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Development and Prospect of Additive Manufacturing Technology in Automobile Field

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Abstract: Additive manufacturing technology (AM) is widely used in aerospace, machinery manufacturing, automotive and other fields; With the arrival of Industry 4.0, additive manufacturing technology has been paid more and more attention by countries all over the world in industrial production. The development of additive manufacturing industry provides a valuable opportunity for the rapid development of modern manufacturing industry and the transformation and upgrading of traditional manufacturing industry. This paper analyzes the existing additive manufacturing technologies in the automotive field, evaluates and classifies the existing technologies, and finally analyzes the development prospects of additive manufacturing technologies.

Keywords: Automobile manufacturing, Additive manufacturing, Machinery manufacturing, 3D printing.

1. Introduction

Additive manufacturing is equivalent to a kind of Subtractive manufacturing and molding Manufacturing

(Formative Manufacturing), which is a digital manufacturing process based on 3D model data and manufactured by layers and layers of materials. With the advantages of mold free, simple production mode, low cost, high efficiency, flexible products, etc. AM can realize the manufacturing of a variety of complex parts, and is widely used in the manufacturing of new types of parts, including aerospace, consumer goods, national defense, energy, automobile and other fields. The rapid development of AM has not only changed our design content, but also changed our design method, affecting the entire design process of engineers in various industries. In the current automobile manufacturing industry, the country vigorously promotes the application of digital manufacturing technology characterized by green, environmental protection, high efficiency and collaboration. Additive manufacturing technology has become the key content of digital manufacturing technology. The upcoming Industry 4.0 makes China's automobile industry face new development opportunities and challenges.

2. Basic Principles of Additive Manufacturing Technology

2.1. Technical principle of additive manufacturing

Additive Manufacturing (AM) is a new manufacturing method based on discrete stacking principle to form physical articles. Throughout the history of human manufacturing, the manufacturing mode has experienced three development stages: equal material manufacturing, reduced material manufacturing and additive manufacturing. Among them, equal material manufacturing refers to the production of articles by casting, forging, plastic and other methods, and the use of mold to control the shape, with the material weight basically unchanged; Material reduction manufacturing is a mass manufacturing method that uses tools to cut materials by turning, milling, planing, grinding, etc. to remove unnecessary materials from the blank; Additive manufacturing makes use of discrete materials such as liquid, powder and wire to rapidly and accurately "bottom-up" material accumulation on the equipment through 3D design data to produce components with arbitrary complex shapes. Additive manufacturing technology has broken through the traditional manufacturing process, turning the traditional "material reduction" manufacturing into "additive" manufacturing. In principle, additive manufacturing has realized the rapid and accurate manufacturing of physical prototypes of new products with arbitrary complex shapes, that is, the integrated development of "design material manufacturing"; Technically, the complex 3D manufacturing is transformed into a series of layered overlays of 2D contours. Without any tools, dies and processing processes, the 3D modeling is completely and truly copied, which reduces the manufacturing difficulty and solves the forming problem of complex structural parts in the traditional manufacturing field. This is not only conducive to the manufacturing and innovation of parts, but also conducive to the realization of personalized private customization. The production mode is simple High production efficiency, high degree of integration, short development and processing cycle, less waste by-products, high degree of automation, rich and diverse products, accurate entity replication, etc. With the emergence of additive manufacturing, there are great opportunities for improvement in all areas of product design, manufacturing and business; Its specific advantages are as follows:

(1) In terms of products: simplified and standardized product assembly reduces size and installation

(2) In manufacturing: shorten the delivery time Reduce the number of quick assembly parts by more than 50%, reduce welding by about 50%, reduce assembly complexity, and reduce assembly steps

(3) In terms of business: accelerate the product launch, adjust the design, meet the specific burning needs of customers, and simplify product maintenance

2.2. Classification of additive manufacturing technology

According to different energy sources, molding methods, material forms, etc., ISO/ASTM 52900 classifies metal additive=manufacturing into the following four categories: powder bed fusion (PBF) and directional energy deposition

(Directed Energy Deposition, DED), Binder Jetting and Sheet Lamination. Three commonly used ones (using metal powder as raw material) are introduced as follows:

Powder bed melting. Powder bed melting includes such technologies as Selective Laser Sintering (SLS), Selective Laser Melting (SLM) and Electron Beam Melting (EBM). When the powder melting process is completed, it will be fused with the sintered materials, and the next layer of powder will be spread on the powder bed again through the roller. SLS and SLM use metal powder as processing raw materials, such as 17-4PH alloy, Ti6A1-4V, etc., which uses laser beam to melt and stack the powder spread on the metal substrate layer by layer; EBM uses more easily available electron beam to provide energy for molten metal powder. The vacuum environment can ensure that the metal powder will not be oxidized during heating

Directional energy deposition. Directional energy deposition uses laser or electron beam to directly irradiate an area of the substrate, and melt the powder at the same time as the powder nozzle is fed. o The molten powder will be deposited on the molten substrate

Cure when the energy beam is removed. The precision of DED is not high (0.25mm), so it can only manufacture structures with low precision and simple components, but it is especially suitable for component repair. Therefore, DED is usually used to make low complex large-scale components can also be used to repair damaged components.

Bonding penalty spray. The ink-jet printing is to deposit the bonded crown to the powder bed armour in a remote manner, and the material adhesive interacts with the powder particles to form the original aggregate, thus forming a cross section layer. After one layer is printed, the powder feeding piston lifts, the forming piston drops, the roller spreads the powder, and the next layer is bonded with the previous layer through the sprayed adhesive. Through the sintering process, the binder will be pyrolyzed, the particles will be sintered together, and the parts will obtain the final strength.

3. Application of Additive Manufacturing Technology in Automobile Field

In the automotive industry, the application of additive manufacturing technology covers prototype design, mold manufacturing, batch printing of parts, etc

3.1 Manufacturing of parts

In the process of automobile manufacturing, there will be many different kinds of parts. The manufacturing cycle, cost and consumption of parts are important indicators of automobile manufacturing. In order to shorten the development cycle of automobiles, the introduction of 3D printing technology in the automobile industry can improve the manufacturing efficiency of parts and greatly improve the production of parts

Quality, and finally reduce the production cost of parts. When 3D printing is used for the production of automobile parts, the minor deviations in part design can be timely excavated, and the working principle and feasibility of components can be quickly reviewed, thus effectively shortening the development cycle of parts. For example, when carrying out auxiliary parts such as rubber, plastic and cylinder head, it does not need to use any mold and metal, which can effectively simplify complex mold processing, significantly save human and equipment resources in the manufacturing process, and reduce cost investment.

3.2 Efficient manufacturing of lightweight parts

In order to promote the green and sustainable development of the automobile manufacturing industry, the automobile industry has put forward higher standard requirements, which require that the automobile production process can be transformed to the direction of energy saving, emission reduction and lightweight operation, and improve the environmental protection and energy saving level of automobile manufacturing. At present, many cars will reduce their weight and energy consumption, thus reducing the weight of various parts inside the car. Some enterprises will manufacture materials and parts in a lightweight way according to the requirements of the market and environmental protection. At present, 3D printing is a displacement way that can realize lightweight manufacturing of parts and reduce the quality. For example, for full size bumper manufacturing, 3D printing can be used for rapid and effective processing. The obtained parts are lighter than traditional production methods, and can also meet the quality requirements.

3.3 Manufacturing of complex moulds

In the development process of the automobile industry, auto parts are not developing towards simplification. On the contrary, many parts are more complex, so the requirements for mold manufacturing are higher than before, and the manufacturing difficulty is also increasing. For parts manufactured in the traditional mode, if the shape of the part is complex and the structure is unreasonable, the mold can only be manufactured by splicing and inlaying, which makes it difficult to ensure the accuracy of the production of the parts, seriously reduces the service life of the parts, and also increases the production time and complexity of the automobile. If 3D printing technology is used for manufacturing, SLS selective laser sintering technology can be used to process molds with complex structures, which can effectively reduce manufacturing time, and better strengthen the control of manufacturing accuracy, thus effectively improving the service life of molds. For example, 3D printing technology can be used to stack materials layer by layer to obtain solid models, and SLS in 3D printing can be used to select laser sintering to promote the whole model. To achieve the goal of manufacturing integration.

3.4 Enterprise application examples

In terms of enterprise application, additive manufacturing technology has endowed innovative functions such as integrated printing, lightweight, efficient heat exchange, application of new materials, and design of multi material functional gradient structure; It is being integrated into the manufacturing process and even the supply chain of existing products on a large scale to innovate traditional manufacturing methods and reduce manufacturing costs. Some advantageous manufacturing enterprises have established a full process technology system, including the design capability of innovative structures based on additive manufacturing technology (such as topology optimization, crystal lattice structure, structure function integration), additive manufacturing forming process control, post-processing, quality inspection and evaluation, etc. A group of

research institutions represented by the Fraunhofer Association for the Promotion of Applied Research in Germany continued to deepen the industrial production and intelligent technology research of additive manufacturing.

In 2019, Siemens has made significant contributions to the integration of additive manufacturing industrialization of automotive parts and Industry 4.0, from redesigning, reorganizing manufacturing to reorganizing business. The role of additive manufacturing involved in various industry fields, in the whole process to promote the development of industry. In addition, Siemens applies additive manufacturing technology to real objects, such as gas turbine blades, locomotive components and gas turbine nozzles, as shown in Fig 1.

Figure 1. Examples of Additive Manufacturing Applications

In 2022, NIO recently set up a new company named NIO Battery Technology, with a registered capital of 2 billion yuan. Its business scope includes battery manufacturing, synthetic material manufacturing, additive manufacturing equipment manufacturing and sales, as well as mold manufacturing and sales. Nio has always chosen the Ningde era as a battery supplier, and it is now clear that it will choose to "make its own battery" like BYD and Tesla. As for 3D printing, domestic car companies or battery manufacturers have not been particularly clear about the technology. According to the newly established battery manufacturing enterprises in the past year, only BYD's Xiangyang Ferdi and Fuzhou Ferdi and NIO include additive manufacturing in their business. Nio, BYD and other well-known auto companies can add additive manufacturing to their newly established battery companies, indicating that additive manufacturing technology has attracted the attention of heavyweight users. At present, the 3D printing technology of battery is not mature enough, as shown in Fig 2 is the 3D battery printer of Blackstone Technology.

Figure 2. Blackstone Technology Battery 3D Printer

4. Conclusion

As far as the current situation is concerned, the problems existing in China's additive manufacturing technology and industrial development include: insufficient common technology research and basic device capabilities, lagging patent layout facing the international market, and the need to deepen the construction of industrial scale and industrial clusters.

It is suggested that national strategic scientific and technological forces represented by various innovation centers should be planned and built under the guidance of the overall national objectives and industrial development needs; Continuous policy support will be provided in key areas of additive manufacturing, and management mode and experience of international advanced research institutions will be used for reference to build a stable and applicable team management mode, taking into account the stable development and division of labor and collaboration of research teams. Establish an industrial chain security early warning mechanism composed of national-level scientific research institutions, industry alliances and third-party institutions, strengthen the strategic research on additive manufacturing frontier technology and industrial development, and formulate the improvement plan, development catalog, standard development and additive manufacturing technology and industry development roadmap for additive manufacturing industry. We will establish a collaborative mechanism for various research institutions and research projects, carry out research on the basis of additive manufacturing industry and key generic technologies, and support solutions to engineering transformation problems of cutting-edge technologies and innovative achievements, so as to provide solid support for upgrading and modernizing the industrial chain of the equipment manufacturing industry.

It is suggested to formulate incentive and subsidy policies to encourage enterprises to use their own technology products, and the assessment and management measures for new science and technology institutions in line with the law of technological innovation. Make clear the assessment orientation, increase the proportion of technological innovation in the assessment, classify the long-term R&D input and output, form long-term support, encourage innovation, tolerance of failure of the assessment mechanism, stimulate the enterprise innovation motivation; We will guide enterprises to shift from relying on excessive resource consumption and low performance/low cost competition mode to relying on technology and application innovation and implementing differentiated competition mode, so as to enhance the international competitiveness of China's manufacturing industry.

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