Application of special lubricating compositions to increase the efficiency of friction surface run-in

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Abstract. The paper presents the results of laboratory studies of a number of additives introduced during operation to motor oil of internal combustion engines. It also evaluates their impact on tribological characteristics of friction pairs. It was found that all studied additives have a positive effect on the running-in quality. Reduced wear of friction pairs, reduced surface roughness compared to base motor oil is determined. The best indicators were recorded with the FENOM additive. The decrease in wear was 46% and roughness – 23.5% compared to the base oil.

1 Introduction

The analysis of the state of the machine tractor fleet of enterprises of the agro-industrial complex shows that farms still operate a large amount of equipment with a significant age and operating time. This situation means that a certain amount of complex types of repairs, including capital repairs, is required for this technology. It is worth noting that the service life of individual units and assemblies, as well as the entire machine after major repairs is much lower.

One of the most stressed units of tractors and cars is the engine. This unit is a resource-determining unit and may account for up to 65% of equipment failures after repair [1]. The quality of repair is determined by the technological preparation of the repair production, the availability of appropriate repair equipment and regulatory and technical documentation corresponding to the qualification of personnel (employees), incoming inspection of spare parts, quality control of the work performed, etc. The final stage of the engine's capital repair is its run-in. The purpose of the run-in is a complex run-in of friction surfaces to form optimal microgeometry and their relative position.

As is known, the running-in contributes to the formation of not only new roughness with certain parameters, but also the physicochemical properties of the surface layers of the material capable of perceiving the operating loads. In this case, the saturated contact of friction surfaces should as close as possible to the parameters of the saturated contact.

Under the action of chemical, mechanical, vibration, thermal, electrical processes the run-in of friction pairs causes changes in friction surface layers, which make it possible to prepare the transition for the unit to be able to hold the operating loads without excessive wear and jamming.

The efficiency indicators that determine the quality of run-in include the formation of optimal microgeometry (surface roughness) and a decrease in the run-in wear.

The works [2, 3] indicate that there are several areas of efficiency improvement that are used at various stages of equipment operation. Taking into account the current state of repair production, the direction for the use of special lubricating compositions for running in surfaces during the run-in period after repair is quite relevant. Many works [4, 5, 6] are devoted to the development of lubricating compositions and the technology of their application. As a rule, lubricating compositions represent a combination of commercial engine oils and additional components (additives) [7, 8]. The analysis of these works showed that additives, which are referred to as "metal conditioners" showed quite good results in the formation of high-quality friction surfaces.

2 Materials and methods

To evaluate the efficiency of using such additives in lubricating compositions, a number of additives were studied during the initial period of friction surface run-in.

Such additives as FENOM, Energy Release (ER), SMT-2 with similar composition and mechanism of action were selected for the preparation of lubricating compositions.

Comparative tests of lubricating compositions including various additives were performed according to the general procedure and research agenda.

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The following lubricants were evaluated during the studies:

1. Base (motor oil M10-G2K, according to SAE 30 classification, according to API classification – CC class).
2. Base + FENOM additive.
3. Base + ER additive.
4. Base + SMT-2 additive.

Motor oil for the study was selected according to the recommendations of the lubrication chart for use in diesel engines.

The concentration of additives used in the lubricating composition was within the limits recommended by the manufacturer (Table 1).

Table 1. Composition of lubricants.

Composition of lubricants	Additive concentration, %
Base + ER	6%
Base + FENOM	4%
Base + SMT-2	6%

The experiments to determine the additive for obtaining the best tribological characteristics were conducted on a universal tribometer. The tribometer (Figure 1) is a research device that ensures the sliding friction mode according to the ring-disk scheme. Special cast iron discs were used for the study, a carbon steel ring was used as a counterbody. The samples were processed on a flat grinding machine. The surface roughness Ra of the samples was within 0.360 μm, which corresponds to the surface roughness of the cylinder liner after repair.

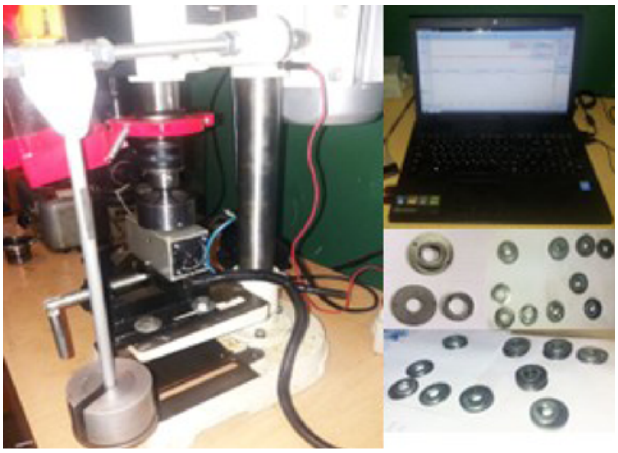

Fig. 1. Universal tribometer with software and samples for study.

The test procedure on the tribometer is not standardized, which allows the selection of the necessary modes and conditions within the technical characteristics.

The design of the tribometer allows simulating the operation of friction pairs in a sliding friction mode. It is equipped with devices for creating and implementing the selected test mode, as well as a system for monitoring and determining the friction parameters of the tested lubricants and samples. The software ensures primary processing of the received data.

The efficiency of lubricating compositions on friction pairs was evaluated according to the following parameters:

1) friction torque;

2) friction temperature;

3) wear of friction surface during testing was controlled by weight method using AND HR-200 scales;

4) surface roughness was determined using the Abris PM7M profile meter-profile recorder.

It is necessary to consider the peculiarities of operation when choosing a load and speed mode to simulate the studied transition. Calculations were made to assess the load and speed parameters for the studied unit.

Taking into account the results of calculations and the capabilities of the tribometer, the following test modes were adopted for the experiment: 1. Load – 450 N; 2. Speed – 1220 min^{-1}; 3. Time – 40 min.

3 Results

The study of tribological characteristics such as the friction torque (Fig. 2) and friction temperature (Fig. 3) shows that all tested lubricating compositions reduce the friction torque and temperature compared to base oil.
The effect of reducing the friction torque appears almost from the very beginning of the experiment in case of using lubricating compositions with additives. However, the dynamics of the friction torque change indicates certain processes occurring during the run-in period.

The action of the components included in the additives contributes to the creation of better tribological conditions for the interaction of friction surfaces compared to the base oil.

The temperature in the contact zone of the mating surfaces during testing increases, and here we can also see different temperature values. In this case, the use of additives in the lubricating composition contributes to the operation of the friction pair at a lower temperature. The comparison of these characteristics in lubricating compositions demonstrates better results of the lubricating composition containing the Energy Release additive.

The comparison of the tribological characteristics of the base oil and the lubricating composition containing the Energy Release additive with the best results shows that in absolute terms the friction torque decreased from 12.6 Nm to 8.08 Nm with the base oil and to 5.47 Nm with the lubricating composition containing the ER additive, which made a 21% reduction. The temperature reduction in the contact zone using the lubricant composition with the ER additive was 17% compared to the base oil.

The comparative wear tests showed that all lubricating compositions including additives have a certain anti-wear effect (Figure 4).

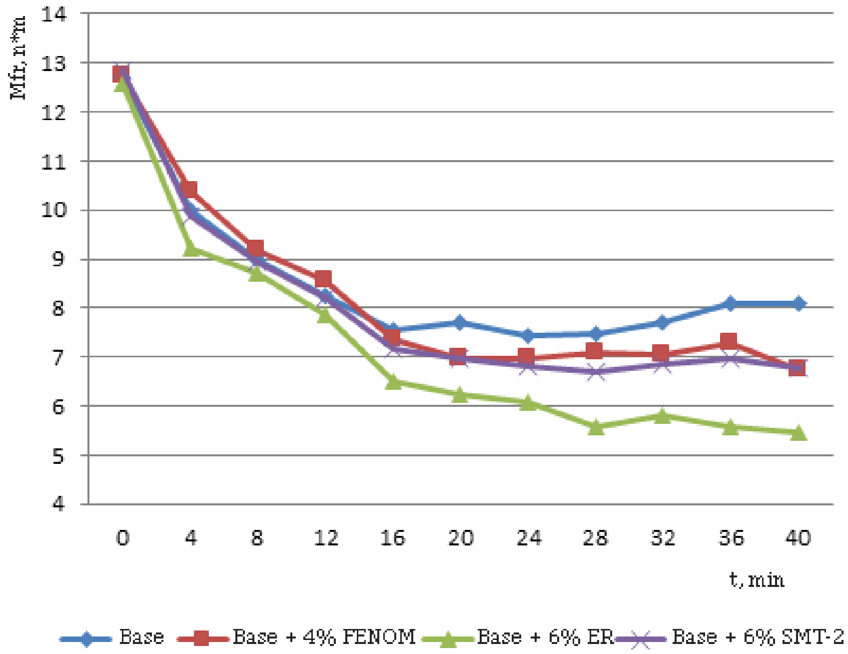

Fig. 2. Change in friction torque over the study period.

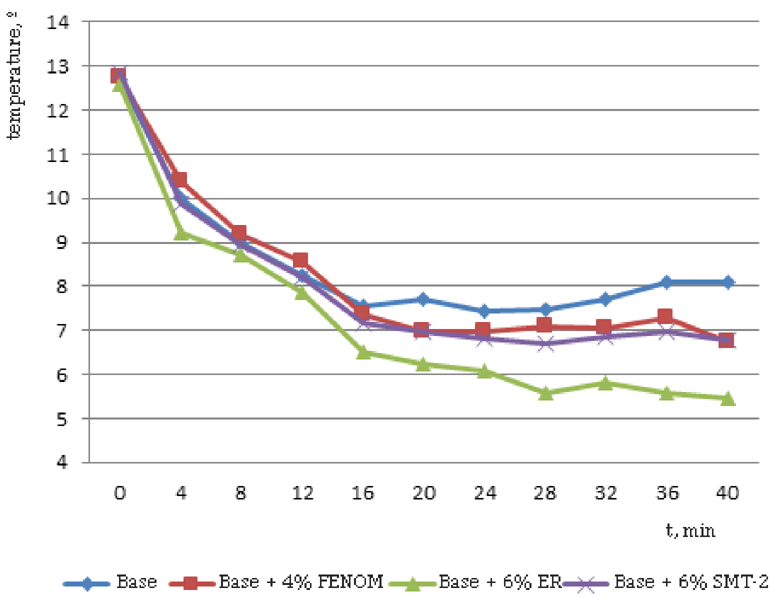

Fig. 3. Temperature change during the study period.

The wear evaluation of laboratory samples used in different lubricating compositions by weight method showed that the wear reduction compared to the base oil amounted to:

1. Base + FENOM – 26%
2. Base + ER – 46%
3. Base + SMT-2 – 37%

These results show that the lubricant composition with the ER additive has the greatest anti-wear effect.

The study of the roughness of sample surfaces before and after the tests made it possible to establish that the friction surface when lubricated with motor oil and oil with the addition of additives is also different (Table 2).

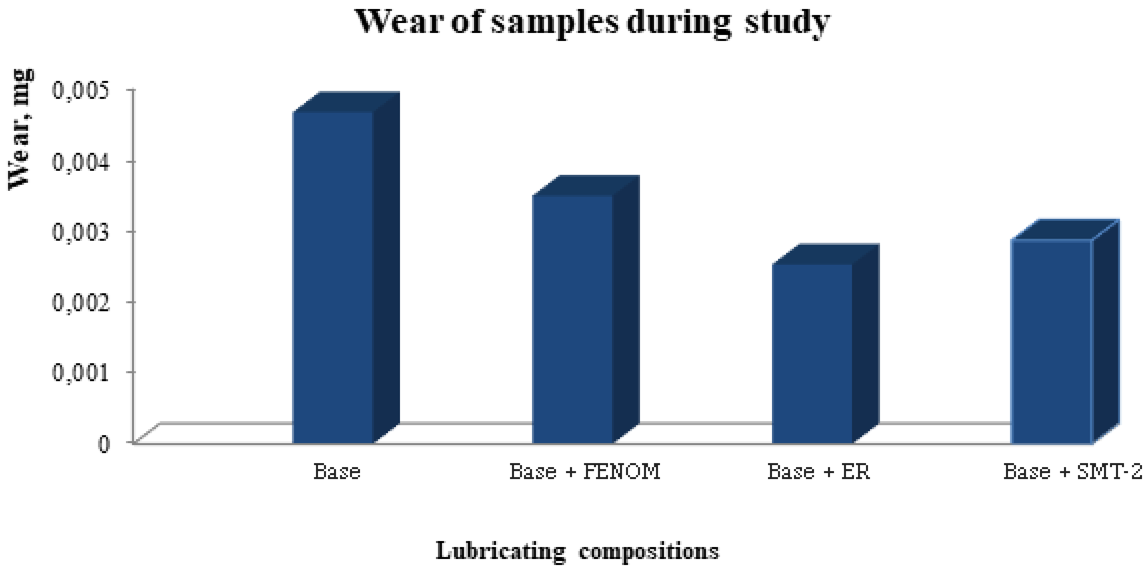

Fig. 4. Wear of samples when operating with various lubricating compositions.

Table 2. Surface roughness before and after tests.

Lubricant composition	Surface roughness, R_a, µm		Change, %
	Before tests (average)	After tests	
Base	0.358	0.326	8.9
Base + Energy Release (ER)		0.242	32.4
Base + FENOM"		0.270	24.5
Base + SMT-2		0.254	26

The roughness of the samples after base oil was Ra = 0.326 µm, and in a lubricating composition with ER additive – Ra = 0.242 µm. The roughness reduction made 32%.

4 Discussion

The comparative tests showed that all lubricating compositions provide higher tribological and anti-wear properties compared to the base oil.

The lubricant composition with the ER additive has the best characteristics among the test compositions. Its use allows reducing the friction torque and temperature in the contact zone by 21% and 17%, respectively.

The quality indicators of the running-in process are also better for this lubricating composition. Wear decreased by 46% and roughness by 23.5% compared to base oil.

The use of such lubricating compositions allows improving the quality of the run-in surfaces, which, with a decrease in wear during the run-in period, increases the post-repair service life.

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