Obtaining Lubricants Based on Local Raw Materials with Improved Performance Characteristics

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Abstract. The article presents the results of the conducted researches on production of lubricants for heavy loaded friction units, such as rail and gear units with improved operational characteristics by using purified waste oils.

1 Introduction

At the present stage of industrial development, large-scale work is being carried out in the Republic of Uzbekistan to ensure the effective use of available financial and material resources. In this direction, an important and relevant issue is the involvement in the production of scientific and applied and innovative projects and developments, the implementation of which addressed issues not only commercialization [1], but also environmental, environmental protection, with the expansion of raw materials to obtain new formulations of import-substituting products, including lubricants [2-4, 6]. Of particular interest is the use of used lubricants, while it should be emphasized that the collection and disposal of used oils and lubricants, on a large industrial scale, allows, to a large extent, to solve the problems of environmental protection from the point of view of preventing its pollution, and significantly expand raw materials for the production of lubricants for various purposes. Of particular interest is the use as a dispersion medium of purified waste oils having a sufficiently high level of protective properties due to residual additives, especially when obtaining sodium-quartz lubricants with high performance properties for heavily loaded friction units [3].The use of used lubricants is of special interest, at the same time it should be especially emphasized that the collection and utilization of used oils and greases on a large industrial scale makes it possible to solve considerably the problem of ecological protection of the environment in terms of prevention of its pollution and to expand considerably the raw material resources for production of lubricants for various purposes [15, 19, 20]. Of particular interest is the use of purified waste oils as a dispersion medium, which have a sufficiently high level of protective properties due to residual additives especially when sodium sulfate lubricants with high performance properties for heavily loaded friction units [5, 12].

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2 Methods

As it is known, modern commercial oils and plastic greases are mainly multi-component disperse systems. They consist of at least three to five different components, sometimes their number may reach 8-10. In this respect, development, production and application of lubricants based on mixtures of petroleum hydrocarbons, mainly of cyclic structure (mainly five- and six-membered cycles) with alkyl substituents of linear or iso-structure of different length, using purified waste oils and oils from vegetable raw materials to increase their biodegradability, by adding various additives, can be considered a promising scientific and applied direction. It should be noted that nanosystems, according to the classification accepted in colloid chemistry, refer to ultradisperse colloidal systems with particle sizes ranging from 1 to 100 nm. This size range corresponds to the maximum degree of dispersity, in which the colloidal system still retains one of its main properties - heterogeneity. Based on the above-mentioned provisions we have made and tested various variants, prototypes of greases for heavily loaded friction units, including for rail lubrication in conditions of Fergana oil refinery [8,]. Nanotechnology principle was used, namely creation of stable structure (dispersion) of colloidal formations (CF) of nanosize in different variants of rail grease production with addition of fine-dispersed graphite, colloidal sulfur and additive DF-11 as additives. DF-11, an additive - antioxidant and anti-wear, is obtained by the conventional method, by interaction of various alcohols with five-sulfur phosphorus, with subsequent neutralization of the obtained acidic dialkyldithiophosphoric acid esters with hydroxides of the corresponding metals. In our case dialkyldithiophosphate of zinc up to 1% was used [16, 17, 18]. The main purpose of the work was to determine the influence of component composition of samples on physico-chemical properties of the railway rail grease, as well as to determine the antiwear properties of the obtained lubricants on the four-ball friction machine under constant load, according to GOST 9490-75 by the diameter of the wear spot [9, 10, 11]. On the basis of analysis of obtained results it seemed possible for us to develop effective technology of greasing materials production by using local raw materials and used oils. The new composition of the rail grease by its wear characteristics surpasses the one used at the "Uzbekistan" depot by 12,5 times and can be used to keep and increase the service life of steel lines of the Republic of Uzbekistan. The developed innovative technology of grease production for heavily loaded friction units is protected by a patent of the Republic of Uzbekistan [7]. Semi-liquid greases have viscosity in a wide temperature range depending on deformation rate gradient and due to these properties these greases can be used for heavy loaded friction units along with gear oils in locomotive gearboxes. It should be noted that the presence of soapy thickener in the structure of a semi-liquid grease helps to expand the temperature range of the reducer operation and makes it possible to start it at 10-30oC below the solidification temperature of the oil which is the dispersion medium of the grease [13, 14].

3 Results and discussion

We have conducted researches on obtaining the reducer grease of OSp-Uz type with enhanced operational characteristics by using the local raw materials with high viscosity index, which will solve the problem of import substitution and creation of high-quality products. One of the important factors of semi-fluid greases application in the traction locomotive gearboxes is caused by solving the issue of reducing the consumption of lubricant, irretrievably lost through shaft collars, labyrinth seals and shell slots in the gearbox housing assembly. It depends on the viscosity characteristics of the reducer grease, physical and chemical characteristics of grease OSp according to TU 38.401-58-81-94 which are given in Table 1.

Table 1. Physicochemical characteristics of gear lubricant OSp according to Technical Specifications (TS) 38.401-58-81-94

Indicators	Norm for the brand		Method of testing
	L	Z	(According to State Standart)
1. Appearance	Homogeneous oily liquid of dark brown to black color.		
2. Ash content, % max	3.0	3.0	1461-75
3. Mass fraction of sulfur, % within	1.3-1.7	1.3-1.7	1437-73
4. Corrosive effects on the metal	can withstand		9080-77
5 Mass fraction of water, %, max	0.5	0.5	2477-65
6. Mass fraction of mechanical impurities, %, max	0.1	0.1	6479-83
7. Mass fraction of free alkali in terms of NaOH, %, not more than	0.3	0.3	6707-76
8. Conditional viscosity at + 100°C, conditional degrees	7-12	7-12	6558-52

Based on the physical and chemical characteristics of the gear grease (TS to OSP -Uz TSh 39.3 - 225.2012) we conducted laboratory research on the development of a new composition of gear lubricant grease using deparaffinized residual oil with residual products of oil refining and oil and grease industry. In developing a new composition of gear lubricant, we took into account the fact that the main developments of foreign companies are not so much compositions of compositions and additive packages, which, if necessary, can be identical competitors, as the ratio of components and the technology of their preparation.

On the basis of abovementioned we thought it possible to develop new technology of lubricant production with the use of extracts of selective purification of oil distillates with additives. Motivation of using extracts in the composition of gear lubricant is that it contains polycyclic aromatic, heteroatomic and resinous asphaltene compounds, which are natural antiwear components. Due to their polar activity they are adsorbed on the rubbing metal surfaces of friction units, improving the lubricating ability of materials.Therefore a grease, the base of which is a mixture of oil and extract, has better tribological properties than a grease, the dispersion medium of which is an oil component.

The components of the extract significantly affect the structure formation process, which allows reducing the amount of thickener introduced into the grease to obtain the desired consistency. In this regard, the main purpose of this work is to investigate the possibility of using extracts as a dispersion medium for semi-fluid greases. Physico-chemical and tribological characteristics in terms of scuffing index and critical welding load are given in Table 2.

Table 2. Physicochemical and tribological characteristics of extracts of selective oil distillate purification

Indicators	Selective oil distillate purification extract	
	II	III
Density at 20°C, kg/m^3	984	964
Viscosity at 100°C, mm^3/s	13.40	31,12
Index of refraction at 50°C	1,5458	1,5298
Flash point (open crucible), °C	222	254
Water content, %wt. trace.	traces.	

Chemical composition of groups, % wt. Hydrocarbons: Naphtheno-paraffinic Aromatic Monocyclic Bicyclic Polycyclic Resins and asphaltenes	 32.5 63.2 26.9 19.3 17.0 4.3	 13.4 75.9 24.9 25.1 25.9 10.7
Tribological characteristics: scuffing index, H critical load, H	 266 657	 274 872

As it is visible from the Table 2 in extract of selective purification III oil distillate of Fergana oil refinery contains more aromatic hydrocarbons and resinous asphaltene substances, which include also sulfur compounds. Hydrocarbon composition of this group in oils depends on fractional composition of oils. Consequently, extracts of selective purification of residual oil distillates contain more natural surface-active substances (surfactants), which, being adsorbed on the friction surface, form a thin (1-2 microns) mono- or bimolecular layer and play a positive role as natural antioxidants, anti-wear and extreme pressure additives.

Naphtheno-paraffin hydrocarbons, which content in the extract of selective cleaning of II oil distillate is 2,5 times higher than in the extract of selective cleaning of III oil distillate, are non-polar and low-polarity compounds characterized by low adsorption capacity and low level of lubricating properties. Physicochemical and tribological characteristics of extracts (see table 2) determined on four-ball friction machine (FBM) according to GOST 9490 confirmed the ability of heteroatomic polycyclic compounds to improve anti-wear and extreme pressure properties of lubricant. The tests showed that the extract of selective purification III oil distillate is characterized by higher values of critical load and scuffing index that is connected with high content of surfactants.

On the basis of the conducted researches a pilot batch of gear lubricant has been obtained. The Fergana oil refinery has produced a prototype of the gear-box grease OSp-Uz in accordance with the technical conditions of the pilot batch TSh 39.3 - 225: 2012 and tested for the compliance of physical and chemical properties and antiwear characteristics of the grease OSp (TU 38:401-58-81-94) viscosity characteristics according to the summer variant. This grease can be used in traction reducers of locomotives. Physico-chemical properties of the test sample are summarized in Table 3.

Table 3. Physico-chemical properties of the experimental sample of the reducer grease

No	Indicators	Method of testing (According to State Standart)	Result
1	Appearance		Homogeneous oily liquid of black color
2	Mass fraction of ash, %	1461	0.76
3	Mass fraction of sulfur, %	1437	1.2
4	Corrosion effect on copper plate	9080	can withstand
5	Mass fraction of water, %	2477	0.1
6	Mass fraction of mechanical impurities, %	6370	0.1
7	Curing point, °C	20287	- 9
8	Mass fraction of free alkali in terms of NaOH, %	6707	absence

9	Mass fraction of free acids, %	6707	1.07
10	Conditional viscosity at +100°C, conditional degrees	6558	8.0

Based on analysis of the results, we had an opportunity to develop an effective technology of obtaining lubricant for heavy-duty friction units, in particular for rail lubrication. So with the ratio of fuel oil components 77.5%, fine-dispersed graphite -3%, antiwear additive DF-11 - 1%, sulfurized waste engine oil - 15%, calcium hydroxide - 0.5%, gossypol resin -3% we got the rail grease with the following physical and chemical properties, presented in Table 4.

Table 4. Results of physicochemical tests of the pilot version of rail grease compared to fuel oil

№	Indicators	Fuel oil	New rail grease composition
1	Flash point, ºC	150	190
2	Conditional viscosity at.50ºC, con.grad.	6.98	14.1
3	Curing point, ºC	+8	-6
4	Wear spot diameter at test on four-ball friction machine (FFM), at point contact time of 30 min, mm	2.1	0.05 (0.05)
5	Coefficient of friction	0.93	0.02

As evidenced by the given results of comparative production laboratory tests of different variants of rail grease, operational characteristics, depending on the composition significantly change. The new composition of the rail grease has better operational characteristics in terms of the wear spot diameter of 0,05 mm, conditional viscosity of 14,1 conditional degrees, which is close to the conditional viscosity used in rail transport. In addition, the new composition has the lowest pour point of -6oC. It also has positive values when the grease is applied on rails during the operation of railroads. Special attention should be paid to the anti-wear characteristics of the new composition of rail grease, which is 20 times higher than the rail grease used at the "Uzbekistan" depot of Uzbekistan Temir Yullari Joint Stock Company.

4 Conclusion

Thus, the conducted researches of physical-chemical and tribological characteristics of selective refining extracts and oil disciplates have shown their positive role as natural antioxidants, anti-wear and extreme pressure additives. Using nanotechnology principles, when selecting components on the basis of oils and additives, it is possible to obtain effective lubricant compositions for heavily loaded friction units including rail lubricants.

Experimental-industrial works on obtaining new rail and gear lubricant compositions using used oils and extracts of selective purification and additives, both winter and summer variants, have been carried out. The conducted works allowed developing new innovative technologies for obtaining lubricants for heavy-duty friction units [5], implementation of which will.

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