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 wide 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].

Table 1 Additive manufacturing classification

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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4	Liquid materials additive manufacturing	Electron beam additive manufacturing	Inorganic non-metallic materials additive manufacturing
5	/	Thermal melting additive manufacturing	/

The strip add itive manufactu ring techno logy is mainly used for the forming of lar ge p arts an d the welding r epair wo rk of surfacing welding. How ever, there are few app lications in ad ditive forming p arts, especially 3D prin ting, and th ere are relatively few response supp orting equ ipment. At present, metal powder an d wire a re th e main research d irections of additive manufacturing.

3. Metal powder additive manufacturing technology

Metal powd er add itive manufacturing mainly cov ers electron beam p owder add itive manu facturing, laser powder add itive man ufacturing, an d plasma powd er additive manufacturing.

According to th e mode of powder feed ing, t he powder add itive manu facturing tech nology is mai nly divided i nto t wo t ypes: powder s preading an d p owder feeding. In the techn ology of powd er spreading additive manufacturing, a layer of powder is laid on the table, and the co rresponding heat sou rce is co ntrolled by th e computer to selectively sintering the powder according to the predetermined path. Sintered ground is co nvenient to form th e solid part of t he parts, and finally the e xcess part can be remov ed fro m th e material to ob tain th e forming parts. A representative technique of this form is selective laser meltin g (SLM) [8,9]. SLM sch ematic diagram is shown in Figure 1. It uses the heat of the laser beam to melt th e metal powd er, th en it fo rms p arts through c ooling an d s olidification p rocess. It has t he characteristics of no binder, high f orming p recision and good mecha nical properties. H owever, SL M t echnology is also limited by so me conditions, such as high requirements for material g ranularity, so it is d ifficult to make. It's n ot suita ble f or l arge parts an d the re pair o f failed parts.

In th e techno logy of powd er feeding add itive manufacturing, h eat sou rce an d pow der feeding nozzle are put together to make the powder directly sprayed into the mo lten pool. Th e t ypical tech nique in th is form is laser meltin g deposition (LM D) [10]. LM D techn ology does not require moulds and can be used to produce parts with co mplex shapes. However, th e h igh fo rming sp eed will reduce t he size accurac y. LMD has l ow production efficiency, but relatively high cost.

From th e ab ove analysis, it can be seen that metal powder add itive manu facturing tech nology is mai nly related t o t he quality requ irements of t he powder itself and the way of powder spreading or distribution, as well as the external heat sour ce. Gen erally speaking, th e forming quality of metal powd er add itive is h igh, wh ich is especially suitable for t he production of precision small p arts. Ho wever, it h as h igher requ irements on th e equipment an d e nvironment of p owder m anufacturing. The cost of powder manufacturing is higher than that of silk, but the efficiency is lower.

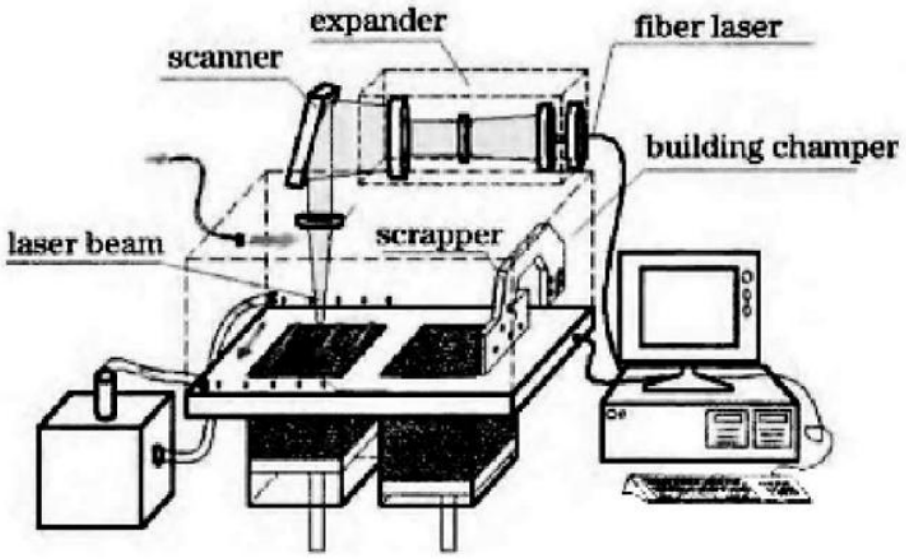

Fig.1 Diagram of SLM technology

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 is a kind of additive technology which uses the corresponding plasma, electrode beam and tungsten electrode arc 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 electrode. It has the characteristics of good forming quality and forming efficiency [11]. It is a kind of additive manufacturing technology that people are exploring gradually, or will become the mainstream in the future.

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 the arc generated between the wire and the workpiece as the heat source. Cold metal transition welding (CMT) additive manufacturing technology has widely used 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 splash, which has attracted wide attention [12].

5. Conclusion and Prospect

Through the systematic analysis of metal powder and metal wire additive manufacturing technology, it is concluded that metal powder additive manufacturing has high cost and good forming quality, but low 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 cross-integration research of additive manufacturing researchers in multiple subjects and fields. At present, there is still a lack of a complete set of standards for additive manufacturing technology and its quality evaluation. The relevant departments should speed up the formulation of technical and quality standards for additive manufacturing industry.

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