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Nozzle Problem Analysis and Optimization of FDM 3D Printer

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Abstract. 3D printing is widely used at present. In terms of technology is gradually mature, but there are still many problems and shortcomings of 3D printing, especially in the design of printer nozzle. In the 3D printer smart devices continue to affect the market conditions, all kinds of problems appearing in the work are to be solved. This paper analyzes and optimizes the printing model collapse, cracking, nozzle clogging and wire drawing which are easy to appear in FDM 3D printer nozzle, and puts forward some measures for improving the feasibility.

Introduction

Fused deposition (FDM) type 3D printing technology is a kind of efficient solid molding technology, the basic working principle of this type of printer is after slicing the computer data, in a relatively short period of time, encoding by computer generated 3D model on the real thing are processed and analyzed. After slicing into a two-dimensional planar graph, namely solid planar contour, using the general layer increasing material-cooling technology, when the wire feeding mechanism will print raw materials delivered to the nozzle and the high temperature of the melt, namely printer nozzle print, print steps will need objects directly in the print reference surface layer printing manufacturing [1]. It is also because the layered printing of the model is based on the cooling of the upper layer, and whether the printing of the next layer can be completed smoothly depends on whether the printing of the upper layer meets the requirements.

Structure and Function of Nozzles

The nozzle is the core components of the printer to complete the fused deposition modeling, according to the requirements of the different printing can choose single or double spray nozzle, the nozzle is a common problem, so the choice of single nozzle are analyzed and explained, the nozzle structure of FDM type rapid prototyping equipment generally includes structure control device, a feeding mechanism, throat cooling unit, cooling device, pipe assembly and nozzle hot end components [2].

3D printer, solid material wire nozzle in the interior of the whole working process is: first, control device to control the signal feeding mechanism, refrigeration equipment and hot end components, solid material into the wire feeding mechanism and feeding mechanism is the molten material from the feed inlet to the transmission cylinder and the materials in accordance with the feed rate into the pipe cooling module set, pipe cooling assembly for cooling pipe assembly, then pipework components hot end components and the nozzle throat cooling component is connected with the thread structure, and the structure and function of nozzle hot end components is that will print the heating materials, the material from solid wire as the molten state.

In this paper, the problems and shortcomings of the hot end components of the nozzle valve needle and nozzle are analyzed, and then the structure function is improved. The following is the structural framework of the sprinkler nozzle:

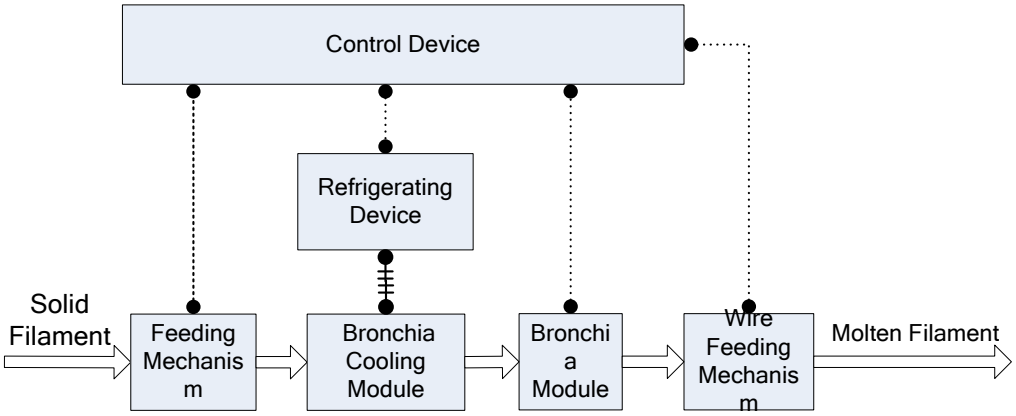

Figure 1. Structure of sprinkler nozzle

Nozzle Problem Analysis and Design Improvement

Model Collapse, Cracking and Solutions. The model of FDM type 3D printed on the printer, by way of the printed layer by layer model, when the cross-sectional area changes too quickly, or when a part of the cross-sectional area is too small, especially the cross section of the bottom of the model is too small, so it is very easy to cause the collapse of print model [3]. The collapse phenomenon appeared in the process of printing, This paper proposes the following solutions: making models before the first control action program of printer was improved, the main improvement is the pre-processing software program, the first to set up a model of maximum slope value and minimum cross-sectional area values, when the computer in the setting of the unilateral range, generating section after the printing process when reaching the critical range, to generate the actual processing path in programming, will free model dynamic adding auxiliary plane. The auxiliary plane added in the model in external, will not affect the results of the original model of the print, so in the production model, by the following layer printing a layer contains two parts, namely the model part and the auxiliary part, the two part of the production is completed, has reached a stable cooling model in the upper layer, stable printing, deformation and collapse will improve the model to a large extent, these problems are obviously improved compared to the past [4].

For the model of cracking, the actual printing, the volume of the model is too large or a direction of length is too long, the model may crack during the printing process. This is because the FDM type printer to realize solid liquid - solid change process in the accumulation layer when the solid model. The key problem lies in the liquid in the nozzle is extruded, depends on the cooling conditions in a layered printing solidified into a solid, and accumulated as the three-dimensional model of the shape of some [5]. At this time due to material affected by the physical factors of expansion and contraction, so it is easy to produce a certain degree of deformation of the solid model from the liquid cooled, and the solution is for printing products with different shrinkage optimal material ratio is low, try to avoid the occurrence of large deformation model, to prevent serious problems when model reaches the limit bearing capacity when the degree of rupture.

Plugging Problems and Design Improvement Measures. This paper discusses the internal factors of the printer itself: uneven distribution of hot runner and temperature field. When the nozzle heat transfer effect is poor, will lead to the internal molten material circulation is not smooth, causing the printer nozzle clogging, and the nose is mainly due to poor heat transfer between the source and the temperature of the nozzle distance is too far away, or is not compact and good sealing connection parts of the nozzle, the heat loss caused by [6] in a certain extent.

According to the material texture and consistency problems can be improved through molten material and with appropriate models to solve these problems, this paper mainly addresses the problems of hot end components of the nozzle was improved, making reasonable improvement in

the nozzle material and structure. The most commonly used material is aluminum bronze, and its thermal conductivity is 56 W/ (m • K), and the thermal conductivity is relatively poor. To further increase the thermal conductivity of the nozzle, the strength, corrosion resistance, corrosion resistance, abrasion resistance of beryllium bronze with superior performance and good thermal conductivity impact, its thermal conductivity is greater than or equal to 105 W/ (M - K), easier to adapt to a variety of harsh and complex environmental conditions [7]. In the structure, the nozzle can adopt the integral form. As shown in Figure 2 of the nozzle to the improvement of structure:

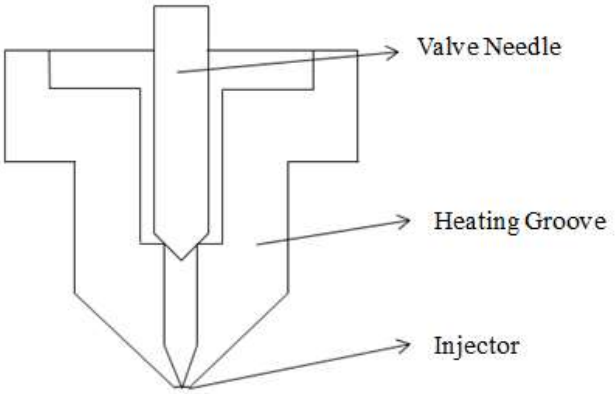

Figure 2. Improvement of two dimensional sprinkler nozzle

The nozzle part of the structure of the parts and the connecting piece is less, in order to improve the heat transfer effect, reduce the heat loss occurs when the printer is working, you can set the heating coil in the external nozzle, in order to better compensate for the loss in the heat transfer process of the temperature, to ensure a steady flow of molten material. Compared with the conventional nozzle structure, the improved nozzle structure is more simplified, the temperature distribution around the nozzle is more uniform, the distance of the hot runner is shortened, the heat loss is improved to a great extent, and the heat insulation performance is greatly improved [8].

Drawing Problems and Design Improvement Measures. The problem of drawing a 3D printer is to print unnecessary plastic filaments on the printing model during printing. The reasons are mainly: the phenomenon of drawing in the modeling process, the printer in a non-printing state controlled by computer or printer nozzle moving interval, when the nozzle at the residual material or retraction function is not up to the requirements, will lead to still have fused logistics, due to the control of the feeding mechanism, residual the material in the nozzle is very small, dropping revealed filaments [9]. This phenomenon has a serious impact on the accuracy of printed matter. Aiming at the phenomenon of drawing making model, this paper will put forward the following measures:

Improving melting materials. ABS material is selected in this paper. The improved material adhesion but low viscosity, and thermoplastic better, let the printing material in the spray nozzle into the molten state the better adhesion of after being heated, stop discharging nozzle, in the absence of new material extrusion under the condition of ABS due to the viscous molten material more, at the same time adhesion, excess material between the spray nozzle is greater than the gravity, in mechanical conditions, a little extra material from the nozzle will not drop out, it does not appear the phenomenon of drawing [10].

Improved nozzle structure. Before the nozzle is common at the heat transfer effect does not affect its internal material, nozzle length and diameter is smaller, based on increasing material adhesion on the nozzle structure reasonably improved, for the original nozzle diameter is not changed, the structure change is the front end of the nozzle lengthened. Principle is by increasing the nozzle wall area, thereby increasing the friction material, when moving downwards at the same time, the adhesion material will be because of the nozzle wall area increases, better to prevent printing materials in stop discharging without pressure when drips down, as shown in figure 3.

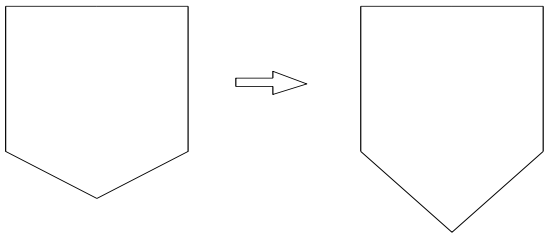

Figure 3. Printer before improvement and improved nozzle

The printer nozzle improved, the inner wall of a larger area, can be attached to the molten material better, the printer stops silk, not excess material needle valve cavity because gravity causes leakage, the improvements made to improve the nozzle drawing of this phenomenon in a large extent. In addition, the inner wall slope is larger, but also for the nozzle clogging problem to provide help, when printing, the discharge will be smoother, not because of near the nozzle of molten material cooling and solidification and lead to nozzle clogging.

Summary

The fused deposition (FDM) collapse, 3D printer common when using the model of cracking, nozzle clogging, drawing and other issues affecting the accuracy of the model is analyzed, summarizes the defects of the existing structure, and aiming at the problems and shortcomings in the aspects of material, structure, control and improvement measures. On the basis of choosing the high thermal conductivity material and the optimal programming control, the improved nozzle structure increases the average temperature of the whole nozzle, and makes the temperature distribution of the flow channel become uniform, and the maximum temperature difference decreases significantly. The heating ring set at the nozzle can minimize the loss of temperature and make the temperature field more uniform. This paper provides a feasible improvement method for the universal problem of FDM 3D printer, which is of great significance for the design of heat transfer structure and equipment improvement of 3D printing equipment in industrial applications.

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