Vol. 39, No. 3 (2017) 302-306, DOI: 10.24874/ti.2017.39.03.04

Tribology in Industry

www.tribology.fink.rs

RESEARCH

Investigation Antiwear Properties of Lubricants with the Geo-Modifiers of Friction

I. Levanov[a], A. Doykin[a], E. Zadorozhnaya[a], R. Novikov[b]

[a] *Department of Motor Transport, South Ural State University, Chelyabinsk, Russia,*
[b] *Scientific and Engineering Center "RS LSM" UB RAS, Ekaterinburg, Russia.*

Keywords:

Lubricants
Gear oils
Geo-modifiers of friction
Antiwear properties

Corresponding author:

Igor Levanov
Department of Motor Transport,
South Ural State University,
Chelyabinsk, Russia.
E-mail: levanovig@susu.ru

A B S T R A C T

The article describes the influence of the geo-modifiers of friction on the antiwear properties of lubricants. Geo-modifiers of friction are the fine powders of mineral materials. This work is directed on the investigation the influence of the geo-modifiers of friction in the form of the hard lubricant compositions, which based on a mineral serpentine, on the anti-wear properties of greases and gear oils. This composition is the fine powder serpentine with the addition of components such as chalk, borax, kaolin and talc. We compared the antiwear properties of the greases without geo-modifiers of friction and the antiwear properties of greases containing the geo-modifiers of friction from 0.5 % to 3 %. The Litol-24 and transmission oil TAD-17 was used for testihg. The four-ball machine of friction was used for tests accordance with GOST 9490-75. As geo-modifiers the serpentine was used, the fraction of which has a size from 0.87 microns to 2.2 microns. Such parameter as the wear scar diameter was used for evaluation of the antiwear properties of lubricants. As a result of tests it was established that the antiwear greases properties improved on 26-50 % depending on the concentration of the geo-modifiers of friction based on the pure serpentine.

© 2017 Published by Faculty of Engineering

1. INTRODUCTION

Geo-modifiers of friction are natural minerals that are added to lubricants to improve their tribological properties, in particular anti-wear properties. In the early 90 s of the last century it was established that the minerals of the serpentinite group possess the best tribological properties among a lot of rocks [1].

Many studies [2-8] indicated an increase of a wear resistance of friction units when the friction geo-modifiers type of serpentinite was added to the lubricant. However, the tribological properties of the lubricant composition depend on a chemical composition and a structure of serpentinite. Since serpentinite as the rock usually contains up to 45-50 % of serpentine, and the rest 7-8 % of magnetite, up to 10 % of aluminosilicates, titanium oxides, calcium (basalts) and silica. Many natural serpentinites are unsuitable for the production of additives to lubricants due to the increased content of abrasives such as SiO_2. The use the unknown composition of serpentinite can lead to a negative result [6].

Breki [2] investigated the effect of nanosized serpentinite on the tribological properties of aviation oil MS-20. He showed that nanosized serpentinite increases the ultimate load capacity of the lubricating layer by 11-20 %, reduces the wear spot by 15-33 %, reduces the boundary friction by 26-41 % relative to the MS-20 oil, which does not contain additives. The author also showed that a mass concentration of serpentinite 1-2 % in the oil MS-20 provides the lowest values of the wear scar diameter. However, the work does not provide information about the composition of used serpentinite.

Nigmatullin et al. [3] investigated the effect of serpentine on the tribological properties of oxidized lubricants. Serpentine produced in the Republic of Bashkortostan was used. The authors concluded that a self-assembled protective metal-ceramic coating (film), which is characteristic of selective transfer (the effect of non-weariness), is formed on iron-containing friction surfaces when serpentine is added to an oxidized lubricant (industrial grade I-40 oil, compressor oil KS-19). Lubricating composition of oxidized oil KS-19 with the addition of serpentine (0.3 %) and $MnO2$ (0.05 %) ensures the greatest efficiency of the friction units. The wear scar diameter is reduced by 40 % when testing the lubricant composition on the four-ball friction machine. The authors also note an increase in the microhardness of the friction surface. Unfortunately, there is also no information about the structure of serpentine.

Medvedev et al. [4] investigated the effect of the particle size of serpentinite on the anti-wear properties of Litol-24 grease. The authors concluded that particle size of 1 μm does not have a positive influence on the antiwear properties of the lubricating composition. The anti-wear properties of the composition with particle serpentinite sizes 10 μm and 30 μm begin to appear at low concentrations. In [5], the authors studied the effect of a mixture of talc and serpentinite on the anti-wear properties of the grease plastic Litol-24. The particle serpentinite sizes were 10 μm, talc was 15 μm. The total mass concentration of the mixture was 10 %. The authors showed that when the mixture of serpentinite and talc was added to the grease, the antiwear properties of the base lubricant are improved. In this case, the wear scar diameter depends on the ratio of talc and serpentinite. The best results are achieved when the percentage of components in the mixture (talc relative to serpentinite) is 100 % to 0 %. Wear is slightly increased with the percentage of the mixture of talc-serpentinite 45/65 %.

Duradji et al. [7] investigated the effect of the antifriction antiwear lubricant composition based on the natural mineral of the serpentinite group. The authors presented the phase composition of the antifriction anti-wear composition, in which 78-85 % is serpentine $Mg_6[Si_4O_{10}](OH)_8$, the rest is additives and catalysts. The composition tested by the authors did not contain any abrasive particles, was chemically neutral, did not dissociate in oils, and did not change their viscosity. The authors investigated the tribological characteristics of the base plastic lubricants Litol-24, Solidol-G and others with the addition of the composition and showed that the friction coefficient is reduced in 1.5-2 times, wear is significantly reduced, abrasive wear is observed with the serpentine concentration of more than 30 %. Serpentine in engine oil M-10DM significantly improves the running-in of the internal combustion engine and does not lead to a change in the microstructure and microhardness of the friction surfaces.

Skotnikova et al. [8] investigated the effect of minerals from the serpentinite group (antigorite, lizardite, chrysotile) on the antiwear properties of motor oils. The authors presented the dependences of the wear rate on the contact pressure and showed that the addition of the lizardite particles with sizes of 3-5 μm in mineral engine oil leads to improvements in their antiwear properties, but degrades anti-wear properties of synthetic oil with a balanced additive package. However, the contact pressure at which wear begins is higher for the modified synthetic oil.

This article presents the results of an experimental determination of the effect of friction on the basis of pure serpentine on the anti-wear properties of Litol-24 grease and TAD-17 gear oil.

2. GEO-MODIFIER OF FRICTION

The study used a solid-lubricating composition "Zvezda-5" based on pure serpentine, which is a further development of the friction geo-modifiers described in [9]. Figure 1 shows the size of pure serpentine, and Table 1 shows the chemical composition. The measurements were performed using the HORIBA Laser Scattering Particle Size Distribution Analyzer LA-950 spectrometer at the Institute of Solid State Chemistry, Ural Branch of the Russian Academy of Sciences.

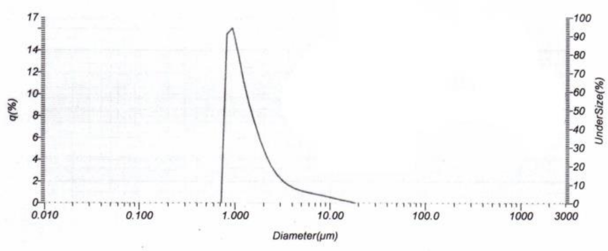

Fig. 1. Serpentine size.

Figure 1 shows that 90 % of the particles have a diameter of 0.88 µm to 3.5 µm and 10 % are particles with a diameter of 3.5 µm to 17.4 µm.

Table 1. Chemical composition of serpintine.

	O	Mg	Si	Ca	Fe
Mass [%]	44.68	28.71	24.97	0.03	1.61
Atom [%]	57.09	24.14	18.17	0.02	0.59

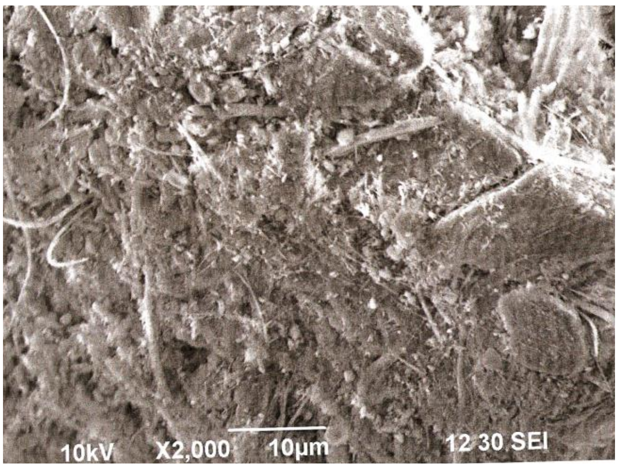

Fig. 2. The image of serpentine under a microscope.

The lubricating compositions were prepared for studies. One of them consisted of grease Litol-24 with the addition of geo-modifiers of friction from 0.5 % to 3 % by weight. Another composition consisted of transmission oil TAD-17 with the addition of geo-modifiers of friction from 1 % to 3 %. The choice of these lubricants is due to their wide application. Lithol-24 is antifriction multi-purpose waterproof grease. It is one of the most common in Russia. It is used for the main friction units of vehicles, industrial equipments, etc. TAD-17 is universal, mineral oil, which contains a multifunctional serophosphorus containing, depressant and antifoam additives. It is used to lubricate gears of cars, including conical and hypoid gears.

3. EXPERIMENT AND RESULTS

Antiwear properties of lubricants were evaluated on the four-ball friction machine (Fig. 3) in accordance with GOST 9490-75. The principle of operation of four-ball friction machine is well described in the literature [10,11].

The anti-wear properties of the TAD-17 gear oil were additionally evaluated in accordance with the guidelines [12]. Dependence of the wear rate on the contact pressure for pure TAD-17 oil and for the lubricant composition TAD-17 with the addition of 3 % the geo-modifiers of friction were constructed after the processing of the measurement results.

Fig. 3. The Four-ball machine.

Litol-24 grease compositions were tested at a load of 196 N, but lubricants based on TAD-17 gear oil were tested at 392 N load. The test duration was a one hour, the test temperature was 20 °C. After the end of the tests with the help of a microscope the value of the wear scar diameter of the lower balls was evaluated.

Figures 4 and 5 show the measurement results of the mean wear scar diameter (MWSD). Figures 6 and 7 show dependence of the wear rate on the contact pressure and on the time.

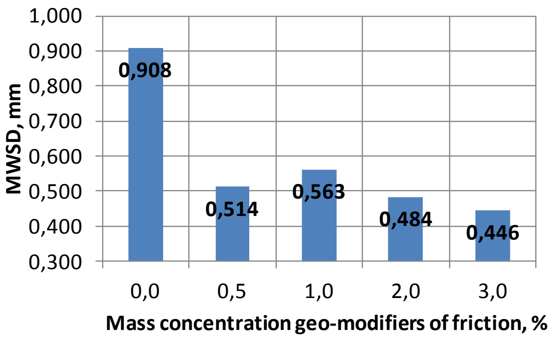

Fig. 4. Mean wear scar diameter at different concentrations of the geo-modifiers of friction (Litol-24 lubricant).

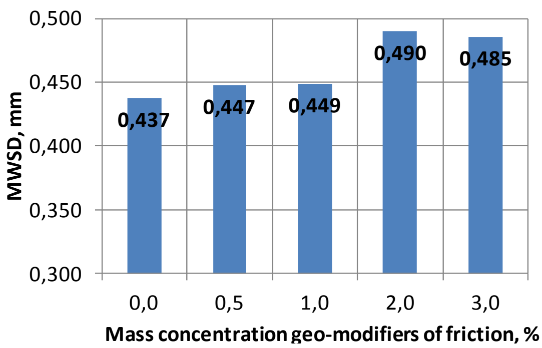

Fig. 5. Mean wear scar diameter at different concentrations of the geo-modifiers of friction (TAD-17 gear oil).

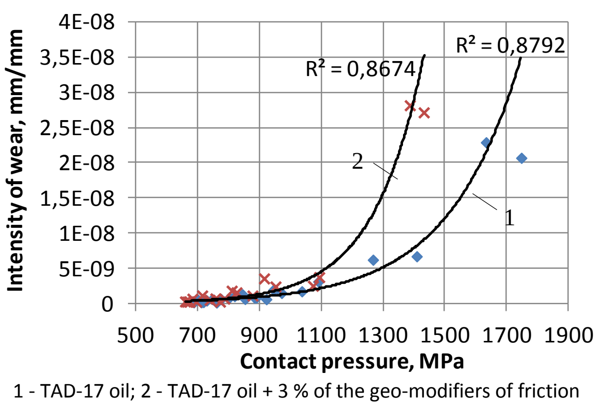

Fig. 6. Dependence of the wear rate on the contact pressure.

Contact areas of samples after four-ball machine test in Litol-24 are presented in Figs. 8 and 9.

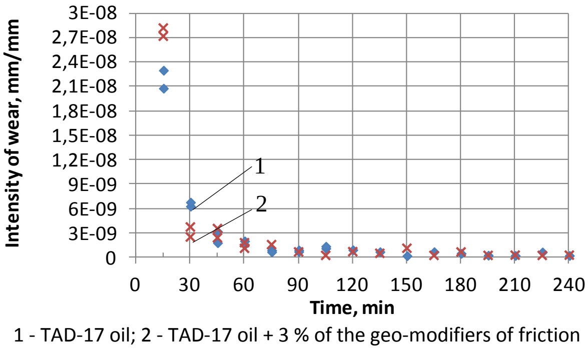

Fig. 7. Dependence of the wear rate on the time.

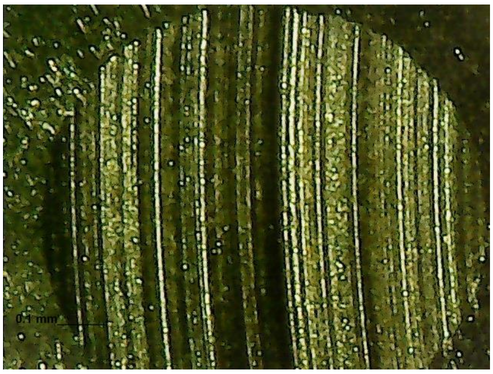

Fig. 8. Contact area of samples after four-ball machine test in Litol-24.

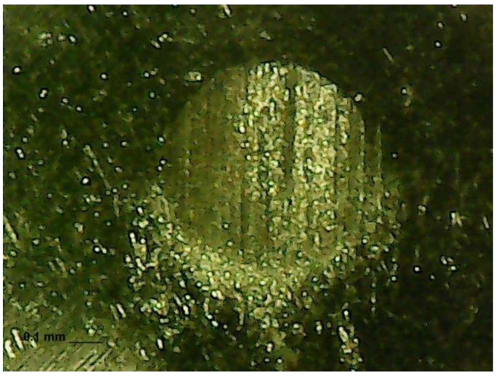

Fig. 9. Contact area of samples after four-ball machine test in Litol-24 + 0.5 % of the geo-modifiers of friction.

5. CONCLUSION

The results of experimental studies allow us to draw the following conclusions:

1. The geo-modifiers of friction based on pure serpentine with the particle size of 0.88 µm to 3.5 µm significantly increases the antiwear properties of Lithol-24 grease. The wear scar diameter is reduced by 26-50 %.

2. The geo-modifiers of friction (3 % by weight) in the gear oil TAD-17 increases the wear scar diameter from 2.3 % to 12.0 %. However, the wear rate decreases more quickly. This fact indicates a decline in the running time of the friction unit.

Acknowledgement

The work was supported by Act 211 Government of the Russian Federation, contract № 02.A03.21.0011.

This work was supported by the Ministry of Education and Science of the Russian project for the creation of high-tech production "Creation of a production of a new generation of energy-efficient transmissions for trucks and buses," the contract № 02.G25.31.0142 of "01" in December 2015 between the Ministry of of education and science of the Russian Federation and the public joint stock company "KAMAZ" in cooperation with the main executor NIOKTR - Federal State Autonomous Educational Institution of Higher Education "South Ural State University (national research university)".

REFERENCES

[1] V.V. Usachev, L.I. Pogodaev, D.M. Teluh and V.N. Kuzmin, 'Introduction in a problem of use of natural layered geomodifiers in pairs of friction', *Friction and lubrication in the machines and mechanisms*, no. 1, pp. 36-42, 2010.

[2] Tribological properties of modified lubricating oils, available at: http:// www.ipme.ru/ ipme/ edu/diss/albreki2011.pdf, accessed: 26.02.2017.

[3] R.G. Nigmatullin, B.Y. Sholom, L.S. Shuster and I.M. Nigmatullin, 'Improving the efficiency of lubricants with friction geomodificators', *Bulletin USATU*, vol. 16, no. 1, pp. 51-56, 2012.

[4] V.V. Medvedeva, A. D. Breki, N. A. Krylov, M. A. Skotnikova et al., 'Investigation of Antiwear Properties of a Plastic Lubricating composite material containing dispersed particles of the Layered friction modifier', *Proceedings of the SouthWest State University Technics and Technologies*, vol. 64, no. 1, pp. 75-82, 2016.

[5] V.V. Medvedeva, A.D. Breki, N.A. Krylov, S.E. Aleksandrov et al., 'Antiwear Properties of a Grease-Lubricating Composite Material Containing a Mixture of Hydrosilicates of Magnesium', *Proceedings of the SouthWest State University Technics and Technologies*, vol. 19, no. 2, pp. 30-40, 2016.

[6] Nanotechnology antifriction powder composition (options), nanotechnology lubricating composition and method of lubrication nanotechnology, available at: http://www.freepatent.ru/patents/2415176, accessed: 26.02.2017.

[7] V.N. Duradji, D.E. Kaputkin and A. Duradji, 'Tribological Studies of Antiwear Antifriction Composition and its Application', *Tribology in Industry*, vol. 38, no. 4, pp. 496-507, 2016.

[8] V.V. Medvedeva, M.A. Skotnikova, A.D. Breki et al., 'Evaluation of the Influence of Particle Size and Concentration of Powereds of Rocks on the Antiwear Properties of Liquid Lubricant Compositions', *News of Tula State University. Technical science*, vol. 11, no. 1, pp. 57-65, 2015.

[9] Solid lubricating composition, Patent of the Russian Federation. № 2553255, 2015 (on Russian).

[10] S. Baskar, G. Sriram and S. Arumugam, 'Experimental analysis on tribological behaviour of nano based bio-lubricants using four ball tribometer', *Tribology in Industry*, vol. 37, no. 4, pp. 449-454, 2015.

[11] C. Georgescu, L.C. Solea and L. Deleanu, 'The influence of degumming process on tribological behaviour of soybean oil', *Tribology in Industry*, vol. 37, no. 3, pp. 330-335, 2015.

[12] RD 50-531-85 *Providing wear resistance of products. The method of experimental evaluation of antiwear properties of lubricants in friction: methodical instructions*, 1986.