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Reduction of Friction by Electric Action on Oils

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Abstract: In the well-known research, testing tribometer TRB-S-DE, in the operation of hundreds of cars confirmed the effectiveness of low-cost and a significant reduction in friction and improvement of working properties of interfaces of components operating in motor and gear oils under electrical stress on the oil. Thus, by 2007 the Kharkiv Academy of railway transport proved the efficiency of processing of motor and hydraulic oils in a constant field up to 1000 V/cm. And by 2013, the Academy has provided heavy machinery Donbass several models of devices for such processing of motor and hydraulic oils. However, Lyubimov D. N. with colleagues provided a more simple method of processing oil - supply voltage converters +12V /+ 50V on the dipstick, or other isolated parts washed by the oil. This was tested at Tallinn University on the Timken friction machine, at the Helsinki diagnostic centre by two tests of the car on a drum stand (fuel economy up to 22.4%) and a bench test of the engine with fuel economy of 3.7%. And in St.-Petersburg Polytechnic University, Shabanov A. Yu. in bench trials of the engine the VAZ-2108, measuring 276 parameters, convincingly showed a varied effect of the filing of charges in oil: mechanical losses decreased by 5.5%, fuel consumption by 4.3%, the exhaust gas temperature by 6-10°C, the content of co and CH by 19%, but NOx increased by 6.53%. The effective efficiency of the engine increased by 4.62%, and the power-by 1%. That is, the savings in gasoline and diesel engines are close. Therefore, in Russia, Lyubimov D. N. converters are already used at 330 facilities. In tests of the Nanocenter at the Moscow Institute GOSNITI on the tribometer TRB-S-DE voltage of +12...33 V and +48 V was applied to the electrodes of iron, graphite, copper, aluminum, zinc and tin, mounted in oil with finger groups steel pin-on-disc. Tests at a sliding speed of 100 cm/s were carried out at a stepped loading to a pressure of 220 MPa. A 3.5 - fold reduction in friction and wear was obtained at low loads, less - at medium and without effect in the nominal mode. In 2018, on 29 modern Russian and imported cars, the supply voltage even on steel parts in engines, in transmission units provided fuel savings of at least 3, in different conditions 10-18, mainly 7-8%. Tribological treatment Pustovoi I. F. by serpentine composition «Fe-do» of the four units of the car's Ford F-150 and emission of charges in their oils have reduced the fuel consumption from 15 to 10-11 l/100 km. Recent testing demonstrated the effectiveness of applying a voltage of 100 V.

Keywords: Electricity, Engine, Friction, Fuel Consumption. Oil, Wear

1. Introduction

Reducing friction and wear is always an urgent task. In this it is important to improve lubricants, for which new bases of oils and additives are created, and during operation a variety of additives are introduced into the oils.

Modern oils and greases have a complex of working properties of high quality, but due to the complexity of production and high prices. Opportunities to continue their improvement in the petrochemical industry is limited and is not economically justified. And physics and chemistry have an arsenal of little-used methods to improve the tribotechnical properties of oils.

Such methods of continuous modifications of working oils can be electrical, magnetic, electromagnetic treatment, changing the structure and properties of hydrocarbons of oil and additives. These effects through the destruction of conglomerates of molecules of additives and oils, the formation of active radicals, the polarization of oil components, the saturation of their charges and the transfer of charges on the surface of friction lead to a change in the tribological properties of oils [1-9].

According to chemmotology, electrostatics is removed from molecules in processed hydrocarbons and therefore they are dispersed, but according to another opinion, hydrocarbons - dielectrics are dispersed precisely because of their polarization in the external field [1-9].

According to the views of the processes on the friction surfaces (physical and chemical adsorption), as well as between the lubricant molecules, they are all affected by electrical and magnetic influences.

The first theories determine the time of formation and «life» of the boundary lubricant, its tribology. The latter theories affect the viscosity-temperature properties of the lubricant, the formation of lubricant layers and the phase state of the additive. However, despite the electrical nature of interactions in the tribosystem, little attention is paid to it in tribology.

The main wear of mates under normal conditions occurs at boundary and mixed friction. Here, an important role is played by adsorption on the parts of polar and polarized in friction molecules of lubricants, additives, additives with the influence of external electric and magnetic fields. But there are not many studies of this effect [10, 11], although some regularities of triboelectrization are revealed, the series of substances by their ability (Faraday, Gezehaus), where it is mistakenly believed, that the bodies are electrified by opposite charges, although it is convincingly proved, that there are no charges different in sign.

According to some data [4, 11], it is believed, that the polar components of oils under the influence of surface energy are combined into globules, which reduces their interaction with friction surfaces and reduces the antifriction properties of oils. From here, the globules of additives and oil clusters, can be destroyed by electric action on the oils, ensuring their orderly adhesion, which, as confirmed by tests [4, 11], significantly improves the tribotechnics of mates. There is also a direct supply of voltage to the friction parts, to the parts washed by crankcase oil.

For example, in the case of a DC voltage of 60 V to a pair of friction in a four-ball machine, Zaslavsky Yu. S [10] reduced the coefficient of friction by 40%. At a voltage of + 4 V, a brown oxide film with a decrease in roughness was formed on the disk and a current of 5 mA wear was practically absent, traces of machining were preserved, but abrasive wear was on the balls. When after 30 minutes the electricity was turned off, we received a very good burnin disk with a coefficient of friction of 0.02. But when applied to the disk minus 4 V tribology deteriorated: the coefficient of friction is increased, the disc without oxide films were intense wear, and the wear of the balls decreased.

In tribotechnical tests with a magnetic field, magnetization of wear particles occurred, a «protective layer» was formed and oxidative, rather than abrasive, wear occurred, since the wear particles themselves were oxidized.

In Moscow University «MADI», a constant current was applied to the cylinder liners of the YaMZ-236 diesel truck MAZ-500. A year later, almost complete absence of wear and prevention of carbon deposits in the cylinder piston group (CPG) was revealed.

Dubinin A. D. [11] have shown the voltage pulses to 192 V and current to 0.03 A by friction of the parts and blow them off the ball. This shows that the electrical processes in friction are more complex than expected. And if the metals have different electric potentials, in tribological pair possible electric erosion current. In general, the results of various studies of triboelectric phenomena are ambiguous.

When friction charge hold only dielectrics and semiconductors, and with conductors charges quickly drain, but they can be controlled by voltage and current. Hence, understandding their dynamics, the relationship with the frictional force and wear rate, it is possible to better optimize the parameters of a tribological pairings.

Hence, the paper presents the way of use of emission charges in the petroleum products, carried out successful laboratory and field test, the proposed innovation at voltages up to 100 V at the electrodes of soft metals in engines, transmissions, hydraulic equipment.

2. Materials and Methods

Laboratory performance studies were conducted on the engine oil M-10G_{2K}. In oil with four laboratory devices with a unique device of ERT, with three industrial converters applied voltage of 3, of 32.9, and 50 V DC, unipolar current with frequency 10, 100 kHz and 1 MHz using copper, aluminum, tin, zinc, coal and iron electrode.

Tribotechnical tests were conducted on the TRB-S-DE tribometer by the Swiss company SCM-Instruments. Operational tests were carried out on a passenger car VAZ-2131M, and colleagues on 27 different imported cars, similarly equipped with on-board means of fuel consumption control.

Very thoroughly laboratory on a tribometer and bench on gasoline and diesel engines tests of emission of charges in oils are carried out by the pioneer of innovation, the candidate of technical Sciences Lyubimov D. N. in Tallinn University, twice-in the Helsinki diagnostic center, at St. Petersburg University twice in six modes (276 measurements) with control of load, mass and specific consumption of gasoline, indicator, mechanical and effective efficiency of the engine VAZ-2108, the content of exhaust gases CO, CHx, NOx. The efficiency of electric charging is shown for gear oil.

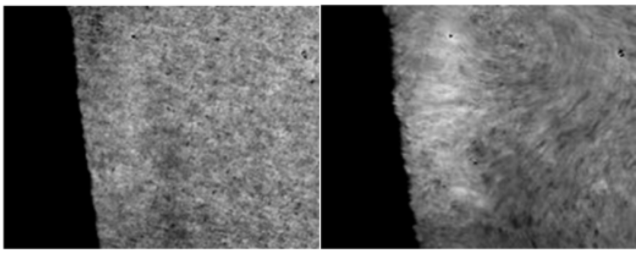
3. Laboratory Research and Discussion of the Results

Electrophysical and tribotech-nical studies with electric treatment of oils were carried out at the Ukrainian Academy of railway transport by the scientific school of prof. Lisikov [3-8]. The influence of electros-tatic, magnetic and electromagnetic fields on the oil is investigated. It is confirmed that they have a significant effect on the molecules of additives and polar molecules of oils [3-8].

Initial premise at the Academy all polar (electrically charged, having an electromagnetic dipole moment) molecules of oil components in non-polar oil tend to minimize free energy. They combine into globules and are highly sensitive to external fields. Therefore, there is a mechanism to control the phase transitions of the polar components of oils, and most importantly – to control their interaction with the tops of the roughness of parts having unsaturated valence and thus a mechanism to improve the tribological properties of friction pairs. But this mechanism requires further study and optimization.

Supposed to form a multi-molecular layer as you gain, eat force fields of surfaces of friction by the supply of energy from the outside [3] and electro-static, electromagnetic effects of the additive when their micelles or dissolved in strong fields, or converted to an ordered group di dipole «packages» [3]. Otherwise: suggested three options for the adsorption of polar components oil on the friction surfaces: micelles, monomer and most the valid - ordered molecular «packages».

Microphotographs of oil samples (Figure 1) are used to confirm the influence of the electric field on the orientation of the polar components of oils, where the structures of untreated and electrostatically treated oil can be seen [7].

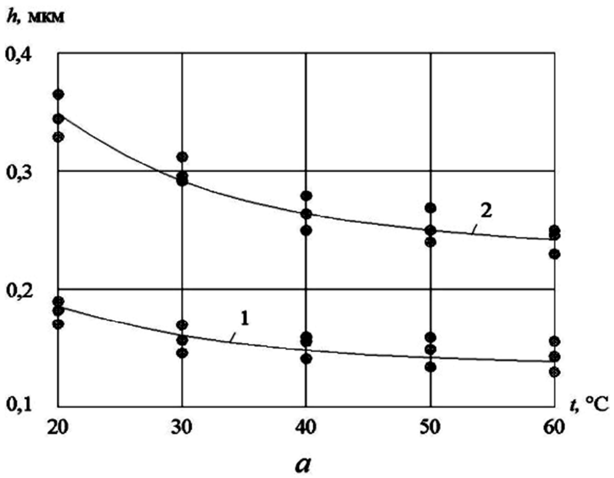


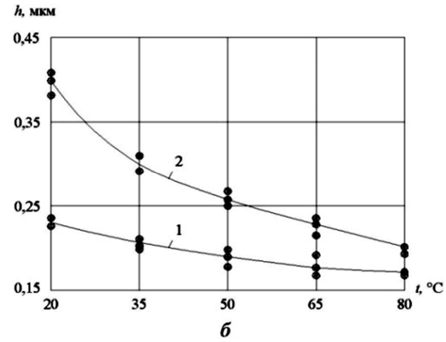
a b

Figure 1. Microphotography of the Liqui Moly oil CC, 10W-40 in the interelectrode space (x1000), where the darkened region is one of the electrodes [3].

a - without applying voltage to the electrodes; b - the voltage on the electrodes 500 V and the ordered arrangement of the molecules of the oil components can be seen

By the «stack of layers» by A. S. Akhmatov [12] measured the thickness of the lubricating film of various oils (Figure 2).

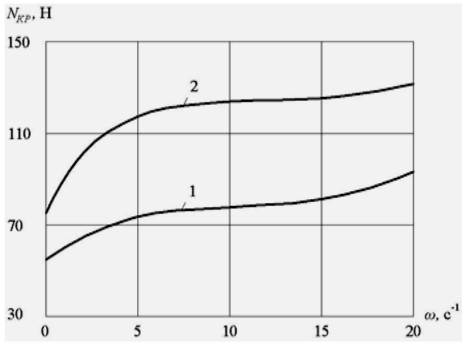




a - oil MGE-46V; b - M-14G$_2$; 1 - without electrostatic effects; 2-with him

***Figure 2.** Dependence of lubricant film thickness on oil temperature [3].*

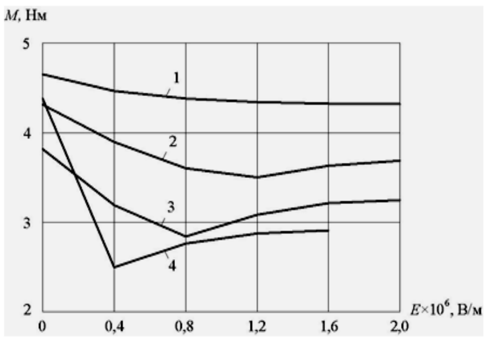
It can be seen that the electrostatic effect on the oil doubled the thickness of the lubricant layer, especially at lower temperatures, which is probably due to the presence in the oils of a large number of surfactant units. But with increasing temperature, they are destroyed, the number of monomers increases, the desorption of molecules from the surface of the parts increases and the thickness of the lubricant layer decreases sharply.



1 - without electrostatic action on the oil; 2-with the effect of

***Figure 3.** Bearing capacity of oil MGE-46V depending on the speed of the upper ball of the tribo-machine MAST-1 [3, 7].*

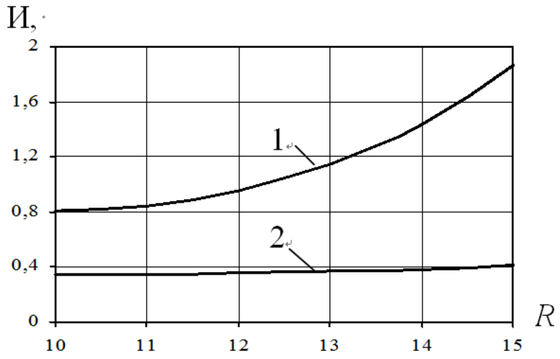
The increase in the thickness of the lubricant layer leads to an increase in the bearing capacity of the lubricant layer by 30 – 40% (Figure 3), to a decrease in friction forces (Figure 4) and wear (Figure 5) of the bronze block - steel roller pair.



1 – 0; 2 - 0,1%; 3 – 0,2%; 4 – 0,3%

***Figure 4.** Moment of friction forces in the pair of «pad-roller»» pair depending on the electro-static field for oil I-20A at a pressure of 8 MPa, sliding speed of 0.25 m/s and the concentration of stearic acid to 0.3% [3, 7].*

Note: The bearing capacity of the lubricant film was determined by the magnitude of the critical load (Nкр) at which the film was destroyed and the electrical resistance in contact with the four ball friction machine of the upper ball with the lower [3, 7].



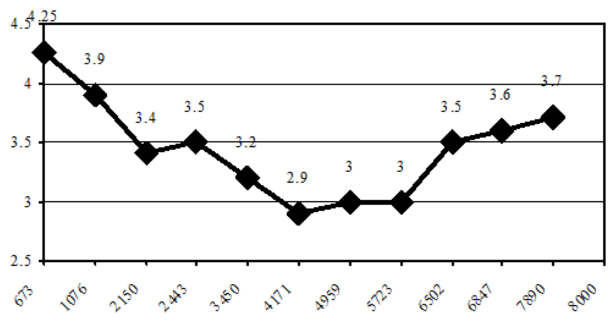
1 - without electrostatic action on the oil; 2-with the effect of

Figure 5. *The dependence of the wear rate (И) bronze pads on the steel roller, similar to the plunger pairs of hydraulic pumps, on the «СМЦ-2» tribo-machine, depending on the purity class «R» of MGE-46 oil: with pure oil, the wear rate is reduced by 4 times [3].*

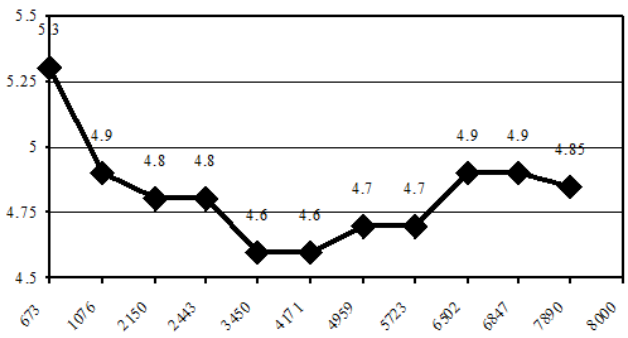
According to the tests (Figure 4), it is proved [3], that the lubricant layer formed from the «packages» significantly reduces the friction force. When injected into the oil I-20A stearic acid without electrostatic treatment, the friction moment has a minimum at an acid concentration of 0.2%, and its increase increases friction. That is, without electrical, oil flows micellar adsorption of surfactants. And in the treated oil with «packages» of components, adsorption increases, the friction moment has a minimum at high acid concentrations and is even more reduced (curve 4) [3].

The formation of groups of molecules of fatty acids in the polymolecular layers was noted by Akhmatov A. S. [12]. However, according to the Ukrainian Academy, molecules of surfactants can coagulate into micelles with a minimum of surface energy and weakly deposited on the details. Therefore, it is argued [3, 7], that electrostatic action on the globules of additives can rearrange their micelles into polar «packages».

For continuous electrostatic treatment of oils in the Academy created several variants of voltage converters and devices [3, 7], through which the oil flows into the oil sump diesels, hydraulic tanks. Figure. 6 shows examples of the effectiveness of one of these devices.



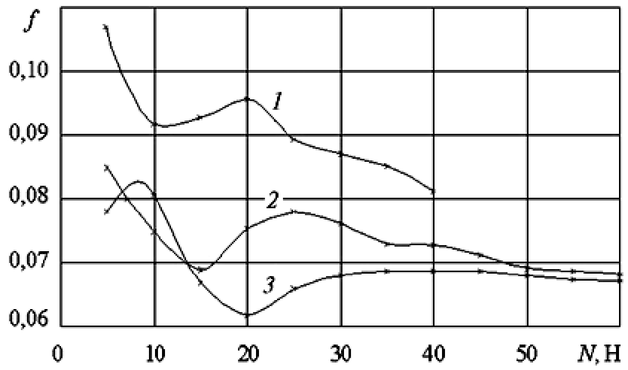
a) - at idle



b) at lifting of the empty arrow of the excavator

Figure 6. *Dynamics of oil pressure at idle of Isuzu 6hk1 diesel engine on operating time of Hitachi 330 excavator [7].*

In the Nanocenter research Institute GOSNITI on the tribometer TRB-S-DE with a couple of «pin on disc» tests of 10 samples of oils M-10$Г_{2K}$, pumped Ph. D. Shore B. I. in electronic fuel catalyst from ing. Evgrafov I. V. (Moscow research Institute VIESH), i.e. exposed to electromagnetic field (7.5-9.0 kV, 7-8 kHz). Figure 7 shows some of their results. Similar results were obtained in the testing of oils treated in the same way by the candidate of technical Sciences V. V. Serbin (Moscow research Institute VIESH) [13].



1-initial oil; 2, 3 - oils exposed to different intensity

Figure 7. *Reduction of the friction coefficient of the «finger — disc» pair in the oil M-10G_{2K} depending on the load at a sliding speed of 100 cm/s from 0,087 to 0,068 for the oil after electromagnetic action.*

In another way, the electric impact on the oil in the engineering Center «Lyubimov & Company» (L&C) [14-19] is realized: an electric charge is supplied to the oil through the isolated parts. It is assumed [8, 9], that the polarization of lubricant molecules is realized, which increases their adhesion to friction surfaces, changes the type of their structural orientation, increases the thickness of the lubricant film and the rate of cladding of friction surfaces by active agents of the lubricant medium.

Developed in the Center «polarizer» [14-19] can be installed in any units, its use is easier, for example, through an isolated oil dipstick (figure 8), drain plug or part in the crankcase, insert into the oil filter, etc. The action of the device is constant, does not depend on the lubricant, the type of coupling, load and speed modes. more than 300 polarizers have been tested on internal combustion engines, pumps, gearboxes in oil production.

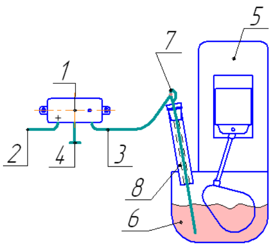


Figure 8. *Connection diagram of the polarizer to the internal combustion engine from Lubimov D. N. [14-1 9].*

1 - polarizer, 2 - power input, 3 - output to the oil dipstick, 4 - output to the mass of the unit, 5 - unit, 6 - oil unit, 7 - oil dipstick, 8 - insulating tube (caprolon)

Laboratory tests of the polarizer were first carried out on the friction machine «Timken» with castor oil according to GOST 18102 (polar, surface-active medium with a high iodine number). At the same time, there were no bullies in the pair, i.e. the boundary lubricant film on the friction surface was held stronger.

In the nanotechnology center of the Institute GOSNITI tested steel tribological pairs «pin-on-disc» in the engine oil M-10G$_{2k}$ on the efficiency of reducing friction and wear of tribological pairs in the feed to the oil electricity. With the standard TRB-S-DE tribometer test method in step loading mode, electricity was introduced into the oil flow behind the finger of the vapor through different electrodes.

At the beginning, tests were carried out on models simulating the polarizer of the «L&C» Center, but with a low-frequency voltage of 3 V and a high-frequency voltage of the unipolar signal of 32.9 V. Their analysis showed that the models of the polarizer in the low-frequency output signal (5-30 kHz) slightly reduce the coefficient of friction at medium and high loads, and at a voltage of 32.9 V this decrease is the largest to 0,010.

Revealed that to reduce wear steel tribological pairs «pin-on-disc» (Figure 9) 1,5 times more favorable low frequency (to 10 kHz) and high signal voltage.

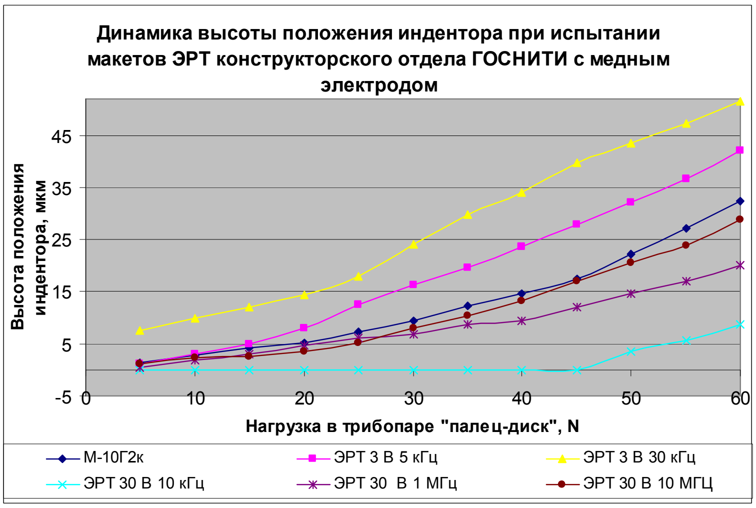


Figure 9. *Test results of model samples of the electronic friction regulator when electricity is supplied to the oil through the copper electrode [13].*

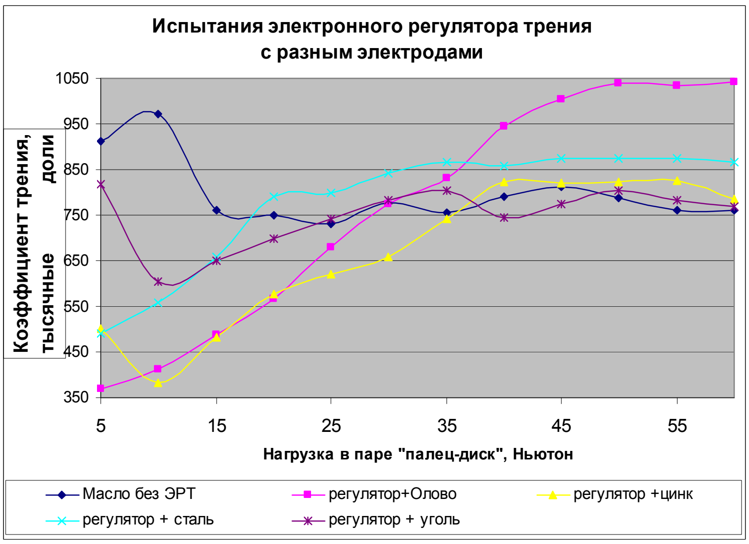


Figure 10. *Test results of the polarizer from the «L&K» Center: with a zinc electrode at a load of 10 N, the friction coefficient decreased by 0,0589 [13].*

Tests and polarizer were carried out from the by device of center «L&K» with copper, aluminum, tin, zinc, steel and carbon electrodes (Figure 10). They showed increased, in comparison with the models, the efficiency of the standard polarizer at low, medium and high loads (reduction of the friction coefficient from 0,0193 to 0,0589).

Control of oil M-10G_{2K} under the action of the polarizer showed that at a distance of 1 cm between the electrodes placed in the field of its action, a voltage of 2.8-3.1 mV was revealed. In general, in the tests of institute GOSNITI, the friction coefficient of the tribopar in the oil subjected to electric action decreased from 0,08-0,09 to 0,037, and wear - by 3,5 times.

Bench tests of the polarizer. In Finland, in a certified laboratory with an AUDI A4 car, long-term polarizer tests were carried out on a drum stand in stationary load-speed modes with simulation of a long country drive in a constant mode: the number of revolutions of the diesel crankshaft 1500 min^{-1} (85 km/h) and 2500 min^{-1} (142.09 km/h), the viscosity class of the oil 15W-40 [16, 17, 19]. It was revealed that at the speed of 85 km/h the economy was 22,4%, and in the forced mode 142 km/h – only 3,7%.

Also conducted bench tests on the engine in the forced mode (engine speed 2000 Rev/min. torque 95 Nm). At the same time, the economy of the fuel was at least 3,2%. Thus [16, 17, 19], both Finnish tests showed a fuel economy of about 4%.

Similar to [19] efficiency recorded in bench trials, the engine VAZ-2108 Ph. D. Shabanov A. Yu. at the Polytechnic University (St. Petersburg): 276 results of control parameters of internal combustion engines is shown that the mechanical losses in internal combustion engines decreased 5,5%, fuel consumption by 4,3%, exhaust gas temperature by 6-10°C, the content of CO and CH by 19%, but NOx increased by 6,53%. The effective efficiency of the engine increased by 4.62% and power by 1%. Subtotal, fuel economy was revealed both on petrol and diesel engines [16, 17, 19].

The action of electro-treated oils on the friction surface, apparently not, modification of oils improves tribotechnics indirectly. Its greatest efficiency is manifested after a certain period (200-500 km), due to the time of accumulation of processed portions of oil in the friction interface. Therefore, taking into account the strict observance of safety, it is possible to increase the output voltage to 100 V, which has already been tested in «L&K» Center.

According to the operational data of the center «L&K» [16, 17, 19] reduction of gasoline, diesel and gas fuel consumption with polarizer reaches 10-12%. But when it is turned off parameters of the internal combustion engine decreasing to the original. For 2019 in Russia more than 327 domestic and imported engines are working with polarizer. Their owners has noted an increase in «pick-up» of the vehicle.

The polarizer, as well as the reception of Moscow University MADI voltage supply to the cylinder liners of diesel YaMZ-236 (journal of Road transport, 1985), cleaning the cleaning cylinders from carbon deposits, lightening the oil, contributes to a noticeable increase in the life of the engine.

In ASTM studies, it is accepted, that if the oil provides 1,5% (Energy Conserving I) or 2,3% (Energy Conserving II) fuel efficiency, it is considered energy-saving [19]. Because of this, the polarizer can be referred to energy-saving facilities.

Operational tests of the polarizer from company «L&K». These tests are conducted in GOSNITI ing. Zeleznicky A. I. on the car VAZ-2131M, twice they are fully processed by the geomodifiers (injection engine VAZ-21214, mileage 55372 km). Continuous fuel consumption controlled device «Prestige y55» electronic control unit engins. Passport consumption – 12,0 l/100 km of gasoline A-95, the actual – 9,5 l/100 km of gasoline A-92.

Averaged over 5 measurements of fuel consumption during the test were as follows:

a. to supply electricity to the oil 7,2-6,5 l/h, an average of 6,75 l/h;
b. when supplying electricity on average – 5,96 l/h, a decrease of 0,79 l/h;
c. after a power cut-off on average - 6,14 l/h.

The minimum difference between costs without electricity and with it – 0,18 l/h or 3%, and in comparison with urban driving about 9% [13].

Extensive testing of the polarizer with the introduction of serpentine modifier friction surfaces «F-do» is carried out Engineer Pustovoi I. F. [13, 19] He substantiated the connection of a polarizer after only 1-2 thousand kilometers from the complex tribological processing engines. Preventry of tribo-composition removes various deposits from the friction surfaces, partially compensates for their wear, which allows more efficient use of the polarizer when the juvenile friction surfaces are open. It is original that the voltage from the polarizer is supplied to the isolated part in the drain plug of the oil sump of the internal combustion engine.

After a complex tribo-treatment during the run of 25 cars on the same section of the St. Petersburg – Petrozavodsk route, the fuel consumption according to the car control readings decreased by 5-6%, and after switching on the polarizer it decreased by 2-3%. Total savings increased to 7-9%. But if the polarizer is included in the process of tribo-processing, the effect of its application is insignificant or within the error of fuel consumption control.

The polarizer was also tested after tribo-treatment by the «Fe-do» composition of the transmission units, the voltage from it was fed into the oils through isolated rods in the drain plugs of the units. After connecting the polarizer, fuel consumption was further reduced by 1,5-2%, i.e. by 8,5-11% [13].

On the car Ford F-150 (gasoline engine V-8) with a mileage of 250 thousand km fuel consumption on the specified control track was 15 l/100 km, and after the described integrated treatment of the internal combustion engine with subsequent connection of the polarizer, the consumption was left – 13,7 l/100 km. The connection of the polarizer to two tribo-treated drive axles and to the transfer box reduced fuel consumption to 13,2 l/100 km. In further operation, the consumption was reduced to 10-11 l/100 km [13].

Test stimulus into oil using industrial transducers is made Inzh. Ryzhov V. G. 2 cars were under control. The first- AUDI 100, V-6, 2,8 l, fuel injection, manual gearbox. The second car - AUDI A4, engine-diesel 2,4 l, turbocharged, manual gearbox [13].

The first car engine repaired, and after processing of serpentine with triboactive «RVD» run-on 8 thousand km of established fuel consumption in the mixed mode of operation was 10,6 l/100 km.

With the converter adjusted to the maximum output voltage of 47.2 V, at the beginning of october 2017 the car passed 17,760 km. All observations of the car were carried out in mixed modes of operation. Control fuel consumption according to the indications of the onboard computer of the car.

The first oil was of viscosity class 5W-40 and in the first 2 hours of travel the changes were not recorded but then the «softness» of the engine was noted. The first all-wide surveillance – the run from Moscow to Yekaterinburg, 2250 km trip, the fuel savings amounted to 8-12%. On the return trip with a trailer (load 400-450 kg), the fuel economy increased to 16-18%, i.e. the consumption was as in the movement without a trailer.

Then 10W-40 viscosity oil was used. In the first 2500 km, no reduction in fuel consumption was detected, but then began saving about 12%, which remains to this day. It is noticed that on the warmed-up engine fuel economy is more than in short trips on the cold engine. The average fuel consumption was 9,6 l/100 km, which is the minimum for the engine management program, but the actual, in mixed mode was 8,5-8,6 l/100 km, and without connecting the converter 9,6-9,8 l/100 km.

It is noted that the converter is more effective with used oils than with fresh ones, and the more the oil is thinner. When the viscosity of the oil 5W-40 fuel economy is considerably greater than the viscosity of 10W-40. At the speed of the crankshaft up to 3000-3200 min^{-1} fuel economy is recorded clearly, and at a frequency of more than 3200 min^{-1} (speed more than 120 km/h) savings are not detected.

On the second car with the connected converter passed 11800 km, 5W-40 viscosity oil was used. Fuel consumption was recorded in urban and highway conditions. After treatment of internal combustion engines triboactive «RVD» average consumption was 4,2-4,3 l/100 km. After switching on the converter the flow rate decreased to 3,9 to 3,8 l/100 km on the testimony of an onboard computer, and in fact, i.e. decreased by 11,05% [13].

4. Results

Thus, all our studies have shown the effectiveness of the emission of charges into liquid oils in all components and assemblies of machines and equipment, when not only their life is extended, but also reduces the energy consumption for their drive.

5. Discussion

Studies have not covered the problem of the emission of charges into the oil. There is not strong understanding and knowledge of the most effective charging mechanism of the oils, their transfer charges in the friction pairing, the interaction of charged molecules of the oils with friction surfaces. It is not clear the delay in improving the lubrication of charged oils and its rapid disappearance with the shutdown of emission. It is important to determine the limit of voltage and frequency of direct or unipolar or alternating current to the electrodes, their best location to the oil flows to the friction units, the most effective electrode materials.

6. Conclusion

Electric impact on the oil with proper use – low-cost effective resource-saving tribo-technical reception in the operation of all self-propelled machines and stationary equip-ment. However, this technique is subject to extensive operational tests in various engine-ering products, optimizing the voltage and frequency of the unipolar or asymmetric sig-nal from the source of charges to the oil, for example, with regular current generators on machines and equipment. It is required to test electrodes made of zinc, magnesium alloys or with coatings of them for installation in the motor oil, in the oil drain line from the oil cooler, in the oil filter, in the main oil line of the internal combustion engine. The install-lation site of the electrodes should provide the highest flow rate of the charged oil com-ponents into the friction mates, especially at high sliding speeds in them. The most neces-sary metal to the electrodes, which would provide the highest intensity of charge emis-sion and the highest emission of metal atoms from the electrode in the interface of fricti-on and cladding of their surfaces, has not been clarified.

It is also required to find out which components of base oils, additives to them are most susceptible to charges from electrodes and to ions of their atoms, how does the operational change in the composition and properties of oils affect their susceptibility to the emission of charges in them. Solving these issues can change the ideology of anti-friction, anti-wear, extreme pressure additives to oils.

It is advisable to expand the approbation of charge emission in transmission and hydraulic oils, as well as various industrial DC converters.

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in Kharkov, Tallinn, Helsinki, St. Petersburg, Chistopol, which is reflected in the literary references.

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