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INVESTIGATION OF ELECTRICAL PHENOMENA OCCURRING IN FRICTION PROCESSES

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Abstract: *Accurate estimation and characteristic of friction process require to consider all external influence and also physical and chemical phenomena. Information on electrical phenomena in friction is ambiguous and in some cases contradictory. This work is focused on studying of electrical phenomena and their impact on tribological characteristics of tribological system (in particular, wear of friction pair). In the research process of tribological phenomena it was observed accumulation of significant electrical potential, by reason of generation of thermal electromotive force and frictional electricity. Then it was shown that the current carrier lead to an intensification of electroerosive and electrodiffusion wear of friction pair. In conclusion, results of studies of electric current impact on wear of tribological pairs were shown.*

Key words: triboprocess, electrical phenomena in friction, wear of friction pair, thermal electromotive force, frictional electricity.

1. INTRODUCTION

One of the most important problems in modern tribology is a research of dynamic friction processes in different systems. Many scientists from different countries pay attention to an analysis of processes of friction and wear in tribopairs.
A considerable amount of research of electromagnetic phenomena in the process of friction and wear is presented in modern literature, but in some cases, the data are ambiguous and sometimes contradictory to each other. Thus it is necessary to conduct a detailed review and make a study of this area. It is necessary in order to try to explain and possibly eliminate these contradictions.

2. PROBLEM STATEMENT

Thermoelectric, electromagnetic and galvanomagnetic phenomena cause a specific wear of all elements of tribosystem, which together with the mechanical wear substantially reduce the operational life. Therefore, the study of these phenomena is important for the solution of the problem to reduce wear of tribosystems, as is also important to investigate the influence of electrical phenomena on the other tribological characteristics.
Currently, the electromagnetic phenomena occurring in the process of friction, not fully explored because of its complexity and of the nature of occurrence of these phenomena. Currently, the electromagnetic phenomena occurring in the process of friction, not fully explored because of its complexity and singularity of occurrence of these phenomena. For this reason, the aim of this work is a detailed overview of the study of electromagnetic phenomena during friction processes.

3. ORIGINATION OF THERMAL ELECTROMOTIVE FORCE IN A FRICTION PROCESS

In fact, the area of a contact of rubbing metal samples can be considered as a hot junction of natural thermocouple, in consequence of intense heat. Thermal electromotive force is generated in this element (Fig. 1).

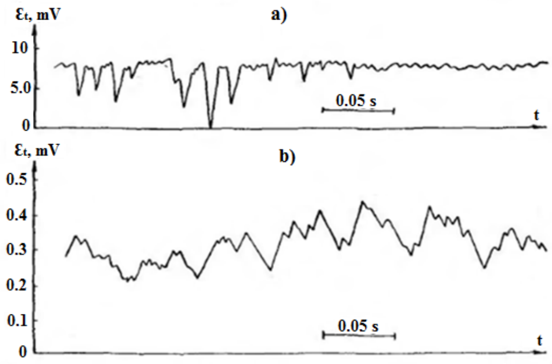

Fig. 1. The thermal electromotive force oscillogram: a) constantan - copper friction pair; b) high-carbon steel - low-carbon steel friction pair

The dependence of this characteristic allows to obtain information on the average temperature on the friction surfaces and the behaviour of deformable contact areas at a relative sliding of metals.

According to quantum theory, the magnitude of thermoelectric power in the case of juvenile surfaces cannot reach high values because the "contribution" of each source is not great. The sources include:

- a thermionic work function;
- a temperature dependence of the kinetic energy (mobility) of charge carriers;
- different concentrations of free electrons.

If the contacting metals is oxidized, it should take into account the properties of the oxide semiconductor films. It should be borne in mind their ability to be a kind of amplifiers thermoelectric effects in areas condensed phases. In this case, the classical Boltzmann statistics can be applied for analysis of thermoelectric phenomena in friction. The low thermal conductivity of oxide (high temperature gradients at the contact areas) causes the appearance of a rather considerable eddy current, which in turn can contribute to localized heat generation [1].

4. ORIGINATION OF FRICTIONAL ELECTRICITY IN A FRICTION PROCESS

Electromagnetic phenomena accompanying frictional effects are realized in all tribosystems and under all methods of lubrication.

In work [2], the regularity of energy conversion sequence was experimentally established. It lies in the fact that the work of the frictional forces in the first act of interaction is spent on the formation of the electromagnetic field and only then it generates heat. However, the frictional engagement acts follow each other and simultaneously at different points of the contacting surfaces. As a result, in real tribosystem electrical and thermal processes develop at the same time, contributing to the change in the energy state of the system.

Integration of a dielectric material (e.g., lubricant) between two mutually moving conductors leads to create a kind of capacitor, in which electric charges are accumulated. Also other electrokinetic phenomena can have some influence (Fig. 2).

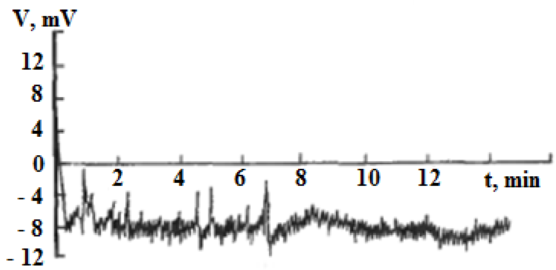

Fig. 2. Curves of triboelectricity (F_{normal} = 96 N; materials: Steel 45 – Teflon; speed: v = 1,42 m/s; lubricant: "bright stock")

During friction, the lubricant film may be broken because of short-wavelength pattern, consequently it may origination of electrical phenomena, especially under high loads. They are similar to phenomena under dry friction: the emission of electrons, thermoelectric effects, contact-potential difference, etc.

As a result of mutual approach microroughnesses of the electrified surfaces on the some distance, it can occur a local dielectric breakdown and a transport of electric charges from one surface to another. The moving electrical charges is becoming a source of magnetic field. The magnetic field, in turn, is a form of electromagnetic field which acting on the specimen with an electric charge or the specimen is having a magnetic moment, regardless of whether they are moving or are dormant [3].

5. IMPACT OF AN ELECTRIC CURRENT ON CHARACTERISTICS OF A TRIBOSYSTEM

For the first time ever, a negative impact of electric current on the tribological characteristics of friction pair was investigated in 1952. The researchers studied the effects of electrical phenomena occurring in the metal friction wear. It was found that the electric current generated in consequence of a frictional electricity and a thermal electromotive force. A friction pair and friction machine is treated as a complete electrical circuit.
According to studies [4,5], we can conclude that the influence of the electric current to the wear of samples in a friction process differs depending on the magnitude and direction of the electric current in the system. Depreciation is significantly reduced when a current has polarity which is reverse polarity of electric current in the friction pair, and greater in magnitude than its own electric current in the system. However, the lowest wear of specimens was observed using electric insulation of tribopair and the highest - with introduction into the friction area of electric current of the same polarity as that of the thermoelectric current in the system.
The work [2] is devoted to solving the problem of reducing wear by using magnetization rubbing bodies. The authors argue that the magnetization of one of the samples (the north polarity) results in a substantial (to 50%) increase of wear resistance. This phenomenon is due to the effect of Riga - Leduc, which consists in the fact that under the influence of a magnetic field induced by electric shock, the heat flow in the friction zone is deflected in the direction of one of the samples. This in turn regulates the abstraction of heat in the friction zone. It should be noted that the magnetization is a known method of improving of the wear resistance.

6. MODERN METHODS OF INVESTIGATION OF THE INFLUENCE OF AN ELECTRIC CURRENT

Studies of the effect of electrical insulation for wear of friction pairs were carried out on the basis of the University of NTI UrFU (Nizhny Tagil).
For the study of wear of tribopairs were used samples of titanium alloy (BT1-0; BT6; BT3-1) paired with high-speed steel. The scheme of friction process is rotational motion (velocity is 200 rpm). The experiment was conducted under the influence of an approximate force 50 N/cm^2 [2].
The results (Fig. 3 and Fig.4) show that the wear of the samples is greatly reduced when using insulation of tribopair.

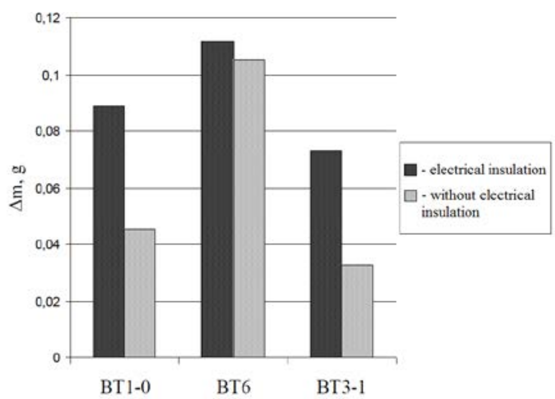

Fig. 3. Changing the mass of samples of titanium alloys

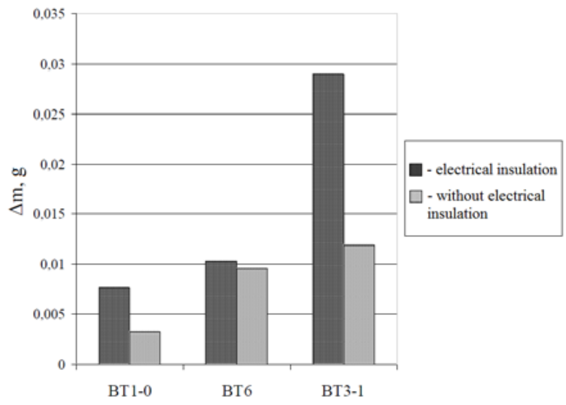

Fig. 4. Changing the mass of samples of high-speed steel

7. CONCLUSION

In this paper, a detailed analysis of the literature relating to the study of electrical phenomena in friction was carried out. It were studied the different positions which describe the nature of the origin of electricity under friction processes and the impact of this phenomenon on the characteristics of the friction pair (for example, wear). We showed various sources of occurrence of electromagnetic forces during friction. Also, the results of research on the influence of electrical insulation on wear were demonstrated.

8. FUTURE WORK

This review helps to study in detail and understand the causes of origin of electromagnetic phenomena in friction. This in turn will allow to take into account an influence of the phenomena under modelling of friction processes.

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