Journal of Multidisciplinary Engineering Science and Technology (JMEST)
ISSN: 3159-0040
Vol. 3 Issue 2, February - 2016

Investigation into the use of some locally available Vegetable Oil as Damping Fluid

Awogbemi, O[1], Adebayo, A[2] and Olanipekun, K.A[3]
Mechanical Engineering Department,
Ekiti State University, Ado Ekiti, Nigeria.
[1]omojola.awogbemi@eksu.edu.ng, [2]adeyinka.adebayo@eksu.edu.ng, [3]kolade.olanipekun@eksu.edu.ng

***Abstract*—This paper reports the systematic study which examines the use of some locally available vegetable oils as damping fluids. Four locally available vegetable oils, namely, Palm oil, Coconut oil, Palm Kernel oil, and Groundnut oil, were investigated and their properties compared with Total oil (SAE 40), an imported Mineral Based Oil. The Pour point, Kinematic Viscosity, Flash point, Vapour pressure, Calorific value, and Density of these oil samples were determined. The oil samples were also subjected to free vibration on a TM16 universal vibration apparatus to determine the coefficient of damping. The results of the investigation revealed that that the density of Palm Oil, Palm Kernel Oil, Coconut Oil, Groundnut Oil, and the Mineral Based Oil were 891.2kg/l, 892.5kg/l, 892.1kg/l, 890.2kg/l, and 886.2kg/l respectively. Also the Damping Coefficient were 10.4 N/ms^{-1}, 2.35 N/ms^{-1}, 4.32 N/ms^{-1}, 6.04 N/ms^{-1}, and 8.57 N/ms^{-1} for Palm Oil, Palm Kernel Oil, Coconut Oil, Groundnut Oil, and the Mineral Based Oil respectively. The research concluded that with adequate blending, use of additives, antioxidants, and pour point depressants, these vegetable oils can be used as damping fluid under different conditions, ranging from cryogenic, room and at elevated temperatures.**

Keywords—Damping, Damping coefficient, Fluid, Vegetable oil, Vibration.

I. INTRODUCTION

Mineral Based Oils (MBO) are often used as damping fluids the world over. The limitations of availability and cost make the desire to find alternatives for them a strong desire. as damping fluids. Using vegetable oils as damping fluid can safe developing countries like Nigeria the very scarce foreign exchange they use to import these Mineral Based Oils. Nigeria currently loose huge foreign exchange in the importation of so many goods, materials, spares parts, products, and services that are readily locally. This has negatively affects the country foreign exchange reserve and the value of her currency, the naira, in the international market. For Nigeria to make appreciable progress in her journey towards industrial revolution, she should look inwards and make use of some of her locally made product. Some of these products are the vegetable oils.

Vegetable oil is a triglyceride extracted from a plant. They are usually liquid at room temperature and can be used as fuels, pet food additive, industrial raw materials, hydrogenated oils, and for culinary uses [1]. There are numerous vegetable oils derived from various sources. These include the popular oil oilseed oils- soybeans, cottonseed, peanuts, sunflower oil, palm oil, palm kernel oil, coconut oil, castor oil, rapeseed oils, etc. they also include the less commonly known oil such as rice bran oil, tiger nut oil, patua oil, kome oil, niger seed oil, and piririma oil. These oils are of different composition and by extension their physical and chemical properties determine their usefulness in various applications apart from the edible use [2, 3].

Although vegetable oils generally have weak resistance against oxidative and hydrolytic degradation, and also poor fluidity at low temperatures, these deficiencies can be taken care of through chemical and genetic modifications, use of antioxidants, pour point depressants, etc. Blending and the use of additives can also improve their properties and enhance their usability and service requirements [4, 5, 6].

Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. In physical systems, damping is produced by processes that dissipate the energy stored in the oscillation. Examples include viscous drag in mechanical systems, resistance in electronic oscillators, and absorption and scattering of light in optical oscillators. Damping not based on energy loss can be important in other oscillating systems such as those that occur in biological systems. Various types of damping are identified. A system that returns to equilibrium without oscillating is set to be over-damped, while a system that returns to equilibrium s quickly as possible without oscillating is said to be critically damped. an undamped system oscillates at its natural resonant frequency but an under-damped system oscillates with the amplitude gradually decreasing to zero. An under-damped system usually oscillates at a reduced frequency compared to undamped system [7].

Researches have been conducted to find other applications for vegetable oils apart from as food, soap, cosmetic and biofuel applications. Abere et al (2014) investigated into the use of vegetable oils as industrial fluid-Automatic Transmission Fluid and reported that some properties of coconut oil, soya beans oil, groundnut oil, and palm oil are within the rage of those prescribed for Automatic Transmission Fluid, and can therefore be used as such [3].

Also Binfa , et al 2015 also tested groundnut oil, soybean oil, coconut oil, and palm kernel oils and found them suitable as base oil for Automatic Shock Absorber Fluids. Linseed oil, a vegetable oil, was found to be very effective for both free and forced vibration damping [4]. It was discovered that the mechanical properties of linseed oil based elastomer were comparable to the commonly used viscoelastic materials such as butyl rubber, nitrile rubber, and silicon rubber for vibration damping applications, and can therefore be used as vibration dampers [8].

This research is to investigate the possibilities of using vegetable oils, namely Palm Oil (PO), Palm Kernel Oil (PKO), Groundnut Oil (GNO), and Coconut Oil (CCO), as damping fluid the results are compared with that obtained with a Mineral Based Oil (MBO).

II. MATERIALS AND METHODS

Sample Description and Selection

Five oil samples were used for this research, namely Palm Oil, Coconut Oil, Palm Kernel Oil, Ground Nut Oil, and the Mineral Based Oil i.e Total Oil (SAE 40). The five oil samples were kept in a clean air-tight plastic container to prevent contamination and at room temperature.

i. Palm Oil

Palm oil is an edible vegetable oil derived from the mesocarp (reddish pulp) of the fruit of the oil palms, primarily the African oil palm, *Elaeis guineenis,*and to a lesser extent from the American oil palm, *Elaeis oleifera,* and the maripa palm, *Attalea maripa.*Palm oil is naturally reddish in colour because of a high beta-carotene content. Palm oil is used as cooking oil, for soap production, and as industrial lubricants for machinery during Britain's industrial revolution. Palm oil is also used to produce both methyl ester and hydrodeoxygenated biodiesel. As of 2011, Nigeria was the third largest producer of palm oil with approximately 2.3 million hectares under cultivation [9]. The sample was bought at the Iworoko Market, Near Ado Ekiti, Nigeria on 6^{th} July, 2015.

ii. Palm Kernel Oil

Palm Kernel Oil is an edible plant oil derived from the kernel of the oil palm, *Elaeis guineesis.* It is semi-solid at room temperature and is commonly used in commercial cooking. It is packed with mystic and lauric fatty acids and therefore suitable for the manufacture of soaps, washing powders and personal care products [10]. Palm Kernel oil is also used as antudotes for poisoning and as surface protectants for minor wounds [11]. The sample was bought at the Iworoko Market, Near Ado Ekiti, Nigeria on 6^{th} July, 2015.

iii. Coconut Oil

Coconut oil is an edible oil extracted from the kernel or meat of mature coconuts harvested from the coconut palm (coconut nucifera). It has various applications as food and in cosmetics. Because of its high saturated fat contents, it is slow to oxidize, and thus, resistant to rancidification, lasting up to six months at $24^{o}C$ without spoiling. Coconut oil is commonly used in cooking, especially for frying, manufacture of soap, as a skin moisturizer, and has been tested for use as a feedstock for biodiesel to use as a diesel engine fuel. It has also been tested for use as an engine lubricant and as a transformer oil [12]. The Coconut oil sample was purchased at the Iworoko Market, Near Ado Ekiti, Nigeria on 6^{th} July, 2015.

iv. Groundnut Oil

Ground nut Oil is a mild-tasting vegetable oil derived from peanuts. It is often used both for general cooking, and in the case of roasted oil, for added flavor. It can be used to make soap by the process of saponification, and as a massage oil. One of the earliest demonstrations of biodiesel technology made use of coconut oil, thus confirming its use as a fuel [13]. The Groundnut oil sample was purchased at the Iworoko Market, Near Ado Ekiti, Nigeria on 6^{th} July, 2015.

v. Mineral Based Oil

Mineral based oil is a liquid by-product of refining crude oil to make gasoline and other petroleum products. Mineral oil is used in a variety of industrial/mechanical capacities as a non-conductive coolant or thermal fluid in electric components as it does not conduct electricity, while simultaneously functioning to displace air and water. It is used as ingredient in baby lotions, cold cream, ointments and cosmetics. It is also used in livestock vaccines, as a lubricant in enema preparations, and as an anti-rust agent for blades, among other uses [14]. Total Oil (SAE40), a mineral based oil, was used for this research and was obtained from the Total filling station in Ado Ekiti, Nigeria on 12^{th} July, 2015.

Analysis of Samples

The five samples were analyzed at the Multi Environmental Management Consultant Limited, Lagos, Nigeria to determine their Density, Specific weight, Calorific value, Flash point, Pour point, Vapour pressure, and Viscosity.

i. Determination of Flash point

The sample was dried in the laboratory on the bench to remove the trace of the water moisture in the sample. The dried sample was poured into the cup of the tester to the mark and it was followed by the replacement of the cup and the cup cover with the left hand pointing toward the left front corner of the test unit. Stirrer driver was fitted into the tester properly and it was followed by the connection of the resistance thermometer probe. Flame and the pilot light were carried out by lighting and the draught screen was closed.

The tester was put on and the heater temperature was regulated and switch for the stirrer was on simultaneously with the tester homogeneity. The flash occurs when a large flame was observed on the cup and the temperature at which this occurs was recorded as the flash point for the oil sample.

The fire point was observed temperature at which the oil combustion was sustained after the flash point of the sample was recorded. The temperature was recorded for the fire point for the sample.

ii. Determination of Pour point

The sample was homogenised and poured into the test jar to the mark level. The jar was closed tightly with the cork carrying the high pour thermometer that was placed 3mm below the surface of the oil. The disc was placed in the bottom of the jacket and the ring gasket was placed around the jar at the 25mm from the bottom. The test jar was then placed in the jacket.

The oil was allowed to cool without disturbance to avoid fictitious result. The test jar from the jacket was removed carefully and tilted to ascertain whether there is a movement of the oil.

The procedure continued in this manner until a point was reached at which the oil in the test jar showed no movement when the test jar was held in a horizontal position for 5 seconds.

iii. Determination of Kinematic Viscosity

The bath was maintained at the operating temperature by regulating the bath temperature by thermo stating it. The wide capillary viscometer tube was selected for the analysis. The sample was filtered through the no. 200 sieve to remove the associated solid particles. Sample was introduced into the viscometer in a manner stated by the equipment manual. The charged viscometer was allowed to stay in the water bath long enough to reach the test temperature.

Suction was used to adjust the head level of the test sample to a position in the capillary arm of the instrument to about 5mm ahead of the first timing mark. With the sample following freely, measurement was done to 0.2seconds, the time required for the meniscus to pass from the first time mark to the second.

iv. Determination of Density

The sample was homogenized and 400ml was poured into the clean 500ml measuring cylinder, air bubbles were avoided during pouring. The temperature was controlled to avoid drifting in the temperature value. Hydrometer was lowered into the oil gently and avoid being lean on the wall of the cylinder. When the hydrometer has come to rest the reading was taken.

v. Determination of Calorific Value

Model 6200 microprocessor controlled isoperibol oxygen bomb calorimeter was used for the calorific tests. It used the time-tested parr 1108 oxygen bomb and oval bucket in a compact calorimeter that produce the reliable result with good repeatability. It involved the removal of the bomb and buckets from the calorimeter and refilled manually for test. All sensors, controls and jacketing in the 6200 calorimeter are built into a single, compact cabinet to provide a self-contained operating units consisting of:

- A temperature-controlled water jacket with a built-in-circulating system and an electric heater
- An 1108 oxygen bomb with an oval bucket which fits into the insulating water jacket
- A built-in- semi-automatic system for charging the bomb with oxygen.
- A high precision electronic thermometer.

vi. Determination of Vapour Pressure

ASTM D6377, a single – expansion method, was employed for the determination of the vapour pressure of the fluid. The pressurized sample was transferred to the measuring chamber and expanded to the final volume by the built-in piston. The value of the vapour pressure was read of the LCD.

vii. Determination of Damping Coefficient

The determination of the damping coefficient of the oil samples was carried out in the Thermofluid laboratory Mechanical Engineering Department Ekiti State University using the Universal Vibration apparatus, shown in Figure 1 below. The Universal Vibration apparatus consist of the following major components: Chart recorder (Figure 2), Speed control unit (Figure 3), and the Dashpot (Figure 4). A convenient means of measuring the amount of damping present is to measure the rate of decay of oscillation.

These are expressed by the term logarithmic decrement which is defined as the natural logarithm of the ratio of successive amplitude on the same side of the mean position. In this experiment, the damping coefficient is assessed in terms of the logarithmic decrement, measured by the decay in amplitude of a free vibration of a beam.

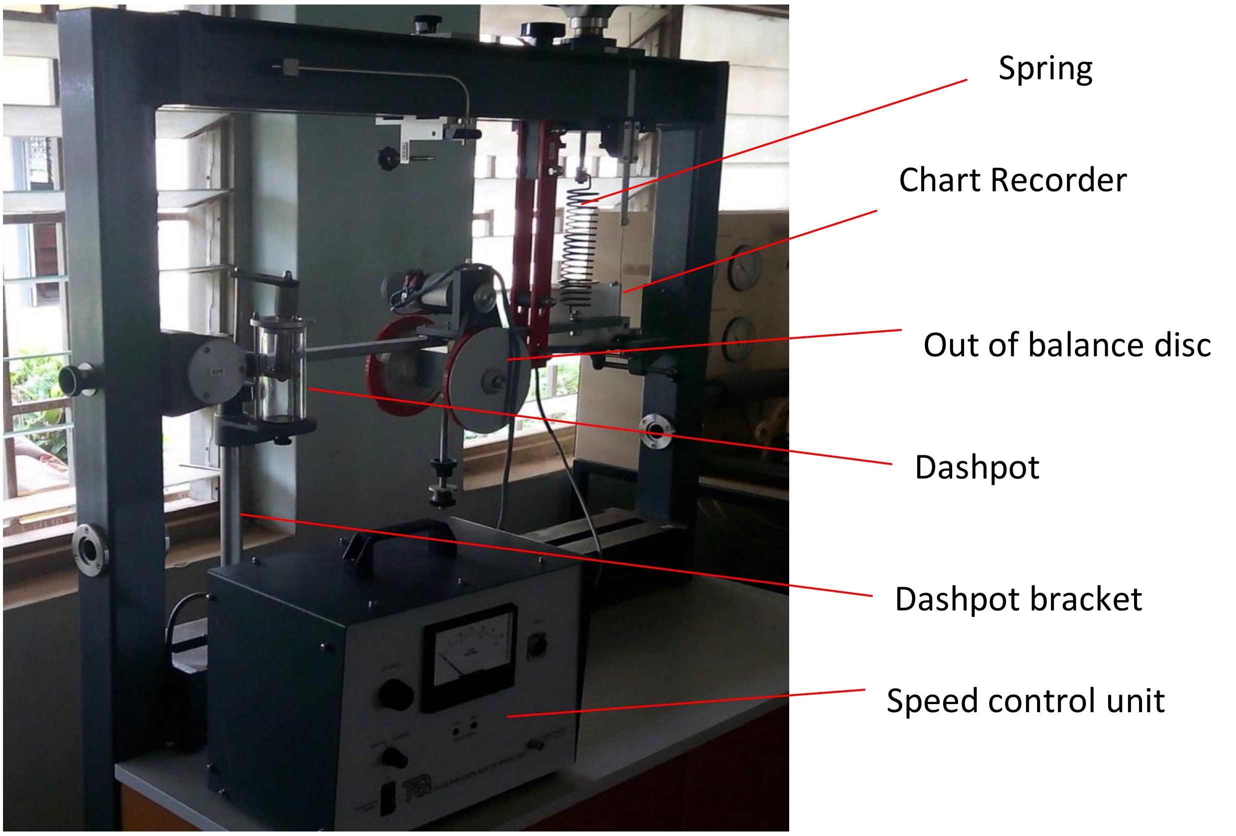

Figure 1: Universal Vibration apparatus

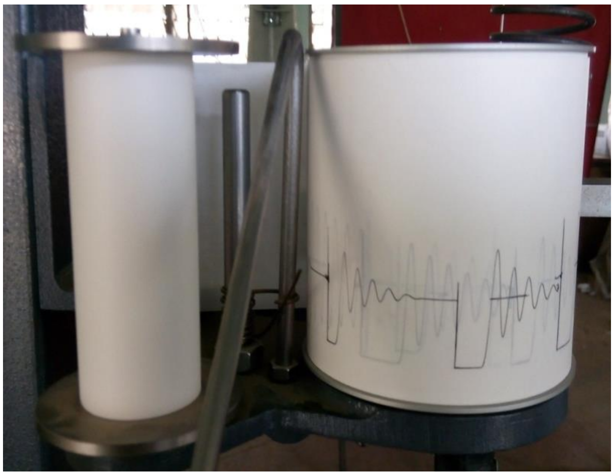

Figure 2: Chart recorder

Figure 3: Speed control unit

Figure: 3 Dashpot filled with oil sample

PROCEDURE

Figure 1 shows the setup of the experiment. The speed control unit regulated the speed of the drum on the recorder unit. The system was set to vibrate freely by pulling down on the free end of the beam a short distance and releasing. I connect the lead from the motor of recorder unit to the auxiliary socket on the speed control unit. I use the chart recorder to obtain a trace of 10 successive amplitudes on the same side of the mean position by bringing the recording pen into contact with the paper to produce a trace of the decaying amplitude of vibration and thus produce a trace of the decaying applied amplitude on the chart recorder paper. The dashpot is clamped along the beam in which different vegetable oils and mineral based oil are used as the damping fluid in order to determine the damping coefficient of each fluid when subjected to free vibration

III RESULT AND DISCUSSION

There are two set of results obtained during this research:

- Result on sample analysis
- Result on determination of damping coefficient of the fluids

i. RESULT ON SAMPLE ANALYSIS

The results of the pour point test, flash point test, kinematic viscosity, calorific value, vapour pressure and density were as presented in Table 1.

The result are also represented on the bar chart shown in Figure 5 – 10

Table 1: Result of the oil samples

Parameter	Palm Oil	Palm Kernel Oil	Coconut Oil	Groundnut Oil	Mineral Based Oil
Pour point ºC	20.5	19.8	18.0	9.2	-6.0
Flash point ºC	260.0	245.2	240.0	250.0	230.0
Kinematic viscosity, (mm^2/s) @ 40 ºC	44.6	32.4	34.2	40.5	46.0
Calorific value (kcal/kg)	9.452	9.215	9.150	9.621	9.563
Density (kg/l) @15 ºC	891.2	892.5	892.1	890.2	886.2
Vapour Pressure (kpa) @ 20 ºC	0.00006	0.00007	0.00008	0.00008	0.00016

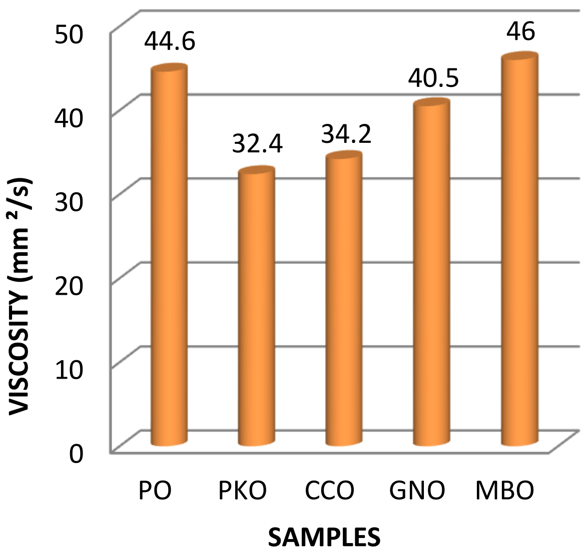

Figure 5 Bar chart showing the kinematic viscosity of the oil samples

As shown in Figure 5. MBO has the highest viscosity of 46 mm²/s at 40 °C followed by PO, GNO, CCO and PKO in that order. Kinematic viscosity is a fluid resistance to flow at a given temperature. The greater the resistance to flow, the higher the fluid viscosity. Kinematic viscosity is one of the properties that determine the suitability of any fluid as a damping fluid.

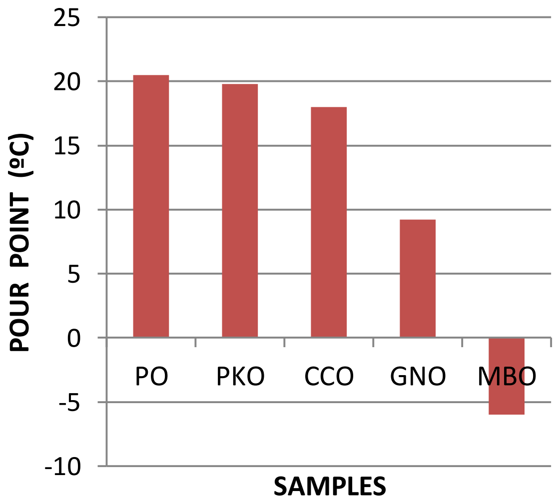

Figure 6: Bar chart showing the pour point of the oil samples

Pour point refers to the temperature at which the oil in solid form starts to melt or pour. In cases where the temperatures fall below the pour point, the entire oil will need to be heated before it can be used. The pour point of GNO, CCO, PKO and PO are 9.2ºC, 18.0ºC, 19.8ºC and 20.5ºC respectively while that of MBO is -6ºC as shown in Figure 6.

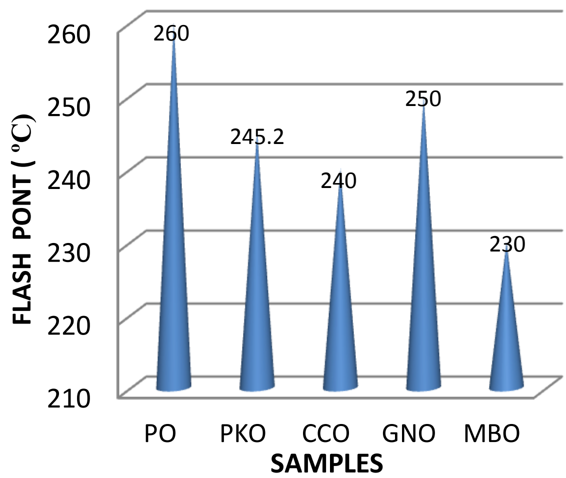

Figure 7 :Bar chart showing the flash point of the oil samples

The flash point of the damping fluid describes the lowest temperature to which the fluid must be heated before it is ignited when mixed with air. The higher the flash point of the oil the better to withstand high temperature. In this research, PO, PKO, CCO, GNO, has a flash point of 260ºC, 245.2ºC, 240ºC, and 250ºC, which is greater than that of MBO as shown in Figure 7.This show that these vegetable oils can withstand temperature below 260ºC.

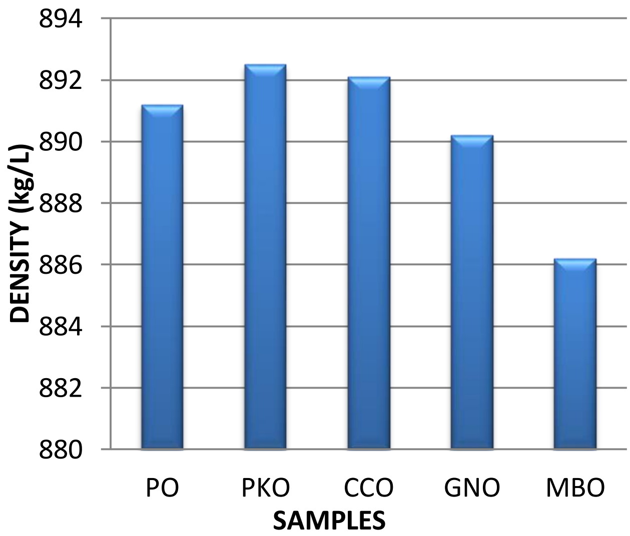

Figure 8: Bar chart showing the density of the oil samples

The density is used to determine the specific gravity of the oil samples. Specific gravity shows the heaviness of the substance compare to water. In this research the result shown that these vegetable oils have higher density greater than that of the mineral based oil as shown in Figure 8. PKO has the highest density.

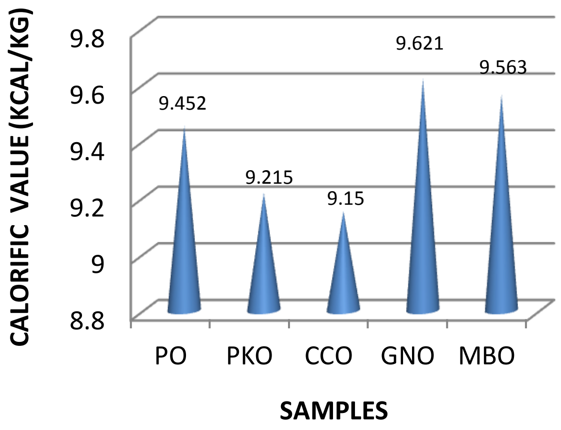

Figure 9: Bar chart showing the calorific value of the oil samples

Calorific Value is the amount of energy produced by the complete combustion of the fluid. In these research the result shown that the calorific value of these vegetable oils are high in which GNO has the highest calorific value as shown in Figure 9. The calorific values of PO, PKO, and CCO are low compared to the MBO.

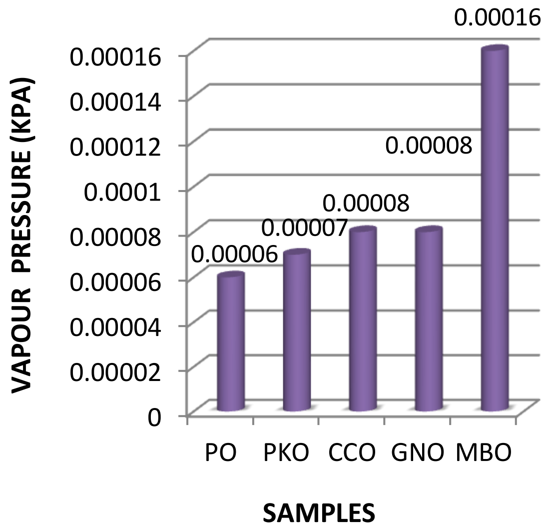

Figure 10: Bar chart showing the vapour pressure of the oil samples

The vapour pressure is an indication of a liquid evaporation rate. In this research it is shown that MBO has the highest vapour pressure at 20°C, while the vapour pressure of these vegetable oils are low compared to mineral based oil as shown in Figure 10.

4.2 RESULT ON DETERMINATION OF DAMPING COEFICIENT OF THE FLUIDS

Table 2 shows the result of the experiment carried out in the thermo fluid laboratory by using universal vibration apparatus in order to determine the damping coefficient of each fluid when subjected to free vibration.

Table 2. Result of the determination of Damping Coefficient of samples

Samples	Amplitude Ratio X_0/X_1	Log Dec. Log X_0/X_1	Period Ʈ (s)	Constant a	Damping Coefficient (N/ms^{-1})
Palm Oil	1.25	0.096	0.340	1.30	10.40
Palm Kernel Oil	1.05	0.024	0.383	0.290	2.35
Coconut Oil	1.11	0.046	0.390	0.540	4.32
Groundnut Oil	1.15	0.062	0.379	0.755	6.04
Mineral Based Oil	1.21	0.084	0.362	1.072	8.57

AMPLITUDE: this is the maximum extent of vibration or oscillation measured from the position of equilibrium. Amplitude ratio is the ratio between two successive sinusoidal wave forms.

$$\text{Amplitude ratio} = \frac{X0}{X1} \quad (1)$$

Where X0 and X1 are the two successive amplitudes which is obtained from the chart recorder as shown in Figure 2.

LOGARITHMIC DECREMENT: this is defined as the natural logarithm of the ratio of two successive amplitude of the same side of mean position.

$$\text{Logarithmic decrement} = \text{Log}\,\frac{X0}{X1} \quad (2)$$

$$l_n\,\frac{X0}{X1} = \frac{a\tau}{2} \quad (3)$$

The constant a is obtained from the equation above where Ʈ is the period of oscillation.

PERIOD: this is the interval of time between successive occurrences of the same state in an oscillating or cyclic phenomenon such as a mechanical vibration. This is the time taken for a complete oscillation.

$$\text{Period of oscillation } (Ʈ) = \frac{\text{Time taken}}{\text{No of oscillation}} \quad (4)$$

Number of oscillation = 10

COEFICIENT OF DAMPING

$$C = \frac{I_A(\mathrm{a})}{L1^2} \quad (5)$$

I_A = moment of inertial of the system along the pivot.

$$I_A = ML_1^2 + \frac{mL1^2}{3} \quad (6)$$

M = Mass of motor including the two disc

L_1 = Distance from the mounting to the position of the motor

L_2 = Distance from the mounting to the position of the spring

m = Mass attached to the motor

The results are also represented on the bar chart shown in Figure 11.

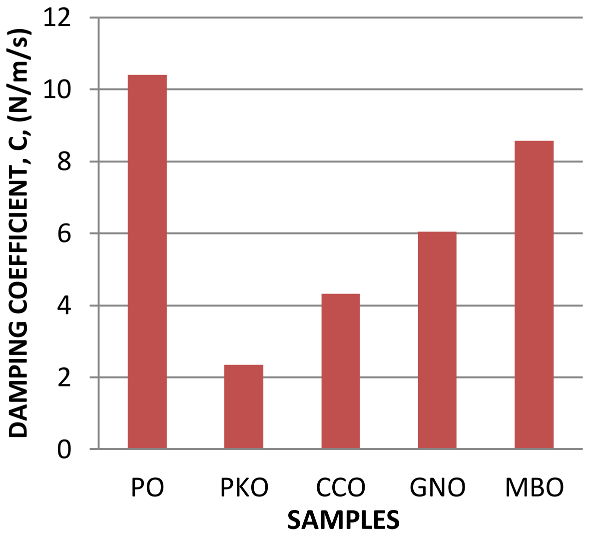

Figure 11: Bar chart showing the damping coefficient of the oil samples

Coefficient of damping is the minimum amount of viscous damping that result in a displaced system returning to its original position without oscillation. As shown in Table 2 and Figure 11, the damping coefficient of the samples varies between 2.35 N/ms^{-1} and 10.4 N/ms^{-1}. The damping coefficient of PKO, CCO, GNO, MBO and PO are 2.35 N/ms^{-1}, 4.32 N/ms^{-1}, 6.04 N/ms^{-1}, 8.57 N/ms^{-1} and 10.40 N/ms^{-1} respectively

1.3 DISCUSSION ON RESULT

Palm oil was discovered to have the highest damping coefficient as shown in Table 2 and Figure 11. Viscosity is the one of the major properties of damping fluid. The viscosity of palm oil is high when compared with MBO at 40ºC, as shown in Table 1 and Figure 5. The viscosity of this fluid is 7.37ºC at 100ºC, this fluid also has a low viscosity index [3] This fluid can be blended with additives in order to increases its viscosity at high temperature, to make it suitable as damping fluid even at high temperature. The flash point of this fluid is the highest as shown in Figure 7, this also serves as an added advantage for this fluid to be used as damping fluid.

Although this vegetable oil has a high pour point when compared with the Mineral Based Oil which is below zero as shown in Figure 6, but can be treated with pour point depressants to make it suitable for use as a damping fluids in tropical region.

Groundnut oil can be used as a damping fluid due to the properties possessed by this Oil. It has a high viscosity of 40.5ºC at 40ºC, the flash point and the calorific value of this fluid are high as shown in Figures 7 and 9, this serves as an added advantage for Groundnut oil to be used as damping fluid. The pour point of Groundnut oil is also high when compared with the Mineral Based Oil, which makes it suitable as damping fluid in a tropical region. Also, this oil can be treated with pour point depressants, in order to improve its effectiveness as a damping fluid particularly in the temperate region.

Palm kernel oil has a high flash point which serves as advantage to this fluid to be used as damping fluid, although the viscosity of this oil is low at 40ºC, as shown in Figure 5 when compared with Mineral Based Oil. The fluid can also be treated with additives in order to increases its viscosity at low and elevated temperatures in order to make it useful as damping fluid.

In this research it was discovered that the flash point of Coconut Oil is high, although the its Viscosity is low when compared with Mineral Based Oil at 40ºC as shown in Table 1 and Figure 5. Coconut oil can be blended with additives in order to increases its viscosity at high and low temperatures, to make it suitable as damping fluid even at high temperature.

CONCLUSION

The investigated vegetable oils are locally produced and readily available in Nigeria at a relatively low cost. The thermo-physical and chemical properties of these vegetable oils make them a potential damping fluid. Palm Oil, for instance has the highest Coefficient of damping of all the vegetable oils even better than the imported Mineral Based Oil. Also the density, flash points, and pour points of all the tested vegetable oils are higher that of the Mineral Based oil, although with lower vapour pressure than Mineral Based Oil, this further confirms the usability of these vegetable oils as damping fluid. It must be noted that there is no property that can be used to solely determine the usability or otherwise of any f=oil as damping fluid, rather a combination of factors and properties.

Factors such as the temperature, pressure, and humidity of the operating conditions also determine, to a large extent the selection of a particular oil as damping fluid. For example, a particular oil might find application under room temperature but might not be suitable under elevated or cryogenic temperatures.

In all, these locally produced vegetable oils have potentials for application as damping fluids, but they must be refined and treated for maximum benefit. The suggested treatments include but not limited to blending, addition of additives, with a view to improving their properties. The application of locally produced vegetable oils as damping fluid will help develop employment opportunities for Nigerian youths, increase foreign exchange earnings and save the country from unnecessary importation.

Further researches are recommended to be carried out on the application of these vegetable oils at elevated and cryogenic temperatures and for various applications in automobile, aeronautics, machine tools and other machineries. Government should equipped the tertiary and other research institutions with laboratory equipment to carry out more researches to discover more areas of practical application for vegetable oils and other locally available materials.

ACKNOWLEDGEMENT

The authors are grateful to the following

1. The management of Ekiti State University, Ado Ekiti, Nigeria for the opportunity to use the TM vibration apparatus for the experiment.
2. The management of Multi Environmental Management Consultants Limited, Ikorodu Lagos State for their assistance in carrying out the analysis of the samples.
3. Ajayi Kehinde Oluwaseun and Ilelaboye Adeleke for their assistance in collating the results.

REFERENCES

1. Information from http://vegetableoils.org/vegetableoil. Accessed on 30th November, 2015
2. Bennion M. Introductory foods. 1oth edition, pp 420-430. Prentice-Hall Inc. upper saddle river, New Jersey, USA. 1995.
3. Abere J.O et al. Investigation into the use of Vegetable Oil as Industrial Fluid- Automatic Transmission Fluid. International journal of Mechanical & Mechatronics Engineering (IJMME_IJENS). Vol.14 No.03. Pp 1-9. 2014.
4. Binfa B. Possibilities of Vegetable Oils as base oil for Automobile Shock Absorbers Fluids. International Journal of Scientific and Engineering Research. Vol. 6, Issue 4, Pp 950-956. 2015
5. Gwarilow, I. Palm Oil usage in Lubricants. Presented at the 3rd Global Oil and Fats Business Forum, USA. Interfacing with the Global Oils and Fats Bussiness. 2013
6. Anjana, S, and Preeti, S. Vegetable Oil as lube base stock: A review. African Journal of Biotechnology. Vol. 12. No. 9. Pp 880-891. Academic Journals. 2013
7. Clarence W. de Silva (2005). Vibration Damping, control, and design. CRC Press. Pp 1-1 – 1-16.
8. Rakesh Das, Rajesh Kumar and P.P Kundu, (2014). Damping evaluation of Linseed oil –based Engineering elastomers by Vibration Response Method. International Scholarly Research Notices ISRN Polymer Science. Vol 2014.pp 1-14 Available on www. Hindawi.com/journals/isrn
9. Information from www.wwf.org.au. Accessed on 15th November, 2015
10. Poku Kwasi (2002). Small-Scale Palm Oil Processing in Africa. Food and Agricultural Organization (FAO) Agricultural services bulletin. 148. Rome Pp 3-5.. Available on www.fao.org. Accessed on 20th December, 2015
11. Atase V.N and Akinhanmi, T.F (2009) Extraction, Compositional Studies and Physico-Chemical Characteristics of Palm Kernel Oil. Pakistan journal of Nutrition, 8: 800-803
12. Grimwood, B.E et al (1975). Coconut Palm Products- their processing in developing countries. Rome. Food and Agricultural Organization (FAO). Pp 49-56.
13. Xiaojun Liu et al (2011). Changes in volatile compounds of Peanut Oil during the roasting process for production of aromatic roasted Peanut Oil. Journal of Food Science, 76(3): C404-C412.
14. Information from http://dictionary.reference.com/browse/mineral_oil. Accessed on 30th November, 2015.