UDC 621.893

THE ESTABLISHMENT OF OPTIMAL CONCENTRATIONS OF NANODIAMONDS IN OIL TRIBOPARS BREAK-IN MODES

DZMITRY LAPATSIN, YURY HAS, ANASTASIYA HUSHCHA
Polotsk State University, Belarus

The article shows the studies of tribopairs with different modes of operation and in the presence of oil with different nanodiamond content, which reveal optimal concentration of nano-sized components. The most optimal mode of operation is also provided.

A life span of friction units of machines is largely determined by the performance of used lubricants. Modern development of technology is associated with an increase in speed and load on friction units, which makes it difficult to solve the problem of ensuring the desired durability of a tribo-conjugation, taking into account the interdependent parameters of the tribounit-maintenance complex technology [1].

To improve the performance properties of a friction surface, it is necessary to further increase the wear resistance of mating surfaces, which requires the development of new lubricants that have an increased load capacity and ensure low wear rates [2].

Recently, attempts to improve the properties of oils by introducing various additives into their composition have become more widespread. The use of additives in oils, and, above all, the joint introduction of additives and fillers, allows the most flexible regulation of the structure of oils. Work on the use of various kinds of nano-sized components as solid additives is becoming increasingly scientific and practical. Their use results in a new qualitative level in comparison with previously used additives. One of the promising areas is tribomodification with nanoscale diamond-containing additives.

Nanocomponents contribute to a significant decrease in the coefficient of friction and wear of the rubbing surfaces. Nanocomponents are detonation nanodiamonds 4-5 nm in size. Their properties in suspension make it possible to form a multitude of microscopic tribofilms on friction surfaces. Microfilms of nanocomponents significantly increase the shelf life and beneficial properties of lubricants used [3].

Task formulation is studying of the effect of the concentration of nano-sized components in oil and operating modes of a tribopair on the degree of wear of friction surfaces

Results and discussion Base oil I20 was used as the main oil (industrial type mineral oil with kinematic viscosity – 29-35 mm/s at 40 °C). The remaining types of oils were obtained by adding nanocomposites to the composition of the I20 oil in an amount from 0.09% to 0.9%.

The studies were carried out according to the "pin-on-disk" friction scheme. The indenter is made of steel ШХ – 15 in the form of a rod Ø 3 x 15 mm, the material was in the annealed condition (heat treatment mode: quenching - annealing at a temperature of 700 – 720 ° C; specimen hardness 25 – 27 HRC). As a counterbody, a disk Ø 70 x 6 mm from hardened steel ШХ – 15 (hardness 57 – 61 HRC) was chosen.

Tribological tests were carried out on a universal friction machine MODEL: MMW-1A of a vertical type with computer control. This model allows you to keep the load force constant with a deviation of ± 2 N. The relative error in measuring the friction force did not exceed ± 2% in the liquid lubrication mode.

Before conducting the study to reduce the surface roughness and, as a result, to improve the accuracy of the data obtained, the samples were subjected to grinding on emery paper with P600 grit.

The main mode of operation was mode with the following parameters: loading force: 212 N; unit load: 10 MPa; sliding speed: 0.2 m / s; distance traveled by samples: 3000 m.

During the tests, the values of the friction force and the friction coefficient with a frequency of once every 1 s were recorded in real time with the ability to save to a file. The obtained data were accumulated in a graphical and textual form and, after approximation, were analyzed.

The imprint method was used to measure wear. The essence of this method is to measure the size of a print before and after testing. After this, the size difference is recalculated to get absolute wear. The size of the prints was taken every 1000 m.

As a measurement equipment, a BUEHLER Model No 1105D microhardness tester was used to determine the Vickers hardness using a pyramidal indenter with an opposite angle of 136 °.

Analysis of the obtained data showed that the highest lubricating properties in this mode of operation are manifested in oils with a nanodiamond content of 0.36% – 0.45%. At lower concentrations, the maximum effect is not achieved, and an increase in the percentage does not lead to a significant decrease in the friction coefficient.

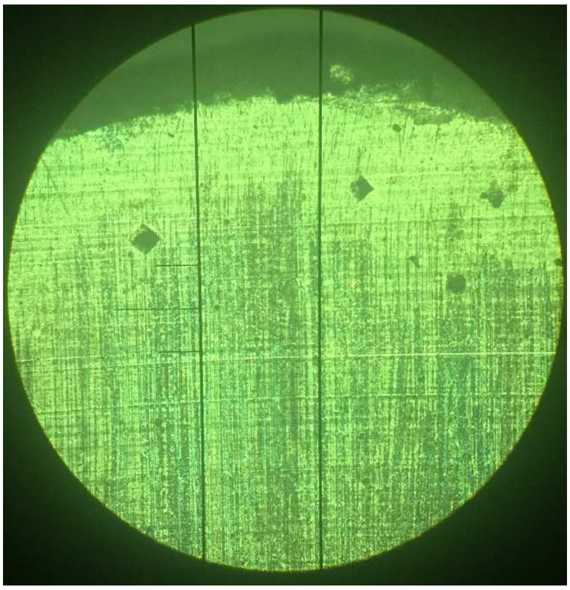

Figure 1. – Friction surface of steel samples ШХ-15 with printed prints

During the tests, the following modes of operation were also considered:

– 1st: loading force 636 N; unit load: 30 MPA; sliding speed: 0.5 m / s; distance traveled by samples: 3000 m.

– 2nd: loading force 636 N; unit load: 30 MPA; sliding speed: 0.1 m/s; distance traveled by samples: 3000 m.

Under these modes of operation it was impossible to determine the wear, because after passing 2000 m, the prints were completely erased.

In addition, in the basic mode of operation, the nature of friction was found to depend on the thickness of an oil layer. With an insufficient thickness, dark wear strips are formed on the samples.

Figure 2. – Dark wear stripes on specimens

In the zone of these dark stripes it was impossible to determine the size of the prints, and as a result, find out the degree of wear. The appearance of dark stripes is associated with a worsening of lubricant leaking into the tribocontact zone and a violation of the lubrication conditions of the friction pair due to the viscosity of the lubricant, as a result of which dry friction occurred in the contact center. The same phenomenon was observed when testing oil with a nanodiamond content of 0.09%. Moreover, in the latter case, an increase in the thickness of the oil layer did not give positive results.

In the main mode of operation, the range of optimal concentration of nanodiamonds coincided with the data obtained in [4] with the unit load of 1 MPa and the speed of 1 m / s. This is explained by the fact that a number of oils with different concentration of nanodiamonds between successive samples of 0.09% were used for the study.

Studies of tribopairs with different modes of operation and in the presence of oil with different nanodiamond content showed that the optimal concentration of nano-sized components in the oil is 0.36% – 0.45%. The most optimal mode of operation is a mode with the specific load of 10 MPa.

REFERENCES

1. Леонтьев, Л.Б. Системный анализ технологии формирования износостойких покрытий на поверхностях трения деталей / Л.Б. Леонтьев, А.Л. Леонтьев, В.Н. Макаров // Фундаментальные исследования. – 2014. – № 12 (4 ч.). – С. 729–734.
2. Pešić, R. Methods of Tribological Improves and Testing of Piston Engines, Compressors and Pumps / R. Pešić, A. Davinić, S. Veinović // Tribology in industry. – 2005. – Vol. 27, № 1&2. – P. 38–47.
3. Масла и пластичные смазки на основе наноалмазов для снижения трения тяжелонагруженных узлов [Электронный ресурс] // Южно-Уральский инновационно-технологический центр. – 2009–2011. – Режим доступа: http://suitc.ru/ru/inno/org/tech_profile/tech_offer/detail.php?ShowIBlock=21&ElementID=2629&ORG_ID=2627&CHILD_ID=2628. – Дата доступа: 20.02.2019.
4. Дудан, А.В. Влияние концентрации наноразмерного компонента смазочного материала на свойства поверхности трения / А.В. Дудан, А.А. Гуща, Э.В. Колесов // Инновационные технологии в машиностроении : материалы Междунар. науч.-тех. конф., Новополоцк, 19-20 апр. 2018 г. / Полоц. гос. ун-т ; под. ред. В.К. Шелега, Н.Н. Попок. – Новополоцк, 2018. – С. 192–194.