

# Application of 3D Printing Technology in Cultural Relic Protection

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**Abstract:** China's ancient cultural relics have been weather-beaten, has been damaged to a large extent, so this requires us to use a reasonable method to restore cultural relics, but also to avoid the problem of secondary damage to cultural relics. This article will explain some feasible schemes of 3D printing in the restoration of ancient cultural relics from the following aspects, and put forward specific restoration processes. It is hoped that through the advantages and disadvantages of 3D printing in cultural relic restoration proposed in this paper, a new way of thinking is proposed for the relevant staff of this technology.

**Keywords:** 3D printing technology; Feasibility study; Antiquities restoration

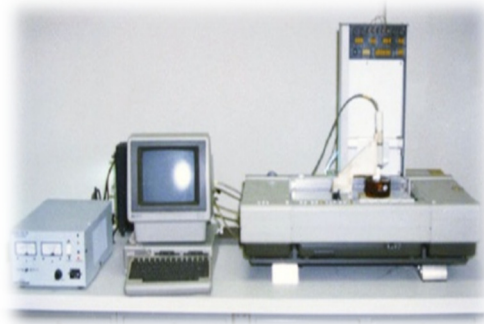
## 1 Introduction

After a long history, many cultural relics have been subjected to the baptism of time, and even some cultural relics have disappeared forever in the sight of human beings, leaving only a picture or written records for future generations to spread widely. Therefore, a new method of cultural relic protection has been inspired, that is, the restoration of cultural relics in the same proportion and with the same color is used for museum exhibitions to meet people's spiritual needs, while the original works of cultural relics are collected and preserved to protect their original state to the greatest extent. For example, to repair a damaged ceramic bowl, it is necessary to use 3D scanning technology to scan the ceramic bowl in all directions, and then import it into specific software for precise repair. After the repair, the missing parts of the ceramic bowl can be printed according to the model. Finally, the damaged ceramic bowl and the printed model can be bonded together. After a few steps, such as coloring and polishing, the final repair can be completed<sup>[1]</sup>.

## 2 Development of 3D Printing Technology

In 1986, scientists in the United States developed the first commercial 3D printer (shown in the first picture) for industries as diverse as aviation, aerospace, medical machinery and the construction and automobile industries. Then, in addition to the United States, some other countries, such as Germany, Switzerland and other countries also gradually joined the research

field of 3D printing. In China, 3D printing originated from university research, such as Tsinghua University, Huazhong University of Science and Technology and some other institutions of higher learning began to study 3D printing.



**Figure 1** The original 3D printer

### **3 Feasibility Analysis of 3D Printing Technology in Cultural Relic Protection and Innovation**

#### **3.1 The guiding role of national policies**

Ancient cultural relics will gradually become dilapidated over time and eventually even disappear, so our modern scientific personnel should make 100% copies of these cultural relics to meet people's spiritual pursuit. As a technician of cultural relics restoration, he can try his best to make a complete copy of cultural relics, but no matter what kind of copy method is used, the original appearance and posture of cultural relics should not be damaged in the copy process, which puts forward higher requirements for many methods of cultural relics replication and protection. However, 3D printing technology can meet the relevant requirements and standards. It can obtain the relevant dimensions and data of the cultural relic through its own scanner without touching the cultural relic, so as to completely copy the cultural relic with 3D printing technology without destroying the cultural relic.

#### **3.2 Demand analysis**

After all, the cultural relic has gone through the baptism of wind and rain for a long time, and it is very fragile. Meanwhile, it is also very rare and precious, so the original of our cultural relic cannot be moved and touched freely. 3D printing technology not only can these cultural relics are one hundred percent reduction and copied, and at the same time can also to those who have the gap or other proper reduction of cultural relics repair damaged, even for some related technology is very high level of technical personnel, they can also be on the basis of the original cultural relics are more meaningful second creation. Figure 2 shows the steps of 3D printing, which can reproduce the damaged cultural relics in equal proportions.

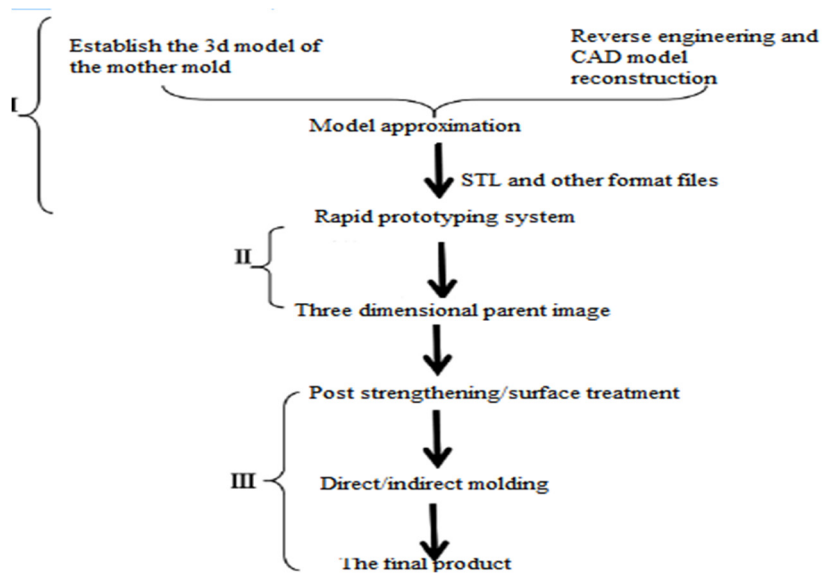


Figure 2 Basic process of 3D printing

#### 4 Basic Technology of 3D Printing

(1) FDM printing technology, namely melt deposition rapid prototyping, is the most common surface forming technology, common consumables are ABS, PLA, PC. The computer motherboard can control the heating nozzle of the printer, the nozzle moves in the horizontal direction according to the data of horizontal stratification, and then the transmission mechanism will send the consumables to the nozzle. After heating and melting, the consumables will be extruded and bonded on the surface of the workbench and then exposed to the air for rapid cooling and solidification. Once a plane is printed, the next layer is printed until the entire entity is printed<sup>[2]</sup>. Figure 3 shows the real object printed in the 3D printing laboratory.



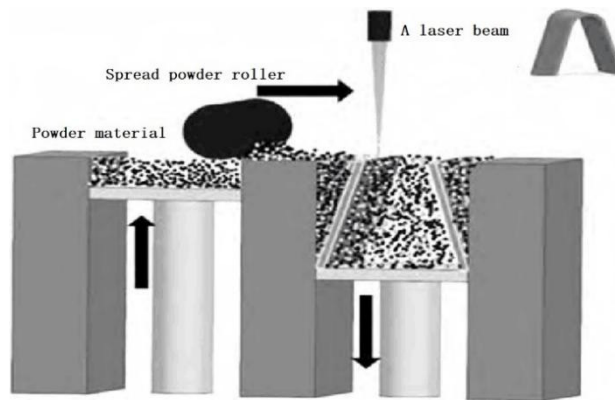
Figure 3 FDM print object

(2) SLA printing. Before printing, it is necessary to draw a 3D model in 3D software and save it in STL file format, and then import it into Red Rabbit software for slicing. It is necessary to pay attention to some disconnected island layers and establish appropriate support to facilitate printing. After the section is established, the printing begins, and the laser beam irradiates to the surface of the liquid photosensitive resin, which will rapidly solidify the resin in the area. In this way, the laser irradiation completes a layer of printing by connecting points into lines and spreading lines into planes. After the layer is completed, the next layer of printing will be continued until the printing of the whole entity is completed. The entity model printed by SLA is shown below. Figure 4 shows an enchanting cat printed by SLA method.



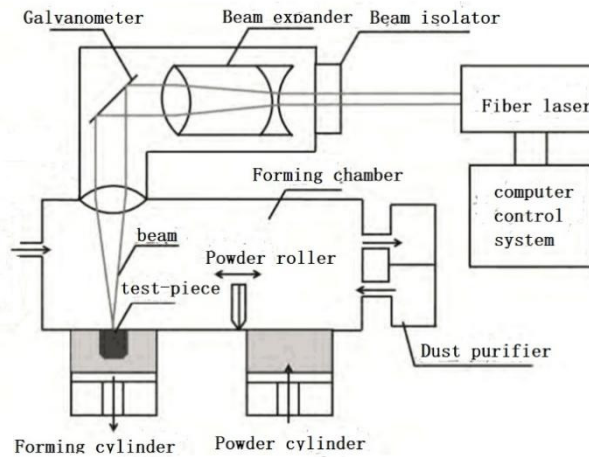
**Figure 4** Solid model of SLA printing

(3) SLS printing technology, namely selective laser sintering technology. The technology is mainly used for metal printing, the printing process is first by the roller will be a layer of fine metal powder evenly tiled on the surface of the molding room, the excess powder from the right side of the slide, followed by the roller back to the original position. The paved metal powder is heated to a certain temperature, and then the laser beam is controlled by the control system to sweep the surface irradiation, when the temperature of the powder rises to the melting point. At this time, the sintered ground plane can be bonded with the lower part of the entity that has been printed. When this layer is printed, the right workbench drops. One layer is raised one level to the left, so that the next layer can be printed again, a new layer of metal powder sintering, and so on until the whole entity is printed<sup>[3]</sup>. Figure 5 is the schematic diagram of SLS printing technology.



**Figure 5** Schematic diagram of SLS printing technology

(4) Selective Laser Melting Forming (SLM). Figure 6 shows the principle of laser selective melting. The basic principle of SLM is to use computer 3D modeling software to design the solid model of the part, and then slice the 3D model into layers with slicing software to obtain a series of profile data. After inputting appropriate process parameters, the laser scanning path is designed from the profile data. The computer control system will control the laser beam to melt the metal powder layer by layer according to the designed path, and pile it up layer by layer to form the solid metal part. The forming principle is shown in the following figure.



**Figure 6** Principle of Selective Laser Melting Forming

## 5 Analysis of the Advantages and Disadvantages of The Application of 3D Printing in Cultural Relic Protection

### 5.1 Advantages analysis of 3D printing

Additive manufacturing technology, also known as 3D printing, is different from traditional artificial restoration methods. Compared with traditional artificial restoration methods, additive manufacturing technology has the following advantages:

(1) Cultural relics can be protected from harm to the greatest extent. 3D printing can use the scanner to scan of cultural relics, the collection of cultural relics of 3D data, do not contact directly with the way for data acquisition, can be to reduce the damage of cultural relics in the largest extent, at the same time our 3D printing technology also need not to open mould of cultural relics, so compared with the traditional artificial repair method, The biggest advantage is that it can protect cultural relics well. The following picture shows an example of cultural relic restoration. Since this paper is used for teaching, in order to make students more clearly see that it is a restored cultural relic, the cultural relic is not embellished after restoration, but the real cultural relic is exactly the same color as the original entity after restoration. Figure 7 shows the restored cultural relic with high accuracy. After the coloring process, it can be almost the same as before the damage.



Figure 7 Cultural relics restored by 3D technology

(2) Can ensure high printing accuracy and efficiency. Its accuracy is very high. Our existing 3D printing technology can shorten the production period of cultural relics restoration and improve the production efficiency, so it can guarantee higher accuracy and efficiency compared with the traditional way of artificial cultural relics restoration. The accuracy of the dinosaur fossils after the following figure 8 is very high, and there is basically no difference from the non -repair part.



**Figure 8** Dinosaur fossils repaired by 3D printing technology

(3) More personalized customization can be made according to people's different wishes.

### **5.2 Analysis of shortcomings of 3D printing**

Under ideal conditions, 3D printing does have many advantages compared with traditional methods of manual restoration of cultural relics. However, 3D printing technology has not been widely used in the process of cultural relic restoration until now, and there are still some problems as follows<sup>[4]</sup>:

(1) The cost is too high. The materials used in 3D printing technology are ABS, PLA, graphite and other materials with relatively high cost. People still have to consider the price when purchasing or satisfying their spiritual needs. So price is also a major factor limiting the adoption of 3D printing technology.

(2) There are no strict standards. According to the current situation, 3D printing technology cannot follow a standardized, standardized and digital rules and regulations, so its management cannot be completely unified, which is also an important factor that makes 3D printing technology not widely used. This requires our country to introduce some corresponding policies and rules and regulations as a reference, so that 3D printing technology has a more standardized and standardized management mode.

## **6 Conclusion**

Although 3D printing has not effectively replaced the traditional manufacturing process in China, it has gradually entered various fields of China's industry<sup>[5]</sup>. Especially in the restoration, 3 d printing can be put into use, while from the point of the present situation, the technology still exist such as the limited price is high, the technology of some deficiencies, but believe that with the continuous development of science and technology in China, 3 d printing technology also will be more perfect and improve, to make it real occupies a place in the field of restoration.

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