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Abstract

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THE INFLUENCE OF SURFACE-ACTIVE MEDIA ON THE REGULARITIES IN THE DEVELOPMENT OF THE SEIZURE PROCESS OF METALS DURING FRICTION

(Presented by Academician P. A. Rebinder, 17 IX 1963)

In recent years many investigations have been carried out to clarify the nature and regularities of the development of the process of seizure of metals ([1–9]). However, due attention has not been paid to studying the influence of surface-active media on the regularities of the development of the process of seizure of metals.

It is known that surface-active media possess, on the one hand, the ability to form strong adsorption films on metal surfaces, preventing the appearance of direct contact and seizure of the paired metals; on the other hand, as shown by P. A. Rebinder and others ([10–12]), the action of surface-active substances is manifested in the facilitation of plastic deformations in thin surface layers of metals. This adsorption-plasticizing action underlies the mechanism of the reduction of external friction, i.e., lubricating action, especially under conditions of high local stresses ([11,12]). In the present work, comparative experimental data are given for the determination of critical specific loads characterizing the onset of seizure of metals, and of changes in the structural state of the surface layers of technically pure iron, aluminum, and copper during friction without lubricant, in pure vaseline oil, and also in this oil with the addition of 0.2% oleic acid.

The tests were carried out on a special machine ([13]), which reproduces during sliding friction the processes of seizure of the first kind (athermal seizure). The specimens tested had the form of a hollow cylinder, and their contact occurred at the ends. The nominal contact area was 1 cm^2. The relative displacement of the paired surfaces was effected by rotating one specimen relative to the other, stationary one, at a speed of 0.25 cm/sec. The magnitude of the normal forces in each experiment increased at a specified constant rate from zero to a specified value. Measurement of the normal and tangential forces arising during friction was carried out by special dynamometers.

The occurrence and development of seizure were determined from qualitative changes in the surface layers of the metals, from the increase in the coefficient

Fig. 1

Figure 1: Fig. 1

of friction, and from the formation of a strong joint (welding) of the specimens tested. In doing so, the strength characteristics of the metals were taken into account.

The investigations showed that, during friction without lubricant, seizure of the first kind occurred at pressures of 8-10 kg/cm^2. It reached its greatest development (complete welding of the specimens over the entire contacting surface) at 30-38 kg/cm^2; here the coefficient of friction was 4.5-6.7 (Fig. 1, point *a*). In pure vaseline oil, seizure occurred at a pressure of 10-30 kg/cm^2 and reached its greatest development within the range 45-80 kg/cm^2. The coefficient of friction in this case decreases somewhat and lies within the range 2.1-4.9.

In vaseline oil with the addition of 0.2% oleic acid, seizure arises and develops at significantly higher pressures—beginning at 105-110 kg/cm^2, and reaches its maximum development at 120-135 kg/cm^2. The coefficient of friction in this case decreases sharply—to 1.0-2.0.

To the article by A. Ya. Gelfman, D. S. Bidnaya, L. V. Sigalova, M. G. Buravleva,
V. S. Koba, p. 894

Fig. 2. X-ray diffraction patterns of polyvinyl alcohol pyrolysis products: *a* —initial sample, *b* —after pyrolysis at 200°, *v* —after pyrolysis at 250°, *g* —after pyrolysis at 300°, *d* —after pyrolysis at 350°, *e* —after pyrolysis at 450°, *zh* —after pyrolysis at 600°

To the article by N. L. Golego, p. 897

Fig. 2. Characteristic changes in the surface of specimens of technically pure iron after testing for resistance to seizure at a constant sliding speed of 0.0025 m/sec: *a* —without lubricant; *b* —in vaseline oil; *v* —in vaseline oil with the addition of 0.2% oleic acid.

Study of the microstructure of the surface layers in a normal section showed that, under friction in conditions of seizure of metals, plastic deformation extends, depending on the activity of the lubricating medium, to different depths. In the presence of a surface-active lubricant, the deformation of the metal during friction is localized in a relatively thin layer, as was established by S. Ya. Veiler and V. I. Likhtman in pressure-working processes ([11]), and under our conditions extends to a depth of 20-30 μ (Fig. 2a; see insert to p. 894). During friction in pure vaseline oil, the deformations of the metal extend to 150-180 μ (Fig. 2b), and without lubricant to 200-250 μ (Fig. 2c).

Fig. 1. Dependence of the coefficient of friction on the specific load in tests for resistance to seizure of two specimens at a constant sliding speed of 0.0025

m/sec. *I* —of technically pure iron, *II* —of aluminum, *III* —of copper. 1 —without lubricant, 2 —in vaseline oil, 3 —in vaseline oil with an addition of 0.2% oleic acid.

Thus, an adsorption-active medium effectively prevents the occurrence and development during friction of the undesirable process—seizure of the first kind—and, in addition, sharply reduces the depth of propagation of deformation into the bulk of the metal.

The ability of a surface-active medium to form strong adsorbed films on the surface of metals and to cause a significant facilitation of plastic deformation concentrated in the thinnest surface layers of metals ensures stable separation of the conjugate metallic surfaces over a wide range of changes in friction conditions, as well as a reduction of external friction and of stresses in the surface layers. Under these conditions, rupture of the protective films and formation of metallic contact (development of seizure of the first kind) occur at relatively high critical pressures.

The critical pressures at which the process of seizure of the first kind arises and develops are, in a surface-active medium, 4–5 times higher than during friction without lubricant or in adsorption-inactive media. A significant reduction in the volume of the surface layer of the metal involved in plastic deformation in the presence of a surface-active medium lowers the tangential forces, reducing the coefficient of friction by a factor of 3–4.

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