

Research Progress and Current Situation of Laser Additive Technology

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Abstract: Laser additive technology additive manufacturing is a manufacturing method that realizes the combination of precise "shape control" of complex structure and high-performance "controllability". After rapid solidification, it forms a surface coating or matrix structure with very low dilution. Such surface coating or structure can effectively combine metallurgical technology, and can improve the wear resistance, corrosion resistance, heat resistance, oxidation resistance and other properties of the surface of the matrix material, or in manufacturing. At present, laser additive manufacturing is widely used in aerospace and military industry for rapid repair and performance enhancement of parts. In terms of metals, selective laser melting (SLM) and laser melting deposition (LCD) processes are mainly represented.

Keywords: Manufacturing, Corrosion resistance matrix material.

1. Introduction

As one of the technologies with the fastest growth rate of the total industrial value in the field of material processing in recent years, additive manufacturing technology integrates multi-disciplinary professional fields such as computer science, mechanical engineering, control engineering and material engineering, especially laser additive manufacturing is related to the field of optics. Research on equipment and process related to powder bed melting and directional energy deposition has been carried out at home and abroad.

Through laser additive manufacturing technology, the problems in traditional processing of complex parts are overcome [1], the dimensional accuracy of printing and forming is high, and the barrier of traditional manufacturing is broken through. Integrated manufacturing ensures the excellent performance of the whole piece. Laser additive (LAM), also known as laser 3D printing, is a rapidly developing advanced manufacturing technology. It uses computer-aided design CAD software to model and layer the target product, control the trajectory of high-energy laser, and quickly melt the metal or alloy raw materials such as powder. By scanning point by point, overlapping line by line, and accumulating layer by layer, it finally obtains the three-dimensional target product [2]. Lam technology has the following advantages [3]: (1) it can prepare complex products that are difficult or impossible to be prepared by traditional processes; (2) It has great advantages in the preparation of small batch products; (3) It can improve the utilization rate of materials and reduce costs; (4) Capable of preparing functionally gradient materials.

2. Two Typical Laser Additive Methods

Forming principle and characteristics of typical (LAM) technology according to its forming principle, Lam technology can be divided into two categories: (1) laser cladding deposition (LCD) technology characterized by synchronous powder feeding; (2) Selective laser melting (SLM) technology characterized by powder bed powder The

following focuses on the forming principles and characteristics of these two typical Lam technologies.

2.1. Forming Principle and Characteristics of LCD Technology

LCD technology is an organic combination of the "stacking accumulation" principle of rapid prototyping technology and laser cladding technology. With metal powder as the forming raw material and high-energy beam laser as the heat source, according to the processing path of layered slicing information of formed parts CAD model, the metal powder sent synchronously is melted, rapidly solidified and deposited layer by layer, so as to realize the direct manufacturing of the whole metal parts. LCD system mainly includes: laser, chiller, CNC numerical control workbench, coaxial powder feeding nozzle, powder feeder and other auxiliary devices. LCD technology integrates the characteristics of rapid prototyping technology and laser cladding technology, and has the following advantages [4]: (1) without mold, it can produce parts with complex shapes that are difficult or even impossible to be produced by traditional methods; (2) The macro structure and microstructure are manufactured synchronously, and the mechanical properties reach the level of forgings; (3) The forming size is not limited, and the manufacturing of large-size parts can be realized; (4) It can not only customize biological prosthesis, but also produce functionally gradient parts; (5) It can quickly repair invalid and damaged parts, and repair and manufacture directional tissue. Main disadvantages: (1) high manufacturing cost; (2) Low manufacturing efficiency; (3) The manufacturing accuracy is poor, so the cantilever structure needs to add corresponding support structure.

2.2. Slm Technology Forming Principle and Characteristics

SLM technology is an advanced laser additive manufacturing technology based on rapid prototype manufacturing technology. After slicing and layering the three-dimensional digital model of the part through the special software and obtaining the contour data of each section, the metal powder is selectively melted layer by layer

by using the high-energy laser beam according to the contour data. The manufacturing of three-dimensional solid metal parts is realized by spreading powder layer by layer, melting, solidification and stacking layer by layer. The selective laser melting system is mainly composed of laser and auxiliary equipment, gas purification system, powder spreading system and control system. SLM technology has the following advantages: (1) the forming raw materials are generally metal powders, mainly including stainless steel, nickel base superalloys, titanium alloys, cobalt chromium alloys, high-strength aluminum alloys and refractory metals; (2) The precision of formed parts is high, and the surface can meet the accuracy requirements after simple post-treatment such as grinding and sandblasting; (3) Suitable for printing small pieces; (4) The mechanical properties of formed parts are good. Generally, the mechanical properties are better than castings and not as good as forgings. Main disadvantages: (1) the layer thickness and spot diameter are very small, resulting in low forming efficiency; (2) The size of the parts will be limited by the size of the powder spreading work box, which is not suitable for manufacturing large-scale integral parts; (3) It is unable to manufacture functionally gradient materials and form directional crystal structures, which is not suitable for the repair of failed parts.

3. Laser Additive Manufacturing Materials

From the process principle of laser additive manufacturing, we can know that materials are the basis of its laser technology in July 2021, and the development of materials has a significant impact on its development. At present, a variety of metal materials including stainless steel, aluminum alloy, titanium alloy and nickel based alloy have been developed in the field of metal laser additive manufacturing, and the corresponding material properties have been optimized according to the characteristics of laser additive manufacturing. At present, the research hotspot mainly focuses on the research of lightweight or high-value structural materials such as titanium alloy, high-strength aluminum alloy, high entropy alloy and so on.

Titanium based alloy titanium alloy has become a common high-performance material in various industries because of its high specific strength, low density, corrosion resistance, good biocompatibility and excellent comprehensive performance. Titanium alloy materials suitable for laser additive manufacturing are mainly Ti Al alloys, mainly including TC4, TC11, TC21 and Ti8Al. Among them, the research on Ti6Al4V has obtained a large number of research results, and the molding process is relatively mature. At present, it has been widely used in aerospace, biomedicine and other fields. Relevant research shows that during the molding process, martensite phase is produced due to rapid solidification α' It will seriously reduce the plasticity of Ti6Al4V molded parts, so it will reduce the α' The content of phase is beneficial to improve plasticity. Liu et al. Achieved by optimizing process parameters α' Phase regulation and reduction α' The content of Ti6Al4V improves the ductility of Ti6Al4V. Xu et al. Achieved martensitic phase decomposition and β Phase precipitation realizes the preparation of Ti6Al4V components with high strength and high ductility. The research work on direct laser deposition of TC21 alloy and Ti5553 alloy is still in the process of research. The tensile properties of TC21 samples show obvious anisotropy under two different heat

treatment conditions. Laser additive manufacturing has the function of rapid solidification, so it is also suitable for laser additive manufacturing of oxide dispersion strengthened alloys. In addition, Ti NB series and Ti Zr series titanium alloys have also been successfully manufactured by laser additive manufacturing, but the molding process still needs to be further optimized, which has a wide application prospect.

4. Conclusion

The development history of additive manufacturing technology is only more than 30 years. Laser additive manufacturing is the most studied and the most successful technical means for industrial application. With the cost reduction of laser additive manufacturing, it will soon be liberated from the auxiliary means of traditional manufacturing industry and become a new manufacturing method integrating design and manufacturing. Through the analysis of market scale and technical potential, the author believes that although the laser selective melting additive manufacturing technology is limited by the market volume, it is only a powerful supplement to the traditional processing methods, but it has been able to support the transformation and upgrading of manufacturing capacity of enterprises. With the development of technology, the new mode of design and manufacturing integration will become the core competitiveness of enterprises. Generative design plus additive manufacturing will be a new engine to stimulate the innovation and vitality of enterprises. New material plus additive manufacturing will stimulate market application and realize blowout development. Combined with new technologies such as big data, edge computing, digital twinning and artificial intelligence, laser selective melting additive manufacturing technology will become an indispensable part of smart factories in the future.

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