Effect of Acids Types on The Recycling of Used Lubricating Oil

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***Abstract*— The recycle of used lubricating oil by acid treatment is investigated. In this research, several types of acid were used such as nitric acid, hydrochloric acid, and Sulphuric acid. Two parameters measured which different types of acids and various concentrations of acid. This research is focused mostly on gaining a high-quality production of oil from used lubricating oil by treatment with acid as an addition to distillation process. The characteristic and quality of the treated lubricating oil is compared with the base oil by several parameters such as pour point, cloud point, dynamic viscosity, kinematic viscosity specific gravity and ash content. Initially, the used lubricating oil is filtered to remove the all the dirt. Then, gasoline is added to used lubricating oil following centrifugation at 1500 rpm for 10 minutes. The atmospheric distillation was conducted for the complete removal of water and gasoline. Finally, the lubricating oil is treated with the acids (nitric acid, hydrochloric acid, and Sulphuric acid) and neutralize with 6% of sodium hydroxide then separated by using settling and centrifuging the supernatant oil to remove remaining suspended solid. The result from the analysis showed that the kinematic viscosity for used lubricating oil is increase from 61.6034 for used lubricating oil to 70.3862 for Nitric acid treatment,73.9876 for sulphuric acid treatment and 70.6906 with for hydrochloric acid. The specific gravity decreases from 0.92 for used lubricating oil to 0.86 for nitric acid treatment,0.88 for sulphuric acid treatment and 0.84 with hydrochloric acid treatment. Other result from different analysis showed that the improvement and the best result is lubricating oil that treated with sulphuric acid which nearly like fresh lubricating oil. For different acid concentration, the lubricating oil that treated with 20% of sulphuric acid shows the best result in reduce contaminant within the used lubricating oil.**

Keywords*— *used engine oil, lubricant, recycled, pollution

I. Introduction

The lubricating oil act as a lubricating medium for various automobile parts such as engines and gearboxes. Lubricating oil is a substance with the function to maintain and create a lubricating film between the two-moving part also provides a heat transfer medium (Kannan, Mohan, Hussain, Priya, & Saravanan, 2014).Lubricant oil is viscous liquid which are from petroleum that has been used extensively to reduce the friction of moving part of various machines, engines and equipment with the purpose to create a lubrication film between the two-moving metal surface, to minimize the material wear and tear also to improve the efficiency of engines and machineries which essential in fuel and energy savings under severe operating condition. Lubricating oil play important role in removing away heat from the machines or engines, also to keep the machines, engines and equipment clean and reduce the corrosion.

Used lubricating oil posed an environmental hazard as it can give impact on health and adverse environmental. The improper handling of used lubricating oil like service station or garage that dumped the used lubricating oil into the drains, streams, river, lakes and ocean nearby led to pollution and harmful for environment. The demand of the lubricant keeps continuously increase year by year with the increase number of vehicle and increase in the establishment of factories. With the increase in demand of lubricant oil, large amount of lubricant oil is produced and consumed globally. However, the increasing the number of automotive and industrial lubricating oil consumption was lead environmental pollution and cause a problem in dispose a huge amount of contaminated used lubricating oil. Even the small amount of pure lubricating oil can cause major amounts pollution of water and roughly a million gallon of water could be contaminated by a gallon of used lubricating oil which include flora and fauna (Rashid et al. ,2013). The used lube oil contains heavy metal such as PCB (poly-cyclic benzenes) and PAH (poly-aromatic hydrocarbons) which are the main contaminants and highly toxic when dumped to environment especially to water as it can cause the blockage of sunlight, obstruction of oxygen from the atmosphere and impair photosynthesis which gives huge impact to aquatic lives. The treatment also will face difficulties as the heavy metal is not easily removed by the conventional treatment methods of contaminated water. In addition, the lubricating oil will cause serious problem for the ground water supplies surround the landfills that leach into the ground. Thus, it is importance to manage the municipal solid waste reduction (Yang, 2008).

Nowadays, the used lubricating oil is one of the significant source of energy. Oil just gets dirty after use for certain period and need to be change and these oil does not wear out. Used oil can be either recovered in into base lube oil or reused as fuel or used as feedstock in producing the petroleum-based products, the commercially valuable products also can be produced through different methods. (Isah et al., 2013) There are some facts about preserving resources by proper handling of used oil. Re-refining of used lubricating oil takings about one-third of the energy needed to refine crude oil to lubricant quality and one gallon of used lube oil that is re-refined produces the same 2.5 quarts of lubricating oil just like 42 gallons of crude oil does. Recycling of used lubricating oil not only protects the environment from used oil contamination, but also conserves a valuable non-renewable resource. (Mekonnen, 2014). Therefore, the management of used oil is principally important because of the large quantities of waste lubricating oil is produced globally, the potential for reprocessing, regeneration and harmful effects on the environment if the waste oil is not properly treated handled, or disposed. Recycling of used lubricating oil also might result in both environmental and economic benefits (Yang, 2008).

II. METHODOLOGY

Materials

The used lubricating oil sample for the acid treatment and for the experiment analysis of this research is collected from used oil dumps from workshop nearby Shah Alam and the test sample for fresh lubricating oil is collected from oil service station.

Table 1: list Of Major Chemical for Acid Treatment and Sample for Analysis

Chemical	Purpose
Sulfuric acid	Deasphalting and settling of acid sludge from used treated oil
Hydrochloric acid	Deasphalting and settling of acid sludge from used treated oil
Nitric acid	Deasphalting and settling of acid sludge from used treated oil
Sodium hydroxide	Acid neutralization
Gasoline	Increase oxidation
Activated bentonite clay	Odour and Colour Treatment

Table 2: list Of Major equipment for Acid Treatment and Sample for Analysis

Equipment	Purpose
hydrometer	Specific gravity test
Vacuum pump	Vacuum distillation
Centrifuge	Separation of oil with other material
Furnace	Ash content determination
Viscometer	Viscosity determination
Electric heater	Distillation
Condenser	Distillation
Shaker	Acid absorption, and neutralization treatment
Thermometer	Monitoring operating temperature

Experimental procedure

The used lubricating oil is filtered to remove the all the dirt and impurities that may exist such as metal chips, sand, dust, particles, micro impurities. The method was using a funnel that filled with a filter paper. then a vacuum pump was connected to the filtering flask. Then, 450 ml of the lubricating oil is measured transferred to a beaker. 150 ml of gasoline is measured then it is added to the used lubricating oil. Next, the mixture is stirred thoroughly to promote homogeneity. The lubricating oil mixture is transferred to the bucker of the centrifuge. Then it is centrifuged at 1500 rpm for 10 minutes. It is then left for settling for another 10 min before decanting into a beaker. The atmospheric distillation is conducted for the complete removal of water and gasoline, Thus, the lubricating oil mixture is heated with a heating mantle from 120°C to 140°C under atmospheric pressure, for an hour. Then the content in the flask is left cooled. The lubricating oil is treated with the acid (nitric acid, hydrochloric acid, and Sulphuric acid) and the mixture is then agitated and allowed to cool. The shaker temperature is fixed at 40°C and the agitation intensity was 250 rpm. The treated sample is then kept undisturbed for 24 hours for Deasphalting and settling of acid sludge. For the process neutralization, the treated oil is mixed with 6% of sodium hydroxide to neutralize any soluble acid remained. The neutralization product (salts) and unreacted sodium hydroxide are left to settle down for about 24 hours the room temperature on shaker with a constant stirring intensity of 300 rpm for an hour. The treated lubricating oil is separated by using settling and centrifuging the supernatant oil to remove remaining suspended solids and salts that present during neutralization process. This step is conducted at 5000 rpm for 45 minutes.

Analyse the quality and characterization of lubricating oil

Cloud point (ASTM D97)

For the pour point 20 ml of the lubricating oil sample was measured and put into a container. The lube oil sample was chilled at specific rate, certain paraffin hydrocarbon (in the form of wax) will begin to solidify and separate out in crystalline form. The temperature at which this happens is called cloud point.

Pour point (ASTM D97)

The procedure was same as cloud point; however, the further chilling was continued until lubricating oil stop to flow. The temperature this happened, is called the pour point temperature.

Specific gravity (ASTM D941-55)

Specific gravity is the ratio of the density of the material to the density of equal volume of water. This was measured using the hydrometer. The density is observed at 60°F and the value recorded.

Viscosity (ASTM D445)

Viscosity (ASTM D445) is analysed by using automated viscometer AMVn. The fresh base virgin oil, the used lubricating oil and the re-fined used lubricating oil that treated with various type of acid was filled inside the capillary block of the clean viscometer to the mark while immersed in a thermostat. Then, the software of automated viscometer AMVn was opened and run, the name of the sample, density and temperature and measuring system AMVn is set and determined. For this analysis, the temperature was set to 40 ^{o}C, then result is obtained and tabulated

Ash Content (ASTM D482).

There is some quantity of incombustible material that might present in a lubricating oil which can be determined by measuring the amount of ash remaining after combustion of the oil in a furnace Measured amount of used oil is put in a crucible and kept for five hours in the furnace at 800°C. Mass of the remaining ash is measured and its percentage is calculated by divide it with initial mass of the sample.

$$\% Ash = \frac{m_{ash}}{m_{initial\ sample}} \times 100$$

III. RESULT AND DISCUSSION

Table 3: analysis of result for acids treatment

Parameter	Used lube oil	Fresh lube oil	Nitric acid treatment	Sulphuric acid treatment	Hydrochloric acid treatment	Standard range
Colour	black	yellow	Reddish black	yellow	brown	-
Specific gravity [g/cm3]	0.92	0.89	0.86	0.88	0.84	0.86-0.98
Kinematic viscosity [Mm2/s]	61.6034	76.6616	70.3892	73.9876	70.6906	-
Dynamic viscosity [mPa.s]	56.6751	68.2288	60.5347	65.1090	60.7939	-
Cloud point [°C]	-34	-8	-13	-10.5	-16	-
Pour point [°C]	-37	-13.5	-17.5	-15	-19.5	-
Ash content [%]	2.3	0.12	0.32	0.26	0.41	< 1.0%

3.1 Characteristics of Used and re-refined lubricating oils: study of various types of acid

i. Colour

The colour of lubricating oils can range from transparent to opaque. A change in oil colour signifies a change in the chemistry of the oil or the presence of contaminants. For example, oil oxidation, mixing two dissimilar types of oil, and carbon insoluble from thermal failure can all darken oil. There is also a possibility that the oil darkening is due to a photochemical reaction from sunlight exposure.

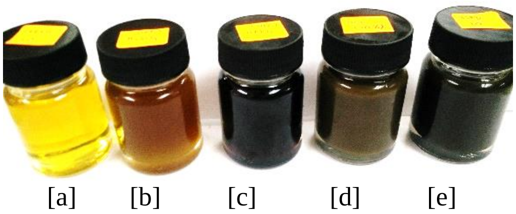

Fig. 1: Effect of refining of used lubricating oil on its color.

Figure 1 shows the results for the fresh, re-fined lubricating oil and used lubricating oils. Which from the left: [a] is fresh lubricating oil (light yellow), [b] is refined lubricating oil that treated with Sulphuric acid (yellow), [c] is re-fined lubricating oil that treated with Nitric acid (reddish black), [d] is re-fined lubricating oil that treated with hydrochloric acid (brown), and last, [d] is used lubricating oil(black). The different colour is influence by chemical composition and contaminant that may present in the lubricating oil, the darker the colour, the higher the contaminant insides the lubricating oil. From the result presented, the colour for the lubricating oil that treated with sulphuric acid is yellow which the lightest as compare to lubricating oil that treated with nitric acid which is reddish black and lubricating oil that treated with hydrochloric acid which is dark brown. By comparisons acid treatment with respect to colour, the selectivity sequence can be given as specify by the following order to Sulphuric acid >hydrochloric acid > Nitric acid.

ii. Specific Gravity

Specific gravity is the proportion of the density of the material to density of the equal volume of water. The temperature at which the density has been measured is essential as the density changes with temperature.

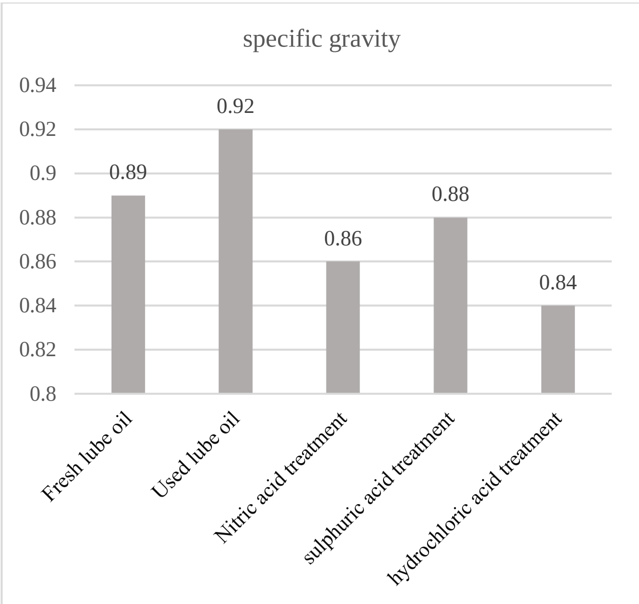

Fig. 2: Effect of refining of used lube oil on its specific gravity.

From the result obtained, the specific gravity for the fresh and used lubricating oils are 0.8806 and 0.9201 respectively, while those treated lubricating oils obtained by the acid treatments methods were 0.86 for treating with nitric acid, 0.88 for Sulphuric acid treatment, and 0.84 for hydrochloric acid treatment. From the result obtain, the specific gravity for lubricating oil that treated with acid is lower compare to used lubricating oil. The specific gravity of contaminated oil may perhaps be higher or lower dependent on the type of contamination (Chevron lubricating oil FM ISO 100). Besides, specific gravity is influenced by the chemical composition of the lubricating oil. The higher the number of aromatic compounds present in the lubricating oil will rise the specific gravity, whereas an increase in the saturated compounds results in a decrease in the specific gravity. Used lubricating oils specific gravity increases with the presence of collective amounts of solids in the used engine oil. From the result presented, the lubricating oil that treated with hydrochloric acid is out of range that is allowable, this is might due to the saturated compound that may present inside the lubricating oil. Meanwhile, the specific gravity for lubricating oil that treated with sulphuric acid is just about the same as fresh lubricating oil. By comparisons acid treatment with respect to specific gravity, the selectivity sequence can be given as indicate by the following order to Sulphuric acid > Nitric acid > hydrochloric acid.

iii. Dynamic viscosity

Viscosity rise might occur as oxidation or contamination present with insoluble matter, from the result obtained, the decrease in dynamic viscosity of the used oil this is due to contamination in form of slush in the used lubricating oil. In general, lubricating oil is considered unsuitable for the usage, if the original viscosity increases or decreases to the next SAE number. Viscosity increase can happen because of oxidation or contamination (Scapin, 2007). Viscosity decrease can occur due to dilution with light fuel. From the Figure 1 below, it shows the results for dynamic viscosity of fresh and used lubricating oils are 68.2288 and 56.6751 respectively, while those treated oils obtained by the acid treatments were: 60.5347 for treating with nitric acid, 65.109 for Sulphuric acid treatment, and 60.7939 for hydrochloric acid treatment. It shows that the dynamic viscosity of the used lubricating oil is higher than the refined one. The result of the viscosity test shows that, the used lubricating oil has lost most of its viscosity due to contamination. However, treatment has restored most of its viscosity.

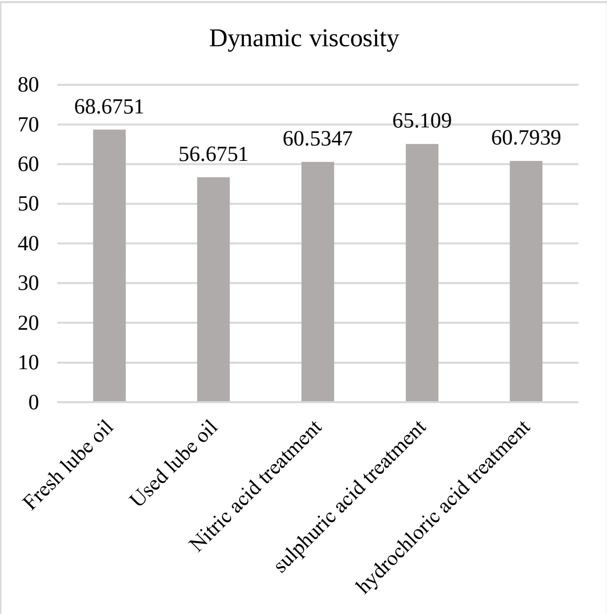

Fig. 3: Effect of refining of used lube oil on its dynamic viscosity.

However, by treated the used lubricating oil with acids has restored most of its viscosity. The result shows also that refining using Sulphuric acid treatment gave the highest viscosity. This can be attributed to the possible conversion of possible contaminants by the acid from the lubricating oil. In view of the attraction of the lubricating oil to act as a coolant or heat transfer medium, it must be able to retain adequate body at elevated film temperature, up till now suitable fluidity elsewhere in the system. This is ensured when the viscosity is above 60. Oil as treated using all four types of acids meet this specification, but the Sulphuric acid has an advantage over others since it is the nearest to the pure fresh lubricating oil.

iv. Kinematic viscosity

Viscosity is a state function of temperature, pressure and density. There is an inverse relationship between viscosity and temperature, when the temperature of the lubricating oil decreases the viscosity increases and vice versa. 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 of the oil viscosity, while decreases in the viscosity of engine oils indicate fuel contamination. Oxidation of motor oils during use in an engine environment produces corrosive oxidized products, deposits, and varnishes which lead to an increase in the viscosity. The kinematic viscosity of the samples was measured by the falling ball viscometer and the viscosity can be calculated by the following equation.

$$\mu = gD_p^2(\rho_p - \rho)t_p / 18L$$

Where tp is the time required for a sphere to fall a distance, L, ρb is the density of the solid sphere, ρ is the density of the fluid, Dp is the diameter of the solid sphere and g is the gravitational acceleration (9.8 m/s2). From the Figure below, it shows the results for kinematic viscosity of fresh and used lubricating oils are 76.6616 and 61.6034 respectively, while those treated oils obtained by the acid treatments were: 70.3892 for treating with nitric acid, 73.9876 for Sulphuric acid treatment, and 70.9806 for hydrochloric acid treatment. Fig. shows a decrease in kinematic viscosity of the used lubricating oil, this is due to contamination in the form of sludge in the used oil. Viscosity increase can occur due to oxidation or contamination Viscosity decrease can be caused by dilution with light fuel.
The result of the viscosity test shows that, the used lube oil has lost most of its viscosity due to contamination. However, treatment has restored most of its viscosity. The result shows also that refining using Sulphuric acid gave the highest viscosity followed by nitric acid and hydrochloric acid. This can be attributed to the possible conversion of possible contaminants by the acid and removal by the filtration from the lubricating oil.

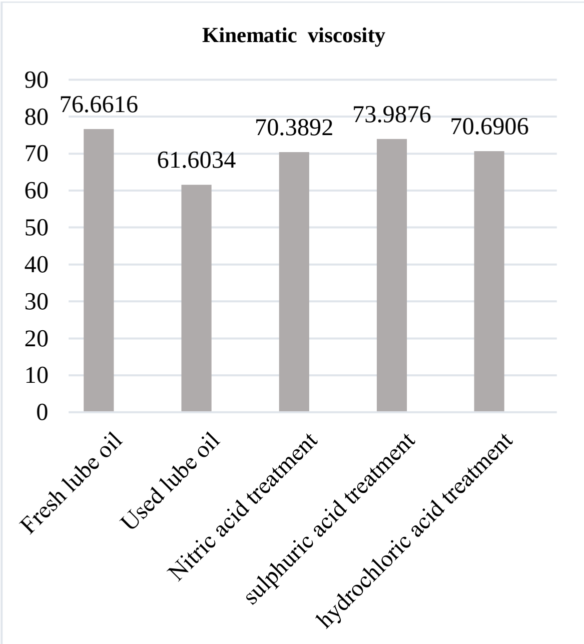

Fig. 4: Effect of refining of used lube oil on its kinematic viscosity.

v. Pour point

The higher pour point of used lubricating oil is cause by the degradation of additives. The result obtains as shown in figure 5 shows that the re-refined oil still possesses good pour point that can still be re-used, because pour point is important when considering oil under a cold weather or condition. From the figure below, it shows the results for pour point of fresh and used lubricating oils are -8 and -34 respectively, while those treated oils obtained by the acid treatments were -13 for treating with nitric acid, -10.5 for Sulphuric acid treatment, and -16 for hydrochloric acid treatment.

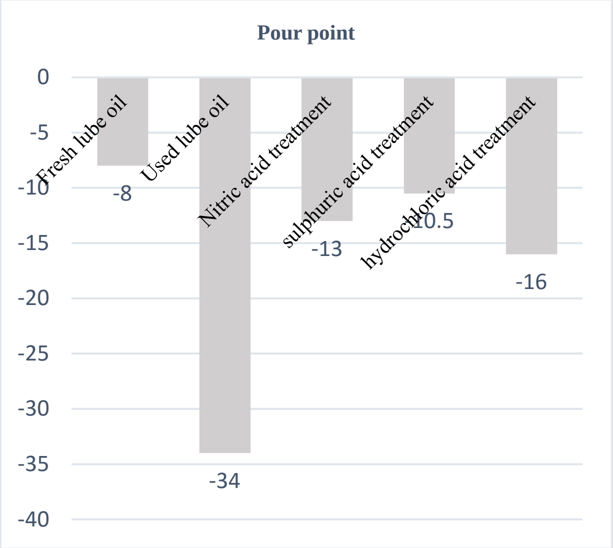

Fig. 5: Effect of refining of used lube oil on its pour point.

From the results obtained for the used oil, pour point for the used lube oil is high. This is since of the degradation of additive in the lubricating oil. Pour point especially is of interest when an oil must be under relatively cold condition. Pour point will vary widely depending on the base, the source of the lube oil and the method of refining, especially if dewaxing has been done (Firas and Dumitru, 2006; Chevron Lubricating oil FM ISO 100). Here, these recovery methods proved alright when compared with that of fresh lube oil.

vi. Cloud point

When the lubricating oil is cooled slowly, the temperature at which it turns cloudy, is called its cloud point; while the temperature at which the lubricant oil cease to flow or pour, is called its pour point. Cloud and pour points indicate the suitability of lubricant oil in cold conditions. Lubricant oil used in a working environment at low temperatures should possess low pour point, otherwise solidification of lubricating oil could cause jamming of machine or engine. The presence of waxes in the lubricating oil could increase pour point. From the figure 6 shows the results for pour point of fresh and used lubricating oils are -13.5 and -37 respectively, while those treated oils obtained by the acid treatments were -17.5 for treating with nitric acid, -15 for Sulphuric acid treatment, and -19.5 for hydrochloric acid treatment. From the results obtained, pour point for the lubricating oil that treated with acid is lower as compared to the used lubricating oil however slightly higher as compare to fresh lubricating oil. The higher of used lubricating oil is due to the degradation of additive in the lube oil. However, the decrease in cloud point for the acid that treated with acid shows the lubricating oil is almost back to its quality and the amount of degradation of additives that present in the used lubricating oil is reduce.

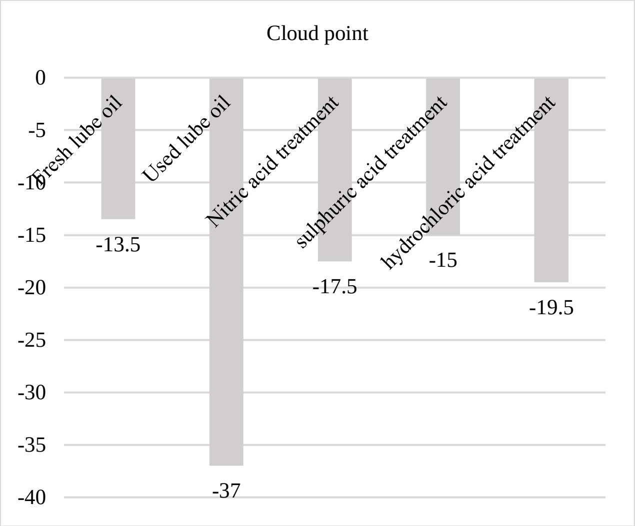

Fig. 6: Effect of refining of used lube oil on cloud point

vii. Ash content

The sulphated ash can be used to indicate the concentration of known metal-containing additives. When phosphorus is absent, barium, calcium, magnesium, sodium and potassium are converted to their sulphates and tin (stannic) and zinc to their oxides. Sulphur and chlorine do not interfere, but when phosphorus is present with metals, it remains partially or wholly in the sulphated ash as metal phosphates. In other hand, the increase in the percentage of sulphated ash is due to the present of contaminant and the degradation of additives. These additives typically contain one or more of the following metals: barium, calcium, magnesium, zinc, potassium, sodium, and tin. The elements sulphur, phosphorus, and chlorine can also be present in combined form. From the figure below, it shows the results for ash content of fresh and used lubricating oils are 0.12% and 2.3% respectively, while those treated oils obtained by the acid treatments were 0.32% for treating with nitric acid, 0.26% for Sulphuric acid treatment, and 0.41% for hydrochloric acid treatment. It has been considerably decreased as compared to the used lubricating oil sample (2. 3%).all the treated lubricating oil is within the range even though it slightly differs from the fresh lubricating oil.

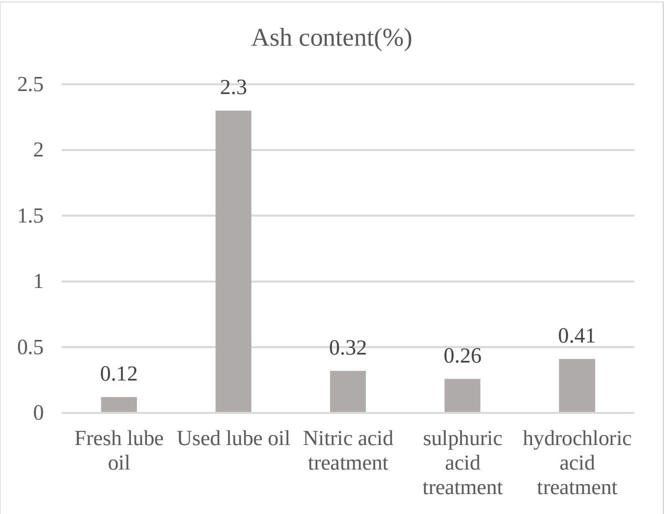

Fig. 7: Effect of refining of used lube oil on ash content.

3.1 Characteristics of Used and re-refined lubricating oils: the effect of various concentration of sulphuric acid

Table 4: analysis of result for acids treatment by various concentration of sulphuric acid

	Used lubricating oil	Fresh lube oil	Treatment with 10% Sulphuric acid	Treatment with 15% Sulphuric acid	Treatment with 20% Sulphuric acid	Standard range
Colour	black	Light yellow	yellow	yellow	Light yellow	-
Specific gravity [g/cm3]	0.92	0.89	0.88	0.87	0.87	0.86-0.98
Kinematic viscosity [Mm2/s]	61.6034	76.6616	73.9876	74.0331	74.5667	-
Dynamic viscosity [mPa.s]	56.6751	68.2288	65.1090	63.6685	64.8730	-
Cloud point [°C]	-34	-8	-11.5	-11	-10	-
Pour point[°C]	-37	-13.5	-16	-17	-15	-
Ash content [%]	2.3	0.12	0.32	0.31	0.21	<1.0 %

viii. Colour

The colour of lubricating oils can range from transparent to opaque. A change in oil colour signifies a change in the chemistry of the oil or the presence of contaminants. For example, oil oxidation, mixing two dissimilar types of oil, and carbon insoluble from thermal failure can all darken oil. There is also a possibility that the oil darkening is due to a photochemical reaction from sunlight exposure.

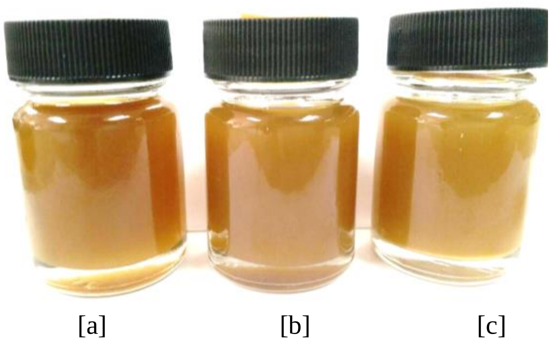

Fig. 8: Effect of refining of used lubricating oil by different concentration of sulphuric acid on its colour.

Figure 8 shows the results for the used lubricating oil that treated with various sulphuric acid concentration. Which from the left: [a] is lubricating oil that treated with 10% of sulphuric acid, [b] is the lubricating oil that treated with 15% of sulphuric acid and [c] is lubricating oil that treated with 20% of sulphuric acid. The different colour is influence by chemical composition and contaminant that may present in the lubricating oil, the darker the colour, the higher the contaminant insides the lubricating oil. From the result presented, the colour for the lubricating oil that treated with 20 % of sulphuric acid is light yellow which the lightest as compare to lubricating oil that treated with 10% of sulphuric acid and 15% of sulphuric acid. This show the higher the concentration of acid, the higher the contaminant can be eliminated.

ix. Specific Gravity

Specific gravity is the proportion of the density of the material to density of the equal volume of water. The temperature at which the density has been measured is essential as the density changes with temperature.

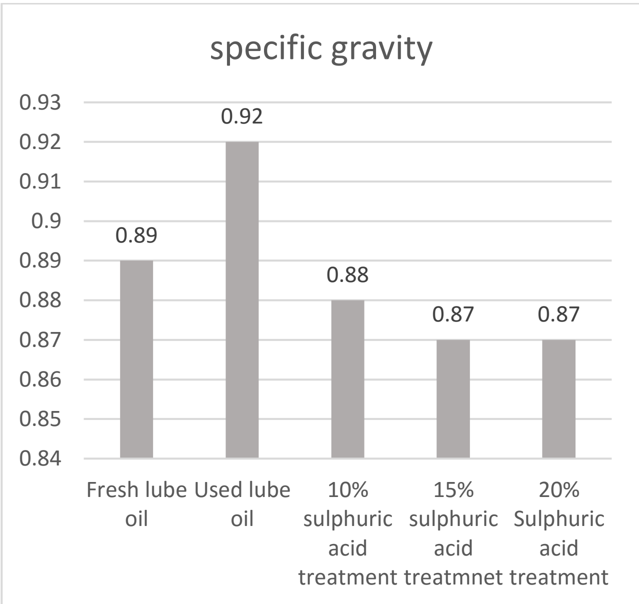

Fig. 9: Effect of refining of used lubricating oil by different concentration of sulphuric acid on its specific gravity.

From the result presented in figure 9 the specific gravity for the used lubricating oil that treated with various sulphuric concentration is nearly like the fresh lubricating oil. From the result obtain, the specific gravity for lubricating oil that treated with sulphuric acid is lower compare to used lubricating oil. The specific gravity of contaminated oil may perhaps be higher or lower dependent on the type of contamination (Chevron lubricating oil FM ISO 100). Besides, specific gravity is influenced by the chemical composition of the lubricating oil. The higher the number of aromatic compounds present in the lubricating oil will rise the specific gravity, whereas an increase in the saturated compounds results in a decrease in the specific gravity. Used lubricating oils specific gravity increases with the presence of collective amounts of solids in the used lubricating oil. From the result presented, the lubricating oil that treated with 10% of sulphuric acid is better than the lubricating oil that treated with 15% of Sulphuric acid and 20% of sulphuric acid. This showed that the lubricating oil that treated with 10% sulphuric acid content less saturated compound as compare to other concentration of sulphuric acid.

x. Dynamic viscosity

Viscosity rise might occur as oxidation or contamination present with insoluble matter, from the result obtained, the decrease in dynamic viscosity of the used oil this is due to contamination in form of slush in the used lubricating oil. In general, lubricating oil is considered unsuitable for the usage, if the original viscosity increases or decreases to the next SAE number. Viscosity increase can happen because of oxidation or contamination (Scapin, 2007). Viscosity decrease can occur due to dilution with light fuel. From the Figure 10 shows the results for dynamic viscosity of fresh and used lubricating oils are 68.2288 and 56.6751 respectively, while those treated lubricating oils obtained by various concentration of sulphuric acid were 65.1090 for treating with 10% sulphuric acid,64.4087 for 15% Sulphuric acid treatment, and 64.8730 for 20% sulphuric acid treatment. It shows that the dynamic viscosity of the used lubricating oil is higher than the refined one. The result of the viscosity test shows that, the used lubricating oil has lost most of its viscosity due to contamination. However, treatment has restored most of its viscosity.

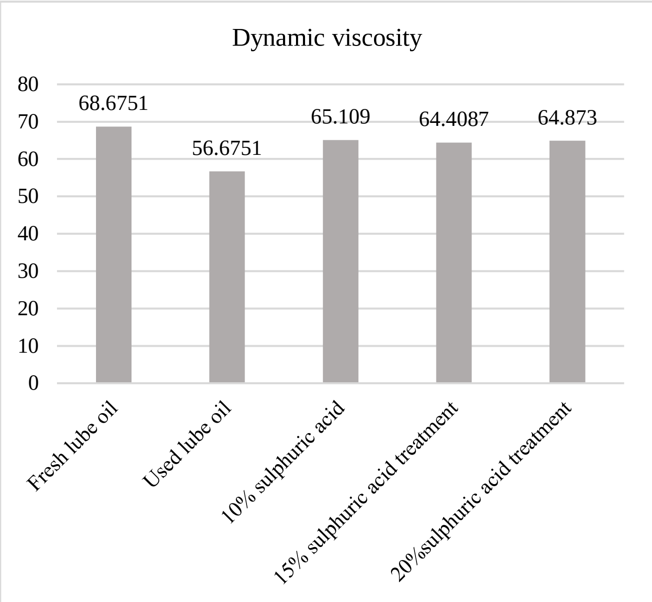

Fig. 10: Effect of refining of used lubricating oil by different concentration of sulphuric acid on its dynamic viscosity.

However, by treated the used lubricating oil with acids has restored most of its viscosity. The result shows also that refining using 10% Sulphuric acid treatment gave the highest viscosity. This can be attributed to the possible conversion of possible contaminants by the acid from the lubricating oil. In view of the attraction of the lubricating oil to act as a coolant or heat transfer medium, it must be able to retain adequate body at elevated film temperature, up till now suitable fluidity elsewhere in the system. This is ensured when the viscosity is above 60. Oil that treated with different type of concentration acids meet this specification, but the concentration at 10%Sulphuric acid has an advantage over others since it is the nearest to the pure fresh lubricating oil.

xi. Kinematic viscosity

From the Figure 11, it shows the results for kinematic viscosity of fresh and used lubricating oils are 76.6616 and 61.6034 respectively, while those treated lubricating oils obtained by various concentration of sulphuric acid were 70.9876 for treating with 10% sulphuric acid,74.0331 for 15% Sulphuric acid treatment, and 74.5667 for 20% sulphuric acid treatment. Figure 11 shows a decrease in kinematic viscosity of the used lubricating oil, this is due to contamination in the form of sludge in the used oil. Viscosity increase can occur due to oxidation or contamination Viscosity decrease can be caused by dilution with light fuel. The result of the viscosity test shows that, the used lube oil has lost most of its viscosity due to contamination. However, treatment with various of acid concentration has restored most of its viscosity. The result shows also that refining using 20% of Sulphuric acid concentration gave the highest viscosity followed by 15% concentration and 10% concentration. This can be attributed to the possible conversion of possible contaminants by the acid and removal by the filtration from the lubricating oil.

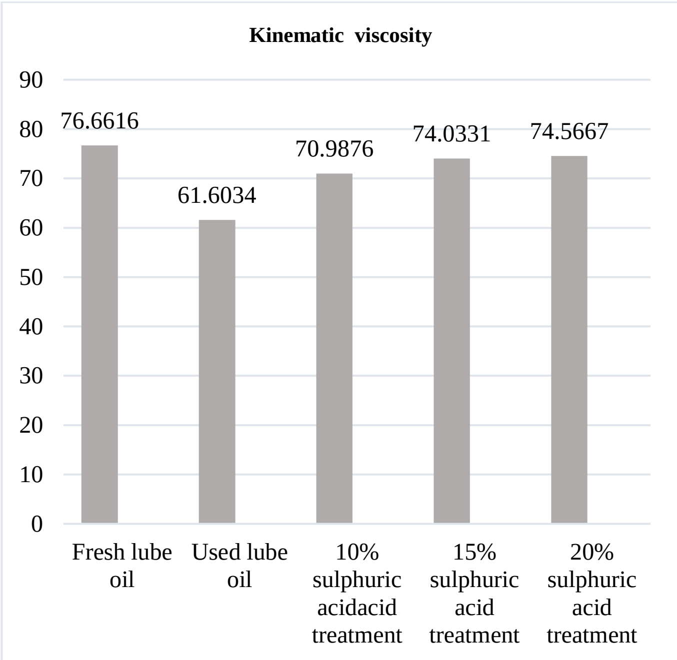

Fig. 11: Effect of refining of used lubricating oil by different concentration of sulphuric acid on its kinematic viscosity.

xii. Pour point

The higher pour point of used lubricating oil is cause by the degradation of additives. The result obtains as shown in figure 12 shows that the re-refined oil still possesses good pour point that can still be re-used, because pour point is important when considering oil under a cold weather or condition. From the figure 12 shows the results for pour point of fresh and used lubricating oils are -8 and -34 respectively, while those treated oils obtained by the acid treatments were -13 for treating with nitric acid, -10.5 for Sulphuric acid treatment, and -16 for hydrochloric acid treatment. From the results obtained for the used oil, pour point for the used lube oil is high. This is since of the degradation of additive in the lube oil. Pour point especially is of interest when an oil must be under relatively cold condition. Pour point will vary widely depending on the base, the source of the lube oil and the method of refining, especially if dewaxing has been done (Firas and Dumitru, 2006; Chevron Lubricating oil FM ISO 100).

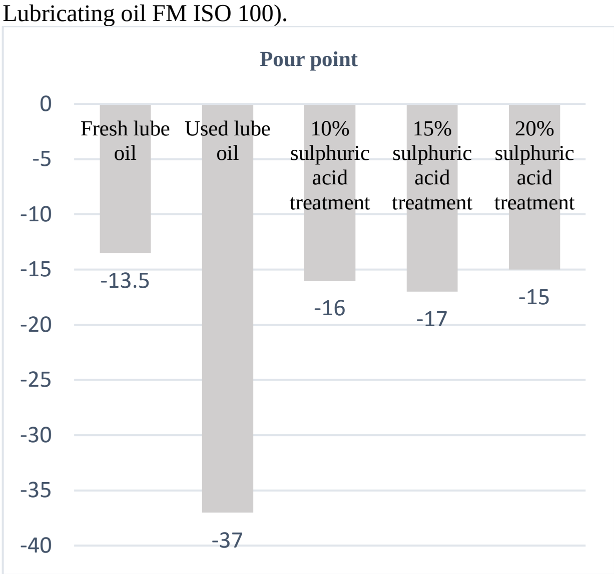

Fig. 12: Effect of refining of used lubricating oil by different concentration of sulphuric acid on its pour point.

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xiii. Cloud point

When the lubricating oil is cooled slowly, the temperature it turns cloudy, is called its cloud point. Cloud and pour points indicate the suitability of lubricant oil in cold conditions. Lubricant oil used in a working environment at low temperatures should possess low pour point; otherwise solidification of lubricating oil could cause jamming of machine or engine. The presence of waxes in the lubricating oil could increase pour point.

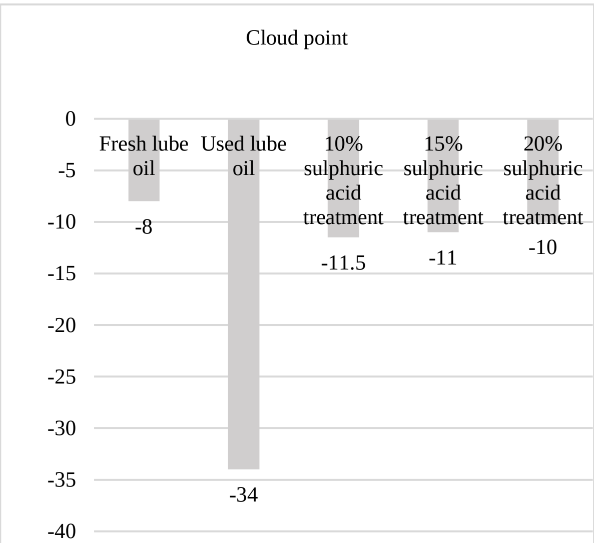

Fig. 13: Effect of refining of used lube oil by different concentration of sulphuric acid on cloud point

From the figure 13 shows the results for pour point of fresh and used lubricating oils are -8 and -34 respectively, while those treated lubricating oils obtained by various concentration of sulphuric acid were -11.5 for treating with 10% sulphuric acid, -11 for 20% Sulphuric acid treatment, and -10 for 20% sulphuric acid treatment. From the results obtained, pour point for the lubricating oil that treated with various sulphuric acid concentration is lower as compared to the used lubricating oil however slightly higher as compare to fresh lubricating oil. The higher of used lubricating oil is due to the degradation of additive in the lubricating oil. However, the decrease in cloud point for the acid that treated with acid shows the lubricating oil is almost back to its quality and the amount of degradation of additives that present in the used lubricating oil is reduce.

xiv. Ash content

The sulphated ash can be used to indicate the concentration of known metal-containing additives. When phosphorus is absent, barium, calcium, magnesium, sodium and potassium are converted to their sulphates and tin (stannic) and zinc to their oxides. Sulphur and chlorine do not interfere, but when phosphorus is present with metals, it remains partially or wholly in the sulphated ash as metal phosphates. In other hand, the increase in the percentage of sulphated ash is due to the present of contaminant and the degradation of additives. These additives typically contain one or more of the following metals: barium, calcium, magnesium, zinc, potassium, sodium, and tin. The elements sulphur, phosphorus, and chlorine can also be present in combined form. From the figure below, it shows the results for ash content of fresh and used lubricating oils are 0.12% and 2.3% respectively, those treated lubricating oils obtained by various concentration of sulphuric acid were 0.26% for treating with 10% sulphuric acid,0.24% for 15% Sulphuric acid treatment, and 0.21% for 20% sulphuric acid treatment. All the treated lubricating oil is within the range even though it slightly differs from the fresh lubricating oil and the lubricating oil that treated with 20% sulphuric acid shows the lowest which less contaminant

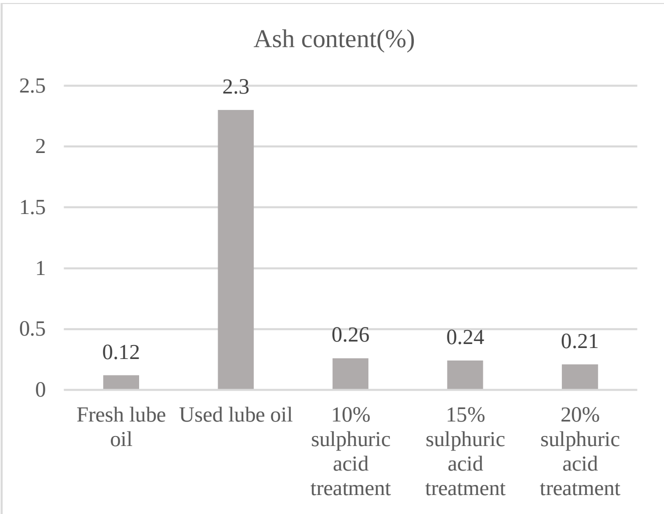

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Fig. 14: Effect of refining of used lube oil by different concentration of sulphuric acid on ash content.

IV. Conclusion

From the result presented, it proves that the three acids use effectively activated and remove the slug from the used lubricating oil and return the oil to it quality form. The result from the analysis showed that the kinematic viscosity for used lubricating oil is increase from 61.6034 for used lubricating oil to 70.3862 for Nitric acid treatment,73.9876 for sulphuric acid treatment and 70.6906 with for hydrochloric acid. The specific gravity decreases from 0.92 for used lubricating oil to 0.86 for nitric acid treatment,0.88 for sulphuric acid treatment and 0.84 with hydrochloric acid treatment. Other result from different analysis showed that the improvement and the best result is lubricating oil that treated with sulphuric acid which nearly like fresh lubricating oil. For different acid concentration, the lubricating oil that treated with 20% of sulphuric acid shows the best result in reduce contaminant within the used lubricating oil. This would reduce the degree and nature of contamination, environmental/health risks associated with disposal.

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