SERVICE PROPERTIES OF FUELS AND OILS

ANTIWEAR AND ANTISCUF PROPERTIES
OF LUBRICATING OILS IN RELATION
TO ELECTRIC POTENTIAL AT METAL–OIL
PHASE BOUNDARY

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In recent years, the view that the surface energy of metals is related to the electron work function of metal surfaces has found widespread acceptance [1, 2]. As a corollary, a change in the surface energy of a metal is related to changes in such mechanical properties as microhardness, wear resistance, antifriction properties, and corrosion resistance.

Changes in the electron work function of metals under the action of lubricating oils of differing chemical composition, at various temperatures, can be evaluated by a number of methods, including the electrification potential of a hydrocarbon fluid [3]. Here, the more negative the electrification potential \( E_e = K_1W \), the smaller the electron work function \( W \), the lower the surface energy of the metal \( \sigma = K_2W \), and hence the poorer the mechanical properties of the metal surface—for example, its wear resistance. With an extremely high value of surface energy, the metal may become brittle.

Additives that are used in lubricating oils to provide antiwear and antiscuff activity will interact with frictional surfaces, and the nature of this interaction can be assessed by means of external polarization of the rubbing parts from a direct-current source, then plotting the relationship between surface wear and the amount and polarity of the current passing through the frictional surface and the oil film that separates the surfaces. These relationships have the character of electrocapillary curves [4], the zero-charge potential of which \( \phi_0 \) is related to the electron work function \( W \) by a simple relationship: \( \phi_0 = W - 4.75 \) [5].

We have studied the antiwear and antiscuff properties of additive oils on various metals with external polarization of the frictional surfaces; these studies were performed in a simple laboratory tribometer.

The apparatus is shown schematically in Fig. 1. Stationary steel balls with an impressed voltage from a...
Fig. 2. Electrocapillary curves for friction of aluminum disks on steel: 1) vaseline oil (white oil); 2) DS-11 (diesel lube); 3) DS-11 + 0.7% OLOA-267.

The design of the experimental unit eliminates the possibility of spark discharges between the frictional surfaces, and hence also the probability of electrical erosion during the test.

As an example, the antiwear action of the dialkyl-dithiophosphate additive OLOA-267 with respect to aluminum disks is shown in Fig. 2. It can be seen that, when metal wear is plotted against the strength and polarity of the current passed through the contacting metal surfaces and creating a voltage drop at the metal - oil interface, the plots have the character of electrocapillary curves. The mechanism of oil antiwear action under these conditions consists of a change in the electron work function relative to the metal surface: the points of zero charge when using DS-11 oil with or without an antiwear additive are displaced in the direction of negative values, in comparison with the zero-charge points for the nonpolar Vaseline oil.

Disk wear was investigated as a function of axial load with a low speed of rotation (0.1 m/sec), with various field strengths (with various currents) for one hour. It was found that, at loads below 10 kg, the wear of copper disks with polarization of the rubbing surfaces was greater than the wear without polarization. At loads above 10 kg, i.e., in the seizure regime, external polarization of the surfaces gave an increase in the antiscuff efficiency of the oils. From the data shown in Fig. 3, it is evident that the DS-11 oil either without additive or with the dialkyl-dithiophosphate additive OLOA-267 (when the rubbing surfaces were operating in the seizure regime) gave electrocapillary curves with two maximums. Thus, the use of an oil with an extremely low concentration of a dialkyl-dithiophosphate additive, with simultaneous action of an electrical field on the frictional surface, has achieved the same antiscuff effect as that given by a special, highly effective transmission oil with a high additive concentration.

When DS-11 oil with the sulfur-containing antiscuff additive LZ-23K is used in operation of the frictional surfaces in the scuffing regime, the electrocapillary curve is of a normal character, with some shift of the zero-charge point to the left in comparison with the additive-free oil.

Apparent the strength of the electrical field generated by the potential drop at the metal - oil phase boundary when current passes through the oil film is commensurate with the changes in field strength at the phase boundary