Research and Practice of 3D Printing Technology in UAV Manufacturing

Chao Zhang

Liaoning mechatronics college, Dandong, Liaoning 118009, China

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Abstract: At present, 3D printing technology has been widely used in creative design, innovative manufacturing and other fields. 3D printing technology is one of the most concerned new technologies in manufacturing industry. According to the manufacturing characteristics of UAV parts, this paper introduces the forming characteristics and technological process of 3D printing technology. According to the research status of foreign 3D printing technology. The necessity that 3D printing technology can be applied in UAV production and manufacturing is expounded. The technology is not very mature in terms of appearance support and UAV fuselage fabrication. Use 3D modeling to customize the UAV model, and use 3D printing technology to print and assemble the UAV fuselage model. According to the achievements of foreign 3D printing technology in manufacturing unmanned aerial vehicles, this paper analyzes the research and development focus of the integration of unmanned aerial vehicle technology and 3D printing technology, and deduces the development trend of 3D printing technology in unmanned aerial vehicle manufacturing.

1. Introduction

3D printing technology is a major breakthrough in the world manufacturing technology field in the past 30 years. It is an integration of mechanical engineering (precision manufacturing), computer technology (software development), numerical control technology, material science and other multidisciplinary technologies. It can quickly and automatically print prototypes or component products with certain structures and functions according to the design of mathematical geometric models [1]. At present, the research and development of unmanned aerial vehicles (UAVs) have received much attention from various countries, mainly because the role of UAVs in military affairs is very important. On the battlefield, reconnaissance and surveillance can be carried out, as well as routine sea patrol, electronic interference, accurate target positioning, relay communication, etc. Due to the characteristics of lightweight, integrated structure and function, short cycle and low cost, 3D printing technology has attracted more and more attention from UAV manufacturers [3]. Not only does the EU aviation engineer team use 3D printing technology to produce and manufacture unmanned aerial vehicles, but the United States, as a Depth Charge and a master of unmanned aerial vehicle research, participates in 3D printing technology from predators to micro-stars. The application of 3D printing technology has great potential in shortening the development cycle of weapons and equipment, reducing the development cost, improving the performance of weapons and improving the equipment support mode [4]. The technical characteristics of 3D printing determine that it is very likely to solve the contradiction between production and consumption, thus realizing personalized, visual and socialized production mode.

2. Introduction to 3D Printing Technology

The origin of 3D printing technology can be traced back to Rapid Prototyping (RP) which started in the 1980s. In the manufacturing industry, the traditional processing method is material reduction manufacturing, i.e. parts are manufactured by gradually cutting off excess materials from the material blank. 3D printing technology is also called "additive manufacturing technology" or "stacking molding technology". The core principle is the discrete accumulation of particles. First, a complete 3D geometric model is formed. The model is divided into different levels. According to the technological requirements, the processing path planning is carried out for each level. At the

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same time, improvements are made according to the original experience. Then the corresponding processing software generates various data into a numerical control program. Under the control of the program, the energy beam melts and bonds the transported raw materials to complete the three-dimensional stacking process from line to surface and from surface to body, thus completing the manufacturing of the whole part through layer-by-layer accumulation and stacking [5]. Under the guidance of design document instructions, 3D printing equipment ejects solid powder or molten liquid material to solidify it into a planar thin layer. After the first layer is solidified, a second layer is formed on the basis of the first layer. In this way, the adjacent sections are solidified or bonded layer by layer in sequence. The product development cycle using 3D printing technology can be reduced by 10% ~ 30% compared with the traditional technology, the early development cost can be saved by 30% ~ 50% compared with the traditional technology, and the machining efficiency can be increased by 3 ~ 5 times [6].

3. UAV Technology

3.1. Key technology

Unmanned aerial vehicle (UAV) is a kind of unmanned aircraft that can be used repeatedly and flies under the control of remote control or airborne program. It consists of body structure, power system, control system, task load, data communication system and take-off and recovery device. Research on aircraft structural strength and ground verification test of full-scale aircraft structural strength. Aircraft structure test technology, composite material structure strength, aircraft structure comprehensive environmental strength, aircraft structure anti-fatigue fracture and reliability technology, in addition, aircraft structure strength and noise are the focus of research [7]. Unmanned aerial vehicles are simple in structure, small in volume, light in weight, good in maneuverability, long in flight time, low in cost, convenient to conceal, do not need an airport runway, can be recycled and reused for many times, and can fly at high speed beyond the physiological limit of pilots. Body material technology. Body material is composed of many parts, structural and non-structural. In addition, the engine material is also important. Relatively speaking, the specific stiffness and strength of the structural material are relatively high and the specific strength should be relatively high, so as to reduce the structural weight of the aircraft. With the trend of multi-functional integration of unmanned aerial vehicles, higher requirements are put forward for quality and endurance, and the cost and production cycle are reduced as much as possible, which puts forward higher technical requirements for the corresponding manufacturing industry.

3.2. Technical characteristics of unmanned aerial vehicles

Task-centered design. In order to design unmanned aerial vehicles according to mission requirements, human factors need not be considered in the design process, so that the speed, altitude, mobility and range of the aircraft can be broken through, the mobility can be multiplied, various precision guided weapons can be carried, and even stealth requirements can be met [8]. Unmanned aerial vehicles (UAVs) have changed from the original target aircraft to military equipment integrating reconnaissance, communications, electronic countermeasures and air strikes. They can also complete civil tasks such as border patrol, nuclear radiation detection, aerial photography, aerial prospecting, disaster monitoring, traffic patrol and public security monitoring. With the progress of science and technology, unmanned aerial vehicles (UAVs) are developing towards lightweight and miniaturization. At the same time, higher requirements are put forward for heavy load and personalized customization. This urges the UAV designers and manufacturers to improve the utilization rate of UAV space in limited space, and it is inevitable to choose the structure design, material selection and fine design of performance. Compared with manned aircraft, unmanned aerial vehicle has relatively simple structure and adopts modular design. In terms of aerodynamic shape, unmanned aerial vehicles are similar to manned aircraft, but considering the whole system, unmanned aerial vehicles are relatively complex. Remote control station and data link are the main

components of unmanned aerial vehicle system. After several local wars in modern times, unmanned aerial vehicles (UAVs) have moved from supporting equipment to the forefront of the war and become one of the most important equipment developed and developed by the military in the world, especially in developed countries.

4. The Current Situation of 3D Printing Technology in UAV Manufacturing Application

4.1. Integral printing unmanned aerial vehicle

In 2011, the world's first unmanned aerial vehicle SULSA with 3D printing was born, and its successor 2Seas also successfully tested with 3D printing technology. In 2012, the university of virginia developed the third 3D printed unmanned aircraft after SULSA and 2Seas, and conducted four flight tests near milton airport in virginia between august and september of the same year with a cruise speed of 72 km/h. In 2014, researchers at the University of Virginia made a UAV using 3D printing technology. The UAV has a cruising speed of 83 km/h and a wing width of 1. 98 m, and is assembled from 3D printed parts. The actual UAV is shown in Figure 1. In August of the same year, the team's researchers conducted four test flights near Milton Airport, all with good results. The Advanced Manufacturing Research Center (AMRC) of the University of Sheffield and Boeing have designed and developed an innovative small unmanned aerial vehicle using 3D printing technology. This unmanned aerial vehicle is all printed using fusion deposition modeling (FDM) technology, including 9 parts, clamped by rigid snap-in elevons controlled by servo systems installed at the rear of the fuselage, thus reducing the installation parts of the fuselage. In October 2014, engineers at NASA Ames Research Center modified the existing RQ-14 Drag-onEye UAV with 3D printed parts. The modified Dragon-Oneye is FrankenEye, as shown in Figure 2. The original components were mainly produced by the aviation environment company. after the 3D printing technology was adopted, the UAV was redesigned and assembled, which saved more energy and its endurance could be increased by three times.

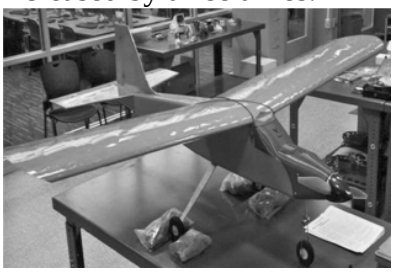

Figure 1 Unmanned aerial vehicles developed by the university of Virginia in the United States

Figure 2 Franken Eye, 3D printing drone

4.2. Print key components of UAV

Aerospace has always been an important field of application of 3D printing technology. So far, Boeing has applied more than 200 3D printed parts on 10 aircraft platforms, including ducts for the introduction of complex cold air into electronic equipment. The components required for 3D printing include optical turret, structural elements, battery compartment housing, and mechanical structures supporting construction and scale models. The reason why 3D printing technology is chosen is because of its short production cycle and low cost. In terms of integrated antennas, scholars from the University of Illinois in the United States have printed out three-dimensional

miniature curved antennas, while Japanese scholars have printed out molded antennas on large curved surfaces. EADS uses laser to heat metal powder to form solid metal parts and print the metal hinges of the engine hood. The new technology not only enhances the strength of the parts, but also reduces their quality by half. Helico, a drone start-up, successfully built the world's first Air Dog with automatic aerial photography using the 3D printing technology of Israel's Stratasys company. The unmanned aerial vehicle is made of ULTEM material with extremely high strength and is printed by Stratasys 3D printing technology FDM. When sending 3D printing equipment to space, astronauts will use 3D printing equipment to make most of the hardware needed for their missions in space, such as consumables, common tools, failed or damaged parts, and even components of small satellites, in order to significantly improve the reliability and safety of human missions in space, while greatly reducing the cost of space exploration.

5. Research and Development Process of UAV Equipment Based on 3D Printing

In the 3D printing of unmanned aerial vehicles, the fuselage model of the unmanned aerial vehicles was measured and made many times. During the test, the model size did not meet the requirements and the strength of the printed finished products was not enough. All of them were perfected one by one, and finally the fuselage equipment of the unmanned aerial vehicles was made. It is an effective method to apply 3D printing technology in the field to ensure the maintenance and replacement of vulnerable parts of aviation products. A U.S. air force base is equipped with corresponding 3D printing equipment, which is used to manufacture UAV body parts, fairing, antenna, etc. in the base to ensure training. The plan is to design a set of unmanned aerial vehicle model that does not need to be assembled by itself. However, during the manufacturing process, it was found that some dimensions and specifications of the unmanned aerial vehicle are different, and the fuselage parts of the unmanned aerial vehicle cannot be placed in the designated positions according to the original requirements, so the assembly method was adopted. In terms of weapons and equipment of unmanned aerial vehicles in our country, we cannot completely follow the equipment ideas of super military powers. We should develop them according to the strategic and tactical ideas of modern local war operations in our country and the tasks of armed unmanned aerial vehicles. The key point is not to attack the ground, but to attack the air "information link" targets and targets of information systems such as ground radar stations. Due to incomplete consideration, the designed UAV needs too many fuselage components, so that the weight of the UAV exceeds the predetermined design, which is not conducive to the endurance and take-off of the UAV. Finally, we adopted the teacher's advice and carried out the third set of plans. We designed and printed the UAV separately and designed it into a simple one. First, we designed the overall framework and then modified the other components.

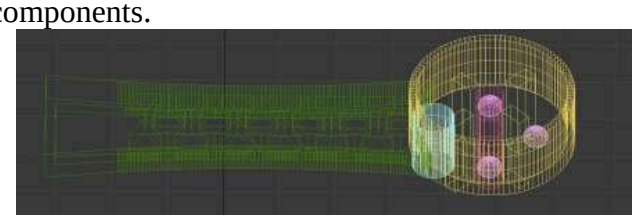

Figure 3 UAV wing wiring diagram

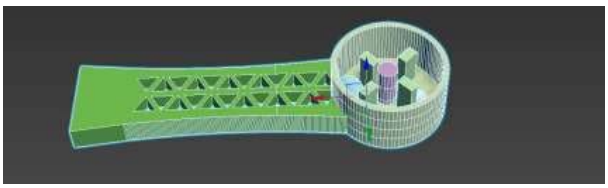

Figure 4 UAV wing model

According to the ratio of the size of the propeller of the unmanned aerial vehicle to the size of the engine at the head of the wing of the unmanned aerial vehicle, a bracket for supporting the unmanned aerial vehicle to fly is designed. The design of the UAV wing head bracket is completed

through 3D MAX as shown in Figure 3, and the final model effect diagram is shown in Figure 4. High-power microwave weapons use high-gain directional antennas to concentrate the microwave energy output by the strong microwave generator into a narrow beam, thus radiating a strong microwave beam and directly damaging the target. For example, the "Pioneer" unmanned aerial vehicle in the United States is equipped with anti-interference spread spectrum communication equipment, high-power solid-state amplifier, omnidirectional VHF and UHF radio relay equipment, etc. It can communicate data, signals, voice and images in C band with a communication distance of 185 kilometers. Then, the UAV fuselage is designed as a base, and the previously designed upper base and lower base are designed as a single-layer base which can be nested, using the plane design method as shown in Figure 5. Assemble the designed UAV base model and the UAV wing support model, and carry out air convection design strictly according to the size of the UAV propeller and the space required between the propellers, as shown in Figure 6. Finally, the battery placement slot of the unmanned aerial vehicle is designed, and the battery of the unmanned aerial vehicle is placed in the designed box by nesting method, and then nested with the bottom as shown in Figure 7.

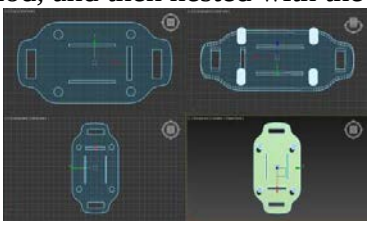

Figure 5 UAV fuselage baseline

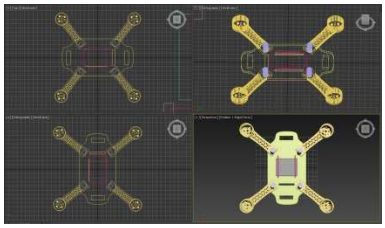

Figure 6 Overall frame diagram of UAV

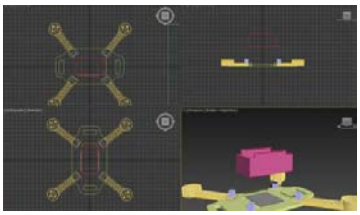

Figure 7 UAV battery loading model

The UAV fuselage model and the UAV support model are printed by a 3D printer, and the printed UAV is used for assembly test flight, and the overall performance is verified through practice. In the process of operating unmanned aerial vehicles, students should not only master certain theoretical knowledge, but also have rich professional knowledge. In this case, the principle-level teaching material system was determined. The wide and mature application of 3D printing technology in various industries has laid a solid foundation for its involvement in the UAV manufacturing field and the processing and production of UAV parts and even complete machines. In the past few years, the application in aerospace manufacturing and medicine has grown fastest, from 2007 to 2011, the direct production of parts increased from 14.9% to 19.2%, indicating that 3D printing technology is increasingly favored by designers and users of engineering application products. Moreover, no matter how complex the product structure and process are, 3D printing technology can produce product prototypes in a short time, enabling researchers to discover product defects earlier, improving product innovation and design capabilities, and improving the weak problems in product design in China.

6. Conclusion

In view of the complicated structure, expensive materials and difficulty in traditional process of UAV manufacturing, 3D printing technology has obvious advantages of low cost, simple process, good repeatability and short realization period. From the work and achievements in the field of unmanned aerial vehicle research in various countries in the world and the changes in the overall planning of unmanned aerial vehicle research in the United States, we can see that the weaponization of unmanned aerial vehicles is an important trend in the development of unmanned aerial vehicles. With the continuous research and development of unmanned aerial vehicle equipment technology, unmanned aerial vehicles have been upgraded from operational support equipment that used to mainly carry out aerial reconnaissance, battlefield surveillance and combat damage assessment to operational support equipment that can suppress enemy air defense systems, attack the ground and even fight alongside manned fighter planes. Therefore, the future development of 3D printing technology must take advantage of the pulling effect of high-end manufacturing of military unmanned aerial vehicles on emerging technologies, vigorously develop 3D printing technology, combine the development needs of the civil market, reduce the manufacturing cost of the entire industrial chain, enhance the original innovation power, and lead the manufacturing industry to realize transformation and upgrading.

References

[1] Jin Dayuan.3D printing technology and its application in the military field. New Technology and New Process, no. 4, pp. 9-13,2015.

[2] Yuan Liqun, Shan Hangying, et al. Application and prospect of composite materials in drones. Fiberglass, no. 6, pp. 30-36,2017.

[3] Wu Xiongxi, Leng Zhijie. Application Research of 3D Printing Technology in Arc Cam Precision Manufacturing. Ordnance Material Science and Engineering, no. 2, pp. 72-75,2016.

[4] Zhou Kai, Zhang Ye. Application research and practice of 3D modeling based on additive manufacturing (3D printing) technology. Modern Manufacturing Technology and Equipment, no. 10, pp. 180-180,2016.

[5] Cui Yanchen, Wu Lizhi, Zhu Hongwei, et al. Application research of UAV in fire communication. Fire Science and Technology, no. 4, pp.526-529,2019.

[6] Lan Bingde. Analysis on the application prospects of 3D printing technology in automobile manufacturing industry. Research of Automobile Industry, no. 8, pp. 23-25,2017.

[7] Li Zize. Development of 3D printing technology and its software implementation. World of Digital Communications, no. 12, pp.117,2017.

[8] Zhu Peng. Research on innovative application of 3D printing technology and mechanical drawing teaching. Contemporary Educational Practice and Teaching Research, no. 10, pp. 187-188, 2017.