Research on the Innovation of Additive Manufacturing Technology in Contemporary Industry Development

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Abstract. Additive manufacturing technology has entered our daily life, seemingly omnipotent. At the same time, a considerable proportion of scholars believe that this technology can not replace the traditional manufacturing industry. How to promote the development of additive manufacturing technology and make it meet the market demand quickly is the purpose of this study. This paper analyzes the problems of additive manufacturing technology from the aspects of "technology readiness index", "driving force and bottleneck", "innovation demand" and "obstacles to commercial promotion", and puts forward solutions.

Keywords: Additive manufacturing; Technological innovation; Industrial development.

1. Technology Readiness Index of Additive Manufacturing
The technology readiness index was first developed by NASA in 1969, which is an index to measure the maturity of technology development. Its core idea is to evaluate the research progress and innovation ladder of science and technology with the technology maturity conforming to the law of science and technology research. This evaluation system sets standards for scientific and technological activities according to certain principles, so that scientific and technological activities can be classified according to the stage, and the maturity of each technology can be quantitatively evaluated. Additive manufacturing technology is currently available, and research and development is underway in other potential areas. For example, the additive manufacturing of simple plastic parts can be considered relatively mature. From the perspective of materials, metal material additive manufacturing and high-performance polymer material additive manufacturing are relatively mature, while other materials are not yet mature.

2. The Driving Force and Obstacle of Additive Manufacturing Development
The rapid development of additive manufacturing is driven by market demand. Research has shown strong interest in additive manufacturing technologies in many industries, such as aerospace, healthcare, creative industries, automobiles and energy. Additive manufacturing technology can be applied in these fields. At the same time, additive manufacturing also faces many obstacles in its development. The most important one is that the production cost is too high. Other problems include limited available materials, immature production technology and equipment, incomplete data, standards and certification, and weak supply chain. In aerospace, high driving factors include increased freedom of design, personalized manufacturing, improved material utilization and reduced energy consumption. In the biomedical field, faster supply chain response time is more important than high utilization of materials. In the energy sector, there is little incentive to use additive manufacturing technology, which explains why it has much higher penetration rates in aerospace, healthcare, and creative industries than in other sectors. Additive manufacturing is also still expensive to produce in
other areas. In the field of aerospace and cultural creativity, there are requirements for the surface finish of products in the production process. Aerospace components need to undergo rigorous testing and verification processes to ensure that the product meets the requirements. For the cultural and creative industry, the perfect processing and production of artistic works can meet the requirements of customers.

3. Analysis of Obstacles to the Innovation and Development of Additive Manufacturing Technology

Additive manufacturing technology has been developing for 30 years and is still immature. In order to clarify the relationship between products and technologies, it is necessary to clarify the development direction and key technologies of additive manufacturing in the future.

1. The production cost is too high
   (1) The price of raw materials is too expensive
   The materials used in additive manufacturing are too expensive. For example, for metal powders, the price of pure titanium and titanium alloy for 3D printing is about $340 ~ $880 /kg, far higher than the price of raw materials used in traditional processes. For photosensitive resin, plastic and other polymer materials, additive manufacturing process materials are also dozens of times the price of traditional raw materials. High raw material cost leads to high production cost of additive manufacturing parts.
   (2) The production speed is too slow
   At present, the rate of additive manufacturing is still very slow, and for most applications, existing production efficiencies need to be improved to meet commercial requirements. For example, for the powder bed fusion process, the scanning speed and material processing capacity of metal-based components need to be increased to 4-10 times of the current speed before large-scale application can be realized.
   (3) Production capacity is limited by machine size
   Additive manufacturing is limited by the size of machinery and equipment, the size of components that can be manufactured and the production capacity of batches are very limited, and it is not possible to achieve more economical mass manufacturing. Therefore, in order to promote the application of additive manufacturing in the field of large components, such as aerospace, the processing size and batch processing capacity of the equipment need to be greatly improved.
   (4) High investment cost of equipment
   For commercial product production, the capacity of the machine is not attractive compared with the price of the product. The price of equipment needs to fall further to meet the needs of mass production.
   (5) There are high barriers to entry for some industries
   For fields such as aerospace and medical devices, new technologies and products require strict assessment, leading to longer R&D cycle, higher product development cost and longer testing and certification time, which affects the ability of SMEs, especially some emerging innovative enterprises, to promote their products to such markets.

2. The materials available are limited
   (1) There are relatively few materials available for additive manufacturing at present
   Additive manufacturing printable polymer materials mainly include ABS, polylactic acid, acrylic acid resin, epoxy resin, nylon and polyether ether ketone, etc. The metal materials are mainly stainless steel, aluminum alloy, cobalt-chromium alloy, chromium-nickel alloy, titanium alloy and gold and silver, etc., which are far from meeting the demands of thousands of kinds of materials in various application fields.
   (2) The performance of the material needs to be improved
   For polymer additive manufacturing products, the strength and weather resistance of existing materials are insufficient, which is due to the lack of moisture resistance and UV resistance of materials. For metal materials, in order to replace existing casting and forging metal products with additive manufacturing products, the mechanical properties of materials should be improved to meet the standards of casting and forging metal products.

3. The technology and equipment are not mature
   (1) The technology is not stable enough
For the same type of machine, the stability, repeatability and uniformity of different batches of products have yet to be improved. Products produced by different types of machines can also be unstable. The main factors include uncontrolled process variables, changes in the supply of raw materials, and differences in the core components of different machines.

2. Lack of online control methods and online monitoring methods

The yield of additive manufacturing products is about 70%. 20% are waste parts produced during manufacturing, and the other 10% have internal physical defects. In areas such as aerospace and defence, product reliability will be crucial. At present, very few online control methods and online monitoring methods are available to manufacturers, which makes it difficult to know whether products are meeting specifications and whether the production process is in order.

3. Design tools and software limit the freedom of design

Although additive manufacturing technology can achieve completely own creative, but relying on existing design tools such as CAD, can not really achieve the creative freedom. These software are largely unable to handle complex lattice structures, honeycomb structures, topological optimizations, and other complex geometries. At the same time, existing software can only be operated by professionals, and it is difficult for non-professionals to use the software to creatively design the products they need.

4. The post-treatment process increases the complexity of production

Additive manufacturing products often require a post-treatment process. This includes surface polishing to achieve a specific finish; Residual stress elimination and heat treatment are used to remove the fabrication support structure and waste disposal. These steps will affect production efficiency and increase production costs. In addition, new process variables may be introduced to affect product quality.

4. Obstacles to Business Promotion

1. Immature industrial chain

The additive manufacturing industry chain is very weak. In the field of raw materials, the relevant suppliers are very limited, and the machines produced by different equipment suppliers also lack unified standards, which leads to the poor match between the raw materials produced by different manufacturers and the equipment produced by different manufacturers. It is often necessary to use special materials sold by equipment manufacturers to achieve the best performance of the product. On the other hand, if the supply chain is disrupted, users need to conduct extensive searches, find new suppliers, and conduct extensive negotiations with partners to reach agreement on technical specifications and requirements.

2. Lack of relevant professional training and education

Material manufacturing related professional training is very limited, which makes this technology interested non-specialists and just in the field of new people cannot get the required professional training and guidance, this limits the design degrees of freedom, and other advantages of the technology level of play, which can lead to some potential applications of commercial value has not been implemented.

3. Low awareness of additive manufacturing technology

Many people don't really realize the impact of additive manufacturing. In addition to the impact on traditional manufacturing, it is even more difficult to recognize the far-reaching significance of this technology for social development. Through the high combination with the mobile Internet, it will derive various novel business models and marketing models. These emerging models will change our current or future way of life, just like the emergence of apple, Taobao, Tesla and other companies. This is why the United States chose additive manufacturing technology as the first advanced manufacturing technology, and established the national Manufacturing Innovation Center for additive manufacturing.

4. Some industries are skeptical of the technology

While additive manufacturing technology has been introduced into the production and development of components in aerospace and medical applications, other industries are skeptical that the technology will meet production requirements. We are already seeing this kind of advanced technology used in ordinary products such as pastries, toys, furniture and buildings. Although most of these applications
are still in the prototype stage, the prospects are promising.

5. Solution Ideas

5.1. Intelligent Technology and Equipment
The development of intelligent additive manufacturing equipment is also an important basis for future applications. It attaches importance to cross-research in the fields of materials, software, artificial intelligence, life and medicine, and strives to expand the application of additive manufacturing technology in the fields of aerospace, navigation, nuclear energy, new energy, medical treatment, architecture and cultural creativity.

5.2. Focus on the Disruptive Technologies of the Future
Space printing and manufacturing of printed biological materials are two subversive research directions, which are directly related to our life safety and health and national defense. You can print small equipment manufacturing devices out of space, you can create giant solar power in space, you can build a one-month launch pad, you can even develop new materials for space equipment. Thus occupy the commanding heights of basic research and industrial applications.

6. The Conclusion
China is in a period of rapid development of additive manufacturing. Increase material manufacturing development "to the application development as the guide, powered by technology innovation, industrial development as the goal" principle, to establish and perfect the material standard of manufacturing system, combining with the cloud, big data, Internet and other emerging technologies, and cultivate a batch of internationally competitive advanced technology and manufacturing enterprises, realize sustainable development, material manufacturing growth impetus of regenerative medicine, biological materials, medicine, engineering and related industry rapid development.

References
[1] Error analysis and Experimental Study of parts in additive manufacturing [D]. Yang Shuxiong. Xi’an University of Technology, 2019
[2] Research on fluidity and Laser Selection Melting Forming of titanium alloy Powder [D]. Wang Chang Zhen. Shandong Jianzhu University, 2017
[3] European Commission Additive Manufacturing in Horizon 2020 [EB/OL]. http://ec.europa.eu/programmes/horizon 2020/en.2013.
[4] ALTMAIER P. National Industrial Strategy 2030[N].China Daily, 2016.
[5] Summary of the White Paper on Manufacturing Industries[R].Tokyo: Ministry of Economy, Trade and Industry (METI), 2014.
[6] FY2016 White Paper on Manufacturing Industries [R].Tokyo: Ministry of Economy, Trade and Industry (METI), 2017.