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Hybrid Teaching for 3D Printing Skill Training and Critical Forming Parts Design

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Abstract

3D printing capability involved with machine operation and maintaining, critical motion mechanical design and key process parts for fused plastic deposition. For high vocational skill training in the polytechnic institution, ensure the students fulfil the goal of talent training for major programs, and reflects the integration of core courses teaching and new technology innovation applications. Through the hybrid teaching and training, students perform the equipment operation, three-dimensional design and process related parts innovation, combined with hands operation and brain thinking, which melton morality and skills. They exercise the craftsmanship spirit of excellence and innovation, and provide useful experience for the development of relevant vocational skills of future advanced manufacturing technical workers.

Keywords

3D Printing; Vocational Skills; Hybrid Training; Innovative Design.

1. Introduction

3D printing, also known as additive manufacturing technology, is a comprehensive and intersecting advanced manufacturing technology, which integrates computer, CAD design, electromechanical, material and other technologies. It has the advantages of high processing flexibility and rapid prototyping. It is based on digital models. , an emerging manufacturing technology that stacks materials layer by layer to create physical objects, and realizes a major shift in manufacturing methods from equal materials, subtractive materials to additive materials [1-5]. Additive manufacturing is an important part of advanced manufacturing and is widely used in industrial production and educational technology. This technology can quickly create physical products directly from 3D digital models without forming tools and blank fixing fixtures. revolutionary change[6-8]. With the rapid development of the 3D printing industry, 3D printing related technologies have become the mainstream new technology in the mechanical program majors of vocational colleges. At present, most of the secondary and higher vocational colleges in China have 3D printing related courses . The advanced manufacturing programs group of Wenzhou Polytechnic has built a 3D printing rapid prototyping training classroom, relying on the Zhejiang Provincial High-skilled Talent Training Base to undertake the teaching of 3D printing new technology courses for the program group, combined with mechanical design, mold design, processes control training, etc. During the practical teaching weeks, the model rapid prototyping verification task was carriied out after the digital design of the corresponding course is completed, and the corresponding 3D design research, process optimization and innovation are carried out in combination with different types of 3D printing processes, different types of mechanical transmission structures, and different materials. From the ability to study, to explore and innovate the vocational skill improvement, realize the cultivation of important vocational skills such as 3D printing equipment operation, structural design, process innovation and so on.

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2. Vocational Skills Training for Rapid Prototyping of Mechanical Parts

In order to better cultivate students' 3D printing molding vocational skills and reflect the differences in the level of 3D printing professional ability requirements for different majors, this teaching reform carries out skills training for rapid prototyping of products, and key molding equipment. The three-level technical skill teaching of structural innovation three-dimensional design and printing process optimization of fusion material molding corresponds to the ability to use 3D printing machine, the ability to innovate and improve the printing equipment, and the practical teaching that can optimize and innovate the process technology. It fits well with the professional ability level of the programs group, realizes the professional ability progression of "practice-research-innovation", and cultivates vocational students from practical 3D printing equipment to innovative design of equipment structure. To be able to innovate and improve the material molding process and key components, it strongly supports the realization of the goal of talent training for programs group, and reflects the integration of program core courses teaching and innovative application of new technologies.

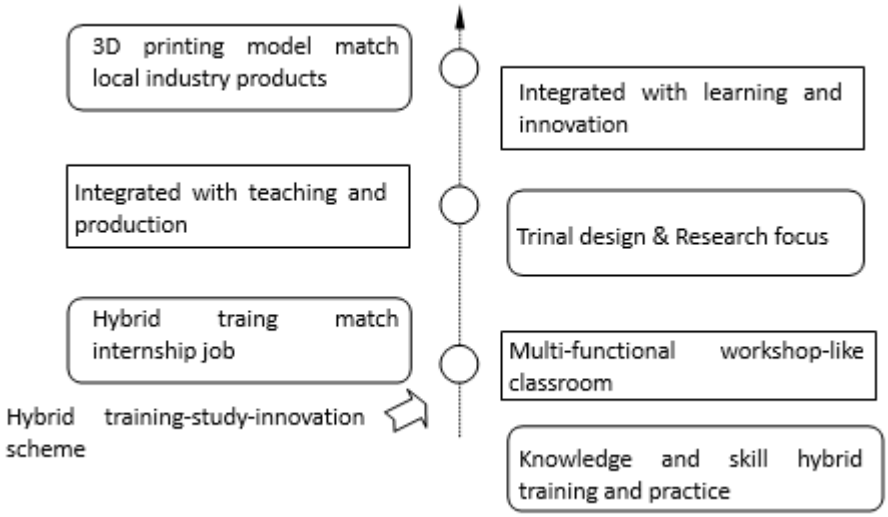

Fig 1. Hybrid teaching and training mode for new technology application

According to the technical skills requirements of the manufacturing industry for 3D printing professionals, combined with the continuous enhancement of the new technology application courses in the advanced manufacturing programs group talent training program, constantly adjust and improve the 3D printing technology application related course programs in the programs group, formulate specific, Specialized 3D printing technology application personnel training specifications, optimize the training process, focus on teaching, training, and improving students' applied operation ability. The construction of the 3D printing related course system is no longer simply superimposing the courses of computer or mechanical manufacturing, but also reconstructing and adjusting the content and form of the courses to ensure the integrity of the course system structure and the rationality of the proportions of various courses. Guarantee the hours of practical courses and promote mutual knowledge melting between related courses.

In the specific implementation process of the project, the 3D printing-related professional courses are mainly divided into two modules: professional core courses and professional practice courses. Among them, the professional core courses mainly aim to highlight the cultivation of professional core competencies, take into account the extension and expansion of comprehensive capabilities, and mainly build the basic principles and material characteristics of 3D printing, additive manufacturing and other product production. This part of the course and traditional mechanical cutting manufacturing can be In contrast, teaching is carried out to

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promote students' overall view of manufacturing technology, and to break through inertia and directional thinking. In terms of 3D printing practice courses, 3D digital model design, 3D printing equipment principle and maintenance, 3D printing design comprehensive training and other courses. In the teaching process, the construction of project-based, practical and applied curriculum resources is carried out to provide a source for the quality of talent training. The logic flow for the hybrid traing-study-inovation-scheme illustrated as Fig 1.

3. Research on Innovative Design for the Prototyping Mcahnie Mechanical Structures

After completing the training objectives of the basic operation ability of operating 3D printing equipment, the backbone program,namely, mold design and manufacturing program, students of the programs group combined the practical teaching content of "Mechanical Design", "Industrial Product Modeling Design" and "Graduation Comprehensive Practice" to conduct team-based Research on innovative design of 3D structure of printing equipment. When the team group researched the three-dimensional design, the mechanical structural parts of the equipment were appropriately simplified, the frame was designed in the form of aluminum profiles and corner codes, the mechanical motion was designed through the synchronous wheel and the synchronous belt, and the printing head and the hot bed platform were controlled by the single chip microcomputer. Temperature control to achieve the dynamic and stable temperature field required for printing. The overall equipment can be subdivided into: the frame part; the moving part; the temperature control accessories part, and the corresponding mechanical structure block diagram is shown in Fig 2.

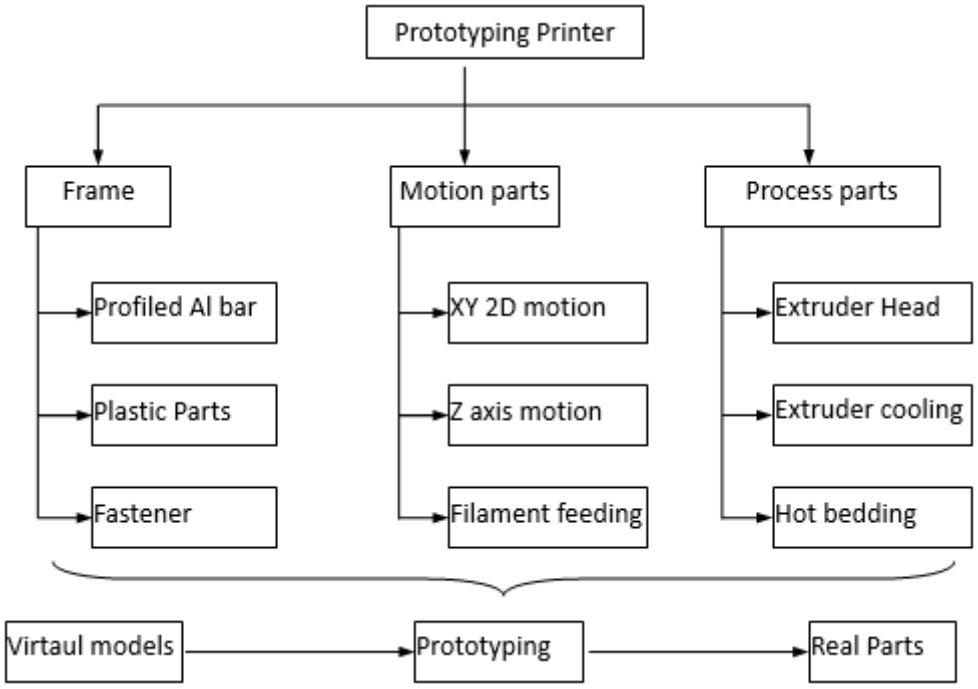

Fig 2. Block diagram of the 3D design of rapid prototyping equipment

3.1. Skeleton Frame Design

The frame is the basis of the entire fuse forming 3D printing equipment, because all the components are installed on the frame. The frame must have a certain strength and rigidity to ensure that the equipment is stable during operation and minimize vibration during machine operation. The whole frame adopts European standard 2040 aluminum profile and its corner code. This profile is distributed with inverted T-shaped grooves on four sides, and a T-shaped

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nut can be placed in the groove for convenient fixed connection with other profiles or components. Due to the larger overall size and heavier weight of the equipment, the 2040 profile is used, and its area and strength are 2 times that of the commonly used 2020 profile, which can maintain the overall rigidity and stability of the frame skeleton.

3.2. XY Motion Mechainism Design

In order to realize the layer-by-layer aggregation of silk like silk spun by silkworms, the extrusion head needs to perform smooth XY arbitrary movement in a plane parallel to the ground. In order to reflect innovative research, the application scenarios of the relevant core courses of the major are comprehensively applied to realize the low-cost, large-scale 3D printing molding space size, so as to meet the requirements of the same mechanical structure to complete more molding space and achieve higher space utilization. Therefore, it is necessary to minimize the weight of the molded moving parts with the same motor performance. Therefore, in the practical teaching, the teachers and students of the project team innovatively designed the linkage XY motion. The realization principle is described as follows: the two drive motors are independently fixed on the frame. The moving parts are driven by a synchronous belt with a unique winding design and the shape of the winding path is the letter H shape. The principle of movement is that when the two motors travel in the same direction, the load moves in the positive direction of the X-axis and is dragged by the two motors at the same time. Since the direction of the synchronous belt is opposite in the Y-direction, the moving distances of the two motors cancel each other out. There is no movement. When the two motors rotate in the opposite direction, the positive direction of X will cancel each other due to the opposite movement of the synchronous belt, and the load mechanism will move in the positive direction of the Y axis. For the reverse movement in the X direction and the Y direction, the motor corresponding to the reverse direction can be realized. The linkage type drive design greatly reduces the weight of the motion mechanism, and can achieve higher speed motion under the condition that the motor power and torque remain unchanged.

3.3. Vertical Lifting Platform Design

Rapid prototyping realizes the plane material gathering of the digital model through the movement of the XY platform. In order to realize the three-dimensional modeling, the forming platform needs to move in the Z direction. Due to the large size of the equipment, the Z platform is driven by dual motors and guided by 4 smooth rod axes with a diameter of 16mm to ensure smooth, stable and rigid movement. The vertical lifting platform designed by the teachers and students of the project has enlarged the diameter of the vertical guide shaft and is driven by dual motors. This innovation strongly supports the forming platform that may be caused by the single-sided motor drive of traditional 3D printing equipment during long-term operation. Due to the tilt problem, the vertical driving force of the equipment is increased by 2 times, and the guidance accuracy is increased by 4 times, which provides a reliable mechanical guarantee for the large-scale, high-precision 3D printing for this innovative research.

4. The Process Relatved Parts Innovation for Better Material Property

4.1. Filameng Feeding Design

In the 3D printing molding process, the most critical part of the process is the temperature, molding accuracy and molding motion control of the filament. The uninterrupted, forming quality and precision are closely related to the wire feeding mechanism. The wire feeding mechanism is designed as a motor-driven gear, which is paired with a passive bearing to achieve rolling feed. In order to avoid the distance between the gear and the bearing being too large or too small, a spring is placed before the gear and the bearing, and there are adjusting bolts on the back of the spring. When outfitting the equipment, by adjusting the depth of the

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bolts, the distance between the bearings of the gears can be achieved to ensure the smooth feeding of the wire material, which will neither make the wire material slip nor break the wire material. There are two fixed positions of the wire feeding mechanism, one is fixed with the forming part for XY plane movement (short-range wire feeding), and the other is fixed on the frame (remote wire feeding). The advantage of the former is that it is close to the wire outlet, which can effectively reduce the expansion pressure inside the wire outlet mechanism and save tailings. The advantage of the latter is that the wire feed motor and gear are fixed on the frame, and the molding moving part is very light in weight, enabling high-speed molding.

4.2. Design of Extrusion Head

The extruder is the core component of the technological innovation of the self-made 3D rapid prototyping equipment, and it is the key to realize the spinning. Its composition and principle are as follows: driven by the gear of the extruder, the wire material enters the extrusion head through a smooth Teflon tube. The upper part of the throat is connected with the cooling block, and the lower part is connected with the heating aluminum block; the heating aluminum block is equipped with a heating rod and a temperature sensor. The heating rod keeps heating until the temperature does not reach the set melting temperature to melt the filament. Driven by the extrusion motor, the melted filmament is spun out through the nozzle at the end to complete the extrusion. The upper part of the throat needs to transmit the extrusion force and cannot rise to high temperature to cause the wire material to soften. Therefore, the heat sink and the corresponding cooling fan are very critical, which are the key to continuous wire spinning in the rapid prototyping design. If the heat dissipation process is unreasonable, the filament material will become soft in advance, so that the silk material cannot be extruded through the nozzle and accumulate in the throat, resulting in blockage and failure of rapid prototyping.

During the whole period of project implementation, facing the teaching requirements of different stages of the programs group, especially the actual situation of structural design research and innovation of molding process components in the comprehensive practice course, it gave full play to most of the knowledge and skills of the students in the professional core courses and reflected high-quality technology. Systematic thinking of three-dimensional design of skilled personnel. At the same time, through prototyping-oriented design, it not only cultivates students' design innovation ability and teamwork ability, but also cultivates students' craftsmanship spirit of excellence, and achieves the comprehensive teaching goal of practical teaching. This practical teaching achievement equipment has advanced overall structure, high molding accuracy, and has achieved the technological level of productive industrial equipment on the market at a low cost. Many products have been formed for related students in 3D printing practice teaching or graduation comprehensive practice. It provides distinctive tools and facilities for the application and promotion of new additive molding technologies in the field of intelligent manufacturing.

This hybrid teaching mode not only meets the teaching needs of the 3D printing fundamental courses for the physicalization of digital models, but also conducts three-dimensional structure research on the frame mechanism and motion mechanism of the fuse forming 3D printing equipment. It integrates mechaincal design, strucutre research and process relateved parts innovation, which reflects the function of comprehensive practice connection and application of professional knowledge and skill points. Through the concentrated practice of "Comprehensive Practice for Graduation", the project team comprehensively and systematically applied the knowledge and skills of the three-year program main courses to benefit the participating students, and realized the skills from theoretical knowledge to practical creation in mechanical design, engineering drawing, prototyping, etc. the perfect leap.

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5. Conclusion

As a new technology of rapid prototyping of digital models, 3D printing has opened up a huge space for the innovative design of products and equipment. As a programs group of advanced manufacturing in higher vocational education, Wenzhou Polytechnic The relevant major programs are oriented to the requirements of different levels of 3D printing vocational skills, from the basic operation of the equipment, to the three-dimensional structure design of the molding equipment, and finally combined with the fused depositions and printing process to carry out innovative design of the process component structure. The students mastered the construction principles, key technologies and the craftsman spirit of excellence in the assembly of rapid prototyping equipment, and deeply felt the design and hands-on manufacturing practice, from digital models to physical printing, and then to the leap in the configuration of printing equipment. This practical teaching exploration, from simple to deep, from operation and design, from operation and maintenance to decoration, integrates and improves the operation ability, design ability and hands-on ability of higher vocational students in the process of practical teaching. In practice, students carry out equipment operation, three-dimensional design and process innovation, which reflects the combination of hand and brain, moral and skill, and fully exercise the craftsmanship spirit of excellence and innovation that higher vocational students must have. Capacity building provides a rewarding experience.

Acknowledgments

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