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BADANIE WPŁYWU MOCY SYGNAŁÓW EMISJI AKUSTYCZNEJ W PROGNOZOWANIU UKŁADÓW TRIBOLOGICZNYCH

Streszczenie: Badane są sygnały emisji akustycznej występujące podczas kontaktu z ciernymi powierzchniami. Badano emisję sygnałów akustycznych, która zachodzi w przypadku trwania procesu uszkadzania powierzchni poddanych kontaktowi ciernemu. Ustalono eksperymentalnie, że promieniowanie akustyczne jest wrażliwe na zmiany w procesach niszczenia powierzchni styku ciernego. Mianowicie, występują natychmiastowe znaczące wybuchy średniej emisji akustycznej..

Słowa kluczowe: moc, emisja akustyczna, tarcie, kontakt, obciążenie

INVESTIGATION OF THE EFFECT OF THE POWER OF ACOUSTIC EMISSION SIGNALS IN PREDICTING THE TRIBOSYSTEM RESOURCE

Summary: Acoustic emission signals that occur during fracture of surfaces of friction contact were investigated. It is experimentally determined that acoustic emission radiation is sensitive to changes in the mechanisms of fracture of surface the friction contact. There is the presence of instantaneous significant bursts of the average power of acoustic emission signals.

Keywords: power, acoustic emission, friction unit, frictional contact, operational load

1. Introduction

When machine parts are operating, the geometric characteristics, structure, properties and stress-strain state of the friction contact surfaces are changed. This requires monitoring of the technical condition of it.
Analysis of the literature about the dynamics of the wear of machine parts shows [1,2] that there are three periods of wear during operation:

1. The breaking-in period is when there is a transition from the initial state of the friction surfaces to stable.

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2. Sustainable wear period. At this stage, it is necessary to determine the wear rate for forecasting.
3. The period of heavy wear, accompanied by changes of the gaps in the friction contact and geometric shape of the parts.

To effectively diagnose the technical condition of tribosystems during operationing, it is necessary to use indicators that allow determining the wear rate and the transition to different mechanisms of wear, including the destruction. According to the results of [3], the indicators that determine the wear rate are different energy criteria.

Therefore, the simultaneous measurement of a number of parameters that characterize the object under study, allows a more complete and accurate assessment of the condition of the object. At the same time, the advantages of some methods compensate for the disadvantages of others, and due to the combination of the possibilities of different methods when used together, are formatted qualitatively new information.

2. Statement of the Task

Most methods used to diagnose tribosystems provide information either on the after effect of contact-friction interaction or on changes occurring in the material's macro-volumes, while the nature of friction and wear is related to microdynamic processes in thin surface layers of friction materials [4].

To describe the state of tribosystems, methods with high sensitivity to the kinetics of processes of structural restructuring and destruction of materials are needed. According to some researchers [5], such methods include the method of acoustic emission (AE), which has the unique ability to obtain reliable information about transient elemental acts of plastic deformation and destruction of materials during friction.

Various parameters of AE signals are used as informative parameters [5]: total number of pulses and speed of account; amplitude; signal energy; amplitude distribution of AE signals; spectral density of signals and the like. Each of these parameters characterizes certain aspects of the process under study.

The authors of [6] established the relationship between the amplitude of the acoustic emission signal and the stress-strain state of the friction contact surface during the destruction of secondary structures I and II.

Since the smallest changes occur in the amplitude of AE signals that pass through the amplification path, the development of criteria based on measuring the amplitude is of great interest. Therefore, when analyzing most of the experimental studies using the AE method, the value of standard deviation the of AE signal amplitude [7], the AE power were used as the criteria.

In order to create complex criteria, it is advisable to use energy parameters such as AE power. However, this requires theoretical and experimental justification.

3. Results of experimental Researches

The object of study is an axial-piston hydraulic machine with a movable block of cylinders, which is the most common in the class of piston hydraulic machines.

The test pump contains the maximum number of friction pairs with different load schemes. The test pump contains the maximum number of friction pairs with different load schemes.

The studies on friction and wear of friction pairs, modeling the operation of friction units of the hydraulic machine were carried out on an advanced friction machine 2070 CMT-1 [8].

During the experiment, the following were recorded: the coefficient of friction, which was calculated through the moment of friction, the magnitude of which was judged on the mechanical losses in tribosystems, the temperature of the elements in the immediate vicinity of the friction zone at a distance of 1 mm.

Analysis the changes of the mean surface temperature in the area of tribological contact during time the tests of friction pair 30HGSA-D16 for a hitch resistance showed that with increasing the applied load there is a significant increase in temperature (Fig. 1).

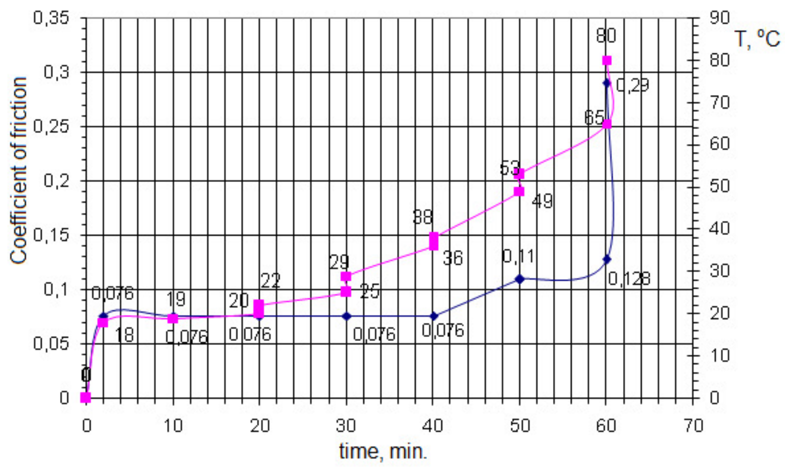


Figure 1. Graph of change of friction coefficient and temperature in the area of contact of tribosystem from time: ■ - the temperature; ♦ - the coefficient of friction

This is probably due to the intensification of energy dissipation processes during friction, which is accompanied by the release of thermal energy. The transition of the tribosystem to the hitch is fixed instantly when the temperature changes at the value of the applied load P_l = 700 N and temperature T_h = 80ºC. It should also be noted that in the load range from 100 to 500 N the surface temperature in the area of tribological contact increased on average by 2-5ºC. With increasing load from 500 to 700 N surface temperature in the area of tribological contact increased on average by 10-20ºC.

Analysis of the change in the coefficient of friction over time showed that the increase in the coefficient of friction after initial running-in occurs when the applied load increases by more than 500 N. The transition of the tribosystem to the hitch is fixed by the change of the friction torque, was instantaneous and took place at the value of the applied load P_l = 700 N and k_f = 0.28.

The nature of the change in the average acoustic emission power over time (averaging time 20 ms) is shown in Fig. 2. Analysis of the change in acoustic emission over time showed a sharp increase in the values of the average power of the acoustic emission signals and the variance of the change in the average power of the acoustic emission already at the value of the applied load of 300 N by 20 min of test. It is indicating that the transition to catastrophic mechanisms of destruction of the friction contact surfaces by 20 min of test.

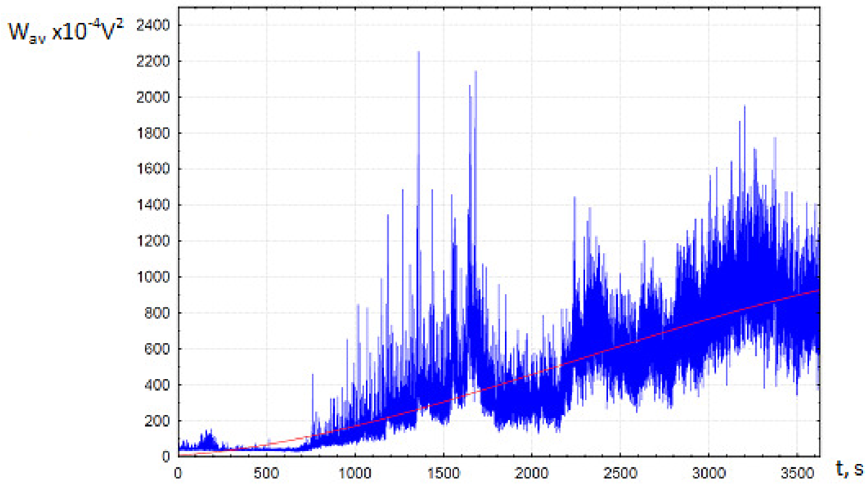


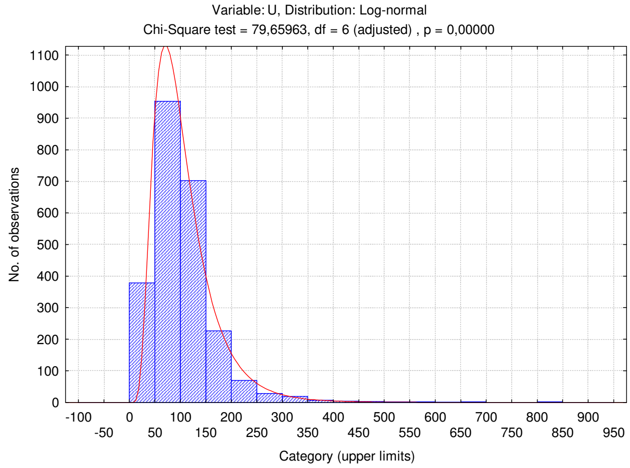
Figure 2. Dependence of change of the average power of AE signals in time (seconds), 30HGSA-D16 tribosystem

In addition, the nature of the change in the average acoustic emission power allows distinguishing several characteristic regions, which has led to additional statistical studies of acoustic emission of the tribosystem. Further analysis showed that during the entire test period, the average acoustic emission power correlates with the intensity (rate) of wear.

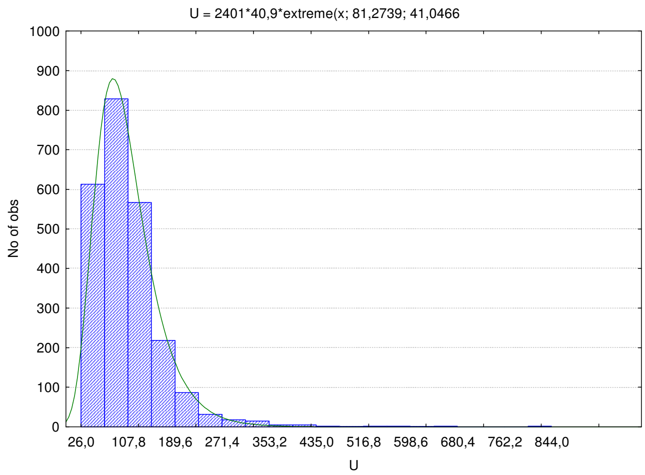
For example, analysis of the acoustic emission diagram at an interval of 11-19 minutes for the 30HGSA-D16 tribosystem shows that from 11 minutes of testing there is a significant increase in the average power of AE from W = 43x10^{-4} B^2 to W = 850x10^{-4} B^2 and variance with 14x10-8 to 4406x10-8.

Given that the averaged acoustic emission power correlates with the intensity (speed) of wear, we can say that there is a significant increase in the intensity (speed) of wear. Interval 11-19 minutes refers to the stage of damage accumulation at the micro level, which is characteristic of catastrophic types of wear of the friction contact surfaces. It is characterized by a sharp increase in the wear rate and the subsequent transition of the tribosystem to damage at the macro level (the appearance of areas of grasp with the subsequent scuff of the surfaces of friction contact).

Histograms of the distribution of averaged acoustic emission signals on the interval of 11-19 min according to the normal and logarithmic distribution laws are shown in Fig. 3.



a



b

Figure 3. Histogram of the distribution of the average power of the AE signals by log-normal (a) and by extreme (b) laws, tribosystem 30HGSA-D16, interval 11-19 min

Experimental proof has shown that the transition to catastrophic wear processes significantly increases the average values of the average power of the AE and the variance of the change of this informative parameter. In the case of the transition of tribosystems to jamming there is a fall in the dispersion of the average power of the AE, which is probably due to the fact that from a certain point in time it is impossible to prevent the hitching of the tribosystem.

Thus, the results of the studies confirmed the sensitivity of the acoustic emission method to the change in the mechanisms of destruction of the friction contact surfaces, namely the transition to processes of catastrophic wear.

4. Conclusion

It has been experimentally determined that acoustic emission radiation is sensitive to changes in the mechanisms of friction contact surface destruction. Namely, the presence of instantaneous significant amplitude bursts of the average power of the acoustic emission signals (W_{av} a burst 5-10 times greater than W_{mav}) at low values of the middle averaged power of acoustic emission and a low dispersion of this informative parameter indicate a mechanism of fatigue wear characterized by a much lower wear intensivity than the wear intensivity of normal mechanical-chemical wear. However, at a normal mechanical-chemical wear, the middle values of the averaged acoustic emission power and a low dispersion of this informative parameter are much higher than with fatigue wear.

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