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Research on the Development Direction of Additive Manufacturing Technology under the Goal of "Double Carbon"

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Abstract: Additive manufacturing technology (3D printing) is an important part of advanced manufacturing and affects the development of advanced manufacturing. This paper analyzes the problems existing in the low-carbon development of additive manufacturing by referring to the related literature of additive manufacturing technology. The existing additive manufacturing technology is summarized. This paper mainly introduces the low-carbon development direction of additive manufacturing technology in aerospace, medical health, automobile manufacturing and other fields, and provides effective reference for promoting the sustainable development of additive manufacturing.

Keywords: Additive Manufacturing; Dual Carbon; Development Direction.

1. Introduction

Advanced manufacturing is an industrial production system and a new industrial form that adopts advanced manufacturing modes, applies new technologies, new processes, new materials, big data and other new elements, and fully reflects the direction of advanced productive forces development [1]. Additive manufacturing technology is a disruptive advanced manufacturing technology that has been widely applied in many fields such as aerospace, automobiles, ships, national defense and military industry, and healthcare; in the communication field, Apple and Honor brands have begun to apply it to the manufacture of mobile phone parts. The global market size in 2022 was $18 billion, and it is expected to reach nearly $100 billion by 2030. Developing additive manufacturing responds to the national "dual carbon" target policy and is an important force for low-carbon development. It is also a typical representative of developing new quality productive forces. The state and local governments have actively taken measures to promote the development of additive manufacturing, but the formulation of the "dual carbon" target still constrains the high-quality development of additive manufacturing. It is urgently needed to study the intrinsic connection between the two, so as to clarify the direction of high-quality development of additive manufacturing in China.

2. Additive Manufacturing Technology Process Route

Additive manufacturing technology, also known as 3D printing technology, is based on 3D model data, the use of powder metal or plastic and other adhesive materials, the use of layer by layer superimposed materials (layer by layer printing). Additive manufacturing technology has been around for nearly 40 years, and many technical routes coexist at present. According to the forming principle, there are seven main processes for additive manufacturing, which are powder bed melting, directional energy deposition, stereoscopic light curing, binder injection, material extrusion, material injection, and thin material lamination. These processes are widely used in the manufacturing industry, especially in the medical field, aerospace field, automotive field, etc., significantly improving the production efficiency and production precision.

The principle of powder bed melting is the additive manufacturing process of selectively melting/sintering the powder bed area through thermal energy. Currently, there are three common powder bed melting technologies, namely laser selective melting (SLM), laser selective sintering (SLS), electron beam selective melting (EBSM), etc. The principle of directed energy deposition is to use focused thermal energy to melt and deposit materials in additive manufacturing processes. There are three common directed energy deposition techniques: laser near net shape (LENS), electron beam fuse deposition (EBDM), and arc additive manufacturing (WAAAM). The principle of stereolithography is an additive manufacturing process that selectively solidifies liquid photosensitive polymers through photopolymerization. It is mainly used in industrial product design and development, innovative and creative product production, and wax molds for precision casting, using non-metallic materials. The principle of adhesive spraying is the additive manufacturing process of selectively spraying and depositing liquid adhesive to bond powders and other materials. It is mainly used in industrial product design and development, casting sand cores, medical implants, medical models, innovative and creative products, construction, etc., using non-metallic materials. The principle of adhesive spraying is the additive manufacturing process of selectively spraying and depositing liquid adhesive powder and other materials. It is mainly used in industrial product design and development, casting sand cores, medical implants, medical models, innovative and creative products, construction, etc., using non-metallic materials. The principle of material extrusion is an additive manufacturing process in which the material is melted and extruded through a nozzle or orifice. It is mainly used for industrial product design and development, innovative and creative product production, etc., using non-metallic materials. The principle of material spraying is an additive manufacturing process that selectively sprays and deposits materials in the form of droplets. It is mainly used for industrial product design and development, medical implants, innovative and creative product production, casting wax molds, etc., using non-metallic materials. The principle of thin material stacking is an additive manufacturing process that involves bonding thin layers of material layer by layer to form a physical object. It is mainly divided into laminated object manufacturing (LOM) and ultrasonic additive manufacturing (UAM).

3. Problems in Low-carbon Development of Additive Manufacturing

Additive manufacturing, due to its advantages in reducing material waste and improving design flexibility, is widely believed by industry experts and scholars to contribute to achieving low-carbon development goals. However, in the pursuit of low-carbon development, additive manufacturing technology also faces some challenges and problems. Mainly reflected in energy consumption, material utilization efficiency, supply chain impact, post-treatment, economic feasibility, carbon footprint assessment, and other aspects.

In terms of energy consumption, although additive manufacturing can reduce material waste compared to traditional subtractive manufacturing, a large amount of energy is required in actual production processes, such as laser melting of metal powders. If the electricity used comes from non renewable energy sources, the indirect carbon emissions during the additive manufacturing process will increase. In terms of material utilization efficiency, although additive manufacturing can reduce the amount of raw materials used, in some cases, additional supporting materials may be required to support the structure or ensure the quality of the parts, which are often difficult to recycle or reuse. Meanwhile, not all materials are suitable for additive manufacturing, which may limit the selection of certain sustainable materials. In terms of post-processing, parts produced by additive manufacturing usually require post-processing steps such as grinding, polishing, and heat treatment, which also consume energy and generate waste. Some post-processing steps may also involve the use of harmful chemicals, increasing the environmental burden.

In terms of supply chain impact, the widespread application of additive manufacturing technology may lead to changes in the supply chain, such as reducing logistics demand but potentially increasing demand for specific raw materials. Changes in the supply chain may also affect the effectiveness of waste management and recycling mechanisms. In terms of economic feasibility, for some enterprises, the cost of investing in additive manufacturing equipment is relatively high, which may affect their enthusiasm for adopting this low-carbon technology. Even if energy conservation and emission reduction are achieved in the production process, it is difficult to promote if the overall economic model is unsustainable. In terms of carbon footprint, current 3D printing technology is not entirely a low-carbon and environmentally friendly technology. Some studies suggest that compared to traditional processes, the carbon footprint of materials directly formed by additive manufacturing may be higher.

In summary, although additive manufacturing theoretically provides the possibility of achieving low-carbon development, there are still many technical and economic barriers that need to be overcome in practical applications. With the advancement of technology and the increasing emphasis on sustainable development in society, these issues are expected to be resolved in the future.

4. Development Direction of Additive Manufacturing

4.1. Aerospace Field

In the field of space, low-carbon development is not only a choice, but also an inevitable requirement. The traditional manufacturing process is often accompanied by a large amount of material waste, and 3D printing greatly reduces this waste, because it can be customized according to the need to use the materials needed to build the object. According to the research table, additive manufacturing technology is particularly suitable for the manufacturing of complex structures in the aerospace industry due to its advantages such as production speed, production cost and resource saving [2]. For example, the key core components of new generation fighter jets, domestic large aircraft, new rocket engines and other key equipment have a large number of applications of additive manufacturing technology, which has solved the forming problems of many complex structural parts that were difficult to manufacture in the past, and achieved lightweight product structure and intelligent product production. Based on the requirements of lightweight, high temperature performance and structural precision parts forming in the aerospace field, in order to promote the sustainable development of additive manufacturing technology in the aerospace field, it is recommended that designers further optimize the design and create lighter and more compact parts; For the additive manufacturing technology of difficult-to-process materials, to achieve a leapfrog improvement in structural performance and function; The structural design and manufacturing technology of force, heat and acoustic metamaterials will be developed to realize the integration of material, structure and function [3][4]. Establish a carbon footprint tracking system and resource recovery system in the field of aerospace additive manufacturing to promote the green and harmonious development of additive manufacturing.

4.2. Medical Sector

In the field of health care, the manufacturing of medical devices has a profound impact on the realization of low-carbon goals. Due to the high cost of purchasing complete medical equipment, the emergence of additive manufacturing technology not only saves costs, but also improves production efficiency, so it is widely used in drug delivery systems, medical implants and parts manufacturing in medical devices[5]. For example, 14 types of additive manufacturing medical implants such as acetabulum cups and spinal interbody fusion devices have been certified by NMPA to achieve clinical applications and expand disease treatment solutions. Time Angel uses additive manufacturing technology to achieve mass customized production of orthodontic dental molds, solve the complex problems of traditional machining and manufacturing, meet the individual needs of patients, and comprehensively improve the level of oral medicine in China. The manufacturing requirements of medical and health equipment parts are extremely strict, involving the selection of materials, processing technology, quality control and other links. Based on this, in order to achieve low-carbon development, additive manufacturing technology should optimize design and reduce material waste, improve energy efficiency and use renewable energy, industry experts to conduct research and development and application of green materials, promote digital and networked manufacturing, and finally policy guidance to promote the industry.

4.3. Automotive Sector

The automotive industry is an important part of Industry 4.0, and its carbon emissions affect the realization of the "dual carbon" goal. Driven by Industry 4.0, 3D printing technology is reshaping the automotive manufacturing industry. At present, 3D printing technology brings a lot of convenience to automobile production, for example, 3D printing technology is widely used in the field of automobile design, parts development, manufacturing and after-sales maintenance [6]. In order to make the low-carbon development of 3D printing technology in the automobile industry, the following suggestions are made: Firstly, optimize the utilization of raw materials and materials for auto parts, and develop environmentally friendly materials from the source of carbon reduction; Secondly, there is a need for low-carbon automotive manufacturing process planning, such as integrating 3D printing technology with automated and intelligent production lines, which can reduce energy waste caused by human operation. In addition, it is necessary to carry out lightweight design and weight reduction: the use of 3D printing technology to manufacture complex and lightweight auto parts, thereby reducing the overall weight of the vehicle, improving fuel economy and reducing carbon emissions.

4.4. Other Fields

The application of 3D printing technology involves all walks of life, for example, in casting, Yinchuan, Ningxia has built the world's first 10,000-ton casting 3D printing factory, applying additive manufacturing technology to sand casting, investment casting and other casting processes, greatly reducing the casting processing process, improving product manufacturing efficiency, and achieving the replacement of traditional casting. In terms of construction, large-scale additive manufacturing buildings such as hybrid Bridges and houses have been completed in various places. In terms of life, advanced hand and lightweight shoes are welcomed by consumers. In the field of communication, Dr. Chu Yushi and Professor Zhang Jianzhong from Harbin Engineering University, in collaboration with Professor Gang-Ding Peng from the University of New South Wales, Australia, successfully manufactured centimeter-level optical fiber prefabrication rods using digital light processing (DLP) 3D printing technology, and obtained single-mode and multi-mode optical fibers through the control of fiber drawing parameters [7]. At present, the manufacturing industry should not only develop at a high speed, but also develop at a high quality to achieve low carbon emissions or zero carbon emissions.

5. Conclusion

Based on its unique technical advantages, additive manufacturing technology has considerable application prospects in aerospace, medical and health care, automobile manufacturing and other fields. This paper first summarizes the additive manufacturing technology, and then summarizes the application of additive manufacturing technology in aerospace, medical health, and automobile manufacturing fields, and puts forward the low-carbon development direction of these fields, providing an effective path for the sustainable development of additive manufacturing technology in various industries.

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References

[1] Donghua Yu . The development Direction and promotion path of Advanced Manufacturing Industry [J]. People's Forum Academic Frontiers, 2023, (17): 15-24.

[2] Zhiyong Li, Dongxue Han, Shikun Jiao, et al. Application of laser additive manufacturing in aerospace field [J/OL]. Chinese Journal of Lasers, 1-27[2024-08-15].

[3] Dongdong GU, Xin Lin, Haibo Tang , et al. Preface to the topic "Aerospace Additive Manufacturing" [J]. Chinese Journal of Lasers, 2024, 51 (10): 9-10+2.

[4] Xuan Sun, Bin Hu, Zhihui Xiong , et al. Research progress of additive metal materials in aerospace field [J]. Shanghai Metal, 2024, 46 (03): 1-12.

[5] Chunxu LI, Dario Pisignano, Yu Zhao, et al. Medical application of additive manufacturing technology [J]. Engineering, 2020, 6 (11): 42-62. (in Chinese)

[6] Jingguang Peng, Weixing Zhou, Di Chen, et al. Application and feasibility study of Additive Manufacturing technology in automotive aftermarket [J]. Powder Metallurgy Industry, 2020, 30 (04): 1-7.

[7] ChuY ,Fu X ,Luo Y , et al. Additive Manufacturing Fiber Preforms for Structured Silica Fibers with Bismuth and Erbium Dopants [J]. Light: Advanced Manufacturing, 2022, 3 (2): 358-364.