a team of master craftsmen who join the parts together and apply colours to the frame according to the computer-generated finite elements calculations. Each joint is custom painted to illustrate the forces acting within it (Multithread, 2020).

Figure 13: MULTITHREAD



Source: (Multithread, 2020)

2.3.3 Steel Case

Steelcase, one of the largest office furniture companies in the world, placed 3D printing at the center of their designs. Thanks to their partnership with MIT's Self-Assembly Lab, creativity reaches a very high level. Many manufacturers do not find the print quality received in existing systems enough. They believe that they have found a solution to this problem with this partnership. This new system consists of a gel tube and a long tube. With this technique, which they call "fast liquid printing", they aim to create products that have both faster and better surface quality. Due to the lack of time and sometimes print quality, many manufacturers put the acceptance of 3D printing on hold. However, those in MIT's Self-Assembly Laboratory believe they've found the solution to this problem, and it's as simple as a gel tube and a long tube. Using a long tube, it injects hard plastic or flexible rubber into a tub of gel that suspends and supports the structures as they are being printed. Using a new technique called "Fast Liquid Printing", the two partners hope to create a more refined product with faster build time than the traditional methods and processes seen today. It is a design made as an example as seen on Fig 14 (Steelcase, 2020).

Figure 14: Figure description (TNR 10pt., centered, italics)

Source: (Steelcase, 2020)

2.3.4 3D Printed Table

The tabletop is milled with CNC and the legs are printed in 3D. It is a structurally challenging and inspiring project. The legs carry the heavy table on top very gracefully. The top and legs are designed primarily on the computer to be in perfect harmony with each other. Then, the upper table was machined on three-axis CNC machines from both sides to give the 3D waveform. This process takes about 6 hours. The legs are printed in the highest possible size with the SLS method. While the upper part is sanded very lightly and a special varnish is applied, no modifications are made to the legs (Aleksastudio, 2019)

Figure 15: 3D Printed Table

Source: (Aleksastudio, 2019)

2.3.5 Printstool One - 3D printed stool

Designer Thorsten Franck has designed a stool collection that is shaped by using small amounts of materials. The three-dimensional structures of the stool's body stand out for efficient use of material. The stool is very strong due to the clever way the seat and base are connected and it can take people weighing up to 100 kg. The renewable and fully biodegradable printing material used in this design There will be prototypes to try out in diverse colours and shapes. Together with this digital revolution that's Industry 4.0, 3D printing is considered a key technology. So, it is possible to produce ready-to-use 3D-printed furniture (Wilkhahn, 2020).

Figure 16: Printstool One - 3D printed stool

Source: (Wilkhahn, 2020)

3. Conclusion

While 3D printing technology was used for prototyping when it first appeared, it is now used in the production of the final product. It is used by companies in product design processes in the furniture industry. These usage processes are examined under three main titles within the scope of the research. All the furniture is produced in 3d printing, some parts of the furniture are produced with 3d printing or only the fasteners are produced with 3d printing. There are advantages and disadvantages compared to traditional methods in all three areas.

Special printers are needed in order to be able to produce the whole furniture with 3D printing. It can be produced faster than traditional methods. Complex geometries can be produced without the need for mold design. In terms of print sizes and capabilities, it also needs engineering studies to provide the required strength.

The production of some pieces of furniture with 3d printing has advantages and disadvantages like the production of all. Here it is possible to combine with different materials. While the design of complex geometries is done with 3D printing, relatively simple geometries are produced by traditional methods and combined.

With the widespread use of alternative materials and methods in furniture design and production in recent years, it is possible to see examples of 3D printing and furniture production in sectoral applications. In parallel with the advances in 3D printing technologies, the sizes and materials that can be printed increase. Today, filaments are produced from high-strength materials such as carbon fiber. In line with the decrease in costs with the spread of technology, it is predicted that furniture produced entirely from 3D printing will become widespread.

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