The Design Research Analysis of 3D Printer Based on FDM

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Abstract. With the great breakthrough of 3D printing technology, it has been widely and deeply applied in the industrial field. 3D printing technology and the Internet of things jointly build an organic intelligent industrial system. The 3D printer using FDM technology can significantly improve the printing accuracy, reduce the processing difficulty of complex parts and make the maintenance and operation process of 3D printer simpler. Based on this, this paper first analyzes the technical principle and characteristics of 3D printer, and then studies the classification and technical classification analysis of 3D printer; finally, it gives the design of 3D printer based on FDM.

Keywords: 3D Printer, FDM, Social Medicine, Control, Structure

1. Introduction

With the iterative development of social economy and the continuous improvement of science and tech, the current manufacturing industry has also made great progress [1]. In this context, 3D printing tech has made a great breakthrough and application. Its application in the industrial field greatly shortens the manufacturing cycle of products, reduces the demand for materials, and makes the manufacturing cost of products greatly reduced. It can be seen that the application of 3D printing tech can significantly improve the market competitiveness and core position, and based on this, the tech has been more in-depth research and application. On the other hand, with the development of industrial Internet of things tech, 3D printing tech and the Internet of things have jointly constructed an organic intelligent industrial system, which makes it possible for personalized product customization, efficient product production and information-based fact control. The application of 3D printer saves cost to a great extent, and gradually develops into consumer electronic products for the public, so it has a wide range of market development and application prospects.

In order to further reduce the manufacturing cost of 3D printer, the development of 3D printer based on Fused Deposition Modeling (FDM) tech has been studied deeply. The application of FDM tech in 3D printer can further optimize the structure of printer, reduce the cost of manufacturing and application, and simplify the maintenance and operation process of printer. Therefore, the 3D printer based on FDM has achieved rapid development, and has been widely used in desktop level.

In addition, the 3D printer based on FDM tech can significantly improve its printing accuracy, reduce the processing difficulty of complex parts, and can process complex parts that cannot be processed by traditional tech [2]. The 3D printing and forming equipment of FDM tech has laid a
certain foundation for the realization of more efficient printing and the gradual development towards the market, and has become the production development direction of manufacturing enterprises. In a word, the development of 3D printer based on FDM tech plays an important function in promoting the competitiveness and level of several aspects as shown in Figure 1 below. Therefore, the research on the design of 3D printer based on FDM tech has important practical value.

![Figure 1](image1.png)

**Figure 1.** Application area of 3D printer based on FDM tech.

2. Technical principle and characteristics of 3D printer

2.1. Technical principle of 3D printer

3D printing tech is based on the discrete analysis of CAD data to obtain the constraints, paths and methods of stacking. The 3D solid model is formed by stacking and stacking materials. Based on the principle of discretization and stacking, 3D printing tech is a kind of laminated manufacturing tech. 3D printing tech makes the reduction of material into three-dimensional printing, and changes the three-dimensional entity into two-dimensional plane, which reduces the manufacturing complexity. Secondly, it is especially suitable for the rapid verification of complex structure, personalized manufacturing and innovative ideas, and has the outstanding characteristics of wide forming materials and excellent parts performance. In addition, 3D printing tech integrates the integration and organic construction of computer, 3D design software, machinery, control, network information and other interdisciplinary subjects. The schematic diagram of 3D printing tech is shown in Figure 2 below, which shows that the printing process involves the conversion of 3D-2D-3D.

![Figure 2](image2.png)

**Figure 2.** The schematic diagram of 3D printing tech.
2.2. Typical technical features of 3D printing

First of all, 3D printing tech provides the driving force for innovation in industrial manufacturing. 3D printing expands the space of product creativity and innovation, without any fixture, and integrates design and manufacturing [3]. That is, design is no longer constrained by traditional tech and manufacturing resources, focusing on product form innovation and function innovation. The application of 3D printing can make the design of parts adopt the optimal structure design, without considering the processing problem, and solve the manufacturing problem of high-end complex and fine structure components. Secondly, 3D printing greatly reduces the cost of product development and innovation, shortens the cycle of innovation and development, and improves the first-time success rate of new product production, which is conducive to the implementation of concurrent engineering.

In addition, 3D printing tech can improve the process capacity of industrial manufacturing. 3D printing tech can integrate multiple parts into a whole, so as to reduce the number of parts, simplify the subsequent assembly work, and further improve the safety and reliability of products. 3D printing breaks through the geometric constraints of structure and can produce unconventional structures, which helps to achieve lightweight parts and optimize performance. 3D printing improves the machinability of difficult to process materials and expands the engineering application field, especially the engineering application range of high-performance materials [4]. Finally, 3D printing tech contributes to the green and sustainable development of industrial manufacturing. The typical characteristics of non-contact and non-pressure forming of 3D printing tech can save materials and reduce pollutant emission in the processing process, which is helpful to realize the repair and remanufacturing of complex parts and save resources and energy.

3. Classification and technical classification of 3D printers

3.1. Classification of 3D printers

3D printers can be divided into selective laser sintering (SLS), light curing molding (SLA), three-dimensional powder bonding (3DP) and melt deposition rapid prototyping (FDM) based on their different working principles and mechanical structures. The characteristics of these types of 3D printers are shown in Table 1.

| Types   | Print materials     | Molding characteristics                      |
|---------|---------------------|----------------------------------------------|
| SLA     | ABS, PLA            | Low material requirement, easy operation and high speed |
| SLS     | Photosensitive resin| High forming speed and high surface precision |
| 3DP     | Metal powder materials | High forming speed and can print color parts |
| FDM     | Metal powder        | High strength of molded parts                 |

3.2. Technical classification and analysis of 3D printers

The technical classification of 3D printers mainly includes stereolithography (SLA), laminated sheet fabrication (LOM), selective laser sintering (SLS) and fuse deposition forming (FDM). Among them, SLA is one of the most widely used high-precision forming tech, which uses a little laser irradiation to solidify the liquid resin [5]. SLA is a widely used high-precision forming process by means of curing liquid resin by laser irradiation, as shown in Figure 3. LOM uses laser to cut the foil. The foils are melted and bonded by hot melt adhesive under the pressure and heat transfer of the hot pressing roller, the prototype is fabricated layer by layer.
Figure 3. High-precision forming process of SLA. In addition, the powder material is sintered point by point by laser, so that the solid adhesive coated on the powder material or the powder material itself is melted to realize the material bonding. FDM is made of filamentous thermoplastic material, which is continuously fed into the nozzle, heated and melted in it and extruded from the nozzle, and then gradually accumulated [6]. The 3D printer based on FDM tech is designed on the basis of function block. Through the combination and assembly of simple parts, a subsystem with specified functions is formed, and then the subsystems are integrated to form a complete system, which reduces the complexity of the overall design of the system, and is convenient for debugging and maintenance after putting into operation. Figure 4 shows a 3D printer architecture using FDM tech.

Figure 2. 3D printer architecture using FDM tech.

4. Design of 3D printer based on FDM

4.1. Structure design of 3D printer based on FDM Tech
The structure of 3D printer based on FDM tech includes extrusion, wire feeding, transmission and working platform, which belong to different functional module systems of printer, such as mechanical, control and software systems. First of all, in the design level of the nozzle extrusion mechanism, the plunger mechanism is selected as the extrusion mode of the printer nozzle extrusion mechanism, because the mechanism is simple, easy to maintain and it can meet most of the printing demand scenarios. In order to improve the stability of the printing structure, it is necessary to fill the inside of
the print. Secondly, it is necessary to confirm the number of nozzles in the extrusion mechanism, and ensure that the size meets the requirements of the printing process and it avoids the adverse effect of the size parameters of the heater inside the nozzle on the motion characteristics of the molten silk. In addition, in the arrangement of the three nozzle extrusion mechanism, the use of a zigzag arrangement can improve the flexibility of the mechanism and the simplicity of the program.

4.2. Finite element analysis of 3D printer components
The transmission mechanism of 3D printer will have a key impact on the positioning accuracy and dynamic characteristics in the working process. In order to eliminate the adverse effects, it is necessary to enhance the strength and stiffness of the transmission mechanism. The finite element analysis can improve the design optimization of its stiffness and strength, the analysis process is as follows: firstly, it is necessary to carry out three-dimensional modeling of the transmission mechanism, and import the model into the finite element software for solid modeling. In this process, it is necessary to simplify the mechanism, so as to make the calculation process more convenient and efficient, reduce the amount of computing resources and improve the operation efficiency. In addition, in the printer's radiator structure and temperature field analysis and optimization level, the annular heat sink structure, adjust the nozzle external heat sink parameters, and realize the system heat dissipation optimization.

4.3. Analysis of 3D printer control system
Firstly, the control flow design of 3D printer based on FDM tech mainly includes slices control flow and work control flow. Secondly, in the level of servo control system, the stepper motor is used to achieve a wide range of speed and better overload, to achieve the optimization of the whole machine structure. In addition, in the level of temperature control system, it is necessary to consider the adverse effects caused by external environment, nozzle moving speed, wire material phase change in the nozzle and other factors, so it is necessary to use temperature acquisition elements combined with control algorithm to achieve accurate control of temperature control system.

5. Conclusion
In summary, the application of FDM tech in 3D printer can significantly improve its printing accuracy, reduce the processing difficulty of complex parts and process complex parts that cannot be processed by traditional tech. The 3D printing and forming equipment of FDM tech has laid a certain foundation for the realization of more efficient printing and the gradual development towards the market, and it has become the production development direction of manufacturing enterprises. This paper studies the technical principle and characteristics of 3D printer. studies its technical principle and advantages. Through the analysis of 3D printer classification and tech classification, the classification and tech classification of 3D printer are studied. Through the research on the design of 3D printer based on FDM, the structure design, finite element analysis and control system design of 3D printer based on FDM tech are analyzed.

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