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The Application of 3D Printing in the Design of Interior Space Form Solid Products

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ABSTRACT

With the continuous development of technology, 3D printing technology has gradually matured and been widely applied in various fields. Among them, 3D printing technology is playing an increasingly important role in the design of physical products in indoor space forms. 3D printing technology is changing traditional manufacturing and playing an increasingly important role in designing physical products in indoor space forms. This article explores the application and impact of 3D printing in the design of indoor spatial form physical products. By introducing the principles and characteristics of 3D printing technology, combined with specific case analysis, the advantages and challenges of 3D printing technology in the design of indoor spatial form physical products are summarized, and future development trends are looked forward to.

Keywords: 3D Printing Technology, Interior Design, Innovation

1. Introduction

New energy, new Internet, and new manufacturing technologies are the three core technologies affecting today's social transformation. 3D printing technology has emerged from all kinds of new manufacturing technologies and has become the most eye-catching and subversive emerging technology. 3D printing technology has attracted the great attention of the major news media and the public at home and abroad since its appearance. As early as April 2012, the famous British magazine Economist published articles to make an introduction and outlook on the development of 3D printing technology, and said that "the future development of 3D printing technology will make large-scale personalized production possible, and it will bring about a major change in the global manufacturing economy." Making

life efficient, progressive and interesting has always been the role of design. And the application innovation of 3D printing technology has quietly infiltrated all aspects of our daily life, "food, clothing and basic necessities". Then, how to use "3D printing", this innovative technology to systematically guide interior space design, has become a dynamic new proposition. It is the key of our research significance to explore the characteristics and laws of the technology in the field of interior space design, make it applicable to the interior space shape design better, and provide strong theoretical guidance.

2. Start of the Art

From 1984, the American Michael Feygin proposed the idea of laminated object manufacturing. By 1986, American Charles W. Hull set up the world's first 3D Systems Company that produced 3D printing equipment and developed the general digital file, and then, in the next ten years, a variety of rapid prototyping printing equipment was invented by the universities and research companies in European and American countries. In 1996, rapid prototyping had a more popular new name, "3D printing" [1]. From the first desktop printer was born, to the emergence of a first high-precision colour printer, as well as the laser sintering printing technology, the printer that used different printing materials at the same time, until today, 3D printing is constantly updated [2]. Europe and the United States have experienced a century of 3D printing technology creation and update, which have made the United States, Germany, Canada and other European and American countries obtain breakthrough progress in the exploration of the 3D printing technology field. Furthermore, relevant applications and academic research have also reached maturity, the scientific research results have gradually become market-oriented, and the basic industrial chain structure has formed [3]. Compared to Europe, the United States and other countries, the start of the technology in China is not too late, but there are still some gaps. The Chinese government attaches great importance to 3D printing technology and has introduced a series of strategic policies that support the development of 3D printing in various industries, especially for the core technology research and development and promotion in high, fine, sharp fields [4]. China's 3D printing technology industry alliance founder and executive director Luo Jun points out that domestic 3D printing can't just stay at the passive printing level but to plan and guide industrialization from a strategic height, conduct the in-depth development in cultural creativity, biomedicine, construction and other fields, achieve the design innovation, and expand the attractiveness and influence of 3D printing products [5].

3. Methodology

Unlike traditional wood reduction manufacturing (such as machine tooling), 3D printing adopts a laminated manufacturing way; that is, the solid object is produced by layer-by-layer printing. As the main components of the 3D printer and the 2D printer are basically same, which are composed of the control components, mechanical components, print nozzles and media components, in the process of hierarchical processing, the ways of 3D printing and ordinary 2D printer inkjet printing are also very similar. The only difference is that the 3D printer uses "print ink" as the raw material, and it can use a variety of raw materials to print, so many scholars call the 3D printer as "universal printer" [6].

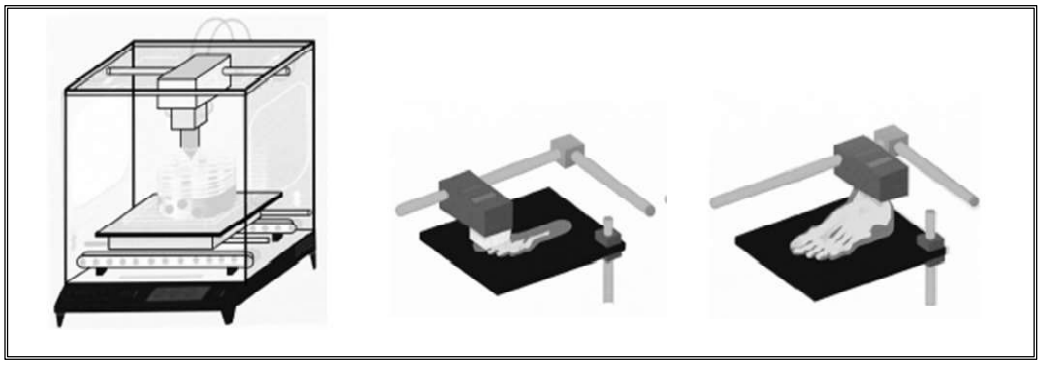

Figure 1. 3D printing technology forming principle diagram

The working principle of 3D printing is also easy to understand. In contrast to the process of fault scanning understood by people, 3D printing "cuts" the solid components that need to be printed into tens of thousands of "slices" that can be superimposed, then, according to superimpose and solidify the "slices" layer by layer, a complete solid object is made up finally, as shown in Figure 1. Before the printing, people use computer-aided design software (such as Auto CAD, 3D MAX) to complete the "digital slice"; then, the digitized file information of these slices is transmitted to the 3D printer for stacking printing. The printing of each thin slice is divided into two key steps; firstly, the machine will pave a layer of special glue that is small and easy to control in a specific area that needs to be printed [7]. Secondly, a thin layer of powdered raw materials is sprayed evenly; the powder that meets the glue will quickly merge and solidify, while the powder in the non-glue area will remain in the original loose condition. Then, after implementing the powder glue alternately spraying printing, the consistent solid entity of the expected model in the computer file is fully presented. After the initial print is complete, the whole product can be printed only to remove the unnecessary powder in the area that isn't solidified by the glue, and the rest of the material can also be recycled and continued to the next printing. Printed solid products are subject to post-processing, such as grinding, curing, later finishing, etc. [8].

Material science support is an important prerequisite for implementing 3D printing, and the diversified development of 3D printing products must rely on the further development and deepening of material science. By analyzing the particle properties of the materials, more and more materials with stable chemical and physical properties have been developed. Now, various powder, liquid, or filamentous materials are researched [9]. As shown in Table 1, it is the 3D printing technology and material type.

Type	Process	Material
Extrusion lon	Fused deposition (FDM)	ABS plastic, wax, polylactic acid, ny-
Line	Electron beam free molding (EBF)	Stainless steel, titanium alloy
Powder	Direct metal laser sintering (DMLS)	Metal alloy powder, carbide compos ite material
	Electron beam fusion molding (EBM)	Metal alloy powder
	Selective Laser Melting Molding (SLM)	Thermoplastic resin powder
	Selective hot sintering (SHS)	
	Selective Laser Sintering (SLS)	Metal powder, ceramic powder
Jet binder	3D printing (3DP)	Cement-based composites, gypsum
Lamination	Laminated object manufacturing (LOM)	Metal film, plastic film
Photopolymerization	Stereo Flatbed Printing (SLA)	Photo hardening resin

Table 1. 3D printing technology and material type

Fused deposition type, FDM, it is also known as the fuse manufacturing technology, plastic jet printing technology [10]. Since the 1980s, invented by ScottCrump, *it has become the most popular 3D printing technology in 3D printing applications. Thermoplastic material with a diameter of about 2mm is melted by heating the nozzle, and the material is sprayed out by the pressure of*

the micro nozzle with a diameter of about 0.2mm-0.6mm at the bottom of the nozzle. Then, through the change of the direction of the nozzle and the vertical descent of the table, the layers of material extruded are fused together and repeated through the fused deposition process until the entire solid modelling is completed.

Selective laser sintering, SLS, belongs to the powder, high energy beam sintering of the filamentous materials or melt moulding process categories [11]. It was researched and developed by C.R. Dechard at the United States University of Texas in 1989. The process mainly takes the metal and ceramic powder as the main materials, which is formed by calcining and bonding. Firstly, a layer of material powder is paved in the 3D printing area smoothly, and the machine is preheated to near the melting point of the material temperature, then, through the high-intensity laser beam or other electron beams, this layer of material powder is irradiated selectively, so that the material layer is cooled and solidified after melting, and through the repeated powder laying, sintering, until the printing product is completed.

Light curing three-dimensional moulding, SLA, which is also known as three-dimensional lithography, or stereolithography, and belongs to the "liquid resin light curing moulding" category [12]. It is worth mentioning that the world's first 3D printer uses the light-curing three-dimensional moulding process. And it was invented by the American Charles W.Hull in 1988, and after it came out, the inventor founded the most influential 3D Systems Company in the 3D printing industry. In the resin tank, it is filled with a sticky liquid photosensitive resin material. Then, the high-speed rotating mirror drives the ultraviolet laser beam to irradiate the liquid resin material, and the polymerization of the irradiation points in the material is triggered so as to make it cured and modelling rapidly. Specific operation: After the start of printing, the table will rise and fall to the location of the next cross-section thickness of the liquid level. Then, the focused laser beam is controlled by computers according to the cross-sectional profile, and a regular scan is carried out along the liquid surface, and the resin in the scanned area is quickly solidified. After completing this section, the operating platform will automatically fall to a lower level, and the next level of curing will be carried out. Finally, after layers of solidification, a print product entity is formed.

Laminated object manufacturing, LOM, is also known as laminating forming. The technology first appeared in 1986, a thin sheet material stacking process [13]. The sheet (paper, composite material or sheet metal) is taken as the raw material, according to the digital data within the computer; the laser cutting system uses a laser to cut out the inner and outer contours of the material coated with hot melt adhesive. After finishing the first layer cutting, the feeding component will superimpose the new layer, and the cutting layers are integrated together through the hot pressing or other equipment; then, entering into the next round of cutting, bonding, and after the final superposition, the threedimensional objects are obtained. The commonly used printing materials are mainly paper, sheet metal, plastic film and ceramic flakes [14].

Inkjet deposition type, 3DP, which is also known as three-dimensional printing bonding moulding, inkjet powder printing, or adhesive jet, belongs to a technique of liquid jet printing [15]. This print type is closest to 2D inkjet printing. It was first developed by the Massachusetts Institute of Technology in 1993. The first is to evenly and accurately lay a layer of printing material powder on the processing platform, and then, according to this level of the cross-sectional shape, the inkjet print head will spray a special glue until the glue and thin layer of powder are completely cured, and then stopped; followed by paving a uniform thickness of powder layer by layer, and continuing to spray special glue, overlaying layer by layer till the whole level of the product printing is completed; finally is to remove the loose powder in the uncured area, then obtain a solid object with a moulding accuracy approaching 0.09mm.

4. Results Analysis and Discussion

In order to verify the feasibility and advanced nature of the previous research, the comprehensive practice of 3D printing technology in interior design was carried out.

Furnishings are the things furnished, that is, a variety of items displayed and furnishings in the design space. Furnishings placed in the living space can cause resonance between the master and guests, contrast the family atmosphere, and highlight the owner's aesthetic taste and human

feelings. Moreover, the furnishings with a certain sense of design can become the punchline in the interior space. 3D printing technology is applied to practice, and the modern design elements are integrated; then, the line with a high degree of exaggeration, generalization, and geometric shape is used to design a set of structured artworks, which not only has the ornamental and decorative value, at the same time, it can also meet certain functional requirements.

3D printing's convenient and fast "integrated moulding" technical features can liberate the design inspiration so that the art structure is not subject to traditional process constraints. As the art manuscript shown in Figure 2, after completing the full shape design, the hollow inner structure is used extensively so that the inner part of the object has more rotating deformation hollows, which can arouse people's imagination and expand the artistic conception while watching, and more space for aesthetic imagination can be left for users and viewers. The appearance looks like the "stone", and the inherence looks like a "net", the new, strange and dangerous elements and structures are integrated together, which are seamless, so that the art works are rich in individual life spirit and have life tension.

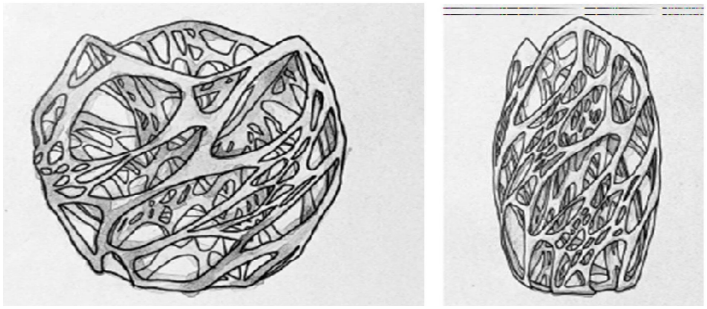

Figure 2. Art manuscripts

Three artworks were taken as a group, and there was a difference in the moulding size, high and low scattered, and they echoed each other when they were placed, which had more sense of shape. The artwork with the minimum body size can set up a glass vessel above the object for discharging incense to adjust the indoor smell; the medium artwork can be used as lamps and lanterns, and the hollow skeleton makes them more artistic; the highest artworks can be used as flower arrangement, to add the room taste.

According to the design, the 3ds max software was used to transfer three painted design sketches from the plane to the computer stereoscopic model. Figure 3 shows the 3ds max modeling file. The interior structure of the furnishings devised was more complicated, and particular attention should be paid to the section transition during modelling. Finally, the STL format file that was appropriate for the 3D printer was exported. It can be found that 3ds max is the modeling software that is suitable for 3D printing, its model can freely switch between polygons and surfaces, and furthermore, the print accuracy is also high.

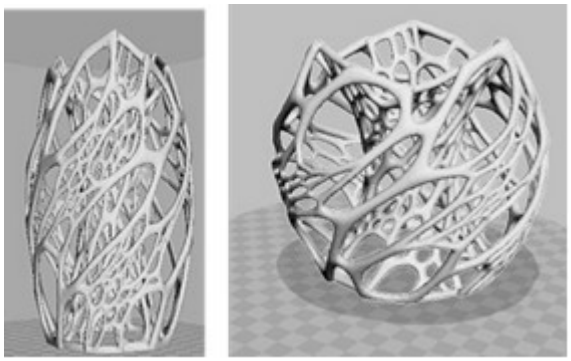

Figure 3. 3Ds max modeling file

The printing material used in this print is polylactic acid (PLA). Polylactic acid is a good polymer derived from plant starch, which is also an environmentally friendly green printing material. The characteristics of the stable property and not easy to deform of polylactic acid are in line with the longterm placing demands of the furnishings; the bright colour and smooth surface features of the products printed with this material can add lustre to the colour and shape of the art. In addition, polylactic acid is a renewable material that is made by taking corn as the raw material, and the green and environmentally friendly characteristics of the material are particularly suitable for making products and contact with people for a long time by placing it in the room.

The STL format model file was imported into the Cura software to set the printer parameters. It should be noted that the print "layer high" setting in the software has a direct impact on the 3D printer's print quality. In the early stages of printing, it is necessary to take into account the effect of printing and constantly adjust the print shell thickness, the printing speed, the packing density, the printing temperature, and other important parameters in accordance with the structure and shape of the model.

Fused deposition (FDM) 3D printing products are used all the time. Whether it is to use the desktop or industrial printers, 3D printing products will inevitably show the layer effect, which means that after the print is complete, the product must be polished. Usually, the sandpaper or file are used for the late grinding, but the use of sandpaper grinding is easy to cause the product surface color mixing, fading, and the file grinding is easy to lead to the product accuracy and details damage, and even fracture damage due to improper control.

During the printing process of the three furnishings, there will occasionally be the phenomenon of the print job standstill due to the clogging of the print nozzle, seriously it can cause the work to fail and needs to be reprinted. Causes of nozzle clogging often due to the excessive accumulation of PLA supplies residue, and the solution is to try to use the needle to clear, or open the nozzle to clean the internal residue. If the internal supplies residue is solidified, the printer nozzle temperature can be adjusted to 240 !, so as to make the internal residue melt, and then let the residue flow out through the print is ok.

As the furnishings designed have the characteristics of complex structure, various changes and too large a rotating angle, part of the hollow place is too small. In the printing process, there is often print failure caused by insufficient support strength and internal structural fracture. Figure 4 shows part of the print failure and the fractured stent part.

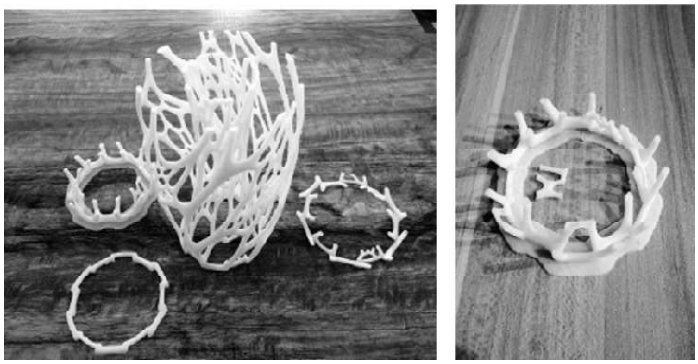

Figure 4. Partial print failure and broken stent parts

In the printing process, there will be the print model fault caused by the nozzle position offset and coordinate error. After repeating the inspection, it can be seen that the reason for the situation is that the synchronization wheel is not tightened or the excessive contamination of the optic axis, thus resulting in too much resistance to the printing process. After troubleshooting the cause of the failure, the targeted solution is carried out.

Eventually, the effects of the three sets of finished products are obtained, as shown in Figure 5. And the practical function display is shown in Figure 6.

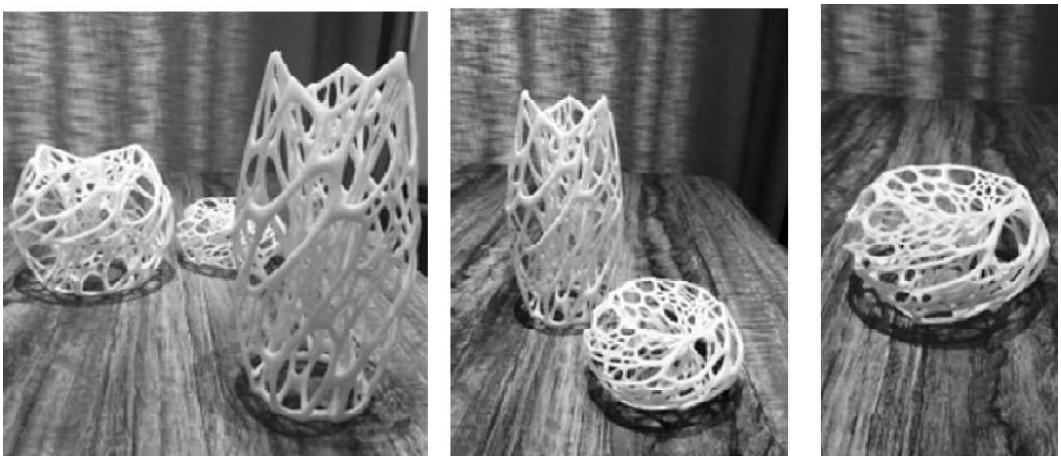

Figure 5. Three sets of finished products set effect

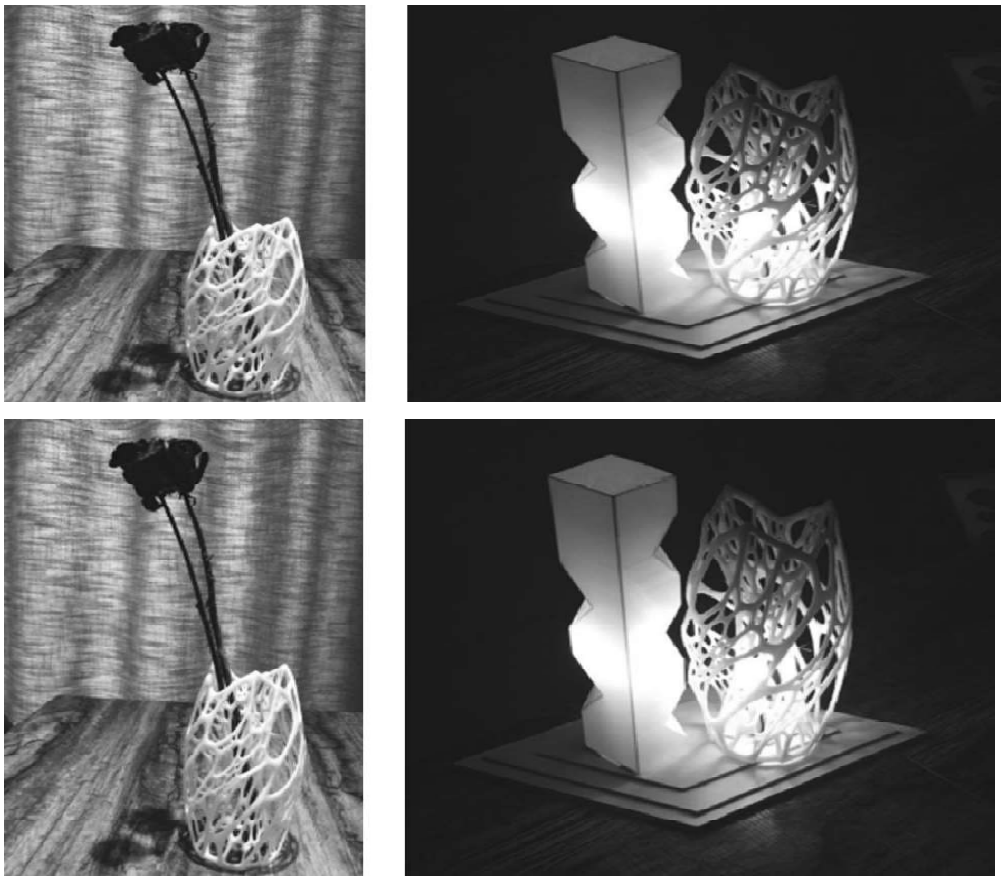

Figure 6. Practical function display

In the design and manufacture of interior furnishings, 3D printing technology can really play its convenient and efficient technical characteristics, and it can also conduct the integrated moulding while facing a complex work of art; besides, three pieces of furnishings can be printed in one day. After the design and "print" of the three pieces of furnishings, a large number of problems also can be identified: on the one hand, during the operation, the interruption is easily caused be

cause of various small problems of the 3D printer, which will affect the printing efficiency and print product accuracy to a certain extent. Therefore, the performance of 3D printers should continue to improve, especially since there is a greater improvement in stability and operability. On the other hand, the surface of products printed using polylactic acid, plastic wire and other materials has different degrees of asperity roughness, which must be artificially polished later. While facing the products that are too small or too thin and prone to fracture due to excessive friction, thereby resulting in damage to the print results, the wire printing accuracy should be strengthened, or the matching polishing machine should be produced in post-processing to achieve do not restricted by the human factors. In general, 3D printing technology can be fully suitable for individuals and families to conduct the indoor components "print" to meet users' personalized, differentiated and diverse needs. In the future, 3D printing technology will have considerable potential applications in the interior design industry.

5. Conclusions

To study the innovative application of 3D printing technology in interior design, this paper analyzed its characteristics of the application in interior design, conducted the targeted research on the major components of interior design by combining with many application cases and discussed its realistic reform significance in the interior design industry. Finally, the following conclusions were drawn: the high degree of integration of the new material and new technology can make 3D printing technology a great development prospect in interior design; on the one hand, the fine process can break through the traditional technical restrictions, and designers can complete the product research and development through the patterned operation under the individual needs of consumption experience era. In addition, 3D printing technology with powerful performance can be innovatively applied to indoor energy, indoor interface, green, and other major interior components to make up for traditional manufacturing and design deficiencies. At the same time, 3D printing technology is of great value in the digital protection and application of interior components, and it will become the indispensable technical support in studying the form of Chinese traditional folk furniture by using digital modelling of 3D printing technology to repair the incomplete indoor components, to complete the protection of cultural heritage. 3D printing technology is in the growth stage, so many technical bottlenecks need to be further explored in the future; for example, 3D printing materials need to be further developed.

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