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Structure Design of FDM Full color 3D Printer Extrusion Device.

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***Abstract*— Color analysis is the major key of the material structure, The current FDM 3d printing Technology is no able to achive multi colorful 3D printing. In order to take care of this matter in printing technology , we must have to have a Look into FDM 3d printer Structure, Globally there have been a huge changes in 3d printer extrusion nozzles , colorful 3d printer nozzle system is planned In CMYK-W. According to Toward printing tests and comparison on colorimetric tests and data analysis , 3D printer extrusion nozzles would be configured for structure planning requirements , and this study provides an constructive results for Multicolor 3d printing Mechanism.**

Index Terms—Multicolor 3D printer, extrusion nozzle , Fused Deposition Modeling (FDM) , structure design

I. INTRODUCTION

third industrial revolution, day by day its getting the attention of the worldwide industries and the investment community, it is a kind of based on the digital model file, using discrete materials (liquid, powder, wire, sheet, plate, etc.), through the accumulation of step by step way to make any complex shape object technology. Fused Deposition Modeling (FDM) 3D printing technology has the advantages of producing a variety of printing parts, convenient and quick, etc.. With the development of society, higher requirements for 3D printing technology and molding equipment are put forward. At present, there is still a problem that the 3D printing extrusion device of molten deposition is still unable to do multicolor 3D printing. Therefore, many experts and scholars have done a lot of research on color 3D printing. The British Pia [9] developed a 3D printer extruder using two different color materials. James [10] designed a sprinkler with a built-in mixing device, but only for two colors. According to the above problem, this paper based on the working principle of the research of FDM, the traditional 3 d printers extrusion device was improved design a set of color 3 d printer based on CMYK - W extrusion device.

METHODOLOGY

The melting deposition of 3D printer is based on the digital model file, which is controlled by computer.

The sprinkler head will be heated in the nozzle to melt the melted filaments or granular melt material (such as ABS plastic material). FDM 3D printer works by feeding wire sent through consumables continuous extrusion device, feeding wire in nozzle would be heated, when the temperature of the material wire reaches to or above the feeding material melting , material filament extrusion will be in action of extrusion force from the nozzle, melted produce plastic deform it self after rapid solidification, thus complete the stacked materials forming step by step. FDM 3D printers are mainly composed of five parts: sprinkler head, wire feeding mechanism, motion mechanism, heating installation and workbench. The schematic diagram of working principle of 3D printer is shown in figure 1. In figure 1, the X, Y and Z axes form Cartesian coordinate system. In the Z axis, the nozzle and the heating device are moved along the X and Y axis.

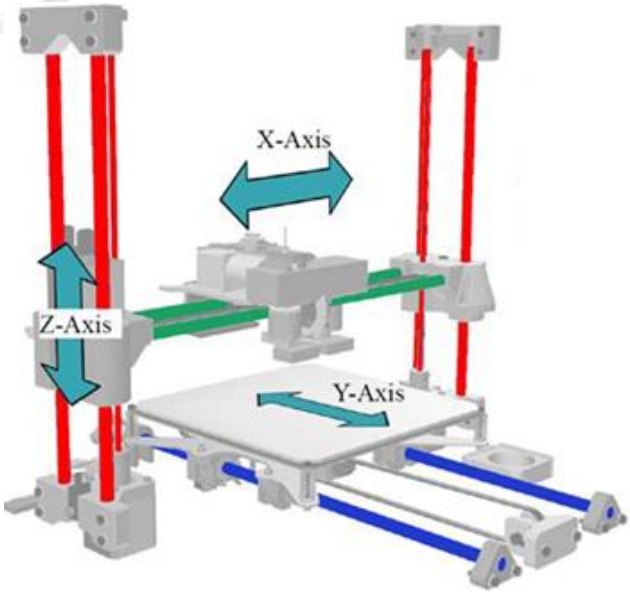

Figure 1 Schematic diagram of working principle of 3D printer.

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Principle of color mixing in 3D printer means that different primary colors are mixed to form another color. Generally, three primary colors are used for mixing. According to color mixing, lightening and darkening are classified into additive color mixing and subtractive color mixing [14]. The color mixing method is shown in figure2.

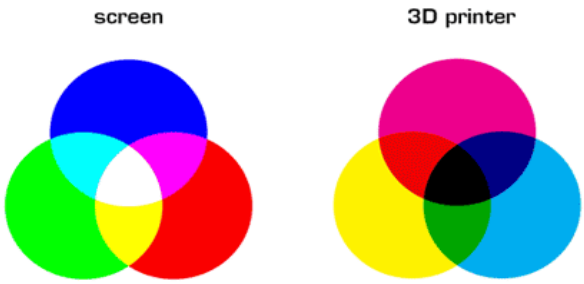

Figure 2 Mixed color schematic

Additive color mixing means that the color is mixed with the brighter color mixing method. As shown in Figure 2 Screen, the three primary colors are Red, Green, and Blue, which are referred to as RGB mode or RGB color space. The display is like a TV. Color display for slides, web, and multimedia generally uses this mode. Subtractive color mixing is the color mixing darker color mixing method, as shown in Figure 2 3D printers, the three primary colors are Cyan, Magenta, and Yellow, which is referred to as CMY mode or CMY color space. Subtractive primary colors are also called as the "three primary colors of dyes", it is widely used in the field of painting and printing.

This article adopts the subtractive color mixing method. Based on the adoption of three kinds of material yarns of magenta, yellow and cyan as the basic color consumables, black and white two basic color consumables are introduced. For the CMY model, the British scholars have found that the three primary colors can be mixed except black. Any color, therefore, in the color printing, in addition to the three primary colors used to add black, in order to deploy a deep,

Heavy colors [15]. However, there is no white color. For a color inkjet printer, since the CMYK printing paper is white, it does not need to be white. For RGB mode, it is widely used in displays, etc., RGB 255 255 255 represents white, RGB 0 0 -0 Indicates black.

In color 3D printing, the print needs black and white. With the introduction of black and white, the color brightness of various prints can be adjusted quickly and easily, which in turn makes the printed media more expressive. The color mixing diagram of the color 3D printer extrusion device is shown in Figure 3. By setting reasonable parameters in the software and controlling the feed length per unit time of the filaments, the five primary color filaments in the 3D printer nozzles are melted and mixed to be extruded from the nozzles, and finally the color 3D printing of the parts can be achieved.

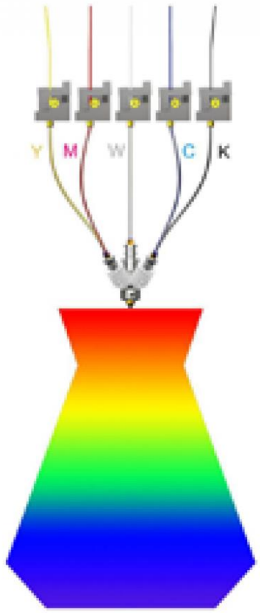

Figure 3 Color 3D printer extrusion device color mixing diagram

The color nozzle wire feeding mechanism design explanations is as Extruder is the most important mechanical part in 3D printers. It mainly includes wire feeding mechanism, nozzles, heating resistors, temperature sensors and nozzles [16]. The wire feeding mechanism pulls the wire into the printer head through a gear drive mechanism, and the temperature sensor can control the wire to be heated to a constant temperature. The wire is heated and melted in the nozzle, and is pushed out from the nozzle to print when the extrusion force is pushed.

Mainstream extruders mainly include The Direct Extruder and The Bowden Extruder. The wire feeding mechanism (cold end) of the short-range extruder and the nozzle heating section (hot end) are integrated and placed above the nozzle. The stepping motor performs the squeezing through the squeezing wheel. This kind of wire feeding mechanism has a compact structure, but it increases the hot end weight, which is not conducive to the improvement of printing accuracy.

The wire feeding mechanism (cold end) and head heating section (hot end) of the remote extruder are placed at different positions of the printer. The cold end is generally located on the rack, the hot end is placed above the nozzle, and the cold end and hot end Place a Teflon tube to guide the feed wire and transfer the driving force of the cold-end wire

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feeding mechanism to the hot end so that the wire enters the melting chamber. The schematic diagram of the remote extruder is shown in Figure 4. This structure reduces the head weight, which contributes to the improvement of printing accuracy and printing speed.

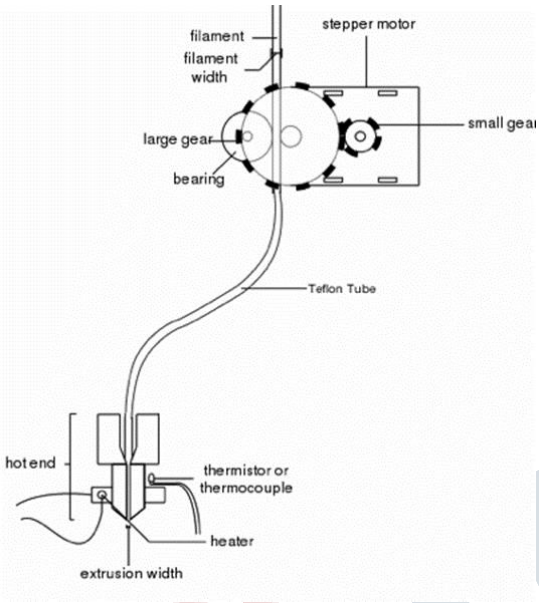

Figure 4 extrusion structure diagram

Due to the characteristics of the color printer extrusion device, five extruder systems are required. This article uses a remote extruder system to reduce the weight of the nozzle.

COLOR EXTRUSION DEVICE DESIGN

Overall design of extrusion mechanism can be explained in couple steps:

The new color 3D printer nozzle extruding device designed in this paper adopts five kinds of color yarns of magenta, yellow, cyan, black and white on the basis of the principle of three primary colors to control the lengths of different feeds in the nozzles of each material. Melt mixing is performed to finally obtain a color print, and the color brightness of various prints can be easily and quickly adjusted. Among them, the design of the extrusion device structure is one of the most important tasks for the development of a color 3D printer. The rational design of the extrusion device enables the five primary color material filaments to be melted and fully mixed in the interior thereof.

The nozzle is the core part of the extrusion device. In order to realize the color 3D printing, this article has designed a five-feed structure water-cooled color printer nozzle, Figure 5,

Figure 6 shows the assembly of the extrusion device and its sectional view. The five feeding devices have the same structure, with a quick interface at the top and a nozzle at the bottom.

As can be seen from Figs. 5 and 6, the color 3D printer extruding device consists of a cooling circulating water storage tank, a throat pipe, a detachable nozzle, and a casing. Components, including the cooling water storage tank water cooling, the throat pipe to play a role in connecting the heat sink and the shell, surrounded by 90 ° hole and the hole connected with the feeding device, heating and temperature measurement device position shown in Figure 6 As shown. In the printing work, the raw material is introduced into the mixing chamber through the PTFE tube in the inner hole of the feeding device, and the five molten materials are fully mixed in the mixing chamber and then extruded to form a deposit.

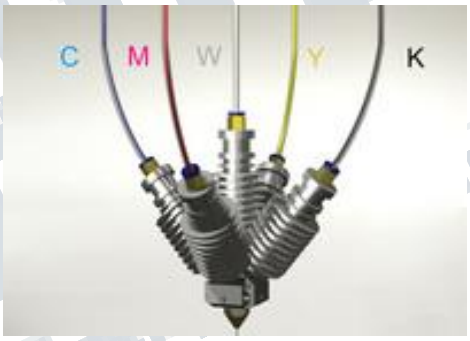

Figure 5 Multi Color 3D Printer Extrusion Assembly Drawing

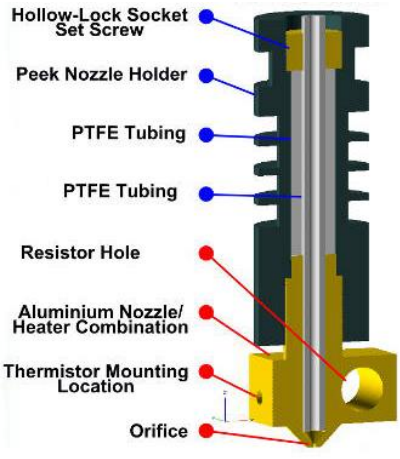

Figure 6 Cross section view of color 3D printer extrusion device

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Shell design procedure:

The housing designed in this paper is shown in Fig. 7 and Fig. 8, on which a removable nozzle, heating assembly, temperature measuring assembly and heat dissipating assembly can be installed. However, the existing FDM 3D printers often use the single feed pipe single nozzle extrusion mechanism or the two feed pipe double nozzle extrusion mechanism, and the outer four out of the five feed components of the extrusion device designed herein are used. The components are symmetrically distributed, and the components in the middle of the five feeding components are perpendicular to the mixing chamber, so that the printing material enters the feeding tube from the feeding tube and enters the mixing chamber after heating. In the extrusion mechanism, the removable nozzle is used to extrude the wire required for the workpiece.

Whether it can work reasonably, reliably and stably depends directly on whether the molding process can proceed smoothly and the quality of the formed workpiece is affected. The detaching nozzle is installed at the lower end of the shell of the extrusion device designed in this article. By accurately controlling the feeding amount of different basic color consumables, the printing materials of different colors are heated and mixed in the mixing chamber to obtain the desired color and then passed through the detachable nozzle. Extrusion, and the resistance changes that the wire is subjected to when it is fed are stable, which prevents the occurrence of resistance mutations, and avoids uneven color mixing due to material resistance changes during the color mixing process.

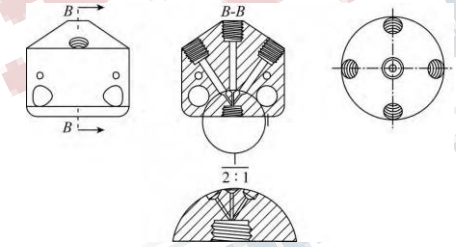

Figure 7 Nozzle housing structure

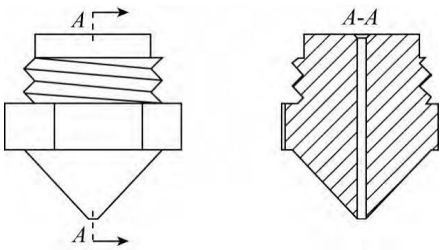

Figure 8 Removable nozzle front view and sectional view

Structural design of cooling section :

The purpose of designing the cooling section is to prevent premature heating of the wire due to excessive temperature in the upper half of the housing, which affects the wire feeding process. The cooling part of a conventional extrusion mechanism uses a single fan to dissipate heat from the extrusion mechanism, also known as air cooling.

At the printing site, the air generated by the fan is very noisy, and it also causes the printing equipment to vibrate. At the same time, the cooling effect is also unsatisfactory, and the nozzle is prone to clogging during the printing process. The cooling device is a water cooling device, the improved cooling device has higher heat dissipation efficiency, and the temperature control is more stable.

TESTING ANALYSIS AND UNITS

Experimental equipment uses the color 3D printer made by the research team and the nozzle diameter is 0. 4 mm, deposition height is (0. 3 mm), forming temperature (205 °C), extrusion speed (ve = 24 mm / s), scanning speed (vf = 30 mm /s) , maximum formable diameter (200 mm), width (200 mm), height (200mm). The experimental material was polylactic acid (PLA) wire, and the diameter of the wire was 1. At (75mm), color samples were printed using the five basic color materials of magenta, yellow, cyan, black, and white, Through the printing test, the horizontal and vertical color information of the print is compared with the standard color card, respectively, and the color information is abundant. Therefore, the designed extrusion device meets the design requirements and realizes color printing.

CONCLUSION

In the fields of industrial manufacturing, cultural and entertainment creativity, architectural model display, animation production, and personalized customization of consumer products, color information is an indispensable element in product expression.

A single-color printing body greatly reduces the expressiveness of a product. Current FDM-based 3D printers cannot complete color 3D printing, which hinders the visual expression of 3D prints. In order to solve this problem, based on an in-depth study of the working principle of the FDM 3D printer, the traditional 3D printer extrusion device was improved and a CMYK-W-based color 3D printer extrusion device was designed. Through the print test, the color information of the printed part is compared with the standard color comparison card, which verifies that the designed color 3D printer extrusion device meets the design requirements and provides an effective solution for the further research of the color 3D printing technology.

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