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The Application of 3D Printing Technology in Medical Device Maintenance

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Abstract: *In the maintenance of medical devices, it is often necessary to replace damaged precision medical components. However, due to some components coming from imported medical devices, not only are they expensive to price, but there may also be no source of goods, which increases the difficulty and cost of medical device maintenance. To effectively solve this problem, 3D printing technology can be used to achieve the modeling and rapid printing of precision components, which is of great significance for improving the quality level of medical device maintenance. This article takes the practice of 3D printing technology in the field of medical device maintenance as the research object, and briefly introduces 3D printing technology and its advantages.*

Keywords: *Medical device maintenance; 3D printing technology; practice*

1. Introduction

3D printing technology has been widely applied in industrial product development, education and scientific research, medical and health care, architecture, military, art and other fields. In recent years, the application of 3D printing technology in the medical field has continuously expanded to customize specific surgical models, implants, prosthetics, and personalized surgical equipment. However, the application of 3D printing technology in medical equipment maintenance is relatively limited.

In daily medical equipment maintenance, it is common for maintenance difficulties to occur due to missing or high-priced spare parts. The advantage of 3D printing technology lies in its ability to manufacture complex items in a short period of time while controlling costs, making its value in medical equipment maintenance increasingly apparent. It can shorten maintenance time and maximize the recovery of losses caused by equipment damage to hospitals [1].

2. 3D printing technology and its advantages

3D printing is a rapidly developing emerging production technology in today's society. With the increasingly mature development of its technology, people's application of 3D printing technology has also penetrated into various fields of life. While experiencing the progress brought by new technologies, research and exploration of their technological development have also deepened, striving to tap into their greater potential and value. Therefore, a clear grasp of 3D printing technology is the foundation and prerequisite for fully utilizing its advantages.

Nowadays, 3D printing technology is classified as rapid prototyping technology, which is a general term for a type of additive manufacturing technology. The American Society for Testing and Materials defines additive manufacturing technology as the process of producing items based on 3D model data, using a layer by layer stacking method opposite to subtractive manufacturing technology. Usually, materials are stacked layer by layer through computer control, and finally the 3D model on the computer is transformed into a three-dimensional physical object. This is a leading technology for the development of mass manufacturing mode to personalized manufacturing mode. That is to say, 3D printing adopts a "layered manufacturing, layer by layer stacking" approach. Firstly, a 3D model is established, converted into an STL format that is uniformly adapted to the 3D printer, and then input for printing. The formation process of the product can be visually seen, and finally, the work is completed through post-processing[2]. As shown in Figure 1.

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Figure 1: 3D printer

From the perspective of processing methods, the currently mature technologies mainly include electron beam melting, direct metal laser sintering, selective laser sintering, laser deposition technology, melt layer deposition technology, 3D lithography printing technology, laser forming technology, 3D lithography ceramic printing technology, etc., which can directly or indirectly process various materials that meet the needs.

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Table 1: Common 3D printing materials and processing methods in the medical field

material	characteristic	Main processing methods	application
macromolecule	Strong plasticity and degradability	SLS,FDM, etc	Stents, bone shaping and repair, etc
metal	Good mechanical performance and high strength	SLM,LENS,dmls,EBM, etc	Mandibular implants, acetabular cups, etc
metal	Good wear resistance and biocompatibility	SLM, SLS, etc	Bioceramic coatings, artificial bones, etc
Biological tissues and cells	tissue engineering	SLA, FDM, etc	Breast implants, artificial tubes, etc

3. Analysis of Common 3D Printing Forms

The most obvious difference between 3D printers and traditional printers in terms of raw material output is that the material input by 3D printers is not ink, but real product raw materials, which are printed into layers of adhesive materials, ultimately forming a three-dimensional product. There are various materials currently used for 3D printing, with common ones including plastic, all metal, ceramics, rubber, etc. Some 3D printers can combine different materials to produce products with different properties. It can also be recognized that 3D printing can combine different printing materials to print products with different properties. For example, Israel's 0object company is currently the company with the most mastery of 3D printing materials. During the implementation of 3D printing technology, the company is able to freely combine 14 basic materials into 107 printing materials, giving 3D printing products more possibilities for production. There are four common 3D printing methods currently available[3].

(1) The form of "inkjet". By using a printer nozzle, a thin layer of liquid plastic material is sprayed

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onto the mold tray, which is then placed in an outdoor environment for further processing. The mold tray is then controlled to descend a very small distance to ensure that the next layer of printed material can continue to stack, ultimately successfully printing and stacking into a three-dimensional product.

(2) The three-dimensional printing form of "melt deposition molding". In this printing form, the main method is to spray some dissolved plastic through the nozzle, and then stack it to form a three-dimensional thin layer by depositing plastic fibers, ultimately achieving three-dimensional product production[4].

(3) Laser sintering 3D printing forming form. This type of printing mainly uses powder micro shoes as the printing medium, which are directly sprayed onto the mold tray by the nozzle to form an extremely thin powder layer on the mold. Then, it is laser melted and cast into a specified shape. Finally, the nozzle will spray some specific liquid adhesive to achieve material rounding and forming treatment.

(4) Using an electron flow in vacuum, the powder particles are grafted to achieve three-dimensional printing. However, for some complex product structures, such as products containing precision holes, some gel agents need to be added to the printing medium to make the material molding more stable. This part of the powder is generally not directly melted, and only needs to use water or air flow and other media to clean the support to form holes.

4. Application of 3D printing technology in medical device maintenance

In the field of medical device maintenance, most of the devices and equipment that need to be repaired do not have serious problems themselves. Most equipment malfunctions or abnormalities occur due to damage to some delicate and small parts and components. Some original components have extremely exquisite structures, high prices, and scarce supply, which greatly increases the maintenance cost and difficulty of medical devices. To address this issue, 3D printing technology can be applied to medical device maintenance. By utilizing 3D printing, it is possible to quickly produce the necessary parts and components for maintenance work, thereby effectively reducing maintenance costs and further improving maintenance efficiency and quality[5].

At present, there are three main types of 3D modeling techniques: first, parametric modeling techniques; Secondly, wired frame model technology; Thirdly, entity modeling technology. The application of parametric design in medical device maintenance can effectively improve maintenance efficiency. So parameterized modeling can be applied to damaged components to obtain corresponding 3D data: (1) This provides certain convenience for later printing with the help of 3D printers. For the design of 3D medical device components, it is necessary to have a certain degree of flexibility. After the model design is completed, in addition to ensuring the practicality of the model, it should also be able to quickly reconstruct and ensure that the component information has a certain degree of reusability. Therefore, in the process of modeling medical device components, the most applicable technology is parametric modeling technology. When carrying out parametric design, designers can fully combine their own design concepts and intentions. After the preliminary outline of the design sketch is completed, the computer system is used to construct the constraint relationships between various design elements in the design object. This ensures that when designers update the sketch parameter information, the system can automatically synchronize the information and obtain the actual position distribution information of geometric feature points[6].

Analysis and modeling practice: In this parameter modeling, Solid Works modeling and design software was used, which has significant advantages, mainly including high compatibility and simplicity. The main object of this modeling is the injection pump spare parts of a certain imported brand. In practical application, this injection pump often suffers from medical device damage due to improper operation by the user or other factors. For example, due to falling, the push rod movable slot of the injection pump breaks, which affects the normal use function of the injection pump to varying degrees. To effectively solve the problem of fracture in the movable slot of the injection pump, we will design a model sketch to replace the spare parts based on the actual usage function of the injection pump. At the same time, we will use a vernier caliper to accurately measure the relevant parameters of the model, and use SolidWorks modeling and design software to achieve the modeling of spare parts. Then, with the help of FDM 3D printing technology, the printer for spare parts is produced. The specific operation process is as follows[7].

Firstly, after designing the 3D model of the injection pump movable card slot, the designed 3D

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model should be promptly converted to STK format to provide convenience for subsequent 3D printer recognition. Next, load the 3D model of the movable slot of the injection pump push rod into the upper computer control software to achieve the slicing production of the model. After slicing, the 3D model of the active card slot will gradually form layers of stacked 2D planes, and there will be significant running trajectories in each 2D plane, providing certain convenience for nozzle recognition and printing of spray images.

Secondly, for the card slot model that has already been modeled, its stress should also be analyzed. For example, for the injection pump in this case, the needle blockage pressure measured by FLUKEIDA4PLUS infusion equipment analyzer 8 can be used to convert the push rod pressure to 500mmHg, and then the push rod pressure is 47N. During the assembly process of spare parts, the back end bottom surface of the card slot model should be fixed on the injection pump. Therefore, when conducting stress analysis work, the back end bottom surface of the model should be used as the fixed surface, and the card slot of the fixed needle tube should be used as the force bearing surface. After calculation, it was found that the position where the push rod bears the maximum pressure is at the connection between the middle and back ends, with a pressure value of 82N. Thirdly, in the stress analysis work, the back end bottom surface of the model should be used as the fixed surface, and the card slot of the fixed needle tube should be used as the force bearing surface. After the analysis work is completed, the computer and FDM 3D printer should be connected, and then the sliced EODE code obtained by the previous computer should be transmitted to the main control board of the printer, which will analyze the code Read the code, convert it into corresponding model printing instructions, and use the X, Y, and Z axes as directions to control the printer in linkage, ensuring that the printing nozzle can carry out printing work according to the set running trajectory. In this process, the temperature of the heating sleeve should be raised to 230 ℃, and a wire extrusion motor should be used to squeeze the solid ABS engineering plastic wire into the heating sleeve, allowing it to melt quickly. At the same time, it should be sprayed out of the printer nozzle, and the stacking printing work should be carried out according to the specified trajectory. The melted plastic wire will be stacked and formed in a short period of time, tightly adhering during the gradual solidification process, and finally forming a three-dimensional material model to achieve the printing and production of components[8].

Fourthly, after completing the printing of the components, remove them from the forming table and fix them on the bottom surface of the rear end. At the same time, apply a thrust of 82 N to the card slot. At this time, it was found that the card slot did not show any signs of breaking, indicating good quality of the printed components. Therefore, in actual 3D printing, selecting 30% of the filling amount can meet the actual printing stress requirements.

5. Summary

In summary, compared with traditional industrial manufacturing technology, 3D printing technology has significant advantages. It not only has higher manufacturing efficiency and lower production costs, but also has more flexible and versatile material combinations, which can be used for complex fog component manufacturing. Therefore, it is very suitable for the maintenance of medical machinery and equipment. It can print out the parts required for medical equipment maintenance in a short period of time, effectively improving the efficiency of medical equipment maintenance and reducing maintenance costs. It can be foreseen that 3D printing technology will have very broad application prospects in the field of medical machinery and equipment maintenance.

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