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Design of Rapid Prototyping Machine for Fused Deposition

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Abstract. Rapid prototyping can quickly realize the forming of parts through the principle of melt accumulation, without complicated processing technology. And it has a profound influence on the development of the manufacturing industry. Rapid prototyping technology is very suitable for complex shapes and precision parts processing, and it is widely used in the field of mold manufacturing and the trial production of new products. Fused deposition molding (FDM) technology is an important branch of rapid prototyping technology. It does not require a high working environment, the noise and the volume are also small, so it is very suitable for home, office and other occasions, and it has great prospects for development.

The paper describes an industrial grade rapid prototyping of melt deposition, it uses the diameter of 1.75mm of the molding wire as consumables, and the design and processing accuracy is 0.2mm. The main structure comprises a spray head, an X-Y horizontal axis linkage mechanism and a Z shaft working platform. The X-axis can be slid on the X-axis, and the X-axis can be slid on the Y-axis rail through the X-axis rail bracket. This enables the X-Y axis linkage in the horizontal plane. At the same time the work platform selected high precision ball screw to drive, and the precision movement can be achieved on the Z axis guide rail. Control part chooses the MCS8031 microcontroller, it can achieve the drive and control of the stepper motor. Through the design, calculation and selection, as well as the improvement of the later, to achieve the design of basic structure and control system ,completed the accuracy requirements, and to achieve the desired objectives.

The Advantages of the Rapid Prototyping Technology

Rapid prototyping technology because of its application of discrete accumulation principle, the exclusion of the complex process of the preparation and machining process, only the three-dimensional design model, and then print directly to generate. This method improves the previous design pattern, shortens the design period of the product, and accelerates the renewal of the product.

In the rapid prototyping technology, Fused Deposition Modeling combines the computer aided design (CAD), computer numerical control (CNC), computer aided manufacturing (CAM), precision servo drives and other advanced manufacturing technology. Therefore, this technology is suitable for machining parts with complex shape and high precision.

Mechanical Design of Rapid Prototyping Machine

The design of X - Y Horizontal Coordinate Linkage Mechanism.

The main component of the fused deposition molding machine is the nozzle assembly, which is a light mechanical movement. Therefore, the design of the melt deposition rapid prototyping machine does not use the traditional screw to drive the precise movement of the nozzle, but to select for fast-moving belt drive to drive the X-Y direction of the nozzle's linkage.

Table 1 Dimension parameters of X-Y horizontal linkage mechanism

project name	X axis parameters	Y axis parameters
Guide rail length（mm）	500	550
Guide rail diameter（mm）	20	20
Toothed belt type	XL	XL
Bandwidth（mm）	25.4	25.4
Standard outside diameter of Pulley（mm）	30.22	39.92
Tooth width of pulley（mm）	30.2	30.2
Outer diameter of pulley flange（mm）	36.62	46.32

Drive Mechanism Design of Shaft Table

In the work process of fused deposition rapid prototyping machine, Z-axis table is moved downward layer by layer to ensure that the To ensure that the workpiece is formed layer by layer, at the same time, it also to be processed to gradually increase the weight of the workpiece to ensure that the final molding accuracy. In order to meet the above requirements, the Z-axis worktable of the fused deposition prototype uses the ball screw as the driving mechanism, and reduces the influence of the table on the forming precision by utilizing the large torque driving force, high rigidity, micro-feeding and high precision of the ball screw, and meanwhile we need to use cylindrical linear guide as a guide device to give the Z-axis table a stable direction of movement. The structure of the Z axis worktable is a screw in the middle which used to drive up and down, and the light bar which parallel arranged on the both sides of the screw.

Design of Nozzle and Wire Feeding Mechanism

The forming mechanism of the molding principle is as follows, through the nozzle heating and melting the molding plastic, and then extruded by the plastic wire which are produced by wire feeding mechanism. By controlling the speed of the stepping motor, the control of the feed speed of the silk material can be realized, and the layered printing of the forming parts is realized by the combination of the thickness of the forming layer and the velocity of the nozzle.

Selection of Fused Deposition Molding Materials

The molding material of this rapid deposition prototyping machine is made of ABS plastic. Considering that the precision of the prototyping machine is set to 0.2mm,so selected the 1.75mm ABS resin which is suitable for high precision. PVA water-soluble materials used in support materials.

Structure Design of Wire Feeding

The design of the rapid prototyping fused deposition using diameter ϕ = 1.75mm ABS engineering plastics as molding materials. In the molding process, the molten material is needed to squeeze by subsequent silk material. Therefore, the wire feeding mechanism is needed to overcome the flow resistance. This requires that the wire can be transmitted to the plastic wire propulsion thrust. As a result of the use of self-pressurized extrusion, the rapid deposition of the prototype select friction wheel to drive.

Analysis of the State of Molten Material and Design of Feeding Mechanism

Through the above design shows that the FDM machine feeding mechanism design is complete, but silk needs to be heated and melted, and then sprayed into all levels of cooling molding, and then complete the final design. Therefore, this part of the nozzle frame to design the hot part. Due to the relative movement between the wire material and the heating chamber inlet, the feed inlet of the heating chamber and the feed wire have a certain clearance Delta, which is convenient for the entry of the silk material to reduce the resistance. The heating cavity of the spray head is divided into a feeding section, a melting section and a melting section.

The design of the fused deposition molding machine uses a pair of roller clamping the silk. Driven by the stepper motor to achieve the feeding of silk material, while the nozzle part is equipped with heating devices and cooling devices to ensure the stability of printing, because the design contains two nozzles, the initial design of a stepper motor drive, it also needs electromagnetic Replacement device to achieve the alternating switching of the support material and molding material.

Design of Rapid Prototype Control System

Through the above analysis of the control system functions, and select the appropriate chip to achieve the function. At the same time, the FDM machine for real-time state through eight digital tube display, is expected to reach to four driving mutually unrelated stepping motors, the X, Y, Z axis linkage, to achieve precise control of the wire feeding mechanism, complete the control system design of FDM machine.

Conclusion

FDM machine as a rapid prototyping machine, it has the advantages of simple forming, high precision, no need of complicated processing technology, etc. The development of FDM machine will be another innovation of the manufacturing industry, so the development prospect of FDM machine is very broad.

The FDM machine, its machining precision is within 0.2mm, ABS engineering plastics used as a molding material, water soluble PVA as the supporting material. The maximum machining size of FDM machine is 300 x 300 x 400 (mm), which can be quickly molded into a 3D solid of any shape within the size range. Support for 3D graphics rendering on the computer into layers STL format analysis data, the memory can then be transmitted directly to the prototype implementation, forming part of the print. This method realizes the integration of design, manufacturing and processing, and has a profound significance to the development of manufacturing industry.

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