Regeneration Of Used Engine Oil Using Activated Carbon As Bleaching Agent

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ABSTRACT

Waste lubricants are those samples of oils which have become unsuitable for their intended applications. They may be recycled through the use of refining process to achieve useful products. In this work the used engine oil were regenerated using activated carbon as bleaching agents. The waste oil was treated with acid and the resulting mixture decanted. The bleached oil was neutralized with hydrated lime and then filtered. The characteristic properties of the oil were analysed and the values were recorded as follows; viscosity = 16.58cP, Specific Gravity = 0.924, flash point = 120^0C, pour point = -15^0C. The regenerated engine oil was compared with fresh engine oil and from the results obtained, it was concluded that used engine oil shouldn't be considered as waste and discarded but should be regenerated and if possible reused as this will also help in prevention of soil pollution arising from discarding of the waste lubricating oil.

1. Introduction

Engine oils or Lubricating oils are viscous liquids used in operation to separate moving parts in a system. They serve to protect rubbing surfaces and promote easier motion of connected parts. In the process, they carry the necessary functions of reducing friction and surface fatigue in addition to the removal of high build-up of temperature on the contacting surfaces (Udonne, 2011). These oils are derived from petroleum base feedstock which consists mainly of complex mixtures of hydrocarbon molecules. Also during machine operation, the unguarded rubbing of contacting part leads to the formation of wearing out of the metal parts and deposition of dirts into the lubricating oil. In the same way, a lot of impurities are generated in the oil due to its subsequent oxidation and thermal degradation of the lubricant (Ihsa, Yusaf, & Rafat, 2013). These impurities contain unsaturates, aldehydes, phenolic compounds, alkanols, acidic compounds, and non-stable products of hydrocarbons. Other sources of contaminants include acidic fuel combustion exhaust gases

andnitrogen oxides absorbed by the oil as well as dust, fuel, water, gums and other products of additive degradation. The effect of these contaminants leads to a drop in performance efficiency of a lubricant. Therefore, this oil must be removed and changed from the automobile after a few thousand kilometers of driving due to these observed stresses from serious deterioration in service . According to (Concawe,2005) these hydrocarbon molecules usually range from low viscosity oils to high viscosity oil. The main service properties of Engine oil are their viscosity, viscosity – temperature properties, fluidity at low temperatures, chemical stability and protective properties. Lubricating oils have viscosities ranging from 10 to 1000 centistokes at 100oF (Susan, 2011).

Regeneration of used lubricating oil simply means the removal of the contaminants or impurities by sulphonating agents such as sulphuric acid, oleum or sulphur trioxide. About 80 % of the aromatics and other impurities are removed in the first circle while the remaining 20 % are removed in the second cycle of the operation (TY, 2016).

During operation of engine, lubricating oil temperature build-up and degrade the oils leading to decline in important properties like: viscosity, specific gravity and flash point. Aside this dirt particle and worn out metal parts from engine surfaces are deposited into the oils. With the passage of time, this engine oil loses its functional properties and must be replaced with fresh lubricant. Considering the fact that huge quantity

of lubricating are oils used on daily basis, the frequent dumping of lubricating oils has now become a source of serious concern. It is on thispremises that most countries of the world are presentlypaying serious attention to the menace ofenvironmental degradation caused by the disposal ofwaste or used lubricating oils (James, 2014)

2. Materials
2.1 sources of plant and materials

Sample of used engine oil to be regenerated was collected from mechanic workshop around Nasarawa Garage area of Nasarawa State while the fresh engine oil waslpurchased from a retailer in Nasarawa market Metropolis.

The activated carbon which is produced from wood charcoal was purchased from Keffi, Nasarawa State.

2.2 Pre-Treatment of Waste/Used Oil

1.0 litre of the used engine oil earlier collected was measured out and poured into a filter cloth placed in a funnel mounted on the flask. During the filtration process impurities such as sand, dust, metal chips, particles was retained in the residue while the filtrate was collected as clean waste lubricant.

2.3 Regeneration of waste oil

The regeneration of the used engine oil was performed using the methods below

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2.3.1 Acid Treatment

300 ml of used engine oil was measured in a 500 ml beaker. Also, 30 ml of sulphuric acid was measured in a separate 50 ml beaker. The regulator hot plate was switched on and the measured oil placed on top. The temperature of the used engine oil was maintained at 40-45°C. At this temperature the sulphuric acid was introduced into the used engine oil simultaneously with stirring of the mixture for 10 minutes.

2.3.2 Sedimentation /Decantation

At the end of the acid treatment step, the acidic oil was allowed to settle 4 hours to form sediment at the bottom of the beaker. After this period, the acidic-oil was properly sedimented and decanted into another 500 ml beaker while the residue i.e. acidic sludge at the bottom of the beaker was discarded.

2.3.3 Bleaching of used engine oil using activated carbon

The acidic oil in the beaker was subjected to bleaching using the activated carbon. The oil was placed on a regulator hot plate and the temperature maintained at a temperature range of 130°C–140°C. 6 wt% of the activated carbon was introduced into the oil and the mixture continuously stirred for 10 minutes. At the end of the bleaching step, the bleached oil was neutralized.

2.3.4 Neutralization

The bleached oil was neutralized to adjust the pH of the oil to neutrality. At this step, 4 wt% of the oil of hydrated lime was introduced into the bleached oil by taken into consideration the pH of the bleached oil at a given point in time. The bleached oil was neutralized with a continuous manual stirring for 10 minutes. At the end of the bleaching and neutralization steps, the oil was allowed to sediment in the beaker for 4 hours and decanted into the beaker, while the residue at the bottom of beaker was discarded.

2.3.5 Filtration

The sedimented oil was finally filtered using a filter cloth and the filtrate was collected in a filtration flask and the residue (filter cake) discarded.

2.4 Analysis of Oil Samples

The properties of used oil, fresh oil and regenerated oil samples were evaluated

2.4.1 Specific gravity determination of Oil samples

The mass of the empty 25ml specific bottle was weighed. The bottle was then filled with oil and weighed again. Finally, oil was removed from the bottle, thoroughly cleaned and refilled with water and the overall weight noted.

2.4.2 Flash point determination of oil samples

20ml of the regenerated oil was measured into a beaker. The beaker was positioned on the bunsen

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burner with thermometer inserted vertically into the oil sample. The burner was then heated until the temperature starts to increase gradually. The test flame was lighted and brought at intervals of 15 seconds to the surface of the oil sample. When the oil ignites and continues to burn for 10 seconds, the thermometer reading was then noted. The test was repeated for the samples of fresh oil and used oil.

2.4.3 Pour point determination of oil samples

20ml of the oil sample was measured into glass container and placed in a cooling thermostatic bath maintained at temperature of -10^0 to -20^0C. After a period of 30 minutes, certain paraffin wax was begin to solidify and separate out in crystalline form. Later temperature was decreased and when it reaches a point where the oil sample stops to flow, the temperature was noted. This procedure was repeated for other oil samples.

2.4.4 Viscosity determination of oil samples

20ml of sample of regenerated oil was measured out and put into the Viscometer. The Viscometer and its content were put into the holder and inverted into the constant temperature bath maintained at 40^0C. 10 minutes was allowed for the oil sample to attain the bath temperature. The oil was allowed to flow by gravity. The efflux time was then noted as it flowed from upper meniscus mask. The test was repeated using samples of virgin oil and used oil.

2.4.5 Moisture content determination of oil samples

A clean empty porcelain dish was oven dried at 110^0C, cooled in a desiccator and weighed. 10g of the oil sample was weighed out and put in the porcelain dish and the overall weight recorded. The porcelain and its content were then heated to 110^0C for 1hour in a hot plate and then oven dried to a constant weight. The percentage moisture content was evaluated from the loss in weight of the specific oil sample. This was also repeated for other oil samples are result noted.

2.4.6 Determination of Total Acid Number of oil samples

10g of the oil sample was weighed into 250ml conical flask. 50ml of ethanol was weighed into another conical flask. 2 drops of phenolphthalein was then added to the flask containing the ethanol and mixture heated to 40^0C. Later, the solution was neutralized by subsequent addition of 0.5N KOH solution. The neutralized alcohol was added to the weighed oil and heated mildly to 30^0C for 15 minutes. The heating was accompanied by thorough stirring to ensure complete extraction of the acid by the alcohol. Again, 2 drops of phenolphthalein was added to the mixture and allowed to cool to room temperature for 20 minutes and it was then titrated with 0.5N KOH solution. The total acid number, TAN was evaluated from the equation below.

$$TAN = \frac{56.1 \, xNV}{W}$$

Where

N = Normality of alcohol solution

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V = Volume of KOH solution

W = Mass of Oil sample

This procedure was also repeated for fresh oil and used oils.

3. Results

The used engine oil, fresh engine oil and regenerated oil which was produced using activated carbon and acetic acid were analysed and the result obtained is shown in the table below:

S/NO	SAMPLES	VISCOSITY (cP)	FLASH POINT (^{0}C)	POUR POINT (^{0}C)	SPECIFIC GRAVITY	TOTAL ACID NUMBER (TAN) (mgKOH)	COLOUR
1.	Used engine oil	16.58	120	-29	0. 924	2.55	Black
2.	Regenerated engine oil	28.38	154	-15	0.865	0.62	Yellowish green
3.	Fresh engine oil	30.84	189	-10	0.894	0.13	Yellowish green

Table 1: Properties of Used Engine Oil, Regenerated Engine Oil and Fresh Engine Oil.

4. Discusiion

4.1 colour

The colour of the fresh oil was yellowish green while that of the used oil was very dark. The

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blackness of the used oil could be due to the formation of small carbon fragments during thermal cracking and also due to the products of thermal oxidation and corrosion. Oil may be contaminated with soot resulting from an incomplete combustion of petrol. The colour of

the regenerated oil was good. This means that activated charcoal can be used as a goof bleaching agent.

4.2 Specific gravity
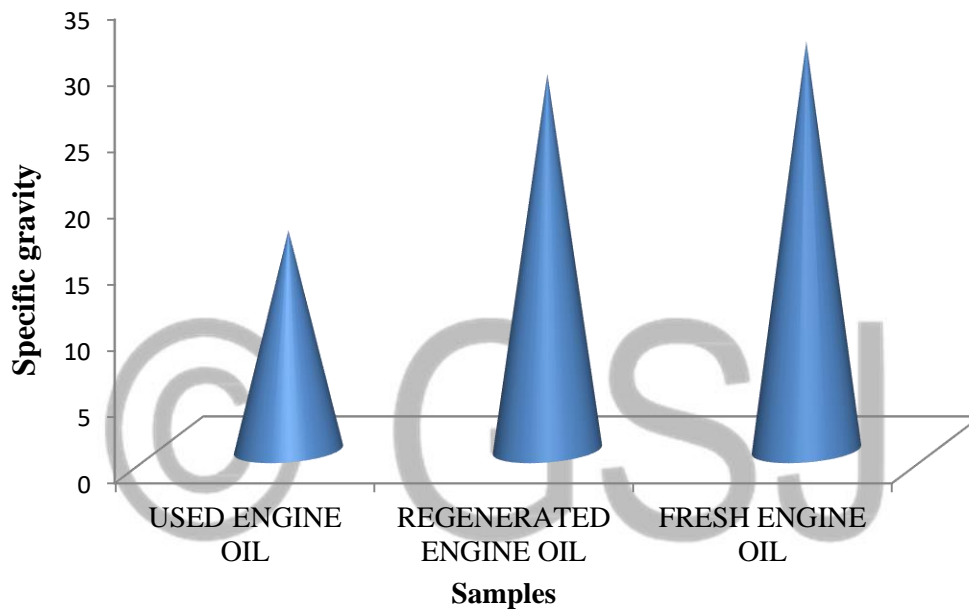
Figure 1: Chart showing Specific Gravity of Used Engine Oil, Regenerated Engine Oil and Fresh Engine Oil.

Specific gravity of treated oil samples was analysed using a specific gravity bottle (Pycometer). Specific gravity of fresh engine oil was 0.894, while the specific gravity of used engine oil was 0.924. The result of the specific gravity for the regenerated oil by acid treatment method was 0.865 as shown in Figure 1. It was

discovered that the value of specific gravity of used engine oil is more as compared to the fresh and regenerated oil. This shows that its high specific gravity could be attributed to the nature and type of contaminations (Shakirulla et al., 2006).

4.3 viscosity

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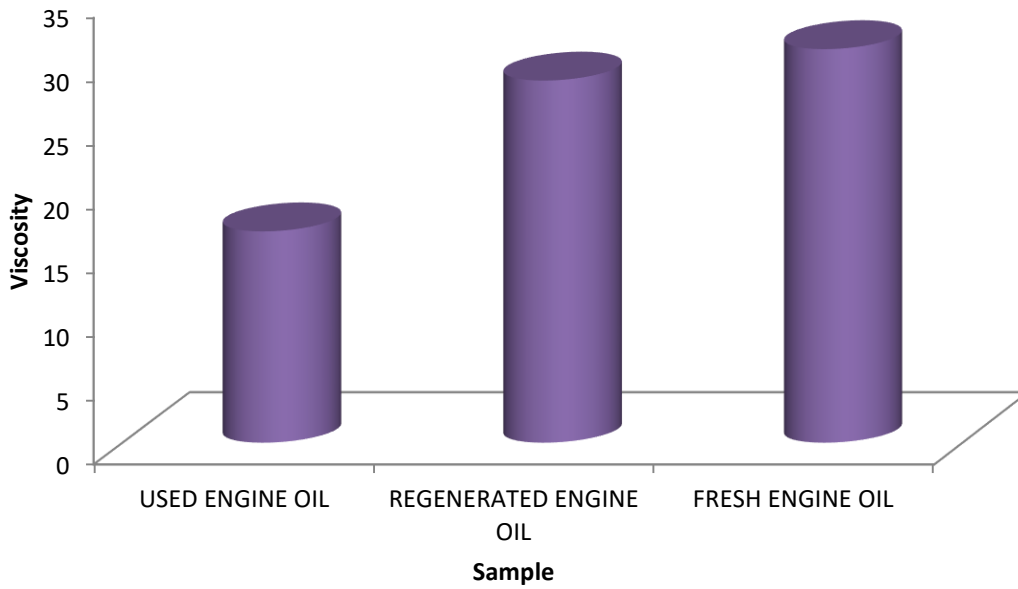
Figure 2: Chart showing viscosity of Used Engine Oil, Regenerated Engine Oil and Fresh Engine Oil

Kinetic viscosity of used engine oil can be increased due to oxidation or contamination, while it may also be decreased due to dilution with light fuels (diesel or petrol) (Fox, 2007). In figure 2 the viscosity of the used oil was observed lower when it compared to the fresh oil, because the viscosity of the used oil decrease with oil combustion in the engine with the fuel, which results in impurities, the results showed the treated oil with acetic acid closed to the fresh oil and this indicates the efficient of using acid treatment.

4.4 Flash Point
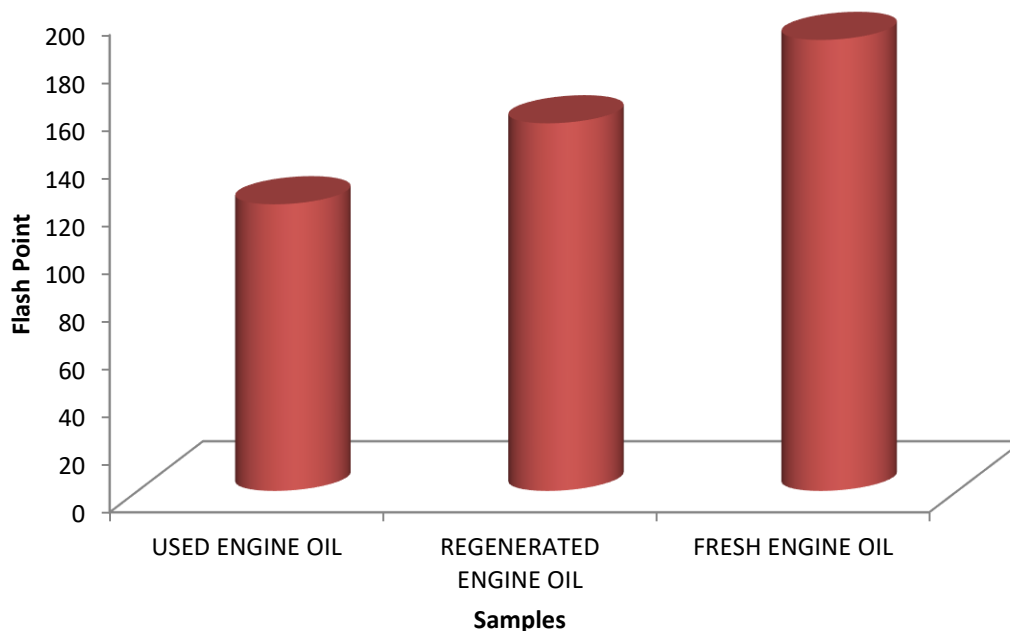
Figure 3: chart showing Flash Point of Used Engine Oil, Regenerated Engine Oil and Fresh Engine Oil.

The flash point is the minimum temperature at which an oil-vapour-air mixture becomes inflammable. The flash point of engine oil is a measure of the degree of contamination (ASTM, 2004). From the results, the flash point of the used engine oil decreased to 120^0C from the value of 189^0C of the fresh oil. The decrease after the service operation may be due to the contamination with oxidized products and degraded light ends of oils. Thus, after undergoing combustion and oxidation at high temperature of the combustion engine, the oil breaks down into component parts which include some light ends (Udonne, 2011, and Eman & Abeer, 2012). The analysis of the result of oil samples regenerated using activated charcoal as activating agent revealed that the sample exhibited commendable fit that is comparable to the fresh oil.

4.5 pour point
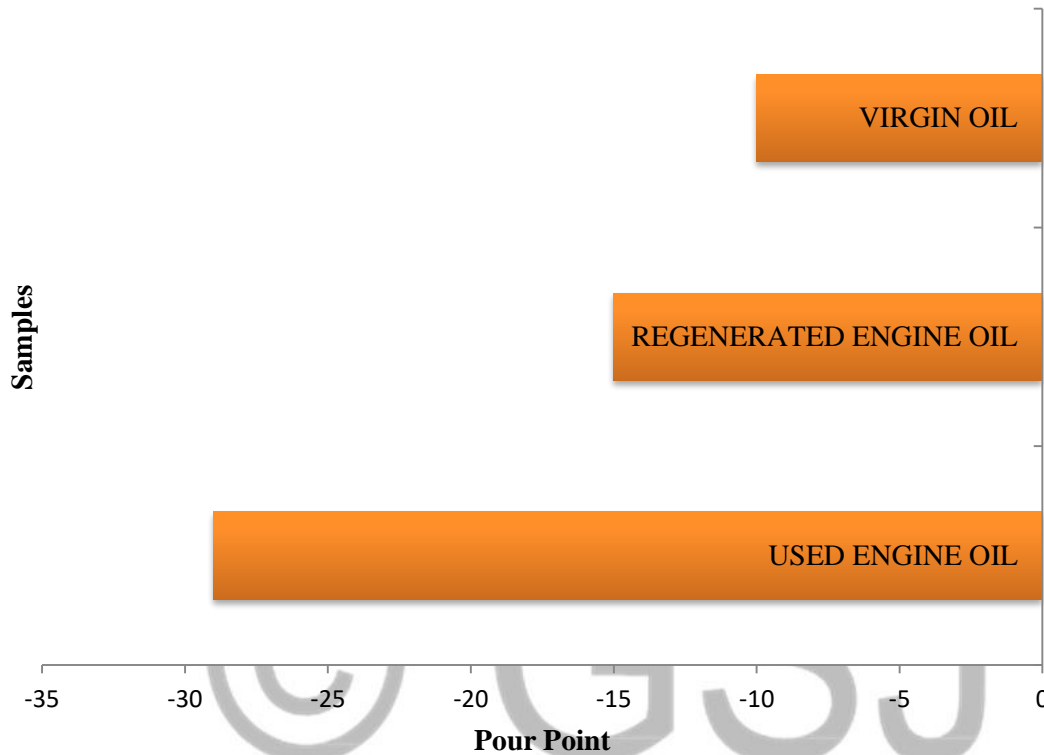
Figure 4: chart showing the pour point of Used Engine Oil, Regenerated Engine Oil and Fresh Oil.

Pour point of lube oil may be decreased and increased, depending on the nature of lube oil method of refining (Isah et al., 2013). The result chart in Figure 5 shows that the pour point of fresh oil is -10^0C and used engine oil is -29^0C. This decrease in pour point is because of degradations of additives, which were present in

fresh oil as pour point depressants. Pour Point values of the regenerated engine oil was -15^0C. This is because the long aliphatic chains attached to the aromatic rings are separated and cracked as a result of oxidation. The oxidation such as aldehydes and ketones have a low pour point as is the case in used oil.

4.6 Total Acid Number

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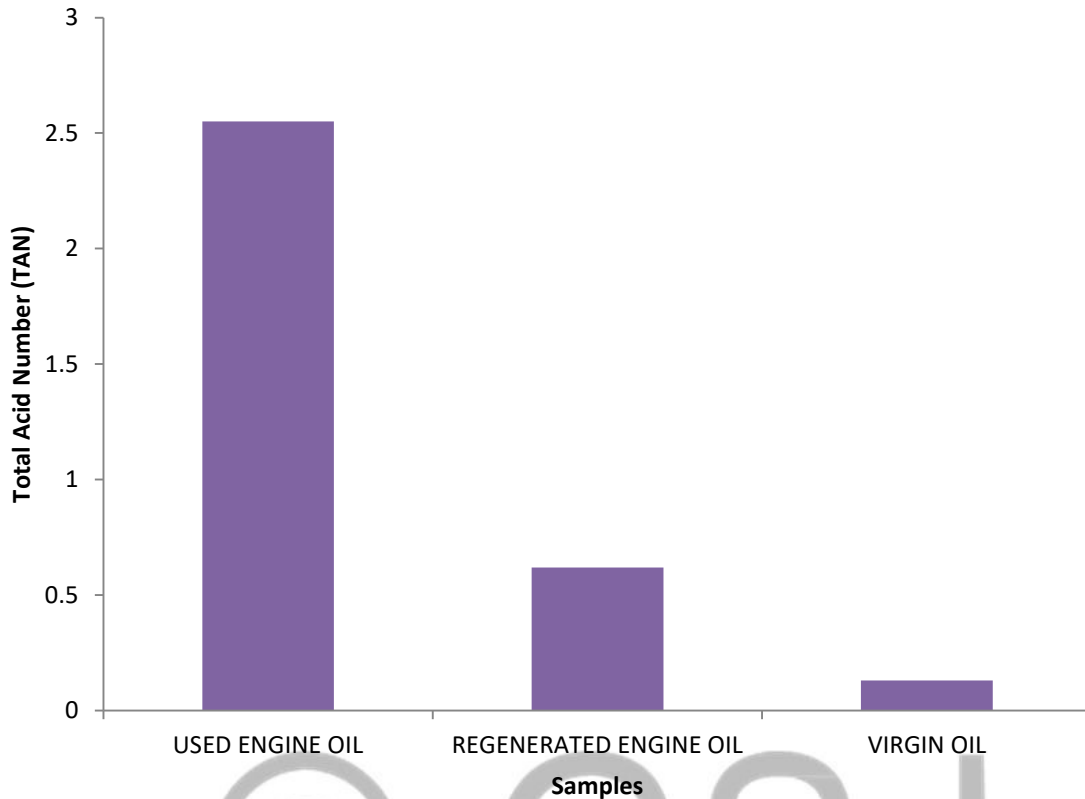
Figure 5: chart showing the Total Acid Number of Used Engine Oil, Regenerated Engine Oil and Fresh Engine Oil.

As shown in figure 5, the TAN of the used oil is measured to be 2.55, a value that is much higher than the TAN of the virgin oil evaluated as 0.13. This may be due to the presence of organic, inorganic heavy metallic salts, ammonia salts, resin, water and corrosive materials which emanate from the oxidation process that occurred at elevated temperatures in the engine (Bakare & Udonne, 2013). As engine oils are subjected to high temperatures, the process of oxidation occurs, which leads to the formation of organic and inorganic acid. Secondly, the presence of oxygen and hydrocarbon which make up the base oil in most engine environments leads to another form of reactions with the formation of carbonyl-containing products. These products subsequently undergo further oxidation to produce carboxylic acids and precipitation of sludge (Ihsa et al., 2013, and Fox et al., 1991). The results shows that the TAN values of the sample regenerated was improved upon with a total acid number of 0.62.

5.1 Conclusion

This research has shown that used engine oil can be regenerated by using glacial activated charcoal as an adsorbent and acetic acid. The study proved that the acid treatment is a process that can effectively remove contaminants from used lubricating oil. The regenerated oil has a comparable quality with the fresh oil indicating the possibility of reusing it.

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Used engine oil properties were determined with standard physical tests. Operational parameters were established in reference with the common acid process and its modification and the research concludes that used engine oil shouldn't be considered as waste and discarded but should be regenerated and if possible reused as this will also help in prevention of soil pollution arising from discarding of the waste lubricating oil.

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