

Re-refining of used lubricating oil.

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Abstract - Small amount pure lubricating oil can pollute major amounts of water eg: groundwater as well as the land on which it is spilled. Used engine oil itself contains a number of additives and is contaminated by impurities and residues resulting from the combustion process. Some of them are poisonous and carcinogenic like lead and PAH (poly-aromatic hydrocarbons). Also the oils used in transformers contains PCBs (polychlorinated biphenyls), which are highly carcinogenic as well. From various sources such kind of used lubricating oils are generated and are disposed improperly. The burning of used oil in kilns and incinerators produces lots of ash and carcinogens causing environmental pollution. Waste lubricating oil is a resource that cannot be disposed of randomly due to the presence of pollutants. In response to economic problems and environmental protection, there is a growing trend to regenerate and reuse waste lubricants. By proper recovery and refinement of it, a lot of valuable product can be obtained. The objective of re-refining is to remove the degraded additives and contaminants and to restore the properties of the oil identical to the standards provided by SAE (Society of Automobile Engineers).

Keywords – Base oil, contaminants, crude oil, lubricating oil, re-refining, SAE standards, used engine oil.

1. Introduction

Lubricant oils have been used primarily for reducing friction between moving parts of various machinery or equipment, minimize material wear, and improve the efficiency of equipment /machinery and for fuel and energy savings. Access to lubricants is essential to any modern society and not only does lubrication reduce friction and wear by interposition of a thin liquid film between moving surfaces, but it also removes heat, keeps equipment clean, and prevents corrosion. One of its important applications includes gasoline and diesel engine oils [1].

Typically lubricants contain 90% base oil (most often petroleum fractions, called mineral oils) and less than 10% additives. A large number of additives are used to impart performance characteristics to the lubricants. The main families of additives are:

- Antioxidants
- Anti-wear
- Metal deactivators
- Corrosion inhibitors, Rust inhibitors
- Friction modifiers
- Extreme Pressure
- Anti-foaming agents
- Viscosity index improvers
- Demulsifying/Emulsifying
- Stickiness improver, provide adhesive property towards tool surface (in metalworking)
- Complexing agent (in case of greases)

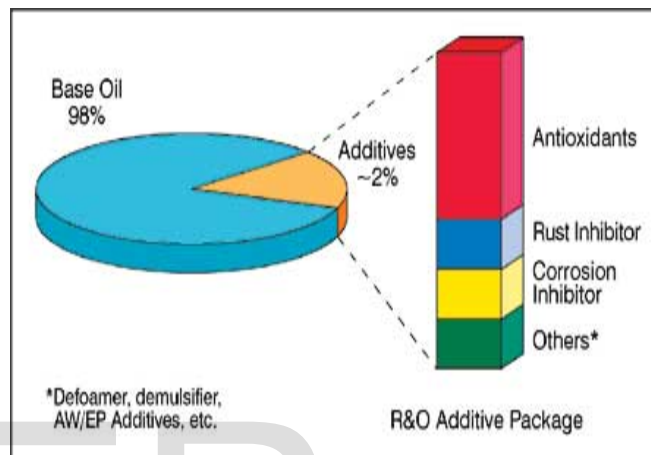


Fig 1 - Constituents of lubricating oil

2. Sources of waste lubricating oils

By far the largest source for used oil in developing countries is lubricating oils from motor vehicles, combustion engines and gear boxes. Apart from that, minor amounts are generated from hydraulic systems, transformers and other diverse industrial applications. Due to increase of the automotive traffic in developing countries the amount of used oil from motor vehicles increased steadily in the past. The majority of used engine oil is generated in small quantities at a great number of places, e.g. garages, small workshops and private premises. There are few major generator of waste oil like railways, large truck fleet operators and large industries.

Waste lubricating oil refers to the engine oil, transmission oil, hydraulic and cutting oils after use. It is also refers to the degradation of the fresh lubricating components that become contaminated by metals, ash, carbon residue, water, varnish, gums, and other contaminating materials, in addition to asphaltic compounds which result from the bearing surface of the engines [2]. These oils must be changed and removed from the automobile after a few thousand kilometres of driving because of stress from serious deterioration in service. The amount of lubricating oils that is collected annually in Europe and USA is very large, approximately 1.7 to 3.5 million tons. This large amount of waste engine oils has a significant impact on both economic and environmental aspects.

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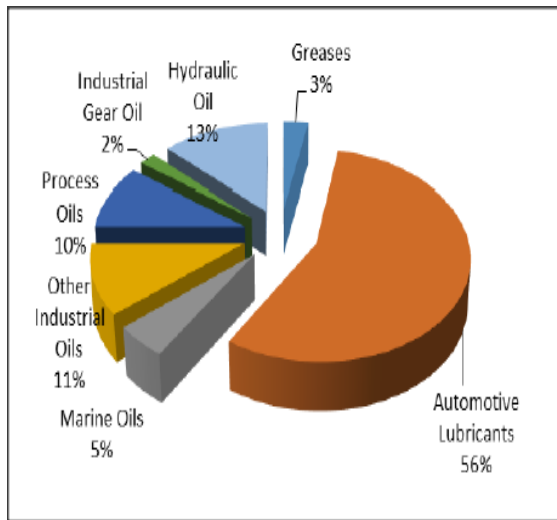


Fig. 2 - Percentage of contribution of waste oils

3. Used lubricating oil

Used lube oil is defined as the petroleum derived or synthetic oil which remains after applications in lubrications, cutting purposes, etc. After a certain period of useful life, the lubricating oil loses its properties and cannot be used as such in machinery. Buildup of temperature degrades the lubricating oil, thus leading to reduction in properties such as: Viscosity, Specific gravity, etc. Dirt and metal parts worn out from the surfaces are also deposited into the lubricating oils. With increased time of uses, the lubricating loses its lubricating properties as a result of over reduction of desired properties and thus must be replaced with fresh one. It is surprising to know that base oil never gets spoiled, it only gets dirty. Lubricating oil becomes unfit for further use for two main reasons: accumulation of contaminants in the oil and chemical changes in the oil. The main contaminants are listed below.

3.1 Combustion products

Water: Fuel burns to CO₂ and H₂O. For every litre of fuel burnt, a litre of water is created. This normally passes out through the exhaust when the engine is hot, but when cold it can run down and collect in the oil. This leads to sludge formation and rust.

Soot and carbon: These make the oil go black. They form as the result of incomplete combustion, especially during warm-up with a rich mixture.

Lead: Tetraethyl lead, which used to be used as an anti-knock agent in petrol, passes into the oil. Typical used engine oil may have contained up to 2% lead, but today any lead comes from bearing wear and is likely to be in the 2 - 12 ppm range.

Fuel: Unburnt gasoline or diesel can pass into the lubricant, again especially during start-up.

3.2 Abrasives

Road dust: This passes into the engine through the air-cleaner. Composites of small particles of silicates, wear metals, iron, copper and aluminum are released due to normal engine wear.

3.3 Chemical products

Oxidation products: Some of the oil molecules, at elevated temperatures, will oxidize to form complex and corrosive organic acids.

Composition of used oil consists of four major groups, which have average values of 76.7% saturates, 13.2% monoaromatics, 3.7% diaromatics and 6.5% polyaromatic-polar material.

Due to degradation of fresh lubricating, it has to be changed from time to time. The removed used oil is then discarded [3].

4. Environmental aspect

Mismanagement of used lubricating oil is a serious environmental problem. All automotive oils have the potential to be recycled safely and productively, saving energy and avoiding environmental pollution. Unfortunately, most used motor oil is handled improperly. Some is emptied into sewers, adversely affecting water treatment plants or going directly into waterways. Some is dumped directly onto the ground to kill weeds or is poured onto dirt roads. Millions of gallons are thrown into the trash, ending up in landfills, where it can contaminate surface and ground water [4].

5. Importance of used oil recycling

Improper used oil disposal is simply a waste of a valuable resource. Every gallon of used motor oil not recovered results in the need to drill for more oil and in some cases it results in increases in oil import. Today, however, most of the crude petroleum produced throughout the world contains very little of the special hydrocarbon chains necessary for motor oil. As a result, refining crude petroleum to produce virgin lube oil is an elaborate, complex, and expensive process that requires nearly three times energy as much as re-refining used oil. Lube base oil can be recovered and 'regenerated' to the quality equal to or better than its original virgin form [3].

A large range of waste oils can be recycled and recovered in a variety of ways, either directly or after some form of separation and refinement. As per the waste management hierarchy, the first option is to conserve the original properties of the oil allowing for direct reuse. Other options could include recovering its heating value and/or using in other lower level applications. Certain types of waste oils, lubricants in particular, can be reprocessed allowing for their direct reuse. The use of waste oils, after treatment, can be either as lube base stock comparable to refined virgin base oil or as clean burning fuel.[4].

6. Treatment Technologies

The idea of recycling used lubricating oil was presented in the year of 1930. Initially the used lubricating oils were burnt to produce energy, and later these oils were re-blended to engine oils after treatment. Due to the increasing necessity for environmental protection and more stringent environmental legislation, the disposal and recycling of waste oils has become very important. The recycling of waste lubricating oils can be accomplished through three basic methods, which are reprocessing, re-refining and destruction.[4]

6.1 Re-refining

Re-refining is the use of distilling or refining processes on used lubrication oil to produce high quality base stock for lubricants or other petroleum products. The use of this method has increased tremendously in developed countries, some countries reaching up to 50% of the country's need for lubricating oil [7]. It requires the conversion of waste oil to a product with similar characteristics to those of virgin oil. The process typically involves, but is not limited to, pre-treatment by heat or filtration, followed by either vacuum distillation with hydrogen finishing and solvent extraction.

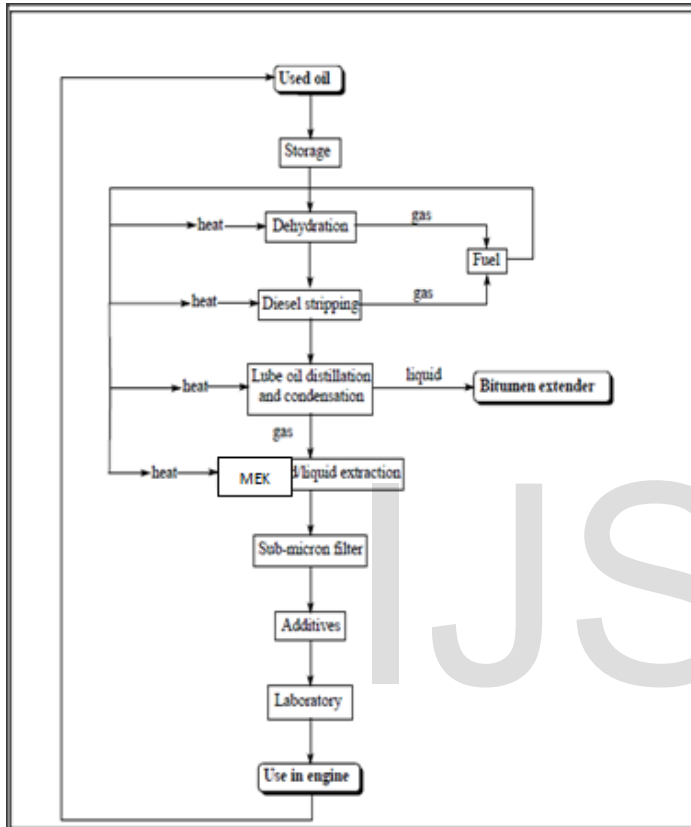


Fig. 3 - Block diagram of re-refining of used lubricating oil
 The amount of crude oil required to produce a certain volume of lubricating oil is nearly 9 times higher to produce the same volume of lubricating oil from used oil [8].

6.2 Process involved

Process: 1 - Dehydration

The oil is heated to 130oC in a closed vessel to boil off emulsified water and some of the fuel diluents. The point at which oil contains the maximum amount of dissolved water is termed the saturation point. Higher the temperature, higher is the saturation point and hence more water held in solution, in the dissolved phase. Similarly, older the oil, higher is the level of water that can be dissolved. Water is a generator of other contaminants in the oil such as waxes, suspensions, carbon and oxide insolubles and even micro-organisms, so it is removed by dehydration.



Fig.4 - simple dehydration and distillation

Process: 2 – Vacuum Distillation

The vacuum distillation column internals must provide good vapor-liquid contacting while, at the same time, maintaining a very low pressure increase from the top of the column top to the bottom. Therefore, the vacuum column uses distillation trays only where withdrawing products from the side of the column (referred to as side draws). Most of the column uses packing material for the vapor-liquid contacting because such packing has a lower pressure drop than distillation trays. This packing material can be either structured sheet metal or randomly dumped packing such as Raschig rings.

The dehydrated oil is then fed continuously into a vacuum distillation plant for fractionation in exactly the same fashion as crude petroleum. The fractions obtained are as follows:

1. Light fuel and diesel: It can produce enough diesels from the used oil feedstock to run all the burners and boilers, giving total self-sufficiency in fuel.
2. Lubricating oil: The bulk of the feedstock will distill off in the plant to produce a lubricating oil fraction.
3. Residue: The non-distillable part of the feedstock. This contains all the carbon, wear metals, degraded additives and most of the lead and oxidation products. This residue is successfully used as bitumen extender for roading [5].

Process: 3-Solvent extraction and final atmospheric distillation

Methyl Ethyl Ketone (MEK) is a selective aromatic solvent employed in the solvent extraction process. The lubricating oil obtained by vacuum distillation is mixed by agitation with MEK in ratio of 2:1. The lubricating oil and solvent mixture is allowed to settle in separator tank. The aromatic content and degraded additives present in the lubricating oil fraction will settle at the bottom and the lubricating oil fraction and solvent mixture layer forms at the top. Solvent mixture is again subjected to atmospheric distillation. The atmospheric distillation is carried out at temperature of around 80oC which is the boiling point of MEK. The MEK vapor produced is condensed and is again used as solvent by blending with fresh solvent. The lubricating oil produced at this stage is similar to that of the base lubricating oil.

Additives have to be added to further improve the properties and to make them eligible for use in the automobile engines [5]. Zinc Dialkyl Dithiosulphate is the common additive added to the lubricating oil.



Fig 5. Left- Rerefined oil & right- used oil

7. Importance and benefits of rerefining:

1. Reduce dependence on base oil imports saving foreign exchange.
2. Prevent ground water contamination and pollution.
3. Preserve natural resources such as coal and crude oil.
4. Reduce sewage treatment costs.
5. Eliminate improper burning of waste oil as fuel, which generate toxic fumes and air pollution.

8. Conclusion

Rerefining of waste lubricants could result in both environmental and economic benefits. Rerefining of waste oil to manufacture base oil conserves more energy than reprocessing the waste oil for use as fuel. The energy required to manufacture rerefined oil from used oil is only one-third of the energy required to refine crude oil to produce virgin base oil. Therefore, rerefining is considered by many as a preferred option in terms of conserving resource as well as minimizing waste and reducing damage to the environment [6].

9. Acknowledgement

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10. REFERENCES

1. Francois, A. "Waste Engine Oils Refining and Energy Recovery", 1st ed.; Elsevier Science and Technology Books: Amsterdam, The Netherlands, 2006.
2. Whisman, M.L.; Reynolds, J.W.; Goetzinger, J.W.; Cotton, F.O.; Brinkman, D.W. Re-refining makes quality oils. Hydrocarb. Process. 1978.

3. "Used Oil. A Renewable Resource and an Environmental Pollutant" by David Layzell.
4. Motshumi J. Diphare, Edison Muzenda, Tsietsi J. Pilusa and MansoorMollagee "Lubricating Oil Treatment Techniques" ICEAFS 2013.
5. ShriKannan C, Mohan Kumar KS, DeepaPriya N, "Re-Refined Used Automotive Lubricating Oil" Res. J. Engineering Sci. 2014.
6. S. Arnaout, "Options for vehicle waste oil management", Lebanon, Ministry of Environment, 1997.
7. J. D. Udonne, "A comparative study of recycling of used lubricating oils" Journal of petroleum and Gas Engineering, vol2.
8. Ogbeide S.O, "An Investigation To The Recycling Of Spent Engine Oil", Journal of engineering science and technology review.