COMPARATIVE ANALYSIS OF BIO PRODUCTS OF PALM OIL AND FOSSIL FUEL AS LUBRICANTS

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Abstract— The advancement of research in search of lubrication oil from the renewable energy sources in replacement of fossil fuel products for the use of mechanical equipment is the only way to secure our environment from the continuous attack of the environment from crude oil by-products.This paper investigates the numerous potentials of palm oil as a substitute to fossil fuel lubricants. Experimental analysis and investigation of fossil fuel by-product (SAE40) palm oil revealed that the tribological properties of palm oil are considerably better in performance compared to SAE40 lubricant.The viscosity and density results of the palm oil and SAE40 lubricant obtained from the experimentation are (45.4, 46.1 and 46.5)m^2/s, (898, 896 and 898)kgm^{-3} and (44.78, 44.42 and 44.8)m^2/s, (848, 850 and 847)kgm^{-3} respectively for three successive experimentation conducted consecutively. Other results obtained also proved the effectiveness of palm oil when used as alternative lubricant. Although, the boiling point results for the palm oil (208.6, 206.7 and 210)℃and SAE40(320, 315 and 318)℃ shows that palm oil lubricant is liable to vapourise at a little rise in temperature,this could be overcome with the addition of additives.

Index Terms— Boiling Point, Density, Fossil Fuel, Iodine number, Lubricant, Palm oil, Peroxide Value, SAE40, Viscosity.

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1 Introduction

Over the years the use of fossil fuel for energy generation has continuously led to the degrading state of our environment. This has resulted to the depletion of the ozone layer causing series of infections, emission of greenhouse gases, carbon-dioxide, oxides of nitrates, soot, and other toxic and powerful pollutants. As a result of these effects research for alternative means of energy generation has taken a lead for the substitution of the use of fossil fuel in our machineries. Hence, the possible use of bio-fuel for sustainable energy production is one focal consideration by scholars [1], [2].

Therefore, in this present research one area of interest is the bio-fuel generation viapalm oil as the raw material index. Palm oil is an edible vegetable oil produced from the mesocarp (reddish pulp) of the fruit of oil palms also known as Elaeisguineensis. It is commonly used for cooking, productionof methyl ester and hydro-deoxygenated bio-diesel. Palm oil methyl ester is created through a process called trans-esterification, whereas the palm oil bio-diesel is often blended with other fuels to create palm oil bio-diesel blends. Conversely, it is reported that the world largest palm oil bio-diesel plant is the Finish-Operated Nest oil bio-diesel plant in Singapore, which produces hydro-deoxygenated bio-diesel [3]. Consequently, during the industrial revolution, West Africa countries like Nigeria and Ghana were the most palm-oil exporting countries were palm oil was used as an industrial lubricant for machinery; however, reverse is the case.

In respect to this, report confirms that the top largest producers and manufacturers of palm oil product in the world are Indonesia with 36-million metric tonnes, followed by Malaysia with 21-million metric tonnes. Others leading countries are Thailand and Colombia with 2.2-million metric tonnes and 1.32-million metric tonnes respectively. Meanwhile, the top two leading countries with the high profile of palm oil production have it as source of sustaining their economy [4], [5].

The adverse effects introduced to the environment by the conventional mineral lubricants can never be over emphasized.This has called for research to stop this ugly trend of occurrence. It is revealed in scholarly research that adoption of appropriate chemical modifications and incorporation of suitable nano-additives, willenhance the properties of bio-lubricants derived from palm oil [6]. This report aligns with

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an investigative study on the usage of palm oil as a lubricant in compression ignition (CI) engines. It attests that the formulated blends of palm oil show similar properties of SAE 20W40; though with a highly reduced level of emissionsto the environment [7], [8], [9]. The use of palm oil as substitute to fossil fuel-based lubricants indicated poor performance as a result of changes in their physical and chemical properties due to oxidation when working at high temperatures and pressure. Meanwhile, oxygen bond in palm oil has the capacity of reducing the structure of a metal [10], [11]. Similarly, it also suffers major drawbacks in terms of thermal stability and weakness in viscosity. Thiswill constraint the application of palm oil as anengine oil because in a reviewed literature, it reveals that a small change in viscosity is desirable to provide wide range ofoperating temperatures over which a given oilwill provide satisfactory lubrication [12].

However, as a result of cost of acquiring the synthetic or mineral oil as lubricants, most researchers in their findings preferred the adaptation of palm oil as an alternative lubricant though subject to improvement [13]. Therefore, based on the adequate means of improving the palm oil as lubricant in substituting its fossil fuel counterpart; it is necessary to carry out analytical study of bio-products of palm oil and fossil fuel which forms the baseline of the current research.

2. EXPERIMENTAL ANALYSIS

A chemical experimentation of the palm oil and a sampled fossil fuel lubricant (SAE40) of the same volume and temperature was carried out in the chemical laboratory of Niger Delta University. The target of this practical analysis is to determine the iodine number, peroxide value, saponification number, andviscosity of both fluids. Thus, at the commencement of the test; samples of both substances as shown in figures 1 and 2 respectively are weighed in a weighing pan.

Figure 1: SAE40 Heavy Duty Engine Oil on a weighing pan

Figure 2: Palm Oil solution on a weighing pan

Meanwhile, 10ml of Weizmann-1 sample was added to a weighed proportion of both fluids and kept for specified time duration in a dark room, allowing halogenation to take place. The process continuous with the addition of 10ml of saturated KCl solution with titration against the test solutions which eventually turns pale-yellow. For further titration to turn the solutions to colourless, five (5) drops of starch indictor were added.

However, experimenting for the peroxide value, samples were evaluated in a pressured porcelain evaporating dish used for turning the solvent and were placed into a hot air-drying oven as shown in figure 3 and 4. The oven was regulated toa temperature of 110℃ to allow samples heat up. At this point, frothing was noticed accompanied with crackling due to the moisture present in the samples. Corresponding reading were recorded after allowing the fuming steam to stop.

Figure 3: Porcelain flask used for turning solvent

Figure 4: A dry woven

Similarly, saponification test and the viscosities of the sampled fluids were carried out. Thus, with the help of a centrifugal stirring machine shown in figure 5, an Oswald type viscometer was used to obtain values of the sample viscosities.

Figure 5: Centrifuge Machine for stirring samples

3. RESULT PRESENTATION AND DISCUSSION

The acceptability of any lubricant for machinery purpose is mostly based on its tribological properties. Thus, these properties ensure the prevention of wearing when two moving metal parts come in contact with each other.Hence, results presented for the cause of this study is on the viscosity, density, peroxide value, saponification number, iodine number, boiling point and other vital properties of both palm oil and the considered product of fossil fuel (SAE40). This has become so imperative because the provision of better performinglubricants for specific applications is the major concern of a tribological scholar. Hence, Table 1 is presentation of practical results of palm oil and SAE40 after three successiveexperimentation conducted consecutively.

Table 1: Properties of Palm Oil and SAE 40 Engine Oil @ 110℃

Properties	*Units*	*Number of Experimental Readings*	*Palm Oil*	*SAE 40 Engine Oil*
Viscosity	*m^2/s*	*1st Readings*	*45.4*	*44.78*
		2nd Readings	*46.1*	*45.42*
		3rd Readings	*46.5*	*44.8*
Density	*Kg/m^3*	*1st Readings*	*898*	*848*
		2nd Readings	*896*	*850*
		3rd Readings	*898*	*847*
Iodine Number	*g*	*1st Readings*	*48.2*	*78.48*
		2nd Readings	*49.48*	*76.78*
		3rd Readings	*47.54*	*77.85*
Saponifiable Matter	*mg*	*1st Readings*	*198.5*	*246*
		2nd Readings	*196.88*	*250*
		3rd Readings	*197.67*	*248*
Boiling Point	*°C*	*1st Readings*	*208.6*	*320*
		2nd Readings	*206.7*	*315*
		3rd Readings	*210*	*318*
Free Fatty Acid	*%*	*1st Readings*	*9.8*	*3.8*
		2nd Readings	*9.78*	*3.76*
		3rd Readings	*9.84*	*3.84*
Peroxide Value	*mol/kg*	*1st Readings*	*0.7*	*1.9*
		2nd Readings	*0.68*	*1.94*
		3rd Readings	*0.71*	*1.92*

In any oil lubrication system, the viscosity of the oil can never be over emphasized because it is considered as the most important parameter. Therefore, it is recommended that the viscosity of an oil for machine parts application should meet the standard requirements. Thus, the main function of a lubrication oil is to create and maintain a lubricating film between two moving metal surfaces and this function is very much dependent on the viscosity of the oil itself.However, it is a known fact that the change in viscosity of a lubricant affects the heat generation in the bearings, cylinders and gear sets due to oil internal friction. This defines the measure of lube oil's resistance to its flow. It usually decreases with an increase in temperature and vice visa. Conversely, established results shows that from all three-test analysis in terms of viscosity, the palm oil values(45.4, 46.1 and 46.5)m^2/s are greater than the SAE40 with corresponding values of (44.78, 44.42 and 44.8)m^2/s respectively. This attests that the palm oil is more viscous than the SAE40. Thus, it explains that the load carrying capacity of the SAE40 is slightly less than the palm oil. This gives more advantage to the palm oil as a better lubricant as compared to SAE40 since one primary function of a lubricant is its load carrying capacity. It equallydemonstrates that palm oil has more molecules with greater cohesion ability. Hence, the application of palm oil as lubricant on machine part will help reduce friction, surface fatigue, heat, noise and vibrations because the palm oil will provide betterformation of physical barrier between moving parts and surfaces than the fossil fuel SAE40.

Similarly, the density of the samples performed in the experiments for the palm oil and SAE40 are (898, 896 and 898)kgm^{-3} and (848, 850 and 847)kgm^{-3} respectively. Density is also recognized as akey property, not only in lubricants but in all fluids, as the measure of the mass of a substance in relation to a known volume, though this varies according to the temperature of the fluid. In a general note, lubricants are less dense than water (1000kgm^{-3}). This is a clear confirmation of accuracy in test results of density of the lubricants considered for the study. However, the obtained densities of the palm oil from the experimentation are bigger than that of the SAE40. Thus, the increment on the densities of the palm oil is as a result of its thickness or content of more viscosity. This implies that viscosity is a function of density.

On a contrary view, results obtained for the boiling points of the lubricants are (208.6, 206.7 and 210)°C and (320, 315 and 318)°C for palm oil and SAE40 respectively. This indicates that the palm oil lubricant will boil so quickly and loose its quality from liquid to vapour, apparently disqualifying it from having good performance characteristics. Although, results obtained from free fatty acid indicates higher values in favour of the palm oil showing (9.8, 9.78 and 9.84)% against (3.8, 3.76 and 3.84)%. This justifies the concept that addition of free fatty acid is to improve and increase the lubrication performance of palm oil at elevated temperatures. However, the evaluation of the iodine number is to determine the amount of unsaturation present in the fatty acids.Thus, this unsaturation is in the form of double bonds reaction with iodine compounds, which increases the double bonds with a higher value of iodine number. Meanwhile, obtained values of iodine number of the palm oil and SAE40 are (48.2, 49.48 and 47.54)g and (78.48, 76.78 and 77.85)g.

On the other hand, the peroxidation values obtained from the study shows low values for palm oil with approximately 0.7mol/kg for all three readings against 1.9mol/kg for the SAE40. This result shows acceptability for palm oil as lubricant to the SAE40 simply because the peroxides play a central role in lube oil degradation. It has been discovered and proved that lubricants with highvalues of peroxides are under the threat of peroxidation degradation, also known as autooxidation influenced by atmospheric oxygen which brought about by radical chain reactions of organic peroxides. Likewise, results obtained with respect to saponification values are (198.5, 196.88 and 197.67)mg and (246, 250 and 248)mg for palm oil and SAE40 respectively. This helps in saponifying the unwanted impurities and contaminations present in the lubricant.

4. CONCLUSION

Based on the findings from the experimental investigative study the following conclusions are made:-

- The palm oil provides more potentials for the successful utilization as bases for lubrication oil.
- Lubricants from the oil palm are more economical and cost friendly since it can be generated massively.
- It is also environmentally friendly, little or no harm to cause dangerous emissions to the atmosphere.
- Finally, with respect to its low boiling temperature, further research is suggested to be carried out, mostly on the addition of additives to palm oil as an alternative source of lubrication oil.

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