

The dissipative function of the tribosystem, correlation with wear rate and friction coefficient

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ABSTRACT

The paper proposes a systematic approach to investigating the dissipative function of a tribosystem. The mathematical model describing the dissipation rate in the tribosystem, represented in the form of a dissipative function, has been further refined. The influence of design, technological, and operational factors on the value of the dissipative function is analyzed. An experimental study confirmed the functional relationship between the dissipative function, the wear rate, and the friction coefficient for tribosystems of various designs operating with different lubricants. It was found that changes in the wear rate follow an exponential pattern, while variations in the friction coefficient are adequately described by a linear relationship. Statistical analysis of the experimental results demonstrated good reproducibility and verified the adequacy of the theoretical curves relative to the experimental data, with correlation coefficients ranging from 0.88 to 0.98.

Keywords: tribosystem, dissipative function, modeling, wear rate, friction force, actual contact area, dissipation rate, surface roughness

INTRODUCTION

The dissipative (or scattering) function is introduced to account for the transformation of energy and ordered motion in mechanical systems into disordered motion, which ultimately manifests as thermal energy. The concept of the dissipative function was introduced into mechanics in 1878 by Rayleigh, which is why its extended name is often used -Rayleigh's dissipative function.

In the works of Ziegler [1–3] sets out the methodological approach to the study of energy dissipation in mechanical systems and defines the

main parameters for such systems on which the rate of energy dissipation depends. These parameters include: voltages on system elements; the rate of deformation of the material of the system elements and the volume of the material involved in the deformation. In works [1–3], the volume of the material is presented as the density of the material per unit volume.

Applying the developed methodological basis of studies of energy dissipation in mechanical systems to tribosystems, it is possible to develop a methodical approach in studies and analysis of irreversible processes in tribosystems.

The main factors in carrying out such studies will be: the stress-deformable state in the surface layers of the contacted materials; the rate of deformation of the surface layer; volume of deformable material with nonuniform distribution of stress and deformation. The listed factors affect the “loading” of triboelements in the tribosystem, which can be estimated by the rate of dissipation. The rate of dissipation, which has the dimension of power, J/s, is an energy parameter and characterizes the rate of transformation of mechanical energy, mainly into heat and other types of energy in tribosystems, which can be represented as a dissipative function of the tribosystem.

This work is the second part of the research on the dissipative function of the tribosystem and is aimed at experimental confirmation of the functional relationship between the dissipative function of various designs of tribosystems and the wear rate and friction coefficient of the analyzed tribosystem.

Analysis of publications devoted to this problem

The basis of the justification of the possibility of using the dissipative function for the analysis of tribosystems is based on the works of Ziegler [1–3]. These studies focus on mechanical systems, in which the author derives the governing equations that describe the relationship between free energy and the energy dissipation function. The author made the following assumptions.

1. The simplest materials considered in the mechanics of continuous media are considered elastic.
2. Processes occurring in materials are irreversible.

The dissipative function of the mechanical system was introduced by the author on the basis of the accepted assumptions. The dissipative function is related to the speed of dissipation in the mechanical system and depends on the stress and the rate of deformation per unit volume of the material.

In our opinion, such a methodological approach can be applied to the development of the dissipative function of the tribosystem as an open mechanical system where irreversible processes take place.

Methodical approach in conducting research

In work [4], the dynamic behavior of the tribosystem as a mechanical system is considered.

The authors note that the appearance of some higher-order nonlinearities in the law of friction leads to the intensification of the dissipative process and the destabilization of the tribosystem. As a result, self-oscillations arise in the elements of the mechanical system, excited by friction, with a wide range of frequencies. Work [5] presents an analysis of the energy dissipation mechanism in a mechanical system composed of two elastic structures in contact. A series of experiments is described that demonstrates the dominant friction mechanism of contacting surfaces in the microslip regime. Experimental results showed that the energy dissipated due to friction is governed by the magnitude of microslip and is independent of the relative sliding velocity of the contacting surfaces. The relationship between energy dissipation and the magnitude of the applied normal load is established.

In studies [6–7], the tribosystem is modeled using four interacting control volumes. Mass balance equations are formulated for these volumes with consideration of their mutual interactions, after which the energy balance is obtained based on the first law of thermodynamics. Two coupled systems of equations are identified, describing the circulation of material and energy flows within the tribosystem. These equations may serve as a foundation for further experimental research aimed at qualitatively and, in particular, quantitatively characterizing various modes of energy dissipation during dynamic contact [6]. As noted in [7], besides heat generation, frictional work is dissipated through several additional mechanisms, including surface roughness evolution, wear particle formation, tribomaterial transformation, and microstructural changes. Material pairs may exhibit identical average friction coefficients while demonstrating markedly different wear behaviors, since the frictional work is distributed differently among the interacting triboelements. In our opinion, the uneven distribution of wear between triboelements is an important fact established by the authors that must be taken into account when developing models.

In work [8], the internal reaction of the material to the accumulation of energy during sliding is studied. The main hypothesis is that any material has an internal limit that limits the rate of dissipation of externally applied energy (work/heat flow). Whenever the rate of application of external energy is less rapid self-dissipation, it

is possible to avoid catastrophic wear, and vice versa. In works [9,10], the relationship between the speed of dissipation in the tribosystem and self-organization mechanisms is considered. The occurrence of self-organization governs the development of physical and chemical processes, as well as mechanisms of structural ordering, in such a manner that entropy production and the unavoidable energy dissipation are minimized. It is demonstrated that self-organization, viewed as a manifestation of system tension, represents a logical expression of the universal phenomenon of structural adaptation.

Theoretical and experimental modeling of the dissipative process of friction in tribosystems is presented in works [11–18]. For example, in work [11] the theoretical and experimental modeling of the dissipative process is based on the use of a frictional harmonic oscillator interacting with the tribosystem. The generator is used as a sensitive element to fluctuations of the frictional force and as a measure of dissipated energy. In work [12], some methodological aspects of the study of tribomaterials in the conditions of sliding cyclic motion are considered. Variability of operating parameters creates dynamic effects in a functioning tribosystem. In work [13] it was established that the dynamics of the tribosystem is determined by various forces in the system. A change in external forces leads to a change in damping forces in the tribosystem. This leads to different accelerations and relative sliding speeds at the interface, and the roughness of the two surfaces will interact with different rates of deformation. Thus, changing the parameters of the system (mass, stiffness, and damping) will lead to a different reaction of the friction process for these surfaces and external influences.

Studies [14–16] investigate the influence of oscillations arising in most tribosystems from the perspective of a quantum-mechanical approach [14,15]. Under these conditions, optimal microdisplacements at actual contact points are achieved through modifications in the rheological properties of the surface layer. Internal instabilities and collapse phenomena in such a perturbed system result in defect formation within the tribopair materials and serve as the basis for the onset of critical friction regimes. Work [16] presents the classical microscopic mechanisms of frictional energy dissipation, including phonon-related dissipation, electron dissipation, and non-contact friction energy losses.

To gain deeper insight into the processes occurring at contact surfaces, the authors of [17] employed a set of energy–entropy statistical characteristics derived from random realizations of oscillatory parameters in tribosystems. This approach enables evaluation of the system's degree of order at the macroscopic level during the transition toward the formation of a dissipative structure under optimal operating conditions from the standpoint of wear resistance. The authors also proposed a method for assessing the dissipative capacity of a tribosystem.

In work [18,22] was developed methodical approach and determination of rational modes of operation of tribosystems taking into account the value of the rate of operation of dissipation, which is determined for each triboelement of the tribosystem. The paper presents calculation formulas for determining the rate of dissipation, which were obtained on the basis of the work of Ziegler [1–3]. Such an approach makes it possible to calculate the limits and reserves of stable operation (robustness) in operation at the design stage, based on the predicted modes of operation.

The analysis of works devoted to the dissipation of energy in mechanical systems allows us to conclude that the “load” of a mechanical system, including tribosystems, can be estimated by the magnitude of the dissipation rate. In our opinion, this approach has a physical basis, which is presented in the analysis of publications on this problem.

To determine the speed of dissipation in a mechanical system [1–3], it is necessary to know the amount of stress on the elements of the system and the rate of deformation of the material in the system. For the tribosystem, these are the voltages on the actual contact spots (ACS) and the rate of deformation of the material of the triboelement on the actual contactspots, taking into account the volume of the material involved in the deformation.

A general analysis of publications devoted to energy dissipation in mechanical systems and, in particular, tribosystems, it is possible to conclude that the speed of dissipation in a tribosystem characterizes the speed of transformation of mechanical energy into heat and other types of energy. The nature of the change in the rate of dissipation can be represented by the dissipative function of the tribosystem, which can be studied to establish a correlation with the rate of wear and the coefficient of friction. To determine the dissipative function of the tribosystem, it is

necessary to calculate the stress values and the rate of deformation of the material on the actual contact spots, the area of the actual contact spots and their quantity on the nominal friction surface, the volume of the material of the triboelements, which is involved in the deformation during the friction process.

Purpose of study. Develop a methodical approach and perform mathematical modeling to study the dissipative function of the tribosystem and experimentally establish a correlation with the rate of wear and the coefficient of friction when the roughness of the surfaces changes, the physical and mechanical properties of the materials of the triboelements, the structural features of the tribosystem, as well as the tribological properties of the lubricating medium.

MATERIALS AND METHODS

Methodical approach in conducting research

The development of the dissipative function of the tribosystem and the establishment of its correlation with the rate of wear and the coefficient of friction are based on the basic principles of system analysis, as strategies for studying complex systems, which include tribosystems. Mathematical modeling is used as a research method, and the main principle in modeling is the decomposition of a complex system into simpler subsystems. With this approach, the mathematical model is built according to the block principle.

Modeling of changes in the rate of dissipation in tribosystems

Based on the works of Ziegler [1–3] in the paper [19] the rate of dissipation of P on a single ACS is determined by the expression:

$$P = \sigma_{acs} \cdot \dot{\epsilon} \cdot V_d, J/s \quad (1)$$

where: σ_{acs} – tension in the material at a single ACS, Pa; $\dot{\epsilon}$ – the rate of deformation of the material on a unit ACS, 1/s; V_d – the volume of material of a single ACS participating in the deformation, m^3 .

The stress in the material at a single ACS is determined by the expression presented in [19]:

$$\sigma_{acs} = \frac{\sigma_n}{\eta}, Pa \quad (2)$$

where: $\sigma_n = N/F_{min}$ is the nominal voltage when triboelements are contacted, Pa; N is the load on the tribosystem, i.e. clamping force of triboelements, N; F_{min} is the smaller friction area of one of the triboelements, m^2 ; η is the relative actual contact area, determined by the expression according to [19].

The rate of deformation of the material on the ACS ($\dot{\epsilon}$) of movable and fixed triboelements, if they are made of different materials, is determined by the expressions given in [19].

For the material of the movable triboelement:

$$\dot{\epsilon}_{mov} = 75(1 + \nu_{mov}) \frac{\sigma_{acs} \cdot v_{sl}}{E_{mov} \cdot d_{acs}}, 1/s \quad (3)$$

for the material of the fixed triboelement:

$$\dot{\epsilon}_{fix} = 75(1 + \nu_{fix}) \frac{\sigma_{acs} \cdot v_{sl}}{E_{fix} \cdot d_{acs}}, 1/s \quad (4)$$

where: ν_{mov} , ν_{fix} is the Poisson's ratio of the material of the movable and fixed triboelements; v_{sl} – sliding speed in the tribosystem, m/s; E_{mov} , E_{fix} – modulus of elasticity of the material of movable and fixed triboelements, Pa; d_{acs} – the average diameter of a single ACS is determined by the formula given in work [19].

The volume of the material of the friction surface (V_d), which participates in the deformation at the actual contact spots, taking into account the roughness, the physical and mechanical properties of the materials and the tribological properties of the lubricating medium, is determined by the expressions.

For a movable triboelement:

$$V_{d,mov} = h_{mov} \cdot A_{acs}, m^3 \quad (5)$$

for a fixed triboelement:

$$V_{d,fix} = h_{fix} \cdot A_{acs}, m^3 \quad (6)$$

where: h_{mov} and h_{fix} is the depth of deformation of the material of the surface layer on the ACS, size m, is determined according to the first part of this work; A_{acs} – the area of a single ACS, size m^2 , is determined by the formula given in the paper [19].

As follows from expression (1), the rate of dissipation depends on the voltage in the zone of actual contact, the rate of deformation of the material, and the volume involved in the deformation.

Formula (1) can be used to calculate the dissipation rate for the tribosystem as a whole, as well as for the movable and fixed triboelements separately. The magnitude of the stress on the ACS in both triboelements is the same, and the rate of deformation of the materials of the triboelements ($\dot{\epsilon}$) differs if the triboelements are made of different materials (different modulus of elasticity E and Poisson's coefficients ν). In addition, the volume involved in the deformation of formulas (5–6) will differ in different materials.

An analysis of the literature sources devoted to this problem makes it possible to assert the presence of an uneven distribution of wear between the moving and stationary triboelements. This is an important fact established experimentally by many authors. Therefore, the term "loading" of triboelements during the friction process, or "loading" of a tribosystem in comparison with other tribosystems, is introduced in the article. It is concluded that the magnitude of "loading" should be taken into account when developing models for predicting service life.

Taking into account the obtained, the expressed speed of dissipation in movable and fixed triboelements on a single ACS is determined by the expressions:

$$P_{mov} = \sigma_{acs} \cdot \dot{\epsilon}_{mov} \cdot V_{d,mov}, \text{ J/s} \quad (7)$$

$$P_{fix} = \sigma_{acs} \cdot \dot{\epsilon}_{fix} \cdot V_{d,fix}, \text{ J/s} \quad (8)$$

The rate of dissipation at a single ACS for the tribosystem as a whole is determined by the expression:

$$P = P_{mov} + P_{fix}, \text{ J/s} \quad (9)$$

Using expression which allows you to calculate the number of contact spots (n) on the friction surface of a triboelement with a smaller friction area (F_{min}), the formula is presented in the first part of the paper, you can write down the final expressions for determining the rate of dissipation work for a movable W_{mov} , and fixed W_{fix} triboelements and tribosystems as a whole W_{TR} :

$$W_{mov} = P_{mov} \cdot n, \text{ J/s}, \quad (10)$$

$$W_{fix} = P_{fix} \cdot n, \text{ J/s}, \quad (11)$$

$$W_{TR} = W_{mov} + W_{fix}, \text{ J/s}. \quad (12)$$

As follows from the obtained expressions, the parameters of the roughness of the friction surfaces (R_a and S_m), the physical and mechanical properties of the materials (E, ν), the load and the sliding speed (N, v_{sl}) affect the value of the dissipation rate (W_{TR}). construction of the tribosystem (F_{min}), tribological properties of the lubricating medium (A). Expression (12) is a dissipative function of the tribosystem.

The results of modeling of changes in the dissipative function (W_{TR}) for various designs of tribosystems (different combinations of materials in the tribosystem and different sizes of friction areas) when the load (N) changes are presented in Figure 1 and Figure 2. The parameters that take into account the design features of tribosystems are presented in work [19].

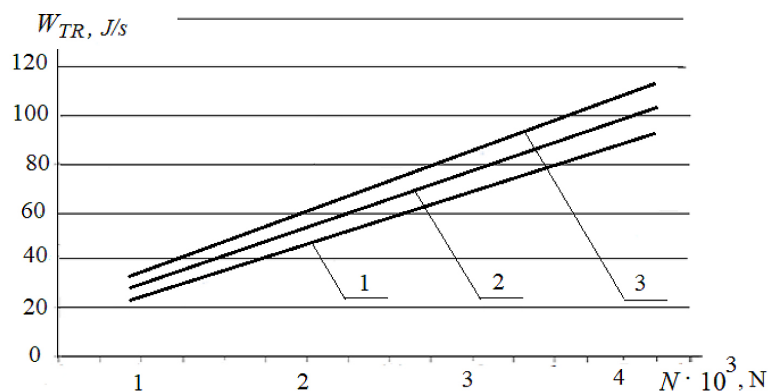


Figure 1. Dependencies changes dissipative functions (W_{TR}) for different constructions tribosystem sat changes loads (N): 1 – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix}=0.35$); 2 – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + seriescast iron ($E_{fix}=1.7 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$); 3 – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + steel ($E_{fix}=2.1 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$)

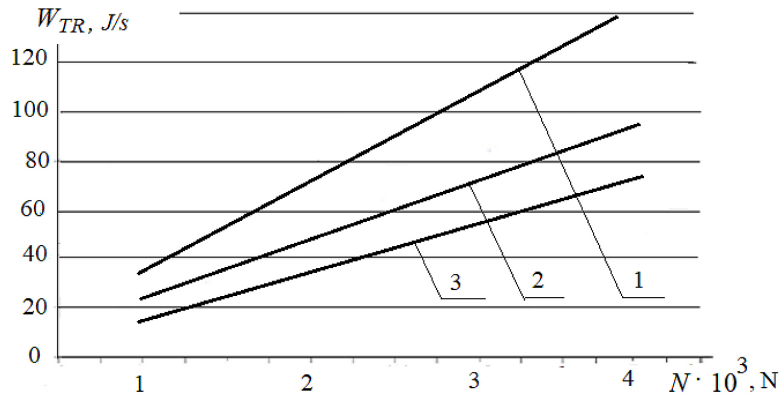


Figure 2. Dependencies changes dissipative functions (W_{TR}) for tribosystems steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix}=0.35$) at changes loads (N) for lubricants en-vironment with different tribological properties [20]: 1 – hydraulic ISO-L-HL oil, $A = 67.2 \cdot 10^{11}$ J/m³; 2 – motor oil, \ SAE 20W-40, API CD, $A = 145.1 \cdot 10^{11}$ J/m³; 3 – transmissionoil SAE 80W-90, API GL-4, $A = 202.79 \cdot 10^{11}$ J/m³

The results of modeling the influence of technological parameters, such as the parameters of the roughness of the contacting friction surfaces: $R_{a,mov}$, $R_{a,fix}$ – the average arithmetic deviation of the points of the profile of the movable and fixed triboelements; $S_{m,mov}$, $S_{m,fix}$ is the average step of irregularities along the middle line of the profile of the movable and fixed triboelements, presented in Figure 3. The parameters R_a and S_m were determined according to the ISO 468:1995 standard.

The results of modeling the influence of operational parameters on the dissipative function, by changing the load on the tribosystem (N) and the sliding speed (v_{sl}), are presented in Figure 4.

The analysis of the obtained theoretical dependences allows us to conclude that there is a functional dependence of the factors listed above with

the value of the dissipative function of the tribosystem. It should be noted that when the design and operational factors are changed, the range of variation of the dissipative function $W_{TR} = 16.8 - 144.8$ J/s. A significant range of changes in the dissipative function $W_{TR} = 7.6 - 723.0$ J/s is characteristic of changes in technological factors, this follows from Figure 3. The presented dependences will allow establishing a correlation relationship with the wear rate and friction coefficient of tribosystems.

Obtaining an expression for calculation and subsequent modeling of the change in the friction coefficient follows from the physical meaning of this parameter, which determines friction losses.

The product of the load N by the sliding speed v_{sl} determines the power that is “supplied” to the tribosystem:

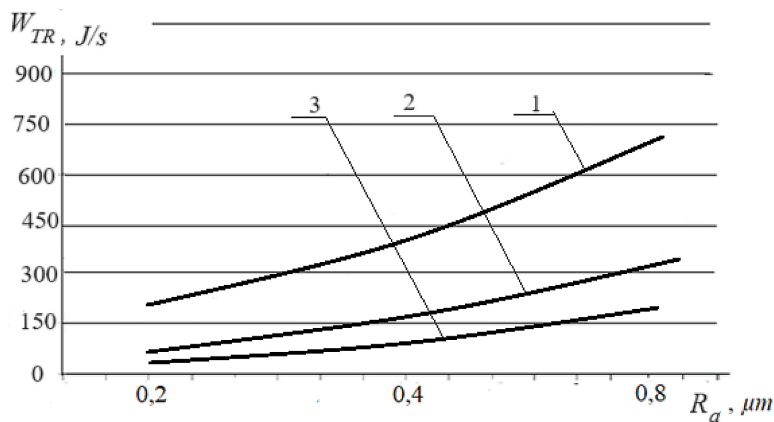


Figure 3. Dependencies of the change in the dissipative function (W_{TR}) for the steel tribosystem ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix}=0.35$), motor oil SAE 20W-40, API CD, $A = 145.1 \cdot 10^{11}$ J/m³, when changing the surface roughness R_a : 1 – $S_m=0.2$ mm; 2 – $S_m=0.4$ mm; 3 – $S_m=0.8$ mm

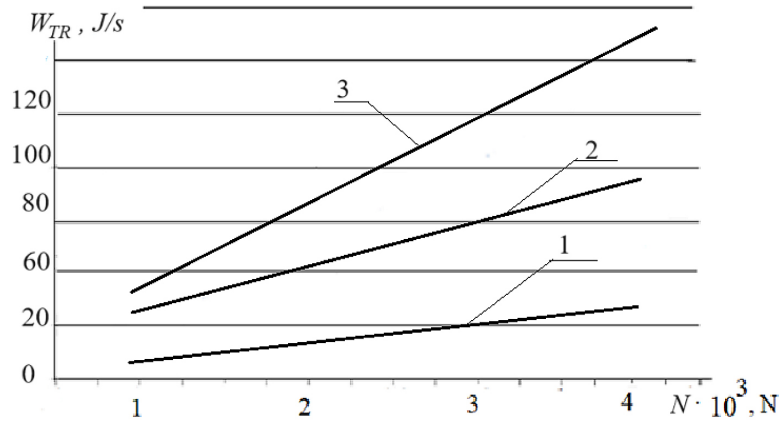


Figure 4. Dependencies of the change in the dissipative function (W_{TR}) for the steel tribosystem ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov} = 0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix} = 0.35$), motor oil SAE 20W -40, API CD, $A = 145.1 \cdot 10^{11}$ J/m³, when the load (N) and sliding speed (ν_{sl}) change: 1 – $\nu_{sl} = 0.2$ m/s; 2 – $\nu_{sl} = 0.5$ m/s; 3 – $\nu_{sl} = 0.8$ m/s

$$W = N \cdot \nu_{sl}; \frac{N \cdot m}{s} = \frac{J}{s} \quad (13)$$

where: N is the load on the tribosystem, N; ν_{sl} is the sliding speed in the tribosystem, m/s.

Calculation of the dissipation rate for movable W_{mov} and fixed W_{fix} triboelements are performed according to formulas (10) and (11), which allows determining the power that is “dissipated” by the tribosystem and turns into other types of energy (for example, heat), W_{TR} , formula (12).

Therefore, the friction coefficient, which determines friction losses in the tribosystem, can be calculated according to the following relationship:

$$f = \frac{W_{TR}}{W} = \frac{W_{mov} + W_{fix}}{N \cdot \nu_{sl} \vartheta} \quad (14)$$

To confirm the functional relationship between the dissipative function, wear rate, and friction coefficient, laboratory experimental studies of various designs of tribosystems in various lubricating media were conducted. In the course of the experiments, the magnitude of the friction moment was recorded, which was used to calculate the friction coefficient f and the wear of triboelements, which was determined by the method of artificial bases. According to the results of the measured wear, the value of the rate of wear I , the dimension m³/h, was determined. Methods of conducting laboratory tests, equipment (friction machine), means of registration of friction parameters and statistical processing of test results are described in works [19–21].

Dependencies of the change in wear rate I from the value of the dissipative function W_{TR} are presented in Figure 5. Dependencies of changes in the coefficient of friction f from the value of the dissipative function W_{TR} are presented in Figure 6.

As follows from Figure 5, the dependence of the change in the rate of wear is approximated by an exponential law:

$$I = 6 \cdot 10^{-10} \exp \left(4,05 \cdot 10^{13} \cdot \frac{1}{A} \sqrt{\frac{\pi}{(\delta_{mov} \cdot \delta_{fix})}} \cdot W_{TR} \right), \text{ m}^3/\text{h}$$

where: δ_{mov} and δ_{fix} are the rheological properties of the structure of the materials of the movable and fixed triboelements, determined according to [19].

The collected experimental data on wear rate were tested for conformity with the normal distribution. The reproducibility of the results across different experiments was evaluated using the Cochran criterion, and the adequacy of the theoretical curve in representing the experimental dataset was assessed according to the Fisher criterion. The correlation coefficient between the wear rate (I) for various designs of tribosystems in various lubricating media and the value of the dissipative function (W_{TR}) was calculated, which was 0.88–0.93.

The dependences of the change in the coefficient of friction (f) for various designs of tribosystems in various lubricating media when the value of the dissipative function (W_{TR}) is changed are presented in Figure 6. The resulting array of data obeys a linear law with a correlation

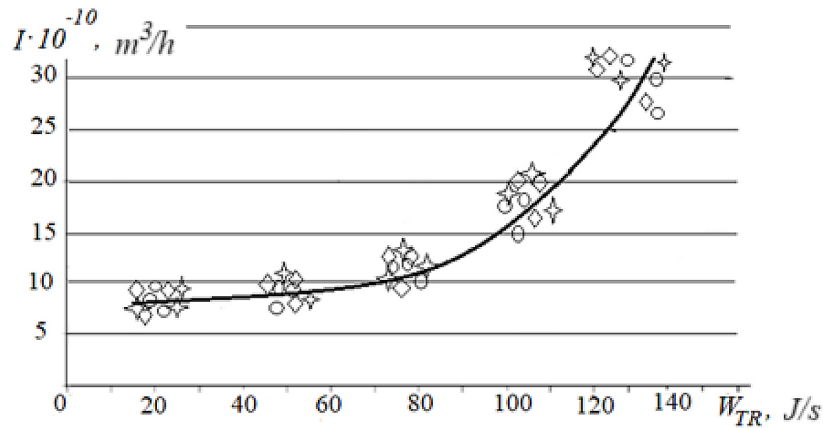


Figure 5. Dependencies of the change in the rate of wear (I) for various designs of tribosystems in various lubricating media when the value of the dissipative function (W_{TR}) changes.

- – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix}=0.35$)
- ◇ – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + series cast iron ($E_{fix}=1.7 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$)
- ☆ – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + steel ($E_{fix}=2.1 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$)

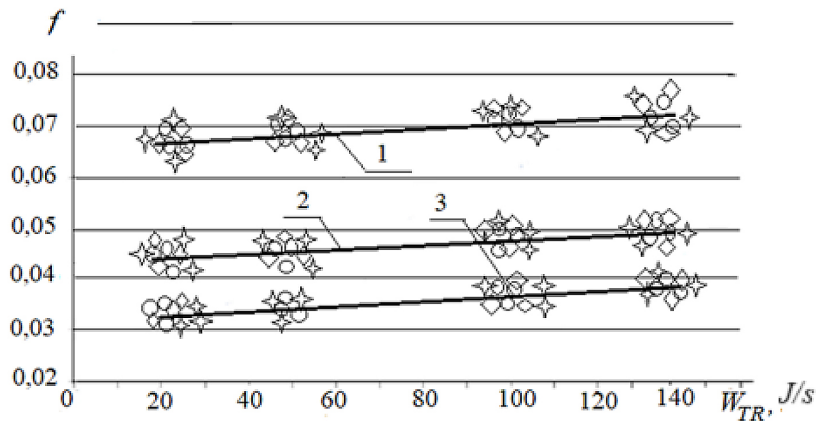


Figure 6. Dependencies of the change in the friction coefficient (f) for various designs of tribosystems in various lubricating media when the value of the dissipative function (W_{TR}) changes:
 1 – hydraulic oil ISO-L-HL, $A = 67.2 \cdot 10^{11}$ J/m³; 2 – engine oil, SAE 20W -40, API CD, $A = 145.1 \cdot 10^{11}$ J/m³; 3 – transmission oil SAE 80W -90, API GL -4, $A = 202.79 \cdot 10^{11}$ J/m³ [20].
 ○ – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + bronze ($E_{fix}=1.2 \cdot 10^{11}$ Pa; $\nu_{fix}=0.35$)
 ◇ – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + series cast iron ($E_{fix}=1.7 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$);
 ☆ – steel ($E_{mov}=2.1 \cdot 10^{11}$ Pa; $\nu_{mov}=0.3$) + steel ($E_{fix}=2.1 \cdot 10^{11}$ Pa; $\nu_{fix}=0.3$)

coefficient of 0.95–0.98. The obtained array of experimental data on the value of the coefficient of friction was checked for compliance with statistical characteristics, as it was done for the rate of wear.

The theoretically justified and experimentally confirmed functional dependence between the dissipative function and friction and wear parameters makes it possible to model the wear rate and friction coefficient for various tribosystems taking into account technological, structural and operational input parameters at the stage of machine design.

CONCLUSIONS

A methodical approach to the study of the dissipative function of the tribosystem has been developed, which contains the following components: the magnitude of the stress on the actual contactspots, taking into account the roughness of the friction surfaces and the physical and mechanical properties of the surface materials; values of the speed of deformation of the materials of friction surfaces on the actual contact spots in movable and fixed triboelements; the size of the volume of the materials of the friction surfaces,

which is involved in the deformation at the actual contact spots in movable and fixed triboelements.

The dependence of changes in the dissipative function of tribosystems on constructive, technological and operational factors is presented. The analysis of the obtained dependencies allows us to conclude that there is a functional connection between the factors listed above and the value of the dissipative function of the tribosystem. It was established that when the design and operational factors are changed, the range of variation of the dissipative function $W_{TR} = 16.8 - 144.8$ J/s. A significant range of changes in the dissipative function $W_{TR} = 7.6 - 723.0$ J/s, is characteristic of changes in technological factors.

The mathematical model of the rate of dissipation in the tribosystem, which is presented as a dissipative function of the tribosystem, received further development. The functional connection of the dissipative function with the rate of wear and the coefficient of friction of various designs of tribosystems with the use of various lubricants was experimentally confirmed. Statistical processing of experimental data confirmed the reproducibility of the results of the experiment, the adequacy of the theoretical curves of the array of experimental data, by calculating the correlation coefficient, which is in the range of 0.88 - 0.98.

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