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Design of 3D Metal FDM Printing Nozzle Based on Melt Forming

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In view of the existing 3D printer of low efficiency and poor precision and expensive raw materials and other issues, in-depth analysis of the working mechanism of the 3D printer, the design model based on Fused Deposition Modeling (FDM) technique 3D printer, put forward three nozzle extrusion mechanisms, improve the shortcomings of the current 3D in the printer. According to the function of each part of the mechanical structure of different 3D printer modules, respectively to study the extrusion mechanism, feeding mechanism, servo system and temperature control system, and also carry on the simulation analysis of nuclear structure. The components of FDM technology based on 3D printer design and assembly, to provide the model simulation analysis of the 3D printer and 3D printer for further improvement; the core institutions (extrusion mechanism) and the structure of clever design, developed three nozzle extrusion mechanism, piston pump type extrusion mechanism and slide pump type extrusion mechanism of 3D; the printer bearing stiffness and strength properties of parts are analyzed, the reliability of the mechanical structure design Inspection Institute; fluid simulation analysis of the extrusion mechanism, simulation of internal fluid 3D when the printer is working mechanism of the actual movement situation, verify the feasibility of the three nozzle extrusion mechanism; research on the flow control of 3D printers, collaboration process analysis 3D printer work extruding mechanism, feeding mechanism and servo mechanism, ensure that the 3D printer Stability of work.

1. Introduction

With the development of Du, the development of the field of processing and manufacturing is improving, the product competition is more and more intense, shorten the development cycle to accelerate the design of the products become a big competitive advantage in the manufacturing industry. However, because of the limitation of the equipment itself, the design and processing of the material parts have a strong correlation, sometimes because of the processing technology and other factors affect the function of the parts CAD (Wu et al., 2016). As the two technical indexes satisfy the forming speed of the work piece surface molding precision and work piece, breaking the traditional layered design of nozzle and different diameter, different height of the work piece forming print; new hierarchical design of work piece surface formed by small diameter nozzle print, work piece support and auxiliary support with internal nozzle diameter print (Ji et al., 2016). A typical 3D printer nozzle schematic is shown in Figure 1.

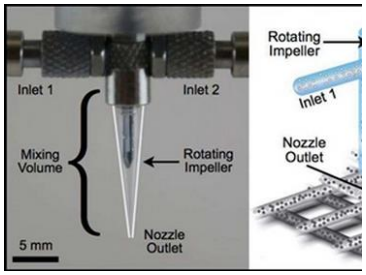

Figure 1: Schematic diagram of a typical 3D printer nozzle

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2. 3D printing principle introduction

2.1 Basic principles overview

We use in our daily life of the ordinary computer printer can print the design of planar items, and the so-called 3D printer and ordinary printer working principle is basically the same, just some different printing materials, printing material is ordinary printer ink and paper, and 3D printer equipped with metal, ceramic, plastic, sand and other different print materials that is real in the raw materials, the printer is connected to the computer, can the print materials layer superimposed by computer control, finally put the computer into a physical blueprint (Zhao, 2016). PC-ABS material is one of the most widely used thermoplastic engineering plastics, used in automotive, home appliances and communications industry. That is, UV resin, composed of polymer monomer and prepolymer composition, which add light (Zi Waiguang) initiator (or photosensitizer). At a certain wavelength of ultraviolet (250-300 nm) irradiation immediately caused polymerization complete curing. Generally liquid generally used to produce high strength, high temperature resistance, and waterproof materials. In three-dimensional printing technology, raw materials only for the production of products needed, using three-dimensional printing technology, and his team produced more delicate parts of the light. When the material has no production restrictions, it can be optimized to achieve its function, therefore, compared with the parts manufactured by the machine, printed products weigh 60% light weight, and the same firm. 3D printer structure schematic shown in Figure 2 and 3. The STL format is a simple method to store the information of the 3D model; it will be complicated in a three-dimensional digital model of a series of triangles to approximate expression. STL model is a space closed, bounded, regular only expression of the object model, with point, line, surface geometric information, can be input to the material manufacturing equipment for rapid production of physical samples (Zhang, 2016).

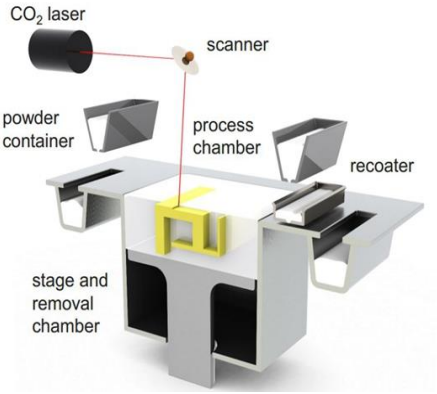

Figure 2: Schematic diagram of 3D printing principle

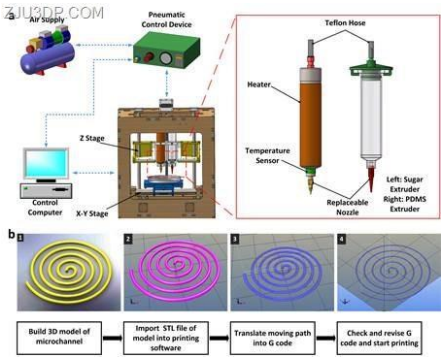

Figure 3: Schematic diagram of the principle of 3D print head

2.2 Design of three nozzle extrusion mechanism for 3D printer based on FDM Technology

Extrusion structure as the 3D printer molding part of the execution, the design of the rationality will directly affect the printing product forming quality W and machine service life. The extrusion mechanism mainly comprises a nozzle, pipe, thermocouple, temperature heating rods, heating and cooling device of lead W.

Based on FDM technology 3D printer working way is a hierarchical way to print. First of all, to the work piece model slicing by slicing file and print the next process, as shown in Figure 4 for the existing FDM technology based on 3D slice printer (Zhu et al., 2015), print the internal support layer thickness and surface thickness were using the same numerical method in this algorithm and trajectory path planning is simple and it is easy to realize, but the actual analysis, found the method to control the thickness of the way simply to give a certain pressure through the nozzle material extrusion, the extruded material is leather to a flat shape, the outer surface of the object molding thickness, if the printing target has the characteristics of thin-walled, 3D printer to achieve processing requirements. At the present stage, a new slicing algorithm and trajectory path planning method are proposed to solve the problem of pressure expansion after extrusion. Therefore, based on the above, the nozzle design of extrusion mechanism, respectively with different wire diameter of the nozzle work piece surface, the internal support and auxiliary support programmes. As the auxiliary support and internal support molding on molding thickness is not too high, so the nozzle diameter corresponding to both nozzles are 0.4mm. In contrast to the proposed algorithm the nozzle outlet diameter responsible for surface molding should be 0.1mm or 0.2mm. By comparison, the thread outlet nozzle diameter of 0.2mm nozzle in the machining accuracy is higher than that of 0.1mm, and the nozzle diameter of continuous screw extrusion of 0.2mm nozzle is better than wire diameter of 0.1mm. To sum up, the diameter of the three nozzles are: 0.2mm, processing work piece surface: 0.4mm, machining auxiliary support: 0.4mm, machining internal support. Piston type extrusion mechanism comprises a nozzle, heating, heating, heating pipes, lead cavity W and temperature thermocouple, the mechanism of the piston forward, with solid wire for the piston, through the 42 step motor for wire transmission, with body wire for the fluid to be pushed, will melt state through material extrusion nozzle. The traditional extrusion mechanism, because the molten wire has a certain viscosity, the residual wire often in the channel and the heating cavity area, resulting in extrusion mechanism blockage, affect the print quality, and because the wire diameter is smaller than the pipe diameter, poor sealing performance, easy to appear out of question. According to requirements, the extrusion mechanism will use 3 stepper motor as a tired power source. According to the relevant parameters (Wang and Tian, 2016), extrusion mechanism adopts 35 step motor to reduce the burden of motor weight. Sliding vane spring explosion view as shown in Figure 4, sliding vane flow extrusion mechanism schematic shown in Figure 5.

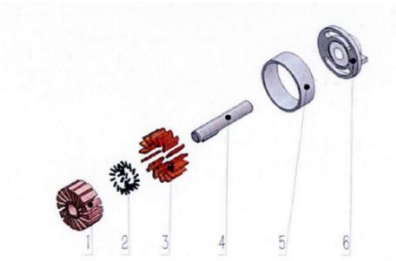

Figure 4: Sliding sheet extrusion spring explosion view

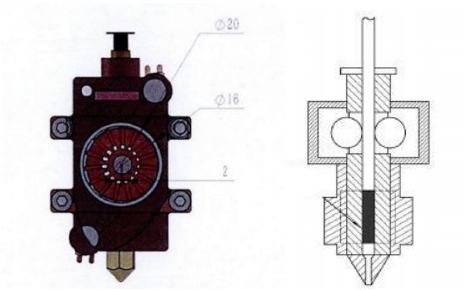

Figure 5: Schematic diagram of sliding vane pump extrusion mechanism

2.3 The selection and arrangement of the three nozzle extrusion mechanism design scheme of the

The characteristics of fluid pump are by adjusting the pump rotor speed to control the flow of the millet, the flow tends to be stable. Through the design of the pump body is added in the extrusion mechanism, can improve the extrusion mechanism outflow problem, at the same time, by reference to the pump body, extrusion mechanism flow can be precisely controlled, to ensure the stability of the output material, improving the forming quality (Chen and Jia, 2015). Analysis of the existing FDM technology based on 3D printer printing

process, wire feeding mechanism work on the wire conveying speed can be W through the program for precise control, to ensure stable extrusion. When designing the wire feeding mechanism, the design scheme should be combined with the extrusion mechanism. In the extrusion mechanism, because the 42 step motor weight is 0.5kg, nozzle and diffuser, gas pipe, iron dragon, lead and lead fixed heating rod a total weight of 0.3 kg, the overall weight of the final design of the extrusion mechanism for 85 kg. Without considering the support under the condition of a single head loading time loading bar extrusion mechanism for 0.8kg, while loading the H head extrusion mechanism, load bearing bar is 2.4kg, compared with single head extrusion mechanism, the mechanism of the similar parts total weight of 3 times of the former; compared with the double extrusion mechanism, this mechanism the similar parts of the total combined weight is 1.5 times of the former. Therefore, the two kinds of wire feeding mode combined with two distal motor wire feeding, a motor still retains the proximal feeding way, reduce the burden of waste light but also to ensure the normal work of the extrusion mechanism.

3. Extrusion device design

3.1 Design of 3D printer heating device based on FDM Technology

By consulting the relevant information, ABS material melting temperature of 220°C, PVA material melting temperature is about 240°C. According to the characteristics of the ABS material, when the heating temperature reaches 240°C, continues to heat up, will cause the ABS thermal degradation, the melt viscosity increased, is not conducive to the cable material extrusion pumping, and the mechanical properties of parts will decline. In addition, ABS plastics containing butadiene, when the temperature is high, some plastic particles will not adhere to facilitate cleaning in the heating cavity flow, ABS solid particles when in continuous high temperature environment adhesion to degrade or carbonation, will eventually become coke yellow or brown particles, with the flow of wire adhesion to the work piece the print, and it is not convenient for later processing. Therefore, in order to ensure the molding quality, ABS wire heating temperature will be controlled at 230°C, PVA wire heating temperature stable at about 240°C. Now the 3D printer heating device on the market is mainly composed of a heating rod (tube), temperature and heating block thermocouple. The heating rod acts as the heat source of the heating device, and the heating block acts as a heat conducting function to disperse the heat source heat distribution so as to make the wire material heat more evenly and avoid excessive heat accumulation. To detect temperature galvanic heating temperature of feedback regulation effect on control system, heating temperature of heating rod, the overall heat adjustment of heating device. The commonly used metal, gold and silver thermal conductivity is highest, but its material cost is too high, so do not consider the thermal conductivity of copper processing materials; ranked second, but the process is not easy, and the heat itself when the heat is not easy to export, easy to become a hidden heat source; thermal conductivity and heat dissipation performance in pure copper after the wrong hardness is insufficient, it is difficult to machining, so do not commonly used materials. In order to play the heat conduction and the companion teqiao and copper hardness and thermal conductivity, so commonly used as alloy material pot heating block, heating mechanism diagram as shown in Figure 6.

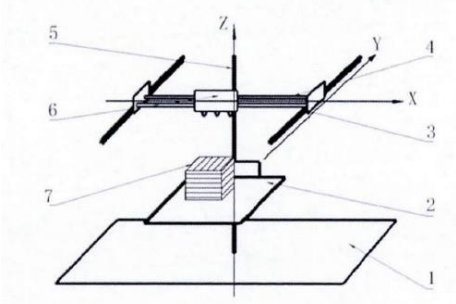

Figure 6: Schematic diagram of heating mechanism

3.2 Design of nozzle feeding mechanism

The servo motor has a pulse function, when receiving a pulse; the motor will rotate a certain angle, and then generates a pulse of a certain number of the pulse echo and the received pulse forming motor, closed-loop control system. Through the motor rotation W can achieve a more accurate positioning - the normal working state servo motor can reach the highest accuracy of 0.001mm. Stepper motor can generate electric pulse signal into angular displacement or linear displacement, belonging to the open-loop control unit stepper motor. In normal operation, the motor speed and stop position are determined by the frequency of pulse signal and

the number of pulses, and it has nothing to do with the change of load. Stepper motor due to the speed and pulse frequency is proportional, so by controlling the pulse frequency can be achieved motor rotation speed regulation, wide speed range. Nozzle feeding mechanism design schematic shown in Figure 7. According to the characteristics of the control system, the closed-loop control system, the control precision is higher than that of the control accuracy of servo motor stepper motor servo motor, but because itself has the function of a pulse, so the motor structure, the servo motor is more complex than the stepper motor, the processing cost is higher, it will not help to reduce the manufacturing cost of 3D printers. In addition, the servo motor is greater than the size of stepping motor dimensions, and put forward the idea of miniaturization is inconsistent; therefore, in the form of motor, the power source design will make the printer of the stepping motor as driving mechanism (Ye and Chen, 2016).

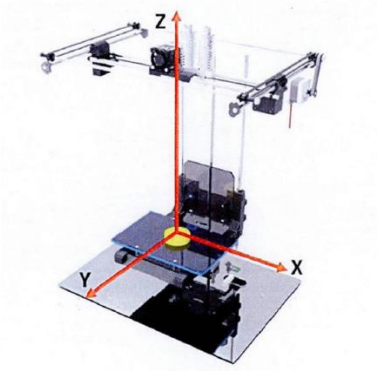

Figure 7: Schematic diagram of nozzle feeding mechanism

3.3 Fluid mechanics design of sprinkler head

The flow patterns of molten wire in the basin are analyzed. Entrance due to the propulsion of solid state equipment to melt the silk material extrusion effect makes melt silk along the channel down the whole. In the process of flow, because the melt always moves along the pipeline, the expansion of the extrusion does not affect the overall movement trend, so the whole melt filament flow belongs to the laminar flow in the viscous flow. According to the temperature change, there are two stages of heating and insulation in the whole analysis process. In the heating phase, the overall temperature (energy) of the analysis object is in a state of change, and the flow velocity changes with the melting degree of the silk. When in the holding stage, because the mechanism through the program control W and external heating radiator to reach thermal equilibrium in the working temperature, the overall temperature in the working temperature maintaining mechanism, but there are small fluctuations, because both cannot be completely stable, W using non steady form to solve. Due to the relatively low flow rate of the extrusion mechanism, the prime mover must cooperate with the reducer to reduce the pump speed. In order to ensure the whole mechanism of miniaturization, satisfy the processing conditions of sliding vane extrusion fluid flow injection process of chestnut, the rotor blade motion, fluid dissipative phenomenon, consider dissipative problem analysis. In order to realize the normal work of 3D printer, the whole control process should be set. First need to slice file loading parts, printers start working first on the extrusion mechanism and working platform for the initialization settings, for preheating plate and extrusion mechanism, to set a good numerical model of the work piece after printing, the 3D printer in the working process of the temperature control system can adjust real-time monitoring of temperature change and ensure temperature stable working temperature in the desired range. Each finished printing a layer of work piece model, screw motor is driven by the platform down a thick layer of distance to the next layer of print, the whole process control system will ensure the printer in the process to complete the work until the work piece model printing.

4. Print head actual verification

Based on FDM technology 3D printer, its heating part is mainly located in extrusion mechanism and heating platform, play the role of heating solid wire material and heat preservation. Heating is mainly made of heating rod and hot bed, temperature control is controlled by temperature controller and thermocouple. The heating bed is the key parts in the workbench, the heating bed FDM 3D printer technology work should be kept in a certain temperature to avoid extrusion wire in contact with the work table based on coincidence due to the temperature difference is too large to have been influencing quality of work pieces with large deformation. Therefore, it is necessary to control the heating bed temperature and heating, W improve the molding

precision and forming quality. The output is two small relays, control heating and stop. When the temperature sensor detects changes in temperature will cause voltage changes, the operational amplifier and the set temperature comparison, when reaching the set temperature will cause the relay off, stop heating equipment. After the analysis of design and Simulation of the virtual model, finally develop a suitable processing scheme, and according to the model, the drawing design style of structure, size of the entity processing, as confirmed by the final design feasibility of FDM technology based on the structure of the 3D printer (Liu et al., 2014), choose a more complex machining, sliced file of silk box will be generated by the SD card and save on a 3D printer for loading and executing. Through actual operation, the final print out the object shown in Figure 8.

Figure 8: Print head test results

5. Conclusions

New technology is designed in this paper, using different diameter nozzles in different stratification height respectively on the surface of printing pressure molding, the internal support and auxiliary support of the work piece, and effectively improve the printing speed and work piece surface printing precision, three nozzle design of extrusion machine structure, the conception of new layered technology, the small diameter nozzle diameter, nozzle print work piece surface fire support and auxiliary support within the print job, improve work piece surface printing precision and shorten the time of work piece work piece printing; auxiliary support printing and the work piece surface is formed by the different diameter nozzles for printing, to facilitate the removal of the late auxiliary support. According to the internal melt extrusion mechanism for fluid analysis, the temperature field and velocity field simulation, determine the different materials of the wire, at the appropriate temperature range to ensure the extrusion mechanism of wire stability, and improve the forming precision of the work piece.

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