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EFFECT OF SLIDING FRICTION MODES ON EXOELECTRON EMISSION PARAMETERS

by

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Thermally stimulated electron emission of 40Kh10G10 steel samples subjected to sliding friction at different sliding velocities Nu was studied in a vacuum using a secondary electron multiplier. Also measured were the magnitude of induced wear, intermediate contact electrical resistance, the coefficient of friction, and the emf occurring under friction. As Nu increases from 0.75 to 4.5 m/sec, two maxima appear on the thermally stimulated electron emission curves in the regions 170 and 270 degrees C. A more intense thermally stimulated electron emission is observed after sliding with V equals 4.5 m/sec, and this also produces greater wear. [AR1024933]

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Wear Resistance						
Electric Resistance						
Electromotive Force						
Steel						
(U)40Kh10G10 Steel						

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EFFECT OF SLIDING FRICTION MODES ON EXOELECTRON EMISSION PARAMETERS

/Article by L. G. Korshunoye; Sverlovsk, Trudy Ural'skogo Politekhnicheskogo Institute imeni S. M. Kirova(Works of the Urals Polytechnical Institute imeni S. M. Kirov), Russian, No 177, pp 53-57, 1969/

Friction of metals is a complex physical and chemical process. Plastic deformation occurs where friction exists in the surface layers of a metal with a high velocity due to intensive heating up of both submicro- and microvolumes and macrovolumes of the surface layers. The amount of heat liberated in friction amounts to almost 75% of all the external expended mechanical work /1/. High temperatures develop on the friction surface which reaches the melting points of the working metals /2/ or even exceeds them /3/.

Strain and strong heating up promotes high activity of the surfacelayers which leads to intensive interaction with the surrounding medium, to the occurrence of diffusion processes, phase transformations, etc., in them and to the development of a new structure in the surface layers which is different from the initial structure in chemical and phase composition /4, 5/. The friction process is also accompanied by electrical phenomena--thermoelectronic, thermoionic and exoelectronic emissions as well as thermoelectrical processes /6-9/. Electrification of the working metals takes place as a result of the occurrence of these processes.

Exoelectron emission with the surface of metals (Kramer's effect) is an energy characteristic of processes taking place during deformation /10/. The intensity and kinetics of exoelectron emission for contact interaction have been linked with change of electron work function /10/ which for metals can essentially change during deformation due to phase transformations and processes of chemisorption, oxidation, etc. in the surface layers /11, 12, 13, 14/. Consequently, exoelectron emission carries in itself significant information about phenomena occurring in the surface layers of deformed metals.

Results are presented in this work of investigations into the effect of sliding friction modes on the parameters of thermally stimulated exoelectron emission. Tests were conducted on a disk friction machine the element of which consisted of a calibrated rotating disk 70-mm in diameter and 8-mm thick. A sample Ø 8 mm in diameter and 50-55 mm long was clamped to the disk surface under the action of an external load with the plane. The calibrated disks were made of steel 4Kh13 and after heat treatment has a hardness of R_c 50. The samples were made of steel 40Kh10G10 and had a purely austenitic structure in the initial condition.

Tests were conducted with an external load of 2.5 kG in the range of slip rates of 0.75-7.5 m/sec. Friction path was 10,000 meters long. The following magnitudes were measured in the process of friction: weight wear, transient contact electrical resistance, average temperature on the sample friction surface and the emf forming during friction.

Thermally stimulated exoelectron emission with the friction surface of a sample was recorded immediately after vacuum testing (2×10^{-5} mm H g) with the aid of a secondary electron multiplier. The apparatus and method of recording ex electron emission have been described in work /15/.

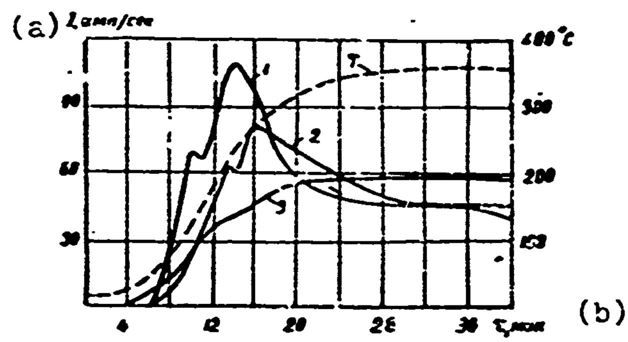

Fig. 1. Thermally stimulated exoemission of steel 40Kh10G10 after friction at sliding velocities of: 1--4.5 m/sec; 2--7.5 m/sec; 3--0.75 m/sec; a--Pulses/sec; b--t, minutes.

Results of investigating the magnitude and nature of exoelectron emission from a friction surface after testing steel 40Kh10G10 at different slip rates have been presented in Fig. 1. Analysis of the data shows that the intensity of exoelectron emission and the nature of its change in heating depend on the friction mode. The temperature relationship of exoemission for samples tested at slip rates of 0.75 m/sec has the form of a saturation curve. Upon heating, two maximums were discovered for samples having slip rates of 4.5 and 7.5 m/sec.

After comparing the obtained relationships it was possible to note that the change in slip rate leads to a difference in the maximum intensity of exoelectron emission as well as in the temperature position of the maximums. Moreover, it was established that heating the samples to 350 C and holding them at this temperature for one hour did not reduce the intensity of exoemission to a background level.

Measurement of the respective parameters was done to establish the interrelationship of exoemission parameters with the characteristics of friction and wear. The nature of change in magnitudes of reduced wear Q_{rw} (1), transient contact electrical resistance R_c, kohm (2), friction coefficient K_f (3) and emf (4) which forms during friction in relationship to slip are shown in Fig. 2.

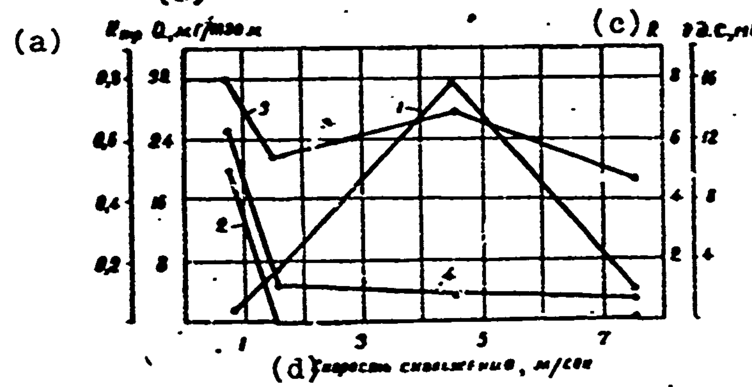

Fig. 2. Change in the characteristics of friction and wear for steel 40Kh10G10 in relation to slip rate: a--K_f; b--Q, mg/1000 m; c--emf, mv; d--slip rate, m/sec.

Electromotive force, measured for friction in this case, is one of the integral characteristics of the processes occurring on the surface of metals. The magnitude and sign of it are determined not only by the physical nature of the contacting metals and temperature on the surface but also by the nature of interaction of the working metals with the surrounding medium. Development of oxidizing and other processes on the surface, associated with the formation of films on them, which differ in nature, are reflected in the changes of magnitude and then the sign of the emf formed during friction /8, 9/.

For a slip rate of 0.75 m/sec on the friction surface an oxide film is formed whose stability bears out the high values of transient contact electrical resistance and coefficient of friction as well as a comparatively small magnitude of reduced wear. The emf at this slip rate has the greatest values and a negative sign.

With increased slip rate up to 1.5 m/sec the transient contact electrical resistance and friction coefficient sharply drop while wear increases. This testifies that the oxide film forming on the surface is unstable. As a result of its rupture the area of purely metallic contact increases and grasping processes actively occur. Here the emf decreases by approximately 4 times. Upon subsequent increase in the slip rate the intensity of grasping is increased, no visible oxide film forms on the friction surface of the sample and wear achieves its highest value.

In the 4.5-7.5 m/sec range of slip rates, wear is reduced. On the friction surface an oxide film was noted. A lowering of emf in the examined range of slip rates can be associated with the fact that slip rates greater than 4.5 m/sec on the friction surface probably cause the formation of an oxide of another type which has thermoelectric and friction properties (low coefficient of friction) and differs from those which posses oxides forming at slip rates below 4.5 m/sec. Conditions of oxide film failure on the friction surface renders a considerably greater effect on the emf magnitude than increased average temperature of the sample surface with an increased slip rate--emf with an increased temperature does not increase.

Comparison of the data in Figs. 1 and 2 makes it possible to make certain conclusions about the effect of sliding friction modes and the physical and chemical processes occurring here on the nature of thermally stimulated exoemission. Formation of an oxide film on the friction surface at slip rates of 0.75-7.5 m/sec causes a lowering of the emission intensity which was probably associated with the formation of chemisorbed and oxide layers leading to increased electron work function /12, 13/. Emission of the greatest magnitude can be observed on the surfaceof a sample the testing mode of which promoted the occurrence of grasping process and intense wear.

The presence of low-temperature maximum and point of discontinuity (at rates of 0.75 m/sec) on the emission curves can be caused by an $\varepsilon \rightarrow \gamma$ transformation occurring during heating. Microstructure studies showed that ε-martensite is formed in the surface layers of steel 40Kh10G10 at slip rates of 0.75-7.5 m/sec.

Thus, these experiments indicate the existence of an interrelationship between exoelectron emission and the most important processes taking place on the surface of metals for different friction modes.

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