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Development of Multi-color 3D Printer based on FDM

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Abstract

With the progress of technology, 3D printing technology has developed a series of branches, such as SLA,SLS,SLM,3DP,FDM, among which FDM (fused deposition molding) is the most economical, which is very suitable for desktop-level consumption. at the same time, Marlin firmware is the most classic, open source 3D printing control software, which can further reduce the burden of desktop users and provide a good environment for promoting this technology. As a table-level product, playability can be compared with precision requirements, so the aim is to design a 3D printer that can print single color and multiple colors.

Keywords

3D-printing; Extruding Unit; Marlin Firmware; FDM.

1. Introduction

3D printing technology (3DP) is a kind of rapid prototyping technology, also known as increased material manufacturing. At present, 3D printing technology has been widely used in automotive, aerospace, biomedical, construction, food processing, cultural relic restoration and many other industrial fields. It has great market potential and is bound to become one of the breakthrough technologies in the future. At present, the common 3D printing technologies mainly include stereoscopic light curing molding (SLA), selective laser sintering (SLS), selective laser melting (SLM), three-dimensional printing process (3DP), fused deposition molding (FDM) and so on. At the same time, 3D printing technology is also sinking to the civilian, desktop level. Among them, FDM technology meets the desktop application market because of its low cost, many optional materials, simple process and other factors. At present, the FDM desktop 3D printer in the market has some problems, such as obvious layer pattern, only one color can be selected for a single print, slow printing speed, high price for large size and so on. A multi-color FDM 3D printer with high printing accuracy, stability and reliability and modular extrusion system has been designed and developed in this project. [1].

2. Frame and Material Selection

First use the Solidwork platform to build a 3D model of the printer, as shown in figure 1. After considering the price, processing difficulty and physical properties of the material, the aluminum profile used in this project is Euro 2020, which is used to build the external frame of the body, and the corner code of Euro 2020 or 2028 is used as the connector. 2020 aluminum profile around chute with Euro 20 T-nut can save about 50% of installation time compared with square nut. Building a stable and vertical frame is the basis to ensure the final printing accuracy. Therefore, it takes a lot of time and enduring patience. First of all, the first step in building a framework should be to complete the connection between the upper and lower faces of the tetrahedron. Secondly, verify whether the corresponding edges of the upper and lower rectangular frames are completely parallel. Finally, install the Z axis of the frame. It should be pointed out that due to the limited physical properties of the

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8mm Chrome-plated metal bearings, the material with higher strength needs to be selected when the horizontal section size of the printed piece exceeds 300×300mm.

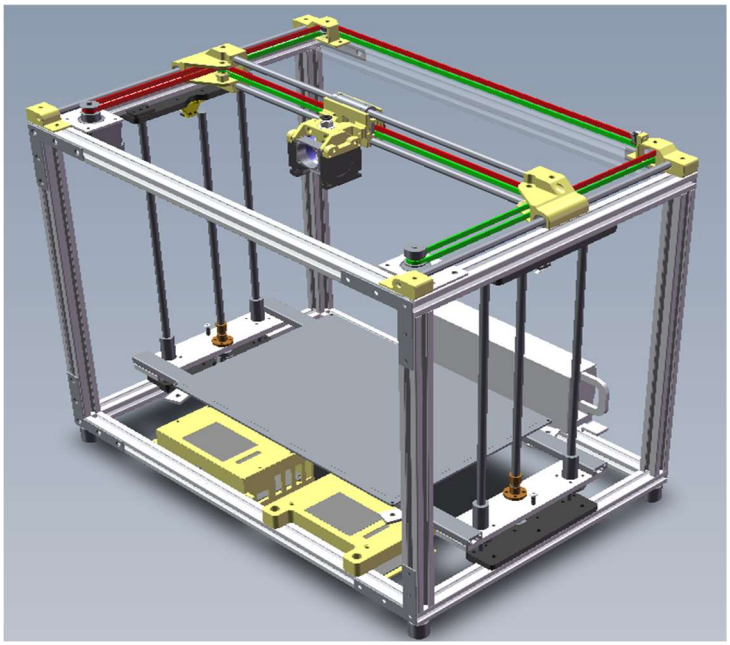

Figure 1. model

Table 1 shows the sizes and quantities of aluminium extruded sections(ACE), chrome-plated metal bearings and T8 screws required when the printing stroke is $300 \times 200 \times 280$mm.

Table 1. frame specifications

Category	Direction	Dimensions (unit: mm)	Quantity
8mm Chrome-plated metal bearings	X	398	2
	Y	334	2
	Z	390	4
AEC(2020)	X	450	4
	Y	340	4
	Z	390	4
AEC(1020)	Hot Bed	467	2
T8 Screw	Z	350	2

Refer to Table 2, the lengths and numbers of ACE, chrome-plated metal bearings and screw rods required for customizing the printing range of the machine can be obtained. Let the dimensions of each axis of the desired printing stroke beX_1,Y_1,and Z_1, respectively.

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Table 2. Frame Specifications for Custom Sizes

Category	Direction	Dimensions (unit: mm)	Quantity
8mm Chrome-plated metal bearings	X	$X_1 + 98$	2
	Y	$Y_1 + 134$	2
	Z	$Z_1 + 110$	4
AEC(2020)	X	$X_1 + 150$	4
	Y	$Y_1 + 140$	4
	Z	$Z_1 + 110$	4
AEC(1020)	Hot Bed	$X_1 + 167$	2
T8 Screw	Z	$Z_1 + 70$	2

3. Control and Execution Material

1) Motherboard. MKS GEN_L series motherboard, which integrates the open source motherboard Ramps1.4 and Arduinomega2560 into one board, solves the tedious and fault-prone problem of Ramps1.4 combination interface, reserves motor pulse and directional output ports, and can be externally connected to DM-542 and other large drivers to drive 57 series, 86 series and other large motors. It also supports conventional drivers such as A4988 and DRV8825 and silent drivers such as TMC2100, and supports multiple motors moving at the same time. Because the size of the machine is large and the printing parts are heavy, the structure of double Z axis is chosen. In order to ensure that the motor drive interface is sufficient to meet the X and Y axes and their double Z axes, MKS GEN_LV2.1 is chosen.

2) Drive. In order to meet the accuracy requirements of the printer, the X and Y axes are driven by TMC2209 mute and 16 subdivisions are selected. At the same time, with graphite bearing sleeve, the movement of the extrusion head can be more delicate, thus eliminating the layer pattern. The movement frequency of Z axis is much lower than that of X and Y axis, low energy consumption and low noise, so A4988 is chosen.

3) Electrical Machinery. The 42HBP56AL4 stepper motor is selected as the Z-axis, the end face size is 57mm and the torque is 1.2Nm. It has the function of power-off brake lock, which can prevent the parts on the Z-axis from slipping after the power is cut off and ensure safety. The speed of the motor can reach 1000r/min under no-load and stabilize at about 500r/min after acceleration under rated load. The matching motor driver is A4988, which supports 64 subdivisions at most, and the drive circuit is similar to servo control, which makes the motor move smoothly at low speed without vibration and noise. it can realize the synchronous operation of two Z-axis motors with one driver and ensure the level and stability of the extrusion sprinkler system. The selection and calculation method of X-axis and Y-axis stepper motor is the same as Z axis, and 42 series stepper motor is also used, the model is MKSSERVO57B, keeping torque 1.2Nm, without lock function, and the widely used DRV8825 stepper motor drive module is adopted.

4) System firmware. Using the open source easy-to-use Marlin2.x firmware[2], and the MKSGEN_LV2.1 motherboard is developed based on this firmware, compared to the Marlin1.1 version, it adds support for 32-bit motherboards, it is configurable, customizable, extensible, and economical. A complete G-code sports suite with intelligent motion systems, including lines, arcs and B é zier curves; and most importantly, it supports up to five extruders working at the same time.

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4. Debugging and Optimization

After installing the hardware such as X, Y axis and hot bed, horizontal and parallel debugging is required. Software debugging focuses on coordinating the working sequence of multiple extruders to ensure the timely replacement of consumables of different colors.

1) Adjust the parallelism of chromium-plated metal bearings. As the executors of the machine, the X and Y axes must maintain parallelism between coaxes and verticality between different axes. The main basis of whether the Y axis is parallel or not is that the X axis is smooth in the process of traveling along the Y axis, and can stay at any coordinate of the Y axis after removing the driving force; similarly, the basis of whether the X axis is parallel or not is that the movement of the whole extrusion head, including the heating block and nozzle, is smooth, and the friction resistance $F_n < 1.2N$ in the whole process of motion. The above debugging work needs to be completed before the optical axis is lubricated.

2) Adjust the distance between the hot bed and the nozzle and its level. The distance between the hot bed and the nozzle is the key factor to determine whether the lamination is obvious or not. The extruder provides consumable materials at a speed of $S = 100\text{mm/s}$. In order to select a suitable spacing M, make the extruder work alone on the hot bed and draw a straight line of 15CM, increase the spacing M from 0 to 2mm, increasing 0.2mm each time. When $M > 0.6\text{mm}$, the melted consumables form clusters on the hot bed, and the straight lines drawn in $M = 0.2\text{mm}$ are not uniform enough. According to the above situation, the M is increased from 0 to 0.2mm, and the 0.05mm is increased every time. After many experiments, the straight line drawn in $M = 0.1\text{mm}$ is the most uniform. The thickness of a piece of A4 paper is about 0.104mm. By using the 5-point height method, a standard A4 paper is selected as a reference, and the nozzle is slightly blocked when it passes through the four corners and the middle part of the A4 paper, that is, the nozzle is 0.1 mm. [3].

3) Software optimization. In the single consumable mode, the route of the consumables is as follows: from the extruder to the pneumatic joint to the heating block to the nozzle and finally deposited and glued to the hot bed. The route of the consumables in the multi-material mode is as follows: extruder 1 or extruder 2 to the pneumatic joint to the heating block to the nozzle and finally deposited on the hot bed. Because the consumables are not extracted in time under the heating condition, the average amount of consumables left between the heating block and the nozzle is 2CM, because the characteristics of FDM technology will not have a great impact on the final model color. [4].

5. Conclusion

In the design scheme given in this paper, the material is easy to obtain, and the construction of the structure can be completed by common tools. Two modes are designed: single color and two colors. It can be switched freely when printing monochrome and multicolor consumables, and it is fast, easy to use and accurate when printing monochromatic consumables. The switching logic of different consumables in multi-color printing mode is clear. Although only two kinds of consumables can be printed at the same time, the existing logic can continue to increase the number of consumables. Due to the improvement under the structure of monochromatic consumables, stutter is still more obvious when switching consumables, but the pneumatic joint can be improved to achieve smooth replacement of consumables.

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