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ACOUSTIC EMISSION DURING SCUFF TESTS OF FRICTION UNITS

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In the work, the results of researches of friction pairs acoustic emission during scuff tests at their explanation are presented. The dependences of acoustic emission parameters which correspond to the alteration of energy dissipation mechanism of friction pairs superficial layers at the transition to "scuff mode "of their operation are obtained.

Проаналізовано результати досліджень акустичної емісії вузлів тертя при випробуваннях на зношення. Отримано залежності акусто-емісійних параметрів, які відповідають механізму дисипації енергії поверхневих шарів пар тертя при переході до режиму зношення.

Проанализированы результаты исследований акустической эмиссии узлов трения при испытаниях на износ. Получены зависимости акусто-эмиссионных параметров, которые соответствуют механизму диссипации энергии поверхностных слоев пар трения при переходе к изнашивающему режиму.

Statement of purpose

The application of the antiscuff electric-spark coverings is one of the effective directions of increasing of friction units reliability of the modern technique [1; 2; 3]. However, the existent recommendations on their application do not take into account the variety of operating conditions of the real friction pair. For example, gearings of automobile transmissions [4] can test different workloads. Surely, that the wide range of loading will influence kinetics of physical and chemical processes, flowing on the surfaces of contact of friction pairs that are modified by different coverings. It, in the end, causes the change of structure and physical - mechanical characteristics of superficial layers of materials, the character and intensity of their wear. In this connection, the application of those or other coverings requires not only the optimization of their choice for the friction pair, made from these materials but also the choice of their optimal thickness.

One of the methods which allow to obtain information about kinetics of processes which take place in the surface layers of materials at the moments of their dynamic contact interaction is the acoustic emission (AE) method [5; 6; 7]. This method has a high sensitivity to the change of an element wearing mechanisms which are due to physic-mechanical processes taking place on the boundary of materials surface layers separation [5; 6; 7; 8].

In this article the basic dependences of AE will be defined at the scuff of the friction surfaces. The influence of the operating loading to AE parameters will be shown in this work.

Materials and methods

Two pairs of samples made of steel of 30ХГСА and duralumin of Д16 have been prepared. The choice of these materials for friction pair is under investigation and the lubricant environment is reasoned by their wide use in automobile transmissions.

Testing of samples has been performed with the help of the automated tribodiagnostic complex [9] on the "plane-plane" scheme according to the certificated methodology of scuff test with the step loading. The draft of sample is presented in fig.1.

Accordingly to this arrangement one plane was stationary while another one was rotating on the spindle of the friction machine.

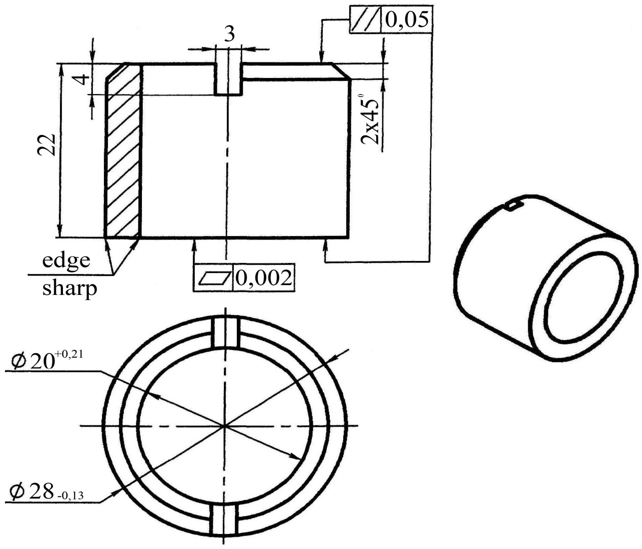


Fig. 1. The draft of sample for scuff tests

On such principle of samples location the direct and reverse friction pairs were tested. The direct pair is a pair where the steel sample rotates; the reverse pair is a pair where the duralumin sample rotates.

The speed of rotation of the friction machine transmission shaft was chosen as close as possible to the condition of operation of modeling units and it was equal to 400 rpm. The size of the loading stage was equal to 100 N. Uptime of friction pair on every stage of loading was 10 min. М10Г2К [10] used as a lubricating environment (expense of working liquid – 1,2 l/hour). At the experimental researches the friction coefficient, middle temperature of surface of tribology contact and AE radiation were registered simultaneously. As the processed parameter of AE the average power of registered signals of AE was used. Time of averaging was equal to 20 ms. The methods of AE processing, and measuring of intensity of wear, with the application of AE method are expounded in work [11; 12]. The used methods allowed measuring the intensity of wear of friction pairs in the real-timescale without their sorting out.

Results of the researches

The results of measurements of the friction coefficient and the average temperature of the contact during the wear test, both for direct and reverse friction pairs, are shown in fig. 2 respectively.

The analysis of dependences of the coefficient of friction showed (fig. 2) that the scuff of the friction pair 30ХГСА - Д16 (direct) occurred when the stiffness load was equal to 600N (fig. 2, *a*).

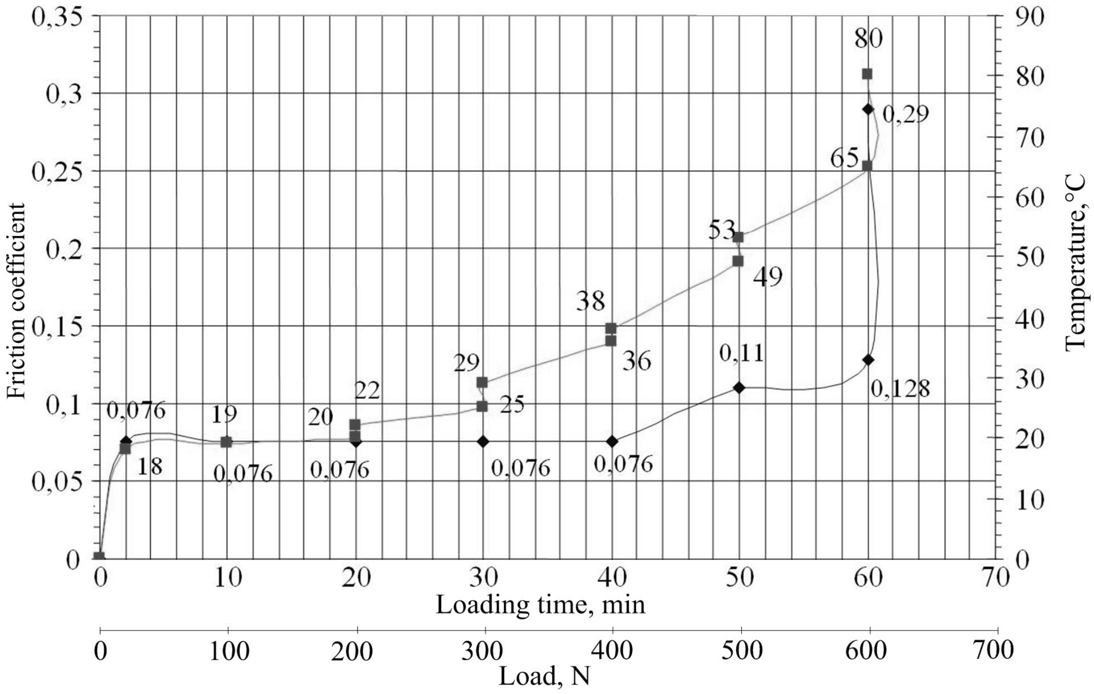
The stiffness load for the friction pair 30ХГСА - D16 (reverse) was also equal 600 N (fig. 2, *b*). For these tribosystems (direct/reverse pairs) the gradual increase in friction coefficient starts at the load of 400N. This increasing of the friction coefficient is connected with the intensification of seizure at the micro level, which subsequently leads to the scuff of the friction pair.

The analysis of the dependences of the average temperature of tribological contact for the 30ХГСА - D16 tribosystem showed that the increasing value of the applied load during the tests is accompanied by a simultaneous increasing of the average surface temperature of frictional contact for both direct and reverse friction pairs (fig. 2).

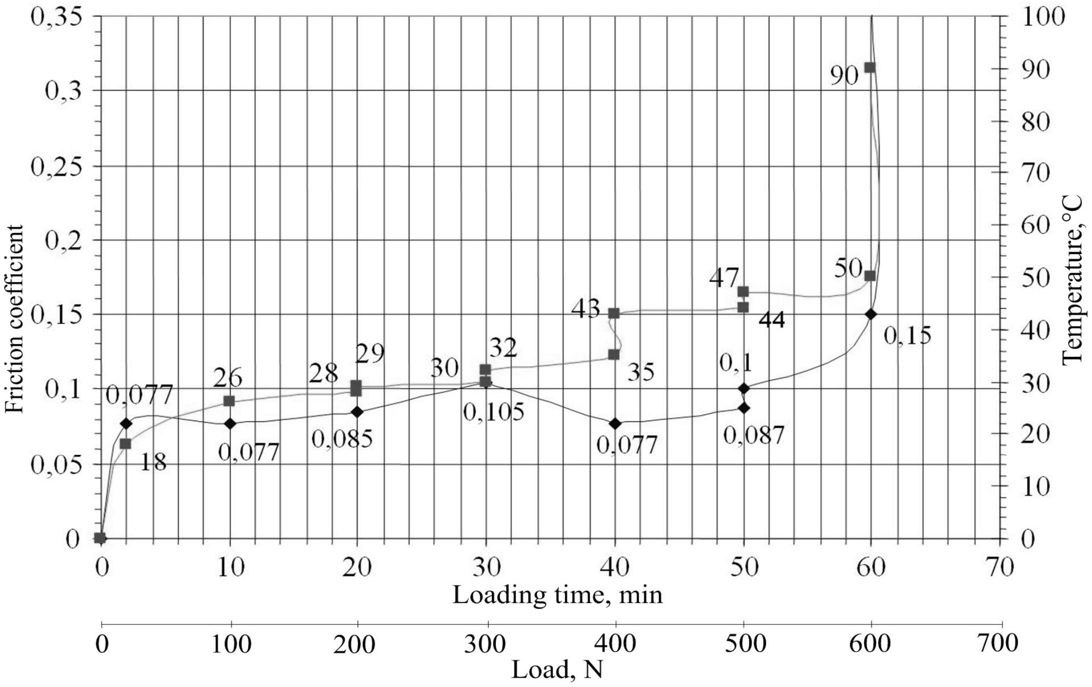
Thus, the obtained results show that the average surface temperature of frictional contact, both for direct and for reverse friction pairs is proportional to the applied load. Moreover, for the tested tribosystems the value of the average temperature of the tribological contact for each of the loading stages is 10–15% higher for the direct friction pairs than for the reverse friction pairs (fig. 2). Large values of temperatures for direct pairs are probably associated with a greater intensity of the processes leading to the deterioration of the friction surfaces.

The results of AE signals processing during the scuff tests have showed that the character of the alteration of averaged power of AE has a complicated character (fig. 3).

Fig. 3, *a* shows that the averaged power of AE signals increases from the moment of time 13 min from the beginning of tests for the direct friction pair. From 33rd minute of the scuff test of the direct friction pair we observed a continuous increasing of the average power (fig. 3, *a*), until the onset of scuffing, which is fixed by the alteration of the friction coefficient (fig. 2).



a



b

Fig. 2. The dependences of friction coefficient and temperature at scuff tests for the friction pair 30ХГСА – Д16:
a –direct friction pair;
b – reverse friction pair;
– friction coefficient;
– temperature

For the reverse friction pair (fig. 3, *b*) the fall of the averaged power of the AE was observed.

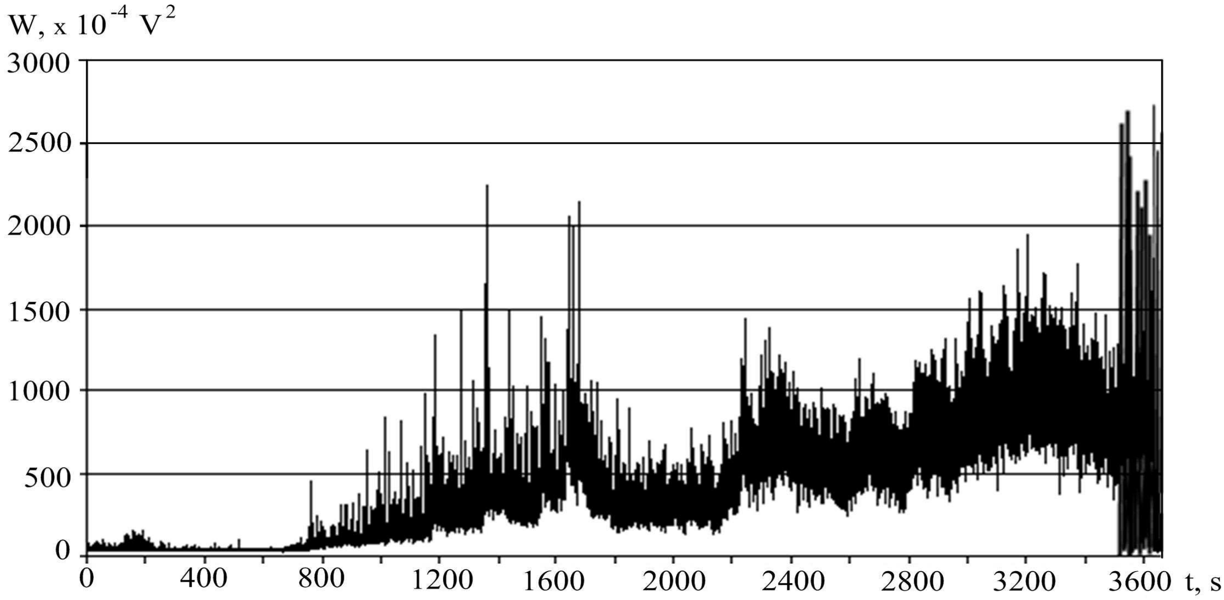
However, starting with 40 min of scuff test average power of AE signals increases, until the onset of scuffing.

Also, the increasing of parameters of AE radiation, obviously, indicates that, during the work of the friction pair, the processes which lead to the scuff emergence, do not occur instantaneously, they develop over time.

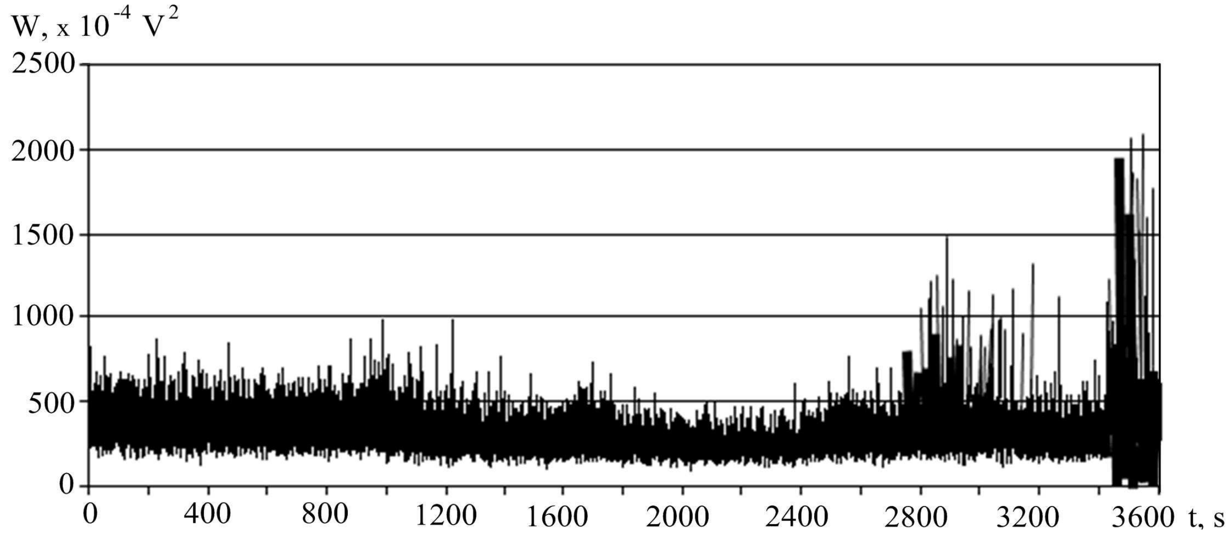
In other words, the obtained results show that the transition of the tribosystem to a catastrophic type of wear needs sufficiently long period of time.

The period of defects accumulation of friction surfaces for the reverse friction pairs is less than for the direct friction pairs. Also the direct friction pairs are characterized by a higher intensity of wear of surfaces of frictional contact than the reverse pair.

It means the worse wearbility, which is fixed by the parameters of AE.



a



b

Fig. 3. Alteration of averaged AE power 30ХГСА – Д16:
a – direct friction pair;
b – reverse friction pair

Conclusion

Thus, the basic regularities of alteration of average power of AE signals at the different workloads of friction pairs during the scuff tests are set up. It is shown that the transition of tribosystem to the catastrophic types of wear at the applied stress changing does not occur instantaneously, but takes over, some, quite a long period of time that is a well-recorded from the processing of the averaged acoustic power.

The period of accumulation of damages for the reverse friction pairs is much less than for the direct friction.

The application of the average power of the AE signals recorded during the testing process can be the basis for developing the diagnostic methods capable of predicting the transition of the friction unit from the normal to the catastrophic mode of wear resulting and the distraction of the friction unit.

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