Additive manufacturing technology and its application in die manufacturing

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Abstract. The increase of material manufacturing because of its direct forming characteristics and is widely used in aerospace, automobile manufacturing, mold manufacturing, medical equipment and other fields, this article, based on the characteristics and advantages of increasing material manufacturing, molding principle to increase material manufacturing technology and process as the research object, analyzes the material manufacturing technology on the accompanying cooling water mold, tire mold and the application of the large mold manufacturing.

Keywords: Additive manufacturing, Mold manufacturing, Direct molding.

1. Introduction
Additive manufacturing, as one of the most symbolic production tools of the third industrial revolution, has become one of the most popular technologies in the world. Additive manufacturing is a processing method integrating computer aided design (CAD), computer aided manufacturing (CAM), computer digital control (CNC), laser precision servo drive, new materials and other advanced technologies. At present, additive manufacturing has developed many forming processes, including: photocuring forming, selective laser sintering, 3D printing forming, melting deposition manufacturing and stacking solid manufacturing. The rapid development of additive manufacturing and molding technology has brought a subversive change to the world [1].

2. Additive manufacturing molding process
The common manufacturing technologies include reducing material manufacturing technology, equimaterial manufacturing technology and additive manufacturing technology. The former two are traditional manufacturing techniques. The material reduction manufacturing USES cutting tools or electrochemical methods to remove unnecessary materials from the blank, and the remaining part is the part or product to be processed. Iso-material manufacturing is the use of mold control, liquid or solid materials into the required structure of the parts or products. Additive manufacturing, or additive manufacturing technology, is different from traditional manufacturing methods in that its processing process is based on the idea of "discrete/stacking molding". Starting from the CAD solid model of parts, the forming materials are stacked to form solid parts by using the layered processing method of CNC forming system through software layering and discretization [2]. The comparison between additive manufacturing technology and traditional manufacturing technology is shown in Table 1.
Table 1. Comparison of additive manufacturing technology and traditional manufacturing technology

| The Index performance | Traditional manufacturing techniques | Additive manufacturing technology |
|-----------------------|--------------------------------------|----------------------------------|
| The complexity of The parts | Can’t make complex surfaces | Making arbitrary surface |
| Material utilization | Low utilization | High utilization |
| Processing method | Remove the molding | The Add molding |
| ManufacturingObjects | Individual | Liquid, powder |
| Tool | Cutting tool | Beam of light and heat |

Additive manufacturing is a manufacturing process from scratch, including five steps of 3D modeling, model approximation, model slicing, molding and post-processing [3]. The specific molding process is shown in Fig.1.

3. Advantages of additive manufacturing technology

Additive manufacturing technology adopts the whole manufacturing scheme of adding French, which overturns the previous processing method of reducing French. Compared with traditional and classical technologies [4], 3D printing has significant advantages in product functions, production efficiency and manufacturing cost, which are mainly reflected in the following aspects:

(1) Product diversification does not increase costs

In traditional manufacturing techniques, a machine is capable of producing a limited variety of products and requires additional staff to maintain them, making the machine highly asset-specific. However, as long as the 3d data and raw materials of the product are available, the additive manufacturing equipment can not only print products of various sizes, shapes and types, but also do not require additional maintenance work by staff, thus reducing the manufacturing cost of the goods.

(2) Immediate delivery

For enterprises, no inventory accumulation, reduce the risk of stocking up, can reduce production costs. The just-in-time production method of additive manufacturing technology makes personalized production according to consumers’ demands, which not only meets customers’ demands, but also reduces the inventory of enterprises, realizing the new transaction mode of on-demand distribution market, zero inventory, low cost and fast delivery.

(3) Zero-skill manufacturing
Traditional manufacturing modes are highly professional. For example, engineers in automobile production lines need professional training before they can enter the production line [5]. The obvious division of labor leads to high cost of education and training. Additive manufacturing technology has broken through the limitations of specialization, staff only need to master the use of the additive manufacturing machine. Therefore, additive manufacturing technology has realized a new model of zero-skill manufacturing.

4. Application of additive manufacturing technology in mold manufacturing

4.1. Application of accompanying cooling mould

The hot stamping die requires the cooling medium in the cooling channel to rapidly reduce the temperature of the annealed sheet to below 200°C. In the past, the cooling channels were completed by drilling holes in the mold, so when designing these internal cooling channels, it was impossible to achieve continuous close to the cooling surface, especially when the cooling surface had complex shapes.

Schuler tried to design the shaped cooling channels flexibly through metal 3D printing equipment manufacturing, so as to achieve a more rapid and uniform cooling effect [6]. During the research and development process, Schuler thoroughly tested the printing process parameters and powder materials to determine the ideal combination of process parameters and powder materials, and selected the printing material as tool steel. Schuler conducts extensive tests on tensile strength and density and further tests on the durability and mass production of hot stamping dies with 3D printed fold-down cooling channels.

Whether hot stamping die or injection mold, THE value created by 3D printing in manufacturing is similar, that is, the 3D printing technology can construct the cooling channel with the shape, so as to obtain a more rapid and uniform cooling effect. This is not possible with traditional technology. Fig.2 shows the comparison between the traditional cooling system and the accompanying cooling system.

![Figure 2. Schematic diagram of traditional cooling system and accompanying cooling system](image)

4.2. Application in tire mold manufacturing

In the processing of the tire mold, the processing procedures are highly concentrated, mainly milling, but because of the processing Angle,

Corner does not wait unified, some decorative pattern still has thin and tall small rib or narrow and deep small groove, for example the high and low structure with irregular surface. These structures have high requirements on the rigidity and cutting tools of machine tools. Metal 3D printing solves the problem of tool interference very well. When complexity and manufacturability are no longer the biggest factors that bother tire mold manufacturing, 3D printing releases the convenience of tire product design iteration and also gives rise to new tire manufacturing capability [7]. The realization of more complex patterns, better grip and stability is undoubtedly the best land for tire manufacturers. Michelin, the automobile tire manufacturer, has recognized the potential of 3D printing technology to produce
complex high-value-added tire molds and launched a series of actions around metal 3D printing technology. In 2015, Michelin set up a joint venture with Fives to develop and sell metal 3D printing equipment. In 2016, Michelin Launched FormUp350, a metal 3D printer. In 2017, MICHELIN officially launched the High-end Four-season MICHELIN CossCimate +, which USES metal 3D printing technology to produce the mold for the tire.

4.3. Application of large molds

To make large parts, such as helicopter structures, it usually takes several tons to dozens of tons of molds to complete the job. And this mold is very expensive through the traditional processing technology, its processing process is also full of challenges. Machine tools for manufacturing large molds require high load-bearing capacity, high rigidity, and a large enough table size and working stroke to fit. Due to the high strength and hardness of the mold, the mold cavity is often processed with a small diameter end milling cutter with large elongation, so the process is prone to flutter. In order to ensure the machining precision and surface quality of the parts, the high speed universal milling machine must have high dynamic and static rigidity to improve the positioning accuracy, tracking accuracy and vibration resistance of the machine tool.

In order to compare the 3D printing method with the traditional manufacturing method, the relevant team specially did the economic analysis of two manufacturing methods. According to the analysis, the cost of 3D printing mold materials is 34% lower than standard mold materials, and the production speed is 69% higher. The 3D printing mold can be completed in three days, compared with eight days for traditional mold manufacturing. 3D printing technology and composite materials bring a new entry point for large-scale mold manufacturing.

5. Conclusion

Additive manufacturing has obvious advantages in both technology and industry and is likely to bring a revolution to the traditional manufacturing field. The United States is the world to add material manufacturing technology and industry development is relatively mature, full of market competition, strong government support, industry association of drive and improve the technical standards, developed over a long period of financial support, strong market demand and integrate the technical route of experience can be for reference material manufacturing technology and industry development in our country. Though, increasing material manufacture in printing speed, material performance, print, the cost of materials, precision molding, etc remains to be improved, and the environment, ethics, safety, etc, there is also a - some doubt, however, with the increase of material manufacturing technology progress, increase material manufacturing will become the engine of the third industrial revolution, will likely bring human mode of industrial production and daily life disruptive effects.

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