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Possibility of Producing Plastic Lubricants by Thermal Destruction of Solid Domestic Wastes

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Abstract

The results of non-catalytic thermal destructive processing of solid domestic waste at atmospheric pressure and temperature of 360°C, which are represented by products of low pressure polyethylene, are presented. The products obtained during degradation can be divided into fuel products (gas, liquid hydrocarbon fraction, coke residue) and fraction (with the beginning of boiling in the temperature range 200-320°C), which can be used in the production of greases. After the heat treatment and cooling of these fractions, a product with properties similar to NYCO 65 VASELINE (Technical petrolatum (GREASE)) can be obtained. For the production of plastic lubricants with other properties and a large temperature interval of application, a scheme has been proposed, it provides for the addition of fillers and additives of different functional purpose to the lubricant obtained.

Keywords: *Thermal destruction; Plastic lubricant; Dispersion medium; Polyethylene products; Quality indicators.*

1. Introduction

The production of plastic lubricants is one of the final stages of the process of crude oil processing and requires the use of distillate oil fractions that have undergone a selective purification phase, and the final content of which amounts to 70-80% by weight of the total production in oils. These fractions are also widely used in the production of lubricating oils of various functional purposes, and therefore are in great demand, and it certainly affects their cost and the cost of the final product – plastic lubricants. Taking this into account, a promising direction in reducing the cost of grease production, while maintaining its quality characteristics, it is necessary to find a cheaper analogue, and its volumes will allow to use it on an industrial scale.

2. Research objective

An analogue that can partly replace distillate oil fractions in the production of greases is solid household waste – waste polyethylene products in the form of various packages, packaging film, etc. These wastes are accumulated in large quantities and are a significant environmental problem in many countries of the world [1]. Consequently, they can become a source of valuable hydrocarbon raw materials. But to obtain a homogeneous plastic grease with certain operational and physicochemical properties, it is necessary to transfer polyethylene products from the solid phase state to the liquid phase, and then, upon cooling and to a consistent state. In this case, the method of controlled thermal degradation of polyethylene raw materials can be applied, it will allow to obtain by-products in the form of gas and fuel fractions and the desired product, the hydrocarbon fraction, which can be used as a dispersion medium in the production of greases.

Destructive processing of polymeric waste is being handled in many countries of the world, and nowadays this is one of the most promising directions, which, on the one hand, allows us to obtain a cheap source of energy, and on the other hand, to improve the ecological situation in the world. But it should be noted that most of these works are devoted to obtaining components of motor fuels from polymer waste. So, it was proposed by pyrolysis method in the temperature range 400-550°C and in the presence of a catalyst – mixtures of Al_2O_3 and SiO_2, to obtain from the plastic polyolefin waste of liquid fuel – a light fraction of diesel fuel, gas and a small amount of solid residue [2]. In the paper [3], the oil (WPPO) was presented, it was obtained by pyrolysis of HDPE waste at a temperature of 330 – 490°C for 2 – 3 hours. The comparison of the properties of the product obtained with the standards for petroleum products ASTM D 975 and EN 590 showed that it meets all the requirements for diesel fuel. Using the technology of pyrolysis in a rotor reactor from plastic wastes, the authors of the work [4] obtained up to 70% (by mass) of fuel, which was identical in properties to diesel, but with a high heat release during combustion in the engine. As by-products, 20% by weight of coke and 10% by weight of hydrocarbon gases were obtained.

High-density polyethylene wastes were thermally degraded in the reactor at 400°C in the presence of a fixed bed of sulfonated zirconium catalysts to obtain a 32 – 53% by weight liquid hydrocarbon fraction consisting of paraffinic, naphthenic and aromatic compounds, and by boiling point related to the gasoline fraction [5]. The authors of the work [6] carried out a two-stage pyrolysis-catalysis of high-density polyethylene to produce a hydrocarbon oil of the gasoline range (C8-C12). The process consisted of pyrolysis of the polymer in the first stage followed by the catalysis of the hydrocarbon pyrolysis gases released in the second stage on solid acid catalysts (mesoporous MCM-41 and microporous zeolite ZSM-5). The yield of the highly flavored product was 95.85% (by weight)

It should be noted that a lot of attention has been paid to the processing of various polymeric raw materials, both in components and in commodity motor fuels, but in our opinion, such a direction as processing aimed at obtaining lubricants is understudied.

So, in this direction, we are interested in a new developed non-catalytic process of polymer pyrolysis waste (polyethylene, 96% of polyethylene terephthalate (PET)) and Fischer-Tropsch wax (FT) at atmospheric pressure and a temperature of 385°C, which converts molecules with high molecular weight into molecules with a lower molecular weight in the lubricating oil range. Then hydroisomerization is used to convert this product into a base oil (UCBO) with a low pour point of -13 to -37°C, a viscosity of 3.4 – 5.4 mm2/s and a viscosity index in the range of 150 – 160 units. The main by-product is diesel fuel with small amounts of C4-gas. The yield of pyrolysis products at a temperature of 385°C was in the range 37 – 57% (by mass), and the yield of the oil was 60 – 70% (by weight) [7].

3. Results and discussion

Considering the long-term world experience in the production of greases, we propose to obtain the main component of lubrication by non-catalytic destruction of wastes consisting of polyethylene products, in particular low pressure polyethylene, in a reactor at atmospheric pressure and at a temperature of 350 – 360°C. Such a method is more economical, in comparison with the methods described above, since it proceeds at lower temperatures and passes in one stage.

A special feature of the method is the uniform, slow heating of the reaction mixture at a rate of 40 – 60°C/min in a batch reactor. At the same time, 75 – 80% (by mass) of a wide hydrocarbon fraction, 10 – 15% by weight of hydrocarbon gases C_3-C_4 and ~ 10% by weight of the coke residue are formed. Further, by fractionation from the broad hydrocarbon fraction, narrow fractions are removed for which dependencies have been obtained between such parameters as the mass fraction yield, the dropping point and the boiling point of the fraction

It should be noted that the range of the obtained fractions was limited by the boiling point of 320°C, due to the fact that in the higher temperature range there is an intensive destruction of the obtained fractions, and it significantly reduces their yield and negatively affects their quality indices.

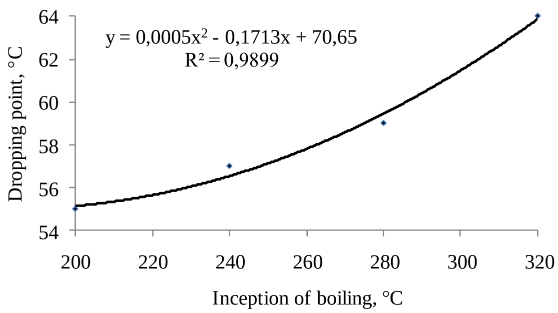

Fig. 1. The dependence between the dropping point and the inception of boiling fractions of polyethylene raw material destruction

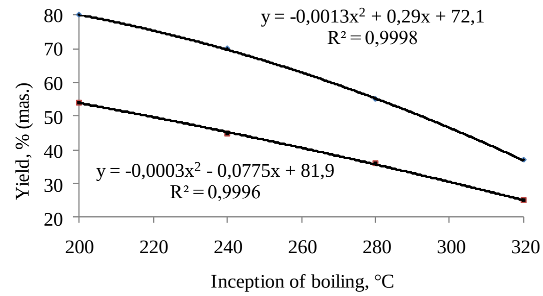

Fig. 2. The dependence between the yield and the inception of boiling of the degradation fractions of polyethylene raw materials: 1-output for raw materials; 2- broad band outlet

For the fraction production, adhesion has also been determined, it is an important performance indicator for greases [8]. The determination of the adhesive capacity of the fraction was carried out taking into account the operating conditions of the lubricant in the bearing.

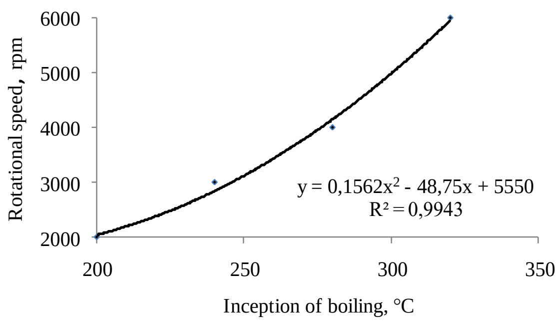

Fig. 3. The dependence between the rotational speed of the centrifuge and the inception of boiling of the degradation fraction of polyethylene raw materials

That is, the rotational speed of the laboratory centrifuge was determined, at which the layer of deposited fraction begins to drop from the surface of the metal plates fixed in it (Fig. 3). With an increase in the boiling point of the fraction, an improvement in the adhesive properties of the fraction is observed, it is expressed in the rate of dropping from the metal plate in the centrifuge.

Thus, the results obtained showed that the largest value of the drop temperature (64°C) in the considered range is observed in the fraction with a boiling point of 320°C. Also, this fraction has maximum adhesion properties, and it corresponds to 6000 rpm.

Taking this into account, for the fraction with a boiling point of 320°C, after its heat treatment to form the desired structure and properties, some of the main quality indicators were investigated, and it determines the scope of greases (Tab. 1).

Table 1 Quality Score for a fraction (> 320°C)

Characteristic	The value for the indicator
Appearance	Simple, brown
Penetration, mm·10^{-1}	156
Droplet temperature, °C	64
Creep temperature, °C	60
Corrosive effect on metals	Withstands (for steel and copper)
The presence of water-soluble acids and alkalis	Not available
Solubility:	
- in water at 100°C	not dissolve
- in gasoline at 60°C	dissolves

We note that, regardless of the beginning of the fraction boiling in the range 200 – 320°C, they all do not exert a corrosive effect on steel and copper, and do not dissolve in water. These positive properties, as well as the dropping point values within 55 – 64°C, make it possible to use them as analogues of NYCO 65 VASELINE (Technical petrolatum (GREASE)).

Later on, as an example of a fraction with a boiling point of 320°C, a production scheme can be proposed for obtaining a wide range of greases, which can include two steps containing a certain sequence of technological steps and be implemented in a petrochemical plant (Fig. 4).

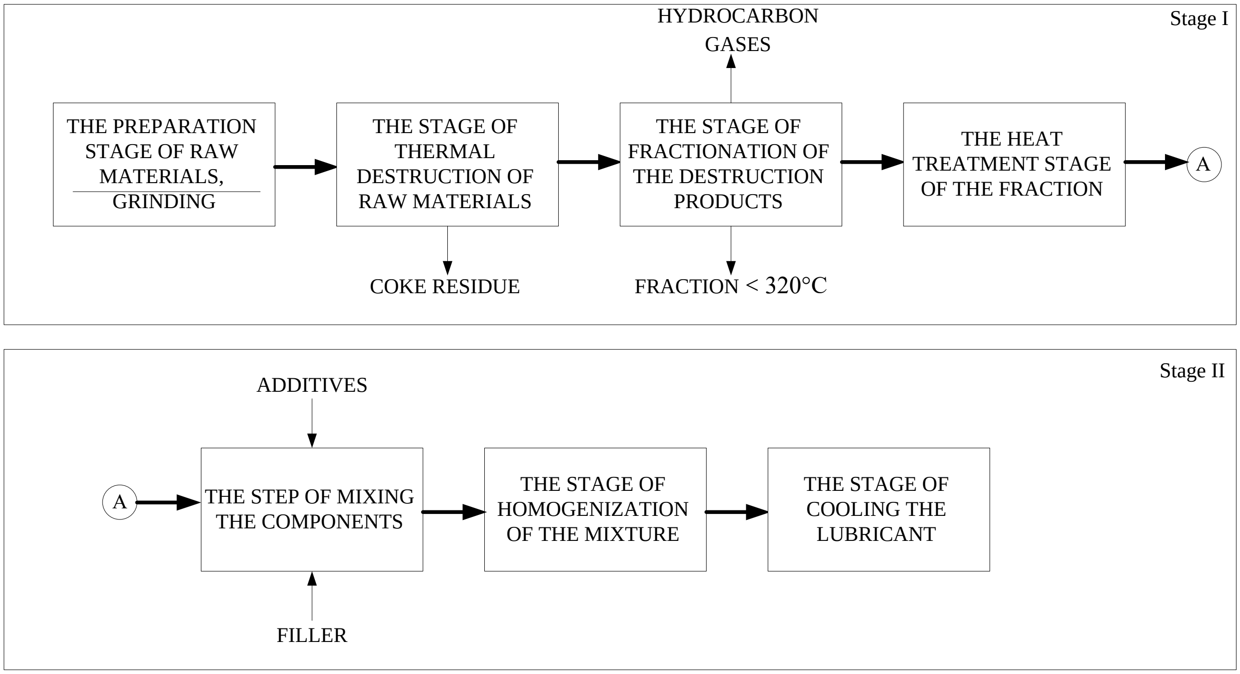

Fig. 4. The scheme for the grease production from secondary polyethylene raw materials

At the first stage, the raw material for processing is carried out, the actual processing and heat treatment of the obtained fraction to form a certain product structure. After the heat treatment of the fraction with subsequent cooling, it already acquires certain properties (Tab. 1) and can be used as grease. At this stage, also, by-products are formed in the form of hydrocarbon gases, hydrocarbon fractions and coke. Hydrocarbon gases can be separated in gas fractionation plants into components and used as raw materials in organic synthesis or used as industrial fuel in this production scheme.

The hydrocarbon fraction (< 320°C) is suitable for the production of furnace and boiler fuel, which can be used, as in the case of hydrocarbon gases, to produce the thermal energy necessary to implement this production scheme. Coke residue can be used in the production of fuel briquettes for domestic and industrial needs.

For the grease production with a significantly higher quality than those listed in Table 1, the scheme provides for the second stage. At this stage, fillers and additives can be added to the resulting lubricant to produce lubricants with other properties and a wider temperature range of use.

4. Conclusions

Polyethylene waste is a valuable source of hydrocarbon raw materials, which must be attracted not only to the technology of fuel production, but also to the technology of grease production. They can be used as fillers for lubricants, obtained by thickening the base oil with metallic soaps, and as an independent basic dispersion medium.

The parameters that were studied during this work (dropping temperature, adhesion, corrosive effect on metals, insolubility in water) make it possible to use narrow fractions with boiling points in the range of 200 – 320°C obtained by destruction of polyethylene waste as plastic grease for plain bearings and protection of metal surfaces against corrosion, it can be analogous to NYCO 65 VASELINE (Technical petrolatum (GREASE)) lubricant. It should also be noted that the expediency of choosing a fraction for the industrial grease production will be affected not only by the values of its quality indicators, but also by the mass yield. For the fractions considered, an improvement in the quality index is observed, depending on the increase in the boiling point of the fractions, but at the same time a decrease in their mass yield.

The scheme has been proposed that provides for the addition of various fillers and additives to the heat-treated base fraction obtained by thermal degradation of polyethylene raw materials, which significantly increase the level of its operational properties, to obtain greases with broad range of application.

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