Development and application of 3D printing technology in various fields

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Abstract. As a cutting-edge and pioneering emerging technology, 3D printing technology is profoundly changing the traditional production mode and production process. This paper analyzes the development of 3D printing technology at home and abroad in recent years, as well as its application in various fields, focusing on the application and development prospect of 3D printing technology in the field of mechanical engineering.

1. The introduction
In recent years, the most advanced and pioneering 3D printing technology is revolutionizing traditional production methods and processes. It uses digital models to construct entities, and its idea is derived from an American patent on topography and topography stratification. The implementation of this technology is quite different from traditional processing, which subtly changes the traditional material reduction technology and changes the whole processing process and process from the beginning of design, involving many fields and disciplines.

The emergence of 3D technology has been well applied in many fields, which has formed many emerging industries and new ideas. It will change the way products are produced, thus changing the pattern of world economic development and ultimately changing the way people live [1].

2. Development status at home and abroad

2.1. Domestic development status
Due to the introduction of 3D printing technology in China in recent years, the gap between China and foreign countries is very large. Currently, the world has developed to metal 3D printing, polymer 3D printing, ceramic 3D printing and biological 3D printing technology, while China mainly focuses on lamination and laser lamp. However, in recent years, China's 3D biological printing technology has been making breakthroughs, advancing the clinical transformation process of 3D printed medical devices and artificial tissues and organs.

Since the development of 3D printing in China in 1988, it has been continuously deepening and expanding its application. In the three years from 2015 to 2017, China's 3D printing industry has doubled in size with an average annual growth rate of over 25%. In 2017, there were more than 500 enterprises related to the 3D printing field in China, with the industrial scale reaching 10 billion yuan. The growth rate slowed down slightly to about 25%, but it was still higher than the global rate by 4 percentage points. In the first half of 2018, China's 3D printing industry maintained a growth rate of more than 25%, and the overall scale is expected to reach $1.83 billion in 2018.
2.2. Foreign development status
3D printing technology has a history of several decades. With the introduction of the third industrial revolution, it has attracted the attention of many companies, universities and research institutes at home and abroad. As early as in the 1980s, 3DSystems of the United States took the lead in launching the first industrialized "3D printing" equipment. After decades of exploration and development, 3D printing technology has made significant progress. Currently, it is possible to achieve 800dpi fine resolution on a single layer thickness of 0.01 mm [2].

At present, 3D printing technology in Europe and America has initially formed a successful business model in the fields of consumer electronics, automobile manufacturing, aviation and medical treatment. According to statistics, the United States produced 70 percent in 2012. Among more than 10,000 3D products, electronics, automobile manufacturing, medical treatment and industrial machinery account for a large proportion. In addition, 3D printing technology has gradually been widely used in the field of personalized product customization. For example, many foreign creative product companies (including Quirky of the United States) solicit customers' designs through online platforms and sell them with 3D printing technology [3].

3. Application of 3D printing in various fields
At present, foreign 3D printing technology has been widely used, mainly covering aerospace, automobile manufacturing, medical care, industrial product design, architectural design and other industrial fields. According to Wohlers Report, 3D printing technology accounts for 14.8% in aerospace, 17.5% in industrial applications, 16.6% in consumer electronics, 16.1% in automobile industry, 13.1% in medical applications, 8.2% in academic institutions, 6.6% in government and military, and 7.1% in other fields.

3.1. Application of 3D printing in the field of aerospace
3D printing technology is valued by the country because of its huge advantages in material manufacturing, and it is strongly supported in military and other fields. In the field of aerospace manufacturing, the scope of its application is also expanding. In addition to printing some parts, it can also achieve the printing of some overall models. The printing time is short, the printing precision is high, and the printing cost is low. Application in stage of parts are many, such as: the American air force's 552th united air control is used in the 3D printing technology, selected the 400 MC Fortus 3D printers, airplane seats armrest is studied by using the printer, plastic cover printing, and print out the finished product has been used in E-3 planes, and in the manufacture of the material cost is greatly reduced, by the past $8 to the current $2.5; Airbus is also a big fan of 3D printing technology. So far, it has used 3D printing technology to produce more than 1,000 aircraft parts, and applied these parts to the production of aircraft. The 3D printing ensures the cycle cost of production and the precision of parts [4]. There are also some applications in the whole plane stage. For example, spacex used 3D printing technology to make an electric rocket engine. The printed engine makes the rocket more affordable to launch [5]; In addition, Russia's Rostec also USES 3D printing technology to print the multi-purpose amphibious uav, which has a short production cycle and low production cost. Increase in maintenance system of equipment support or base 3D printing technology deployment, for example: south Korean air force is using 3D printing to make out the 15 k F - fighter jet engine high-pressure turbine cover plate, a technique for reducing cost is huge, reduced from 40 million won to 3 million won, sourcing and manufacturing time from 60 days to 30 days, 3D printing technology, the manufacture of conveyor speaker cover in Europe also have larger contribution to the production time from the previous six months sharply reduced to 4 ~ 6 h, production cost has reduced the unit price of $600 to $35 [4]. On the other hand, it can print out old parts that have been discontinued to improve its own military maintenance capacity. 3D printing on the space station has been made possible by transporting the required raw materials to the international space station for printing on demand. Spaceflight has developed a 3D printer that operates in a vacuum and delivered it to the international...
space station in August 2014. In addition to printing 3D test parts, functional structural parts have also been printed [4].

3.2. Application of 3D printing in the medical field
With the development and improvement of 3D printing technology, the medical field has begun to introduce this technology, especially the making of medical models. Medical model in the field of medicine in the teaching of doctors and clinical trials and so on
It is a very important medical appliance in the field of medicine. Medical models are complex and diverse, and different age, gender and other characteristics will make their medical models different. The medical model materials made by traditional processing methods are mostly gypsum and other materials, which are easily damaged in clinical trials and daily medical activities. And using the 3D printing to make medical model and the mold, using the plastic and powder adhesive materials such as metals, will greatly improve the quality of the medical model and the damage degree, will speed up the model of mould manufacturing, improve production fine degree of medical model, also can meet the personalized requirements in the teaching of clinical trials, strain capacity, enhance medical staff to cope with different characteristics and circumstances of patients. The application of 3D printing technology in medical model manufacturing will bring a lot of convenience to medical staff and patients [6].

3.3. Application of 3D printing in the field of automobile manufacturing
For automobile manufacturers, the storage of some parts is likely to be in short supply. At this time, if the traditional manufacturing method is adopted, it will not only consume a lot of mold development costs, but also consume a lot of time in manufacturing, which is not conducive to the rapid completion of relevant tests and verification. At this time, 3D printing technology can be adopted to solve this problem. For the urgently needed parts, 3D printer can be directly used for manufacturing, which on the one hand reduces the manufacturing cost, and on the other hand can quickly complete the experiment and verification. Especially for some large-scale automobile manufacturing equipment, if the parts have problems, the 3D printer can be used to quickly manufacture the faulty parts to facilitate the normal production of enterprises. In addition, the internal parts of some large equipment are not standard parts, and there are no corresponding products in the market. In case of failure to purchase, 3D printing technology can also be used to quickly solve problems [7].

3.4. Application of 3D printing in the field of industrial design
3D printing in the industrial design industry application effect is significant in the process of design, a designer and modeler or modelers can use 3D printing technology to design products quickly into a physical object, which can quickly and easily for customers and design team to come up with product model, intuitive understanding of the product to customers, promote timely communication between clients and designers, promoting communication between the customer, market and enterprises, adjust scheme, make products to maximize the market recognition [8].

3.5. Application of 3D printing in the field of architectural design
3D printed buildings are much more difficult to print than other things. At present, printed buildings are still in the experimental stage, and there are still many problems to be solved. China's 3D printed buildings are still far from the actual use of today's social activities, but if it is used to add value to the construction project, it is completely enough. At present, the application prospect of 3D printing technology in construction engineering mainly focuses on the following aspects: during the period from the commencement of construction project to the completion of construction, the 3D printing technology is used to make design drawings according to the construction process, construction time, machine and tool configuration and construction site layout, etc., and coordinate with the construction drawings for pre-rehearsal. Compared with the planar construction drawings, it is more intuitive and
accurate. It even finds the deficiencies of the original construction arrangement in advance and conducts the dislocation drill in the construction process in advance [9].

4. Analysis of 3D printing in the field of mechanical engineering

4.1. Comparison between 3D printing and traditional manufacturing industry

In the machinery industry, with cars, milling, planing, grinding and traditional removing material, such as mold production processing of manufacturing production mode is still used today, although at present have been used to upgrade the original machine tool numerical control system and innovation, but the staff's personal operation technical factors still has certain influence to the quality of production, and use a mold to produce parts production mode is still in a large area of widespread application. The above two typical production and manufacturing methods have poor working environment, long production cycle, high manufacturing cost and high technical requirements for employees, which make the traditional manufacturing technology incompatible with the fast pace of modern society.

![Figure 1. Comparison of operation flow of 3D printing technology.](image)

**Table 1.** Comprehensive comparison between 3D printing technology and traditional manufacturing technology.

|                        | Traditional manufacturing | 3D printing technology |
|------------------------|---------------------------|------------------------|
| The processing principle | Traditional processing principle | Layer by layer printing and manufacturing |
| Product material       | Almost everything          | Plastic, photosensitive resin, metal, etc |
| Technical characteristics | Reduction of material manufacturing | Add material manufacture |
| Processing environment  | Harsh environment          | The environment is good |
| Material utilization   | The lower                  | higher                 |
| The intensity of the product | good                      | The lower              |
| Input costs             | high                      | At the end of          |
| To adapt to the industry | unlimited                 | Molds, toys, samples, etc |
| The production cycle    | A long                    | short                  |
| The scale of production | mass                      | Single piece, small batch |
| Green manufacturing     | no                        | is                     |
| The operation           | complex                   | Simple and safe operation |
| Employee requirements   | The employees have professional knowledge | Less demanding |
| Production equipment    | Processing workshop, production line | No fixed production environment |
And 3D printing process is very simple, the first to use computer aided design (CAD), then the data into the 3D printer, for simple set up, after finish printing can be processed products, compared with the traditional manufacturing technology, 3D printing technology because of its simple operation, the operator expertise request is not high, and simple production process, production of product diversification, flexible production mode, and the work environment is good, because its design can be achieved without drawing, mode of production is the characteristics of environmental protection, so widely attention [10]. The comparison between the most basic operation flow of traditional manufacturing technology and the operation flow of 3D printing technology is shown in Figure 1. The comprehensive combination of 3D printing technology and traditional manufacturing technology is shown in Table 1.

4.2. Advantages of 3D printing technology
For 3D printing technology, its advantages mainly include the following aspects:

(1) The technology does not need to cut the object, and does not need to apply the mold;
(2) In the practical application process, the processing speed of this technology is relatively fast, and its production cycle is relatively short;
(3) For some objects with complex structure and small volume, it shows obvious application advantages. For some models that are difficult to be completed by traditional manual work, it can be easily realized through the application of this technology, mainly because they can be formed in one and do not need secondary processing;
(4) Capable of mass production and on-line operation, thus enabling remote operation.

4.3. Problems existing in 3D printing technology
Although 3D printing technology has many advantages, there are still many problems to be improved, including the following aspects:

(1) High cost and high power consumption. In China, despite the popularity of 3D printing technology, the cost of 3D printers is generally high, and the price of printing materials is still high. In addition, the printed materials are still largely confined to the plastic sand, plaster, resin, ceramic, and metal, etc., so can be used for 3D printing material is very limited, and the use of 3D printing technology in the process of production, require special treatment to the printing material, tooling cost and power consumption is higher, especially compared to traditional mass industrial production, but no advantage on the cost and power consumption. Therefore, cheaper and more reliable technology paths need to be explored.

(2) Limitations on size and materials. At present, 3D printers are mostly used in the production and manufacturing of small size parts, but they cannot realize the production and manufacturing of large size parts. In addition, although there are many types of materials required for 3D products, most of them are chemical polymers, which will make the overall physical and chemical properties of the molded products relatively poor, and thus cause some safety risks.

(3) Strength. The strength of 3D products has been a fatal flaw in 3D printing technology. Due to 3D printing technology development is not perfect, especially in automatic control systems, rapid prototyping software technology research is not enough mature, with print materials restrictions, layer upon layer stacking accumulation of "material", make now the strength of the moulded part can not be compared with the traditional manufacturing technology in the production of components, make its can't satisfy the engineering application, can only be used as a prototype sample.

5. Development prospect of 3D printing technology
After years of development and accumulation, China is moving faster and faster on the road to realize the industrialization of 3D printing. Under the guidance and support of "made in China 2025" and other relevant policies, China's 3D printing industry has witnessed rapid development, breakthroughs in key technologies and significant improvement in equipment performance [11]. At the same time, its work model is gradually systematized, the service field is also expanding. However, 3D printing technology
has reached a certain bottleneck at present. In order to achieve large-scale industrialization, there are still many problems to be solved in the future. In a word, in the coming decades, the development prospect of 3D printing industry is quite broad.

And in the context of big data and informatization, the single and purely mechanized 3D printer can no longer meet the needs of the development of The Times. Therefore, the combination of control technology and big data, informatization and intelligence will become the new trend of the development of 3D printing technology.

6. Conclusions
With the introduction of the fourth industrial revolution, the manufacturing field has been constantly combining some new technologies, including new information technology, control technology and material technology. 3D printing technology has also been raised to a quite high level. By analyzing the application of 3D printing technology in all walks of life, as well as its advantages and disadvantages, it can be seen that 3D printing technology has a lot of room for development in the future. Therefore, we must pay attention to, utilize and study 3D printing technology, or explore the new mode of "3D printing + traditional manufacturing", so as to obtain more optimized new products.

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