Vol. 38, No. 4 (2016) 496-507

Tribology in Industry

www.tribology.fink.rs

RESEARCH

Tribological Studies of Antiwear Antifriction Composition and its Application

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Keywords:

Friction
Wear
Lubricant
Wearless friction
Servovite film
Coating
Running-in

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A B S T R A C T

In recent decades appeared the considerable interest in the use of the antiwear, anticorrosion and restoration technologies in friction units, including the internal combustion engines. These technologies allow reducing the friction coefficient and the wear of friction surfaces during the operation without disassembly of the components and assemblies.
The present work involves the studies of the tribotechnical characteristics of the friction pairs when using the antiwear antifrictional (AWAF) composition, injected in the lubricating medium. The results show, that injection of the AWAF composition in the lubricating material does not cause the changes in the microstructure and microhardness of the surface of friction pairs, friction coefficient decreases in 1.5 – 2 times, the amount of wear of the rubbing parts is close to zero. The obtained effect is causes by the establishing of the selective transfer process (wearless friction) with the formation of the servovite film. Application of this composition allows to improve efficiency of machines and equipment, considerably reduce the content of CO and CH as well as solid impurities in the engine exhaust gases, and reduce the running-in time of the diesel engines.

1. INTRODUCTION

The diversity of part destruction types during the friction is associated with number of physical-chemical and mechanical processes in the contact area, mainly, with environment, friction conditions and applied constructional and lubricating materials.

For a long time the main directions of the struggle against wear and the decreasing of friction forces was the increasing in the friction surface hardness. At increase in hardness of the material, decreases the mutual penetration of one surface into another, plastic deformations and oxidation processes reduce, as well as the abrasive action. Many methods was developed to increase the parts hardness: cementing, chrome plating, nitriding, surface hardening, hard-surfacing and other, that allowed to solve many issues associated with increasing in lifecycle of the machines and equipment [1,2].

However, the friction pair can be considered as a thermodynamic system, where can be the exchange of energy and substance between the friction surfaces and the external environment (lubricant), and consequently, the formation of new structures based on self-organizing processes is possible [3]. Based on this phenomenon new metalplacking additives were developed, which are injected into the lubricating materials, reduce the friction energy costs and significantly improve the wear resistance of the rubbing parts of machined and mechanisms. To this group of substances, apparently, can be attributed antiwear antifriction composition based on mineral – serpentine.

Antiwear antifriction technology with its physical nature and with its impact character on the friction surfaces is one of the varieties of methods to improve the wear resistance of the machine parts, based on the effect of the wearlessness during the implementation of the selective transfer. The selective transfer – a special kind of friction, which is caused by the spontaneous formation in the contact area of the thin non-oxidizing metal film with low shear resistance and incapable to the cold work hardening. Such a protective film with thickness 1-4 microns is called servovite.

The formation of the servovite film during the friction process is caused by its creative nature, defined by the intensity of energy and matter exchange between the friction unit and external environment, as well as the collective behavior of metal ions. The properties of the protective servovite film, formed during the friction process, are other than the original metal.

It should be noted, that during the friction the parts contact on a very small area, which is 0.01-0.001 of the nominal area of the mating surfaces. As a result, the actual contact areas are experiencing a very high stress, which leads to their mutual penetration, plastic deformation, and consequently, to the intensive wear. In case of the selective transfer the contract of mating surfaces is carried out through the actual contact area and increased tenfold.

Known the metalplacking lubricants[3-5], whose operating principle consists in forming in areas of actual contact of the protective films based on a soft metals (Cu, Sn, Pb, Zn and other), which decrease the force impact and the wear intensity of the mating surfaces. However, these materials have a number of disadvantages (the dependence of the film formation efficiency on the concentration of metals in the environment, low resistance of the dispersions of metal powders, high purity powders, etc.), due to which their application is mostly limited to plastic lubricants for the certain friction units.

It is of interest to obtain cladding layers with natural friction geomodifiers based on serpentinite, and establish the possibility of their use in the form of additives for lubricants: in oils and lubricant greases.

2. EXPERIMENTS

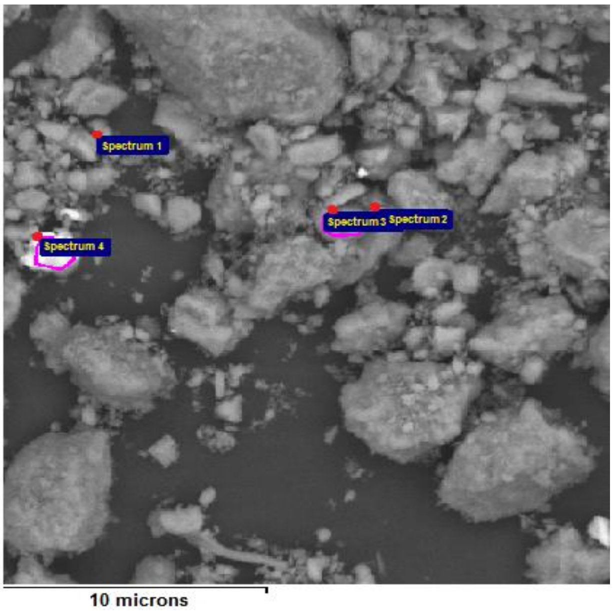
Antiwear antifriction composition [6,7] – it is ultradispersive, multi-component mixture of the minerals, additives, catalysts. The main raw materials for its production are natural materials of serpentinite group.

The decrease in the number of particles with high hardness is obtained due to the fact that after preliminary crushing and grinding of the mineral with appropriate additives (particle size 0.1 – 0.2 mm) particles of magnetite, pyroxene, and silica are removed from the mixture by an electromagnetic selection. Then the remaining part is mechanically crushed in the planetary centrifugal mill, resulting in ultradispersive powder (particle size up to 40 microns) with phase composition given in Table 1.

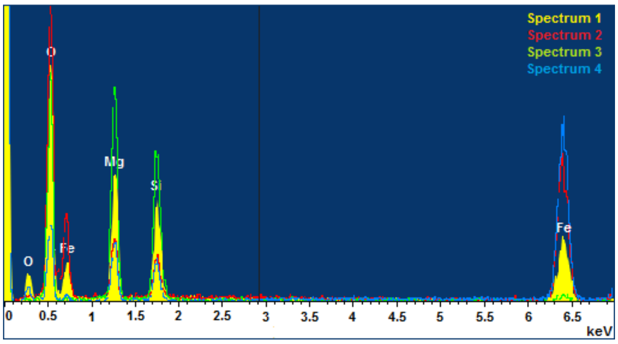
Table 1. Phase composition of the antiwear antifriction powder.

The identified phase	Chemical formula	Content, wt.%
Serpentine (chrysotile and lizardite)	$Mg_6[Si_4O_{10}](OH)_8$	78-85
Chlorite	$(MgAlFe)_2[(Si,Al)_8O_{20}](OH)_{16}$	2-3
Magnetite	Fe_3O_4	1-2
Amakinite	$(Mg,Fe)(OH)_2$	1-2
Amphibole	$Ca_2(Mg,Fe)_5(Si,Al)_8O_{22}(OH)_6$	1.5-2
Calcite	$CaMg(CO_3)_2$	0.5-1.0
X-ray amorphous phase		9-12

AWAF composition is powder with the dispersion: from 40 microns to 10 microns – 15 %; from 10 microns to 1 micron – 20 %, the rest of the composition is less than 1 micron (Fig. 1 a, b). This composition does not dissolve in oils and other carriers and does not enter with them into chemical reactions; does not change the viscosity of the oil, due to its very low concentration in it (0.05-0.1 g/l); it is not an abrasive material. Harmless both in the initial state (powder) and in the process of the running-in.



a)



b)

Fig. 1. a) AWAF structure, b) Combined spectrogram of 4 spectrums.

Metallographic studies of friction pair surfaces made from different metals (steel10 – steel10, St.45-St.45, St.45-bronze, St.45- aluminium alloy, St.45-cast iron etc.) were carried out using a microscope MIM-8 and microhardness PMT-3 with an increase from 500 to 1200-fold. These studies were conducted both for initial samples and for samples tested on the friction machine using the consistent greases (Lithol-24, Buksol, Solidol) and industrial oil I-20A with the addition of antiwear antifriction compositions of various concentrations from 0.05 to 1 %.

The obtaining of the tribological characteristics of various friction pairs for various compositions was partially carried out by means of friction machine SMC-2 and mainly by means of friction machine MTU-01. Universal friction machine MTU-01 is intended for testing on friction and wear of the metallic and non-metallic materials in terms of the various lubricants application (oils and plastic lubricants). A special feature of the friction machine is usage of original friction unit block in the friction installation, which allows keeping the parallelism of the friction surfaces during the operation, and to use as a drive a commercially available bench-drilling machine. The testing time varied from 1 to 8 hours. The pressure on the friction pair was varied in the range 1-5 MPa, the linear speed of rotating rollers was varied from 1 to 2 m/s (1000 RPM for consistent greases and 600 RPM for oils). The friction torque was determined using the load cell. The registered parameters were recorded and processed using a PC. The change in weight of the samples is determined by weighing on a laboratory scales VLE134 and electronic scales model Sartorius 1201. The surface quality was controlled visually (the presence of scratches, grooves and burrs) by means of the optical microscope at a magnification of 100 to 500-fold.

As a friction pairs were used: plates made of brass, steel 10, st. 45, an aluminium alloy, cast iron SCh 24 (same as DIN 1691 GG-25) and rollers made of steel 10 or St. 45 (hardened with a hardness of 45-47 HRC). To measure the surface roughness of the samples and parts of diesel engine before and after the running-in was used a profilometer mod. 201 factory "Kalibr".

It is known that under the same cooling conditions the temperature of the lubricating oil is directly dependent on the temperature of friction surfaces. Therefore, the change in the temperature of friction surfaces was evaluated by the temperature of lubricating oil using the thermocouple “chromel – copel”, which was mounted in a PVC tube. The thermocouple was connected to the potentiometer KSP-4.

The test of the running-in oil M-10DM with AWAF composition was carried out on overhauled diesel engines D-180. The test engines were assembled from parts that have the same size group. The inserts and CPG parts were installed new. Tests were carried out on the break-in-brake stand KI-5541M, designed for running engines of this size.

The running-in of the engines with pure oil M-10DM is carried out in modes in accordance with typical technology, and with AWAF composition in modes of the experimental technology. To register engine parameters the analyser of the pneumatic density and tightness of cylinders AGC 2.

The experiments were performed with a scanning electron microscope model VEGA2 TS 5136XM running at high and low vacuum. Scanning electron microscopes (SEM) series TESCAN VEGA- fully controlled via a personal computer.

3. RESULTS AND DISCUSSIONS

3.1 Tribological properties of the antiwear antifrictional composition

In the search for means to increase the wear resistance of the machine parts, the selective transfer during friction was discovered [3]. The selective transfer – a special kind of friction, which is caused by the spontaneous formation in the contact area of the thin non-oxidizing metal film with low shear resistance and incapable to the cold work hardening. On a film, in its turn, the polymer film is being formed, which creates additional antifrictional layer.

The complexity of the selective transfer consists in a fact that numbers of its chemical and physical processes are not found in practice of a friction research. These include the processes occurring in the servovite film, when the accumulation of dislocations during its deformation is maintained at a low level, thereby providing the wearlessness of the contacting surfaces. Servovite film – the protective metal film, appearing at the initial stage of the friction as a result of the selective dissolution of the anodic components of the material surface layer.

For the implementation of the selective transfer in the friction pairs steel-steel, cast iron-steel, etc. that do not contain film-forming material, the metalplacking lubricating materials are used. The metalplacking lubricant – the class of the lubricating materials, containing (by weight from 0.1 to 10 %) additives: powder of metals, alloys and their oxides, salts and complex compounds of metals or organometallic compounds, that release metal during the decomposition in the friction area. The most widespread metalplacking lubricating materials, which form a copper, tin or lead servovite film.

The metalplacking lubricating materials by phase characteristic are divided into homogeneous and heterogeneous. The first ones as an additives contain metal compounds soluble in a base lubricating medium, the second ones contain metal or its oxides in form of powder. However, these materials have a number of disadvantages (the dependence of the film formation efficiency on the concentration of the metals in medium, low resistance of the dispersions of metal powder, high purity of the powders and other) due to which their application is limited mainly to the plastic lubricants for certain friction units.

In recent years, a number of technical solutions appeared [4-9], according to which the layered natural hydro silicates (serpentinite, talc, serpentine, jade, dolomite and other) are used as a filler of solid-lubricant compositions. The presence of the powder of these compounds in the lubricant composition under certain conditions of its manufacturing and injection between friction surfaces and their running-in leads to the formation on the friction metal surfaces of the protective film, which significantly reduces their wear. Some authors believe that the protective layer is a servovite film [3,5]. Strength and antifrictional characteristics of the servovite film depend in particular on manufacturing conditions, composition of the lubricating material, the running-in after its injection between the friction surfaces and their state, etc.

However, it is possible to assume that the establishing mechanism of the selective transfer (ST) process and formation of the servovite film for the metalplacking additives and for antiwear antifrictional (AWAF) composition is different.

Mechanochemical activation of the AWAF composition in the planetary centrifugal mill depending on the activation time, ultimately, can lead to the formation of the nanoparticles of such size, which are commensurate with the crystal lattice parameters. Further dispersing inevitably entails restructuring (change of the crystal lattice, amorphization) with a corresponding change of all thermodynamic characteristics of the substance and its reactivity.

The presence of x-ray amorphous component (Table 1) indicates the content in the AWAF composition of nanoparticles with a developed surface, having a high catalytic ability that promotes the accelerated and efficient formation of the servovite film. Besides, nanoparticles of less than 100 nm are held in the liquid (lubricating material) by the Brownian motion that promotes the more efficient use of the AWAF composition, by reducing the concentration of injected powder, since a smaller portion is precipitated by gravitational forces or retained in the fine filter.

It should be noted, that there is an optimal time of the mechanical activation depending on the number of parameters: design of the mill, material and diameter and mass of the balls, amount of the load, rotation frequency, the medium, where the activatable composition located and the like. With further increase in processing time, the nanoparticles aggregation starts or the substance destruction will occur (mechanolysis, mechanical cracking, dissociation, etc.). When the ultrafine grinding occurs, the original mineral ceases to exist in its original structure or chemical composition, turning into a new substance with the different properties, structure and even elemental composition.

The AWAF composition particles (due to the property – the perfect cleavage) are splitted as long as do not form nanoparticles – sols. This is liquid colloidal systems with particles of the dispersed phase freely and independently from each other moving during the process of Brownian motion. In the friction area under the action of electrostatic forces, they reach the metal surface. It can be assumed, that because of the mechanochemical reactions at the friction surface, the self-organizing protective layer is formed – the servovite film.

Carrying out of tribological tests for lubricant greases using as a base: Litol-24, Solidol-G, Vaseline etc. (made by different companies) is complicated by the fact that all these lubricants contain various additives, sometimes abrasive particles, as a result the wear amount during 1-hour testing period can range from 3-4 mg up to 100 mg. In this connection, we can't clearly determine what the reason of the obtained negative result is: it is a lubricant composition or it is an added composition. Best unequivocal results are obtained when using as the base lubricating medium the natural lubricant – Soliton, which does not contain any extraneous additives. The amount of wear of the friction pairs in this medium is 4.0 mg for the plate (steel 10) and 6.0 mg for the roller (steel 10). The nature of the friction coefficient change with time under load 160 N is presented on Fig. 2.

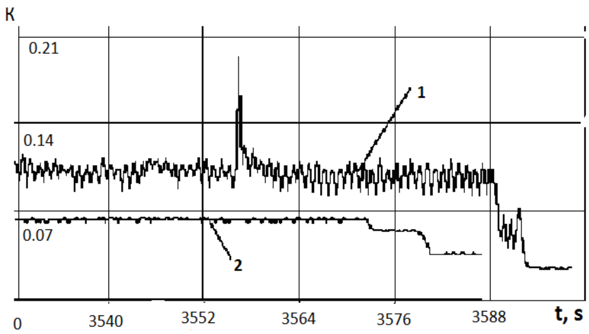


Fig. 2. Friction coefficient oscillograms: 1 – lubricant Soliton, 2 – lubricant Soliton with AWAF.

In studying the effect of concentration values of the antiwear antifrictional composition in the lubricant grease on the tribological characteristics, its concentration varied from 2 to 30 %. Research show that the increase in concentration more than 10 % leads to the increase in wear values and when concentration is 30 % the abrasive effect is being observed. Possible, that in real mechanisms the composition is not so intensely gets into a friction area as in the friction machine and it is possible to use such concentrations. In further, the research was carried out with AWAF concentration in the lubricant grease 1-5 %. Experiments show that in case of using Soliton as a base lubricant the friction coefficient decreases and its value is 0.6-0.8 from the friction coefficient of the clean lubricant (Fig. 2). Besides, on the plate surface, apparently, the protective coating is formed, since no wear been observed, but stable gain of the plate within 1-1.5 mg, i.e. of 0.8-1.3 mg/cm^2, this means that the thickness of the protective layer can be 1.5-3 microns. This effect was obtained for all researched compositions. In work [10], on a friction surfaces by means of the electronic microscopy revealed the presence of the protective film with the thickness about 6 microns having a non-metallic character.

The dependence of the mass change of friction pairs: the rollers and the plate using lubricating medium – oil I-20A, from the concentration of the injected composition varying from 0.008 to 0.06 % under the load 160 N are shown on a Fig. 3. In these cases, the weight gain of the rotating part (rollers) is observed. At that with increase in the concentration of AWAF composition up to 0.048% the weight gain of the roller is observed, but at further increase in the concentration the value of the weight gain decreases, tending to zero. For the second counter body (the plate), the weight change with increasing concentration of powder in oil up to 0.048 % is almost not observed. With increasing concentration of the AWAF composition, more than 0.05 % the value of the plate wear begins to grow noticeably.

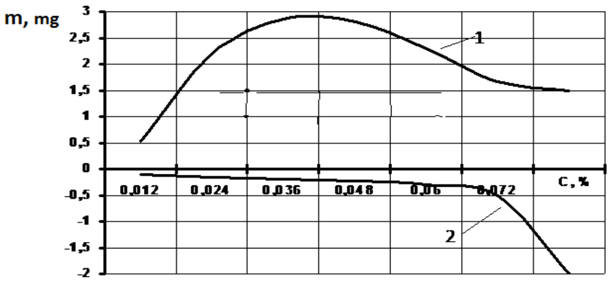


Fig. 3. Weight change of the roller (1) and plate (2) depending on the concentration of the AWAF composition (the friction pair steel10 – steel10).

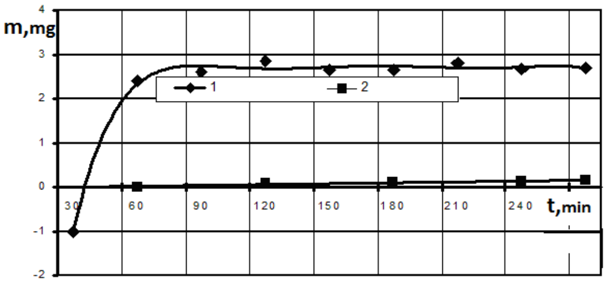


Fig. 4. Weight change of the roller (1) and plate (2) depending on the processing time (the friction pair steel10 – steel10).

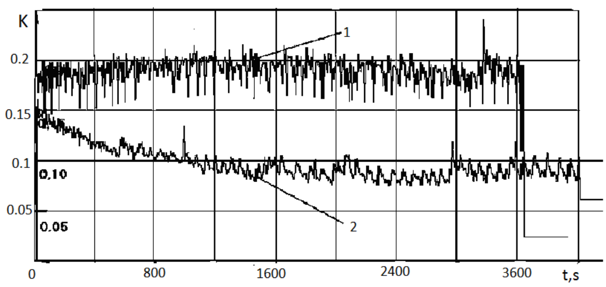


Fig. 5. Friction coefficient oscillograms: 1 – oil I-20A; 2 – oil I-20A with AWAF composition (the friction pair steel10 – steel10).

The conducted research of the wear amount (Fig. 4) and friction coefficient (Fig. 5) from the running time of friction pairs show that major changes on the friction surfaces occur mainly during the first hour of work, during which the formation of a protective (servovite) layer occur, and in further the weight of samples (roller and plate) remains unchanged.

The antiwear antifrictional nanodispersed (AWAF) composition, getting together with an oil or lubricant grease on the friction surfaces of parts, initiate the formation process on the friction surfaces of the modified coating with high wear resistance and low friction coefficient. Thus, during the process of interaction of the AWAF composition with friction surfaces the value of gap between the rubbing parts gradually stabilizes and approaches the optimal over the entire area of contact spots.

The resulting nanoparticle of the AWAF composition, apparently, have the enhanced catalytic ability, the increased reactivity and the excessive electric charge due to which they don't leave the friction area and concentrate on the metal surfaces of friction units.

One would assume that effect of the selective transfer caused not by the physic-chemical properties of the composition, but due to a size of the particles forming the composition. Thus, if the particles of some substance become commensurable with nanoparticles, then this substance could realize the process of selective transfer. To check this assumption the tribotechnical tests of lubricating substances were conducted with addition of the nanopowders (particle size less than 100 nm), boehmite (AlOOH), talcum powder, cobalt, carbon nanofiber and other. However, there were not such effect of decrease in the friction coefficient and decrease in the value of wear as with antiwear antifrictional repair-regenerative composition. This means that effect of the selective transfer is caused by the unique physic-chemical properties of this composition.

As mentioned above, modified coatings with high wear resistance and low friction coefficient are formed on the metal surfaces of the friction pairs and the effect of the selective transfer is being observed. In order to establish whether these properties decisive in the phenomenon of the friction coefficient reduction and the wear amount reduction, the tribotechnical tests of the friction pairs were conducted in accordance with the following scheme: 1 – during 4 hours the friction pair worked in the lubricating environment containing antiwear antifrictional composition; 2 – then the lubricating environment was replaced by the pure oil and alternately every hour, keeping the friction surface unchanged, the friction coefficient and the amount of wear were measured. The tests have shown that after the replacement of oil containing AWAF composition with the pure oil the protective (servovite) layer is retained on the friction surfaces, the friction coefficient and the amount of wear were slightly different from the values they had directly after work in the lubricating environment containing antiwear antifrictional composition. These results are confirmed in practice: in particular, car engines with lubricant containing antiwear antifrictional composition retained technical indicators for 50-80 thousand kilometres, despite the fact that a planned oil change was carried out every 10 thousand kilometres. It means that this composition is not simply identical to the solid lubricants, but related to the effect of selective transfer (wearless friction).

It is natural, that conducted metallographic studies of the friction surfaces and tribological tests are not enough to create action models of antiwear antifrictional composition. However, the conducted research allow to make a conclusion that with the injection of this composition into a lubricating medium the self-organizing protective (servovite) film specific to the selective transfer (wearless friction) is formed on the friction surfaces. The theory of this process is sufficiently developed for metalplacking additives [3,5,11-19], but for this moment there is no such theory for the additives based on the minerals.

3.2 Application of the AWAF composition for the treatment of motor transport engines

In recent years, dramatically exacerbated the problem of environmental protection, especially in large cities, where concentrated tens of millions of vehicles. The content of harmful components in the exhaust gases increases during the operation of the worn internal combustion engines, leaking oil through the faulty seals result in contamination of agricultural land, decline in the quantity and quality of received production, growth of diseases of people and animals, other adverse effects. Besides, usage of the low quality oil and fuel leads to additional wear of the friction pairs, power reduction, increased fuel consumption, oil burnout, and reduction of the vehicle exploitation efficiency as a whole.

The antifrictional additives provide guaranteed fuel economy by reducing mechanical friction loss and a corresponding increase in efficiency of the motor. They are most effective when the boundary friction mode, for example, between the compression piston rings and cylinders close to the upper dead points. Their advantage is their efficiency, both at low and at high temperatures.

The protective antifrictional layer, which formation is caused by the physic-chemical composition of the injected additive, could have various structures, providing the significant decrease in the friction coefficient and the amount of wear. At that with the increase in the operating time of the friction unit, the friction coefficient tends to the value 0.03 – 0.04 and the amount of wear tends to zero.

However, along with these indicators the operating results should be considered. For example, for the metalplacking compositions it is necessary to inject next portion after each lubricating medium replacement. In addition, after prolonged use occurs stripping of the protective layer from the friction surface. It should also be taken into account that metalplacking compositions are deposited not only on the friction surface, but also on the closed cavities [4].

The polymerized substances are characterized by the rapid onset of the effect of the friction coefficient reduction. However, the Teflon coating, during the process of friction unit operation, is being saturated with fine products of wear and works in further as an abrasive [4]. The uses of preparations based on molybdenum disulphide significantly increase the sulphate ash content of engine oils exceeding the permissible limits. It should be taken into account that the use of halogen compounds in the lubricants promotes the formation of acids, which increase the acid number of the base lubricant and, hence, its corrosivity.

Application of the antiwear antifrictional composition [7] allows getting on the friction surfaces the protective layer, which persists when the vehicle mileage is 50 thousand kilometres and more, i.e. during several replacements of oil in the internal combustion engines. Let us consider some of the results of the processing of automobile engines.

Application of the antiwear antifrictional composition is accomplished by direct addition into the engine according to the required concentration (the calculation is carried out depending on the quantity of the lubricant and oil in the engine). Then you can immediately continue the exploitation in the normal mode without any restrictions.

Processing of the internal combustion engine with the antiwear antifriction composition was carried out according to the scheme: - warm up to the operating temperature, - taking of testimony of the engine parameters; - processing of the engine with the repair-regenerative composition; - running-in at least 500 km; taking of testimony of the parameters. Technical condition of these engines corresponds to the category of the technical condition "acceptable". Measured parameters in the process of diagnosis for several types of vehicles are shown in Table’s 2 and 3.

Table 2. The values of compression in cylinders for the engine TATRA 815 (air-cooled).

Cylinder №	1	2	3	4	5	6	7	8	9	10
Compression before treatment, kg/cm^2	22.5	20.0	22.5	20.5	20.0	24.0	22.0	23.0	22.0	24.0
After treatment										
Compression, kg/cm^2, mileage 2 500 km	25.0	23.0	25.0	23.5	24.0	25.0	25.0	24.5	24.5	25.0
Compression, kg/cm^2, mileage 30 000 km	27.0	26.0	27.5	24.5	27.0	26.0	26.0	27.0	27.0	28.0
Compression kg/cm^2, mileage 95 000 km	29.0	29.0	30.0	30.0	30.0	29.0	29.0	29.0	29.0	29.3

Table 3. The results of processing engine of Opel Astra car.

Car	Opel Astra			
Full mileage	106540	106632	106900	107870
Mileage after application		92	360	1330
Oil level	MAX	MAX	MAX-0,2 kg	MAX-0,5 kg
Compression				
1°	9	14.4	14.9	14.9
2°	6.5	14.4	14.8	15.3
3°	12.5	14.4	14.8	15.2
4°	14.4	14.4	14.9	15.3
Exhaust gases				
The gas temperature	55 °C	55 °C	55 °C	55 °C
CO	1.2-1.7 %	0.06 %	0.06 %	0.00 %
CO_2	14 %	14 %	13.70 %	14 %
O_2	0.48 %	0.25 %	1.20 %	0.51 %

The engine processing with the antiwear antifrictional composition leads not only to wear reduction of the parts, but also to the certain stabilization of gaps. Especially it concerns the cylinder-piston group and the crank mechanism. This in turn leads to a decrease in the impact intensity of the parts and, consequently, to noisiness reduction.

As known, one of the main sources of the engine wear is the start-up mode, especially at low temperatures. The engine processing with the antiwear antifrictional composition simplifies the cold start conditions, due to the reduction of power losses to overcome the friction forces, and reduced start-up time. In addition, the growth of the compression also facilitates start of the engine. This has a positive effect on reducing the wear of all interfaces of the friction units.

3.3 Application of the AWAF composition for running-in of the vehicle engines

Carrying out the running-in of the vehicle aggregates, such as internal combustion engine and elements of the transmission, is caused by the presence of defects in the manufacture and assembly of parts and components leading to the grasp of the friction surfaces and the possible appearance of burrs on them and also the need to identify possible hidden manufacturing defects.

It is known, that most of the vehicle don't need the operational running-in, however, for some of them it is mandatory process step both at automotive factories and repair shops. The necessity of the running-in, as a technology operation, is caused by the fact that even when the perfect assembly and accordance of the waviness and roughness of working surfaces to the drawings requirements, almost impossible in other process steps to achieve optimal tribological properties of the surface layers of friction parts. Running-in largely determines the reliability of a diesel engine, especially in the initial period of operation and at a minimum of the running-in and steady-state wear of the tribological connections provides the increase of the diesel engine resource.

For the diesel engine, the duration of running-in is 30-40 machine hours or about 5000 km of mileage for the vehicle. The development of mechanical engineering indicates the need to accelerate this process and reduce it to 2-3 min., necessary to control the operability of the product and identify possible hidden defects.

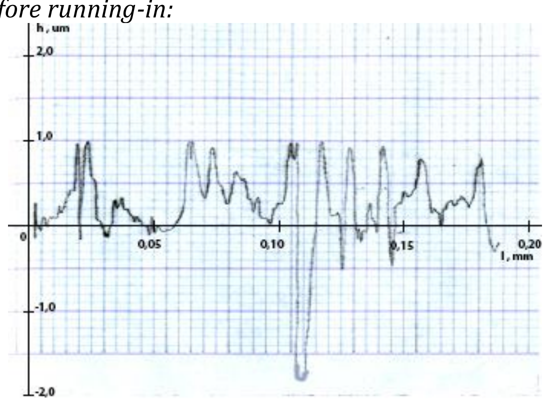
When the running-in there is a change in geometry of friction surfaces and physico-mechanical properties of surface layers of materials during the initial period of friction, manifested under constant ambient conditions and consist in reducing friction, temperature and wear rate. Running-in of the parts is carried out at the automotive factories and repair shops in the process of bench testing and in households - consumers during the operational running-in. It should be understood that almost any disassembly of rubbing joints leads to necessity of carrying out operations of running-in of the reassembled unit with loss of a part of interrepair resource on the running-in wear. The application of the running-in preparations will not only allow to reach faster the normal operation mode (reduce the running-in time) but also significantly increase the overhaul life of machinery units (improve the quality of running-in).

Adding the AWAF composition in the oil M-10DM contributes to the acceleration of the running-in and improvement of the quality of the run-in surface, since this composition contains the most effective components of lubricating and plastically-deformable action - the serpentine and magnetite. When the temperature of friction surfaces increases over 473 °K (hot running-in) the serpentine forms on the friction surfaces, in places of their contact, a thin antifriction film which is able to withstand a higher load than the lubricating film of mineral oil. At that, the contacting irregularities are not cut off, but plastically deform under a film of the serpentine. The force and temperature of friction significantly decrease.

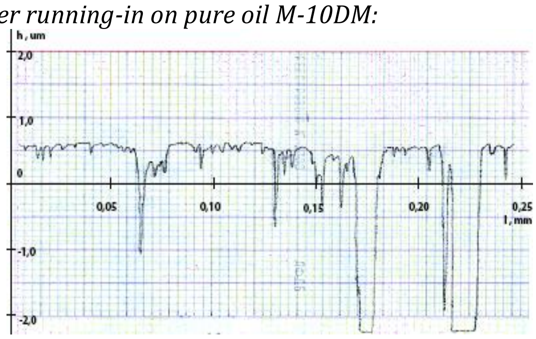
The presence of the hard magnetite particles in oil should lead to the intensive wear of the friction surfaces. However, small abrasive particles don't intensify wear, but also inhibit to it [15]. In some cases, the particle size of less than 5 microns is considered safe and even beneficial. This is due to the polishing effect. Mechanical impurities contained in the used oil, wherein the dispersant effect of the additives is weakened, represent complexes, in the centre of which are located the solid abrasive particles coated with a multilayer colloid protection consisting of the polar-active oil oxidation products. The positive impact of these particles is manifested in the fact that they intensify heat transfer between the friction surfaces, increase the electrical conductivity of the oil film and eliminate the roughness on the surface. Furthermore, the micro abrasive enhances physic-chemical processes in the friction area, causing slight deformation of the surface layers and the formation of new surfaces, which are active sites for chemical reactions and diffusion processes. The presence of the micro abrasive particles up to 1.5 % in the lubricating oil decreases the friction coefficient, accelerates the formation of the optimal micro relief on the entire contact area.

The quality of the running-in is estimated also by the intensity of surface roughness change depending on the test time. It is known, that the initial surface roughness of the rubbing parts becomes operational roughness. The formation of the operational roughness is influenced by a complex set of different kinds of mechanical, physic-chemical, electro-chemical and other processes occurring in the contact between two rubbing bodies. Therefore, in the work was studied the surface roughness of the friction pair "piston ring - cylinder liner" using the studied running-in oils as a lubricant. The initial roughness of the friction surfaces of both samples (roller, plate) R_a = 0.63 microns. Fig. 6 shows the profilograms of samples surfaces before and after running-in.

Before running-in:



After running-in on pure oil M-10DM:



After running-in on oil M-10DM with AWAF composition:

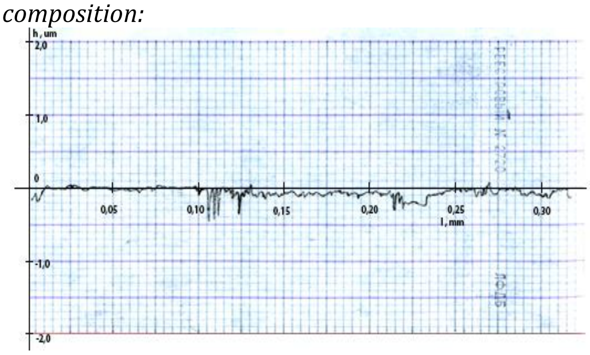
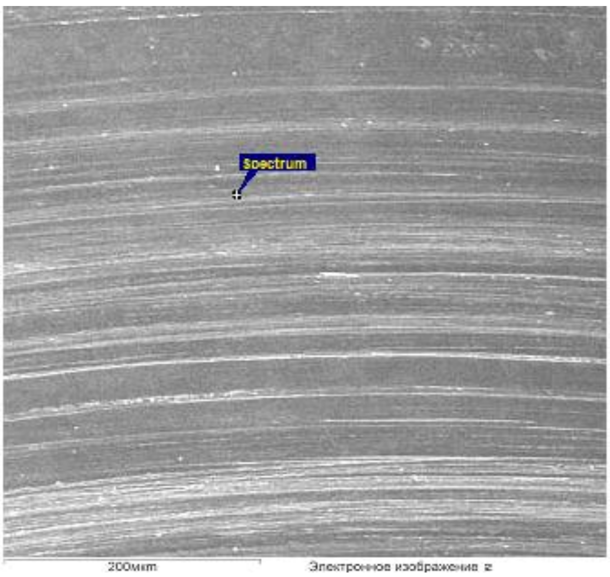
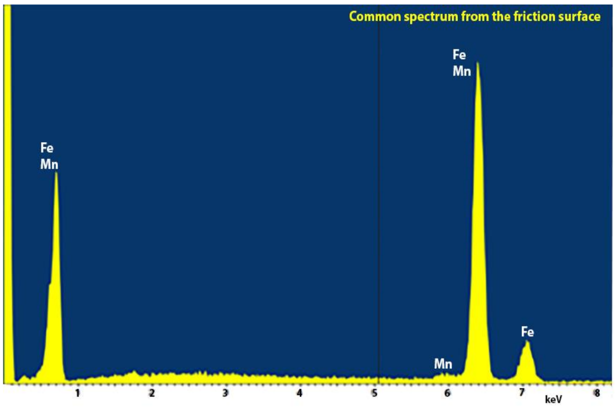


Fig. 6. The profilograms of friction surfaces of the parts samples.

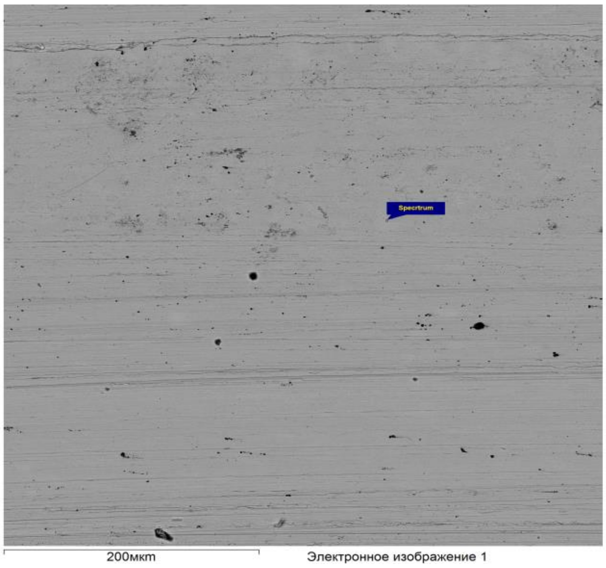


a)

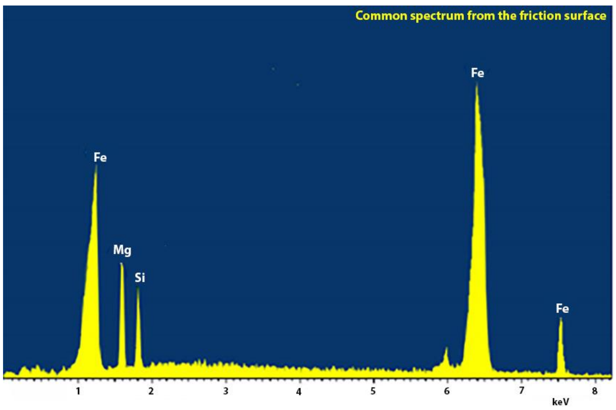


b)

Fig. 7. a) sample surface, run-in on oil M-10DM, b) the spectrogram of the sample surface, run-in on oil M-10DM.



a)



b)

Fig. 8. a) Sample surface, run-in on oil M-10DM with AWAF composition, b) The spectrogram of the sample surface, run-in on oil M-10DM with AWAF composition.

The best results obtained on the oil M-10DM with AWAF composition. Thus, the roughness stabilized after a 30 minute test on the value of

R_a = 0.14 microns, which is 60 % less than with pure oil M-10DM. Within 15-20 minutes of the tests, takes place the plastic smoothing of the roughness peaks up to the platforms, which gives a better distribution of the load and the reduction of the actual pressure between the rubbing pairs. The nature of changes in these parameters shows that the running-in process takes place under more favourable conditions and completes much earlier as compared to pure operating oil, i.e. serpentine and magnetite, which are included in the AWAF composition allow to speed up the running-in process of parts and get higher physical and mechanical properties of the friction surfaces.

In studying the sample surfaces, lapped in the oil M-10DM with AWAF composition, it was found the presence of a metal-ceramic layer. This fact is confirmed by the X-ray microstructure analysis of the surface (Figs. 7 (a, b) and 8 (a, b)), which shows that the sample surface consists of iron, magnesium, silicon, and carbon. The presence of such elements as magnesium and silicon indicates that the elements of the AWAF composition bind to the surface of the running-in sample.

4. CONCLUSION

As a result of the X-ray spectral, metallographic analysis and tribological tests of the friction units using the lubricating materials containing the antiwear antifrictional composition, it is established that no hardened layers with high hardness is formed on the friction surfaces. Injection of the AWAF composition in the lubricating material does not cause changes of the microstructure and the microhardness of the surfaces of friction pairs, wherein the friction coefficient is reduced in 1.5-2 times, amount of wear of the rubbing parts is close to zero. We consider that the resulting effect is mainly caused by the establishment of the process of selective transfer (wearless friction) with formation of the servovite film.

Thus, in order to establish the process of selective transfer (wearless friction) using the metalplacking additives it is necessary to pick up their composition so that the particles were in a dissolved state, then using the antiwear antifrictional composition based on the layered silicates this requirement is eliminated and it is possible to inject them into any lubricating medium.

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