THE IMPORTANT FACTORS OF LASER CLADDING REMANUFACTURING GEAR

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Abstract

In this paper, a gear tooth was remanufactured by laser cladding forming technology. The result shows that the disabled gear can be remanufactured by laser cladding forming technology, while suitable technological process, powder materials and laser scanning path were adopted. The bonding zone interface, forming shape controlling and mechanical character of form structure are the important factors to achieve excellent performance of form structure. Some methods were also given to solve these problems.

Keywords: laser cladding, forming, remanufacturing, gear

1 Introduction

The gear plays an important role in machine. It is easily to failure because of the complicated loading during its service. Wear, spot corrosion, spalling and break are the mainly failure modes. It will be destroyed due to the failure of one part of the gear. This induces serious resource waste because the gear is high-cost. Thereby, remanufacturing gear is a very significative thing to save resource.

The laser cladding forming technology (LCFT) is one of the most suitable technique to remanufacture gear parts because of its excellent performance, such as outstanding mechanical behavior, small heat-affected zone, high repair efficiency, little post processing. The LCFT combines the advantage of laser cladding technology and rapid prototyping technology. The metal powders, which can lay on the part's surface beforehand or jetting by air in-step, is melted in laser irradiation, then freezing quickly and combined with the matrix. Different laser cladding layers added and fusing step by step. At last, 3D thick metal structure was fabricated. The laser cladding layer has high hardness and bond strength, which leads to outstanding wear-resisting property. That high performance alloy powder clad on the lower cost metal part using laser cladding technology can increase the part performance. Part with slight wear can be repaired by this technique too [1-3]. This technology is suitable to repair high precision parts because the remanufactured parts have small heat-affected zone and little distortion. LCFT is adaptive to repair local damage of parts. The forming bonding zone, shape control, and mechanical character of formed structure are the important factors during the course of remanufacturing gear by LCFT. In this paper, the above three factors are discussed with a sample of remanufacturing gear.

2 The forming bonding zone interface

The bonding of formed structure and matrix is one of the important factors. The bonding zone of excellent formed structure must be metallurgical bonding with matrix, and there are few inclusions, few pore and few micro-cracks in it.

As cladding the first layer, a low laser scanning speed and powder conveying capacity is adopted to get the metallurgical bonding between cladding structure and the gear, which makes them tightly-bonded. Fig.1 gives the morphology of typical bonding zone with low scanning speed and powder conveying capacity. From Fig.1, it can be seen that a white metallurgical cingulum was achieved, which approve an excellent bond between the cladding structure and matrix. There are few inclusions, few pore and few micro-cracks in the bonding zone.

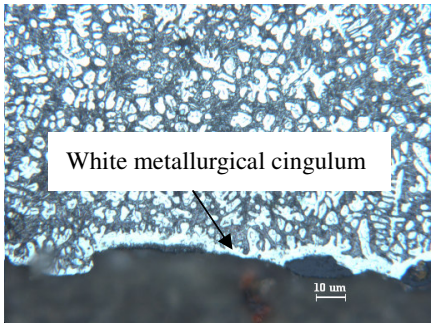

Fig.1: Morphology of typical bonding zone with low scanning speed and powder conveying capacity.

3 Forming shape control

While using laser cladding forming technology remanufacturing parts, the shape control is one of the key factors too. One example was given to depict the course of gear tooth shape control as followed.

3.1 Fore treatment

Fore treatment, such as cleaning, milling and machining, is the first step of remanufacturing part and it is very important to the shape control. There are two function of the fore treatment. One is removing defective structures,

for example, exfoliation, etch pits, and residual stress layer of repair surface. This is to assure a high bonding strength between cladding structure and matrix. The second is removing defective structures with a specifically shape, such as circular hole and square groove. It aims to build model easily, program and project laser scanning path conveniently.

The breaking structure was milled from the root of gear tooth. Then burnish the machined surface. Fig.2 shows the gear after fore treatment.

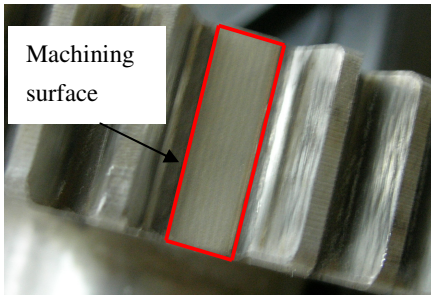

Fig.2: The gear after fore treatment.

3.2 Modeling

3D model of the defective parts was built with AUTOCAD software according to the original size and fore treatment size. Fig.3 shows the 3D model of gear tooth, which the size is 20 mm × 6.25 mm × 6 mm.

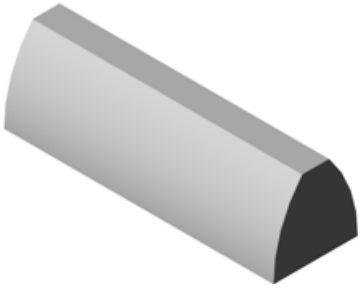

Fig.3: The forming model.

3.3 Model stratified and laser scanning path programming

The fore 3D model was stratified directly using the slice function of AUTOCAD software.

The thickness of typical cladding layer was determined by typical forming processing parameters. The optimized cladding layer thickness with typical parameters is 0.7 mm according to the experimental results. Consequently, the fore 3D model was sliced to nine layers. Then the 3D model of single layer can be obtained with AUTOCAD software. At last, laser cladding scanning path of forming layer was programming. Fig.4 depicts the laser scanning path of first layer.

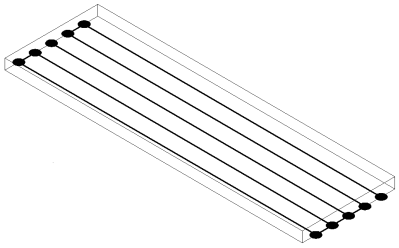

Fig.4: The laser scanning path of first layer.

3.4 Laser cladding forming

A high power diode pumping laser (1000W) which transmitting by fiber was adopted as high energy beam. And robot held laser processing lens was employed as the scanning device. The move path of robot was programmed according to the programming scanning path. Then the typical forming processing parameters were given to the robot. At last, 3D metal structure was achieved layer by layer, which has been showed in Fig.5.

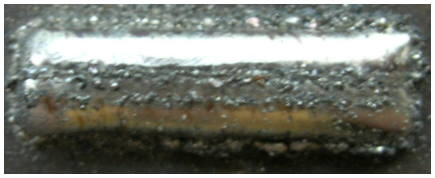

Fig.5: The formed gear tooth.

3.5 Post processing

The fore remanufacturing part must be treated with a series of post processing. Fig.6 gives topography of the remanufactured gear after sanding. And further precision machining is necessary according to the requirements of original design. The post treatments also include various detections, random sampling probation and so on.

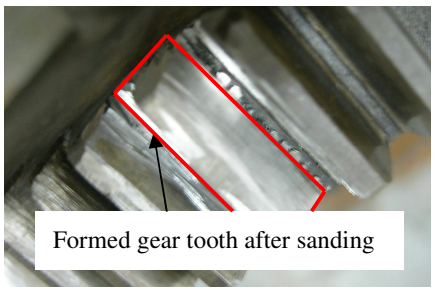

Fig.6: The remanufactured gear after sanding.

4 Mechanical character of formed structure

The purpose of parts remanufacturing, which aimed to resume the function of the failure parts, required the performance of the remanufacturing parts is equivalent or more excellent than that of the origin parts. There are many methods of achieving excellent properties, which was showed in the followed.

4.1 Suitable laser cladding powder material

High tenacity and high hardness are the mainly properties of the gear tooth material. The forming powder material in previous experiment was Fe90

powder, which was provided by Beijing General Research Institute of Mining and Metallurgy. Parameters of the powder were showed in Table 1. The experiment results indicate that the Fe90 powder have an excellent forming behaviors.

Element (wt.%)	*Cr*	*B*	*Si*	*Mo*	*Fe*
	13	1.6	1.2	0.8	Bal

Table 1: Powder element.

4.2 Optimized technology parameters

The technology parameters have significant effect to mechanical character of the formed structure. The change of parameters, such as laser power, scanning speed and shielding gas flux, can significantly change cooling rate of cladding molten bath, which leads to different mechanical character. Fig.7 is the typical microscopic structure of cladding structure with SEM, which obtained with optimized forming technology parameters. It can be seen that microscopic structure is composed of small equiaxed crystals. And flash set character was indicated in Fig.7. This caused an excellent performance of the formed structure, such as high hardness and toughness [4].

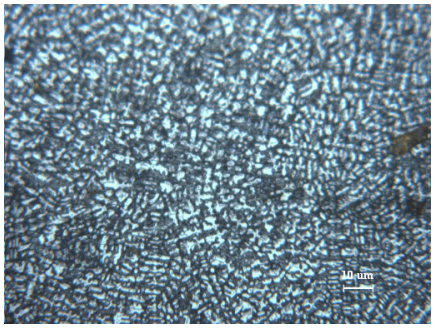

Fig.7: The typical microscopic structure of cladding structure with SEM.

4.3 Laser scanning path

The laser scanning path may influence mechanical character of the formed structure too. Elimination of heat of variant laser scanning path is the main influencing factor. The forming program must be attention, and appropriate laser scanning path be adopted to avoid badly elimination of heat.

5 Conclusions

The disabled gear can be remanufactured by laser cladding forming technology, while suitable technological process, powder materials and laser scanning path were adopted. The bonding zone interface, forming shape controlling and mechanical character of form structure are the important factors, which assure the excellent processability of the remanufacturing parts.

References

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