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A Review on Recycle of Waste Lubricant Oil and its Properties Enhancement

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Abstract: ***Continuous use and disposal of lubricating oil causes land, water and air pollution and also increases dependence on crude oil. This is the reason for the spread of disease, which affects every living being. Reuse of waste oil is the easiest option to avoid such pollution and dependence on crude oil. Another benefit of reusing waste oil is converting waste into money. Recycling waste lubricating oil has become an increasingly important aspect of sustainable waste management and resource conservation. Lubricant oil is made with 90% of base oil and rest of additives. In the lubricant oil, Base oil is never spoiled but after continues use of lubricating oil, it loses their properties because of continues friction, heavy load, and dirt metals absorbed hence it's become waste oil. Here, we review the methods available to recycle the waste oil with the help of various treatment including acid treatment, clay treatment, adsorption, and solvents. The viscosity modifiers and additives used to make the SAE (Society of Automotive Engineers) grade recycled oil have also reviewed.***
Keywords: Waste lubricant oils, SAE grade oil, additives, viscosity modifier

I. INTRODUCTION

Continues use of lubricating oil, results in decline in their physical and chemical properties, and increase friction in moving parts generates excess heat in engine. Due to the shortage of fossil fuel and environmental degradation of waste lubricating oil, there is need to investigate a reuse of this waste lubricating oil to fulfil the increasing demand of lubricating oil in form of SAE grade oils for transport vehicles and others heavy machineries as well as reuse of refined base oil. Refine or reuse of lubricating oil is considering as one the of the most attractive and environmental friendly process that can help in reduce the demand of base oil which are produce from fossil fuel (Mohd. Hanif Dewan, 2014). The many refining process and additives do reuse of waste lubricating oil. Additives are employed in lubricants to maintain their lubricating properties. Generally, lubricant oil has 70-90% base oil and the remaining is additives (Pirro D et al 2016). In 1923, U.S society of automotive engineers (SAE) categorised engine oils, on the basis of viscosity, as light, medium and heavy lubricating oils. The main objective of using additives is to protect the lubrication properties of the base oil. The other function of additives is reducing friction, physical damage, deformation and to restrict the change in chemical properties (Speight et al, 2014).

After a determine cycle of useful life of any lubricant oil, it becomes contaminated with chemical and physical impurities. These contaminants are dependent on two factors that are external contaminants and by products of oil spoilage. External impurities such as metal particles, carbon particles, and metal oxides are come from the moisture, air and dust. Due to the continuous use of lubricating oil in engine several by products are formed. Dirt sludge is the first which is a mixture of dust, oil, water and other impurity particles. The second is the lacquer, which is the hard sticky substance, and the last is the oil soluble product, which is the result of oil oxidation of the product. Facilities that produce waste lubricant oil are vehicle garage, supple maintenance set up, industry etc. Waste lubricant oil is also produced by humans who changed their engine oil of vehicles and are identified as home adulterated oil changers (Boughton et al 2004).

Refined or reused of lubricating oil is consider as one the of the most attractive and environmental friendly process that can reduce to demand of base oil which are produce from fossil fuel (Mohd. Hanif Dewan, 2014). The main purpose for using lubricating oils is that they have the capacity to reduce friction, wear and tear and thus help in isolating surfaces under all conditions of temperature, speed and load. It also helps in absorb the excess heat generated by friction or some other external factors, and hence act as a coolant. The important properties of lubricating oils are viscosity, viscosity index, flash point, pour Point.

In API Publication annexed E, the American petroleum institute (API) has introduced and identifies a simple way to classify the lubricant base oil. This classification is now used as a base stock selection guide for a wide range of lubricating oil products. The definitions have developed into current three group level in 1995 which is shown in Table 1 (Gary et al 2007). The API grading of base oil is illustrating in Table1.

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Table 1 API base stock oil classification (Speight et al., 2014, Gary et al 2007)

	Types	Saturates (%)	Sulphur (%)	V.I.
Groups I	Solvent Refined	< 90	> 0.03	80 to <120
Groups II	Hydro Finished	≥ 90	≤ 0.03	80 to < 120
Groups III	Hydro Cracked	≥ 90	≤ 0.03	≥ 120

Recycling of waste lubricant oil is achieved by many refining process such as acid treatment, clay treatment, solvent extraction treatment and properties enhancement treatment as well as use of additives. The main reason of using additives is to protect the lubrication properties of the base oil. The functions of additives are reduction in friction, physical damage and deformation as well as to restrict the change in chemical properties of oil. The different types of additives used in oil are shown in table 2.

Additives are divided into three main categories- surface protective additives, performance additives and lubricant protective additives (Zhou Y et al 2017). Surface protective additives are the first class additives that provide new properties to lubricants e.g. - dispensers, detergents, corrosion inhibitors, extreme pressure additives and anti-wear additives. The performance additives are additives, which are used to enhance the already existing property of the lubricant e.g. - pour point depressor, viscosity index corrector, friction modified, viscosity modified. Lubricant protective additives make lubricant oil long lasting throughout life. This includes antifoam and antioxidants (Berman D et al 2018).

Table 2 Types of lubricant additives

S No	Purpose of Additives	Additives	Reference
1	Viscosity Index Improvers	Olefin Co polymers , dienes, Alkylated styrenes, methacrylates	(Leslie 2003)
2	Antiwear additives	Chlorinated waxes, alkyl phosphates, ash less dithiophosphates	(Nehal 2008, Rizvi 2009)
3	Antioxidants Additives	Hindered phenols, sulphurized phenols, aromatics amines, Zinc dithiophosphates	(Ludema 1996,Rizvi 2009)
4	Extreme pressure Additives	Alkyl sulphides, polysulfides, sulfurized fatty oils, metal triborates.	(Nehal, 2008)
5	Pour point depressants	Polymethacrylates, alkyl aromatic polymers	(Leslie 2003, Ludema 1996)
6	Rust and Corrosion inhibitor	Alkyl amines phosphates, metal dithiocarbamates, fatty acids,	(Nehal 2008, Rizvi 2009)
7	Friction Modifiers	Glyceryl monooleates, molybdenum compounds sulfurized fatty acids.	(Rizvi 2009)

II. TREATMENT METHODS FOR WASTE LUBRICANT OIL

1) *Acid Treatment Methods:* Recycling of waste lubricant oil with the help of acid treatment found easiest and cheapest method. In this method, oil is treated by some different acids to remove unwanted sludge like hydrocarbons, additives, suspended metals particles and oxidized polar compound (Giovanna et al 2012). Acid treatment methods followed simple process with unskilled operator as well as low cost required. Eman et al 2015 had treated waste oil with different acid as acetic acid, methanoic acid, sulpuric acid and phosphoric acid. They observed great changes in waste oil in terms of reducing waste sludge and kinematic viscosity improvement with acetic acid (Eman A et al 2015). Shanbhag et al 2020 had treated the waste lubricant oil with glacial acetic acid at room temperature along with active charcoal. They findings suggest that the glacial acetic acid has less impact on the environment as compare to others acids (Sharad Shanbhag et al 2020).
2) *Solvent Extraction Methods:* Use of solvent produce better quality base oil and low pollution but it required skilled operator with some initial cost (Aremu et al 2012). In the solvent extractions method, the solvent blend with waste oil thus it reacts with sludge and then further it extracted with help of vacuum pump. Osman et al 2018 used toluene, 1-butanol and methanol to treat waste oil. Their outcomes showed that oil and butanol with 1:3 ratios gave more sludge removal capability as compare to other solvent (Doaa I. Osman et al 2018). Riyanto et al 2018 studied the effect of butanol solvent on the waste oil treatment as well as the extraction of undesired metals. The best result found with 1:3 ratios of oil and butanol solvent along with 2 grams of KOH (Riyanto et al 2018). Osman et al 2017 reported the highest sludge removals rate at 80°C temperature with methyl ethyl ketone and waste oil (2:1 ratio) using vacuum distillation unit (Osman et al 2017).

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3) *Clay Treatment Method:* After acid or solvent extraction method to remove the odor and color of recycle oil clay treatment is used. In this method clay serves as an absorbent which use to remove odor and change the color of oil. Clay minerals such as kaolin have high adsorption capacity and can effectively remove contaminants from waste lubricant oil. It can adsorb heavy metal, organic pollutants and other impurities present in the oil. The adsorption process relies on the physical and chemical interactions between the clay surfaces and the contaminates (Udonne and Bakare, 2013). After the adsorption process oil- clay mixture undergoes a separation process to purified oil from the clay adsorbent. Various methods can be employed for separation such as gravity setting, centrifugation or filtration. Riyanto et al 2018 found the best results in waste oil treatment with kaolin (2 grams). Kaolin adsorbed the Cr, Fe, Pb, Mg, Ca metals and other contaminants present in the waste oil (Riyanto et al 2018). Activated bentonite, fullers earth, palygorskite clay are also used as an adsorbent to purified waste oil under clay treatment method (Merai Yash P, 2015).Above all the method contributes to recycle the waste lubricating oil acid treatment method directly or indirectly contributes to harm environment but as mentioned above glacial acetic acid has less impact on environment. Solvent extraction method needed more skilled operator as well as wealth. Methyl ethyl ketone has more useful solvent as compare to others. For removal of metals impurities, kaolin powder can be a good adsorbent. All three methods can be used to make the oil reusable.

4) *Properties Enhancement:* The recycle oil received after using the different treatment methods needs to enhance the properties of recycle oil in term of viscosity and viscosity index before using in vehicles. For the oil properties enhancement viscosity modifiers are added. Polymetharcylatesviscosity modifier is high molecular weight polymer derived from methacrylate monomer and used as viscosity index improver in lubricants (Ashlie Martini et al 2018). Olefin copolymer (OCP), polyisobutylene (PIB), and hydrogenated styrene-diene (HSD) etc are also employed to improve the viscosity of oil. Fernandaet al 1993 used olefin copolymers like EPDM (ethylene propylene diene monomer) at different concentration in base oil SN150 of group I.

5) *Additives:* To make lubricant oil, additives are to be carefully selected and added to recycle oil these additives can be various types such as antiwear agents, detergents and dispersants, antioxidants, corrosion inhibitors, frication modifier, pour point depressants, extreme pressure (EP) etc. Manyuchi et al 2018 worked with Methyl ethyl ketone (MEK) and waste oil with 6:1 ratio. They used zinc dialkyl dithiosulphate (ZDDP) additive (20 grams per 100 ml used oil) for properties enhancement (Manyuchi et al 2018). They found the effect of additive on flash point, pour point of the waste oil. Lukic et al 2006 has found that the selective additive n-methyl pyrolidine with 8% and 92% engine oil gave standard physical quality of the lubricant oil (Lukic et al 2006). To make lubricant oil, it is very important to select right additive with proper concentration and ratio with oil at suitable temperature range to get optimum results to get any grade lubricant oil. The enhancement of properties and the use of additives in recycled oil play crucial roles in maximizing its performance and extending its useful life. By incorporating additives, the recycled oil can overcome limitations and achieve desirable characteristics that are comparable to or even better than those of virgin oil.

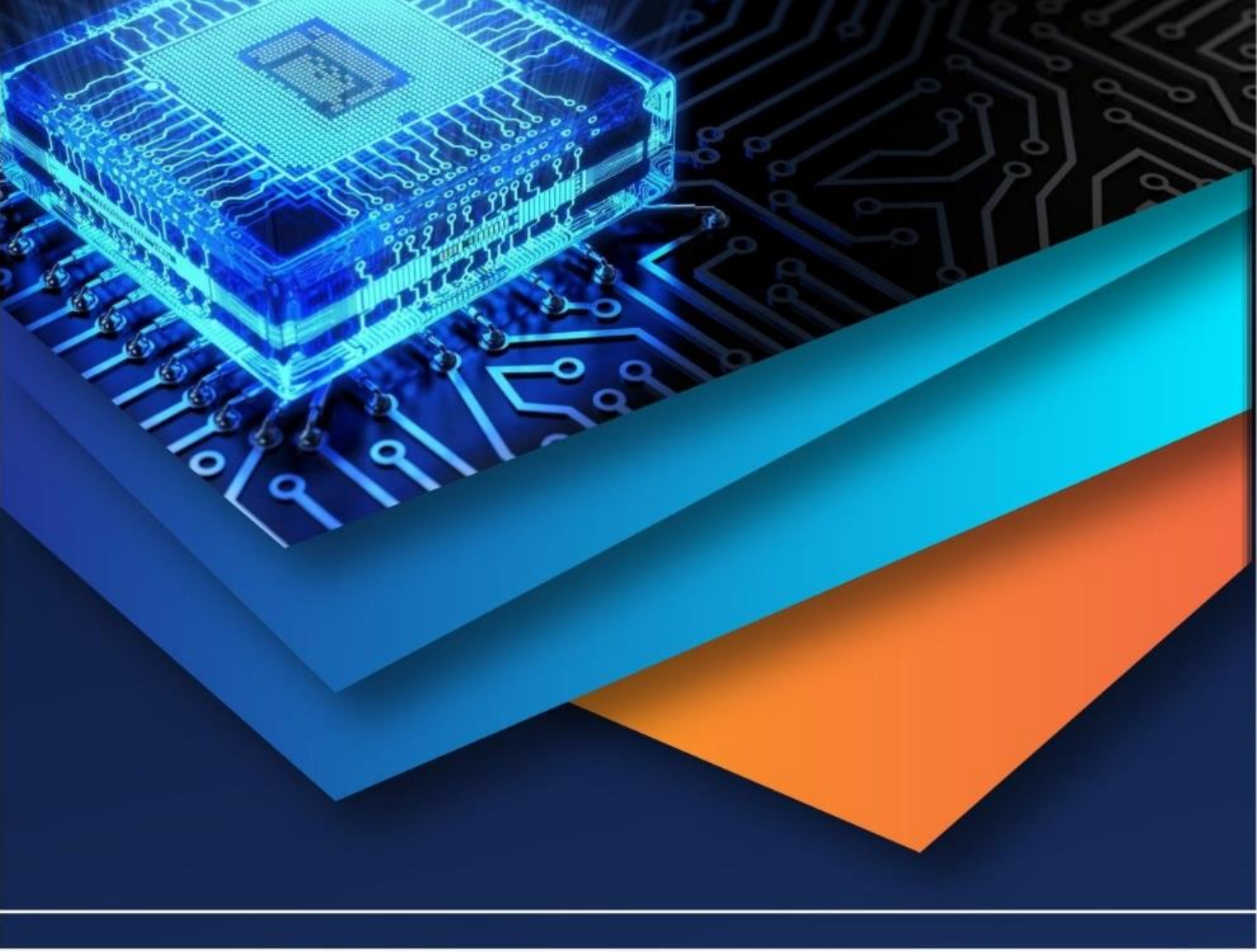
III. CONCLUSION

Conversion for waste lubricant oil to recycle oil is essential to safe guard an environment. Acid treatment, solvent extraction, clay treatment method is used for treatment of waste oil. Acid treatment and clay method are used to remove smell and dark colour of waste oil. The benefits of using glacial acetic acid for the acid treatment method result in less impact on the environment and the removal of unwanted sludge from waste oil. Solvent extraction method helps in removal of unwanted hydrocarbon and sludge from the waste oil. The MEK solvent improves the properties of the recycle oil as well as removes all high condensation elements with lesser ratio of solvent and oil as compare to other solvent. The specific amount of viscosity modifier and additives required to produce a SAE grade of lubricating oil from waste oil can vary depending on several factors, including the desired grade, the quality of the waste oil, and the specific performance requirements for the intended application etc. This review provides the useful information of process for conversion of waste oil into SAE grade oil.

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