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Laser Alloying of Wear Surfaces with Metal Components

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Abstract

Different researches have proven that the indicators of efficiency and wear resistance of the details which were renovated with the help of the laser cladding method often exceed the rate of new details, causing additional reserves for reducing labor costs for subsequent repair and improvement of reliability of the machines. According to the theory of freezing the formation of the highly dispersed structure is associated with the occurrence of high concentration overcooling which initiate the appearance of a large number of crystallization centers. Thermohardening and laser alloying by metal components initiate the homogenization of the special surface layer, which determines its high wear resistance and load carrying capacity. The microhardness of the cladded layer is almost 1.5 times higher than that of the cladded by high-frequency current. Also, the initial (workup) step is faster than the traditional kinds of surface modification because the supporting surface of wear is created earlier and has a less total contact area. At the same time, the volume of pockets in the contact area persist longer that's why increasing the accumulation of lubricant in all the parts of the contact surface and reducing the possibility of seizure and intensive wear of friction surfaces. Gradual wear of the modified surface bearing capacity can be reduced, but outside of the maximum level of microhardness of the modified layer, providing the equilibrium state of the surface for a longer period. Also, these features and advantages are typical for the mating surface wear. If each one of the friction pair is exposed to the laser modification, it nearly doubles the effect of the increasing of the tribomechanical parameters.

Keywords: laser alloying, wear, metal components, machinery, welding, engineering.

INTRODUCTION

Restoration of worn parts is a topical issue in operational and repair industries. It became possible to significantly reduce the refurbishment costs with the help of laser alloying (cladding) of wear surfaces by powder filler materials. In addition to reducing the costs for spare parts you can save hundreds of tons of high-quality metal and significantly reduce labor costs for production and transportation of spare parts.

GENERAL METHODOLOGICAL REQUIREMENTS

Statement of the research problem

Different researches have proven that the indicators of efficiency and wear resistanceof the details which were renovated with the help of the laser cladding method often exceed the rate of new details [1,2,3], causing additional reserves for reducing labor costs for subsequent repair and improvement of reliability of the machines. Also by optimizing the alloying mode and selecting the appropriate filler material, it becomes possible to control the formation of the modified layer with the desired properties with the help of little submelting bases. [1,4,5].

The degree of mixing of the filler material with the base material has a significant impact on the mechanical properties of the recovered layer and its chemical composition, i.e. the presence of the base metal in the cladding materials almost always leads to a reduction of operational properties of the modified surface.

Thus, the depth of fusion of the base of the material should be regulated, and the mixing ratio γ, – area of the single spot of the molten underlying metal to the area of the entire molten metal in the welding cross section must be limited with the value: γ = 0,05 ... 0,15 [3 5.6]. Thus, using the cladding of filler powder of the system Ni-Cr-B-Si carbon and boron content in the material decreased to 8%, whereasusing the traditional methods of cladding it reaches 20% [3,5,7].

Filler materials of this system are widely used for the recovery of components operating under the combined action of wear and corrosion, as well as at high temperatures. Wear resistance of the recovered layers cladded from the powder of this system with a help of the laser cladding method can exceed the index produced by claddingHFC (by freezing) in 10 times, and in 3-5 times – the index of plasma sprayed coatingscladded by gas-flame melting [3.8]. This is due to the specific conditions of crystallization and the formation of the fine structure after laser processing.

It is well known that the friction unit wear is quite a complex process, and the wear of mating parts depends on the mechanical and tribological properties of each material of mating parts and the conditions under which the friction unit is working itself [9,10, 11-14]. In this context, the study of the influence of laser processing methods in different types of modification of mating parts surfaces. This refers not only to the laser alloying, but also hardening (thermohardening) using the various combinations of these types of modification.

The aim of this work is to conduct experimental investigationsof wear resistance of the frictionsurfaces exposed to a heat treatment and laser alloying, as well as the establishment of the wear mechanism of the modified layer.

THE RESULTS OF THE EXPERIMENTAL RESEARCH

The research of the mating surfaces, exposed to surface engineering with a laser, carried out in the for laboratory tribotechnical installation «shaft - friction bearing» using metallographic analysis and test samples. As study structural materials the steel grades 30XGSA and 18H2H4BA as well as bronze grade Br.A9ZhZL were used. It is known that these kinds of steel can be processedwith the laser hardening, and have a wide industrial usage in friction units. [8, 15-16]. At the same time, the principles of the formation of the modified layer have got its own special aspects and requirestheirexamination.The structure and the phase composition of therecovering surfacesunder the process of laser cladding is determined mainly be the composition of filler material and base material, technological parameters of laser processing, and also heating and cooling rates. Melt crystallization mechanism and the structure formation during laser processing is very similar to the traditional cladding methods. The key is its excess rates of heating and, especially, cooling. The cooling leads to the formation of supersaturated solid solutions and promotes a shift of critical transformation points with respect to the same points on the alloy phase equilibrium diagrams [1,2, 17]. However, there is a significant size reduction (amorphization) of the structural components and the chemical composition of some of them. Fig. 2a shows the microstructure of the cladded layer, and Fig. 2b shows filler powder zone alloy PG-HN80SR2. Claddingwas carried out by the continuous emission of 800W CO2 laser by dosed supply of filler powder into the alloy zone at a constant movement rate of the sample and a constant focus position of the lens relative to the cladded surface.

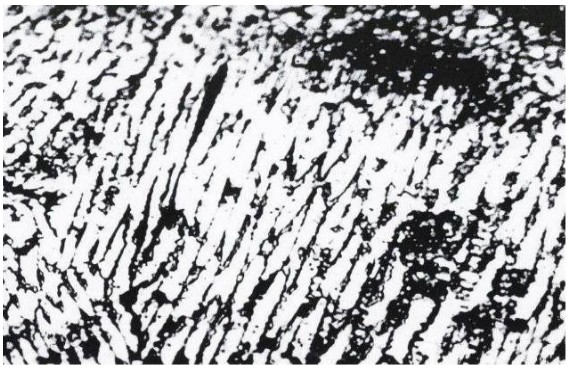

Figure 2a: The microstructure of the cladded powder alloy PGSR20M. X800

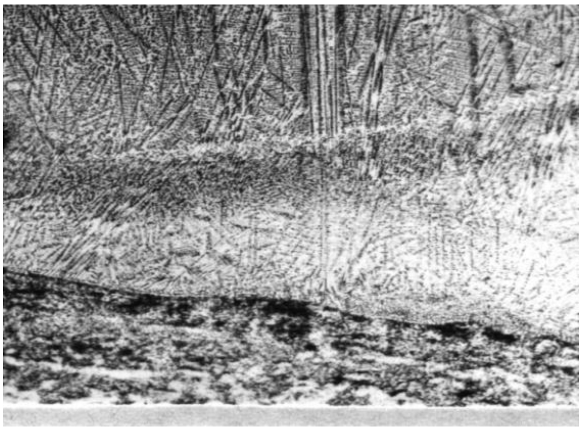

Figure 2b: The microstructure of the alloy zone

Metallographic analysis showed that cladding zone has a highly dispersed cellular and dendritic microstructure, which chemical composition is little different from the composition of the filler material. This zone has the highest rate of microhardness – 8500 ... 9000 MPa and a low degree of chemical milling. The following zone is the mixing one, its chemical composition is characterized by the increased iron content and the reduction of microhardness to about 600 ... 800MPa relative to the top layer. As a wear resistance criteria we took the material mass of the bearing and the shaftemitted because of the wear. These comparative tests are shown in the table.

Core indicators of how the laser modification impacts on the materials wear resistance

Friction pair's material	Conditions of the laser processing	Wear resistance increase (times)	Note
Shaft: Steel 30XGSA Bearing: Bronze Br.A9ZhZL	Cladded Unprocessed	8,2 1,4	Related to the one, quenched in normalconditions
Shaft: Steel 30XGSA Bearing: Steel 30XGSA	Cladded Unprocessed	8,7 1,6	
Shaft: Steel 30XGSA Bearing: Steel 30XGSA	Cladded Hardened without melting	7,8 3,4	
Shaft: Steel 30XGSA Bearing: Steel 30XGSA	Cladded Cladded	8,7 7,6	
Shaft: Steel 30XGSA Bearing: Steel18H2H4BA	Cladded Unprocessed	8,0 1,8	
Shaft: Steel 30XGSA Bearing: Steel 18H2H4BA	Cladded Thermohardened without melting	7,9 4,3	
Shaft: Steel 30XGSA Bearing: Steel 18H2H4BA	Cladded Cladded	8,8 7,8	

Data analysis showed a significant increase in wear resistance of the cladded surfaces both shaft and bearing. Thus, we can see not only the increase of the modified layer, but alsothe increase of the mating surface of the sample, which simulate a plain bearing, even if it is in the initial state. This pattern is observed in all the mating materials under study. The maximum decrease of wear of investigated triboelementscan be achieved by mutual modification of shaft and plain bearing surfaces. Wear resistance of thermohardened surface is less than wear resistance of the cladded one but it is still significantly higher than that which was hardened under the normal conditions.Alongside the increase of wear resistance we can find an accelerating conformability of laser-modified surfaces. It becomes evident that if and when the wear appears after the initial phase of operation the surface layers withhigh physical and mechanical and tribological properties as well as the specific microstructural structure come into operation.This leads to a gradual and slow decrease in wear intensity and thus to the inclination of the wear curve, both during the thermohardening and laser surface cladding.

According to the theory of freezing the formation of the highly dispersed structure is associated with the occurrence of high concentration overcooling which initiate the appearance of a large number of crystallization centers. Concentration overcooling makes the structure become dendritical and leads to its size reduction in accordance with the function [3,7,11, 18-20]: $L = 2K_d \cdot V^{-p}$ where: L - width of axes crystallites; K_d - coefficient of diffusion; V - crystallite growth rate; p - coefficient depending on the crystal growth rate. During the laser cladding the distance between the axes of dendrite of the second order is about (1,5 ... 2,5) $*10^{-6}$m., While during the high frequency current cladding it is about (12 ... 20) $* 10^{-6}$ m and $200*10^{-6}$ m. for the arc cladding. With increasing of the cooling rate the diffusion process is suppressed resulting in partial or complete elimination of formation of separate phases in the multiphase structure. The features of laser cladding structures mentioned above, which include the dispersion hardening, dissolving of brittle carbide phases and the formation of supersaturated solid solutions are,obviously, the ones thatprovide high serviceability properties of the cladded layer.

CONCLUSION

Thermohardening and laser alloying by metal components initiatethehomogenization of the special surface layer, which determines its high wear resistance and load carrying capacity. The microhardness of the cladded layer is almost 1.5 times higher than that of thecladded by high-frequency current [3,12, 21-26]. Also, the initial (workup) step is faster than the traditional kinds of surface modification because the supporting surface of wear is created earlier and has a less total contact area. At the same time, the volume of pockets in the contact areapersist longer that's why increasing the accumulation of lubricant in all the parts of the contact surface and reducing the possibility of seizure and intensive wear of friction surfaces. Gradual wear of the modified surface bearing capacity can be reduced, but outside of the maximum level of microhardness of the modified layer, providing the equilibrium state of the surface for a longer period. Also, these features and advantages are typicalfor the mating surface wear.If each one of the friction pairis exposed to thelaser modification, it nearly doubles the effect of the increasing of the tribomechanical parameters.

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