Analysis and design for 3D printing control system based on cement component

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Abstract: The main content of this research design is the system analysis and design of 3D printer based on cement component. The goal of the research design is to analyze and design a 3D printer system model based on cement components that can be controlled systematically. Some algorithms can be tested.

Key Words: 3D printing, cement components, Model analysis

1 Introduction

In recent years, under the environment of industry 4.0, China has made the "made in China 2025" plan and made efforts to this end. Our goal is to become a manufacturing power. In order to achieve this goal, intelligent manufacturing is essential, and in such an environment, 3D printing of buildings is booming. With the development of science and technology automation technology, computer sensors, CNC and other related technologies have been greatly improved, precision control and automation system has been greatly improved. Many of the most repetitive, dangerous, and difficult jobs have been replaced by automated production systems. Modern production assembly and computer-aided design have become the modern manufacturing standard. In short, people put forward higher requirements for the running difficulty, reliability, speed and cost of basic manufacturing. However, the existing rapid manufacturing methods have disadvantages such as high price, high cost and strict requirements on external conditions. Therefore, 3D printing rapid prototyping technology has become a hot spot in the rapid manufacturing industry due to its advantages of small pollution, fast printing speed, comprehensive products and simple operation[1,2,3].

Both the United States and Japan have invested heavily to address the relevance of the construction sector to automation technology to meet production safety, quality, and cost targets. However, because the operation and detection of the mechanical system cannot be carried out in real time, the single-task mechanical building area is small. In addition, the automation equipment has a lot of prefabricated parts, which leads to additional storage costs, transportation costs and maintenance costs of mechanical equipment, thus greatly increasing the total cost. Therefore, if the traditional automation technology is used to complete the automation of the building industry is a large amount of capital.

The reasons for the slow development of automation technology in the construction industry are as follows: Automation technology is not suitable for large construction products. The cost of raw materials used in automatic construction products is high and the scope of application is small. The cost of automation equipment is higher than that of traditional construction. Automation has a certain impact on the traditional construction project methods and management. To sum up, the current automation technology is not enough to solve these problems economically and effectively, and the automation development of the construction industry needs a new construction technology. And 3D printing is such a new technology. 3D printing, a layered manufacturing technology, has a promising future in large-scale buildings. Different from traditional top-beam architecture, 3D printed architecture is a holistic architecture, which has many applications in aerospace, medical equipment and small building industries [4-8]. This paper will introduce the application of 3D printing in cement construction industry.

As an emerging industry, 3D printing has become one of the hottest industries in recent years, which is favored by consumers and manufacturers. The government also attaches great importance to it. This also makes the development of China's 3D printing technology industry into a golden era. The main difference between 3D building printing and other 3D printing is that it requires a large extrusion device, which squeezes out cement and concrete, etc. This paper analyzes and designs a cement component printer based on 3D printing technology, and introduces and analyzes the existing 3D types and process flow of common buildings. Finished the analysis and design of PLC control system, motion system, printing material extrusion system, transmission system, protection system and hardware equipment.

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2 Technical analysis of architectural 3D printing principle

3D printed buildings are practical buildings with building standards automatically printed by mechanical equipment according to the set procedures. In order to achieve this, a lot of technology is needed and the process is very complicated.

The principle of architectural 3D printing is the same as that of other 3D printing products. Compared with traditional 3D printing products, it only has different requirements on the products. The principle of 3D printing is to produce buildings that conform to architectural standards and have practical USES through 3D printing technology. The first step in 3D printing is to design a 3D model. There are two common methods of 3d modeling: one is direct modeling using cad software; Secondly, through reverse engineering, the 3d solid model is derived from the data structure. After the modeling is completed, the 3d model should be approximated. It is to transform the 3d model obtained by computer aided design software or reverse engineering into an applied data pattern which can be recognized by the system software through the necessary conditions. At present, the commonly used identifiable data patterns mainly include STL, LMI, CLI, etc.

After the approximate simulation of the 3d model, the layered slicing process is carried out. 3D printing is a process of stacking and layering. In order to meet the requirements of processing, 3D models must be fitted with many parallel and equally spaced 2d models. This process is called layered slicing. The more layers, the higher the precision of the product, but the longer the processing time; The fewer the layers, the lower the accuracy of the product, and the shorter the processing time. After slicing the 3d model, slicing path planning is needed. According to our requirements, 3D printing is processed. Firstly, the layered slice information data obtained from the layered slice processing is converted into the running path of the 3D printing nozzle. This process is called laminated path planning. In order to get a good print effect, we need to convert the laminated data into a specific running path of the nozzle and optimize the design. Finally, the print is processed and overlaid. Let the equipment run according to our preset nozzle running path, squirt out raw materials, make the raw materials pile up, and finally form the product we need. The above method is applicable to all 3D printing technologies. After the detailed programming mentioned above, the error is very small and the precision is very high, which can be applied to precision instruments, even medical materials for human body and so on. This paper is the 3D printing of large buildings, the maximum direct printing can reach 20×5×53m, the diameter of the printing nozzle is also relatively large, so the system in this paper allows small printing errors, so in the programming directly according to the object CAD model using interpolation program to program, is also one of the characteristics of the equipment system introduced in this paper. In summary, building 3D printing is a technology that USES building materials to build buildings. Although called printing, the building's 3D printers are much larger and more complex than traditional printers, including control systems, hardware machinery, special printers and special printing materials. The 3D printing of the building is based on the 3D model data designed on the computer, and the raw materials are printed layer by layer through the running of the program until the production of the product is finished.

3D printing makes use of the principle of 3D printing to superimpose raw materials on top of each other and make objects by adding materials [9-11]. it has a lot of its own characteristics and advantages compared with the traditional processing material reduction. Digital manufacturing: unlike traditional construction, 3D printing USES computer software to turn a product into a data program and then mechanical equipment to process the raw materials into the original product.

Layered manufacturing: 3D printing technology converts physical objects into layer information through a computer, further into the running path of the nozzle, and then prints and stacks on top of each other. Stacked manufacturing: 3D printing is the manufacture of layers, which are stacked to form the final product. Direct manufacturing: unlike the traditional cutting and polishing of the material reduction manufacturing, 3D printing is direct molding, one time

Raw materials are manufactured layer by layer without reprocessing. Rapid manufacturing: the 3D printing of buildings can be directly produced as long as the drawings are designed on the computer, which is fast and efficient. Compared with traditional building construction, architectural 3D printing technology has the following advantages: 1. High building efficiency, and the ability to build a variety of complex buildings in a variety of environments and conditions. 2. Architectural 3D printing USES computer-aided design, and its data are derived from software models, so the design of 3D printing has greater freedom and higher accuracy. 3. Save labor cost. 3D printing of buildings can realize full automatic production, which greatly saves labor cost. 4. Low requirements for working environment, 3D printing of buildings USES mechanical equipment, which can work in any terrain environment, even in outer space. 5. It has little damage to the environment. 3D printing technology USES few raw materials, and some can be produced by using construction wastes. Less waste is produced, and almost no construction waste is generated in 3D printed buildings. So it's a very environmentally friendly way of building.

Of course, 3D printing of buildings has been under development for a short time, although there are also examples of large houses being built. But much of the technology needs to be improved, and the usefulness of the products it produces remains to be improved. The safety of using it to build tall buildings at a time when land is scarce remains to be seen.

3 The Research Content

Although 3 d printing technology from overseas since the 1980 s, proposed the theory of related technologies and a wide variety of based on the different technological process of 3 d printing is also constantly updated equipment, especially the core technology of 3 d printing patents expire in 2009, is to lower the price of 3 d printers for more than a dozen times, all kinds of models have emerged in the market. However, 3D printing still has many shortcomings in terms of materials, technology and equipment. It is precisely because of your continuous research that the materials available for 3D printing are more abundant, the price is lower and lower, and the materials are more and more convenient. After the expiration of the core patent in the process, the domestic researchers make full use of the various process technologies to learn from each other and achieve the effect of technological progress. The commonly used methods of 3D printing for architecture, such as contour process, d-shape and concrete printing, are the mixed products of traditional 3D printing process. And in the equipment is more earth-shaking changes, the size of the subdivision of minicomputer and mainframe, the system is a hundred flowers and a hundred schools of thought contend. To sum up, this paper studies whether the selected materials of this system are suitable, whether the process flow matches, and whether the equipment system matches each other, so as to check whether the whole system scheme is perfect.

According to the principles of layer upon layer, layered printing and direct manufacturing of 3D printing, problems and difficulties existing in the practical application of 3D printing of physical objects can be mainly divided into materials, processes, equipment and so on. In terms of materials, whether it is extruded cement concrete or other materials, or the lifting platform carries out selective adhesion of raw materials, it has high requirements on materials. Extrusion materials: in extruding curing class 3 d printing, such as contour printing craft, concrete, their demand for printed material requires special 45 - speed dry, layer upon layer overlay in extrusion raw materials such as contour process, concrete printing dry raw material must have a good speed to ensure print objects can rapid prototyping, but cannot be used inside the hopper directly curing effect. Support, used to ensure that the first printed raw materials can support the later printed materials, so that the print in the absence of external support conditions can exist normally and will not collapse. Plasticity, the printed raw material must be able to carry out a certain amount of transformation and adjustment while ensuring that it does not collapse. Fluidity: the printed material needs a distance from the hopper to the nozzle, which requires a certain amount of fluidity. Water retention, printing material whether it is cement concrete or other adhesives contain a lot of water, the loss of water will let the raw material quickly solidify, lose the building performance, so there should be water retention agent to retain water. Adhesiveness: the printing raw materials must have adhesiveness, and only with adhesiveness can 3D printing be realized by layer-by-layer construction, so that the printed articles printed in layers become a whole. Tensile strength and compressive strength, 3D printed objects have certain practical USES, such as Bridges in construction, metal frames in medical equipment and artificial blood vessels, which all need to be tensile strength and compressive strength. 3D printing finally extrudes the printing raw materials through the nozzle, so the raw materials have a certain degree. Selective bonding materials, based on the selective bonding of printing, such as d-shape it is the principle of the nozzle out of the adhesive, through the overall platform of the fall, so that the binder selective bonding of raw materials, the final form of printing the whole. So his raw materials are divided into powder materials and adhesive materials. Powder material powder material first to consider its particle size, the choice of binding 3D printing nozzle diameter is very small, so the selection of raw materials should not be too large, resulting in the spray nozzle of the small binder can not achieve the overall bonding effect, and ultimately make the printing accuracy reduced. The interaction force between the small particles is strong on the whole, but the particles should not be too small, and the small particles rising and falling on the platform are likely to generate dust and block the nozzle [12]. Bonding materials we can choose to bond curing materials into three types: no bonding liquid. A liquid that reacts with the printed material. A liquid having a certain adhesive action. The liquid itself does not bond, only provides the mutual connection between the raw materials, through the self-hardening of the raw materials and the molecular interaction force to achieve the purpose of bonding. The common reaction with raw materials is the reaction between gypsum and water, cement and water and other chemical reactions to solidify the raw materials. There is a certain bonding effect of adhesives the general principle is the liquid volatilization of the remaining adhesive to the raw material powder bonding together, and the raw material together to form a printed article

Of course, no matter for extrusion or bonding, in addition to the suitability of raw materials for 3D printing, it should also meet the requirements of the building itself. For example, hardness, durability, corrosion resistance, temperature affecting stability and so on are all important factors for the selection of printing raw materials. Besides, the country advocates green building, so it has to achieve environmental protection, energy conservation, health and so on. Of course a few special buildings such as print house even consider the comfort of the human body, heat preservation performance, sound insulation performance, heat insulation performance. And in certain environments, such as outer space, there is also a lot of research, such as building a space station on the moon with local materials.

Different from traditional architecture, architectural 3D printing has its own materials, processes and equipment. It is a building manufacturing process based on layer upon layer process. This paper studies the printing of large cement components based on 3D printing technology. PLC control system is used to control the flow of each module, so as to complete the printing of large volume cement.

The overall design principle of the system equipment introduced in this paper is (1) a production equipment designed to realize the printing of large-scale and large-volume cement components with the application of 3D printing technology. Can achieve a large number of batch production of cement components. (2) own independent intellectual property rights and patents for the equipment. (3) the equipment can be maintained, upgraded and replaced. (4) the equipment should be highly intelligent and automatic, with self-check and feedback functions, and can be controlled in real time. (5) it has perfect safety supporting equipment and functions.

This equipment is controlled by PLC for the control system in control, control the XYZ three-axis motion system and print the extrusion system of raw materials, and its control principle is by controlling the XYZ triaxial and discharging servo motor drive, driven by servo motor, but also through the simple switch principle of PLC control solenoid valve of the nozzle, nozzle in motion when there will be no leakage, complete some suspension control, stop control and back to zero control, and some basic operations. In the aspect of hardware with the erection of the steel frame, of XYZ triaxial above the nozzle is hopper, Siemens S7-200 PLC, servo drives, servo drive X Y Z, servo drives, servo drive P (nozzle), servo motor, servo motor, servo motor Y Z, X P, nozzle, servo motor control nozzle solenoid valves, operation panel and so on. In terms of software program, different from other articles, the equipment first layers and then converts the layer information into a program through software. In this paper, my tutor directly USES interpolation program to write through the physical CAD model, and then writes.

4 Conclusions

This paper analyzes and designs a system based on 3D printed cement components. The system working process is, first of all through the printing material to complete the design of the program, is different from other systems convert printed material to CAD model, again through the software to generate STL class program, directly from the CAD model in this paper, system program, although increased the difficulty of programming, but for the core secrets protection has a good effect. The program was then stored in the Siemens s7-200, which was powerful but inexpensive and cost-effective, greatly reducing the cost of the equipment. PLC control XYZ triaxial motor and feed motor to complete the motion control of the printing system. In order to work safely, the limit setting is set and the proximity switch is selected. In terms of the motor, servo motor and servo controller are selected, because the hopper is together with the nozzle while controlling the nozzle movement. This design reduces the intermediate transportation of raw materials, and also avoids the problems of blockage and leakage of the feeding tube. But this design makes the nozzle very heavy, which requires more power and precise control, so servo motors and servo controllers are used. A servo motor is used to control the screw rod in the extrusion system to complete the discharge control. In terms of transmission, gear transmission is used.

The hardware equipment of the building 3D printing system and the corresponding system formed by them. And why you chose these hardwares. In the field operation and debugging of the equipment, we found that the selected hardware equipment can basically meet the requirements we want to achieve. In the field assembly process, no problems were found. During the test, the PLC could work normally to send signals to the servo driver, control the speed of the servo motor, and the kinetic energy was transmitted to the mechanical arm sprinkler head through the gear drive system, so that the sprinkler head could be used. At the same time, the instruction is sent to the feeding servo motor to make the screw screw rotate, the nozzle solenoid valve is opened, when the nozzle runs to the limited position, the timer works, the nozzle decelerates to stop. What should pay attention to is that the equipment installation must be strictly in accordance with the requirements of the instruction, pay attention to do a good job of electromagnetic shielding and protection, or the equipment may be running after the failure of electromagnetic interference.

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