Research Status and Problem Analysis of 3D Printing UAV

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Abstract: As one of the representative technologies of the third industrial revolution, 3D printing technology has attracted more and more attention from industry and investment circles. This paper introduces the characteristics of UAV technology and the application and development of 3D printing technology in UAV field. This paper analyzes the existing problems in the manufacture of 3D printing unmanned aerial vehicles, and points out that there are still some problems in the design concept, raw materials, process stability and talent team construction of 3D printing unmanned aerial vehicles. Finally, the problems to be solved by 3D printing UAV are analyzed from the aspects of structural design concept, 3D printing materials and products, 3D printing manufacturing process, industrial value chain and personnel training.

1. Introduction

In recent years, the unmanned aerial vehicle industry is surging. Worldwide, Amazon, Google, Facebook and other giants are laying out the drone market. Facebook founder Zuckerberg said in his speech at the World Mobile Communications Conference (MWC) that he hoped to use unmanned aerial vehicles to carry communication equipment such as wireless hotspots to help people in poor areas connect to the Internet. Its principle is to use CAD and other software to draw the three-dimensional model, decompose it layer by layer according to a certain coordinate axis, and then print it layer by layer by specific equipment using materials such as metal, ceramic, sand, plastic, resin, etc., and pile up each printed layer until it becomes a solid component consistent with the three-dimensional model [1]. Compared with the traditional processing technology, it completely breaks through the limitations of design and traditional processing technology and does not need a mold. Therefore, 3D printing can overcome some designs that cannot be achieved in traditional manufacturing and produce more complex structures. Moreover, it has high utilization rate of materials, short design-delivery period, and many processable materials, and is making extraordinary achievements in the research and development and production fields of aerospace, military defense, energy, oil and gas, biomedical, automobiles, high-end jewelry, etc.

Unmanned aerial vehicles are mainly used in military and civil fields. Modern people's demand for life has greatly increased and the application of unmanned aerial vehicles has been expanded. Both developed and developing countries are actively expanding the industrial application and technology of unmanned aerial vehicles [3]. The concept of 3D printing technology is "manufacturing by adding materials", that is, realizing the manufacturing process by gradually adding materials [4]. All walks of life are thinking about how to use 3D printing technology to improve efficiency and reduce costs. As 3D printing technology becomes more and more mature, its application scope will be more and more extensive, and the concept, method and pattern of world manufacturing industry will be profoundly changed in the future [5]. This paper will comprehensively describe the latest research and application status, existing problems and development trend of 3D printing UAV technology.

2. Classification and Characteristics of 3D Printing Technology

3D printing technology is an advanced manufacturing technology developed in the 1990s. Its essence is "rapid prototyping technology", also known as "additive manufacturing technology" or "stacking molding technology". Through corresponding software processing, particles are discretely

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stacked on the 2D surface to form a three-dimensional solid, and finally complete parts are manufactured. After rapid development in recent years, 3D printing technology has shown full development potential from the initial emerging technology to industrialization. On the basis of digital model documents, metal powder, ceramic powder, plastic, cell tissue and other special materials are stacked and bonded layer by layer to form an object [6]. In short, it is to divide the object into very thin layers and finish the layering, and finally achieve the required effect by superposition. The principle and steps of 3D printing are shown in Figure 1. According to molding materials, 3D printing technology can be divided into non-metallic materials and metallic materials. According to the heat source mode, it can be divided into laser heating, electron beam heating, arc heating, heating wire heating and other heating modes of 3D printing. It can also be divided into auxiliary manufacturing and direct manufacturing 3D printing technology according to the purpose and means of molding. The 3D printing technology is divided into 5 categories: 1) FDM technology based on thermoplastic materials; 2) LOM technology using paper, metal film and plastic film as materials; 3) 3DP technology with gypsum powder and ceramic powder as materials and glue for bonding and forming; 4) photopolymerization molding technology using liquid photosensitive resin as material, including SLA, PloyJet, DLP and other molding technologies; 5) Laser sintering/melting molding technology is collectively referred to as laser powder molding technology by taking metal, alloy, thermoplastic, ceramic and other powders as materials. Although the steps of 3D printing are basically the same, there are many ways in the form of layering.

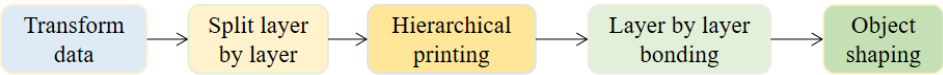

Figure 1 To print in 3D

The characteristics of these 3D printing technologies include: short cycle time, from the 3D design model of parts in the computer to the prototype product of samples, the whole manufacturing process takes very short time because no tooling is needed; The cost is low, the utilization rate of the added material manufacturing material is high, and the manufacturing cost of the mould can be saved, so the development of new products and the manufacturing cost of small batch production are low; Diversification of products does not increase costs. A 3D printer can print many shapes with only different digital design blueprints and a batch of new raw materials, saving the cost of training mechanics or purchasing new equipment. However, traditional manufacturing equipment has few functions and limited types of shapes. Flexible manufacturing, what you see is what you get, is not limited by the manufacturing process, can freely design the shape of parts and realize the perfect reproduction of innovative design. Zero time delivery. 3D printers can be used in print on demand. Enterprises can use 3D printers to make special or customized products according to orders to meet customers' needs and carry out real-time production, thus reducing the physical inventory of enterprises. If people need goods to be produced nearby on demand, zero-time delivery production can minimize the cost of long-distance transportation. Highly integrated, 3D printing technology is an advanced manufacturing process integrating computer-aided design, laser processing, material forming and mechanical processing. The whole production process can be digitized and automated, and parts models can be edited and modified at any time, thus truly realizing the integration of design and manufacturing process [7]. The design space is infinite. Traditional manufacturing techniques and the shapes of products manufactured by craftsmen are limited, and the ability to manufacture shapes is limited by the tools used. For example, traditional wooden lathes can only make round objects. The molding machine can only make molding shapes. The 3D printer can break through these limitations and open up huge design space.

3. Research Status of 3D Printing UAV

Unmanned aerial vehicle is a very flexible equipment, which is often used in aerial survey, photography, environmental monitoring and military fields. The design and manufacture of some parts on board are very expensive and time consuming [8]. Foreign 3D printing technology has been

applied to unmanned aerial vehicles for many times. The University of Sheffield and Boeing Company jointly established a research center in 2001. The center uses melt deposition molding technology and ABS plastic as raw materials to print a UAV with a wingspan of 1.5 m. The UAV is equipped with two engines and can fly at a cruising speed of 20 m/s. In July 2013, researchers from the University of Southampton in the UK created a 3D printing UAV named 2Seas, with a wingspan of 4 m, which is too long for the current 3D printer. Therefore, only the central wing box, oil tank and engine bolts are printed in 3D, and the wing and tail are made of carbon fiber. The twin-engine engine can fly at a speed of 100 km/h for 6 h. The 2Seas unmanned aerial vehicle is designed to perform long-term flight surveillance missions for coast guards in Britain, the Netherlands, Belgium and France. On the basis of this UAV technology, the team built a UAV with a wingspan of 3 m and a natural gas turbine as the engine at the 2014 US exhibition. Researchers from an advanced manufacturing research center (AMRC) in the UK used FDM technology, made of ABS plastic, printed out a UAV with a wingspan of 1. 5 m, and carried two EDF engines, achieving a cruise speed of 20 m/s.

China has also successfully applied 3D printing technology in aerospace manufacturing. Researchers at Northwestern Polytechnical University have used 3D laser stereo printing technology to manufacture titanium alloy spars with a length of more than 5 m for domestic passenger planes. In addition, the laser solid forming technology and casting technology were combined to establish the laser combination technology, and the rear casing of an alloy composite bearing for the first aero-engine in China was successfully manufactured. In 2015, the 3D printing industry ushered in the first national development promotion policy. The Ministry of Industry and Information Technology officially released the "National Development Promotion Plan for Materials Manufacturing Industry (2015-2016)" (hereinafter referred to as the "Plan"). The "Plan" pointed out that enterprises with advantages in material production are encouraged to engage in the research and development and production of special 3D printing materials, and to break through a batch of special 3D printing materials in response to major demands in the fields of aerospace, automobiles, cultural creativity, biomedical and so on [9]. Beijing University of Aeronautics and Astronautics has successfully manufactured a number of titanium alloy structural parts with a single weight of more than 110 kg and the largest large integral titanium alloy aircraft main bearing structural parts in China. For the first time in the world, it has completely broken through the laser forming process of difficult-to-machine, large and complex integral key components such as titanium alloy and ultra-high strength steel. In addition, scientific research institutes such as Tsinghua University and Northwest Nonferrous Metals Research Institute have also made gratifying achievements in EBM technology application, equipment research and development and parts manufacturing, and have made outstanding contributions to promoting the development and application of 3D printing technology in China.

4. Analysis of Existing Problems and Development Prospects

4.1. Consumables for 3D Printing

The 3D printing technology materials are mainly made of the above materials. However, in order to meet the needs of different fields, more economical and convenient processing materials need to be developed, and quality inspection procedures should be developed according to the characteristics of processing materials, so as to improve the normative standards of material performance data. Based on the existing design concept, the structural form of parts using 3D printing technology has little or no advantage in manufacturing. Secondly, materials used in some parts of unmanned aerial vehicles, such as carbon fiber reinforced resin matrix composites, cannot be printed in 3D at present, and their substitutes have not been developed, thus limiting the application of 3D printing technology. For metal powder, the requirements of particle size distribution, bulk density, oxygen content, fluidity and other properties of the material will be higher. For living organs, how to maintain the activity and function of cells is particularly important. In addition, finding suitable 3D printing materials for application in important industries is also a

problem to be solved.

4.2. The 3D printer itself

According to relevant data, there is only one printer capable of processing various materials at present, but due to the restriction of processing technology, the precision and surface quality of products often cannot meet the use requirements and can only be used in prototype mode. With the development requirements of large-scale unmanned aerial vehicle, stealth of its shape, lightweight of its structure and digitalization of its manufacturing, it is necessary to introduce 3D printing technology into the structure manufacturing technology of unmanned aerial vehicle. Whether the traditional supervision mode can adapt to this highly efficient and highly specific 3D printing medical device also needs to be verified. Although 3D printing technology uses superposition manufacturing process, it cannot be compared with traditional forgings even though the connection between layers is tight. The United States, the European Union and other countries all regard aerospace products as the first application target of 3D printing technology, which is one of the representative directions of information fusion, digitization, precision and high-end development of aerospace equipment manufacturing technology. However, the application of 3D printing in unmanned aerial vehicles and even high-end manufacturing still needs to gradually solve a series of problems. At present, 3D printing technology mainly relies on digital models for processing, but ordinary users still have great difficulty in mastering CAD molding technology. Therefore, there is a need to upgrade many "industrial" technologies so that 3D printing and manufacturing will change from a technology mainly used for rapid prototyping to a production and engineering technology.

4.3. Value chain of 3D printing industry

The current research and development of 3D printing and manufacturing technology is aimed at a single element in the product life cycle in the value chain, and the development phase is discrete, without adopting an integrated and systematic method to reduce costs and shorten the cycle [10]. The 3D printed solid prototype itself has certain structural properties. At the same time, the 3D printing technology can be used to directly manufacture metal parts or melt dies. Then metal parts can be cast by investment casting, and even functional parts and samples with special requirements can be printed and manufactured. Therefore, it is necessary to develop a series of interrelated systems engineering technologies to better integrate all elements of the 3D printing industry value chain and product life cycle. Moreover, it should be realized that with the development of more complex three-dimensional structural materials and various material parts, design and testing will become new bottlenecks. 3D printing technology is a high-tech technology formed by combining the advantages of many disciplines. With the continuous development and maturity of 3D printing technology, it will revolutionize the development of new materials and intelligent manufacturing technology, thus driving the development of other related industries.

4.4. Team building of 3D printing professionals

At present, there is no special discipline in the field of 3D printing and manufacturing. Most of the personnel engaged in 3D printing are professionals who have changed jobs in similar disciplines. There is a big gap between them and the standard requirements for 3D printing design, manufacturing, post-processing, inspection and testing, etc. 3D printing has changed the cutting and assembling methods of traditional raw materials, thus effectively saving raw materials and time. For example, in the aerospace manufacturing industry, its main metal material is solid titanium, of which more than 90% will be wasted. If titanium powder 3D printing technology is adopted, materials with the same characteristics as traditional solid titanium can be processed, thus greatly saving raw materials. 3D printing technology is a high and new technology that comprehensively applies CAD/CAM technology, laser technology, photochemistry, control, network, material science and other technologies and knowledge. The continuous maturity of 3D printing technology will push new material technology and intelligent manufacturing technology to achieve a big leap forward, thus driving the development of related industries. However, the internal organization characteristics of metal materials produced by 3D printing will interfere with the test process,

resulting in inaccurate test results, thus affecting the engineering application of products. This also requires professionals to study characterization methods. Therefore, the construction of talent team is the primary task for the promotion and engineering of 3D printing technology.

5. Conclusion

3D printing technology is a new revolutionary technology, although it has many shortcomings, such as the current high cost of 3D printers, which is not conducive to popularization; Limited choice of printing materials; The physical characteristics of molded products are poor, the printing accuracy is not satisfactory, and the printing efficiency is far from meeting the needs of large-scale production. However, its advantages and characteristics can bring greater influence to the future development of manufacturing technology. At present, with its unique advantages, 3D printing technology has gradually become the technological core of advanced manufacturing in the information age, and has attracted extensive attention and concern worldwide. Introducing 3D printing technology into UAV manufacturing can reduce cost and cycle loss. As the technological core in the field of information manufacturing, 3D printing technology has attracted extensive attention and concern all over the world. All countries are developing 3D printing technology. With the maturity of 3D printing technology and the expansion of 3D printing materials, 3D printing technology will definitely become one of the benchmark technologies in the new era in the future. We believe that 3D printing will bring us more surprises and impacts, and 3D products will be within our reach in our life.

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