

# REGENERATION OF USED LUBRICATING OIL AS A SOURCE OF ENERGY

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## Abstract

Conservation of natural resources by refining used lubricating oil was attempted in this work. Used lubricating oil was purified and distilled. The distillates obtained were divided into two temperature ranges of 60 - 210°C and 210°C - 330°C. Analyses of the physicochemical properties of the two samples revealed that they have similar properties with gasoline and diesel fuels respectively. This result shows that used lubricating oils, which are usually regarded as waste, can be regenerated to obtain useful hydrocarbons that can be used as fuels to power internal combustion engines.

## 1. Introduction

With the depletion of our natural industrial resources such as fuels and lubricants, it becomes imperative that recycling of waste lubricants for use as secondary products or sources of energy be examined so as to conserve natural resources and reduce environmental pollution. Lubricants can be defined as materials that control friction and wear between interacting surfaces (Bever, 1986).

Lubricating oil, which is mostly used in internal combustion engines today, is essential for its satisfactory operation. It prevents excessive wear and deposit accumulation, and removes heat from areas of high temperatures within the engine. Most engine oils are composed of base oils and additives. The base oils are usually mineral oils, but some are synthetic. Chemical additives are incorporated in engine oil formulations to impart desirable performance characteristics that are not provided by base oils alone (Avalone and Baumeister, 1997). Since the basic functions of lubricants are to reduce friction, prevent wear, act as a coolant and sealing fluid, inhibit corrosion and retard formation of deposits on the engine part, a number of methods have been developed over the years to increase oil performance.

To certain extent, the use of oil filter in machines helps in reducing waste and improving operation. Recovery and reuse of waste lubricating oil for other purposes such as the preparation of anti-termite mixtures are common in Nigeria. The following modern physical and chemical methods are employed in waste oil recovery:- gravity differential separation, vacuum filtration, acid treatment, temperature change, electrostatic cleaning, centrifugation, chemical treatment, flocculation and sedimentation, dissolved gas flotation, extraction, agitation and ultrasonic vibration (Cheremisinoff and Young, 1975).

Disposal of used oil on land is the most widespread method used in this area, though incineration of the oil is practiced. While land disposal of oil wastes pollutes both land and water, incineration of oily substances is expensive and also causes air pollution.

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Used or spent lubricants are among the most problematic wastes in the industrial sector because they contain some poisonous elements like cyanide, sulphur, lead and carbon, which are harmful to the environment (Connor *et al.*, 1968).

The need to find the most logical approach for the use of this hydrocarbon-rich waste cannot be over emphasized. Hence, investigation of the possible recovery of hydrocarbons, for re-use was carried out in this research. The objective of this work was to regenerate used lubricating oil for application as an energy source.

## 2. Materials and methods

### 2.1 Materials

Materials and chemicals used in this investigation include: used engine oil drained from Honda Accord (1986 model), distilled water, detergent, active animal charcoal, aluminium sulphate and sodium hydroxide. Others used were vacuum pump (Jenway:Model-8515), conical flask, rubber tubings, boiling chips, round bottom flask, condenser, kerosene stove, filter paper/cloth, measuring cylinder, thermometer, stirrer, spatula, wire gauge, cotton wool, stop watch (smiths), funnel, cardboard, fuller's earth, gas mask and beakers.

### 2.2 Experimental procedures

Used lubricating oil was drained from a Honda Accord (1986 model) petrol engine. A quantity of 650 ml of the oil was collected in a beaker and allowed to stand for 2 hours for proper settlement after which it was filtered with a cloth. Some 20 g of detergent was dissolved in 10ml of water. The solution was then added to the filtrate and stirred thoroughly for 5 minutes in order to precipitate the gums, grease and scrums remaining in the filtrate. The precipitate was later treated with dissolved aluminium sulphate ( $\text{Al}_2(\text{SO}_4) \cdot 16 \text{H}_2\text{O}$ ). About 27.5 g of aluminium sulphate was dissolved in 26 ml of distilled water and this was added to the filtrate and stirred for 5 minutes. This was left to stand for 48 hours in order to allow for settlement and separation of the contents. After this period, the mixture split into separate layers of water and oil, with some coagulants of dirt at the bottom of the beaker and this was decanted.

The oil collected was added to 7 ml of sodium hydroxide (NaOH) solution and was stirred thoroughly in order to neutralize the acidic compound in the oil. The mixture was later rinsed with water and stirred thoroughly to remove soaps and reactants. It was then poured into a funnel and allowed to stand for 24 hours for further settlement and separation. The filtrate tapped off from the separating funnel was further treated with activated carbon through column chromatography technique. In this technique, treated sample of engine oil was passed through a sequence of layers made up of cotton wool, animal and wood charcoal with the aid of a suction pump in order to hasten the filtration process. At the end of the process, about 480 ml of oil filtrate was recovered from the engine oil sample (Figure 1).

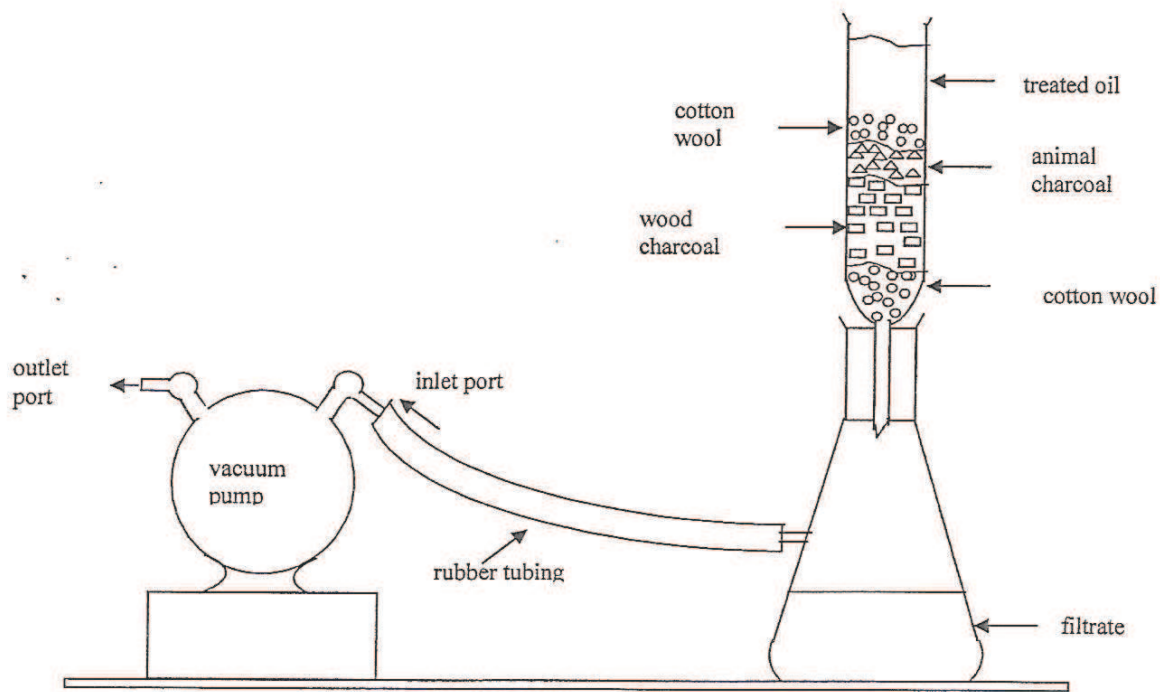


Figure 1: Set-up for column chromatography

The 480 ml of the treated oil filtrate recovered was poured into a round bottom flask containing some broken pieces of glass. This was clamped on a stove and the apparatus for distillation was set up as shown in Figure 2. The two liquid products (which formed 97% of the products) were analysed in order to determine their properties and were compared to those of gasoline, diesel and untreated used engine oil. The properties investigated were density, specific gravity, viscosity, aniline point, diesel index and flash point.

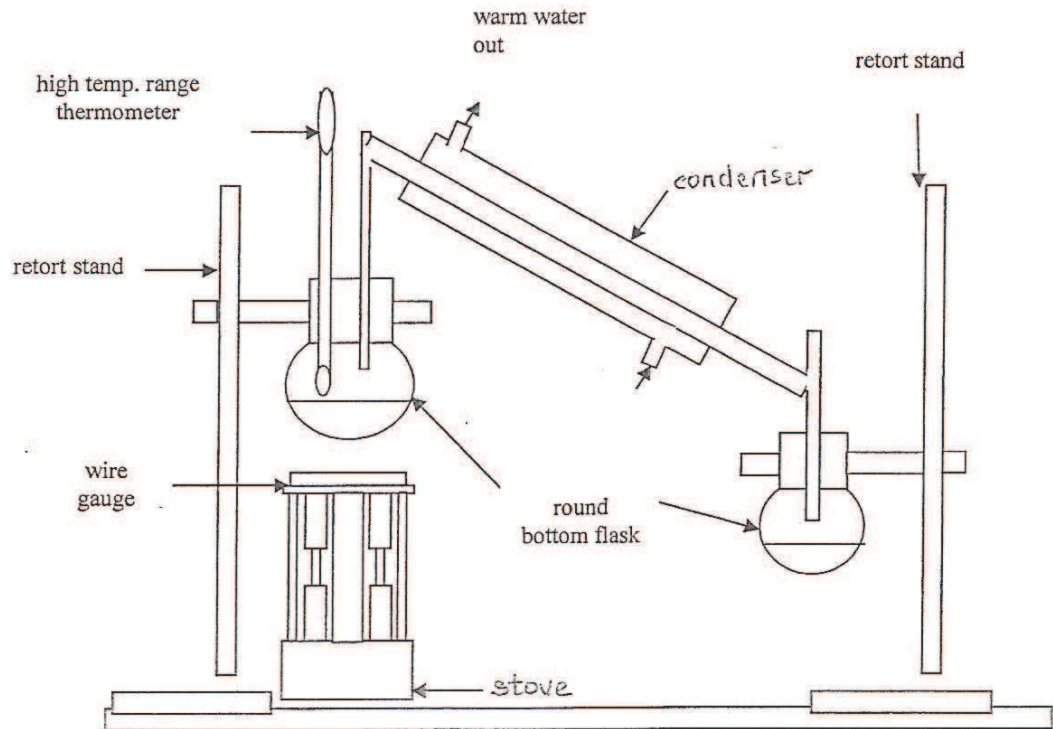


Figure 2: Distillation set-up

### 2.2.1 Determination of Parameters

#### (i) Density and specific gravity

The procedure used for the determination of density and specific gravity of samples was the mass/volume technique (Abbott, 1977). In using this technique, 10ml of each sample was measured into a 25ml beaker and their masses determined at ambient temperature of 35°C and density of water was taken as 1000kg/m<sup>3</sup>.

#### (ii) Viscosity:

The falling sphere method (Hugh, 1992), was used to determine the viscosity of the samples. In this method, the following relationship holds:

$$F_g = \rho_s g \frac{4}{3} \pi r^3 \quad (1)$$

$$F_B = \rho_L g \frac{4}{3} \pi r^3 \quad (2)$$

$$F_V = 6 \pi \mu r V \quad (3)$$

$$F_g - F_B - F_V = 0 \quad (4)$$

Where,

$F_B$  = up thrust force

$F_g$  = gravitational force

$F_V$  = viscous force

$\rho_s$  = specific gravity of steel (7.8)

$r$  = radius of falling sphere (0.75mm)

$\rho_L$  = specific gravity of liquid sample

$\mu$  = coefficient of viscosity

$V$  = terminal velocity given by Equation 5 below:

$$V = \frac{2}{9} r^2 g (\rho_s - \rho_L) / \mu \quad (5)$$

The coefficient of viscosity ( $\mu$ ) was calculated using Equation 5 above, while the kinematic viscosity ( $\gamma$ ) of the samples was determined using the relationship

$$\gamma = \mu / \rho_L \quad (6)$$

(iv) Aniline and Flash points

Aniline point was determined for diesel and product B (210°C – 330°C fraction) using NAE 440 Aniline Point Tester, while flash point was determined using Setaflash Series 3 Model 30000-0.

(v) Diesel index

Diesel index was calculated for both diesel and the 210°C – 330°C fraction using Equation 7:

$$\text{Diesel index} = \frac{\text{aniline point (}^\circ\text{F)} \times \text{specific gravity}}{100} \quad (7)$$

### 3. Results and discussion

The percentage recoveries of distillates are shown in Table 1, while Table 2 shows the density and specific gravity of samples. The ball velocities in various samples calculated are shown in Table 3. Table 4 shows the values of coefficient of viscosity ( $\mu$ ), kinematic viscosity ( $\gamma$ ), aniline point, diesel index, flash point, viscosity and the colour of samples.

**Table 1: Percentage recoveries of distillates and other products**

Product	Temperature range (°C)	Volume (ml)	% Recovery
A.	60 – 210	105	22
B.	210 – 330	360	75
C.	Above 330	15	3

Table 2: Density and specific gravity of  $10^{-5} \text{ m}^3$  samples

Sample	Mass (kg)	Density ( $\text{kgm}^{-3}$ )	Specific gravity
Gasoline	$5.86 \times 10^{-3}$	585.0	0.5850
Diesel	$6.85 \times 10^{-3}$	685.0	0.6850
Used engine oil	$6.683 \times 10^{-3}$	668.3	0.6683
60°C-210°C fraction	$6.037 \times 10^{-3}$	603.7	0.6037
210°C-330°C fraction	$6.872 \times 10^{-3}$	687.2	0.6872

Table 3: Ball velocities in various samples

Sample	Time (s)	Velocity ( $\text{ms}^{-1}$ )
Gasoline	0.905	0.1657
Diesel	8.241	0.0182
Used engine oil	8.242	0.0166
60°C - 210°C fraction	1.250	0.1204
210°C - 330°C fraction	6.303	0.0238

Table 4: Physico-chemical properties of distillates/standard product

Sample	Colour	Viscosity ( $\text{m}^2\text{s}^{-1}$ ) $\times 10^{-6}$		Aniline point ( $^{\circ}\text{C}$ )	Diesel index ( $^{\circ}\text{F}$ )	Flash point ( $^{\circ}\text{C}$ )
		$\gamma$ ( $\text{m}^2\text{s}^{-1}$ ) $\times 10^{-6}$	$\mu$ ( $\text{kg/ms}$ ) $\times 10^{-6}$			
Gasoline	Red	0.913	0.5339	-	-	-
Diesel	Redish	1.124	4.7938	-	-	-
Used engine oil	Dark Brown	6.998	5.2682	64.0	1.008	75
60°C-210°C fraction	Brownish Black	5.333	0.7329	67.0	1.049	78
210°C-330°C fraction	Black	7.883	3.6647	-	-	-

From the results in Table 4, the variation in the properties of the standard products (gasoline and diesel) compared with that of the distillates (60°C – 210°C fraction and 210°C – 330°C fraction) is not so wide. The viscosity of the 210°C – 330°C fraction ( $5.333 \text{ m}^2\text{s}^{-1}\times 10^{-6}$ ) is within the 2.5 to 15.7 centistokes at 38°C range for diesel fuel of grade B (Shukla and Pandey, 1979). Gasoline fuel and the 60°C and 210°C fraction show only a slight variation in their properties (viscosity and specific gravity). While gasoline has specific gravity and viscosity of 0.5850 and  $0.913\times 10^{-6} \text{ m}^2/\text{s}$ , the 60°C - 210°C fraction has specific gravity and viscosity of 0.6037 and  $1.124\times 10^{-6} \text{ m}^2/\text{s}$  respectively. Such variations can be attributed to the presence of various inorganic elements. These inorganic elements may include Pb, Zn, Fe, S,  $\text{NH}_4$  and Cu.

From the above, the products of distillation of used lubricating oil can be proposed for use as fuels to power internal combustion engines since both fractions (60°C -210°C and 210°C-330°C) are closer in physico- chemical properties to gasoline and diesel respectively.

#### 4. Conclusion

Distillation of treated filtrate of used lubricating oil as a means of conserving resources and converting potential waste to fuels has been demonstrated in this study. The products produced can find application in a number of ways, such as fuels for powering internal combustion engines having identified them to have similar properties with standard fuels such as gasoline and diesel.

#### 5. Recommendation

As this study is preliminary, it is recommended that further investigations be carried out on what has been done and also on other properties (such as volatility) that were not considered here.

#### References

- Abbott A.F. (1977). *Ordinary Level Physics*. Third Edition, Heinemann Educational Books, London.
- Avallone E.A. and T. Baumeister (1997). *Marks Standard Handbook for Mechanical Engineers*. 10th Edition, McGraw- Hill Book Company, Singapore.
- Baver B. M (1986) *Encyclopaedia of Material Science and Engineering*. Volume 4, Pergamon Press, Inc. U.S.A.
- Cheremisinoff N. P. and A.R. Young (1975) *Pollution Engineering Practice Handbook*, Ann arbor science publishers, Inc. Michigan, U.S.A.
- Connor J.O., J. Boyd and E.A. Avallone (1968) *Standard Handbook of Lubrication Engineering*. McGraw – Hill Books Company, New York.
- Hugh D. Y. (1992) *University Physics*. 8th Edition Addison Wesley Publishing Company, U.S.A.
- Shukla S.D. and. G.N. Pandey (1979) *Chemical Technology Textbook* Vikas Publishing House Limited, New Delhi.