Hindawi
Advances in Multimedia
Volume 2023, Article ID 9893468, 1 page
https://doi.org/10.1155/2023/9893468

Retraction

Retracted: Improvement and Experimental Explore on Coordinated Control of Kinematic Mechanism of FDM 3D Printer

Advances in Multimedia

Received 12 December 2023; Accepted 12 December 2023; Published 13 December 2023

This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] G. Li, "Improvement and Experimental Explore on Coordinated Control of Kinematic Mechanism of FDM 3D Printer," *Advances in Multimedia*, vol. 2022, Article ID 4422616, 9 pages, 2022.

Hindawi
Advances in Multimedia
Volume 2022, Article ID 4422616, 9 pages
https://doi.org/10.1155/2022/4422616

Research Article

Improvement and Experimental Explore on Coordinated Control of Kinematic Mechanism of FDM 3D Printer

Guozhu Li [1,2]

[1]*School of Mechanical and Material Engineering, Xi'an University, Xi'an, 710065 Shaanxi, China*
[2]*Shaanxi Key Laboratory of Surface Engineering and Remanufacturing, Xi'an, 710065 Shaanxi, China*

Correspondence should be addressed to Guozhu Li; lgz1976@xawl.edu.cn

Received 19 July 2022; Revised 25 August 2022; Accepted 29 August 2022; Published 16 September 2022

Academic Editor: Tao Zhou

As the main component of the 3D printing industry, the fused deposition process covers all aspects of the industry with its advantages of low R&D investment, high practicability, and open source programs. However, due to process problems, problems have arisen in terms of printing efficiency and molding quality. To this end, we designed a large-scale multinozzle FDM printing device using the high-current fused deposition (FDM) printing principle. The defects of small size, slow printing speed, and low precision are deeply studied, and the machine structure is optimized according to the structural strength analysis. In this paper, the theoretical design and static analysis of the overall mechanical part of the large-scale FDM device are carried out, and then, the selection of the movement organization structure and movement method is theoretically analyzed. A modular flow chart is designed for the control system to coordinate and control the parallel and precise operation of multiple nozzles, and the relationship function between the main controller, power driver, and heating module is designed. By modifying the firmware parameter command, we can find out the optimal method running on the platform and discuss the function usage of the slicing software in detail. According to the current problems of FDM printing equipment, various factors affecting printing speed were analyzed from the perspective of printing accuracy, and the process parameters of 3D printer were studied through orthogonal experiments. Speed, nozzle temperature, idling speed, and fill rate were studied, and the relationship between factors affecting printing speed and printing accuracy was obtained. Use a simple model print to measure the overall performance of your product. The stability of the system is verified by short-term and long-term printing tests. The analysis results show that the forming performance and stability of the large-scale FDM are improved significantly.

1. Introduction

There are many professional explanations for 3D printing technology, such as manufacturing free solids, additive manufacturing (AM), and rapid prototyping [1]. 3D printing technology refers to the use of an ever-increasing amount of geometric representation to generate physical data. In recent years, this 3D process has found many amazing applications [2]. The first commercial 3D printing process was done by Charles Hull in 1980. Currently, 3D printers can be used to make artificial heart pumps, jewelry collectibles, 3D printed corneas, PGA rocket engines, Amsterdam steel bridges, and others related to the aerospace and food industries [3]. In addition, being the main component of 3D printing technology, FDM printing technology has become the most commercialized 3D printing solution in the world [4]. The product has huge development space and market prospects [5].

3D printing technology originated from the traditional technique of fabricating 3D components layer by layer directly in computer-aided design (CAD) [6]. 3D printing is a truly innovative application technology, which has become a multifunctional technology stage [7]. It is now possible to print common thermoplastics, porcelain, graphene materials, and metals with 3D printing technology [8]. The application of 3D printing technology can greatly improve the manufacturing quality and reduce the labor cost caused by mass production [9]. At the same time, consumers' requirements for the quality of 3D printers directly affect the capital investment of 3D printers in industries such as additive processing. 3D printing technology facilities will be geared towards different consumers, allowing companies to be more flexible and faster in production processes, and better in quality management. Moreover, when companies adopt 3D printer technology, the requirements for global transportation will also be greatly reduced. This is mainly because the entire delivery process can be carried out using fleet tracking technology as the product is manufactured close to its final destination, saving energy, and time costs. Finally, the whole process can be managed through 3D printing technology, which brings more comprehensive and convenient management services.

Today, 3D printing machines are widely used in the world. Among them, the realization principle of FDM printing function is a comprehensive reflection of 3D printing technology, which can be widely used in the production of any type of open source design such as mass customization, agriculture, medical care, automobile industry, and aerospace industry [10]. In addition, there are some problems in the application of 3D printing technology in industry [11]. Therefore, the main goal of adopting 3D printing technology will be to reduce the use of labor in manufacturing, so intelligent manufacturing will also greatly impact the economic manufacturing of developed countries that rely on a large number of low-skilled labor. In addition, by using FDM-3D printing technology, users can also print a variety of different types of product items. This is why FDM-3D printing technology is very simple to apply, and there are many kinds of raw materials. 3D objects can be generated from sketch designs and then set data in machine print [12].

In summary, 3D printing technology has become a fairly flexible and powerful technology, widely used in industrial fields, and has been applied in many developed countries [13]. In recent years, with the continuous breakthrough in the development of new materials and the continuous innovation of thermal printing technology, biological materials have gradually evolved from the original low-melting polymer materials to the current cemented carbide, biological macromolecules, biological ceramic materials, and living cell printing [14]. Therefore, in-depth research on the technology of 3D printing manufacturing products has great practical significance and important scientific research value [15]. Therefore, studying the key technologies of 3D printing manufacturing has important practical significance and scientific value [16]. In this paper, the static mechanical design and analysis of the entire mechanical part of the large-scale FDM equipment are carried out, and then, the choice of the movement mechanism and movement mode is theoretically analyzed. The process parameters of the 3D printer, including layer thickness, feeding efficiency, nozzle temperature, airflow efficiency, and filling amount, were studied by means of orthogonal experiments. The relationship between various factors affecting printing efficiency and printing quality is studied, and the overall performance of the platform is evaluated by simple model printing.

2. State of the Art

2.1. Research Background of 3D Printing Technology. The history of 3D printing (3DP) technology is only over 40 years old [17]. But the revolutionary development in the fields of science, engineering, and society has brought this new technology to a high level of development [18]. 3D printing (3DP) is a rapid prototyping technology, also known as additive manufacturing, that builds objects by printing layer-by-layer, based on digital model files, using powdered metal or plastic bonding materials. The evolution of the three-DP technology can also be explained in different contexts, such as the difference in material characteristics and technology timing. Some researchers divide the different stages of developmental history into major sections, for example, infancy: 1981-1999, adolescence: 1999-2010, and adulthood: 2 011 to present [3].

This idea has been refined, and the map has been redesigned to combine transparency panels and topology interpretation. Invented by the company Di Matteo in 1974, this technique can also be used for other months (48 hours) of traditional methods that are more accurate and time-saving. Zang refined this idea in 1964 and Gaskin in 1973 and redesigned the map by combining transparent panels and topological interpretation. Invented by Di Matteo in 1974, the technology can also be applied to other difficult-to-machine materials such as propellers, air wings, 3D cams, and molds. The three-DP theory proposed by Hideo Kodama and Alan Herbert, which has received extensive attention in the academic community under the name of rapid prototyping technology, is based on continued research on the theory of combining photopolymers and lasers [19]. Table 1 lists the file format conversion rules and relevant parameters of general design and industrial 3D modeling software.

2.2. The Beginning of 3D Printing: 1981-1990. In the ten years from 981 to 1990, the company released two of the most popular and widely used 3D printers: highly selective laser sintering technology (SLS) and FDM. Chuck Hull built the world's first commercial 3D printer in 1986 and called it a 3D object manufacturing facility for stereolithography. At the same time, he developed the STL (standard subdivision language) file format. This machine can generate particles of resin, metal material, ceramic, and glass powder, and use high-energy laser to produce 3D solid matter. The most commonly used 3D desktop fdm printer was developed by Scott Crump in 1989 and commercialized in mass production by Stratasays. German EOS company has developed computer-aided design (CAD) software for design objects of 3D printers [20]. FDM printer has the advantages of simple structure and operation, low maintenance cost, and safe operation of the hot melt extrusion head system. The molding speed is slow, and the products produced by melting deposition method do not need the post-treatment process of scraper in SLA. Prototypes formed in wax can be directly used in melt casting.

2.3. Development of 3D Printing: 1990-2010. The two decades from 1990 to 2010 have witnessed the rapid growth of the existing new 3D printers, new printers, and printing

Table 1: File format conversion rules and related content technical parameters of commonly used architectural design and engineering 3D model software.

3D design software	Parameter setting conversion
CREO	1. File- > save a copy- > STL; file- > export- > PRT.Model 2. Expose options- > set the chord height of the grid control 3. Expose options- > set the network angle control value
UniGraphics NX	1. Output item - > rapid prototype - > set data type 2. Output options - > set the triangle precision value 3. Output options - > set the adjacent tolerance value, usually straight 0.12
AutoCAD	1. The solid does not contain a surface, and the broken surface must be solidified 2.Order-faceters-range 1 to 10, select low-precision correction, and high-precision entities on the set value

equipment markets. The first printers limited their ability to batch 3D objects due to equipment conditions at the time and technical problems with the printers. Therefore, improving printer technology and printing efficiency is a key development goal, focusing on laminate production and SLS large-scale printing. At the same stage, various printers such as thousand flowers bloomed, marking important milestones such as the development of 3D printed organs and ears created from patients' cells. Envisiontec proposed the Perfactory machine model in 2001, which is capable of producing unusually large parts with moderate precision and relatively high operating speeds, but very large parts with precision and relatively large operating speeds, but accuracy is low, and equipment production costs are high. Chinese researchers are the first to 3D print kidney and blood vessel tissue and can even print real prosthetic limbs that do not require assembly at all. Another major event in this period was that the patent of the FDM printing tool had expired, thus expanding and becoming inaccessible, laying a solid foundation for the development of open source slicing applications in the future. As a result, thousands of stakeholders around the world have started to easily apply and enjoy the technology. And, in an era of dramatically increased demand and widespread use of the technology by stakeholders, FDM printing products have taken over the industry as a whole.

2.4. Mainstream Classification of 3D Printing Technology. Based on the characteristics of intelligent production, 3D printers cover all aspects of industrial production, from small- and medium-sized to large scale, from home desktop computers to large-scale printers for industrial production. According to the physical and chemical properties of the material and the different forming methods, 3D printing technology generally includes the following three types:

(1) FDM (fused deposition modeling) takes the melting characteristics of materials as the premise and uses the thermoplastic melting change law of polymer materials to stack raw material particles or filamentous harness materials one by one. Its advantages are very significant, and it is the most popular way of mainstream commercialization. It has the advantages of simple operation, wide sources of raw materials, good quality of formed products, nontoxic, and harmless. Most ready-made 3D printer devices in the market today are centered on integration

(2) The principle of SLS (selective laser sintering). The principle is to use the safflower laser as the main heat source to sinter the powder, the powder is selectively sintered by the pressing roller on the platform, and the laser beam is controlled by the computer. The bottom is sintered layer by layer, and the unsintered powder can be removed after sintering. Because metal materials such as glass and ceramics are all nonsingle crystal materials, it is difficult to determine their melting point. However, laser sintering technology can process not only ordinary alloy powder and ceramic powder materials, but also high-quality polymer materials such as polyamide fiber, wax, and ABS and PC better support. However, laser sintering also has some disadvantages that cannot be ignored, such as high-power consumption, strong environmental pollution, poor surface quality of the manufactured products, and high equipment maintenance costs. For the products sintered from alloy powders, the stress release time will change due to the effect of high temperature sintering

(3) Compared with other molding technologies, UV-curable resin molding has better molding accuracy and more significant molding efficiency. The material used is based on liquid photosensitive resin, which is characterized in that the resin is cured layer by layer by light beam irradiation, and the printing plane is placed on the liquid resin medium. At the end of each layer of solidification, the beam is swept across each layer of liquid resin and solidified. Since the product is suspended in the liquid solution, the structure is not limited to any structure in the air, and the requirements for supporting materials are relatively small. Compared with other molding methods, the printing method has higher precision and better quality. It also requires less surface treatment, thus enabling the rapid production of products with more complex polymorphic appearances. However, due to the poor recyclability of the photosensitive resin itself, the unused photosensitive resin will also be damaged, and the cost of the

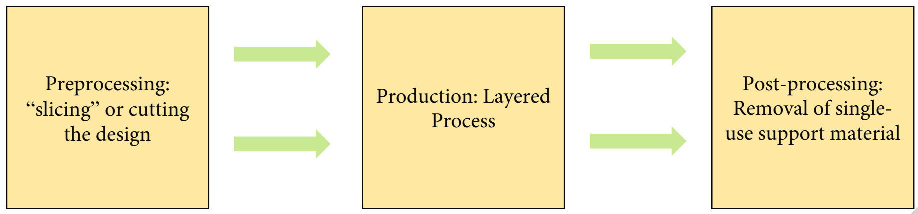

Figure 1: Working principle flow chart.

photosensitive resin itself is high, and the molded part will expand, thus affecting the printing efficiency. In addition, the photosensitive resin itself is not conducive to preservation, with a certain degree of radioactivity. In the long-term printing environment, it may also cause great disturbance to the environment. Therefore, it cannot be used due to raw material constraints and environmental disadvantages. Get a further boost

3. Methodology

3.1. The Working Principle of FDM. FDM is a new rapid additive production technology. Additive production is formed by the top-down stacking of materials. This technology does not rely on lasers as a molding energy, and heats and melts various consumables (such as engineering plastics ABS, and polycarbonate PC), and then stacks them for molding. At the same time, the characteristics of rapid solidification of materials such as thermoplasticity, hot meltability, and cohesion are used to form large-section profiles, which are not disturbed by the spatial structure of materials, and are fundamentally different from conventional processing and production methods. Traditional production produces the desired graphic products through material processing such as cutting, injection, and casting. The operation process is trivial and complicated, and the production preparation cycle is long. However, the application of FDM printing technology has greatly improved and improved the molding process of traditional production. FDM completes the simplest three-step process that is highly intelligent. The process flow and principle are shown in Figure 1 below. Its manufacturing process is simple and efficient.

3.2. Composition of FDM Institutions. According to the forming characteristics of melt deposition technology, the FDM-3D printer is studied, the part of the machine system is designed, and the basic structural frame of the whole machine system is provided. The whole machine system is mainly divided into transmission mechanism, fuselage frame, hot forming platform, and nozzle assembly. The fuselage frame is the basic component of the thermal printing device, which mainly provides a solid foundation for the installation of the transmission mechanism and the forming platform, and the transmission mechanism mainly drives the installation and forming of the thermal printing nozzle. This paper studies the general working functions of the platform and other executive parts. The forming platform is mainly a support platform for extruding filaments. The printer nozzle assembly is mainly responsible for feeding printer consumables into the flow channel, then heating or melting, and finally extrusion to the molding platform by the nozzle. Its basic mechanical structure is shown in Figure 2.

3.3. Design of the Stepper Motor Position Feedback Control Algorithm. Although stepper motors in 3D printers mainly work under open-loop control, the characteristics of motion actuators in 3D printers can be improved by using closed-loop control. Due to the nonlinear electromagnetic relationship of the stepping motor, the control system of the stepping motor belongs to the nonlinear control problem, which has been paid much attention in the professional literature. The control of motor pressure or motor flow as the system control signal, including linear feedback control, sliding mode control, robust control, and backward control, has been successfully used in stepper motor controllers. But this control method must measure or calculate the system state, such as the flow, pressure, stator speed, and rotor speed of the motor at different times. Although constitutive nonlinear observers can be used to predict situations that cannot be tested, more performance predictions generally require more motor data. Because the sampling of the permanent magnet controller is periodic, the clocks used by each step are different according to the running speed of the stepping motor, so the adaptability to the nonlinear aperiodic running process of the stepping motor is also very strong.

According to these phenomena in the feedback control of stepper motors, a stepper motor motion feedback control algorithm driven by step events has been developed. In this method, each stepper motor is identified as an event, and then, the stepper motor measures the event through the inductor. As for position and speed, the next speed needs to be set according to the current operation of the stepping motor to ensure the control accuracy of the stepping motor.

Suppose the ideal relationship between the stepper motor speed $v*(k)$ and the load position $p(k)$ is shown in Figure 3.

Among them, $v*(k)$ is the ideal speed of the kth time, that is, the frequency of the stepping pulse; p(k) is the position of the kth time, in steps; and $v*(k)$ is the measured speed of the kth time.

Second is a function representing the ideal velocity versus position relationship.

Suppose:

$$v^*(k) = \varphi(p(k)). \tag{1}$$

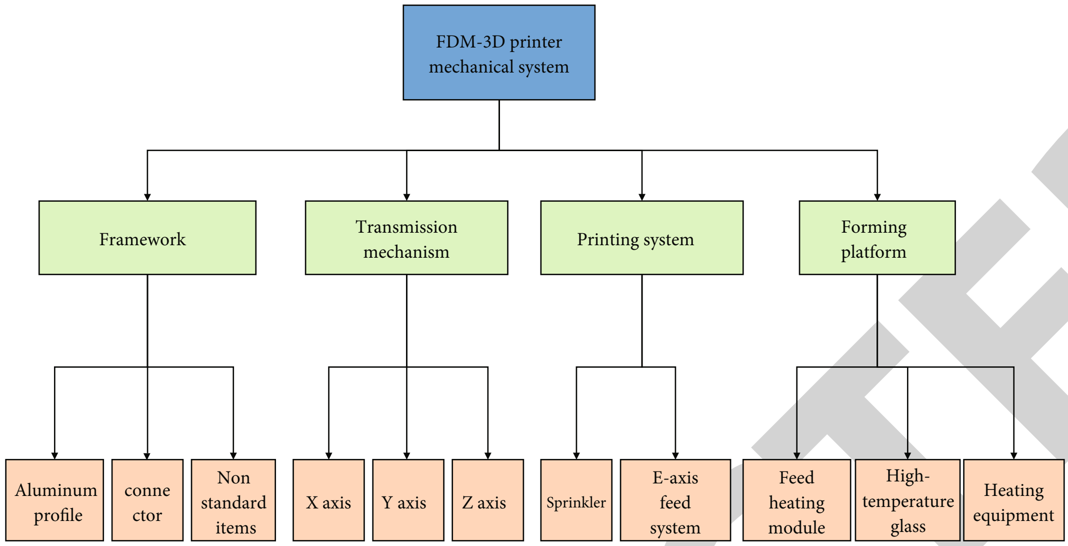

Figure 2: Mechanical composition of FDM-3D printing system.

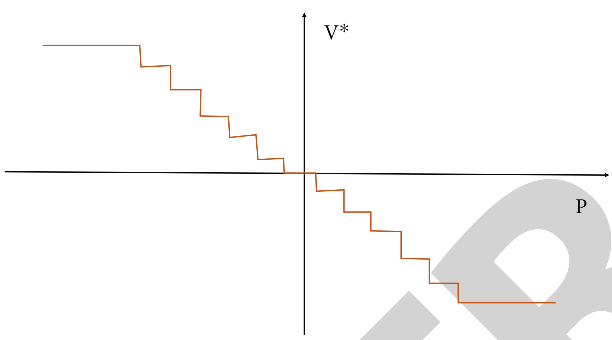

Figure 3: Ideal speed and position curve of stepper motor.

That is, a functional relationship is satisfied between $v*(k)$ and $p(k)$. Then, the ideal speed of the $k+1$th time

$$v^k(k+1)=\varphi(p(k))+\operatorname{sgn}(v(k)). \tag{2}$$

Among them, sgn is a symbolic function, that is

$$\operatorname{sgn}=\begin{cases}1 & x>0\\ 0 & x=0\\ -1 & x<0\end{cases} \tag{3}$$

Then, after calculating the expected speed $v^{`}(k+1)$ of $k+1$ times according to the actual speed v(k), the rotation law of the stepper motor is gradually converged to an ideal trajectory, namely

$$v'(k+1)=\varphi\left(\varphi^{-1}(v(k))+\operatorname{sgn}(v(k))-v^*(k+1)\right). \tag{4}$$

Among them, $\varphi^{-1}(v(k))$ corresponding to the ideal request, you change the position of the K-th stepper motor.

Calculate the velocity $v(k+1)$ of the next beat according to (1) (2) (4):

(1) If

$$\left(v'(k+1)-v^*(k+1)(v(k)-v^*(k+1)<0,\right. \tag{5}$$

but

$$v(k+1)=v^*(k+1). \tag{6}$$

(2) If $v'(k+1)(v(k)<0$,

but

$$v(k+1)=0. \tag{7}$$

(3) If the above two conditions are not satisfied, then

$$v(k+1)=v'(k+1). \tag{8}$$

The print head expected speed estimation model calculates the next expected speed of the print head by setting the expected speed and the position error obtained by the deviation calculation model:

$$v'(k+1)=v^*(h)+\varphi(\Delta p(k)). \tag{9}$$

4. Result Analysis and Discussion

4.1. Experimental Data and Environment. In this experiment, a self-made large-size double-cross FMM-3D printing system was used to study and discuss all parameters in the printing process, the slice setting of the software, and the parameter design of the servo stepper motor and nozzle.

Table 2: Parameters of one-dimensional slide table.

Name	Parameter
Stepper motor	Forty-two series two-phase stepping motor, the maximum stepping angle is 1.8 degrees
Synchronized gear	20 teeth/rev
Timing belt tooth spacing	2 mm
Rotary encoder	A and B have two outputs, four hundred pulses per revolution
Motor driven	9 V-24 V DC power supply

Table 3: Influencing factors and distribution.

Influencing factors	Slice layer thickness	Nozzle setting temperature	Idle speed	Grid fill rate	Feed rate
Number	I	II	II	IV	V
1	0.1	180	90	20	50
2	0.2	190	110	30	55
3	0.3	220	120	40	60
4	0.4	230	130	50	70

The temperature setting is reasonable. Adaptive adjustment and definition of layered filling path parameters in machining shaped slices: The feed rate provided by the large double-nozzle double-cross FDM is more stable and efficient. In this paper, the rated speed is set at a moving speed that can reach one hundred and twenty mm/s. Here, the dynamic adjustment mode is usually 80 mm/s-140 mm/s. The most common wire PLA is used in this test experiment, and the temperature range is in the range of 200-230°C. High fill rate does not include internal mesh support for reconstructing the outer contour, and fill density represents the packing density of the particles in the solid. On the premise that the thickness of each layer meets the printing test, set a reasonable thickness of each layer. Typically, the thickness interval is determined based on the size of the model. Here, the thickness is selected in the range of 0.1-0.4 mm. Idling retraction: When the nozzle is operating without a melt operation, its mobile retraction acceleration enables accelerated and decelerated retraction modes. The experimental platform includes a stepper motor, a conveyor belt, and a cable position sensor. The test equipment includes a stepper motor, a conveyor belt, and a cable sensor. The specific technical parameters are shown in Table 2.

4.2. Experimental Results and Analysis. The use of large-scale FDM printing equipment can study various process parameters and analysis of product forming quality, and the main parameters affecting the quality of FDM printing parts can include the following five factors: orthogonal experimental test analysis, comparison test analysis of different parts of the same parameters, and a comparison test between various parameters on the same part, as shown in Table 3. Table 4 uses orthogonal experimental comparison groups formulated under different conditions. The table lists the five main effects that influenced the experiment. Based on the five-factor and four-level orthogonal comparison experimental verification method in the above figure, in order to ensure the correctness of the test, this paper selects the experimental mode for verification as the most convenient and efficient rectangular bar module.

Table 4: Five-factor four-level orthogonal distribution test table.

Influencing factors	Slice layer thickness	Nozzle setting temperature	Idle speed	Grid fill rate	Feed rate
Number	I	II	II	IV	V
1	0.1	180	90	20	50
2	0.1	190	110	30	55
3	0.1	220	120	40	60
4	0.1	230	130	50	70
5	0.2	180	90	20	50
6	0.2	190	110	30	55
7	0.2	220	120	40	60
8	0.2	230	130	50	70
9	0.3	180	90	20	50
10	0.3	190	110	30	55
11	0.3	220	120	40	60
12	0.3	180	90	20	50
13	0.4	190	110	30	55
14	0.4	220	120	40	60
15	0.4	230	130	50	70

Table 5: Experiment record form.

Test serial number	X-axis direction/ mm	Y-axis direction/ mm	*z*-axis direction/ mm	Time consuming
1	-0.015	0.04	0.08	29
2	-0.02	0.03	0.67	23
3	-0.03	0.05	0.23	30
4	-0.04	0.05	0.62	69
5	0.18	0.57	0.41	68
6	0.13	0.38	0.52	35
7	0.12	0.10	1.09	25
8	0.09	-0.09	1.17	19
9	0.12	0.39	0.93	72
10	-0.31	0.09	0.34	57
11	0.05	0.50	0.81	35
12	-0.35	0.49	1.10	25

Because the test model used is very easy to calculate and master, a more precise Menel micrometer is selected to measure the difference of the printed pattern in the three directions of x-axis, y-axis, and z-axis. Set up in the same location, testing is usually performed on the center and two ends of the finished printed model. Take the value of each corresponding sample as the average value of its measurements, and fill in as shown in Table 5.

According to the above error data table, it can be determined that the following error and data set curves can be obtained from the direction of the molding deviation of the model.

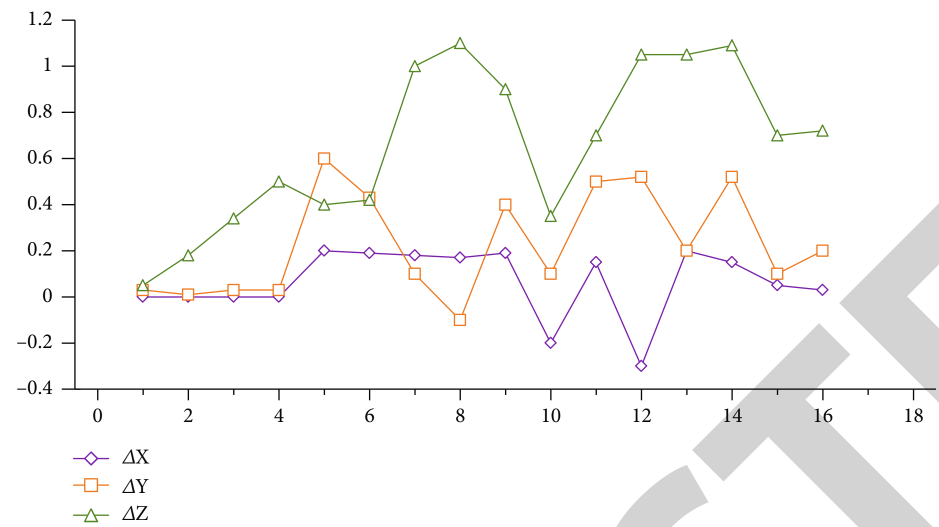

Figure 4: Line chart of printing size error.

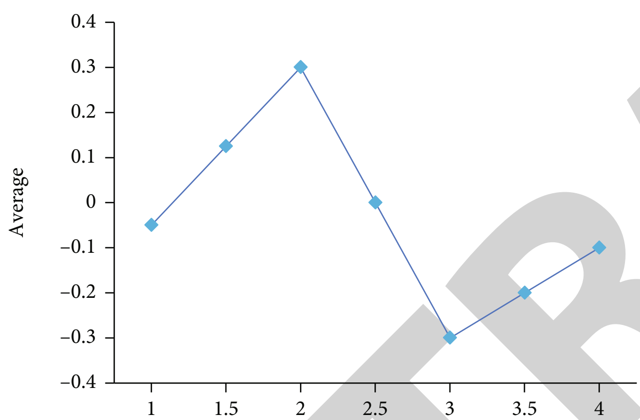

Figure 5: Line chart of the mean error of factor I.

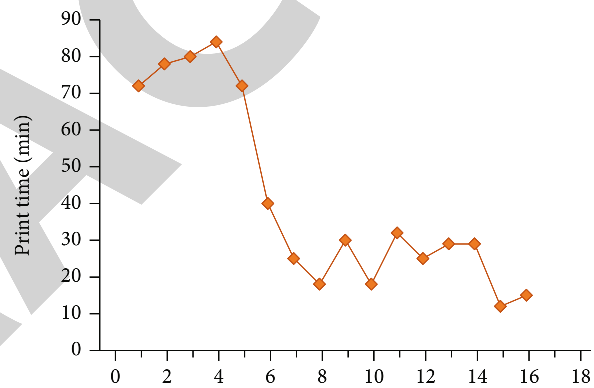

Figure 6: Line chart of the mean error of the factors in the experimental group of printing time.

δX on the line chart is the ratio between the actual printed x-axis value of the model and the actual design value of the modeling software, as shown in Figure 4. Similarly, ΔX and ΔY can be obtained. In general, in the measurement test of the self-designed and built FDM printing device, most of the deformation degrees of the measured model in the x-axis and y-axis directions are lower than the theoretical design size, while the maximum deviation in the z-axis direction is captured.. The degree also exceeds the theoretical model design size. The occurrence of this deviation also shows the difference in material characteristics. The shrinkage characteristics of the printing material also cause the deviation between the theoretical printing size and the actual size, but the degree of error can still meet the needs of sufficient accuracy for the normal operation of the machine and can be obtained from the data. To obtain the effect of the three-axis direction, this factor is mainly caused by the thickness of the layer, which is strongly related to the cross-sectional shape of the melt filament as summarized previously. The effect of filling amount and filling temperature is relatively weak, so the average printing time of each image is 80 minutes. It took at least 12 minutes, and the process accuracy of the samples was kept within reasonable limits. It is not difficult to see that the setting of co-printing process parameters is of great significance and has a very important impact on the molding quality.

Through the analysis of the factors affecting the accuracy of different directions, it can be seen that the layer thickness, nozzle filling speed, nozzle temperature, and nozzle idling speed have the greatest impact on the forming accuracy of the printer, and the filling rate has the least effect on the forming accuracy. As shown in Figures 5 and 6, according to the error analysis, the optimal combination is I1II3III1IV4V2. Among these influencing factors, the depth of base layer has the greatest influence on printing efficiency, followed by filling rate, printing efficiency, and idle speed. According to Figures 3 and 6, in the low operating temperature region, the print head temperature has the least effect on the printing efficiency. The higher the fill rate, the greater the fill rate and no-load operation efficiency, and the shorter the printing time, conversely, the longer the printing time. In the daily printing process, different technical coefficients can be adjusted as required. When the accuracy requirements are not high, the processing parameters can also be reasonably changed, thereby improving the printing efficiency and manufacturing effect.

5. Conclusion

The article also discusses the development of FDM 3D printers in China. According to the actual situation of the slow printing speed and poor printing quality of the current FDM 3D printer, a large-scale FDM dual-nozzle 3D printer is proposed, and the overall mechanical structure of the printer is analyzed, and the FDM dual-nozzle 3D printer is studied. The coordinated control of the moving structure is consistent with the control process.. Printing parameters were also investigated. In this paper, a new cross-forming system is introduced. Because the structures are interlaced, the structures have good stability in the same plane, and a new wire feeding mechanism for 3D printers is proposed. According to the operation characteristics of the ball screw stage, this paper proposes a new type of cross-drive mechanism to improve the printing efficiency, accuracy, and reliability of the current 3D printer. The reliability of the formula is verified by experiments and analysis, and the printing error caused by the line width accuracy is theoretically verified. The experiment and data analysis proved its feasibility and technically proved the printing influence brought by the line width precision. After experiments and data analysis, we found that the technical parameters that have the greatest impact on printing accuracy are layer depth, filling efficiency, nozzle temperature, idling efficiency, and filling rate.

Data Availability

The labeled data set used to support the findings of this study is available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest.

Acknowledgments

This work is supported by Xi'an University.

References

[1] X. He, S. Xie, X. Li, X. Lv, and R. Huang, "Experimental and mechanism research on vacuum carbothermal reduction of zinc-containing electric arc furnace dust," *JOM*, vol. 74, no. 8, pp. 3039–3048, 2022.

[2] M. A. Boca, A. Sover, and L. Sltineanu, "Theoretical and experimental research on the quality of thermoformed foils using 3D-printed plastic moulds," *IOP Conference Series: Materials Science and Engineering*, vol. 1235, no. 1, article 012065, 2022.

[3] R. Zhou, L. Meng, and X. Yuan, "Research and experimental analysis of hydraulic cylinder position control mechanism based on pressure detection," *Machines*, vol. 2, pp. 21–29, 2022.

[4] A. M. Megahed, "Improvement of heat transfer mechanism through a Maxwell fluid flow over a stretching sheet embedded in a porous medium and convectively heated," *Mathematics and Computers in Simulation (MATCOM)*, vol. 187, pp. 97–109, 2021.

[5] W. Jiang, X. Liu, and H. Chen, "Analysis and experimental research on dynamic characteristics of operating mechanism of fast vacuum transfer switch," *IEEE Transactions on Applied Superconductivity*, vol. 31, no. 99, p. 1, 2021.

[6] D. Chen, M. Liu, and B. Hu, "New insights into the promotion mechanism of (NH 4) 2 SO 4 in sulfidization flotation: a combined experimental and computational study," *Politechnika Wroclawska Oficyna Wydawnicza*, vol. 12, no. 5, pp. 23–31, 2021.

[7] S. Akhtar, W. Lee, M. Kim, M. S. Park, and W. S. Yoon, "Conduction mechanism of charge carriers in electrodes and design factors for the improvement of charge conduction in Li-ion batteries," *Journal of Electrochemical Science and Technology*, vol. 12, no. 1, pp. 1–20, 2021.

[8] L. Ruan, J. Tong, F. Luo et al., "Magnetic improvement and relaxation mechanism of the Tb-Ph thalocyanine single-molecule magnet by absorbing CH2Cl2Molecules," *The Journal of Physical Chemistry C*, vol. 125, no. 18, pp. 10165–10172, 2021.

[9] J. U. Xin, "Experimental research on the dynamics of ultravioletlaser-induced damage," *Scientia Sinica Physica, Mechanica & Astronomica*, vol. 51, no. 9, article 092005, 2021.

[10] D. Jiang, X. Cheng, and S. Wang, "Study on the pyrolysis mechanism of unsaturated fatty acid: a combined density functional theory and experimental study," *International Journal of Energy Research*, vol. 46, no. 2, pp. 2029–2040, 2022.

[11] S. Salajegheh, K. Shahriar, H. Jalalifar, and K. Ahangari, "Numerical and experimental research of rock failure mechanism and its dependence on mi Hoek-Brown failure criterion," *Faculty of Mining, Geology and Petroleum Engineering*, vol. 36, no. 3, pp. 157–165, 2021.

[12] Z. F. Zhou, "Research on mechanism configuration and coordinated control for power distribution network live working robot," *Industrial Robot: An International Journal*, vol. 2, pp. 33–46, 2020.

[13] H. X. Huang, W. J. Yao, W. B. Li, X. M. Wang, Z. Y. Lu, and X. J. Zhang, "Determination of and experimental research on the parameters of the Johnson–Holmquist-II (JH-2) constitutive model for granite," *Rock Mechanics and Rock Engineering*, vol. 55, no. 7, pp. 3901–3917, 2022.

[14] S. Song, J. Zhou, Y. Li, J. Liu, J. Li, and P. Shu, "Network pharmacology and experimental verification based research into the effect and mechanism of Aucklandiae Radix-Amomi Fructus against gastric cancer," *Scientific Reports*, vol. 12, no. 1, pp. 88–99, 2022.

[15] H. El Jjouaoui, G. Cruz-Martinez, and J. C. Avila Vilchis, "Modeling of a remote center of motion spherical parallel tensegrity mechanism for percutaneous interventions," in *International Symposium on Advances in Robot Kinematics*, vol. 12, no. 1pp. 56–67, Springer, Cham, 2022.

[16] J. Ding, C. Zheng, and C. Song, "Experimental study on the improvement of yaw stability by coordination control between the *Caudal Fin and Anal Fin*," *Journal of Bionic Engineering*, vol. 1, no. 1, pp. 22–34, 2022.

[17] L. Shiyi, Z. Peng, W. Senyang, Z. Chengqian, F. Jianzhong, and C. Zichen, "A pellet 3D printer: device design and process

parameters optimization," *Advances in Polymer Technology*, vol. 2019, Article ID 5075327, 8 pages, 2019.

[18] J. Wang, "The design research analysis of 3D printer based on FDM," *Journal of Physics: Conference Series*, vol. 1992, no. 2, article 022143, 2021.

[19] J. Liu, Z. Fang, and Y. Wang, *Experimental research on the mechanism of chemical energy conversion to light energy under thermal induction*, vol. 11, no. 1, 2021Heighten Science Publications Corporation, 2021.

[20] D. G. Zisopol, I. Nae, A. I. Portoaca, and I. Ramadan, "A theoretical and experimental research on the influence of FDM parameters on tensile strength and hardness of parts made of polylactic acid," *Engineering, Technology and Applied Science Research*, vol. 11, no. 4, pp. 7458–7463, 2021.