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DEVELOPING AN EFFECTIVE SYSTEM OF USED OILS RECYCLING

Master's degree program: Petroleum chemistry and refining

Executive summary of master's dissertation

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Introduction

There are more than 1 billion 15 million vehicles officially registered in the world. The usage of automobile transport implies consumption of a wide range of fuels and lubricants, including lubrication oils.

This work focuses on engine oils, which, in contrast to cooling, brake and hydraulic fluids, as well as other types of lubricating oils, require more frequent replacement due to rapid loss of their properties when applied to the engine.

Used oil contains a large number of different contaminants and impurities. According to the orders of the Ministry of Natural Resources of the Russian Federation, wastes of mineral, synthetic and semi-synthetic engine oils and vehicle waste oil purification filters are classified as "third-class hazard".

There is no integrated system for collecting and environmentally friendly processing of used oils in the Russian Federation. In the absence of a system, the ineffective usage of used oils causes huge damage to the environment. In spite of the fact that used oils are classified as hazardous waste, they can also be considered as valuable feedstock.

The aim of this project is to study feasibility of creating an environmentally friendly and cost-effective system for reusing used oils, including their collection, transportation, subsequent re-refining into valuable products and marketing.

To achieve this aim the project team:

- collected information about composition of used oils, technologies and equipment for recycling of used oils as well as commercial products which could be produced from used oils;
- carried out market analysis;
- chose a re-refining technology for recycling of used oils;
- made performance calculation;
- determined the location of the prospective plant;
- made calculations of cost and payback period.

1 Modern technologies for producing automobile engine oils

Automotive engine oils consist of a base (base oil) and an additive complex. All automobile engine oils are divided into three groups by the technology of production of the base oils: mineral, semi-synthetic and synthetic. Mineral base oils are obtained directly from oil refining. Synthetic oils are formed by chemical synthesis. Semi-synthetic oils are a mixture of mineral and synthetic oils.

1.1 Production of mineral base oils

Mineral base oil is generally defined as a component boiling at the temperatures ranging between 300°C and 565°C produced by refining crude oil and containing hydrocarbons with a carbon number of 18 to 40.

Mineral base oil is a product of oil distillation, its quality and chemical composition depend on oil properties and technologies which were used for its purification. Constituents of mineral base oil are extracted from crude oil, which undergoes a preliminary purification process (sedimentation), atmospheric distillation and vacuum distillation. Within the atmospheric distillation tower, the constituents of petroleum are separated from each other. After the atmospheric distillation tower, the atmospheric residuum is sent to the vacuum tower, where intermediate products are produced.

To produce mineral base oils of acceptable quality, the following processes are used:

- chemical refining processes;
- hydroprocessing;
- solvent refining processes;
- solvent dewaxing;
- catalytic dewaxing and hydroisomerization;
- finishing processes;
- blending.

1.2 Production of synthetic base oils

Synthetic lubricating oil is a lubricant consisting of chemical compounds that are artificially synthesized. Synthetic oils were originally designed for the purpose of producing high-purity base oils with required properties.

Synthetic oils may cover a wide range of chemicals but are generally found within the following categories:

- synthetic hydrocarbons (PAOs);
- hydrocarbon esters;
- phosphate esters;
- glycols;
- chlorinated hydrocarbons;
- silicone oils.

2 Used lubricating oils: composition, causes of oil deterioration

Used lubricating oil is any lubricating oil, whether refined from crude or synthetic components, which has been contaminated by physical or chemical impurities as a result of use.

Lubricating oil loses its effectiveness in operation due to the presence of certain types of contaminants. These contaminants can be divided into: extraneous contaminants (dust, dirt, moisture, air, metallic particles from the engine etc.) and products of oil deterioration (sludge, lacquer, oil-soluble products).

3 Impact on the environment and human's health

In general, used oils are not volatile and do not pose a serious threat by inhalation. However, some components are hazardous, for example, accumulated polynuclear aromatic compounds. Used oils also contain residual amounts of additives, some of which are irritants to the eyes and skin and cause a sensitizing effect (an effect caused by the phenomenon of increased sensitivity of the human body to the effects of chemicals and leading to the development of allergic diseases).

In case of ineffective handling of used oils, they can cause pollution of soils, atmosphere, underground and terrestrial water resources.

4 Options for secondary utilization of used engine oils

There are plenty of ways of subsequent usage of used engine oils. But not all of these ways are environmentally friendly and legal. For instance, direct burning/use as fuel is the worst way of using used oils because of the danger it poses to the environment and people's health caused by hazardous substances such as heavy metals, polychlorinated biphenyls and other dangerous compounds.

However, there is a number of legally and environmentally friendly ways of disposal of used oils. Currently, they are:

- reprocessing – usually involves a treatment to remove insoluble contaminants and oxidation products from used oils such as heating, settling, filtering, dehydrating, and centrifuging. Depending on the quality of the resultant material, this can be followed by blending with base oils and additives to bring the oil back to its original or an equivalent specification. Reprocessed oil is generally returned to its original use;
- reclamation – usually involves a treatment to separate solids and water from a variety of used oils. The methods used may include heating, filtering, dehydrating, and centrifuging. Reclaimed oil is generally used as a fuel or fuel extender;
- regeneration (re-refining) – involves production of base oils from used oils as a result of the processes which remove contaminants, oxidation products, and additives. These processes include predistillation, treatment with acids, solvent extraction, contact with activated clay and hydrotreating.

All three of the above-listed processes can be combined into one group which is called recycling.

5 Relevant global experience of recycling used oils

There are many technologies for recycling used oils, but the most effective and widely known are only two: the Mohawk process (The CEP–Evergreen process) and the Viscolube / AxensRevivoil process.

In the Mohawk process a combination of thin-film evaporators with a subsequent hydrotreatment to produce higher grade base oil products was first used. The technology is used on the plants in the USA, Canada, Mexico, Australia and Indonesia.

CEP argues that the required minimal amount of feed for the technology to be cost-effective is 15 000 tons per year.

The Revivoil process is used on the plants in the USA, Serbia, Italy, Greece, Indonesia, Poland, Venezuela. The main purpose of the process is producing high-quality lubricating engine oils.

6 Amount of used oils and collection in Krasnoyarsk Krai

There are the following sources of used engine oils:

- motor transport enterprises;
- oil change station;
- dealerships;
- service centers;
- DIY (do it yourself) oil changers.

To determine the amount of used oils produced in Krasnoyarsk Krai estimation was made. It is based on the scope of oil supplies from nine major distributors of fresh motor oils on the regional market in 2016. The total amount of fresh oils was 21 230 000 liters in 2016. The amount of used oils available to re-refining constitutes around 8 000 tons per year.

7 Areas of application of used oils in Krasnoyarsk Krai

The search of the main applications of used oils in Russia and in Krasnoyarsk Krai in particular was conducted by the authors. The data is shown in Figure 1.

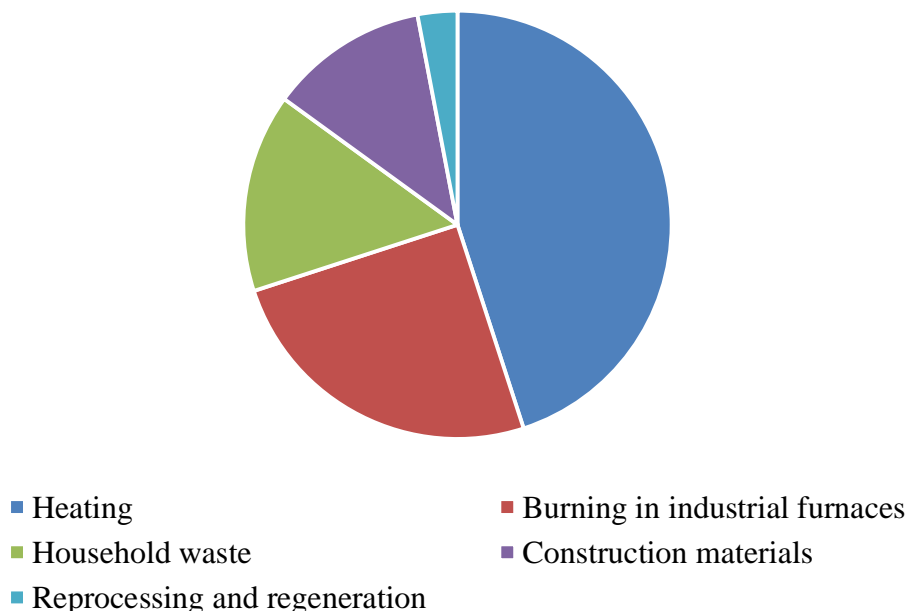


Figure 1 – Areas of application of used oils in Krasnoyarsk Krai

The largest amount of used oils (about 70%) is burned for heating. About 15% of used oil is dumped with household waste or drained into sewerages. Approximately

12% of used oil is used in construction. And about 3% of used oils go to regeneration to obtain new lubricating oils and be processed into other commercial products.

A survey conducted by the authors has shown a high demand for engine oils produced from used oils. About 70% of people surveyed expressed willingness to try them out. Currently, there are no such oils on the Russian market.

RESULTS AND RECOMMENDATIONS

The most common environmentally safe option for recycling of used oils in the world is re-refining into base oils. The existing technologies make it possible to produce high quality products from used oils that could be sold on the Russian market.

Sociological surveys conducted by the authors have shown the demand for this kind of products among Krasnoyarsk citizens.

However, it was concluded that it is impossible to implement the above-described option in Krasnoyarsk Krai. The main reason is the lack of sufficient amount of feed to ensure the economic efficiency of a process described in chapter 5.

The authors propose the following solutions:

a. to place a small production capacity unit for the processing of used oils on the territory near Krasnoyarsk, where 37% of the total population of Krasnoyarsk Krai live and about 500 thousand cars are registered;

b. to implement an integrated system of collection of used oils in the eleven largest cities of Krasnoyarsk Krai;

c. based on the positive experience of the USA, to bring in new legislation obliging retailers and service stations in the eleven largest cities of Krasnoyarsk Krai that cell considerable amounts of motor oils to accept used oils from the public at no charge. To equip such service stations and retailers with external advertising, informing about the possibility of handing over used oils;

d. to ban by law misuse of used motor oils in the eleven largest cities of Krasnoyarsk Krai. Rational use is to take delivery to reception points, or to licensed collectors for subsequent transportation to the processing plant;

e. to bring in legislation for supporting financially the participants of the proposed system of used oil recycling.

The implementation of the set of measures will allow to regulate the turnover of used motor oils in Krasnoyarsk Krai and thereby significantly reduce the harm to public health and the environment caused by uncontrolled direct combustion, disposal with household waste, and also in case of contaminating soil and water resources.