

ARTICLE

PRODUCTION OF MOTOR OILS ON A MINERAL AND SEMI-SYNTHETIC BASIS

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ABSTRACT

In this work, the production of oils on a mineral and semi-synthetic basis is considered and studied in detail. Objective of the work is to study and analyze the production of motor oils. In the process of our work, we conducted research of the production of motor oils. We performed an analytical review of the data, where we have considered the basic and technical requirements for petroleum oils, the classification of products and symbols of commercial oils. In the course of studies, we have also reviewed and carried out technological calculations of a dewaxing plant. We considered the process of cleaning crude oils, the classification of petroleum oils and the main indicators of their quality, cleaning methods, and continuous-flow types of motor oils production. Oil additives, their purpose, classification and mechanism of action were also studied. We studied the working conditions of motor oils and the process of preparing commercial oils.

INTRODUCTION

KEY WORDS
motor oils, synthetic oils,
semisynthetic oils,
mineral oils, analysis, raw
materials, depareft,
supplements.

Motor oil is a substance that is used to service parts of various kinds of mechanisms. Motor oil is one of the important elements of engine design. It is divided into synthetic, semi-synthetic, mineral and hydrocracking oils. Many people believe that synthetic products work better than mineral products, but not everyone has an idea of what synthetic and mineral motor oils are and what they are intended for.

Mineral motor oils are simply refined oil, but synthetic oil was created in laboratory conditions. Mineral oils are productive in use and have the least destructiveness to details. In many cases, they are not applied in pure form and therefore about 10% of various additives are added to them. And due to additives, mineral motor oil becomes anti-corrosion, more corrosion preventive and have higher detergent properties. The main disadvantage is the accelerated wearing and also due to additives mineral oil cannot maintain a stable mixture homogeneity for a long time. Mineral oils are divided into several types, such as: aromatic, paraffinic and naphthenic. The increased viscosity of such oils minimizes the formation of oil leaks in parts with increased wear.

Synthetic oils are designed to provide our engine with a higher level of protection against wear and temperature rise. In addition, when we use synthetics, the resistance level is lower and because of this, our engine shows higher power and fuel economy. The main disadvantage of synthetic oil is its high cost. Synthetic oil differs from mineral oil, first of all, at the molecular level. It is not necessary to add a large amount of additives to a synthetic oil, as to a mineral one; the necessary substances are already synthesized in its composition when it is created.

Semi-synthetic oils are a mixture of petroleum products with synthetic ones. The composition of semi-synthetics allowed for to combine the best characteristics of mineral and synthetic oils, as a result, we get a product with excellent performance characteristics and low cost. The most important characteristics of semi-synthetics are: low evaporation, high viscosity index, etc.

METHODS

Petroleum oils are a complex hydrocarbon mixture (the number of carbon atoms is 20-60; molecular weight is 300-750, boiling point is 300-650°C). Raw materials for the production of motor oils are fuel oil, and the main process of processing is vacuum distillation, as a result of which narrow (close cut) oil fractions (from 1 to 4) and tar are obtained [1].

Resinous asphaltene, polycyclic aromatic and high molecular weight paraffinic hydrocarbons are undesirable components that impair the physicochemical and operational properties of commercial oils, therefore the production technology of the base oils is based on selective removal of undesirable hydrocarbons from the oil fractions while preserving the components that provide the required physical-chemical and operational properties of resulting commercial oils. Some components are usually considered harmful and can be very valuable in some areas:

- Resins, fatty and naphthenic acids increase the stickiness and durability of the adsorption film of the oil (improve lubricity);
- Some sulfur and nitrogen compounds exhibit antioxidant properties; therefore, during deep cleaning of the oil, some of its lubricating, antioxidant and anticorrosion properties may deteriorate [1].

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Cleaning removes:

- sulfur compounds and organic acids;
- resinous and asphaltene compounds;
- unsaturated hydrocarbons;
- solid hydrocarbon compounds dissolved in oil;
- polycyclic compounds.

Viscosity index characterizes the change in viscosity of lubricating oils depending on temperature. A relatively small change in viscosity occurs with temperature for oils with a high viscosity index; oils with low viscosity index feature a significant change in viscosity.

A simple treatment with sulfuric acid, lime and bleaching clay turns distillates into products with acceptable quality and a low viscosity index. For the production of products with high and medium viscosity index, it is necessary to use certain types of extraction with solvents separating colored, unstable and having low viscosity index components. At the final stage, the oil is dewaxed (that is, paraffins are removed from it) to obtain a product with a pour point of from minus 10° C to minus 20° C. This process is carried out by dissolving the oil in methyl ethyl ketone (MEK) followed by cooling and filtration [1].

At most plants, three or four fractions are obtained by mixing of which the whole range of marketable oils is produced.

Synthetic base products

Synthesis processes make it possible to create molecules of relatively simple compounds with the desired properties. The main classes of synthetic materials used as components of oils [1] are listed in [Table 1].

With the exception of poly glycolic fluids, all synthetic base oils have a viscosity within the limits typical of the lightest high-index distillate mineral oils. However, their viscosity index and flash point are higher, and their pour point is significantly lower [1].

Table 1: Main classes of synthetic materials

Type	Main application
Alkylated aromatics	Automobile and industrial oils
Oligomers of drying agents	Automobile and industrial oils
Dibasic acid esters	Aviation and automobile oils
Polyol esters	Aviation and automobile oils
Polyalkylene glycol	Industrial oils
Phosphoric acid esters	Industrial oils

The main disadvantage of synthetic oils is that by their very nature they are more expensive than mineral ones. This limits their use in the field of special oils and lubricants. Ester-type fluids have another one drawback: they cause more swelling degree for sealing materials than hydrocarbons, so they should be used with care in applications where they can come into contact with elastomers designed for working with mineral oils.

Methods for cleaning oil fractions are the following

1. Chemical methods with the use of reagents (acid, alkali, hydrogen) that chemically interact with the components to be removed (alkalization, sulphate or hydrogenation process)
2. Physical methods with separation of the oil fraction into 2 parts without changing the chemical structure of hydrocarbons:
 - a) Extraction processes - deasphalting, selective cleaning;
 - b) The process of extractive crystallization (a kind of extraction process) - dewaxing;
 - c) Adsorption cleaning with the use of adsorbents [2].

Types of additives applied to motor oils

Antioxidant additives which protect oil hydrocarbons from oxidation [3].

Antifricition, antiwear and extreme pressure additives - contribute to reducing friction, wear and tearing of the rubbing surfaces of metals [4].

Corrosion inhibitors and anti-corrosion additives protect metal parts of machines and mechanisms (during their storage and operation) from environmental exposure (oxygen, moisture, chemically active products) [4].

Detergents (or detergent and dispersant additives) prevent deposits, varnishes and sediments from forming on engine parts [5, 6].
 Depressor additives lower the pour point of the oils [4].
 Viscous additives improve viscosity and temperature properties.
 Antiseptics increase the resistance of oils to fungi and bacteria [4].
 Anti-foam additives prevent the formation of oil foams.
 Adhesive additives increase adhesion and prevent the spreading of oils [4].
 Multifunctional and multicomponent additives simultaneously improve several performance properties of oils [4].

RESULTS AND DISCUSSION

Let's consider the process of extractive crystallization

There are two dewaxing processes:

1. Conventional dewaxing with obtaining oils having a freezing point of -10 to -15 o C,
 2. Deep dewaxing is obtaining oils with a freezing point of -30 o C and below.
- Dewaxing is a low temperature process.

Cooling agents are propane or ammonia. The first stage of crystallization is the isolation from a supersaturated solution of nuclei of crystals which are the smallest particles of a crystallizing substance [6].

The optimum composition of the solvent is determined in a practical way; solvent composition, % (mass.) - MEK (60-75), toluene (25-40). The higher the viscosity of the raw material and the content of paraffin in it, the greater the dilution ratio; the ratio of solvent to solvent: raw materials for distillate raw materials – 2.8: 1 to 4: 1; for residual raw materials - from 4: 1 to 4.5: 1).

The final cooling temperature must be below the set pour point of deparaffinate by the value of TED (5-10 o C) [temperature effect of dewaxing] [6].

In this paper, calculations were made of the installation of oil dewaxing.

Regeneration department: Calculation of a regenerative crystallizer.

Baseline data for the calculation:

- Fresh feed rate: $G_c = 250$ thousand tons / year = 684.93 t / day = 28538.75 kg / h;
- Since the scheme has four parallel streams identical with each other, the performance of one stream is $G_1 = 7,233.75$ kg / h.
- The ratio of solvent to the raw material is 5: 1;
- The solvent is fed in portions; each portion is served in a 1: 1 ratio
- Temperature of raw materials supply to regenerative crystallizers $T = 303$ K.

The solvent is a mixture of methyl ethyl ketone and toluene in a ratio of 60:40 wt.

We determine the physical and chemical indicators of raw materials and filtrate of the first stage in charts 1, 2, 3.

In this section, technological calculations of the heat exchange surface of the regenerative crystallizer were carried out.

We calculated the speed of raw materials and filtrate movement in the mold. We determined the parameters of the 1st stage filter where the data on the composition and heat capacity of the filtrate, and the absolute density of the raw materials were entered, and from these values the average heat capacity and density of the raw materials supplied from the raw material reservoirs were found.

The heat capacity of the oil fraction is determined by the formula:

$$C = \frac{1}{\sqrt{\rho_{15}^{15}}} \times (0.762 + 0.0034 \times T) \quad , \text{ kJ / kg K} \quad (1)$$

Where ρ_{15}^{15} is the density of the oil fraction at a temperature of 15 ° C; T - K process operating temperature;

The oil fraction density at a temperature of 15 ° C is determined by the formula:

$$\rho_{15}^{15} = \rho_{4}^{20} + 5a \quad (2)$$

where, ρ_{4}^{20} is the density of the oil fraction at a temperature of 20 ° C;

a - the coefficient which is determined by the table.

The speed of movement is found by the formula:

$$W = \frac{Gc}{3600 \cdot \rho c \cdot S_{\text{æ}} \cdot \hat{a}} \quad \text{m}^2 \quad (3)$$

where, Gc- raw material consumption kg / m³; ρc is the density, kg / m³ ; S_æ - cross-sectional area, m² ; Next, based on the criteria of Reynolds, Prandtl and Nusselt, we calculated the speed of movement of raw materials and filtrate in the mold.

Reynolds criterion:

$$Re = \frac{D \cdot W}{\nu} \quad (4)$$

where D is the internal diameter of the pipe, m; W- flow velocity, m / s; ν - kinematic viscosity m² / s

Prandtl criterion:

$$Pr = \frac{C_c \cdot \mu}{\lambda} \quad (5)$$

where C_c is the heat capacity, kJ / kg K; μ - dynamic viscosity, Pa • s; λ - coefficient of thermal conductivity, W / m K

Nusselt criterion:

$$Nu = 0.21 \cdot Re^{0.8} \cdot Pr^{0.43} \cdot \left(\frac{Pr_{ct}}{Pr} \right)^{0.25} \quad (6)$$

where Re is the Reynolds criterion; Pr - Prandtl criterion; Pr_{ct} - determined at the temperature of the pipe wall.

Similarly, the heat transfer coefficient from the wall to the filtrate solution was calculated in the same way. According to the data obtained, we selected a standard mold with a heat exchange surface of 70 m², while the surface margin was 44%.

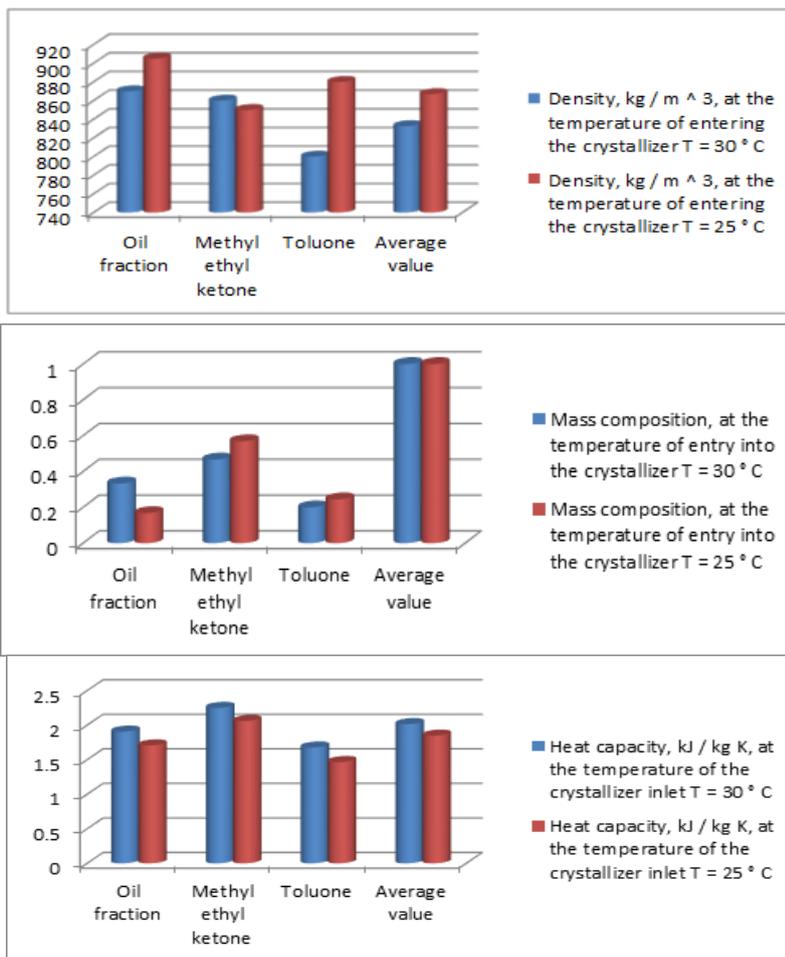


Fig. 1, 2, 3: Physical and chemical parameters of the first stage.

Calculation of the ammonia crystallizer

Before entering the cooled suspension into the ammonia crystallizer, the third portion of the cooled solvent (second stage filtrate) is added to the raw material and then cooled. The heat capacity and density of the oil fraction were determined. We found the amount of ammonia required for cooling the suspension from the heat balance equation.

We calculated the coefficient for heat transfer from the wall to the filter solution according to the cross-sectional area, the amount of ammonia vapors formed, and the linear velocity of ammonia vapors according to Reynolds, Prandtl and Nusselt criteria. Then we determined the heat transfer coefficient.

Next, we calculated the heat exchange surface and selected a standard mold with a heat exchange surface of 70 m², while the surface margin was 41%. [7,8]

CONCLUSION

Varieties of dewaxing processes that can be introduced into production:

1. Dewaxing with propane (propane is used as a solvent, a cooling agent and an inert gas), the ratio to the raw material is 0.8: 1 up to 2: 1 (because of its high dissolving capacity), and its disadvantage is deep cooling [7].
2. The Edeleanu process (solvent: a mixture of dichloroethane 40-70% [precipitates solid HC] and methylene chloride 60-30% [dissolves non-crystallizing components]); high filtration rate (200kg / h); solvents are non-combustible, therefore they do not require an inert gas in the system, low temperature TED (0-1 o C); the disadvantage is the low thermal stability of solvents (they decompose at 130-140 o C with the formation of corrosive products).
3. The Dilchil process. Solvent: mixture of MEK with methyl isobutyl ketone or toluene using Dilchil crystallizers of the original design (direct injection of cooled solvent and flow of dewaxed raw material heated in a steam heater) [7].
4. Hydrocatalytic dewaxing: a decrease in the freezing temperature of diesel fuels and lubricating oils through selective hydrocracking and hydroisomerization of n-paraffins on selective catalysts.
5. Urea dewaxing: the process intended for obtaining low-hardening fuels, low-viscosity oils and liquid paraffins is carried out at positive temperatures. It is based on the ability of urea to produce crystalline complexes with n-structure paraffins (the number of atoms is less than 6). Pure carbamide has a tetragonal structure; in the process of complex formation, the crystal structure is rearranged to a hexagonal structure consisting of six carbamide molecules arranged in a spiral. Inside the spiral, a channel is formed with a diameter of 5.25 Å. The cross section of the molecules of n- alkanes is about 4.2 Å, which allows them to fit into the channel and to be held by the van der Waals forces.
6. The process of microbiological dewaxing: it is based on the ability of certain types of microbes to selectively oxidize n-structure paraffins as a source of energy for their vital activity. Deparaffinate is used as a component of winter diesel fuel, and biomass is used to produce feed protein. [9]

In this paper, we conducted a study of methods for the production of motor oils. We studied the requirements, classifications and system designations of motor oils. We performed an analytical review of the data, where we have reviewed the basic and technical requirements for petroleum oils, the classification of products and symbols of commercial oils. [9]

The following issues were considered: the process of refining oil feedstock, the classification of petroleum oils and the main indicators of their quality, methods of refining, and flow-through schemes for the production of oils. Also we studied additives to oils, their purpose, classification and mechanism of action, the operating conditions of motor oils and the process of preparing commercial oils.

CONFLICT OF INTEREST

There is no conflict of interest.

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None

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