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Analysis of the Development of Modern Ceramic Production Based on 3D Printing

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Abstract:

As one of the traditional industries in my country, ceramic production has a history of thousands of years and has formed a unique ceramic culture. With the development of modern science and technology, the modern ceramic manufacturing industry has shown a new development trend. The application of 3D printing technology has made ceramic modeling more diversified and decoration more diversified, and it also plays an important role in ceramic restoration. This paper briefly expounds 3D printing technology, analyzes the impact of 3D printing technology on ceramic production, specifically studies the development and application of 3D printing technology in modern ceramic production, and introduces several ceramic 3D printing technologies.

Keywords:

3D Printing Technology, Ceramic Production, Modeling, Raw Materials, Application

1. Introduction

3D printing technology mainly uses software to generate three-dimensional data, build three-dimensional models, and then convert the models into real objects through 3D printers. At present, 3D printing technology has been widely used in many industries. The use of 3D printing technology in ceramic production can design more complex and diverse shapes, and ceramic decoration can also be more diversified. The most important thing is that three-dimensional models can be designed, modified and experimented many times, which effectively saves money. The cost of ceramic production avoids material waste. From the perspective of the long-term development of the ceramic industry, the application of 3D printing technology can better meet the individual needs of users, and customize ceramic products according to user needs. effect.

2. Overview of 3D Printing Technology

3D printing technology was born in the 1990s. The first commercial 3D printer was developed by American scientist Charles Hull. 3D printing technology mainly uses light curing and paper lamination to complete rapid printing. Its working principle is basically the same as that of ordinary printing technology. First, the 3D model is built

in the computer, and then the printing material is stacked layer by layer by using the computer to control the 3D printer. , and finally turn the computer model into a real thing. At present, 3D printing technology has been widely used in industrial design and manufacturing, mold production and other fields, and some directly produced products have also begun to use 3D printing technology. The emergence of 3D printing technology has had a profound impact on the production process and craftsmanship of traditional manufacturing, and has had a subversive impact on some industries.

3D printing is to first model by computer modeling software, and then "partition" the built three-dimensional model into layer-by-layer sections, that is, slices, so as to guide the printer to print layer by layer. The printer reads the cross-section information in the file, prints these sections layer by layer with liquid, powder or sheet materials, and then glues the layers of sections in various ways to create a solid. The feature of this technique is that it can create objects of almost any shape.

3D printing technology avoids the cutting procedures of traditional manufacturing, does not need to be manufactured through molds, has a faster processing speed, and has a relatively short production cycle. More importantly, 3D printing has great advantages when manufacturing objects with small volumes and complex structures. Advantage. Through the integrated printing technology, no secondary processing is required, and mass production and remote control are realized through online operation with a computer. The most representative of 3D printing technology is fused deposition forming technology. Its working principle is to feed the hot-melt filament material into the nozzle through a wire feeding device, and under the control of computer software, the nozzle is heated to extrude the softened material. Begin to move along the contour of the object until the filling and solidification of the semi-fluid material is complete, forming a 3D printed product. For example, for the 3D printing of plastic products, the plastic is melted by heating the nozzle of the 3D printer, and the plastic cools rapidly after extrusion and bonds and coats the surrounding material. At present, fused deposition modeling (FDM) technology can print metal, paraffin, ABS, polylactic acid (PLA), artificial rubber, etc., and the produced 3D models, mechanical parts, daily necessities, etc., are widely used in construction, automobiles, aerospace and medical fields. Compared with traditional mechanical processing production, FDM technology has the advantages of low cost, wide range of materials, high utilization rate of raw materials, and low pollution.

3. Analysis of the Impact of 3D Printing Technology on Ceramic Production

3.1. The production cycle is shorter

The production process of ceramics is cumbersome and the production cycle is relatively long. It takes several weeks from material screening to the final burning of paper, and the production staff needs to take care of the whole process during the second time, which is time-consuming and labor-intensive. The use of 3D printing technology to make ceramics can greatly shorten the production cycle. From product design to production completion, it can be as short as a few hours or as long as a few days. The production cycle is greatly shortened and the cost of ceramic production is lower. The fundamental reason why 3D printing technology shortens the ceramic production cycle is to simplify the production process. The traditional ceramic production method needs to go through multiple links such as material screening,

green body modeling, decoration, and paper burning, and each link contains multiple processes. The production process is relatively complicated. 3D printing technology only needs to complete the three-dimensional model modeling in the software, and then connect the printing equipment for printing, which simplifies the intermediate link of ceramic production.

3.2. The shape is more abundant

The shape of ceramic products is largely subject to the ceramic production process. Traditional ceramic production methods rely on manual production, so the shape is relatively simple, and some ceramics with complex shapes or complex internal structures are often difficult to produce. With the development of the market economy, the individual characteristics of user needs are becoming more and more prominent. If the individual needs of users cannot be fully met, the development of the ceramic industry will inevitably be restricted. The advantage of 3D printing technology is that as long as the design of ceramic products is completed, even if the structure is complex and the shape is changeable, it can be printed by printing equipment, and there is no need to worry about collapse. Therefore, the design of ceramic products can be more free. Designers can completely turn their creative ideas or user needs into reality.

3.3. Lower skill requirements

The use of 3D printing technology to make ceramics is different from traditional craftsmanship. Relatively speaking, the use of 3D printing technology to make ceramics requires lower skills for the producers. The traditional ceramic production process is cumbersome and complex, and each process has corresponding requirements. It is difficult to complete the production process of a ceramic product, requiring a long period of professional study and training, and the entry threshold is relatively high. The use of 3D printing technology is relatively simple. It only needs to be proficient in operating the modeling software. The manufacturer only needs to build a 3D model in the software, and then connect the 3D printing equipment to complete the product production. The skill requirements are relatively low.

4. Development and Application of 3D Printing Technology in Modern Ceramic Production

4.1. Ceramic materials

Ceramic production has high requirements for raw materials, including the origin and quality of raw materials. The traditional ceramic production process mainly uses natural minerals such as clay, feldspar and quartz stone, among which clay is the main raw material, which is directly related to the quality of ceramics. quality. Due to the different characteristics of raw materials in different regions, the production process and product characteristics of ceramics in different regions are also different. For example, the famous Jingdezhen porcelain and Ru kiln porcelain in my country have their own distinctive characteristics, which has a lot to do with the raw materials they use. The raw materials used in 3D printing technology are mainly ceramic powder. Compared with the traditional ceramic production process, it has lower requirements for raw materials and a wider range of raw materials. For example, aluminum silicate, aluminum oxide and zirconia can be used as raw materials. At the same time, the clay is replaced by a binder, which makes the raw material more excellent in plasticity and

fluidity. In addition, when using 3D printing technology to make ceramics, other components can be added to make ceramic products produce different effects, showing richer shapes and diverse decorative effects. The application of 3D printing technology has also had a subversive impact on ceramics. In terms of raw material selection, it not only has a wider range of options, but also has lower requirements for raw materials, which is of great significance for the long-term development of the ceramic industry.

4.2. Ceramic modeling

The traditional ceramic production process is extremely complex, which can be roughly divided into mud mining, mud refining, drawing, cutting, drying, carving, glazing, kiln firing, and painting. There are as many as 72 processes. Among all the links, the shape of the ceramics is mainly determined by the drawing link. In the traditional process, the drawing is mainly affected by the technical level of the production personnel. The drawn shapes are mostly circular, and some relatively complex shapes can only rely on the mold Completed, but there are many restrictions on the mold, and some processes cannot be completed. For example, the hollowing process can only be hand-carved. The technical level of the engraving personnel is high, the product damage rate is high, and the finished product is difficult. The application of 3D printing technology fundamentally solves the shortcomings of traditional ceramic production technology. Complex structures that cannot be produced by traditional technology can be directly printed without relying on the mold or the personal technical level of the manufacturer, and even some complex three-dimensional structures that were difficult to achieve before. The structure can also be printed, and the shape of ceramic products is no longer limited by the technical level, and can present a richer variety of shapes. In addition, in terms of ceramic decoration, the use of 3D printing technology can omit the painting process. 3D printing is layer-by-layer printing, which can produce different texture effects by controlling the thickness and flow rate of the mud, and the color can also be directly added to the raw materials. What comes out is the finished ceramic product, which does not need to be painted and decorated.

4.3. Ceramic repair

Ceramic repair requires a lot of time and energy for high technical requirements, great difficulty and slow progress, especially for some precious ancient ceramics. It is difficult to accurately grasp, and a little carelessness in the repair process may cause damage to the ceramic. The emergence of 3D printing technology perfectly solves the problem of ceramic repair. As long as the three-dimensional information of the ceramic to be repaired is collected, the three-dimensional model is built in the software, and the size data of the missing part of the ceramic is calculated according to the existing size data. The corresponding size of the tiles, and high precision, only need to manually complete the splicing and bonding in the end. This fundamentally solves the problem of ceramic repair, especially in the repair of some precious ceramics with a high degree of fragmentation, the use of 3D printing technology can not only completely restore the old appearance of ceramics, but also greatly reduce the difficulty of repair. At present, 3D printing technology is not only limited to the restoration of ceramics, but has also been applied to the restoration of cultural relics, avoiding secondary damage to cultural relics during the restoration process to the greatest extent, and achieving good results.

5. Several Current Ceramic 3D Printing Technologies

5.1. Inkjet Printing Technology

There are two main methods of inkjet printing technology, namely inkjet deposition method and three-dimensional printing, in which three-dimensional printing first lays powder on the worktable, and uses nozzles to spray the binder to the designated area to bond with the powder. The table is then adjusted down, refilling the powder until the finished ceramic product is produced. The advantage of this method is that it is easy to control the microstructure and composition of the ceramic green body, but the disadvantage is that the green body needs insufficient strength, low precision, and requires secondary processing. The inkjet deposition method is to spray the suspension containing nano ceramic powder through a nozzle, and form a ceramic product under the action of deposition. The key to this method is that the ceramic suspension must be uniformly dispersed, otherwise the quality of the ceramic product will be affected,the main factors restricting its development and application are the difficult configuration of ceramic inks and the easy clogging of inkjet print heads

5.2. Hierarchical entity manufacturing technology

The layered entity manufacturing technology is essentially a superposition process of sheet materials, so this technology is also called selective cutting of thin materials. Its basic working principle is to use lasers to complete the cutting of thin materials and adhesives. , and then adjust the table, cut again, and stack the thin materials, and complete the process from single layer to whole by repeating the above operations. The advantage of this technology is that the molding speed is relatively fast, and it is especially suitable for ceramic products with complex structures; no support structure is required during the production process, and the post-processing is relatively simple. The disadvantage of this technology is that the material waste is relatively serious. The inevitable result of this laser cutting is that compared with other technologies, the utilization rate of raw materials is not high. At the same time, due to the use of laser cutting, the production cost is also relatively high

5.3. Laser selective sintering technology

Laser selective sintering technology mainly uses the cooperation of laser, pressure roller and worktable to complete 3D printing. First, use the pressure roller to spread the ceramic powder on the worktable, and use the laser to scan the ceramic powder in the designated area. The binder will begin to melt and bond with the ceramic powder to form a layered structure; then adjust the worktable, re-apply the ceramic powder, and scan again with the laser to bond with the previous layered structure. The above operations are repeated continuously, and the finished ceramic is finally printed. The disadvantage of this technology is that there are few types of binders that can be used, the dosage of binders is not easy to control, and the mechanical properties and density of ceramics may be affected after using binders, resulting in poor quality of ceramic products. . The use of laser also leads to the relatively high cost of this technology and increased equipment maintenance costs, which seriously limit the development and application of this technology.

6. Conclusions

In summary, the application of 3D printing technology in ceramic production has shortened the ceramic production cycle, enriched the ceramic modeling, and reduced

the difficulty of ceramic production. With the in-depth application of 3D printing technology, various 3D ceramic printing technologies will become more and more mature. It is foreseeable that in the future, ceramic production will be further limited by factors such as raw materials and personnel technical level, and more complex and diverse shapes and structures can be produced. More complex ceramic products continue to emerge, so as to better meet the unique needs of users and promote greater development of the ceramic industry.

Conflicts of Interest

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