19h International Research/Expert Conference
”Trends in the Development of Machinery and Associated Technology”
TMT 2015, Barcelona, Spain 22-23 July 2015

INVESTIGATION OF WEAR AND COEFFICIENT OF FRICTION IN SLIDING FRICTION PAIRS USING OIL WITH ADDITIVES

Armands Leitans, Janis Lungevics, Janis Rudzitis
Riga Technical university, Institute of Mechanical Engineering
Ezermalas str. 6k, Riga, Latvia LV-1006

ABSTRACT
Although oil contains different additives that manufacturer has already added, there are variety of additional chemicals which are meant to improve wear resistance and extend friction pairs life. The research is made to find out the effect of additional oil additives on friction coefficient and wear processes that occur between slide friction pairs.
Keywords: oil additives, coefficient of friction, wear

1. INTRODUCTION
Prolonging the lifetime of different friction pairs is one of the most topical problems nowadays in many branches. Anti-friction oil additives could be used in order to reduce the friction and wear by making protective oil film between the contacting surfaces. To ensure such a protective and anti-friction cover and to improve friction properties of two contacting surfaces it is necessary to find the proper oil additive composition for lubricating material.
The experimental work is planned to test the various manufacturers oil additives based on various a surface active agent bases. Additives by manufacturer recommended concentrations (to determine the volume of oil) will be mixed with SAE-20 viscosity class conformity industrial mineral oil I-40. In experiments on the base will be used selectively purified industrial mineral oil, that is free of any additives, in order to exclude the impact of other additives [1]. All additives are added in liquid consistency to the following basis composition: copper, molybdenum disulphite (MoS_2), polytetrafluoroethylene (PTFE), ceramic and metal-ceramic.
Experiments will be tested for coefficient of friction and friction pair wear.

2. MATERIALS AND METHODS
2.1. Determination of the coefficient of friction
The first experimental stage was connected with the determination of the coefficient of friction for different concentrations of the oil additive in industrial oil. Tribological study was done using tribometer made by “CSM Instruments” (Switzerland), besides testing conforms to the following standards DIN 50324, ASTM G99, ASTM G133 [2,3,4]. The measurements were carried out by the scheme “ball-on-disc” (see Fig.1.). The experimental settings could be seen in Table1.

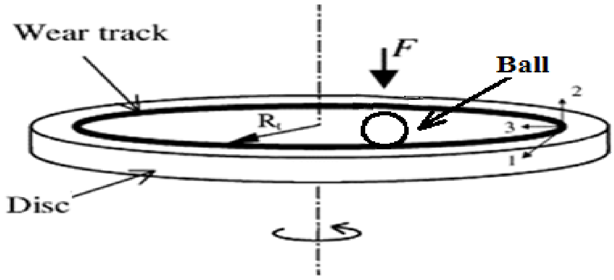

Fig.1 “Ball on disc” test equipment’s scheme

The sample size and configuration was made according to the recommendations of tribometer's manufacturer ("CSM Instruments", Switzerland). The diameter of the rotating disk is 31mm and thickness - 6mm, it was produced by turning with further grinding and polishing. Sample surface roughness was measured with a profilometer *Taylor Hobson Surtronic* (England). Five measurements were made. The sample hardness was measured with *Equotip Picollo EP-002-0095* (Switzerland) also making five measurements.
The experiment was carried out by the scheme ball-plane, where the plane is working as a testing sample, but the ball as a counter-body.

Table 1. Experimental settings

Force	5 N
Measurement period	3000s
Linear velocity	0.10 m/s
Radius of ball's contact	5,5 mm
Distance	172.7m
Diameter of the ball	6 mm
Material of the ball	100Cr6 (DIN,EN)
Material of the flat (disc) sample	Steel S235 (EN)
Hardness	HB 140...148
Surface roughness	Ra=0.18 ... 0.34 µm
Liquid for surface cleaning	Alcohol solution
Experimental conditions	
Atmosphere	Air
Temperature	20°C (room)
Moisture	41% (room)

Beginning of the experiment coefficient of friction values were measured studied industrial oil without additives. Other measurements studied oil with additives. Three thousand seconds measurement period includes 10,000 rotational cycles. Before the coefficient of friction measurements were prepared exploration of oil and additive mixture of materials. Oil volume 100ml adding additives at the manufacturer's recommended concentration, shown in Table2. Samples were prepared immediately before the experiment carried out pouring oil additives and mechanical agitation, for about three minutes.

Table2. Aditive concentrations

Oil additive	Aditive concentration on the oil volume; %
Molibdenum disulphite (MoS_2)	2
Copper	2
Polytetrafluoroethylene (PTFE)	30
Ceramic	4
Metal - ceramic	3

2.2. Oil and oil additive's effect on material wear

The second task was connected with the determination of oil additive's effect on the wear process. The experiment was made by Reichert's testing scheme (cylinder-on-ring) (see Fig. 2) [5][6]. The experimental settings are as follows: the cylindrical sample is pressed with 100N force to the rotating ring that has a rotation speed of 480 rpm (linear velocity 1.1m/s). The experiment lasts for 30 seconds. At the end of the experiment the wear area of cylindrical sample is evaluated after using different lubricating materials. In each experiment new cylindrical sample and rotating ring's path is used. As a ring material is used bearing's outer ring with 44mm diameter and a cylindrical bearing's roller with 6mm diameter. Both samples are made of material 100Cr6 according to EN standard.

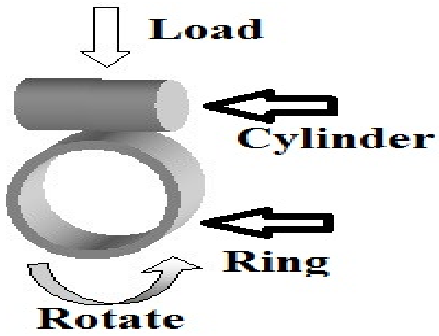

Fig.2 Reichert "Cylinder-on-ring" test equipment's scheme

The wear path on the samples [6],[7] is measured using *Motic Binocular* digital laboratory stereo microscope BA-310-MET with the help of which it is possible to make a photo and measurements.

3. RESULTS AND DISCUSSION

3.1.Coefficient of friction mesurements.

Summary friction coefficient curve shown in Figure 3. Evaluating the friction coefficient in the experiment results, it can be concluded that the coefficient of friction values of all investigated sample cases fluctuates around 0.12 ± 0.01, characterized boundary lubrication cases. In assessing the results after the criterion of the lowest coefficient of friction value can highlight lubricating composition with MoS_2 and PTFE additives, which from the beginning to the end of the experiment is relatively low value, which is also much different from pure oil I-40.

Evaluating by the criterion stable friction coefficient curve the whole length of the experiment, can be singled out in ceramic additives, the value of all measurement time ranged within ± 0.001 units, which are considered stable performance and it can be concluded that this additive on the friction surface in a short period of time make up your own layer, with its own specific coefficient of friction value.

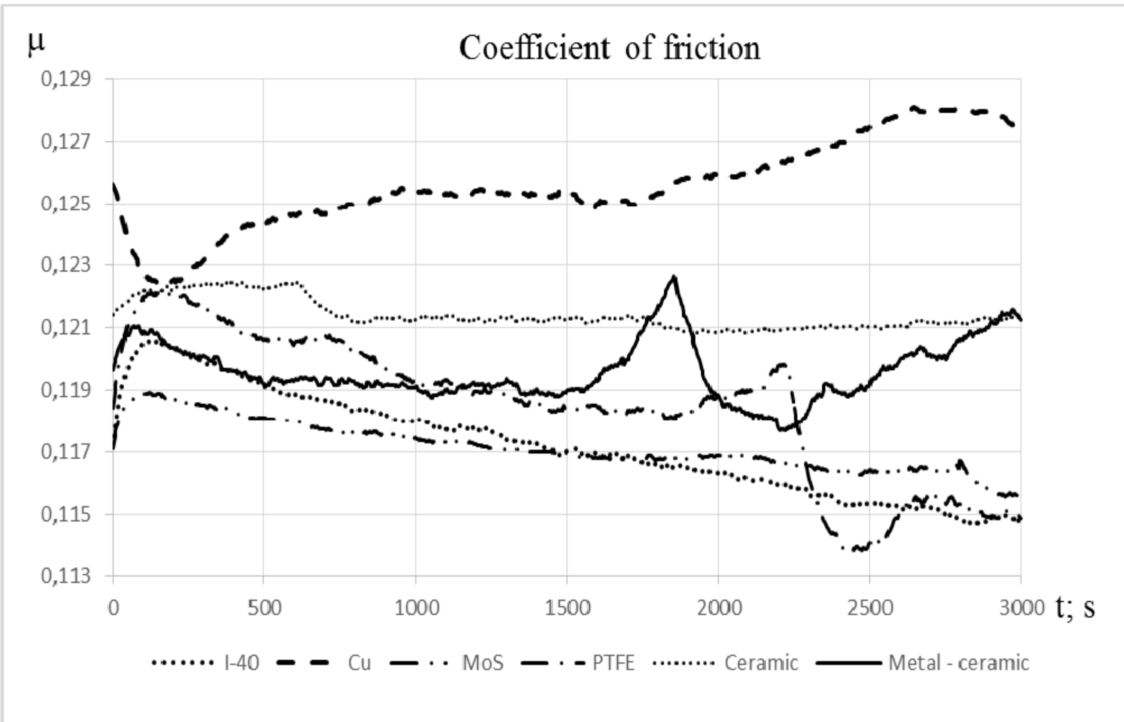

Fig.3. Summary coefficient of friction curves.

3.2. Wear mesurements

After the experiments measuring the worn spot on the cylindrical sample obtained as follows worn areas in Table 3. Figure 4 shows the three samples obtained from ceramic, PTFE and MoS_2 worn pitches. I-40, cooper, metal-ceramic additive sample size did not fit the field optical microscope measuring range and are measured with an instrument microscope BMI -1.

Table.3 Wear mesurements results.

Sample	Worn sample area, mm^2
I-40	5,31
MoS_2	1,92
Cu	5,08
Ceramic	1,26
PTFE	3,32
Metal-ceramic	4,97

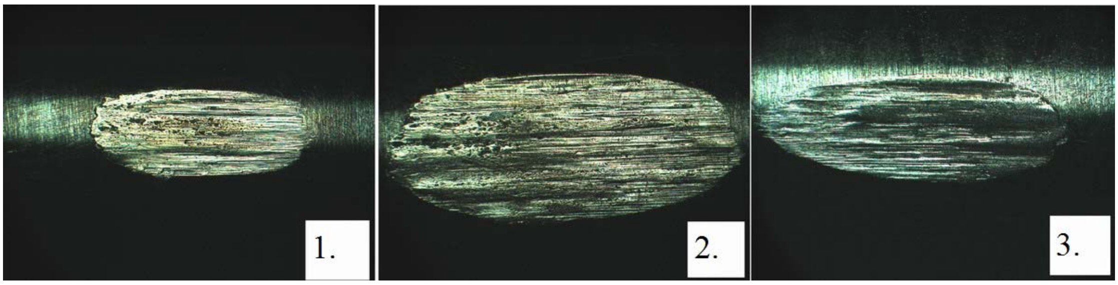

Fig.4. Wear areas on the cylindrical samples 1-ceramic, 2- PTFE, 3-MoS_2

4. CONCLUSIONS

According to experiments carried out by the coefficient of friction can be concluded that the coefficient of friction value corresponds to normal operation boundary friction value and admixture of additives to the oil does not significantly affect the coefficient of friction value. Summing up the abrasion resistance of experimental results can be observed significant oil additive effects on friction wear resistance ceramic samples, and PTFE, MoS_2 cases in relation to the pure industrial oil. This additive wear value decreases even several times. In particular, can bring out the ceramic additive which wear at the given experimental conditions reduce the four times. After the experimental work can be concluded, that the addition of additive can increase the contact pressure lubrication material resistance to oil film disruption. Copper and metal ceramic additives at the given conditions does not affect the abrasion resistance nor coefficient of friction value.

ACKNOWLEDGEMENTS

This work has been supported by the Latvian Council of Science within the Project Nr. 110/2012 "Titanium compound wear-resistant nano-coatings in mechanical engineering

5. REFERENCES

[1] Tochilnikov D.G., Kupchin A.N., Shepelevskiy A.A., Shiyan P.A., Gincburg B.M., Ponimatkin V.P Impact of products on the frictional wear and anti-wear properties of industrial oil I-20 and I-40 in friction greasy surfaces. Friction and Wear Vol.32 No.3, May-June 2011 (in Russian)

[2] DIN 50324 "Tribology; testing of friction and wear model test for sliding friction of solids (ball-on-disc system)",

[3] ASTM G99 "Standard test method for wear testing with a pin-on-disk apparatus" 2012

[4] ASTM G133 "Standard test method for linear reciprocating Ball-on-flat sliding wear", 2010

[5] Simon C.T., Totten G.E.: Automotive Lubricants and Testing, 2012, p.178

[6] Bayer R.G.: Wear analysis for engineers, 2002

[7] Vadiraj A., Manivasagam G., Kamani K., SrenivasanV.S.: Effect of Nano Oil Additive Proportions on Friction and Wear Performance of Automotive Materials Tribology in Industry.Vol. 34, No.1 2012.