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INFLUENCE OF FRICTION GEO-MODIFIER ON ANTI-WEAR PROPERTIES OF PLASTIC LUBRICANTS

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Abstract. The article describes the influence of friction geo-modifier on the antiwear properties of greases and gear oils. Geo-modifiers of friction are the fine powders of mineral materials. This work is directed on the investigation of the influence of geo-modifiers of friction in the form of hard lubricant compositions, based on a mineral serpentine, on the anti-wear properties of plastic lubricants. 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 geomodifiers of friction from 1 to 3%. The Litol-24, Shell Gadus S3, Mobilgrease XHP 222, Castrol LMX greases were used for testing. The four-ball machine of friction was used for tests. As geo-modifier the serpentine was used, the fraction of which has a size from 0.87 to 2.2 μm. The parameter as the wear scar diameter was used for evaluation of the antiwear properties of lubricants.

Keywords: geo-modifier of friction, serpentine, plastic lubricant, wear scar diameter.

AIMS AND BACKGROUND

Friction geo-modifiers (GMF) are natural minerals that are added to lubricants to improve their tribological properties, in particular anti-wear properties. In the early 90s 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

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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[3] investigated the effect of serpentine on the tribological properties of oxidised 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 oxidised lubricant (industrial grade I-40 oil, compressor oil KS-19). Lubricating composition of oxidised oil KS-19 with the addition of serpentine (0.3%) and MnO_2 (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.

Medvedeva[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 antiwear properties of the composition with particle serpentinite sizes 10 and 30 μm begin to appear at low concentrations. Authors[5] 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[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[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 antiwear properties of synthetic oil with a balanced additive package. However, the contact pressure at which wear begins is higher for the modified synthetic oil.

The article presents the results of experimental determination of the influence of geo-modifier friction on the basis of pure serpentine in antiwear properties of such grease-like lubricating materials, such as Litol-24, Shell Gadus S3, Mobilgrease XHP 222, Castrol LMX. These lubricants have different thickeners. It is important to understand the compatibility of the geomodifiers of friction with thickener greases.

EXPERIMENTAL

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

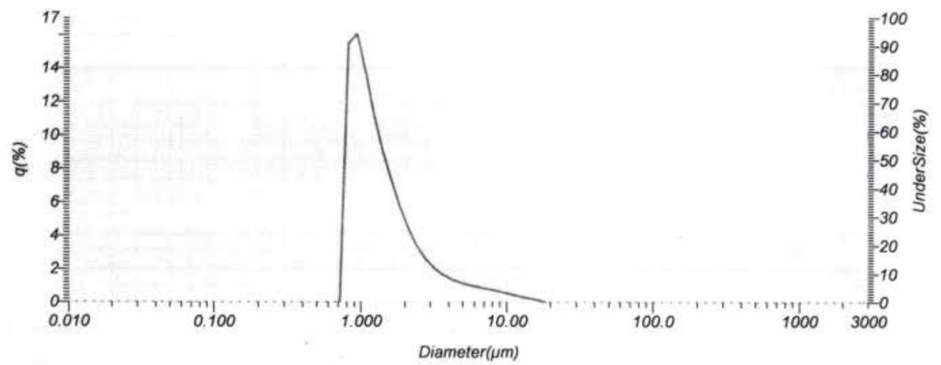


Fig. 1. Serpentine size

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

Table 1. Chemical composition of serpintine

Parameter	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

The Litol-24, Shell Gadus S3, Mobilgrease XHP 222, Castrol LMX lubricants were used for testing. The friction geo-modifier was added into the lubricant from 1 to 3% by weight. Litol-24 and Castrol LMX contain a lithium-based thickener, lubricant Shell Gadus S3 contains polyurea thickener, lubricant Mobilgrease XHP 222 also contains a lithium complex and is reinforced with 0.75% molybdenum disulphide.

The purpose of the experiment was to study the influence of the friction geo-modifier based on pure serpentine on antiwear properties of greases with different thickeners. Antiwear properties of lubricants were evaluated on the four-ball friction machine (Fig. 2) in accordance with ASTM 2266. The influence of friction geo-modifiers on the anti-wear properties of Litol-24 lubricant was investigated in Ref. 11. The principle of operation of the four-ball friction machine is well described in literature[11] and is not presented here.

Fig. 2. Four ball tribometer

Lubricant compositions were tested at a load of 392 N. The test duration was 1, the test temperature was 75°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.

RESULTS

Figure 3 shows the measurement results of the mean wear scar diameter (MWSD). Figures 4–7 show typical wear scar.

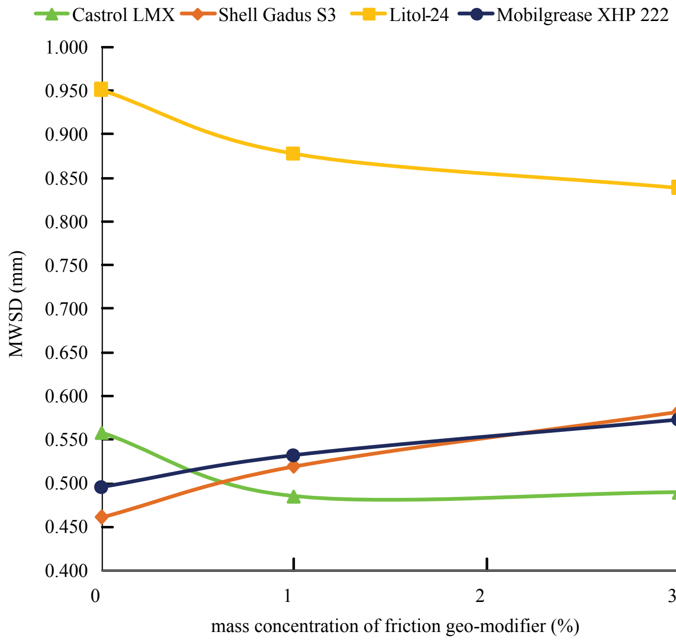


Fig. 3. Mean wear scar diameter at different concentrations of friction geo-modifier

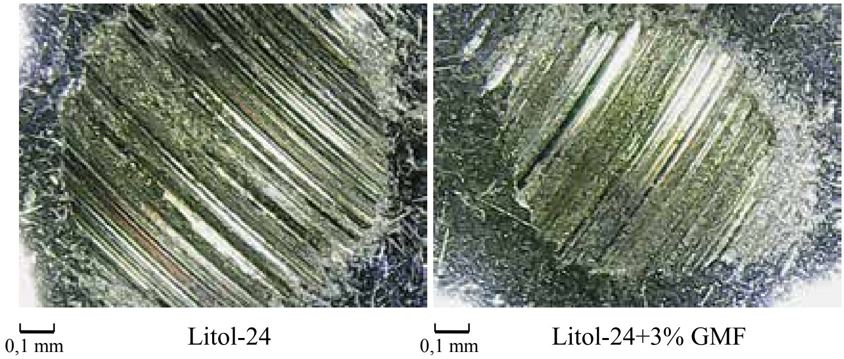
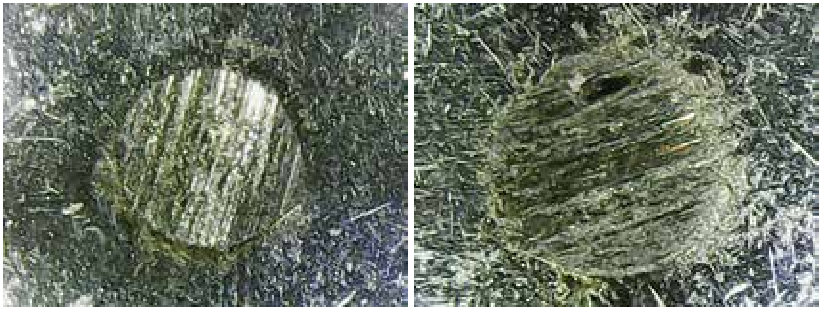
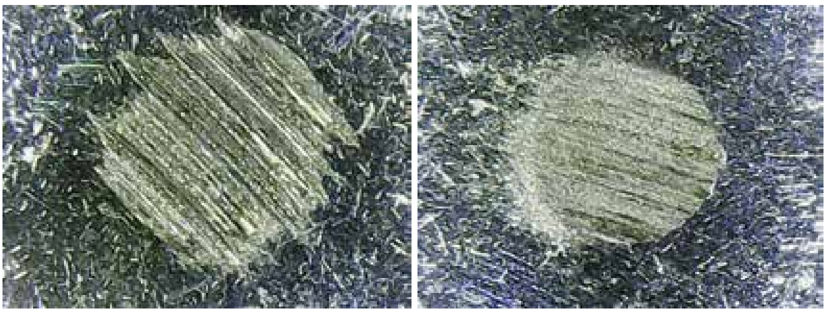


Fig. 4. Wear scar lubricant Litol-24



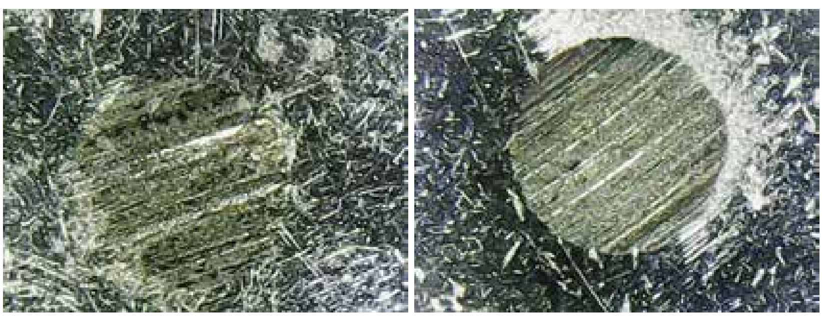
0,1 mm Shell Gadus S3 0,1 mm Shell Gadus S3+3% GMF

Fig. 5. Wear scar lubricant Shell Gadus S3



0,1 mm Castrol LMX 0,1 mm Castrol LMX +3% GMF

Fig. 6. Wear scar lubricant Castrol LMX



0,1 mm Mobilgrease XHP 222 0,1 mm Mobilgrease XHP 222+3% GMF

Fig. 7. Wear scar lubricant Mobilgrease XHP 222

CONCLUSIONS

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

1. The friction geomodifiers based on pure serpentine with the particle size of 0.88 to 3.5 μm increases the antiwear properties of plastic lubricants with a

lithium-based thickener. The wear scar diameter is reduced by 12% for Litol-24 and Castrol LMX.

2. The antiwear properties of the lubricant Mobilgrease XHP 222 and lubricant Shell Gadus S3 decrease with the addition of the friction geo-modifier. Application of friction geo-modifier to plastic lubricants containing molybdenum disulphide is impractical.

3. The antiwear properties of the lubricants Mobilgrease XHP 222 and Shell Gadus S3 decrease with addition of the friction geo-modifier. Application of friction geo-modifier to plastic lubricants containing molybdenum disulphide and polyurea thickeners is impractical.

The friction geo-modifiers are environmentally friendly anti-wear additives to plastic lubricating materials of lithium-based.

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