Research on Regeneration Technology of Internal Combustion Engine Lubricating Oil

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Abstract: This paper studies the high efficiency regeneration technology of waste lubricating oil and the development of related equipment, to provide the necessary technical support for the high efficiency regeneration of waste lubricating oil, and make the technology obtain the commercial promotion. After the completion of the project, the waste lubricating oil can be purified and recycled to meet the requirements of national standards and actual use needs. The treated recycled lubricating oil can function normally and can be used directly again.

1. Introduction

Lubricating oil is widely used in power equipment and other machinery. The lubricating oil used in all kinds of machines plays the role of lubrication, cooling and rust prevention [1, 2]. From a physical and chemical point of view, the waste lubricating oil only loses part of its function and changes part of its physical and chemical properties. In fact, it does not contain many metamorphic components, and its waste lubricating oil content is less than 10% [3-5]

After proper physical and chemical methods, pollutants and metamorphic components are removed. After processing, the qualified standard of lubricating oil can be reached, and the regeneration rate can reach more than 50-70%. Lubricating oil is expensive, the commonly used lubricating oil for internal combustion engine is 12-15 yuan per liter. Using lubricating oil regeneration technology can greatly reduce the consumption of lubricating oil and save the running cost.

2. Domestic and international present situation and the insufficiency

At present, domestic waste oil recovery rate is very low, less than 20% of the total waste oil. The main direction of waste lubricating oil is:

2.1 Directly Discarded or Incinerated

Direct disposal or incineration will cause environmental pollution and waste of recyclable resources, which will affect economic and environmental benefits.
2.2 Used as Fuel or Mixed Fuel after Pretreatment
This method can effectively reduce environmental pollution, but the economic benefits are not high enough.

2.3 Recycling
Recycling of waste lubricating oil can effectively reduce environmental pollution and can form considerable economic benefits.

International waste oil regeneration process is divided into three categories. The first is re-purification. Mainly including sedimentation, centrifugation, filtration, flocculation and other physical treatment methods, the purpose is to remove the water in the waste lubricating oil, suspended mechanical impurities and mechanical impurities dispersed in a colloidal state, but cannot remove the impurities dissolved in the lubricating oil. The process mainly produces fuel oil, but heavy metal oxides, polycyclic aromatic hydrocarbons oxides and halogen compounds in the flue gas pollute the environment.

The second kind is again refined. Chemical refining or adsorption refining is added on the basis of re-purification, mainly to produce cutting fluid, hydraulic oil, gear oil and stripper oil with lower quality requirements.

The third category is re-refining. It mainly includes pretreatment, vacuum distillation, solvent extraction, film evaporation and hydro-refining.

The existing lubricating oil regeneration industry and technology are relatively backward, distillation-sulfuric acid - clay refining process is still dominant. The fatal disadvantages of this process are as follows: secondary pollution is formed after the regeneration of waste oil, which forms acid residue, waste clay and waste water that seriously pollutes the environment and is difficult to be treated, which also leads to the decline of the competitiveness of this process.

What's more, after refining, only cheap base oil can be provided. Almost all the expensive additives in lubricating oil are lost, and their value is greatly reduced, which is of little significance for lubricating oil recovery.

3. Technical solution

3.1 Content of This Project
In order to realize the purification and regeneration of waste lubricating oil, the research work starts from two aspects:

3.1.1 The exploration of treatment process: In the process of repurification or refining, select, combine and innovate unit operations to completely remove impurities, water, oxidation by-products and fuel oil, and try to retain additives. Meanwhile, the failure analysis of waste lubricating oil is carried out, and the synthesis, compounding, modulation and supplement of additives are carried out on the basis of the balanced understanding of additive formula.

3.1.2 Complete the development and verification of purification equipment: To achieve the purpose of industrial mass production.

3.2 Technical Route
Waste lubricating oil regeneration treatment is a combination and application of various lubricating oil treatment technologies, including:

3.2.1 Electrostatic treatment: The electrostatic generator is connected to the electrode to generate a high-voltage electrostatic field, which polarizes the pollutants in the oil and has positive and negative charges. By controlling the intensity of the high-voltage electrostatic field, the charged pollutants are opposite to each other under the action of the electric field. The neutral particles are moved by the charged particle
stream, and finally all impurities, including solid particles, water, colloids and gases are adsorbed, so as to achieve the purpose of high purification.

The technology is sensitive to water, which exceeds 0.5 percent in the fluid, short-circuiting the discharge electrode and collector plate. At the same time, due to various technical reasons, electrostatic adsorption equipment has flow restrictions, and as the accumulation of more particles, the efficiency of collection will be lower and lower. Therefore, dehydration should be carried out first to ensure the proper concentration of particles in the electric field.

Electrostatic treatment equipment is shown in Fig. 1.

3.2.2 Centrifugal process: Centrifugal separation is the method of separation according to the density difference of two phases, centrifugal force is proportional to the square of rotation speed, so the centrifugal separation speed is dozens or even hundreds of times of free settlement.

The flash point and viscosity of the waste lubricating oil have changed a lot. In order to ensure its properties, it is necessary to distill the low-boiling steam, coal and diesel oil by distilling the light impurities such as diesel oil and gasoline. In order to remove mechanical impurities and moisture from the waste oil, the method of settling is adopted.

When the diameter of suspended particles in oil is 0.05-10 microns, the settling velocity obeys stokes' law. Compared with waste oil, mechanical impurities are easy to settle, and the larger the particle size and specific gravity are, the easier the mechanical impurities settle. The viscosity of some waste lubricating oil is large, not conducive to precipitation, can be appropriately heated, reduce the viscosity of waste oil, achieve the purpose of rapid settlement.

Centrifugation is good for removing free water and large particle impurities, but poor for small particle impurities, and the filtered particles will stick to the surface of the drum, making cleaning difficult. In order to treat the particles, ultra-high-speed centrifugation technology is adopted, and the surface self-cleaning mechanism needs to be arranged.

Centrifugal processing equipment is shown in Fig. 2.

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Fig. 1. Electrostatic treatment equipment.

Fig. 2. Centrifugal processing equipment.
3.2.3 Coalescence purification: In the process of coalescence separation and dehydration, fully emulsified lubricating oil is passed into the fiber coalescence material, so that the liquid droplets in emulsified state in the oil are firstly adsorbed by the fiber, and then the adsorbed liquid droplets can increase their particle size by coalescence with other small droplets or with other droplets captured by the fiber. As the droplet grows larger, it detaches from the fiber surface and is easier to detach from the oil-water mixture due to increased gravity. Coalescence separation and dehydration can remove droplets with small particle size, low energy consumption and high dehydration efficiency.

Coalescence separation equipment is shown in Fig. 3.

It takes a long time for particulate matter impurities in the waste lubricating oil to become large, resulting in a long purification cycle and low purification efficiency. Therefore, a long-path multi-loop clustering structure should be arranged. The wetting and coalescence mechanism of two-phase separation is involved in coalescence purification.

Wetting occurs because the interaction between liquid molecules and solid molecules is greater than that between liquid molecules. Different liquids have different wetting ability to different solids, which is due to the difference of physical and chemical properties between liquids and solids, especially the difference of surface properties.

Wetting coalescence is due to the droplets in the flow field in the first (solid) on the surface wetting coalescence medium and adsorption, then the small droplets and the adsorption of droplet collision and coalescence together, make the medium of liquid droplets by continuous increase, when increases to a certain degree, fluid drag force will coalescence of droplets from the surface of the medium emergence, so through continuous wetting, adsorption, collision, aggregation and the emergence of the cycle, can make the continuous phase dispersed phase separation, thus separating the two.

3.2.4 Magnetic treatment: Magnetic separation is a physical separation method, which is based on the magnetic difference of different components in the separated material. Magnet filter absorbs magnetic particles, but cannot separate other non-magnetic impurities. It can be used as an auxiliary technology, and a self-cleaning device must be arranged.

3.2.5 Filtering processing: Due to the high viscosity of the waste lubricating oil, the filtration material flux is low, and there are serious problems of secondary pollution of the filtration material in the separation process, which also significantly affects the filtration speed of the waste lubricating oil film and reduces the service life of the filtration material. Therefore, an efficient self-cleaning mechanism is designed, which can automatically find the blockage of the filter material and automatically clean the filter system.
The filter processing equipment is shown in Fig. 4.

![Filtration equipment](image)

**Fig. 4. Filtration equipment.**

3.2.6 *Fractionation process*: In order to remove the water in lubricating oil and fuel oil, fractionation technology is adopted. That is to say, different boiling points of water, fuel oil and lubricating oil are used to separate the water in lubricating oil and fuel oil by setting different temperature intervals.

Distillation is the process of vaporizing a liquid mixture many times and condensing the resulting steam many times to separate the mixture completely and obtain the components of desired purity. In the process of distillation, the gas and liquid phases in the mixture flow reversely in the rectifying column. It is essentially a mass transfer process accompanied by heat transfer.

In the distillation unit, the separation of the mixture can be realized by repeated vaporization and condensation based on the different volatilization of different components.

In the process of distillation, heat absorption is needed for vaporization of solution mixture, and heat emission is needed for condensation. Therefore, the whole distillation operation cannot be completed by a single distillation tower, and the distillation process must be equipped with auxiliary equipment such as reboiler and condenser.

After rectification, the excess water in lubricating oil and fuel oil can be separated to improve the quality of lubricating oil.

Fractionation treatment equipment is shown in Fig. 5.

![Fractionation treatment equipment](image)

**Fig. 5. Fractionation treatment equipment.**
3.2.7 **Supplementary additive:** The waste lubricating oil can remove some pollutants after the above process treatment, and at the same time, most of the additives in the waste oil can be retained, including cleaning dispersant, anti-oxygen anti-corrosion agent and anti-friction agent. On this basis, based on the basic additive formula in engine oil, focusing on viscosity index, add regenerative additives to lubricating oil.

4. **Market analysis**

4.1 *The User*
All kinds of lubricating oil consuming units, such as bus enterprises, coal mines, metal mines and waste oil recovery plants, etc.

4.2 *Benefits*
At present, there are 100 QSK60 diesel engines in a coal mine, each diesel engine has 375 liters of lubricating oil, and the lubricating oil is changed every 2-3 months, and the lubricating oil is 12-16 yuan per liter. It can be seen that the QSK60 diesel engine alone consumes 15,000-200,000 liters of lubricating oil and costs 2,000,000 to 4,000,000 yuan each year. Add in the oil used in other diesel engines and the cost is staggering.

This project studies the regeneration technology of lubricating oil, which can reduce the consumption of lubricating oil by 70%, that is to say, save the replacement cost of lubricating oil by 2 to 3 million yuan every year, and has obvious environmental protection benefits and significant effects.

5. **Technical indicators**
After the completion of the project, the recycled lubricating oil reaches the following targets:

5.1 *Viscosity*
Viscosity [6], according to the national standard, the deviation is within ±10% of the standard value.

5.2 *Water Content*
Water content, ≤0.1% according to national standards.

5.3 *Particulate Matter*
Particulate matter, ≤ ISO 20/18/15.

5.4 *Chroma*
The chromaticity, ≤ 6.5.

5.5 *Combined loss of Additive*
Comprehensive [7] loss of additive, ≤10%.

5.6 *Regeneration Ratio*
Regeneration rate, 50-70%.

6. **Conclusion**
This paper studies the development of quality maintenance management technology and related equipment for aero engine oil under wing condition, so as to provide necessary technical support for improving the performance of lubricating oil in aero engine sliding tank, and make the technology popularized and applied in airlines.

After the completion of the project, the lubricating oil with declining performance in the engine sliding tank can be purified and recycled, to further meet the needs of safety and economic benefits in the field of civil aviation.
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