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On the Influence of Corrosion Inhibitors on Corrosion-Mechanical Wear

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As is known, the character and intensity of wear of metals depend in many respects on the nature of the surrounding medium. Among the principal factors determining the influence of the medium on wear one may include its lubricating action, the effect of adsorption-induced reduction of strength (1), and the corrosive action of the medium on the metal. Wear of metals in an atmosphere of dry air is usually accompanied by oxidation by oxygen of the continually exposed new areas of the metal surface and by spalling of the oxide film that has formed. It has been established that in deoxygenated air the rate of wear of steel decreases (2); when friction units operate in electrolytes or in moist air, processes of electrochemical corrosion must also be borne in mind.

In the first case, for example, during machining by cutting, the corrosion factor plays no substantial role, since the thickness of the chip removed is many times greater than the thickness of the natural oxide film. In the second possible case, the rate of wear is so small that the corrosive and mechanical factors exert equal action. Such a phenomenon, one may suppose, occurs, for example, in the operation of the ring—traveler pair under conditions of wet spinning of flax.

In one revolution of a steel traveler, on average, a layer corresponding to a metal layer only 2–3 Å thick is removed from the surface of a ring made of nitrocarburized steel 4 × 13. Here it is necessary to take into account not only the formation of a brittle oxide film but also electrochemical corrosion under the action of a thin film of water. Finally, in the third case, under conditions of motion of an aggressive electrolyte containing an abrasive, destruction of the metal may occur chiefly as a result of corrosion processes; the mechanical factor has a subordinate significance. By means of protector protection it proved possible to reduce the wear of steel during its friction against a textolite bearing in sea water (3), which testifies to the participation of electrochemical processes in wear.

In the present investigation the possibility was clarified of reducing the corrosion-mechanical wear of nitrocarburized steel 4 × 13 in Moscow tap water with the aid of corrosion inhibitors. The experiments were carried out at 40° on an Kh2M apparatus (4), in which a disk of high-speed steel R9 rotating in the electrolyte wore the test bar, forming a groove on its surface. The volumetric wear calculated from the length of the groove serves as the criterion of the wear resistance of the specimen. In all experiments the load on the specimen was 2.25 kg, and the disk rotated at a speed of 600 rev/min. It had previously been established that the composition and pH of the water have a great influence on the wear resistance of steels ([5,6]).

To determine the role of electrochemical processes during wear, in the first series of experiments the influence of anodic and cathodic polarization on the wear of steel 4×13 was determined. Platinum foil served as the second electrode. Each of the obtained wear values corresponds to an independent |

experiment, and each series of experiments was carried out on the same specimen.

The average results of the experiments are shown as curves in Figs. 1 and 2.

As can be seen from the course of the curves (Fig. 1), anodic polarization leads to a 25% increase in corrosion-mechanical wear. As a result of cathodic polarization, the volumetric wear of steel 4×13 after 3000 revolutions of the disk decreases from $\sim 75 \cdot 10^{-3}$ to $45 \cdot 10^{-3}$ mm^3, i.e., by $\sim 40\%$. Thus, under the conditions considered, the corrosion and mechanical factors

Fig. 1. Effect of polarization on the volumetric wear (v) of steel 4×13 in tap water: 1—without polarization; 2—under anodic polarization: $D_a = 1$ mA/cm^2; 3—under cathodic polarization: $D_k = 0.1$ mA/cm^2

are quite comparable, and experiments on cathodic protection show that they play approximately the same role. Therefore, it was to be expected that corrosion inhibitors could substantially reduce the rate of wear.

As is known, in neutral solutions anodic corrosion inhibitors effectively reduce corrosion of steel; their action is usually due to the formation of a protective oxide film ([7]). It could be expected that such corrosion inhibitors, because of the reduced ability of the oxide film to undergo re-formation, would lead to an increase in the rate of corrosion-mechanical wear.

Fig. 2. Effect of the addition of corrosion inhibitors on wear of steel 4×13: 1—without additive; 2—with addition of 500 mg/l sodium nitrite; 3—with addition of 500 mg/l liquid glass; 4—with addition of 200 mg/l sodium hexametaphosphate

As can be seen from Fig. 2, the addition to water of sodium nitrite, which is a typical anodic corrosion inhibitor, as well as liquid glass, causes a marked intensification of wear. In the presence of sodium nitrite the wear rate increases by 50%.

Among the cathodic corrosion inhibitors for steel that retard corrosion processes proceeding with oxygen depolarization are sodium sulfite and sodium hexametaphosphate ([8,9]). The first of these, comparatively easily oxidized in aqueous solution in the presence of atmospheric oxygen, at a concentration of 1000 mg/l in our experiments caused a decrease in the rate of corrosion-mechanical wear by $\sim 25\%$. Fig. 2 also shows the results of tests carried out with and without the addition of hexameta-

sodium phosphate. The addition of sodium hexametaphosphate, as can be seen from the course of the curves, makes it possible to reduce wear by approximately 25%.

Thus, the experiments carried out confirmed the assumption that, in corrosion-mechanical wear, electrochemical processes can play a substantial role, and established the possibility of reducing the rate of wear of steel 4×13 in tap water by adding a cathodic corrosion inhibitor—sodium hexametaphosphate.

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