Application of computer 3D printing technology in jewelry processing model

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ABSTRACT

In the 21st century, human beings have entered the information age. Knowledge and technology have become the core competitiveness. Computers are widely used in all walks of life and become an indispensable thing in our lives. People's thoughts, inner spiritual needs and artistic aesthetics are also imprinted on it. The imprint of the information age. In recent years, 3D printing technology has penetrated into our lives, and artists are constantly experimenting due to its novel molding methods. The main purpose of this paper is to study the application of computer 3D printing technology in jewelry processing models. Starting from the advantages of computer 3D printing technology, it analyzes how computer 3D printing technology is applied in the processing model of jewelry, and the necessity of application, through the comparison of casting model statistics and casting methods.

Keywords: Computer 3D printing, jewelry, jewelry model, jewelry processing

1. INTRODUCTION

In recent years, 3D printing technology has been continuously praised, and it is widely used not only in paleontology, medicine, architecture, and industry. The development and progress of art always go hand in hand with the rise of new technologies[1-2]. In the 21st century, under the background of 3D printing technology permeating life, many artists have begun to use this emerging technology to express their inner thoughts, state concepts, and do not limit the creation of materials, which is an important feature that distinguishes traditional jewelry. The development of computer 3D printing technology has made a qualitative leap in jewelry art, and has become one of the most important means of jewelry production.

The application of computer 3D printing technology abroad is very avant-garde. Many years ago, Mara G and his strategic partner produced the PreciousM080 system specially used for 3D printing jewelry[3]. Prior to this, 3D printing equipment could only print wax molds of jewelry, and the lost wax casting method had to be used to make precious metal jewelry. Shahrubudin N produced 3Design, a professional jewelry design software, which is used by many famous international brands as the main design software, with powerful design functions [4]. Therefore, attention should be paid to the application of computer 3D printing technology in jewelry processing models.

The main purpose of this paper is to study the application of computer 3D printing technology in jewelry processing models. Focus on the characteristics and advantages of 3D printing, analyze the application of computer 3D printing technology in jewelry; make predictions on its development based on the application status. This paper hopes to have an in-depth study on the processing and application of computer 3D printing technology in contemporary jewelry through theory and practice, so that the public can discover the innovation and development potential brought by 3D printing technology to jewelry design.

2. DESIGN RESEARCH ON THE APPLICATION OF COMPUTER 3D PRINTING TECHNOLOGY IN JEWELRY PROCESSING MODEL

2.1 Advantages of computer 3D printing technology

(1) Reduce labor intensity, save labor time, and improve the accuracy of model plate making. In the past, craftsmen hand-carved wax and made plates, which was time-consuming and laborious, and the accuracy was not high. Once there was a problem with the original version, it had to be reworked. 3D printing technology is different. It draws jewelry

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models by computer, and in the process of drawing models, it is controlled by computer with precise data, which is more accurate in size and shape than traditional manual work. The three-dimensional graphics drawn by the computer are clear, intuitive and easy to modify. The most important thing is that after connecting the 3D printer, the wax model can be directly sprayed for subsequent processing.

(2) Free your hands, reduce the constraints of craftsmanship, and provide assistance for design innovation. Traditional jewelry making requires multi-component welding for complex shapes. The process is complicated and labor costs are high. Even some shapes cannot be produced due to process limitations. The layer-by-layer printing manufacturing method of 3D printing technology can print any complex shape. This is not only the improvement of manufacturing technology, but also greatly liberates the constraints of craftsmanship on design and promotes design innovation. In addition, in the past, it took many years of craftsmanship and manual practice to cultivate an excellent starting master. To a large extent, the factory would rely too much on the starting master, which also increased the restraint of production.

(3) Reduce the production cost of complex modeling jewelry. Traditional jewelry processing is mostly manual work, so labor costs need to be considered. For some complex jewelry shapes, if manual work is used, compared with simple jewelry, the labor cost will be very high, so it will cause The market value is also higher than that of simple jewelry. The contemporary design thinking under the values of the modern era has profoundly affected people's views on value. It is no longer simply the embodiment of craftsmanship and beauty, but more of the value content after design. The selling point of a piece of jewelry, especially commercial jewelry used for mass production, lies more in the design connotation it embodies. If too much additional cost is added to the production, it will affect the overall value of the jewelry and affect the sales[5-6]. 3D printing technology can well balance the issues of craftsmanship, complex modeling and product value. Because of its integrated manufacturing method, whether it is simple modeling or complex modeling, the required process technology is the same, but the number of materials is slightly different. That's it. This technology can play a huge role in both custom jewelry and batch jewelry processing.

In a word, jewelry design urgently needs to introduce new ideas and new technologies to meet market and social needs. How to apply these new design methods and new technologies more deeply and effectively in the field of jewelry design and combine them with design is a top priority.

2.2 The application of computer 3D printing technology in jewelry design

Since the 1990s, 3D printing technology has been used in jewelry making, and 3D printing has become one of the important means of jewelry making, making jewelry art develop rapidly. The main role of 3D printing technology in contemporary jewelry design is assisted molding and direct molding.

(1) Auxiliary molding

Assisted molding refers to the 3D printing technology and other means to help the molding of the work at a certain stage in the jewelry production process. It is mainly used to produce works with high finished product accuracy, low printing cost and large room for manual adjustment. However, in the entire production process, 3D printing technology is only an auxiliary function, which is easily limited by traditional processes.

(2) Direct molding

Direct prototyping means that 3D printing can directly produce a complete work. After the printing materials and scanned content are completed, they are the final work. As long as the finishing work is completed, the final work is completed. It is mainly used to make larger conceptual jewelry works, and the production design is free and not bound by tradition. However, there are few suitable materials, low precision, slow printing speed and high cost, which need to be further improved [7-8].

2.3 The necessity of applying computer 3D printing technology in jewelry processing model

(1) Judging from the development status of jewelry design at home and abroad, foreign jewelry design has a long history, and has developed economy, leading productivity, strong design examples, and advanced and active creative thinking. They focus on the use of advanced and rich design methods. Computer-aided design has long been widely used in jewelry design in Europe and the United States, and many 3D drawing software are also designed and developed in Europe and the United States. With its three-dimensional simulation features, virtual design methods, and convenient design modification process, these software can be integrated with jewelry processing and production, which greatly improves the efficiency of jewelry design.

(2) From a market point of view, jewelry is determined to be a luxury item due to its special material. In reality, most of the people who have demand for jewelry are young people who do not have strong spending power. Their spending power is limited but their desire to consume is considerable. If jewelry still maintains its expensive value, it will cause consumption to such a group with a leading consciousness obstacles[9-10]. Using 3D printing technology and parametric design can save design and production time, and the production cost of jewelry will be greatly reduced. Designing complex and exaggerated jewelry shapes that meet the tastes of modern young consumers will greatly improve to stimulate young consumers.

(3) From the perspective of sales model, jewelry can be roughly divided into two categories: custom jewelry and commercial jewelry. Custom jewelry is generally designed according to the specific needs of the buyer. The shape, craftsmanship and material of the jewelry can reach a high level, and the cost is very high. Commercial jewelry is mostly factory assembly line operation and mass-produced. This kind of jewelry is generally more common in shape, and it is a common style. It has no new ideas and lacks creativity. Generally, metals such as gold and silver are used or matched with gemstones. Most of the people who buy it are public. Traditional jewelry design and manufacturing methods are difficult to achieve such customization requirements, but if parametric design is used for jewelry design, multiple design schemes can be quickly generated for selection, effectively saving design costs; cooperate with 3D printing technology to carry out The manufacture of complex shapes not only does not increase production costs, but also has fast production speed, high product precision, cost savings, production time and can improve product quality, whether it is large-scale production or customized production. Lian's custom jewelry is not a problem.

(4) From the artistic expression of jewelry, modern jewelry is not only used as body decoration, but also can give people the resonance and experience of the soul. At present, more and more artists, under the influence of their respective cultural backgrounds, use jewelry as a carrier to express their emotions and perceptions of society, art and life. They seek various breakthroughs in terms of materials, design intentions, forms of expression, and production techniques. Jewelry is no longer simply a worn object, or its value is determined according to its material. Today's jewelry, as a medium for the wearer and the viewer to express each other, far exceeds its role in expressing status. For us, contemporary jewelry not only has the basic function of decoration, but has gradually evolved into a medium for the balance and integration of art, craftsmanship, technology, ideology, culture and life. People pay more and more attention to the relationship between jewelry and the human body, the relationship with sports, and the relationship with social life, and more and more new technologies are used in jewelry creation[11-12].

2.4 Algorithm Research on the Application of Computer 3D Printing Technology in Jewelry Processing Model

(1) Contour recognition

The contour recognition is carried out by the relationship of its circumscribed rectangle, without intersection judgment, and the method is simple. Apply the following relationships:

$$\begin{cases} x_{\max} > x'_{\max} \\ y_{\max} > y'_{\max} \\ x_{\min} > x'_{\min} \\ y_{\min} > x'_{\min} \end{cases} \tag{1}$$

The coordinate value of the lower left corner of contour A is V1 (Xmin, Ymin), and the coordinate value of the upper right corner is V2 (Xmax, Ymax). The coordinate value of the lower left corner of contour B is V1 (Xmin', Ymin'), and the coordinate value of the upper right corner is V2 (Xmax', Ymax').

(2) Fill scan

The final path planning is fill scan, the most commonly used is line scan. Draw the equidistant parallel lines of the scan line on the contour plane, then calculate the intersection of the parallel line and the contour, and connect the intersection points according to certain rules to form a fill scan. Assuming that the scan line is parallel to the x-axis, the scan spacing is $\triangle$y, the maximum value of the contour line in the y-axis direction is ymax, and the minimum value is ymin, then the scan line can be described as the following equation:

$$y = y_{\min} + \Delta y \times i \tag{2}$$

where i=1, 2, 3, ..., n, and $n = (y_{\max} - y_{\min})/\Delta y$.

3. EXPERIMENTAL RESEARCH ON THE APPLICATION OF COMPUTER 3D PRINTING TECHNOLOGY IN JEWELRY PROCESSING MODEL

3.1 3D printing materials

(1) Liquid photosensitive resin material

The main components of photosensitive resin are oligomers, photoinitiators, diluents, etc. It is composed of polymer monomers and prepolymers. The photosensitive resin has a relatively rapid curing speed, and the photosensitive resin also has the characteristics of high strength, high temperature resistance, water resistance, etc., which makes it have a smoother appearance and low odor after molding. The photosensitive resin materials we usually see include somos NEXT material, somos 11122 material, epoxy resin, etc. somos NEXT material has good toughness, strong rigidity, exquisite craftsmanship and precise shape; somos 11122 material is like transparent plastic, stable and waterproof; epoxy resin material is used to make extremely precise rapid casting molds.

(2) Nylon powder material

The nylon material applied to 3D printing is a white powder, and the jewelry printed with it is relatively light, heat-resistant, friction-resistant, and wear-resistant. Due to the small diameter of its powder particles, the model made with it is relatively accurate, and the 3D printed nylon jewelry can have high tensile strength without special treatment. However, nylon material has no characteristics in appearance color, but its appearance color can be enriched by spray painting, dip dyeing, etc.

3.2 Application of computer 3D printing technology in jewelry processing model

(1) The main application methods of computer technology in rapid prototyping plate making

There are two main ways of rapid prototyping plate making, one is high-precision curing molding; the other is CNC engraving and milling. The application process of computer technology is divided into pre-processing model data output, data input, typesetting, processing file output, rapid prototyping plate making and model post-processing.

(2) Core technology and parameter requirements in relevant links

1) Preprocessing file output

Regardless of whether it is formed by solidification and accumulation or CNC engraving and milling, in general, the parts of the main metal part of the jewelry are processed. Gemstones and non-metal parts do not need rapid prototyping equipment to process, but if the parts of the jewelry are wood, shells, volcanoes, etc. Stone and other materials can be formed by CNC engraving and milling. All gemstones and non-metallic parts need to be hidden or deleted before the pre-processing file is output; in addition, if there are moving parts, they also need to be disassembled, such as the melon seed buckle of the pendant, the link of the bracelet, the left and right parts of the bracelet, etc. If you encounter a relatively large jewelry or ornament model, it may exceed the processing layout and processing height of the rapid prototyping equipment, or the volume is within the maximum processing size range of the equipment, but it will affect the completion time of other models on the same layout. In this case, large-scale models are often split.

2) Document input and typesetting

Under normal circumstances, different rapid prototyping equipment is equipped with special typesetting software, which cooperates with users to typesetting of pre-processed models. However, there are two types of typesetting methods and software commonly used in the jewelry processing industry. For molding equipment, Jewel CAD is generally used for overall software layout, and then the processing data suitable for the corresponding rapid prototyping equipment is output; the second is CNC engraving and milling rapid prototyping equipment, which generally uses Art CAM software for layout and tool path processing code programming, and then Connect data to CNC equipment.

3) Application of accumulation curing type rapid prototyping equipment

At present, the more commonly used accumulation-curing rapid prototyping equipment in the jewelry industry mainly includes the German Envision Tec Perfactory resin spray rapid prototyping machine and the American 3Dsystem CPX series of wax spray 3D printers. Because the CPX series wax spraying machine does not need to make support when the model pre-processing file is output, and the performance of the molding wax material is similar to the traditional lost wax casting wax mold and easy to cast, it is very popular among enterprises. The key elements in rapid prototyping plate making mainly include: when the processing file is input, preview and check whether the processing file exceeds the maximum layout size of the equipment processing, and ensure that the template is processed according to 1:1; processing accessories can be deleted to save processing materials; check whether the raw material warehouse is sufficient Use the best processing raw materials to avoid stopping work due to insufficient supply of raw materials during the processing process, causing unnecessary waste; regularly detect the laser head or clean the printing nozzle to avoid affecting the quality of the stencil due to insufficient light intensity or blockage of the nozzle, which will affect the follow-up Process production.

4) Application of engraving and milling type rapid prototyping equipment

At present, the engraving and milling type rapid prototyping equipment used in the jewelry industry is mainly based on CNC with four-axis and five-axis linkage. The key elements in its application are: cutting according to the modeling size of the simulated processing (usually brass, 925 silver, green Wax, etc.), use materials reasonably to avoid waste; use fixtures correctly to ensure that the materials to be processed are clamped to avoid falling or shifting during processing, resulting in dislocation of engraving and milling; according to the accuracy of engraving and milling and the location of the jewelry model, Configure the corresponding tools, follow the principle of first coarse and then fine to increase the processing speed; pay attention to the method and strength when taking the template at the end of engraving and milling to avoid damage to the template; clean the work cabin in time and keep it clean; pay attention to safety, and avoid opening during processing Work hatches and touch knives.

5) Post-processing of rapid prototyping models

There are mainly two aspects: removing the jewelry template and removing the template support material. The method of removing the jewelry stencil: one is to make a supported photo-curing template, usually using a scalpel to cut off the full-page model and split the models of each style; the other is to make a photo-curing template without support. There are two types, one of which is a resin stencil, the method of removing the stencil is to use a special shovel to shovel off the stencil; The other is a wax stencil, which uses a heater to heat the working plate (aluminum plate) from the bottom, and the temperature is controlled at 40 ℃-46 ℃, when the bottom of the stencil begins to melt, you can remove the stencil and place it on the workbench for use; Third, the method to take the engraving and milling template is to open the clamp. If there is a support point or connection point, it can be easily removed with a scalpel.

4. EXPERIMENTAL ANALYSIS ON THE APPLICATION OF COMPUTER 3D PRINTING TECHNOLOGY IN JEWELRY PROCESSING MODEL

4.1 Casting consumption

Precision casting is one of the most important manufacturing technologies. It is a relatively traditional manufacturing technology and widely used metal forming technology. As shown in Table 1, the casting consumption of various industries in China is as follows.

It can be seen from Figure 1 that the consumption of castings in various industries in my country is very large, and the demand for castings is considerable, especially in the automotive industry, which even accounts for 30% of the total. Therefore, it is urgent to increase the development and manufacturing of molds.

4.2 Accuracy comparison of casting methods

There are various casting methods, each with its own distinct characteristics, but the most common ones in real life are pressure casting, precision casting and sand casting. Traditional sand casting has simple process, low cost and wide application. However, its flexibility is poor, and there are many disadvantages in making complex parts. The accuracy comparison of several common casting methods is listed below, as shown in Table 2.

Table 1. Quantity of castings consumed by users in various industries in China.

Industry name	Consumption (10,000 tons)	Percentage of total (%)
Car	1500	30
Metallurgical Mining Machinery	500	10
Cast iron pipes and fittings	500	10
Construction machinery	450	9
Internal combustion engine	350	7
Machine tool	340	6.8
Agricultural machinery	280	5.6
Generator, electricity	260	5.2
Rail	250	5
Ship	60	1.2
Textile	40	0.8
Other	410	8.2
Total	5000	100

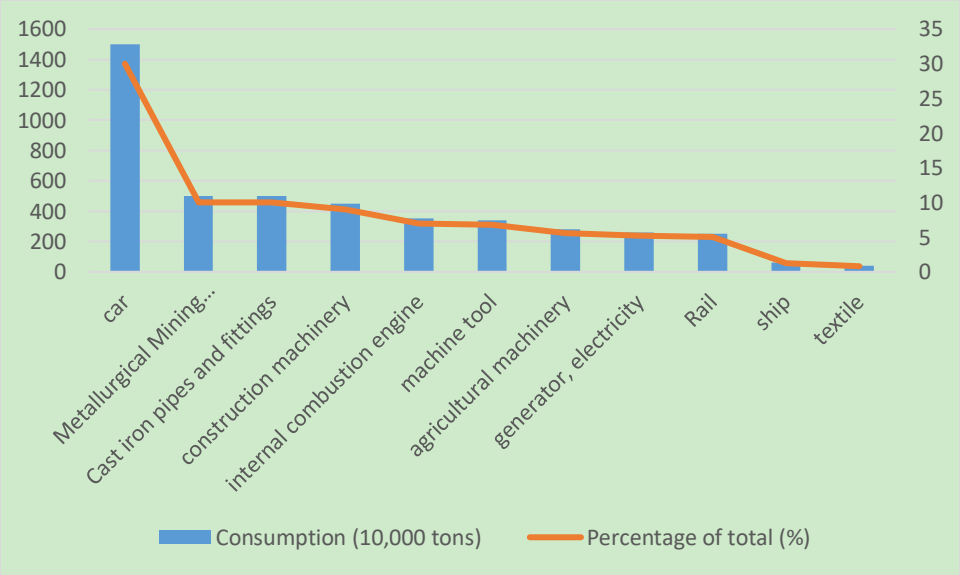

Figure 1. Quantity of castings consumed by users in various industries in China.

As shown in Figure 2, in terms of casting accuracy, although my country has made certain achievements in precision casting technology, if we look at the overall situation of the entire industry, my country is still in the stage of development, research and application. But still learning and developing.

Table 2. Comparison of several casting methods.

Casting method	Dimensional accuracy	Surface roughness Ra/μm
Investment casting	4~7	1.6~12.5
Ceramic mold casting	5~7	3.2~12.5
Precision casting	4~6	0.8~1.6
Lost Foam Casting	5~7	6.3~12.5
Coating transfer method	4~7	3.2~6.3

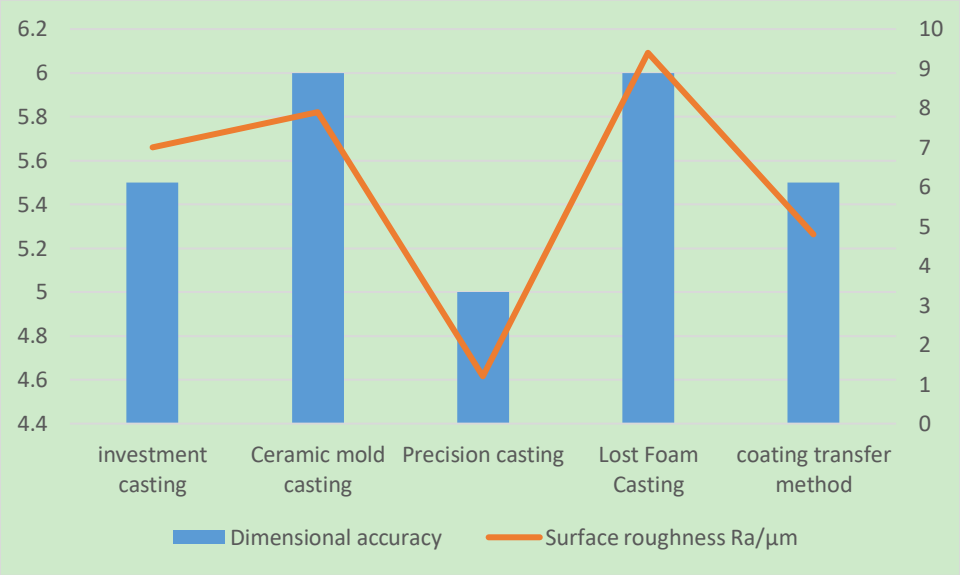

Figure 2. Comparison of several casting methods.

5. CONCLUSIONS

3D printing technology, like forging, welding, casting and other traditional jewelry making technologies, is to allow jewelry people to better express concepts, use materials and promote the development of contemporary jewelry art. People is still the main body of creation, and the expression of individuality, creativity, diversity and the artist's thinking concept is still the main theme of contemporary jewelry art creation. Traditional handicraft will not be replaced with the development of 3D printing technology. The application of technology in jewelry design has instead given a new definition of handicraft in contemporary times. At this stage, computer 3D printing technology still has many limitations and has not yet reached the conditions for full popularization. For the application of computer 3D printing technology in jewelry processing models, we also need to stand in the right position, take it as the driving force to promote jewelry creation and jewelry art design, and actively explore and conduct in-depth research.

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