Application of Alloyed Industrial Oil in Friction Units of Power Equipment

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Abstract – Polyfunctional lubricant performance properties indicates its significant impact on the longevity and efficiency of work of contact pairs. Therefore, the correct choice of lubricant depends on energy consumption to overcome friction, wear of rubbing surfaces. The most economical way for the improvement of work of the friction units in different environmental conditions is the development of new lubricant compositions with the addition of an effective multifunctional additives as so base oils don't meet all of requirements put forward to them.

The polymethacrylate additives with enhanced functionality were obtained in this work. The influence of the concentration of the additives on the viscosity-temperature, depressor and anti-wear properties of industrial oil I-20A were studied.

Found that received additives improve the performance properties of oil-20A, respectively, contribute the reliable lubrication of the friction units in power plants at different natural conditions.

Key words – lauryl methacrylate, methyl acrylate, polymethacrylate additive, alloyed industrial lubricant I-20A, operational properties.

I. Introduction

The intense development of technical devices requires the use of lubricants with new performance properties. The quality of the lubricants, particularly of the motor oil, can be improved by adding to the oil some special chemical substances – additives [1]. The additives must meet certain requirements: namely, be soluble in oil or form stable systems; keep solubility and stability throughout the operating temperature range during transportation, storage, and use; produce no sediment on the filter; withstand water; and sustain other operational properties of the lubricant. Besides, the additives should not cause any deterioration and negative interaction with metal, rubber or polymer products; they must be compatible with the other additives that are introduced into the lubricating composition and must be technologically and economically feasible and affordable. These requirements limit the range of compounds that can be used as additives to lubricants; therefore, a very limited range of products is used. Polymethacrylate multifunctional additives occupy one of the main places among the whole variety. They meet all requirements put forward to them. Therefore, the urgent tasks are to obtain such additives and to study their influence on the operational properties of an alloyed industrial lubricant.

II. Analysis of previous stadies and statement of the problem

There are additives with various chemical compositions on the market: polyolefins [2], poly(alkyl methacrylates) [3], copolymers of hydrogenated styrene-butadiene [4], terpolymers [5], etc. Each chemical composition of the polymer provides a balance between cost and performance characteristics that make them more or less suitable for using in certain compounds of lubricating oils.

The most effective among additives that possess viscosity and depressor properties are the copolymers based on higher alkyl methacrylates. Ghosh and Das synthesized polymethacrylate additives based on esters of methacrylic acid with fatty alcohols fractions C_{14}-C_{26} that can effectively limit the reverse crystallization of paraffins, which also facilitates the oil mobility and vastly extends the range of operations at low temperatures. This type of additives allows production of mineral oils without the expensive dewaxing process.

It should also be noted that Neveu et al. identified that polymers of a linear structure have a better thickening ability compared to similar branched polymers due to the presence of a larger number of possible conformations of chain macromolecules. Poly(alkyl methacrylate) copolymers with different molecular weight and consisting of monomers with various functional groups have an antifriction effect owing to adsorption on the surface and forming a thin film in the boundary friction [3].

To date, despite the large number of studies in the field of oils and lubricants, there are no reliable criteria for selecting a lubricant additive for gear pairs that work in some specific conditions. Attempts to justify the use of additives in industrial oils are mentioned in Lazutina's PhD work. However, the recommendations contained therein are either very general or are intended for very narrow application. Therefore, studies aimed at synthesizing new polymers with enhanced functionality and testing them as multifunctional additives are very important from scientific and applied perspectives. Such a study can provide a solution to the problem of producing competitive and high quality lubricants in Ukraine.

III. The aim and objectives of the study

The study is aimed at obtaining new polymethacrylate additives with enhanced functionality and studying the influence of their concentration and composition on the operational properties of the alloyed industrial lubricant I-20A.

To achieve this aim, it is necessary to solve the following tasks:

– to obtain polymethacrylate additives by copolymerization of lauryl methacrylate with methyl acrylate in benzene;

– to study the operational properties of the alloyed lubricant I-20A.

IV. The research results of obtaining polymethacrylate additives and the operational properties of the alloyed oil I-20A

Polymethacrylate additives were synthesized in the medium of an inert gas (argon) in a two-neck flask equipped with a reflux condenser and a thermometer. Lauryl methacrylate (LMA) and methyl acrylate (MA) were dissolved in benzene (5.6 mL); the amount of the monomers depended on the required polymer composition. The volume ratio of the monomer to the solvent was equal to 1:1. Benzoyl peroxide was used as an initiator of the polymerization process in an amount of 0.5 wt.% against the total weight of the monomers. The polymerization process was conducted during 3 to 4 hours at 80±1 °C. After polymerization, the reaction mixture was precipitated with ethanol. The obtained polymer was several times reprecipitated with ethanol from benzene solution. The final polymer was dried in a vacuum (at P = 1.330-3.990 Pa and T = 60-70 °C).

The main indicators of the operational properties of the alloyed industrial lubricant, which were determinant in the experiment, were chosen as follows: kinematic viscosity (υ_{50} and υ_{100}), a viscosity index (VI), a freezing point (T_{Fr}), and antiwear properties.

The research of viscosity-and-temperature properties of the alloyed industrial lubricants was performed by determining the following:

(1) the dependence of viscosity on the concentration of the additive in the oil and

(2) the dependence of viscosity on the composition of the additive.

The concentration of polymethacrylate additives (PMAs) in the oil was respectively 1, 2, 3, and 4 wt.%.

As can be seen in Table 1, the viscosity index of the oil I-20A increases from 97 (for base oil) to 99-145 (I-20A with the PMA additive) with an increase of the additive concentration from 1 % to 2 %. Such a viscosity index change can be explained by the fact that in dilute solutions the macromolecules are less dependent on each other in their heat flows, and under the influence of Brownian forces they can take many forms in oil. A further increase of the additives' concentration in the oil from 3 % to 4 % does not significantly influence the viscosity index of the oil because of significant structural changes of the macromolecules in the solution, which makes the samples less mobile.

TABLE 1

OPERATIONAL PROPERTIES OF THE ALLOYED OIL I-20A

Lubricant	[LMA] : [MA], mol %	The VI of the oil I-20A with the PMA additive				T_{Fr}
		Concentration of the additive in the oil I-20A, wt.%				
		1	2	3	4	2
Oil I-20A	–	97				–15
I-20A+PMA10	90:10	99	100	103	105	–15
I-20A+PMA20	80:20	115	140	142	143	–19
I-20A+PMA30	70:30	137	145	147	147	–16

Based on the above listed data and research description, the study of the depressor properties of the lubricant was carried out at the optimum concentration of 2 wt.% of the PMA additive in the oil I-20A. The depressor property of the oil, thickened with additives, was studied by determining the freezing temperature.

The oil I-20A thickened with the PMA20 additive was tested for its antiwear properties. The high viscosity index of the oil with the PMA20 additive (2 wt.%) was found to reduce mechanical friction losses at low temperatures. The antiwear properties of the base oil are significantly improved with the addition of the PMA20 additive, with the wear index (Di) for the base oil I-20A Di = 0.41 mm and for the I-20A with 2 wt.% of the PMA20 Di = 0.32 mm. The lowering of the wear index to 0.32 mm occurs due to formation of a stable boundary film at high contact loadings during the FBM testing.

The main task of further research in this field is to study the use of the oil I-20A thickened with the multifunctional PMA20 additive whose 2 % concentration in the oil makes it a lubricant for reducing friction in the equipment of power plants.

Conclusion

Polymethacrylate additives were obtained via (co)polymerization of lauryl methacrylate with methyl acrylate in benzene, and their physicochemical properties were studied further. The qualitative composition of the additives was confirmed with the infrared spectrometry. According to a thermogravimetric analysis, it has been found that synthesized (co)polymers are thermally stable up to the temperatures of 255-265 °C.

The influence of polymethacrylate additives in the oil I-20A on the rheological, depressor and antiwear properties was also studied. It has been found that the PMA20 additive with a concentration of 2 wt.% in the oil can be used for obtaining an alloyed industrial lubricant as a commodity with desirable operational properties.

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