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**THE FORMATION OF DISSIPATIVE STRUCTURES IN FRICTION**<sup>1</sup>V. Romanov, <sup>2</sup>A. Turmukhambetov<sup>1</sup>East Kazakhstan State Technical University, Kazakhstan, Ust-Kamenogorsk<sup>2</sup>Kazakh National Technical University named after K.Satpaev, Satpaev st, 22, Almaty, 050035, Kazakhstan, Akylbek.turmukhambetov@gmail.com

*Represented the results of study of the surface wear intensity with load increasing. Given conditions for the occurrence of dissipative structures on the friction's surface.*

**Keywords:** dissipative structures, friction's surface, surface wear intensity, deformation. thermodynamic system.

Representation of the non-equilibrium thermodynamics can be applied to the friction only when the replacement of macroscopic processes of plastic deformation on the microscopic diffusion processes, which takes place at a high concentration of vacancies.

Moreover, these diffusion processes in the result of interaction would have to establish the complex organization, called the dissipative structure [1]. Such an organization exists in the nature of deformation of very thin surface layers in the form of micro-plasticity.

This mechanism is the interaction of particles of diffusion flow of vacancies and dislocations in the film, when at the periodic deformation of film occurs the periodic annihilation of dislocations, which originate during the deformation and outing to the surface under the effect of osmotic forces and forces of images.

Physical features of micro-plastic deformation of the solids surface layers and their effect on general macroscopic kinetics of deformational consolidation were considered partly by Alekhin V.P.

He consider the mechanism that is, non-conservative motion (climb) of dislocations under the action of the chemical potential gradient of point defects and appearance of osmotic forces of corresponding magnitude [2]. This mechanism is underlying of micro-plasticity of surface layers.

The transition from the conservative motion of dislocations to the climb is the kinetic phase transition, which is a sign of what is possible in the future formation of dissipative structures.

It is interesting to the practical realization of a dissipative structure at the friction. As known, the curves of wear are due to the nature of wear. The contact-fatigue process of the surface layer fracture at the friction in boundary lubrication regime is associated with the stresses of load. In this way the increase of wear intensity characterize the increasing of load. In this case, the dependence of relative wear resistance on load is linear (Fig. 1, line 3).

The use of different methods of wear intensity reduction (within the limits of zero synergy) may lead to a shift in the values of wear on the straight line parallel to themselves or tilting. Such character of change is connected with destruction of contact fatigue under the stress.

A different kind of change of the wear curve takes place in a dissipative structure of surface layer, where the dissolution of surface atoms takes place, and the surface layer is at much lower stresses due to the more contact area and a special system of lubricating action [3].

Having some number of measurements of wear as the values  $J$ ,  $t$  of relative wear resistance depending on pressure, we can determine the optimum on wear and the region of realization of selective transfer on pressure for an accepted complex of lubricant material - alloy. Figure shows three cases when the dissipative structure is realized (curve 2), when realized in a narrow range (curve 3) and when not realized despite the film formation (line1).

X-ray analysis confirms the enrichment of the friction surfaces of steel and bronze with lead [4], seen from the diagrams of distribution of elements, lead in percentage proportion dominates the

copper and tin, as in the case of "evaporation" in general they overlap them, i.e. the lead films form on the friction surfaces. The formed film of lead is not only responsible for the friction moment in a pair, but also for the wear intensity. Under experimental conditions the latter is equal to 2.5 microns per hour.

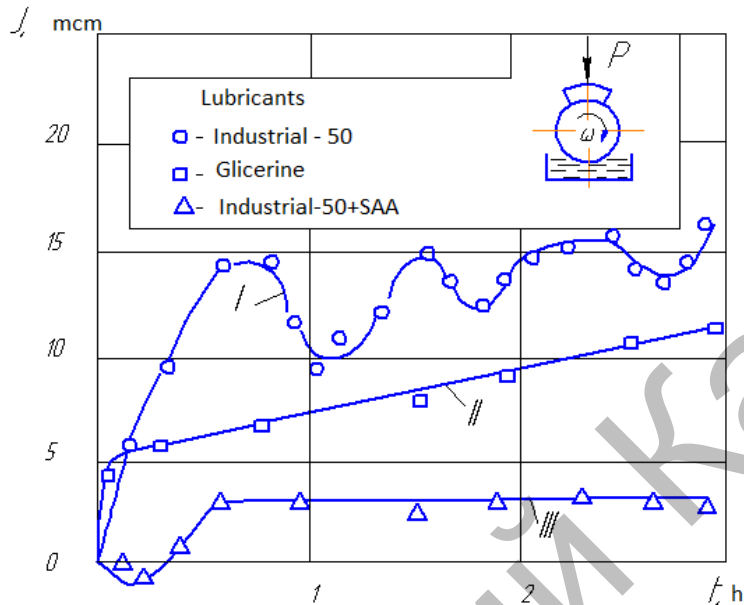


Fig. 1. Dependence of the total linear wear on testing time and lubricants

In case of glycerin lubricant the friction bronze BTL 8-21 (bronze-tin-lead) on steel 45 has the stable character, the moments of friction is significantly lower, and carrying ability of the pair is higher than in case of conventional lubricant.

Curve 2 shows the average intensity of the total linear wear of the pair friction lubricated with glycerin. As seen, the pair earns quickly (15 minutes), then wear is stabilized, but its intensity is higher than in lubrication "Industrial 50". 3 hours testing wear up to 12 microns, due to the high activity of glycerin. The observed reddening of the friction surfaces talks about formation of copper, but the stabilization process in friction in mode of selective transfer is not observed. The formed film does not seem to have an optimal thickness (it is much more) that in the presence of the active medium does not allow it to be thermodynamically stable.

The films formation is confirmed by the nature of the wear intensity. As seen, we have the increase in linear dimensions, however, it is also reduced quickly and the period of this process is very small, which shows the non-stability of dynamic equilibrium at film formation. The addition to the lubricant surfactant surface active agents (0.1% oleic acid) significantly improves the work of friction pair BTL 8-21 - Steel 45. The coefficient of friction decreases in boundary lubrication to the value of liquid, and the cost increases almost 2.5 times.

Curve 3 shows the character of the total linear wear in this case. As seen, break-in period has significantly reduced as well as the magnitude of wear in this period. With a further increase in the wear test is terminated. The nature of the curve indicates the presence of an equilibrium process in the friction zone. The film formation takes place also in this case. As seen from the graph, in the initial period there is an increase in linear dimensions, i.e. there is a film formation, which seems to continue to be responsible for anti-friction properties of pair. However, as noted in [4], this film is different from *servovit* copper film, which is formed by friction of bronze of BTP (bronze-tin-phosphorus), BAFM (bronze-aluminum-iron-manganese) types. In this case, you may talk about a modified *servo it* film, such as tin or lead.

Dissipative structure is realized by friction in the regime of selective transfer in formation of minimal dissipation area with a minimum of wear for 2-3 orders of magnitude lower than for boundary lubrication at the same parameters of loading. Depending on the activity of lubricating and properties of the alloy, this region extends to larger or smaller range of loads. The width of the range connected with the preservation of certain concentration of vacancies in the film, in which there is a climb of dislocations.

In the selective transfer the super saturation of vacancies is  $C/Co = 10^3 \dots 10^4$ . Under such conditions, an intense climb is characteristic process, which is expressed in particular in the growth of dislocation loops [2].

Since at the selective transfer the surface dislocation barriers reduced (no oxide films, the saturation of vacancies), it is naturally the yield of dislocations on the surface from a depth of plastic zone, at which the vacancy coagulate in disks because of their inner stresses. In this way, it is carried the transition from almost equilibrium linear motion of dislocations in the surface film to their non-linear motion (in the selective transfer regime), known as a diffusion-vacancy mechanism in the theory of plasticity.

Thus, the model of the mechanism of deformation in friction in the selective transfer regime corresponds to the standard model of flows interaction in an open thermodynamic system of dissipative structures with non-linear character, inverse connection, the exchange with environment, away from the equilibrium and supporting subsystems of entropy reduction [5].

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