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*Corresponding Author:
*** A.V. DUNAEV**
Federal state budget scientific institution «Federal scientific engineering Center VIM», Russia, 109428, Moscow

Email: *dunaev135@mail.ru*

Experience in the use of Electrical Stimulation Oil and Friction in them

A.V. Dunaev
Federal state budget scientific institution «Federal scientific engineering Center VIM», Russia, 109428, Moscow

Abstract

Analysis of the results of well-known studies, original laboratory, as well as operati-onal on dozens of cars, confirms the possibility of low-cost and noticeable improvement of tribotechnical properties of mates working in motor and transmission oils by electrical ex-posure to them. In laboratory tests, DC voltage supply of 12-33 V, and possibly up to 100 V, on parts made of copper, aluminum, zinc and tin alloys, washed with oil, achieved a significant reduction in friction and wear at low loads, less - at medium and no effect in the nominal mode. In the conditions of operation, the modernization of machines by sup-plying DC voltage to the oil-washed insulated even steel parts in the engine and transmis-sion units provides savings of at least 3, in different conditions, 10-18, and mainly 12% of motor fuel. The same expedient processing of oil hydraulic equipment.

Keywords: electricity, oil, friction, wear, complex processing, tribotechnical composition, the internal combustion engine, the transmission assembly, the fuel consumption.

Introduction

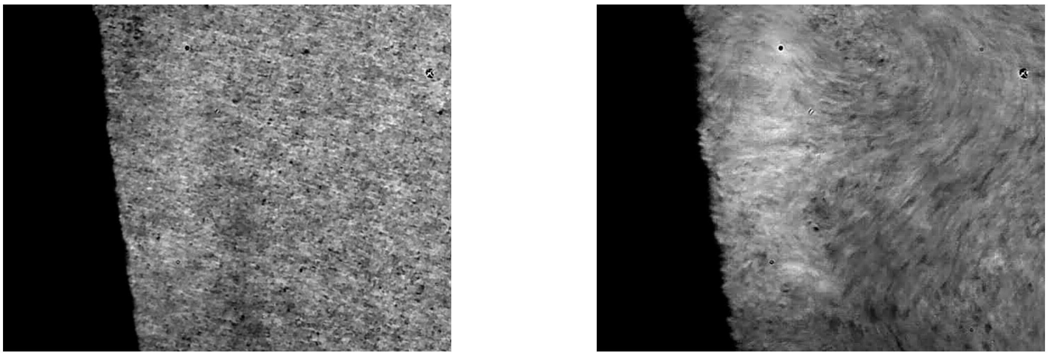
Reducing friction and wear is always an urgent task. In this it is impor-tant to improve lubricants, for which new bases of oils and additives are created, and dur-ing operation a variety of additives are introduced into the oils. Modern oils and greases have a complex of working properties of high quality, but due to the complexity of production and high prices. Opportunities to continue their imp-rovement 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, magne-tic, 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 [1-4]. According to chemmotology, electrostatics is removed from molecules in processed hydrocarbons and therefore they are dispersed, but according to another opinion, hydrocar-bons - dielectrics are dispersed precisely because of their polarization in the external field [1-4]. 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 fric-tion. 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 [5, 6], 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 [2, 3] 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 globu-les of additives and oil clusters can be destroyed by electric action on the oils, ensuring their orderly adhesion, which, as confirmed by tests [2, 3], 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, ZaslavskyYu.S 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 burn-in disk with a coefficient of friction of 0.02. But when applied to the disk minus 4 V tribology deteriorated [5]: 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. [6] 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 potenti-als, 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, unders-tandding their dynamics, the relationship with the frictional force and wear rate, it is pos-sible to better optimize the parameters of a tribological pairings.

Problem statement:

The task is to carry out laboratory tests to identify the reduction of friction, wear when exposed to electricity, as well as operational tests to improve the efficiency of machines, where the impact of electricity on motor and transmission oils is used.

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 [2, 3]. 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 [2, 3]. Initial premise at the Academy all polar (electrically charged, having an electromag-netic 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 ha-ving 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 [2] 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» [2]. Otherwise: suggested three options for the adsorp-tion 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 [3].



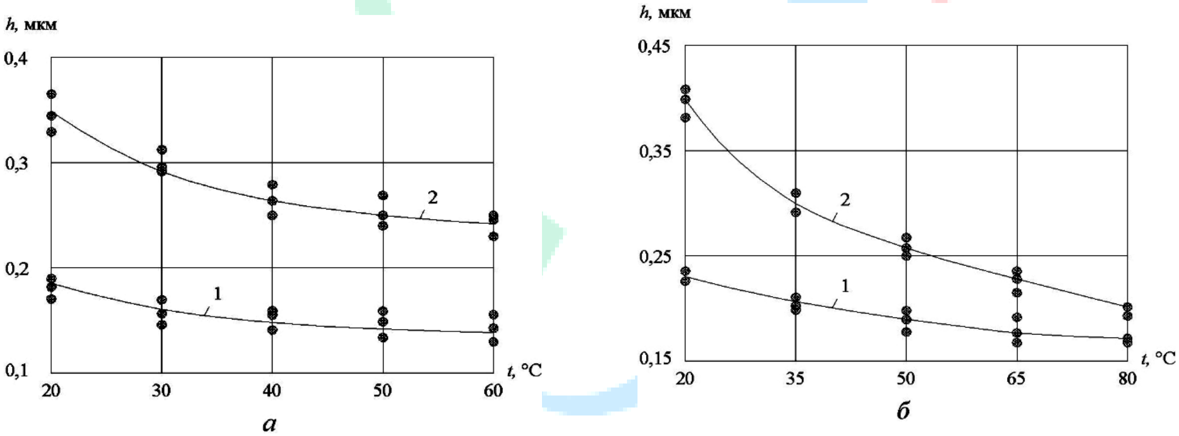
A B

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

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 [2]

By the «stack of layers» by A.S. Akhmatov [7] measured the thickness of the lubricating film of various oils (figure 2).

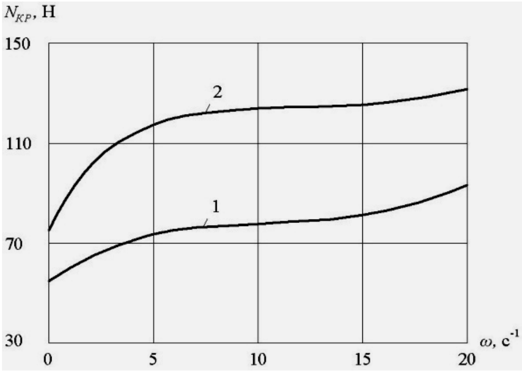


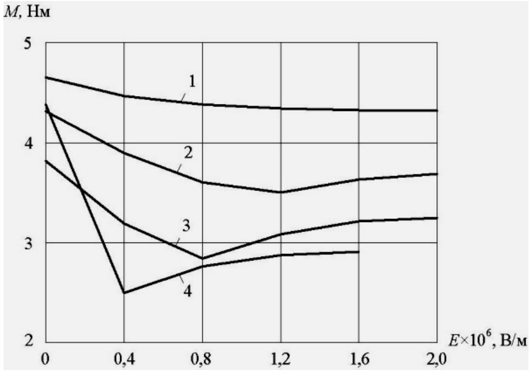
a - oil MGE-46V; b - M-14G$_2$; 1 - without electrostatic effects; 2-with him

Figure 2: Dependence of lubricant film thickness on oil temperature [2]

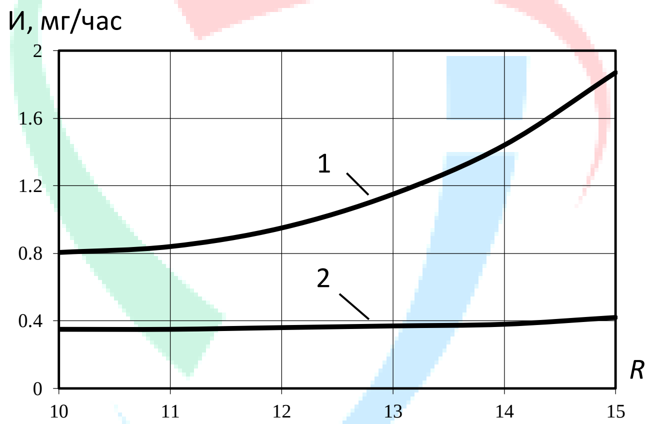
The electrostatic effect on the oil doubled the thickness of the lubricant layer, especially at lower temperatures, which is probably due to the presence in the oils of a large number of surfactant units. But with increasing temperature, they are destroyed, the number of monomers increases, the desorption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

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 [2, 3].





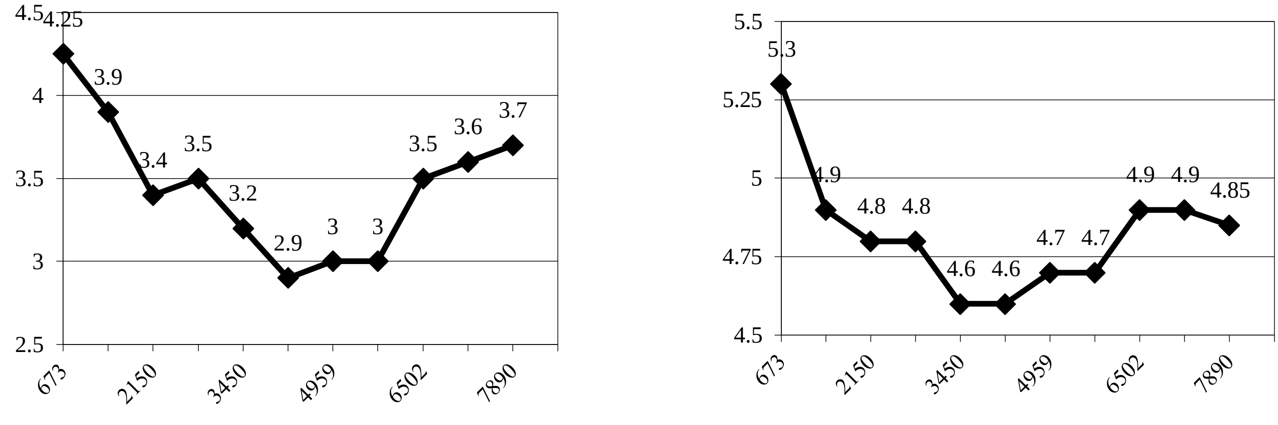
1 - without electrostatic action on the oil; 2-with the effect of **Figure 3:** Bearing capacity of oil MGE-46V depending on the speed of the upper ball of the tribo-machine MAST-1 [2, 3]	1 – 0; 2 - 0,1 %; 3 – 0,2 %; 4 – 0,3 % **Figure 4:** Moment of friction forces in the pair of «pad-roller»» pair 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 % [2, 3]



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 mach-ine, depending on the purity class «R» of MGE-46 oil: with pure oil, the wear rate is reduced by 4 times [2].

According to the tests (figure 4), it is proved [2], 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) [2]. The formation of groups of molecules of fatty acids in the polymolecular layers was noted by Akhmatov A.S. [7]. 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 [2, 3], 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 [2, 3], through which the oil flows into the oil sump diesels, hydraulic tanks. Figure 6 shows examples of the effectiveness of one of these devices.

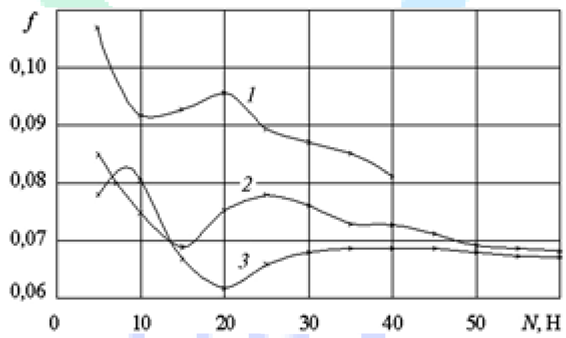


a b

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 [2]

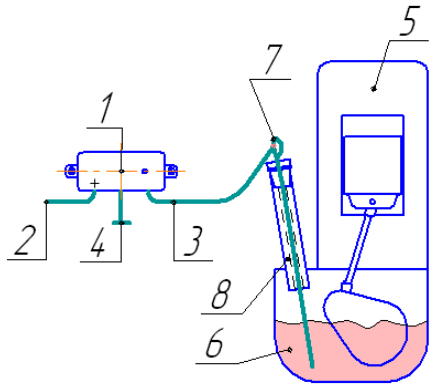
In the Nanocenter research Institute GOSNITI on the tribometer TRB-S-DE with a couple of «pin on disc» tests of 10 samples of oils М10Г$_{2K}$, pumped Ph.D. Shore B.I., in electronic fuel catalyst from ing. Evgrafov I.V. (Moscow research Institute VIESH), i.e. exposed to electromagnetic field (7.5-9.0 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).



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) [8] is realized: an electric charge is supplied to the oil through the isolated parts. It is assumed [8], 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» [8] 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.



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)

Figure 8: Connection diagram of the polarizer to the internal combustion engine

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.

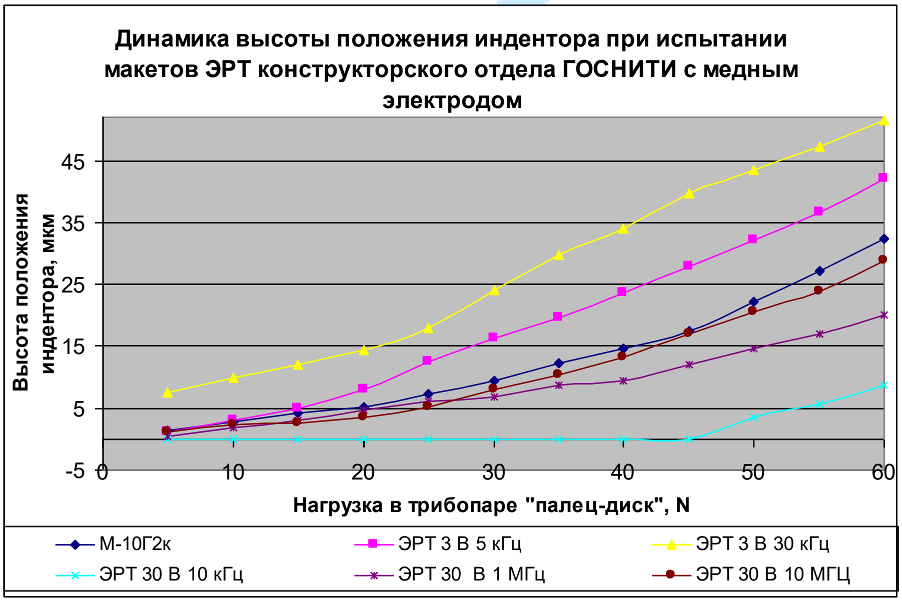


Figure 9: Test results of model samples of the electronic friction regulator when electricity is supplied to the oil through the copper electrode

Tests and polarizer were carried out from the 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).

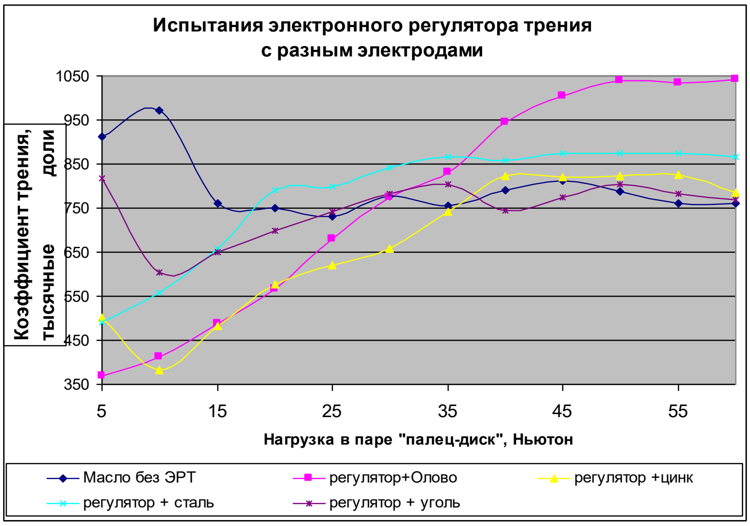


Figure 10: Test results of the polarizer from the «L&K» Center: with a zinc electrode at a load of 10 N, the friction coefficient decreased by 0, 0589

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 and discussion of their results

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 [8]. 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 [8], both Finnish tests showed a fuel economy of about 4 %. Like [9] 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 are 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 internal combustion engines increased by 4.62 % and power by 1 %. Subtotal, fuel economy was revealed both on petrol and diesel engines [8, 9]. 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. According to the operational data of the center «L&K» [8] 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 300 domestic and imported engines are working with polarizer. Their owners have noted an increase in «pick-up» of the vehicle [8]. 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 [8]. 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. Zeleznick 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:

- to supply electricity to the oil 7,2-6,5 l/h, an average of 6,75 l/h;
- when supplying electricity on average – 5,96 l/h, a decrease of 0,79 l/h;
- 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 %. Extensive testing of the polarizer with the introduction of serpentine modifier friction surfaces «F-do» is carried out Engineer Pustovoi I.F. [9] 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 %. 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. 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. 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 %.

Conclusion

Electrical impact on the oil is a low-cost effective resource-saving tribotechnical technique. However, it is subject to the optimization of the voltage of the current source, the development of electrodes from zinc, magnesium alloys for installation in the motor oil, in the drain line from the oil cooler, in the oil filter, in the main oil line of the engines. Appropriate electrification oils and in hydraulic equipment.

References

1) Ashurov V.A., Syunyaev Z.I., Ivankovsky V.E. Application of external force fields to improve the quality of lubricants /Chemistry and technology of fuels and oils. - Moscow: Chemistry, 1988.- P. 34 – 41.
2) Alexandrov E.E., Kravets I., Lysikov E. and others. Increasing the resource of technical systems through the use of electric and magnetic fields /NTU «KPI». - Kharkiv, 2006. - 544 p.
3) Voronin S.V., Dunaev A.V. The influence of the electric and magnetic field on the mechanism of action of additives to oils / Friction and wear, 2015.- Vol. 36.- № 1.- P. 643-649.
4) Golikov Y.I. Belokonev D.V. Patent of the Russian Federation № 2373405. Filter «ECOMAG-200G» magnetic cleaning and processing of engine oil of the internal combustion of the car.
5) Zaslavsky Yu.S., Artemieva V.P. New in tribology of lubricating materials: Monograph / M.: Publishing House «Oil and gas» RGUNG im. I.M. Gubkina, 2001.- 480 p.
6) Dubinin A.D. Energy of friction and wear of parts / Kiev: Mashgiz (southern branch), 1963.- 140 p.
7) Akhmatov A.S. Molecular physics of boundary-value physics / M.: Fizmatgiz, 1963.- 472 p.
8) Lyubimov D.N., Dolgopolov K.N., Vershinin K.N., Dunaev A.V. Antifriction efficiency polarization oils – an innovative factor in the modernization of machines / M.: Proceedings of GOSNITI, 2014.- Vol. 116.- P. 40-44.
9) Lyubimov D.N., Dolgopolov K.N., Pustovoi I.F., Shabanov A.Yu. Effects of the use of minerals as active agents of lubricating media / Tractors and agricultural machinery, 2015.- № 3. - P. 38-44.