Research of the Effect of Nanopowder Additives on Some Main Properties of Lubricants

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Abstract. The possibility of improving the basic properties of a lubricating composition based on Litol 24 lubricant, by adding nanopowders (molybdenum, tungsten carbide, tungsten) obtained from their carbide wastes, has been considered. The structure of nanopowders has been studied. Their X-ray spectrum analysis was carried out. It has been shown that the addition of a molybdenum nanomodifier to the base lubricant mixture results in improved tribotechnical properties. The optimal concentration of molybdenum nanopowder was determined to be 0.1 wt%. Also paper contains results of operational tests of lubricant composition. The resulting lubricant composition may be a competitive product in the lubricant market.

1. Introduction

Today, the requirements for the level of reliability and performance of various machines, equipment and mechanisms are constantly growing, which necessitates their provision with high-performance lubricants. One of the ways to improve their quality is the introduction of certain functional solid additives, the most promising is the use of nanomodifiers: metals (Cu [1], Mo, W [2]), metal oxides (TiO₂, CuO [3], ZnO [4]), carbon based nanoparticles (nanodiamonds, fullerene [5,6]), nanocomposite (CuS-ZnO [7], Cu-MoS₂, Ag-MoS₂ [8]).

The popular use of nanomodifiers is due to the fact that the size of solid additives has a great influence on the processes occurring in the contact zone, in particular, the formation of structures in the friction zone that can withstand contact pressures in combination with shear deformations.

The development of new compositions of greases based on new functional additives that contribute to reducing friction and increasing the wear resistance of the leading parts of machines and mechanisms is an urgent problem.

This paper considers the possibility of improving the performance of the lithium lubricant based lubricant composition Litol 24 by adding nanomodifiers. The choice of Litol 24 grease is due to availability, low cost and widespread use in technology. Nanopowders of molybdenum, tungsten carbide, tungsten are produced according to unique technology of nanopowders production from hard alloy wastes [9]. This method enables to obtain a larger volume of nanopowders at a lower cost compared to analogues.

2. Experimental part

A lubricant composition consisting of a multipurpose lithium antifriction lithium grease Litol-24 diluted with I-40A industrial oil at an optimal lubricant: oil ratio of 1:1 was used as the basis for introducing the modifier.
The mechanical stability of the lubricant was evaluated by a change in penetration after mixing. As can be seen from the results of the studies (Figure 1), with a stirring time of 1 hour, the penetration value is maximum. With further stirring, the penetration value is not changed. For further studies of the lubricating composition with the addition of nanopowders, we will use a stirring time of 1 hour.

Figure 1. The dependence of penetration on the mixing time.

Molybdenum, tungsten and tungsten carbide powders were used as lubricant composition modifiers.

Nanomodifiers were investigated using a Phenom ProX scanning electron microscope (Phenom–World B.V., Netherlands) with an integrated energy dispersive analysis system. The maximum magnification is 150,000, the resolution is 10 nm, the accelerating voltage is 5, 10, 15 kV. Elemental analysis of the powders under study was obtained using the Phenom Element Identification program, which allows the use of a Phenom ProX electron microscope to analyze samples by energy dispersive spectroscopy.

In Figure 2 microphotographs of powders used as additives to the lubricant composition are presented.

Figure 2. Micrographs of powder particles used as modifying agents of lubricating composition:

   a – tungsten carbide (x100000), b – tungsten (x78000); c – molybdenum (x140000).
As can be seen from the obtained data, tungsten carbide powder is prone to agglomeration during storage with the formation of shapeless agglomerates ranging in size from several tens of nanometers to 2 μm (Figure 2a). A sample of tungsten and molybdenum is also represented by agglomerates with sizes up to 800 nm.

The chemical purity of the powders is confirmed by the data of X-ray microanalysis (Table 1). A small amount of oxygen (nanopowder of tungsten carbide) due to the technological features of obtaining powders which, if necessary, is eliminated by vacuuming.

| Table 1. Elemental composition of powders. |
|-------------------------------------------|
| **Element Symbol** | **Atomic conc.** | **Weight conc.** |
|-------------------|------------------|-----------------|
| **Nanopowder of tungsten carbide**        |                  |                 |
| W                 | 24.78            | 82.26           |
| C                 | 55.35            | 12.00           |
| O                 | 19.87            | 5.74            |
| **Nanopowder of tungsten**                |                  |                 |
| W                 | 100.00           | 100.00          |
| **Nanopowder of molybdenum**              |                  |                 |
| Mo                | 100.00           | 100.00          |

Tests for the operating time of the lubricating composition with the addition of a modifier were carried out in the gearbox of the angle grinding machine MSU-2 angle grinder (JSC "PLANT" FIOLENT" Russian Federation), where they were tested for a number of parameters (power consumption, vibration level, sound pressure, etc.).

3. **Analysis of the results**

To assess the efficiency of using tungsten, tungsten carbide, molybdenum nanopowders as modifiers to lubricating media, the effect of each additive on wear was studied (Figure 3).

![Figure 3. Comparison of wear intensity change of lubricant composition (%) of modified nanopowder of tungsten carbide, tungsten, molybdenum relative to initial composition without adding.](image-url)
Analyzing the experimental data (Figure 3), it can be seen that the addition of a molybdenum nanomodifier to the base lubricant mixture results in an improvement of its tribotechnical properties by almost 50% over the original lubricant composition without adding of a modifier. The use of tungsten powder adversely affects the wear intensity of the lubricant. Further studies have considered a lubricant composition with the addition of molybdenum nanopowder.

Optimization of molybdenum nanopowder composition was performed by checking the wear intensity of samples with different nanomodifier content (Figure 4).

![Figure 4](image)

**Figure 4.** Change of wear intensity at different content of molybdenum nanopowder in lubricant composition.

The optimal concentration of nanopowder (Figure 4) at which minimum wear rate is observed is 0.1 % of the mass.

![Figure 5](image)

**Figure 5.** Changes in operational parameters (%) of the lubricant composition with the addition of molybdenum nanopowder compared to TRANSOL 100A lubricant.
The test results for the operating time in the gearbox of the MSU-2 angle grinder of the studied lubricant composition in comparison with used TRANSOL-100A lubricant (LLC "SIE Agrinol" Ukraine) are presented in Figure 5.

As can be seen from the results of the experiment, the modified sample reduces power consumption by 4.5%, vibration level by 45%, sound pressure by 2%, lateral clearance increased by 7% (the value is within the acceptable range) compared to the used serial grease.

After an operating time of 65 hours, failures were not recorded. No grease leaked from the gearbox. No gear defects were found. No thickening and coagulation of the lubricant was detected.

4. Conclusion

It has been experimentally shown that the addition of molybdenum nanopowder in an amount of 0.1% wt. In a lubricating composition consisting of a Lithol-24 lubricant improves performance. Operational tests have shown that the lubricant composition can be a competitive product in the lubricant market.

Further research may be directed to the introduction of the lubricant composition into other processing units, the use of other bases of lubricant compositions.

References

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