Improvement of tribological characteristics of rubbing surfaces as one of ways to increase energy efficiency of power plants

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Abstract. In this study, the team of authors solves the problem of increasing the energy efficiency of power plants by reducing losses while lowering the coefficient of friction. This problem is solved with the help of a multifunctional additive to lubricating oils, which are a surface-active substance (surfactant) capable of changing the friction conditions of contacting surfaces in a small amount when introduced into tribological units. The tests were carried out on a friction machine II5018 on a block-roller friction pair (the material of the roller is gray cast iron SCh20, the material of the block is steel 65). During the study, the moment and coefficient of friction were determined. A friction coefficient decrease of up to 50 % was obtained, which proves the effectiveness of the proposed compositions.

1. Introduction
Today, the problem of energy efficiency of power plants is relevant. Power plants are becoming increasingly loaded, and at the same time, they are subject to increased requirements for reliability and resource.

There are several ways to fulfill these requirements:

- Changing the design of the power plant.
- The use of various types of coatings (sprayed, deposited galvanic, etc.)

These methods, although promising, require significant costs both for research and development, and for testing and subsequent implementation of developments in production. In this study, the authors try to solve the problem in another way.

2. Problem Statement
In this work, the team of authors sets the task to solve this problem by using surface-active substances (surfactants). These substances are able to change surface energy, affecting the processes occurring at the phase boundary. In particular, in this study, borates of ethanolamides of carboxylic acids (BECA) were
used [1]. The structure of the substance’s molecule is shown in Fig. 1. These substances are multifunctional additives to motor and gear oils, have a wide range of applications, for example, they can significantly reduce friction and wear, and increase the corrosion resistance of ferrous and non-ferrous alloys [2, 3]. This article discusses the effectiveness of these compounds as an additive to industrial oil I-20A.

![Structural formula of the borate of ethanolamides of carboxylic acids](image)

Figure 1. The structural formula of the borate of ethanolamides of carboxylic acids.

3. Materials and Methods

For the study, two types of oil were taken:
- Industrial oil I-20A
- Industrial oil I-20A with the addition of 10% BECA.

The tests were carried out on a friction machine II5018, on a pair of friction roller-block. The block is made of steel 65, the roller is made of cast iron grade Sch20. The appearance of the friction machine, block and roller is shown in Figure 2.

![Friction machine and samples](image)

Figure 2. a – Appearance of the roller and test block; b – appearance of the friction machine II5018.

During the tests, the speed of rotation of the roller was constant, the clamping force of the samples changed from 200 to 800 N in increments of 200 N. The moment of friction force was determined, which was later used to determine the coefficient of friction by the formula:

$$k = \frac{M_{fr}}{F_N \times R}$$

where $M_{fr}$ is the frictional moment;
- $F_N$ is the force of mutual clamping of samples;
- $R$ is the roller radius, equal to 0.025m.
4. Discussion of Results

The data obtained are summarized in Table 1, and the dependences of the friction moment and temperature on the clamping force of the samples for the studied compositions have also been plotted. The indicated dependencies are presented in Figures 3 and 4.

Table 1. The obtained experimental data

| Composition                        | Clamping force of samples $F_N$, N | Friction moment $M_{fr}$, N*m | Coefficient of friction $k$ |
|------------------------------------|------------------------------------|-------------------------------|-----------------------------|
| Oil I-20A                          | 200                                | 1.05                          | 0.21                        |
|                                    | 400                                | 1.5                           | 0.15                        |
|                                    | 600                                | 2.25                          | 0.15                        |
|                                    | 800                                | 2.85                          | 0.143                       |
| Industrial oil I-20A with addition of 10% BECA | 200                                | 0.75                          | 0.15                        |
|                                    | 400                                | 0.9                           | 0.09                        |
|                                    | 600                                | 1.2                           | 0.08                        |
|                                    | 800                                | 1.5                           | 0.075                       |

Figure 3. Dependence of the moment of friction force on the clamping force of samples

Figure 4. Dependence of the coefficient of friction on the clamping force of samples
From the above dependencies it can be seen that the use of BECA as an additive to lubricating oils leads to a significant decrease in the friction coefficient, which, accordingly, leads to an increase in the efficiency of the mechanism.

5. Conclusion
In the present work, a method for reducing friction in tribological conjugations using surfactants is clearly shown. It is known that with a decrease in the coefficient of friction, the temperature in a unit, its wear and tear also decrease, and its reliability increases. To quantify these parameters and their dependence on the experimental conditions, an additional series of experiments is required, the results of which will be presented by the authors in future works.

References
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