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THE USE OF PROCESSED POLYETHYLENE PRODUCTS IN THE MANUFACTURE OF PLASTIC LUBRICANTS

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Abstract

It is proposed to expand the raw material base for the production of greases by using used motor oils and solid waste polyethylene products. The results of a laboratory study have been presented; they made it possible to establish that the optimal concentration of the thickener in oil fluctuates within a rather narrow range of 5.0–7.0 wt%. Thus, the obtained greases are identical in quality to the greases of the type Estan 2 (Exxon Co.) and AGIP Grease CC 2 but are much cheaper in production. The approach to attracting secondary energy resources to the technological process of greases production will meet the existing demand for lubricants and significantly reduce the environmental burden on the environment.

Keywords: *secondary hydrocarbon raw materials; plastic grease; thickener; base oil; polyethylene products; quality indicators; adhesive ability.*

1. Introduction

Over the past decade, there has been a rapid increase in the global fleet of construction and agricultural machinery, which in turn contributes to an increase in demand for lubricants, and it can be met in modern conditions only by expanding the resource base.

A promising direction in expanding the raw materials base for the production of lubricants, in particular, greases, may be the involvement in the process of various types of secondary hydrocarbon raw materials, the amount of which is capable of providing industrial production volumes and it will significantly reduce the cost of the final product, and also contribute to improving the environmental situation of the country.

2. The purpose and objectives of the research

The main components in the production of greases by classical technology are the base oil of a mineral or synthetic nature, a thickener (metallic soaps), fillers and additives [1]. Base oils other than the production of greases are widely used in the production of other lubricants so that they are always in great demand. Metal soaps, in turn, have a significant cost, and also for the creation of a spatial structure, they require deep purification of the base oil, which is added from tar-asphaltene substances [2]. Ultimately, this all significantly reduces the volume of industrial production of greases. It is possible to radically change this situation when secondary sources of hydrocarbon raw materials are involved in the grease production. In particular, the base oil can be replaced with various used oils, various functional purposes, wastes of selective cleaning of base oils, high boiling fractions of oil sludges, fuel oil, tar, and pre-prepared acid tar. But for this base (dispersion medium), classic thickeners – metal soaps are completely unsuitable and require their replacement by other substances that are not so demanding for the hydrocarbon composition of the dispersion medium. Such thickeners can be used plastic products, in particular, from polyethylene.

3. Results and discussion

There are a number of works in which it is proposed to use polyethylene as the main component of grease. For example, it was proposed in work [3] to use low molecular weight polyethylene, a waste product for the production of high-density polyethylene, as a dispersed phase in the production of greases.

It was proposed in work [4] to add various wastes and pure polymers (polyethylene, polypropylene and EVA copolymer) to lithium grease as modifiers of its viscosity. It has been established that the processed polymers significantly improve the rheological properties of the lubricant than the pure polymers. But in cases where the lubricant containing these polymers was subjected to significant mechanical stresses, its stability was deteriorated.

Also, the following studies have been carried out in the direction of the grease manufacture, by adding base oils of Group I and Group II (kinematic viscosity at 40°C = 160 mm^2/s) to the mixture. These oils are manufactured by Indian Oil Corporation Ltd. (Faridabad, India), a mixture of polypropylene and high-density polyethylene (PP+HDPE). The result of this work was the grease production with high rheological properties [5].

Based on the mixing of two components, melted polypropylene or low density polyethylene in the base oil and the base oil that was thickened with sodium stearate, grease was obtained, which is 80-85 % more resistant to water than a conventional sodium lubricant [6].

Taking into account the positive properties of polyethylene as a thickener, we propose a plastic lubrication, which consists of SAE 10W-40 API SL engine oil, the amount of which and the negative impact on the environment predetermine the need for its utilization [7], and crushed solid polyethylene products in the form of household packages and film. But to further study the properties and performance characteristics of such a lubricant, first of all, it is necessary to determine the necessary concentration of polyethylene – a thickener, which will meet the requirements of the regulatory documentation concerning the quality of greases.

In the laboratory, two plastic lubricants were obtained, one of which was thickened with crushed products from low-density polyethylene (LDPE), and the second one was obtained with crushed products from high pressure polyethylene (HDPE). The lubricants had a homogeneous, greasy brown-dark structure, and the concentration of the thickener in them varied within 1.0–10.0 wt%.

Further, it has been studied the change in the quality parameters of lubricants (penetration, colloidal stability, volatility, the temperature of sliding and dropping), characterizing their structure and properties [8], from the change in their concentration of thickener (Fig. 1-5).

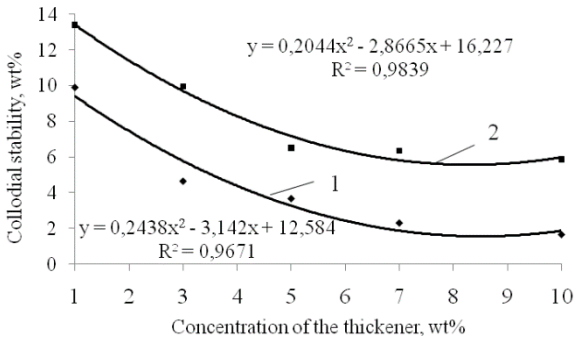

Fig. 1. Dependence of the colloidal stability of the lubricant on the concentration of the thickener: 1 – LDPE; 2 – HDPE

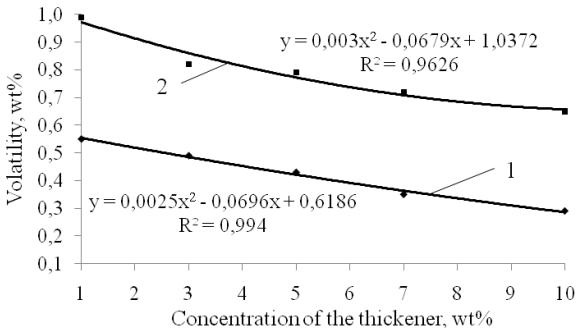

Fig. 2. Dependence of oil volatility on the thickener concentration: 1 – LDPE; 2 – HDPE

With an increase in the concentration of the thickener from 1 wt% to 10 wt%, the colloidal stability of the lubricants is improved (Fig. 1). Thus, for a lubricant that is thickened with LDPE, a decrease in the value is observed from 9.92 wt% to 1.65 wt%, and for greasing with HDPE: from 13.4 wt% to 5.87 wt%. Also, evaporation significantly decreases (Fig. 2): for

lubrication with LDPE – from 0.55 wt% to 0.29 wt%, for greasing with HDPE – from 0.99 wt% to 0.65 wt%. An important indicator, like lubricant penetration (Fig. 3), also decreases significantly, indicating a change in the consistency of the lubricant, that is, the compaction of its structure.

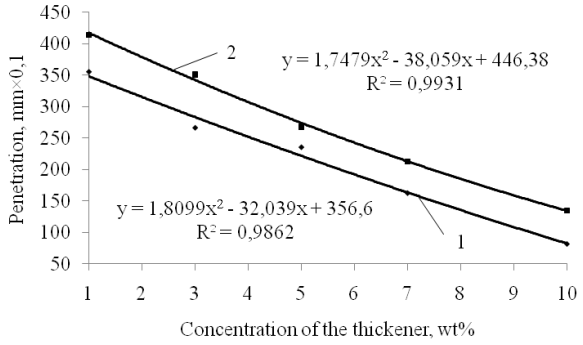

Fig. 3. Dependence of lubricant penetration on the thickener concentration: 1 – LDPE; 2 – HDPE

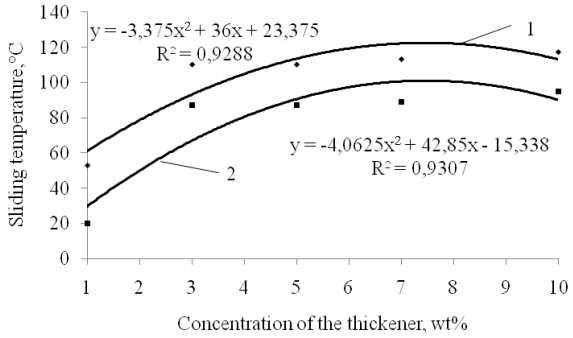

Fig. 4. Dependence of lubricant sliding temperature on the thickener concentration: 1 – LDPE; 2 – HDP

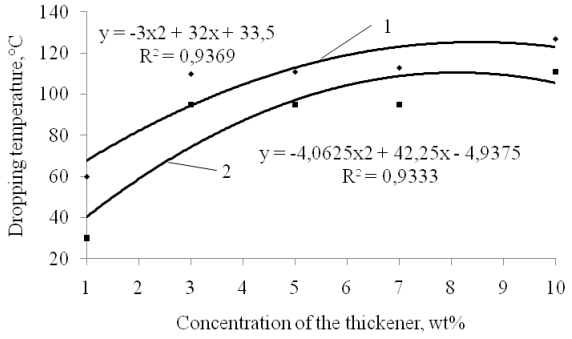

Fig. 5. Dependence of the dropping temperature of the lubricant on the thickener concentration: 1 – LDPE; 2 – HDPE

The temperature of sliding and dropping of grease (Fig. 4-5), at a concentration of the thickener at a level of 3 wt%, reach a certain level, which remains to 10 %, then their value slowly increases to 117°C and 119°C for greases with LDPE and 95°C and 110°C for HDPE lubrication respectively. It should also be noted that samples with LDPE at equal concentrations of thickener always have significantly better quality values than grease with HDPE. This is due to the difference in the melting point of these grades of polyethylene, which in some cases is about 40°C.

For the obtained lubricant samples, a very important indicator was also determined, and it characterized the possibility of using lubricant under certain conditions – the adhesive capacity [9]. Actually, according to this indicator, it was decided to determine the optimum concentration of thickener in the lubricant. It is proposed in work [10] to determine the adhesiveness of greases that contain various polymers and are used in sliding and rolling bearings using the method ASTM D 2979.

But we chose the method of determining the adhesive ability, which simulates the forces that affect the lubrication during the operation of the bearing. It consists in determining the rotational speed of the laboratory centrifuge, in which the layer of applied lubricant begins to drop from the surface of the metal plates fixed in it.

It was found that at 2000 rpm all the samples except those where 1 wt% of HDPE and LDPE were kept firmly on the plates. At 3500 rpm, only two samples are retained on the plates, with 5 wt% of LDPE and 7 wt% of HDPE. This indicates sufficiently high adhesion properties of these samples. At thickener concentrations of up to 3 wt%, the lubricant has a soft structure and centrifugal force discharges it from the plate. In the case of thickener concentrations of more than 10 wt%, a denser lubricant structure is formed, which also leads to deterioration of the adhesion properties, and as a result, dumping from the plate under the influence of centrifugal force.

4. Conclusion

Using solid household waste in the form of waste polyethylene products as thickener of the base oil, it is possible to obtain a rather wide range of plastic greases for various functional purposes. With this approach, there is no need to use distillate fractions as the base oil, and it is possible to use waste oil even without deep pre-treatment and various highly boiling fractions of oil residues.

It has been experimentally established that the optimal concentration of thickener fluctuates within a very narrow range of values, within the range of 5–7 wt%, depending on the method of polymer production. The greases obtained in this way are identical in quality to the greases of the type Estan 2 (Exxon Co.) and AGIP Grease CC 2, but are much cheaper in production.

Expanding the raw material base for the grease production by attracting secondary energy resources will help meet the existing demand for lubricants and significantly reduce the environmental burden on the environment.

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