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# PRODUCTION OF PLASTIC LUBRICANTS ON THE BASIS OF WASTE LUBRICATED OILS

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**Abstract**

The results of studies of used lubricating oils, various functional purposes and greases obtained on their use as a thickener 5 wt % of secondary low-pressure polyethylene have been presented. Depending on the operating conditions in the samples of waste oils, the content of water and mechanical impurities varies in the range of 0.03-0.3 wt %, 0.08-1.30 wt %. Heating the oils to a temperature of 230°C showed that in the area of heating to a temperature of 200°C, the mass loss and decrease in viscosity are not significant, however, if this temperature is exceeded, an intensive process of destruction of oil hydrocarbons begins, and it will negatively affect the quantitative yield and performance properties of the lubricant. The obtained results showed that the lower the viscosity of the base oil from which the grease is made, the less stable it is during storage and operation, the worse its adhesive properties. Waste motor and transmission gear oils are advisable to use in the production of antifriction greases while hydraulic and industrial plastic lubricants are better to use in the production of protective greases.

***Keywords***: *Plastic grease; thickener; polyethylene products; base oil; quality indicators.*

## 1. Introduction

Plastic lubricants (greases) today are one of the most popular petroleum products, which, due to their operational properties, are widely used in various industries.

Current trends that have emerged in the global oil refining and petrochemical industries are such that most of the manufacturers of plastic lubricants, to ensure competitiveness, are forced to go the way of reducing the final cost of their products while maintaining their quality.

The main directions in choosing such a path are the improvement (optimization) of the technological process of production and the expansion of the raw material base due to the involvement of new, cheaper materials in the technological process.

## 2. The purpose and objectives of the research

In general, the composition of any grease can be represented in the form of a structural block diagram shown in Fig.1.

The main component in the composition of greases is base oils (not less than 70 wt %) of mineral or synthetic nature [1-2].

*Mineral oils*, distillate or residual, are high-boiling fractions (boiling point > 350°C) obtained in primary oil refining plants by distilling fuel oil or tar under vacuum. Further, these fractions are cleaned using selective solvents from high-boiling paraffin hydrocarbons and tar-asphaltene substances.

*Synthetic oils* have better viscosity-temperature properties and higher stability against oxidation, compared to mineral oils. They are obtained by special directed synthesis in the presence of catalysts, which makes them more expensive than mineral oils. In view of what, they are used in the manufacture of special types of lubricants for use in harsh environments. Synthetic oils include polyolefins, esters of carboxylic, phosphoric and silicic acids, polyglycolic esters and siloxane oils.

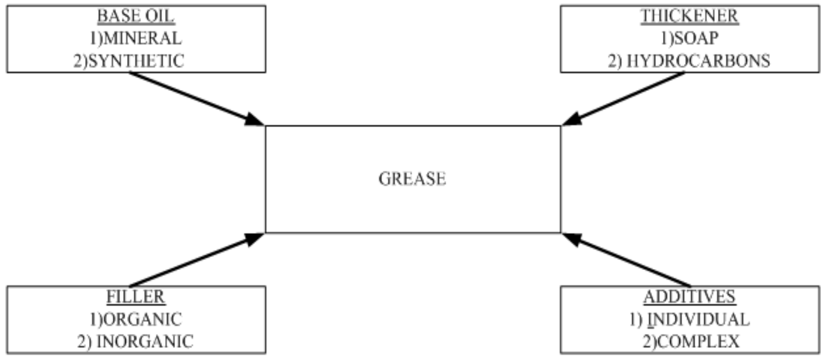


Fig. 1. The composition of the grease

The main property of base oil, both mineral and synthetic, on which many physical properties and tribological characteristics of plastic lubricants depend, is considered to be viscosity [3-4].

Thus, choosing cheaper basic components of grease – base oil and a thickener, you can significantly reduce the cost of the final product. In this regard, recently a number of works have appeared in the technical literature in which it is proposed to use waste oil as base oil - lubricating oils of various functional purposes. Under this approach, on the one hand, the expansion of the resource base of the technological process is gained and, on the other hand, the reduction of the harmful environmental impact of toxic industrial waste is achieved [5].

In the works [6-7], on the basis of waste oil, from which mechanical impurities, oxidation products of hydrocarbon oil and decomposition of additives, and a thickener – sodium and calcium soaps, obtained on the basis of bottom synthetic fatty acid residues were extracted, and the general-purpose antifriction lubricant was obtained. Also, as a base for the production of greases, besides used motor oils, purified waste vegetable oils can also be used [8].

A common drawback of the works cited above is the need for deep cleaning of the base oil, which is a very time-consuming, a multi-stage process that requires significant material costs for its implementation. This is mainly due to the softening effect of the detergent-dispersant additives found in the waste oil on the formation of the structure of lubricants thickened with metal soaps. Also, the oxidation products of hydrocarbons in the base oil have a negative effect on the process of structure formation of the grease during its production, and, as a result, the surface properties of commercial grease [6-7, 9].

At the same time, the additives found in the waste oil possess anticorrosive properties, and the oxidation products of hydrocarbons are surface-active substances, which ultimately will help to improve the tribological characteristics of plastic lubricants based on them.

The most rational approach in the development of technology for the production of greases based on used oils may be the search for a new type of a thickener, for the application of which it is not necessary to carry out a deep cleaning of the base oil.

Taking into account that temperature properties of the use of greases depend on the properties of the thickener, we will propose to use secondary high-density or low-pressure polyethylene for this purpose. The use of polyethylene as a thickener has a number of positive aspects: lubricants containing polyethylene have high rheological properties [10], polyethylene has a rather high melting point (more than 100°C) and, finally, recycled polyethylene is a harmful household waste, and its recycling allows to significantly improve the global environmental situation.

Therefore, in the future, we will consider the possibility of using various used lubricating oils, without their deep purification, for the production of plastic lubricants, in which the thickening agent is the secondary polyethylene.

## 3. Results and discussion

At the first stage of the laboratory study, the following used lubricating oils were taken: engine oil SAE5W-40 (sample No. 1), engine oil SAE10W-40 (sample No. 2), transmission oil SAE90W-140 (sample No. 3), hydraulic oil HLP 46 (sample No. 4), industrial oil I-40 (sample No. 5). In all the samples, the kinematic viscosity at 100 °C, the content of water and mechanical impurities, and the corrosive effect on metals: copper and steel plates were determined (Table 1).

Table 1. Results of laboratory research waste oils

| Indicator name | Sample number | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Kinematic viscosity at 100°C, $mm^2/s$ | 14.75 | 12.31 | 29.92 | 6.74 | 7.74 |
| Water content, wt % | 0.3 | 0.2 | 0.1 | 0.05 | 0.03 |
| The content of mechanical impurities, wt % | 0.11 | 0.09 | 1.3 | 0.10 | 0.08 |
| Corrosive effect on the copper plate in the liquid phase, points | 2 | 2 | 1 | Not available | |
| Corrosive effect on the copper plate in the vapor phase, points | 1 | 1 | 2 | Not available | |
| Corrosive effect on the steel plate in the liquid phase, points | Not available | | | | |
| Corrosive effect on the steel plate in the vapor phase, points | Not available | | | | |

Taking into account the data obtained, we note that the corrosive effect on metals in some samples is absent or varies in the margin from weak (1 point) to moderate impact (2 points), and the oils themselves do not need additional anti-corrosion treatment. The content of water and mechanical impurities, practically in all samples, also fluctuate in a rather narrow range of values and can be removed to the required level without the use of any special equipment, but only due to the sedimentation of oils when heated, on average, to 100-110 °C.

The exception, from the considered samples, is transmission oil with the content of mechanical impurities of more than 1 wt %, which is quite explicable by the conditions of its operation. In this case, it will be possible to apply centrifugation to the oil purification, or taking into account the nature of mechanical impurities and magnetic cleaning.

Further, the behavior of the oils under investigation was studied when they were heated in the temperature range up to 230 °C, with exposure at each fixed sample temperature for 30 minutes (Fig. 2).

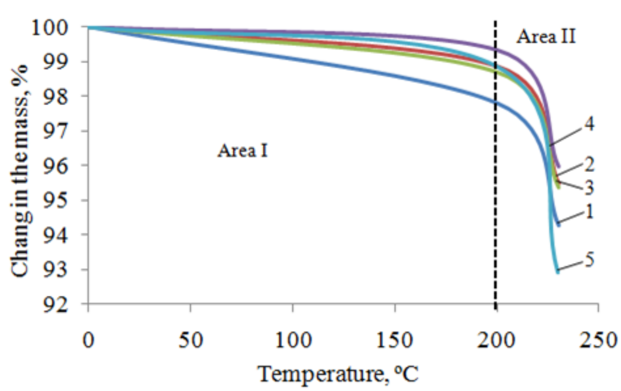


Fig. 2. The change in the mass of oil samples when heated: 1, 2, 3, 4 and 5 – sample numbers

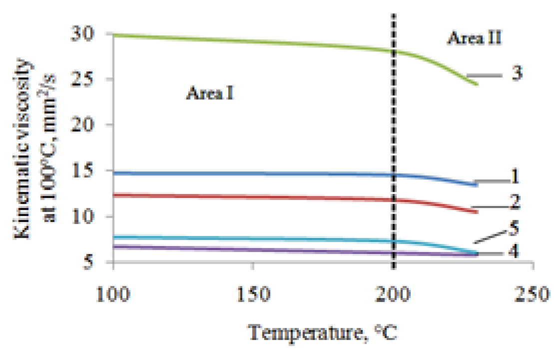


Fig. 3. The change in kinematic viscosity of oil samples when heated at 100°C: 1, 2, 3, 4 and 5 – sample numbers

When samples of waste oil are heated to a temperature of 200°C (Fig. 1), which corresponds to the area I, there is a gradual loss of sample mass, which is associated with evaporation of water and light hydrocarbon fractions, which can be formed during the operation of oil. After 200ºC, area II, there is a more significant loss of mass of the samples, which indicates the beginning of the destructive processes of oil occurring with hydrocarbons, which will deepen with increasing temperature. In this regard, the temperature of about 200ºC can be recommended as the final one during the heat treatment stage of the grease.

It is possible to judge the destructive processes occurring during the heating of oil samples by the rate of change of the kinematic viscosity, which is determined at 100°C (Fig. 3).

Thus, in the area I for all oil samples there is a slight decrease in the kinematic viscosity relative to the initial value. This change can be quantitatively characterized by the rate of viscosity change from temperature (by 1ºC): sample No. 1 $v^{100}/t$ = 0.0020 ($mm^2/s$); sample No. 2 $v^{100}/t$ = 0.0051 ($mm^2/s$); sample No. 3 $v^{100}/t$ = 0.0180 ($mm^2/s$); sample No. 4 $v^{100}/t$ = 0.0070 ($mm^2/s$); sample No. 5 $v^{100}/t$ = 0.0044 ($mm^2/s$).

In area II, destructive processes of hydrocarbon raw materials occur and the same rates for each oil sample take higher values (by 1ºC): sample No. 1 $v^{100}/t$ = 0.0037 ($mm^2/s$); sample No. 2 $v^{100}/t$ = 0.041 ($mm^2/s$); sample No. 3 $v^{100}/t$ = 0.122 ($mm^2/s$); sample No. 4 $v^{100}/t$ = 0.0080 ($mm^2/s$); sample No. 5 $v^{100}/t$ = 0.0413 ($mm^2/s$).

The next stage of the laboratory study involved obtaining, on the basis of the studied samples of used lubricating oils, plastic greases containing up to 5 % of a complex additive, in which thickened secondary low-pressure polyethylene acted as a thickener, in an amount of 5 wt % for raw materials.

In the resulting grease samples, some quality indicators (Table 2) were determined that were directly related to the viscosity of the base oil.

Table 2. Indicators of the quality of the resulting greases

| Indicator name | Grease on the base oil | | | | |
|---|---|---|---|---|---|
| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 |
| Evaporation, wt % | 0.16 | 0.22 | 0.12 | 0.25 | 0.34 |
| Colloidal stability, wt % | 7.10 | 8.23 | 5.90 | 9.65 | 11.96 |
| Penetration at 25ºC, mm·0.1 | 224 | 237 | 219 | 324 | 308 |
| Adhesive properties, discharge in a centrifuge, rpm | 3000 | 3000 | 3500 | 2000 | 2000 |
| Corrosive effects on metals (copper, steel) | Not available | | | | |

The obtained results showed that the lower the viscosity of the base oil from which the grease is made, the less stable it is during storage and operation, and the worse its adhesive properties are.

## 4. Conclusion

Used lubricating oils of various functional purposes, today, can be used as a raw material in the production of plastic lubricants. The use of such raw materials has a number of positive aspects: low cost, the presence of residual potential of additives and disposal of hazardous industrial waste.

However, it should be noted that when using metal soaps as a thickener, it is necessary to perform a deep cleaning of the oil from additives and products of aging, and this, in turn, affects the increase in the cost of the final product. In this case, effective thickeners, which allow obtaining high-quality greases with minimal cleaning costs while preserving the residual potential of the additives in the oil, are secondary polymers, in particular, low-pressure polyethylene.

The best raw materials for the production of anti-friction grease are engine and gear oils. The lubricant obtained on the basis of the oils has high stability and good adhesive properties during storage and operation. It makes most senses to use hydraulic and industrial oils in the production of lubricants used in assemblies at relatively low rotational speeds or protective lubricants.

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