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Abstract

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ON THE MECHANISM OF MUTUAL ATOMIC TRANSFER OF COPPER DURING FRICTION OF BRONZE AGAINST STEEL

(Presented by Academician P. A. Rebinder on 30 III 1960)

Earlier experiments on the friction of BrOSN and BrOF bronzes against steel under lubrication with an alcohol-glycerol mixture or with glycerol established that a thin layer of bronze, enriched with copper, forms on the surface of the steel. During friction, particles of this layer passed from the steel surface to the bronze surface, and then back again from the bronze to the steel surface (mutual transfer), which accounted for the practically complete absence of wear. This phenomenon was termed "atomic seizing" ([1]). The physical processes occurring during atomic seizing had not been studied.

The following scheme of the processes occurring during friction of bronze against steel under lubrication with glycerol appears possible to us.

Contact between the parts occurs at individual contact spots, the total area of which is many times smaller than the nominal friction surface ([2]); it is therefore natural to assume that, on the bronze surface during friction, there are regions with intense heat evolution, at which reduction by glycerol of copper from the oxide film always present on the surface takes place. Owing to atomic inhomogeneity in composition, reduction of copper from the oxide film occurs at those regions that are enriched with copper. These regions of the bronze are active with respect to their ability to seize with steel. Regions of the bronze not enriched with copper wear during the friction process under running-in, and the wear products are carried away with the glycerol. As a result, the steel surface is gradually covered with a thin layer of almost pure copper. With further operation, reverse transfer of copper occurs from the steel surface to the bronze surface.

To prove the selectivity of the process of seizing of copper with steel, the following experiment was carried out.

On an “MI”-type machine, two steel specimens were tested in friction at a specific pressure of 30 kg/cm^2 and a sliding velocity of 0.4 m/sec, under lubrication with glycerol containing black copper oxide CuO powder in suspension. After 20–30 min of testing, a thin copper deposit was obtained on the surface of the steel specimens. Consequently, near the contact points of the specimens, owing to the rise in temperature, glycerol reduced copper from the oxide, which then seized with the steel.

To prove the reverse transfer of copper from steel to bronze, the following experiment was carried out: on a lathe, at the center, a steel rod 25 mm in diameter was mounted. The finish of its surface corresponded to class 11 according to GOST 2789-52. After the surface of the rod had been cleaned with crocus cloth, in order to remove the thick oxide film, and after the surface had been wetted with glycerol, a rod of BrOF bronze was pressed against the rod, rotating at a speed of 40 rpm, with a force of 100 kg/cm^2. Friction of the bronze rod against the rod was carried out in two ways (Fig. 1). In the first case the bronze rod had a longitudinal feed—

···; in this case the surface of the rod came into contact with each of its sections only once. After 200 revolutions, there were no traces of copper on the friction surface of the rod, just as there were none on the friction surface of the bronze bar. In the second case, the bronze bar had no longitudinal feed and came into contact with one and the same place on the steel rod. After 100 revolutions, the surface of the rod, as well as the mating surface of the bronze bar, was covered with a layer of copper.

The results of the experiment show that the formation of a copper layer on the surface of the bronze bar is possible only when it is transferred from the steel surface. Thus, when bronze rubs against steel in glycerin, transfer of the copper component of the bronze to the steel surface first occurs, and then the reverse transfer from the steel surface to the bronze surface takes place. The continuous thin layer of copper formed on the friction surfaces of the bronze and steel prevents direct contact between the steel and the bronze. The copper coating at the contact sites easily seizes, which leads to mutual transfer of copper between the friction surfaces and to an almost complete cessation of wear.

Fig. 1. Scheme for testing a steel rod with a bronze bar: *I* —the bronze bar comes into contact once with each point of the surface of the steel rod; *II* —the bronze bar comes repeatedly into contact with each point of the surface of the steel rod

Friction of bronze against steel in other liquids besides glycerin (kerosene, mineral oils, distilled water), including nonpolar vaseline oil, was not accompanied by the effect of mutual atomic transfer of copper.

On the basis of the experiments described, it may be asserted that friction of bronze against steel under glycerin lubrication is accompanied by physicochemical processes that may serve as the basis for new methods of treating friction surfaces.*

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CITED LITERATURE

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* Author' s certificate No. 115744.

Note: Figure translations are in progress. See original paper for figures.