Research on Sculpture Art Based on 3D Printing Technology

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Abstract: With the development of society and economy, modern buildings around the world have spread rapidly, but these buildings are the same and lack artistic appeal. With the development of 3D printing technology, the combination of the traditional craftsmanship and 3D printing technology has made the building's artistic sculptures more realistic and customizable. This article introduces the precise manufacturing process of art sculpture components based on 3D printing technology from the aspects of art sculpture component production, 3D modeling, 3D printing output, and post-processing.

Keywords: Decorative Engineering, Art Sculpture Components, 3D Modeling, 3D Printing

1. Introduction

At present, modern architecture is sweeping the globe, but these buildings are too monotonous and lack artistic appeal. Therefore, the practical and concise modern architecture embodies the advantages of early architecture and the gorgeous "post-modern architecture" came into being. The shape is free, the pursuit of dynamics, the rich decoration and sculpture, and the baroque art with strong colors have been shown in "postmodern architecture" [1].

In recent years, 3D printing technology has become more mature, the printing accuracy has gradually improved, and the size of printable components has also become larger and larger, and it has been able to meet the size requirements for printing proportional art sculpture components [2-3]. However, at present, 3D printing materials are still mainly plastic powder and metal powder. Metal powder equipment and raw materials are too expensive, and they do not have any promotion and application advantages in the highly competitive construction industry. The basic performance
requirements of decorative materials [4-6]; at the same time, due to printing speed, batch production cannot be achieved to meet the requirements of the actual construction progress on site. Through research and analysis, 3D printing technology can be introduced for the initial model production link, and 3D printing technology is used to complete the initial model production, which combines 3D printing technology with traditional craftsmanship.

2. Sculpture art 3D modeling
The advent of 3D engraving software has brought the term "high-precision models". Correspondingly there will be "low-precision models". High and low are a relatively fuzzy concept of quantification. Here, high and low are not the same as the number of model faces, but the details of the model. In order to represent more details of the model, more faces are needed. Due to the limitation of the number of faces when making models in traditional 3D software, the detailed folds of the model often need to be represented by texture drawing, not a true 3D model. Users of 3D engraving software can express the details of an object to the fullest, and all the details can be reflected on the model. The 3D engraving software modeling process is as follows: making the basic model → detail engraving → increasing the subdivision level.

2.1. Basic model
The requirement is a brief summary, to accurately express the outline, momentum and proportion of the object, not one part at a time, so that it is easier for us to fully grasp the model. Start with simple sketches, show the basic ideas you want to sculpt, and then go straight to sculpting. Start with a sphere and focus on the overall outline of each angle until it looks appropriate before moving on to the next step. It's a mistake to add too much detail too early. Don't delve into the details too early. If you don't even create the shape in step 1, studying the details will only waste time. CAD drawings (as shown in Figure 1), photos or drawing manuscripts (as shown in Figure 2) can be used as a reference for the establishment of the basic model to ensure that the shape of the basic model is accurate. Draw the basic model in the Z-ball mode and convert it into a mesh, so that subsequent sculpting brushes can be sculpted and adjusted further. Mubbox software does not have basic modeling capabilities. At this stage, 3DS Max software is required to establish the basic model.

![Figure 1. CAD auxiliary reference drawing of manuscript](image-url)
The principle of 3D printing is as follows. Assuming that \( P \) is a unit vector in the selected molding direction, it is shown in equation (1):

\[
P = \begin{bmatrix} \sin \theta_1 \cos \theta_2, \sin \theta_1 \theta_2, \cos \theta_1 \end{bmatrix}
\]  

(1)

Among them, \( \theta_1 \in [0, \pi] \), \( \theta_2 \in [0, 2\pi] \)

In addition, the 3D printing molding time is used to evaluate the efficiency of 3D printing, as shown in formula (2).

\[
Q = x \sin \theta_1 \cos \theta_2 + y \sin \theta_1 \cos \theta_2 + z \cos \theta_1
\]  

(2)

The mathematical model of forming efficiency can be expressed as shown in equation (3):

\[
T = 1/h \{ \max(Q) - \text{MIN}(Q) \}
\]  

(3)

Where \( T \) is the number of layers / layer

2.2. Detail carving

The model making at this stage requires proficient grasp of the engraving software, and strives to accurately express the connotation of the work and deepen the form. If the biological model is sculpted in 3D software, the corners near the bones are required to be hard and compact, while the flesh part must be expressed differently according to the characteristics of the work. If divided
according to body parts, there are often squeezed or piled or loose skin at the moving joints, and the non-moving parts are often compact. We need to experience the feeling of "square in a circle" in the continuous accumulation of experience. Carving the whole model in-depth to make the model's shape more intrusive and lay the foundation for the final detailed description.

2.3. Increase the subdivision level

After refining the model as a whole, it is refined for each aspect of the model. The 3D engraving software must pay attention to engraving with different details at different subdivision levels. Only a higher level of subdivision can smoothly show some small traces, making the final model as smooth and delicate as a sculpture. In the model making process, as the model making progresses, there may be inconsistent results in individual parts, and appropriate adjustments need to be made according to the actual situation to make the model coordinate as a whole (see Figure 4).

![Figure 4. Carved model](image)

2.4. Pre-processing of 3D printed models

When designing a 3D model, only focus on the visual effects of the model, no need to consider the authenticity, the objects need not be connected to each other. But 3D models can be a lot different for 3D printers.

1) The object model must be closed

The popular saying is "Watertight". 3D printed objects must be completely closed without any gaps. 3DMax's STL Check (STL Check) function can be used to detect the model and close the model.

2) Object needs thickness

3D models usually exist in the form of patches, but there is no zero thickness in realistic models, and 3D printed models must have reasonable thickness.

3) Correct normal direction

All face normals in the model need to point in the correct direction. If the model contains the wrong normal direction, the 3D printer cannot determine whether it is the inside or the outside of the model, and the model cannot be closed properly.

4) the maximum size of the object model

The maximum size of the object model is based on the maximum size that a 3D printer can print. When the model exceeds the maximum size of the 3D printer, the model cannot be completely printed.
In Cura software, when the size of the model exceeds the maximum print size of the setting machine, the model is displayed in gray, and the model needs to be processed by the model scaling tool.

5) the minimum thickness of the object model

The nozzle diameter of a 3D printer is constant, and the wall thickness of the printed model must take into account the minimum wall thickness that the printer can print and the strength properties of the printing material. Otherwise, there will be failed or wrong models, or the models are prone to damage during cleaning and use. Generally, the minimum thickness is 2mm, which varies according to different 3D printers.

6) Reserved tolerance

Due to the large size of the decorative components of the building, a combined model is required, so special attention should be paid to the reservation of the stitching tolerance. Reserve a width of 0.4mm in places where tight bonding is required; leave a width of 0.8mm in looser places.

7) Cantilever treatment

According to the technology used by 3D printers to determine whether design support is needed for the cantilever part, such as FDM fusion lamination molding technology. When a 3D printer prints a model, any protrusions that exceed 45° require additional support materials to complete the model printing. The support consumes materials and is difficult to handle. If it is not handled properly, it will destroy the beauty of the model. SLS selective laser sintering technology does not need to consider the cantilever problem.

2.5. Post-processing of 3D printed models

Post-processing of 3D printing refers to processing the printed model surface and details to make the model more accurate. It is basically divided into 4 steps: ①Remove the model from the printer; ②Remove the support on the model, etc. (This step is not necessary if the support is not needed); ③Refine the details; ④Polish Bad).

1) The process of FDM printer with polymer material is as follows: ① Use a small shovel to separate the product from the printing platform; ② Use scissors or a cutter to remove the internal and external supports; ③ Use a soldering iron that can adjust the temperature for fine Carving; ④ Use sandpaper or sander to polish the model to remove residual protrusions on the surface, such as support and drawing.

2) The process of 3DP and SLS printers using powder is as follows: ① After the printing process is finished, the printed model needs to be left for a period of time to completely solidify the formed powder, and the component has a certain strength before being taken out; ② When the model is When it has a preliminary hardness, the model can be further cured by additional measures according to different types of materials, such as heating, vacuum drying, and ultraviolet light irradiation; ③ With strong hardness, it is necessary to remove the residual powder on the surface and use a brush to remove most of the surrounding powder Sweep away, and the remaining less powder can be removed by mechanical vibration, microwave vibration or blowing; ④ Fine parts need to be trimmed with a tool such as a sculpting knife; ⑤ The common method of surface treatment of the model is to wax the model. The printed model is immersed in molten paraffin to increase its strength, preventing the strength from weakening and powdering on the surface due to water absorption.
3. Summary and conclusion
After the 3D printed model is cleaned and spliced, the art sculpture components can be produced according to traditional methods. During the 3D model making process, 3D scanning can be used for repairing the existing components, to repair the scanned model in the software, which can quickly complete the model establishment process. For the initial model making process, 3D printing technology can be introduced, and 3D printing technology is used to complete the initial model production, which combines 3D printing technology with traditional craftsmanship. At present, only a simple attempt and adjustment is performed for the early model making stage of traditional construction technology in this article. With the maturity of 3D printing technology and the emergence of new printable materials, the production of personalized art sculpture components will become easier and more convenient.

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