EFFECT OF LASER TREATMENT ON THE WEAR OF PARTS IN AN ABRASIVE–OIL MEDIUM

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It is well known that treatment of metals and alloys with a laser beam leads to substantial changes in their structure and in their physicomechanical state. The effect of the changes taking place on the working capacity of parts and, in particular, on their wear resistance, has been insufficiently studied. The present article gives the results of an investigation of the effect of laser-beam treatment of steel and cast iron samples on their wear resistance in an abrasive–oil medium. Tests were made of Steel 40Kh in hardened and low-annealed states and after normalizing, as well as of high-strength cast iron VCh 50-1.5. The heat treatment of the cast iron was: normalizing followed by high-temperature annealing (HB-210); the cast iron samples were cut from the connecting-rod pins of the shafts of M-21 automobile engines.

The wear* was set up in accordance with a ball race–bearing scheme in AS-8 oil with the addition of 0.1 wt.% quartz sand [1], in MI-1M friction machines. The bearings, in the form of segments with a width of 10 mm, were made of BrOTsS 5-5-5 and antifriction alloy SOS6-6†. The ball-race samples had a diameter of 57.25 mm and a width of 10 mm.

The friction surfaces of the steel and cast iron ball-race samples were treated using a laser generator [2], containing an active element made of neodymium glass, with a diameter of 15 mm and a length of 260 mm (Fig. 1). The laser beam was focused on an area of a ball race with a diameter of ~3.5 mm, using lens 4 with a focal length of 60 mm. The energy of the light pulse of the generator, working under free conditions, was ~70 J with a pulse duration of ~4 msec, and a frequency of 1.5 pulses per minute. The density of the energy fed was so selected for the material so that there would be no appreciable ejections of the metal. By rotating the sample by 3 mm each time, heating of the whole surface of the ball race was achieved. After the laser treatment, the surface of the ball race had a laminar form, with roughnesses of 0.2-0.3 mm. To improve the microgeometry of the surface, it was ground, thus removing an upper layer with a thickness of 0.25-0.35 mm. The purity of the surface, determined in a Model 201 profilographic-profilometric instrument, corresponded to ∇7.

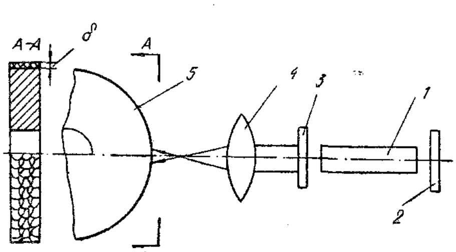

Fig. 1. Schematic diagram of unit for laser treatment: 1) active element made of neodymium glass; 2,3) mirrors of resonator; 4) lens; 5) ball-race sample; δ) depth of treated layer.

The tests showed that, as a result of laser treatment, in the surface layers of the samples there is a sharp change in the structure and in the physicomechanical properties of the metal. At the points of the treatment there appears a white layer whose thickness, after grinding of the samples, is 1000 μ for Steel 40Kh in a hardened and low-annealed state, 420μ for Steel 40Kh in a normalized state, and 440

*The wear of the ball-race samples was determined using the method of artificial bases (notched holes), and the wear of the bearing-samples by the weight method [1].

†The tests of cast iron, paired with an alloy, simulated the work of the journal–bearing pair of the shafts of automobile engines.

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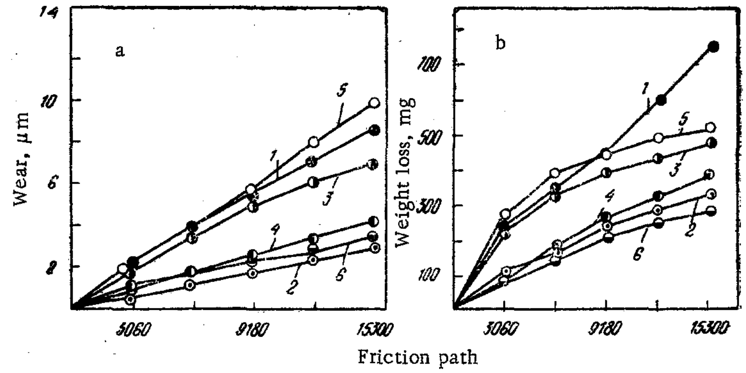

Fig. 2. Dependence of the wear of the friction pairs steel–bronze and cast iron–antifriction alloy on the friction path: a) ball race, b) bearing: 1) ball race made of normalized Steel 40Kh, ground, the bearing of bronze; 2) same, ball race with white layer; 3) ball race made of hardened and low-annealed Steel 40Kh, ground, bearing of bronze; 4) same, ball race with white layer; 5) ball race made of cast iron (normalized and high annealing), ground, bearing of Alloy SOS 6-6; 6) same, ball race with white layer. Specific pressure 37.5 kg/cm^2. Rate of sliding 1.27 m/sec.

μ for cast iron VCh 50-1.5. In comparison with the initial structure, the microhardness of the white layer is greater by approximately three times for steel after normalizing, by more than twice for cast iron, and by 15% in comparison with martensite hardened steel. With treatment of hardened and low-annealed steel, beneath the white layer there is observed a zone of lowered microhardness; in the case of normalized steel and cast iron, this zone is not present.

During the treatment of the surface of the samples with a laser beam, there is pulsed local heating of the metal up to very high temperatures, right up to a plasma state [2]. The pulsed action of the temperatures and the rapid removal of heat into the depths of the metal promote the formation of the white layer. In spite of the brief duration of this process, a certain redistribution of the elements (C, Cr, Mn) in the metal after the laser treatment has been established by microspectral analysis. In the white layer, there is noted an increased content of carbon and chromium, while, beneath the white layer, there is a very slight decrease, in comparison with the starting metal.

As tests have shown, laser treatment, bringing about the above changes in the surface layers of parts, increases the wear resistance of friction pairs in an abrasive medium. The wear of Steel 40Kh in a normalized state, as well as hardened and low-annealed, with a white layer, is lowered in comparison with a polished layer by ~3 and 2 times, while the wear of a bronze bearing is lowered by 2 and 1.5 times. In the case of the pair cast iron–antifriction alloy, the wear of cast iron with a white layer is less by 3 times, and that of an SOS 6-6 bearing by 2 times (Fig. 2).

Thus, treatment of parts using a laser beam, operating under free conditions, can be used to improve the wear resistance of machine parts. It must be emphasized that, with continuous action of the beam, the uniformity of the white layer will obviously be high, the physicomechanical state of the metal more favorable, and the operating characteristics better.

LITERATURE CITED

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