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Laser re-manufacturing of failure 18Cr2Ni4WA gear in low-speed heavy-load mining machine transmission

X F Chi[1]

[1]Ordos Vocational College, the Inner Mongolia Autonomous Region, China

Abstract. This article investigated laser re-manufacturing technology application in mining industry. The research focused on green re-manufacturing of failure spur. Leave the main gear body stay intact after the dirty, rust, fatigue and injured part were removed completely before the green re-manufacturing procedure begin. The optimized laser operating parameters paved the road for excellent mechanical properties and comparatively neat shape which often means less post processing. The laser re-manufactured gear surface was systematically examined, including microstructure observation, and dry wear test at room temperature. The test results were compared with new gear surface and used but not broken gear surface. Finally, it proved that the green re-manufactured gear surface displayed best comprehensive mechanical properties, followed the new gear surface. The resistance of dry wear properties of used but not broken gear surface was the worst.

1. Introduction

The laser technology, rapidly developed in the recent decades have boost and give birth to a huge amount of new laser research branches and facility applications. The merits of finer microstructure, metallurgical bond with substrate and rapid heating and cooling procedure which are unrivalled and unique in laser technology made it the almost the best fitted technology in green re-manufacture industry for the re-manufacturing of components made of expensive and rare metal. Nickel base alloy have been widely researched and used in corrosive, abrasive and high temperature work conditions [1-4]. There is no doubt that nickel base alloy is more compatible than ferrous alloy in the study of protective re-manufacturing strengthen coating for mining entry-driving machine transmission components.

This article systematically researched the laser re-manufacture of 18Cr2Ni4WA steel low-speed, heavy-load spur gear in entry-driving machine transmission system. And the wear test without lubrication proved the good properties of re-manufactured strengthen coating on gear surface.

2. Experiment

The failure gears were cleaned and got rid of rust and fatigue layer. This part of layer has a deepest depth of 0.25mm on gear surface therefore the removal depth for each gear top surface should be 0.3mm indeed to make sure the entire fatigue layer can be ground clearly.

2.1. The alloy powder and substrate

The chemical compositions of both the nickel base alloy powder for laser treatment and the substrate steel were listed in table 1. The average diameter of alloy powder is 80μm and particles diameter range from 25-125μm. The original substrate surface was carburized and the micro-hardness reached 60 HRC on top surface.

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Table 1. Chemical compositions of Nickel base alloy powder and substrate steel 18Cr2Ni4WA in wt.%.

	Cr	S	P	Si	B	C	Fe	Ni	Mn	Mo	W
Niickel base Alloy	18	-	-	4.1	3.7	0.85	7.0	Bal.	-	-	-
18Cr2Ni4WA	1.35-1.65	＜0.025	＜0.025	0.17-0.37	-	0.13-0.19	Bal.	4.00-4.50	0.30-0.60	0.25-0.35	0.80-1.20

2.2. Laser operating parameters

The alloy powder should be dry in vacuum drying oven at 200℃ for 1h. The gear surface were grind and polished and cleaned before laser operating. Both carrying and shielding gas were argon. The laser parameters were listed in table 2 in detail.

Table 2. The parameters in laser cladding.

Parameter	Value
Power	2.0 kW
Laser Track Wide	3 mm
Laser beam diameter	2 mm
Overlap Rate	25 %
Cladding Mode	Single layer straight track
Feed Powder	8.0 rpm
Shield Argon	600 ml/min
Laser Move Speed	8 mm/s

2.3. Gear surface cladding

The figure 1 is the gear cross sectional sketch drawing of laser re-manufacture. The orange semi-spherical shape showed the laser tracks which filled the flank of low-speed heavy-load 18Cr2Ni4WA gear.

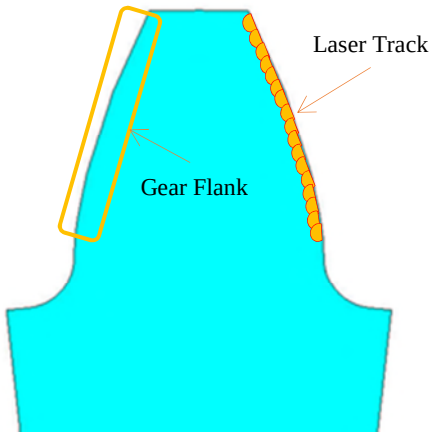


Figure 1. Sketch diagram of gear surface.

3. Wear tests & Discussion

3.1. Microstructure

The cross sectional of laser re-manufactured gear sample was shown in figure 2:

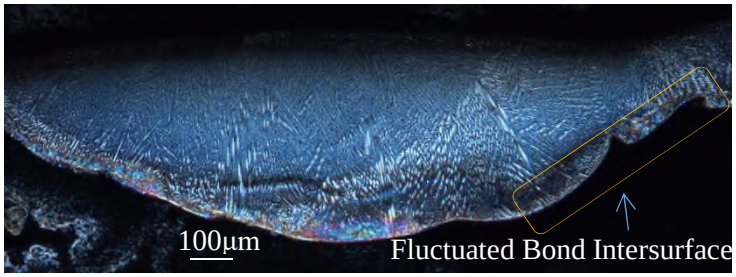


Figure 2. Optical microscope of laser re-manufactured gear.

The OM photograph of figure 2 showed the microstructure distribution of laser clad re-manufactured gear flank. In the middle and bottom of coating there appeared some coarse acicular structure. The bond interface displayed fluctuated curve especially in overlapped area. This may be caused by previous carburization hardening of gear flank. Generally the microstructure of coating is compact and small.

3.2. Wear test

The wear tests were conducted on UMT-2 tribometer and the load was 25N, test time 2h, ball-on-disk strait reciprocating mode was adopted.

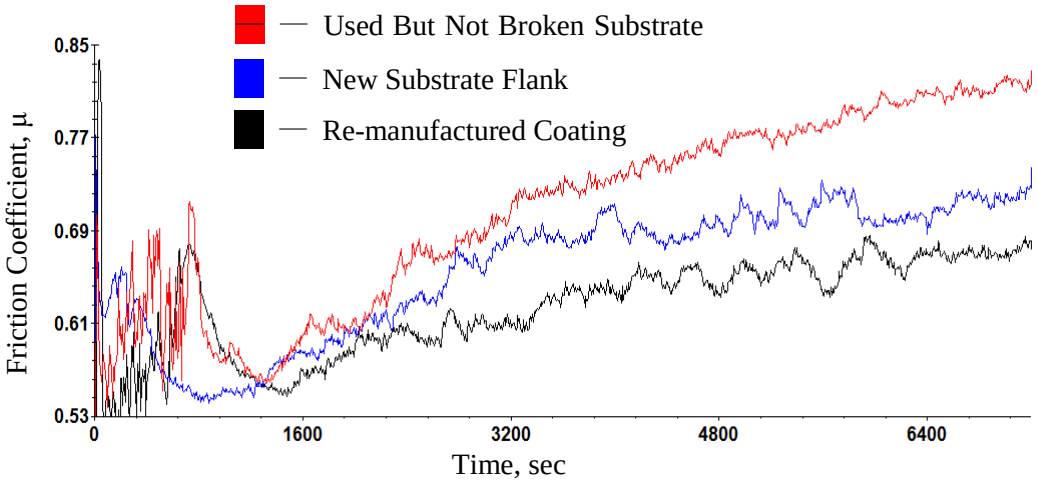


Figure 3. COF of the laser re-manufactured gear coating, old gear surface and new gear surface.

In figure 3, the coefficient curve of re-manufactured coating dropped below the coefficient curves of both new and used substrate steel flank specimens science 1600s when the stable wear procedure began.

By comparing figure 4 (a, b, c) a conclusion can be reached that the scratches in the worn surface of laser clad re-manufactured coating was the slightest and lightest. The figure 4 (c, f) showed the micro groove which may stem from fatigue caused by heavy-load transmission in the worn surface of old, but usable gear surface sample. The latent fatigue spotting and peeling region may not visible but can be shown in wear test. Such fatigue damage might cause deep scratches in figure 4(c) and micro plough in figure 4(f). The laser clad re-manufactured coating and newly produced gear flank samples did not form micro groove in worn surface, the friction pair GCr15 ball didn't appear micro plough neither.

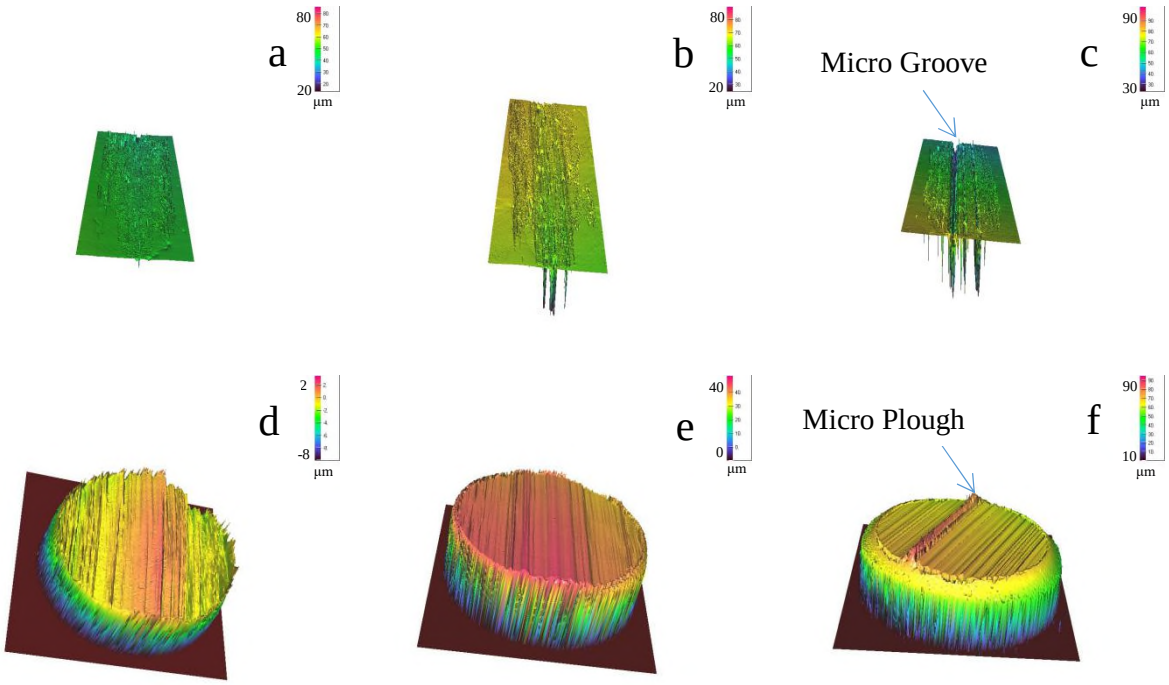


Figure 4. Worn surfaces of (a) laser re-manufactured gear coating, (b) newly produced gear flank, (c) used but still usable gear flank, (d) the friction pair of GCr15 ball for laser re-manufactured gear coating, (e) the friction pair of GCr15 ball for newly produced gear flank, (f) the friction pair of GCr15 ball for used but still usable gear flank.

4. Conclusions

The main worth while to note points in this research are:

- The microstructure in re-manufactured gear flank coating was compact and the bottom interface appeared fluctuated curve which probably may be caused by carburization hardening of gear surface.
- The COF curve of laser re-manufactured coating kept lower than that of both newly produced and used, but still usable.
- The scratches in the worn surface of laser re-manufactured coating sample was the lightest compared with new and old gear flank samples. The micro groove appeared in the worn surface of used, but still usable gear flank specimen which could be stem from the top surface fatigue. Both of laser re-manufactured coating and new gear flank samples did not have such problem.

5. References

[1] Raj D, Tyagi R, Chaubey S K, Souza A D, Palani I A and Jain N K 2015 *J. Mater. Today: Proc.* **2** 1755.
[2] Bobzin K, Brögelmann T, Stahl K, Stemplinger J P, Mayer J and Hinterstoißer M 2015 *J. Surf. Coat. Tech.* **284** 290.
[3] Savaria V, Bridier F and Bocher P 2016 *J. Int. J. Fatig.* **85** 70.
[4] Lv Y, Lei L Q and Sun L N, 2017 J. *Int. J. Fatig.* **98** 121.
[5] Farahmand P and Kovacevic R 2015 *J. Surf. Coat. Tech.* **276** 121