Metal Powder and Wire Additive Manufacturing Technology

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Abstract. Additive manufacturing technology can quickly manufacture parts with dense microstructures and excellent mechanical properties, so that it shows a broad application prospect in aerospace and other fields. Additive manufacturing technology was briefly introduced in this paper. On this basis, the technology and characteristics of metal powder and wire additive manufacturing were systematically analyzed and compared, and the development of additive manufacturing technology was prospected.

1. Introduction

Additive manufacturing also known as 3D printing, is a technology that combines subjects such as materials science and computer-aided design. Through the control of the software and the numerical control system, the corresponding raw materials are melted, sintered, and light-cured according to the three-dimensional model, and physical objects are produced layer by layer. Compared with the past machining methods of cutting and assembling raw materials, it is a manufacturing method in which materials are superimposed from bottom to top [1,2]. This makes it possible to make complex structural parts that were previously restricted by traditional production methods and were difficult to achieve [3,4]. With the rapid development of the manufacturing industry in the 21st century and the proposal of "Made in China 2025", additive manufacturing technology has received widespread attention. It has made great progress in military manufacturing, medical industry, automobile manufacturing, construction industry, aerospace, food industry, small jewelry manufacturing and other aspects [5].

This article outlines the classification of additive manufacturing, and expounds the research status of metal powder and wire additive manufacturing technology. In addition, the characteristics and applications of metal powder and wire additive manufacturing technology are compared and analyzed.

This has certain theoretical and practical value for the realization of new materials and new technologies in the rapid manufacturing of parts and intelligent manufacturing in the future.

2. Classification of additive manufacturing

Additive manufacturing started from the end of the 90th century to the middle of the 20th century. It can be said that the focus of additive technology is layered manufacturing. The classification of commonly used additive manufacturing is shown in Table 1 [6,7].

| Number | According to materials' form | According to heat source | According to the type of materials |
|--------|-----------------------------|--------------------------|-----------------------------------|
| 1      | Wire additive manufacturing | Wire and arc additive manufacturing | Metal materials additive manufacturing |
| 2      | Strip/Sheet additive manufacturing | Laser additive manufacturing | Organic polymer materials additive manufacturing |
| 3      | Powder materials additive manufacturing | Light curing additive manufacturing | Biomaterials additive manufacturing |

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The strip additive manufacturing technology is mainly used for the forming of large parts and the welding repair work of surfacing welding. However, there are few applications in additive forming parts, especially 3D printing, and there are relatively few response supporting equipment. At present, metal powder and wire are the main research directions of additive manufacturing.

3. Metal powder additive manufacturing technology

Metal powder additive manufacturing mainly covers electron beam powder additive manufacturing, laser powder additive manufacturing, and plasma powder additive manufacturing.

According to the mode of powder feeding, the powder additive manufacturing technology is mainly divided into two types: powder spreading and powder feeding. In the technology of powder spreading additive manufacturing, a layer of powder is laid on the table, and the corresponding heat source is controlled by the computer to selectively sintering the powder according to the predetermined path. Sintered ground is convenient to form the solid part of the parts, and finally the excess part can be removed from the material to obtain the forming parts. A representative technique of this form is selective laser melting (SLM) [8,9]. SLM schematic diagram is shown in Figure 1. It uses the heat of the laser beam to melt the metal powder, then forms parts through cooling and solidification process. It has the characteristics of no binder, high forming precision and good mechanical properties. However, SLM technology is also limited by some conditions, such as high requirements for material granularity, so it is difficult to make. It’s not suitable for large parts and the repair of failed parts.

In the technology of powder feeding additive manufacturing, the heat source and powder feeding nozzle are put together to make the powder directly sprayed into the molten pool. The typical technique in this form is laser melting deposition (LMD) [10]. LMD technology does not require molds and can be used to produce parts with complex shapes. However, the high forming speed will reduce the size accuracy. LMD has low production efficiency, but relatively high cost.

From the above analysis, it can be seen that metal powder additive manufacturing technology is mainly related to the quality requirements of the powder itself and the way of powder spreading or distribution, as well as the external heat source. Generally speaking, the forming quality of metal powd er additive is high, which is especially suitable for the production of precision small parts. However, it has higher requirements on the equipment and the environment of powder manufacturing. The cost of powder manufacturing is higher than that of silk, but the efficiency is lower.
4. Metal Wire additive manufacturing technology

In additive manufacturing of metal wire, the metal wire is easy to make and cheap. In particular, the additive manufacturing technology with wire as electrode has obvious advantages in welding speed. It does not need additional wire feeding equipment, so it can save space and increase efficiency.

4.1. Laser fuse additive manufacturing technology

Laser fuse additive manufacturing technology is to melt and accumulate the wire fed into the laser beam through the laser heat to form the required parts. It is often called laser cold wire additive manufacturing technology. The diameter of the laser fuse is small and the appearance of parts is good.

4.2. Non-consumable electrode metal wire additive manufacturing technology

The non-consumable electrode metal wire additive manufacturing technology uses the corresponding plasma, electrode beam and tungsten electrode as heat source to melt the wire being sent in and then form it. Tungsten inert gas welding (TIG) additive manufacturing is a typical metal additive manufacturing technology in which wire is not used as an electrode. It has the characteristics of good forming quality and forming efficiency. Laser cold wire additive manufacturing technology has high forming efficiency.

4.3. Consuming electrode metal wire additive manufacturing technology

The consuming electrode metal wire additive manufacturing technology is mainly the method of melting and stacking metal wire by using a torch generated between the wire and the workpiece as the heat source. Cold metal transition welding (CMT) additive manufacturing technology has been adopted in recent years. Generally this kind of additive technology has fast forming speed and high production efficiency, but the surface is rough. CMT has the characteristics of low heat input and no spatter, which has attracted wide attention.

5. Conclusion and Prospect

Through systematic analysis of metal powder additive manufacturing technology, it is concluded that metal powder additive manufacturing technology has high cost and goes on forming quality, but it has forming efficiency. The additive manufacturing technology of fused electrode metal wire has high forming efficiency and low cost. Its appearance forming quality is worse than that of powder additive. It needs to be processed again. The formability and manufacturing cost of additive manufacturing technology of non-fused metal wire are between the above two.

Additive manufacturing technology is a multi-disciplinary technology with many influencing factors. Therefore, it is not limited to study one subject, but to increase the understanding of integration research of additive manufacturing researchers in multiple subjects and fields. At present, there is still a lack of standards for additive manufacturing technology and its quality evaluation. Therefore, relevant departments should set up the relevant technical and quality standards for additive manufacturing industry.

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