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“Journal of Economics and
Social Sciences”

Structure of coating based on 10R6M5-steel after wearing in friction pair

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Abstract

The pressing challenge of modern technology is to increase the service life of friction pairs operating under high dynamic loads and lubricant fluid deficiency. Due to their high hardness, red hardness and wear resistance, high-speed steels are beginning to be used in the manufacture of punches, dies and structural strengthening of rolling mills and friction pairs. In this paper we investigated the friction pair “coating 10R6M5 steel – steel ShKh15”. The region of catastrophic wear was detected during the wear resistance test. The paper studies the wear characteristics of 10R6M5-based steel coating after discrete surface laser melting in a friction pair with heat-treated ball bearing steel.

Keywords: High-speed steel, friction pair, laser melting;

1. Introduction

The pressing challenge of modern technology is to increase the service life of parts of friction pair operating under high dynamic loads and lubricant fluid deficiency [1-7]. Due to their high hardness, red hardness and wear resistance, high-speed steels remain a promising material not only for the production of various types of cutting tools, but also beginning to be used for the manufacture of punches and dies, structural strengthening of rolling mills and friction pairs. Numerous studies [5, 6] prove the superiority of cast high-speed steels in abrasion resistance over deformed ones of a similar chemical composition and processed for the same hardness.

During the test for wear resistance of the friction pair “coating 10R6M5 steel - steel ShKh15” a region of catastrophic wear was detected (speed 2.4 and 3.6 m/s, load 40 - 60 N). A sharp wear increase occurs due to a temperature increase in tribocontact, which leads to ductility increase of the matrix and the inverse $\alpha \rightarrow \gamma$ transformation. This contributes to the destruction of the network of eutectic carbides M6C.

Laser melting of metals provides a dispersed non-equilibrium structure on the surface due to high-speed directed crystallization of the melt [8]. It can be assumed that surface laser melting of 10R6M5 composite coatings in air will allow the formation of a microcomposite structure in a remelted volume similar to that formed in a pair of friction “coating 10P6M5 steel - ShKh15 steel” in the area of catastrophic wear. These microstructural changes should exclude the area of catastrophic wear of the friction pair.

The purpose of this paper is to study the features of wear of 10R6M5-based steel coating after discrete surface laser melting in a friction pair with heat-treated ball bearing steel.

2. Materials and methods

Hardening coating based on a powder of high-speed steel 10P6M5 obtained by electron beam welding in vacuum [6] was used for surface laser melting. The “Blacklight” laser system based on a neodymium laser with lamp pumping and controlled discharge was used for laser melting (LM) of the samples. The melting surface was irradiated by single pulses without overlapping nearby points.

Friction tests were carried out on an automated complex for tribological conjugation. During the static tests a “wheel - two block” scheme in conditions of boundary lubrication (water) with a stepwise increase in pressure P (0.75; 1.5; 2.25 and 3 MPa) and velocity V = 0.5 m/s was used. A wheel with a diameter of 62 mm and a width of 15 mm, made of hardened ball bearing steel ShKh15 (HRC 63..65). The coating surface of half of the samples was subjected to staggered laser melting. The fraction of the melted surface was ~ 40%. Four experiments were carried out with a friction path of 2000 m after running in a friction pair at constant pressure P. Ratio of the volume of material lost by the samples during the test to the friction distance (mm3 / km) was used as a measure of the wear rate.

3. Results and discussions

Figure 1 shows the dependence between the wear rate of the 10R6M5 steel based coatings and the pressure at a sliding speed of 0.5 m/s in the tribotechnical contact “wheel - two blocks”. The wear rate of the coating after LM (curve 2) over the entire pressure range is 40-60% lower than that of the initial coating (curve 1). Figure 2 shows the friction surfaces of the samples and the results of profilometry of these surfaces obtained perpendicular to the direction of sliding. The analysis of sliding surfaces indicates the development of the abrasive-oxidative wear mechanism. Abrasive particles are products of wear of rubbing pairs. An intensive smearing of wear products on the friction surface is observed (Fig. 2e, f) for the initial coating at pressures of 1.5 and 2.25 MPa. This leads to a certain decrease in the wear rate for the indicated pressures, (Fig. 1, curve 1). Simultaneously, individual coating chips elongated along the sliding direction appear on the friction surface starting from a pressure of 2.25 MPa. The intensity of spalling increases (Fig. 2g) with increasing pressure up to 3 MPa, which sharply increases the wear rate (curve 1 in Fig. 1). According to the profilometry curves, the depth of the chipped areas ~ 6 μm (Fig. 2g, h).

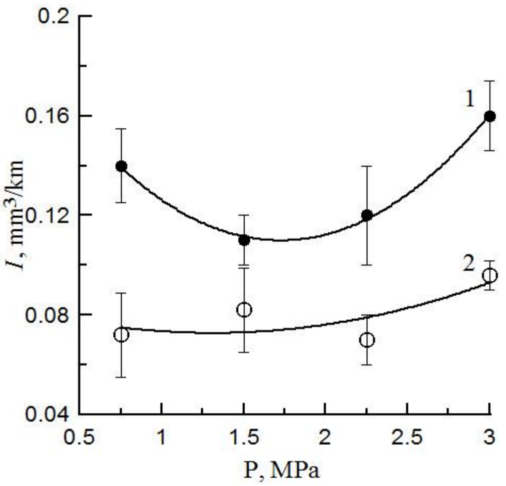
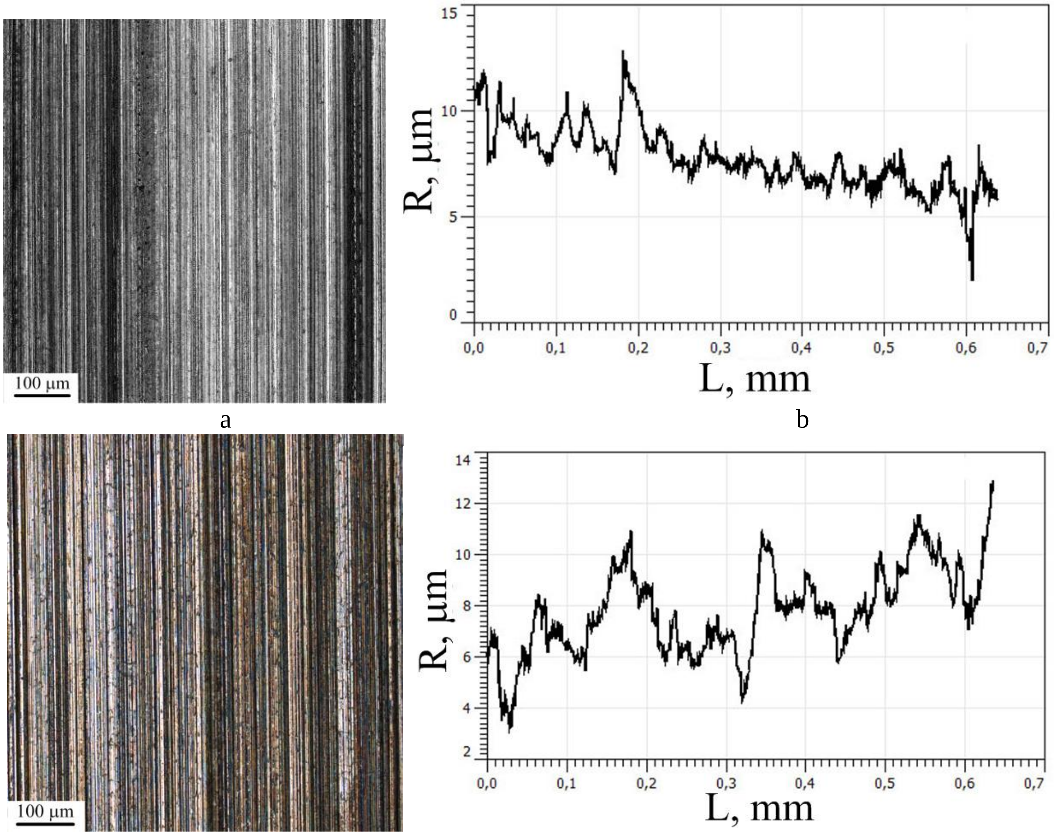


Fig 1. Intensity of the coating wear from pressure in tribological contact



a

b

c

d

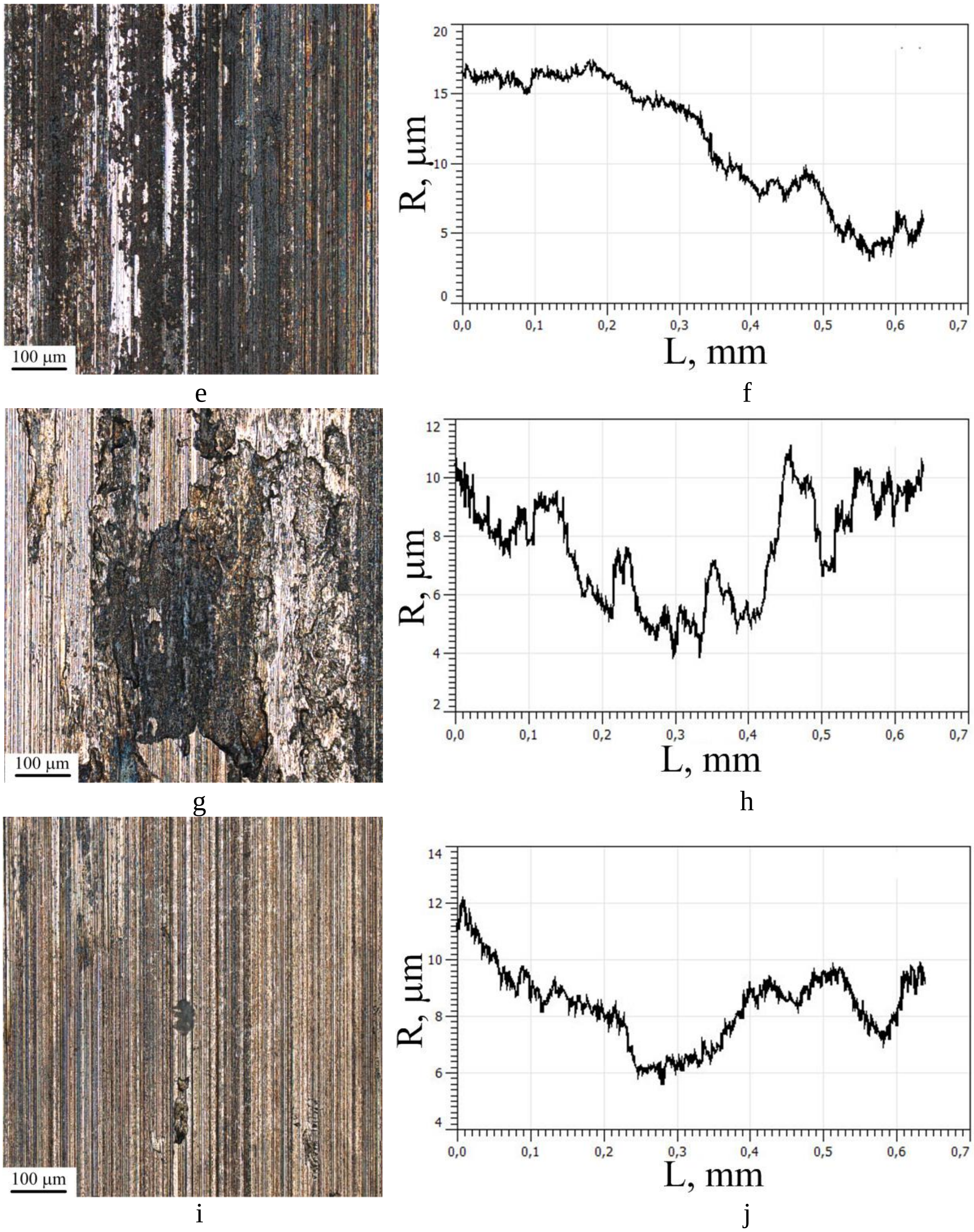


Fig. 2. The surface structure of the coatings after wear tests and profilometry
a-d – 0,5 MPa, e,f – 1.5 MPa, g-j – 3 MPa
(a, b, e, f – source coating, c, d, i, j – coating after LM)

Both smearing and chipping of the whole conglomerates of coating are not observed (Fig. 2c, d, i, j) for additionally treated LM coatings. This keeps the wear rate virtually unchanged in the pressure range (Fig. 1, curve 2). According to X-ray powder diffraction data for tribotechnical contact surfaces, the fraction of martensite from the total matrix volume virtually does not change in the studied pressure range for both types of coatings and remains at the level of the initial samples.

4. Conclusion

Therefore, the initial coating, which has a large volume fraction of the brittle component (~ 90% martensite of the total matrix volume and M_6C and VC carbides) is not able to effectively resist wear and lead to premature chipping of large conglomerates of the composite coating. Coatings after LM in the melted areas have only 47% martensite of the total matrix volume, which allows to effectively relax the stresses arising in these areas and, therefore, to maintain a low and unchanged wear rate in the studied pressure range.

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