Research on the Application of 3D Printing Technology in Ceramic Modeling

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Abstract: 3D printing technology, as one of the new technologies, can quickly complete the printing of three-dimensional works in a fixed space by layer printing digital models. Today, with the development of 3D printing technology, the printing range is becoming increasingly wide, and the printing materials are also diverse, such as rubber, cement, resin, metal, paper and other materials. Ceramics, due to their highly stable chemical properties, have also become the earliest application material in 3D printing technology. This article first analyzes the advantages and disadvantages of 3D printing technology, and then explores the types and production processes of printing technology, hoping to provide some reference and inspiration for colleagues.

Keywords: 3D printing technology; Ceramic modeling; Application research

3D printing technology is also known as additive manufacturing technology. As an emerging technology, 3D printing technology and ordinary 2D printing technology are almost identical in working principle. The specific operation process is as follows: using a computer for graphic design, issuing printing tasks through connection with printing equipment, and the printing equipment will stack the loaded "printing materials" such as liquid or powder layer by layer based on computer data, ultimately achieving the transformation from 2D blueprint to 3D entity. Additive manufacturing technology or 3D printing technology was first used for model manufacturing in fields such as molds and industrial design. However, as the technology continues to mature, 3D printing technology has begun to enter people's daily lives, such as building models, shoes, figurines, toys, and other applications.

I. Analysis of the advantages and disadvantages of 3D printing technology

The advantages of additive manufacturing technology: The biggest difference between additive manufacturing and subtractive manufacturing is the way they save materials. In additive manufacturing technology, the use of computer programs and high-end equipment can effectively reduce the generation of waste in the production process, greatly improving the utilization of resources and materials. At the same time, with the help of 3D printing technology, some product shapes that cannot be manufactured by CNC technology can also be produced. In addition, due to the integrated control of the program, it does not involve traditional model making processes such as clamping, cutting tools, and machine tools, and can easily complete the production of complex shapes. As long as the program, blueprint, and materials are sufficient, the production of ceramic products can be completed. In actual production, it also helps to shorten the product development cycle and achieve customized small batch personalized products. The disadvantages of additive manufacturing technology: 3D printing technology has obvious advantages, but its disadvantages are also obvious, such as high production costs, expensive equipment prices, and low production efficiency. Especially in large-scale production, the drawbacks are more apparent. At the same time, in terms of technology, there are few printing materials available, which can only be concentrated in a limited number of materials such as plastic, gypsum, ceramics, sand, resin, and metal. Among these materials, there are even fewer materials that support ceramic 3D printing and ceramic modeling. Furthermore, in ceramic printing and shaping, its physical and chemical properties are far from comparable to traditional ceramic processes.

II. Research on the Application of 3D Printing Technology in Ceramic Modeling

1. Liquid deposition 3D ceramic printing technology

As a common 3D ceramic printing technology, the working principle of liquid deposition printing technology is to squeeze the viscous mud material through professional equipment, so that it is stacked layer by layer in a strip like manner, gradually forming a three-dimensional shape. Afterwards, the mud material is transported to the interior of the machinery using air pressure, and the injection and stop of the mud material can be controlled by the rotation of the screw inside the equipment. After the mud material is stacked according to the computer program, it can become a three-dimensional model with a certain strength after drying in the air for a period of time. Due to the high precision of the clay strips extruded by 3D printing equipment, newly formed works have a strong sense of hierarchy. At the same time, different colors of clay can be added according to the color of the work, making ceramic works more exquisite and unparalleled. Moreover, the printing principle and method are relatively simple, and the cost of material loss is not high, making it very suitable for the public to try. After the printed work is dried and initially polished, it can be fired into ceramics, greatly shortening the firing cycle of ceramics. With the continuous maturity of liquid deposition 3D ceramic printing technology and equipment, users can not only create some small ceramic shapes, but also print some large ceramic shapes, and their printing accuracy, color, and variety are constantly improving.

2. Indirect Ceramic Forming 3D Printing Technology

At present, there are two main ways to produce 3D models: one is 3D printing photopolymerization technology, and the other is hot melt deposition plastic 3D printing technology. The biggest difference between the two technologies is the material composition, and the

main material of photopolymerization 3D printing technology is photosensitive resin. At room temperature, photosensitive resin materials exist in liquid form, and upon exposure to ultraviolet stimulation, cross-linking reactions occur between the internal molecules of this material, which then transform from liquid to solid. The working process of photopolymerization 3D printing technology is to use ultraviolet light to accurately and continuously irradiate the surface of photosensitive resin, and then gradually pull the cured part until the ultraviolet light irradiates all the liquid photosensitive resin material, gradually curing from liquid to solid, and finally printing a complete ceramic three-dimensional work.

From the current perspective, photopolymerization printing technology can print high-precision ceramic shapes, but the overall material usage cost is relatively high. The plastic hot melt deposition 3D printing technology is achieved by heating hot melt plastic, using an extruder and nozzle to extrude liquid hot melt plastic, layer by layer bonding it together, allowing it to cool and solidify on its own, and finally forming a ceramic shape. Compared to photopolymerization 3D printing technology, the accuracy of hot-melt deposition plastic 3D printing technology is relatively low, but its material cost is lower. The printed template shape can be used as a template, and then the ceramic shape can be printed, followed by flipping, grouting, glazing, and firing to finally complete the ceramic shape. Compared with traditional manual mold flipping techniques, this ceramic manufacturing method has shorter operation time and uses fewer materials.

3. Ceramic powder 3D printing technology

Ceramic powder 3D printing technology is a printing method that mainly uses ceramic powder mixed with other printing materials. For example, in photosensitive resin materials, ceramic powder is added in a certain proportion to complete the preparation work of ceramic powder 3D printing technology materials. The process of ceramic powder 3D printing technology is similar to that of photopolymerization printing, both of which use ultraviolet light irradiation and photosensitive resin as the “adhesive” to gradually bond the ceramic powder together during the curing process, forming an integrated printing material. With the continuous irradiation of ultraviolet light on the three-dimensional shape, the ceramic shaping production is gradually completed. However, after the initial completion of the body, processes such as removing the binder, polishing, and firing are still required to ultimately complete the production of the ceramic product. Powder spreading 3D printing technology is also a commonly used ceramic printing technique. The working principle of powder laying 3D printing technology is to lay a layer of ceramic powder on the workbench, and then spray the adhesive onto the designated position through a nozzle to bond the ceramic powder and adhesive together, thus completing the printing work of that layer. Then gradually lower the workbench to continue the process of laying ceramic powder and spraying adhesive, thus completing the printing of the second layer of material. The above process is carried out in sequence, stacking ceramic shapes layer by layer, and finally cleaning up the excess powder on the ceramic shapes. The cleaned powder can be retained for the next printing of ceramic shapes. After the ceramic molding is completed, a sintering process is required to obtain the final ceramic product.

At present, ceramic powder 3D printing technology is not yet mature, and ceramic powder is usually mixed with other printing materials in a certain proportion before printing the work. However, this technology has high standards for the use of printing equipment and printing materials, so the cost of producing ceramic products will also be much higher, almost only used for printing and processing ceramic parts.

III. Research on Ceramic Modeling Production Based on 3D Printing Technology

1. Model reproduction grouting

When the 3D model is printed, it is necessary to remake the gypsum model, which is crucial for the later grouting process. After the 3D model printing is completed, it is necessary to determine the central axis of the model and divide it into two parts along the central axis. At the same time, it is necessary to do a good job of sealing the fence to prevent gypsum from flowing out of the sealed container and causing material waste. Pour the evenly mixed gypsum slurry into a sealed container at a constant speed. When the gypsum slurry is at the same height as the model template, stop pouring the gypsum slurry. Wait until the gypsum solidifies and forms to complete the flipping of one side of the model. The next step is to replicate the model on the other side. Firstly, in order to improve the success rate of gypsum demolding, it is necessary to apply soapy water and demoulding agent on the other half of the gypsum, and then use relevant tools to drill holes in the gypsum. Pour the well mixed gypsum slurry evenly into the other side of the model template, wait until the gypsum is dry, carefully disassemble the gypsum, and take out the 3D model template printed inside. After the gypsum flipping is completed, the surface of the gypsum can be polished with sandpaper or equipment, while the interior of the gypsum model does not need to be polished. Moreover, the master mold can be used repeatedly for a long time. Making multiple master molds at once can greatly reduce the frequency and time of model flipping. At the same time, ceramic shapes can be disassembled and printed in sequence to reduce the workload caused by cutting the master mold.

After all the gypsum is turned over, we can start the grouting process. Firstly, carefully configuring the grouting mud according to the proportion can ensure the fluidity, plasticity, and stability of the grouting mud, and ensure that the mud body reaches the ideal shape. It should be noted that when preparing clay, if the fluidity of the clay is poor, an appropriate amount of water glass can be added to make the clay flow more smoothly. However, the amount of water glass needs to be controlled properly, otherwise it may cause cracking and damage to the clay. Afterwards, start injecting mud into the interior of the gypsum. It should be noted that the centrifugal grouting method is used for mud injection, which can make the internal mud close to the edge of the model under the action of centrifugal force, forming a high-density body, thereby improving the quality and quality of ceramic products. Finally, after successful demolding, the next steps need to be taken -

bonding and repairing the billet. This step should control the moisture content of the clay material, which must be maintained at 70% -80% to effectively ensure the plasticity of the model. At the same time, when repairing the billet, try to achieve the smoothness of the surface of the main object as much as possible. After completing all the above processes, you can proceed to the firing step.

2. Ceramic polishing technology

Ceramics have the characteristics of wear resistance, high hardness, high temperature resistance, light weight, high brittleness, and poor toughness. Therefore, during the polishing process, it is necessary to ensure the integrity and accuracy of the main object. However, traditional ceramic polishing techniques are no longer able to meet the needs of social and economic development. At present, domestic ceramic material grinding technology has made great progress, greatly improving the efficiency and accuracy of ceramic material grinding. After the completion of digital molding and firing, high-speed deep grinding, slow feed grinding, high-speed grinding and other polishing techniques are generally used. Taking high-speed grinding and polishing technology as an example, the principle of this technology is to increase the linear speed of the grinding wheel to achieve the expected polishing effect on the ceramic surface. At the same time, during high-speed grinding, the abrasive grains remain undeformed, the grinding force decreases, and the cutting thickness also decreases accordingly, thus achieving a smooth surface while protecting the ceramic surface well.

In addition, the degree of cutting deformation is small, the grinding thickness becomes thinner, and the depth of residual cutting marks of abrasive particles becomes smaller, which can effectively reduce ceramic shaping errors. However, long-term high-speed grinding and polishing of ceramics can significantly reduce the service life of the grinding wheel and affect the final shape of the ceramics. Therefore, when carrying out high-intensity and high-speed grinding and polishing of ceramics, it is necessary to select some high-strength grinding wheels and take corresponding safety protection measures to effectively reduce the probability of cracks on the ceramic surface caused by polishing. In addition, to determine the cause of damage during the ceramic molding process, non-destructive methods such as optical microscopy, thermal wave imaging, and bubble testing can be used to test the cracks on the ceramic surface

IV. Conclusion

In summary, in traditional ceramic production techniques, it is a ceramic product manufacturing process that is primarily human centered. Unlike traditional ceramic firing processes, 3D printing technology is primarily a ceramic manufacturing process that relies on computers, printing equipment, printing materials, and other components. At present, ceramic modeling 3D printing technology mainly includes liquid deposition 3D ceramic printing technology, photosensitive resin 3D printing technology, paper printing technology, ceramic powder printing technology, and hot melt stacked plastic 3D printing technology. When using 3D printing technology to manufacture ceramic shapes, users can choose printing materials that are suitable for their printing purposes.

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