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Nanodispersed Ferrofluid Oil Lubricity Improvement with Processing Methods

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Abstract

The article proposes and justifies the use of technological methods of improvement of nanodispersed magnetic oil lubricating properties. It is shown that if the ferrofluid oil producing process includes additional operations, which are aimed at the removal of excess surfactant stabilizer and big magnetic agglomerates from its composition, it allows decreasing friction and wear of lubricated surfaces by tens of percent.

The authors have chosen ferrofluid lubricant oil that had been synthesized based on dioctyl sebacate for the research due to its good lubricating properties, low volatility and viscosity and a wide temperature range of operability. To remove the excess of the surfactant stabilizer dissolved in a ferrofluid oil dispersion medium the dispersion medium replacement method proposed by R.E. Rosenzweig was used. To remove large magnetic units from magnetic fluid the authors used magnetic separation.

In boundary friction surfaces lubricated by ferrofluid oil there might be their abrasive wear by agglomerates from single-domain magnetic particles. In this connection, the article experimentally proves the necessity of modifying magnetic liquid unit friction surfaces using MAO-technology to protect them from abrasion wear.

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1. Introduction

Recently the problem of applying nanotechnologies to improve reliability of various vehicles and machinery draws attention of many researchers. It’s known that some nanodispersed magnetic liquids might be used for lubricating tribounits that work in hydrodynamical and boundary friction mode [1-4]. Such magnetic liquids are

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usually called ferrofluid lubricating oil [5-8]. The main advantage of ferrofluid oil over traditional oil for lubrication is that the ferrofluid oil goes to the area of contacting friction surfaces as required under the influence of stationary thermomagnetic fields. Lubricating layer restoration occurs spontaneously. It does not require complicating tribounit design and using various extra devices to control oil movement. However, the results of ferrofluid oil triboengineering tests showed that their antifrictional and antiwear properties are not always high enough.

One of the most effective methods of increasing antifriction and antiwear properties of ferrofluid oil is introducing additional oil additives and fillers, which do not worsen its colloidal stability. This method has been studied well [4,6,7] and is effectively used in practice.

The aim of this work was to improve lubricating action of ferrofluid nanodispersed oil using technological methods. Works of many researchers, for example, the works of Professor D.N. Garkunov [9] show great potential of a similar approach to improving reliability and durability of friction units. The authors emphasize that the choice of tribounit elements for their technological improvement must be based on the system approach. In this context, it becomes clear that the term “lubricating effect” underlines the technological dependence of magnetic liquid tribounit properties not only on magnetic lubricant characteristics, but also on a friction material, surface topography, magnetic field sources, etc.

The analysis of ferrofluid oil test results obtained according to the same process scheme, but from different test batches showed unacceptably large variation in lubricating and rheological properties. For example, a friction coefficient for surfaces lubricated by ferrofluid oils based on a diester of carboxylic acid and taken from different batches could vary by 20÷30%, the range of wear rate values reached 50÷100%. It has been found that triboproperties are highly sensitive to redundant content in the dispersion medium of surfactant stabilizer oil of a colloidal structure. A stabilizer activates negative processes of friction surface mechanochemical wear, metal alloy surfaces in particular. In addition, even after careful peptization magnetic oil always contains solid aggregates of monodomain magnetic particles with the size reaching 10-6M. The hardness of magnetite typical dispersed particles exceeds 5 GPa and significantly exceeds the hardness of many antifriction nonmagnetic alloys and especially polymers. According to ex-perimental data, the agglomerates of the dispersed particles increase the overall wear tribosurfaces because of their abrasive action. Hence, the first task of investigations was to include in the ferrofluid oil obtaining process some additional operations aimed at removing not adsorbed stabilizer from oil and separating large magnetic agglomerates, as well as assessing what changes of lubricants and other oil properties it will lead to.

In the process of boundary friction of surfaces lubricated by magnetic oil there might form new agglomerates that stimulate abrasive wear under the influence of magnetostatic forces and as a result of mechanical destruction of magnetic particle solvation shells. Usually in magnetic liquid tribounits one friction pair element should be made of a magnetic material and the other of low magnetic readily available structural material (aluminum alloy, bronze, brass), with its hardness lower than magnetite hardness. Therefore, if it is possible to use abrasion resistant steel as a friction pair magnetic material, then it is necessary to protect counterface from wear technologically using solid antifriction coating. After a detailed analysis of various coating application technologies the authors have selected a microarc oxidation technology (MAO-technology) [10,11] for aluminum alloy surfaces. The main advantage of MAO-technology relating to magnetic liquid tribounits is that it allows obtaining high quality corundum coating on details with complex surface geometry. Hence, the second task of the researches was to prove applicability of microarc technology for applying protective coating on friction surface of magnetic liquid tribounits.

2. The object of research and experimental equipment

For the research the authors have selected ferrofluid lubricating oil, which had been synthesized based on dioctyl sebacate. This carbonic acid diester is good as a dispersion medium due to its good lubricating properties, low volatility and viscosity, wide temperature range of performance. Ferrofluid oil synthesis was carried according to a traditional technology [12] that includes comprising magnetite precipitation (dispersed phase) of an iron salt solution, disperse phase dehydration with acetone and magnetite processing by a fatty acid solution in dioctyl sebacate at high temperature.

In order to remove excess surfactant stabilizer dissolved in a ferrofluid oil dispersion medium the authors used a dispersion medium replacement method proposed by R.E. Rosenzweig [13]. The method is about dispersed phase revertive flocculation using the polar flocculation agent. Then, the liquid phase with a mixture of an initial

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