# Recycling and Analysis of Spent Engine Oil

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**Abstract:-**This paper describes an investigation to study the recycling and analysis of spent engine oil. Recycling the spent oil reduces the environmental pollution by the disposal of spent engine oil.
In this paper we recycled the spent engine oil and the result of the analysis of the spent engine oil was recorded and was compared with that of the fresh engine oil and again we took different compositions of recycled spent oil and fresh engine oil and analyzed with fresh engine oil. Finally it is found that properties like flash point, fire point and viscosity of the compositions and fresh engine oil are almost comparable.

**Key words-** Flash Point, Fire Point, Spent Oil, Viscosity

## 1. INTRODUCTION

### 1.1 Introduction to lubricating oil

A lubricant (engine oil) can be defined as an oil product that divide the metal parts of an engine, reduce friction and keep it fresh. Lubricant deals with the purpose of lubricating oil to machine [1]. Lubricants were at one time exclusively animal or vegetable oils of fats, but modern prerequisite in both nature and volume have petroleum as the main source of supply, lubricating oil can be produced by modern process of refining from most crude and they range from thin easily flowing spindle oils to container cylinder oils [2].The lubrication system of a engine is intended to avoid the increase of wear, overheating and seizure of rubbing surfaces to reduce the expenses of indicated power on overcoming mechanical losses in the engine and also to remove wear products of a machine[3].

There are four major types of lubricant, namely – liquid, solid, gaseous and plastic Lubricant, example of lubricants include oil, grease, air and graphite. Liquid and plastic lubricants are the most commonly used lubricant in industries because they are inexpensive, simply applied and high-quality coolants while Gaseous and Solid lubricant are recommended only in some special application. In view of the problem encountered, lubricating oil is designed to impact varieties of properties and to guard engine in so many ways. Lubricating oil is highly specialized product carefully developed to perform many necessary functions among which are the following. Permit easy starting of engine, reduced friction, protecting machine against tarnish and corrosion, lubricating of
engine parts etc [4].

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### 1.2 Used lubricating oil

Used lubricating oil often referred to as waste oil without further qualification 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 [5].
Lubricating oil loses its effectiveness during process due to the presence of certain types of contaminants. These contaminants can be divided into:

(1) Extraneous contaminants and
(2) Products of oil deterioration.

### 1.3 Methods of conversion of lubricating oils

The four most commonly used re-refining technologies, with respect to aiming at ensuring optimal product yield, meeting usefulness and energy necessities, limiting harmful chemicals used and waste volumes produced are

(1) The acid/clay re-refining process
(2) The vacuum distillation/clay process
(3) The vacuum distillation/hydro treating processes (hydro processing)
(4) The solvent extraction/distillation processes [5].

## 2. Objectives of the Paper

The objectives of this paper are to:

1 Highlights the sources and collection of spent engine oil.

2 Investigate a better and efficient way of recycling spent engine oil.

3 To test the performance of the recycled engine oil produced with fresh engine oil, Analysis of composition of recycled engine oil and fresh engine oil, testing flash point, fire point and viscosity of both oils and compare them.

### 2.1 Composition of Engine Oil

The most important consideration in engine oil is the reduction of friction and control of wears [6] where viscosity is the primary factor performance which was obtained by blending base stock or base oil with various compositions of various additives. So achieving the right viscosity relies on selecting the right base stocks and blending recycled oil with performance additives to enhance functional performance. The advanced refinery technologies specifically the lube processing, is a sophisticated refining technique e.g. Hydro treating/hydro cracking is introduced to convert the undesirable components of the base stocks. United State Environmental Protection Agency noticed that, the base stocks used in the formulation of this engine oil are either of crude petroleum or synthetic origin. Crude petroleum base oils are obtained by refining crude. While synthetic on the other hand is those products made from petroleum or vegetable feed stock and are often "tailor made" for specific application.

### 2.2 Classification of Engine Oil

Engine oil is normally specified in terms of their performance and viscosity grade [7]. Table-1 shows the engine oil viscosity classifications, three types of automotive lubricants have been defined and classified by the Society of Automotive Engineers (SAE) of USA:

| SAE Viscosity Grade | Viscosity at temperature cp @ $^0$C maximum | Borderline pumping temperature $^0$C maximum | Viscosity (ASTM d-45 cSt Maximum | Minimum |
|---|---|---|---|---|
| 0w | 3500@-30 | -30 | 3.8 | <3.3 |
| 5w | 3500@-25 | -25 | 3.8 | <2.5 |
| 10w | 3500@-20 | -25 | 4.1 | <3.5 |
| 15w | 3500@-15 | -20 | 5.6 | <4.9 |
| 20w | 4500@-10 | -15 | 5.6 | <4.6 |
| 25w | 6000@-5 | -10 | 9.3 | <8.5 |

**Table-1 physical composition of crude based oil**

i. Crankcase oil
ii. Transmission and axle lubricant
iii. Fluids for hydraulic torque converters and fluid coupling

### 2.3 Source and Collection of Spent Engine Oil

The sources of used oil varies with the point of use and the role the virgin oil perform [8].The table-2 below shows the classification of spent engine oil and their source.

**Table-2 Classification of spent engine oil and their source**

| Classes of waste | characteristics | Probable source point |
|---|---|---|
| Aqueous waste | Waste water containing oil and more highly contaminated waste | Refineries and petrochemical Facilities, oil storage, installation, vehicles or car wash park |
| Spent motor oil | Contains contaminants which are volatile (fuel) soluble (oil additives) and insoluble (carbon pices),metal oxides including lead oxide together with a large number of other trace metal, and detergent | Garages, commercial transport undertakings, service stations, industrial sites |
| Spent oil emulsion | Mainly water soluble cutting oil, wastes containing dispersed mineral oils in water, soap type emulsifiers lube oil additives and other contaminants like tramp oil | Metal working industries, machine shops, manufacturing industrial engineering activities |
| Non-emulsified oil mixtures | Mainly mineral oil waste containing 10%-90% water, oil, oxidized lubricants, waste metal particles and tramp oils | Metal working industries, energy sectors, manufacturing industries |

## 3. Methodology

### 3.1 Recycling and its mechanisms

As per United State Environmental Protection Agency, recycling is the process of generating used material substances so that it can be used again. The recycling of used engine oil has to do with the mechanism and processes involved in removing the impurities in the used oil and bringing it to the initial state. Engine oil is used up when there's no function of additive again [9].

The used oil colour is dark, due to carbon from wears. The acid present in engine oil maintains its colour but in used oil, the acid is weakened by the neutralization of a base. The popular physical methods include setting, centrifugation, filtration, distillation and scrubbing with water for removing water soluble acids.

The additive are incorporated into the recycled engine oil and sometimes mixed with fresh oil [10]. The recycling processes are the various purifications that are invented for the treatment of used engine oil such that it can be used again. As per latest research that various methods have been used for the purification of spent engine oil, but this research investigates the use of Solvent extraction using activated carbon and Sulphuric acid.

The choice of methods determines the level of cleanliness for re-use of the treated oil.

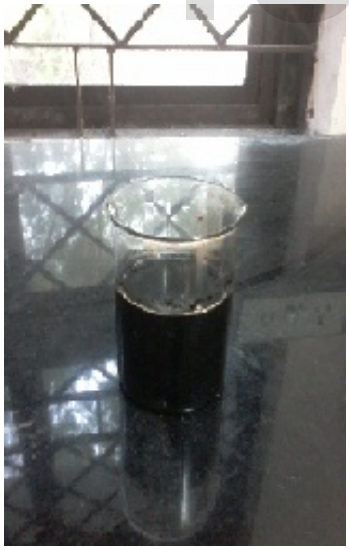

**Fig-1 Used lubricating oil**

### 3.2 Equipments and reagents

**Equipments**

The essential equipment need for the experiments are Beaker, Conical flask, Bunsen burner, Thermometer, Cleveland open cup tester, Viscometer, Refractometer, Test jar, oven, Sieving machine, Test flame applicator, Litmus paper, Magnetic stirrer. **Reagents**

The reagents and its preparation to be used are dictated by the purification techniques we adopted because the reagent differs from one recycling process to another. The reagent is decided as per the procedure adopted.

### 3.3 Solvent extraction using sulphuric acid and activated carbon

**Experimental Reagent**

The basic reagents needed for the experiment include:

**Activated carbon:**- Used to remove number of varieties of contaminants from the spent engine oil. It is the most frequently used for organic compounds.

**Carbon-tetra chloride:**- It is a synthetic chemical compound, it is clear, colourless liquid. It forms homogeneous mixture with the spent engine oil. It is used for testing for the iron content of the treated oil.

**Base Stock:**- This is the base fluid , usually a refined petroleum fraction or a selected synthetic material. The additives are blended to produce finished lubricants.

**Sulphuric Acid**

**Titration Solvent** ( in acid clay method).

**Titrant** ( acid clay method).

**Indicator:** used to get the end point of the titration process

### 3.4 Recycling process

There are different methods of preparing activated carbon in this project we made activated carbon by burning wood as shin in fig-2

**Fig-2 Activated Carbon**

The sample of spent engine oil is mixed with 70% concentration of Sulphuric acid in the ratio 10 ml to 1 ml

and then heated to 60$^0$C for one hour, and allowed to settle for 6 hours to enable the insoluble mater and water remain to settle at the bottom of the beaker.

**Fig-3 Oven used for heating**

The treated oil is decanted and sludge formed removed from the beaker. The treated oil is then mixed with activated carbon, and treated at 200–250$^0$C for 3 hours. The treated oil is filtered and allowed to cool. After which, the treated oil is analyzed.

**Fig-4 weighing of activated carbon with the help of digital balance**

The activated charcoal acts as an adsorbent and adsorbs the impurities present in the spent oil. When it is filtered impurities are removed. After contracted with activated charcoal the spent oil is heated with the help of a magnetic stirrer for two hours and then it is again filtered and analysed.


**Fig-5 Heating with the help of a magnetic stirrer**

### 3.5 Analysis on the recycled oil

**Finding the flash point and fire point**

A clean Cleveland open cup tester was filled with sample oil up to meniscus line, excess oil to be removed before proceeding to test. The cup positioned on the Bunsen burner with thermometer inserted vertically into the sample oil and held vertical with the thermometer holder. The bubbles on the surface of the sample oil during heating must be getting off when we move the stirrer in the oil.

Test flame may be lighted and the burner switched on, set to a minimum value for approximate value for approximately 15 seconds. The heater is lowered to half the maximum value. When the sample is approximately 56% below the anticipated flash point, the heat is lowered on the third setting.

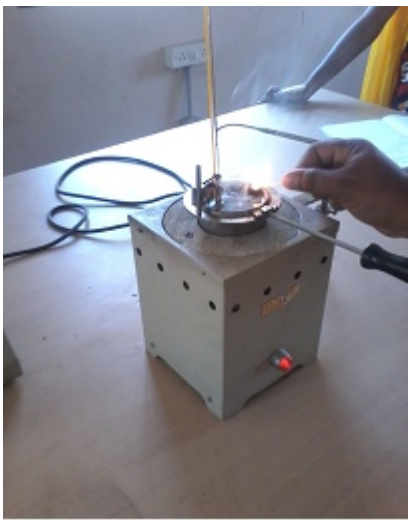

**Fig-6 Testing for flash point and fire point**

When a flash appears at any point on the surface of the oil, the temperature at that point must be noted as the flash point. Heating is continued at one-third setting number and the applicator continually moved across the center of the oil. When the oil ignited and continues to burn for at least five (5) seconds, the thermometer reading was noted at that time. The test is then repeated.

After finding out the flash and fire point for spent oil flash and fire point for SAE 40 grade oil is also determined and then the values are compared.

**Test for viscosity**

.Using say-bolt viscometer the viscosities of spent oil and pure oil are found and compared. Spent oil is taken and the temperature is increased gradually. As the temperature increases viscosity decreases. The time taken to fill a 60ml beaker is noted and viscosity is calculated based on it.

## 4. Results and Discussion of Results

**Flash point**

The temperature to which a combustible liquid must be heated to give off sufficient vapour to momentarily form a flammable mixture with air when a small flame is applied under specified conditions.

**Fire point**

The temperature to which a combustible liquid must be heated so that the released vapour will burn continuously when ignited under specified conditions.

**Table-3 Flash Point & Fire point**

| Type of oil | Flash point $^0$C | Fire point $^0$C |
|---|---|---|
| Fresh oil | 235 | 250 |
| Spent oil | 195 | 215 |

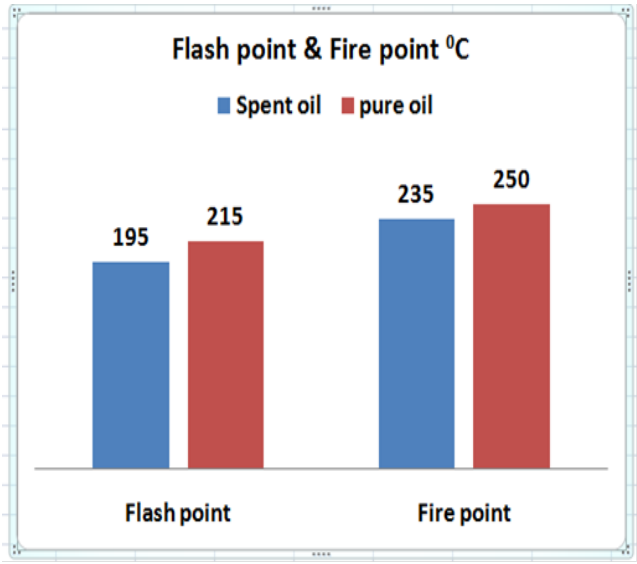


**Fig-7 Comparison of flash point and fire point**

As seen in the above graph fig-7 the flash point and fire point values for fresh oil and spent oil are nearly equal, so we can use the recycled spent oil instead of fresh oil.

**Viscosity**

It is a measurement of fluid resistance to flow. The common metric unit of absolute viscosity is the poise, which is defined as the force in dynes required to move a surface 1cm$^2$ in area past a parallel surface at a speed of 1 cm/s, with the surfaces separated by a fluid film 1 cm thick. In addition to kinematic viscosity, there are methods for determining viscosity, including Saybolt universal viscosity (SUV), Saybolt Furol viscosity, Engler viscosity, and Redwood viscosity. Because viscosity varies inversely with temperature, its value is meaningless until the temperature at which it is determined is reported

**Table-4 Absolute Viscosity for different compositions**

| Temperature ($^0$C) | pure | spent | 70%spent/ 30%pure | 50%spent/ 50%pure |
|---|---|---|---|---|
| 30 | 0.143848 | 0.3096 | 0.18416 | 0.118 |
| 40 | 0.08458 | 0.2676 | 0.08024 | 0.06168 |
| 50 | 0.02347 | 0.18937 | 0.045 | 0.0450 |
| 60 | -0.0222 | 0.01447 | 0.01447 | 0.02638 |

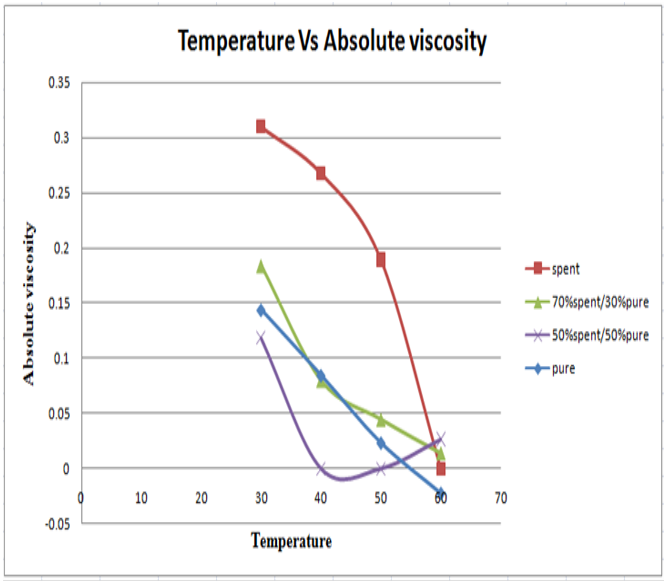


**Fig-8 Graph of temperature vs absolute viscosity**

**Viscosity and its temperature dependence**

The most important property of lubricating oil is its viscosity and how this varies with changes in temperature under the operational conditions to which it is subjected in the lubricated equipment. It is the characteristic of a liquid that relates an applied shearing stress to the velocity gradient it produces in the liquid. Viscosity is strongly dependent on the temperature and is also a function of pressure and density. With increasing temperature, the viscosity has to be stated for a certain temperature.

Viscosity testing can indicate the presence of contamination in used engine oil. The oxidized and polymerized products dissolved and suspended in the oil may cause an increase in the oil's viscosity, whereas decreases in the viscosity of engine oils indicate fuel contamination. Oxidation of base oils during use in an engine environment produces corrosive oxidized products, deposits, and varnishes that lead to an increase in viscosity. Lubricating oils are identified by their SAE number.

The SAE viscosity numbers are used by most automotive equipment manufacturers to describe the viscosity of the oil they recommend for use in their products. The greater or higher the SAE viscosity number, the more viscous or heavier the lubricating oil (Mang 2007). Viscosity numbers are often presented in terms of Saybolt second universal (SSU), or in centistokes. Viscosity is strongly dependent on the temperature with increase in temperature; the viscosity of the oil can decrease rapidly. The addition of certain additives is for the improvement of viscosity–temperature characteristics.

**Table-5 Temperature & Time during Viscosity**

| Temperature ($^0$c) | 70%spent/ 30%pure | 50%spent/ 50% pure | spent oil | pure oil |
|---|---|---|---|---|
| 30 | 112 | 78 | 180 | 91 |
| 40 | 60 | 58 | 157 | 62 |
| 50 | 45 | 45 | 110 | 37 |
| 60 | 34 | 38 | 34 | 24 |

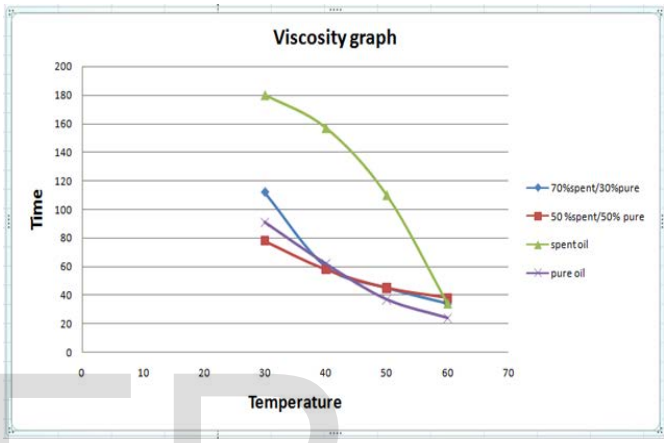


**Fig-8 Graph of temperature vs Time**

## 5. Conclusion

The recycling process has shown from research, the possibility of obtaining good quality base oils from spent engine oils. The cost of recycling (of spent engine oil) is relatively low compared to its production from crude oil as the number of purification stage involved is reduced. The highlight of the sources and collection of spent engine oil was also indicated.

From the experiments conducted the flash point and the fire point of the lubricated oil and the used lubricated oil are comparable and the viscosity got decreased along with the increase in the temperature.

The used lubricating oil can be recycled and can be used in the place of the lubricating oil, so that the disposing of the used lubricating oil can be avoided which helps in the reduction of the pollution. Samples of spent oil and fresh engine oil are also analyzed with different composition and results are comparably similar. So we can also use the composition recycled spent oil & fresh oil for better output than recycled spent oil. Finally we can observe that the recycling of spent oil proposed a durable solution to pollution caused by waste oil.

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