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THERMAL PROPERTY EVALUATION OF BIO LUBRICANTS IN ATV

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Abstract— ***The study deals with the thermal property evaluation of various grades of bio lubricants used in All Terrain Vehicle (ATV). The lubricating oil of suitable grade is blended with various percentages of Palm seed oil. The obtained blend is then tested for thermal properties such as flash point, fire point, cloud point, pour point and viscosity. After the blending and testing of the bio-lubricant, the comparison among the various grades are prepared. The bio-lubricant oil is used in the All Terrain Vehicle (ATV). The study of emission characteristics is carried out to determine the composition of pollutants like NOx, CO, unburnt hydrocarbons in the exhaust. The results are compared with the emission characteristics of a regular lubricant. The project provides the detailed analysis on the reduction on emission levels and increased lubrication property in the ATV which in turn provides better efficiency.***

Key Words: Bio-Lubricants, Engine, Blending, Palm Oil

I. INTRODUCTION

Lubricants are utilized every day for automotive, farming, industrial, aviation, and marine applications. Approximately 50 percent of all lubricants, mostly mineral based, are released into the environment during use, spills, and disposal. This is a concern since traditional lubricants are not completely biodegradable and have high toxic content. Therefore, new and used lubricants can cause significant damage to the environment, especially to water sources. Additionally, burning lubricants for disposal produces airborne pollutants and waste containing heavy metal. Although used lubricant can be recycled.

The growing interest of researchers in green tribology to save energy, enhance the environment and reduce dependency on petroleum base lubricating oils have necessitated the use of certain percentage of renewable-oils in vehicles and machineries. Lubricants have been classified into two major categories based on their sources; the mineral oil lubricant and the bio lubricant. Most of the oils which have been used to meet lubricating needs are originated from petroleum. The depletion of the world’s crude oil reserve, increased oil prices and the demand to protect the environment against pollution exerted by Lubricating oils and their uncontrolled spillage have brought renewed interest in the development and use of alternative lubricants.

Bio Lubricant: A lubricant is a substance introduced to reduce friction between moving surfaces. It may also have the function of transporting foreign particles. The property of reducing friction is known as lubricity. Bio-lubricants has emerged as a good alternative to the mineral and petroleum based products that come at a cost of environmental degradation.

Bio-lubricants, also known as bio-based lubricants or bio-lubes, are made from a variety of vegetable oils, such as rapeseed, canola, sunflower, soybean, palm, and coconut oils.

The sources of natural oils and fats are also numerous, comprising of animal, marine and plants. The usefulness of oils and fats is determined by their chemical properties, which differ according to their composition of various fatty acids and esters.

Can vegetable oils make good lubricant base stocks? Research conducted till date indicates that chemically and genetically modified vegetable oils have excellent potential to perform adequately as lubricants. Vegetable oils have been used as lubricants for machinery and transportation vehicles for a prolonged period before the discovery of petroleum resources. In the past decade, the initial applications have been niche markets such as chain saws, track lubricants, and other total loss lubricants. Some technical and logistic concerns have been marked regarding the ability to maintain consistent profile of vegetable oils that would meet the final application and performance specifications.

Applications of bio-lubricants are as abundant as the number of industries that require constant use of lubricants in every-day processes, i.e., almost every industry. But the best application is in the field where machines loose oil directly into the environment and the machines that are used in areas near water. Examples include railroad flanges, cables, two-stroke engines, dust suppressants and marine automobiles.

Need for Bio-lubricant: Compared to petroleum-based lubricants, use of bio lubricants. Produces a cleaner, less toxic work environment and fewer skin problems for those working with engines and hydraulic systems. Offers better safety due to higher flashpoints, constant viscosity, and less oil mist and vapor emissions. Are highly biodegradable. Costs less over the product's life-cycle due to less maintenance, storage and disposal requirements. The use of bio lubricants can reduce pollution in storm water from leaks in engines, hydraulic systems, and brake lines. Many European countries now require bio lubricants in selected environmentally sensitive areas.

Life Cycle of Bio Based lubricants

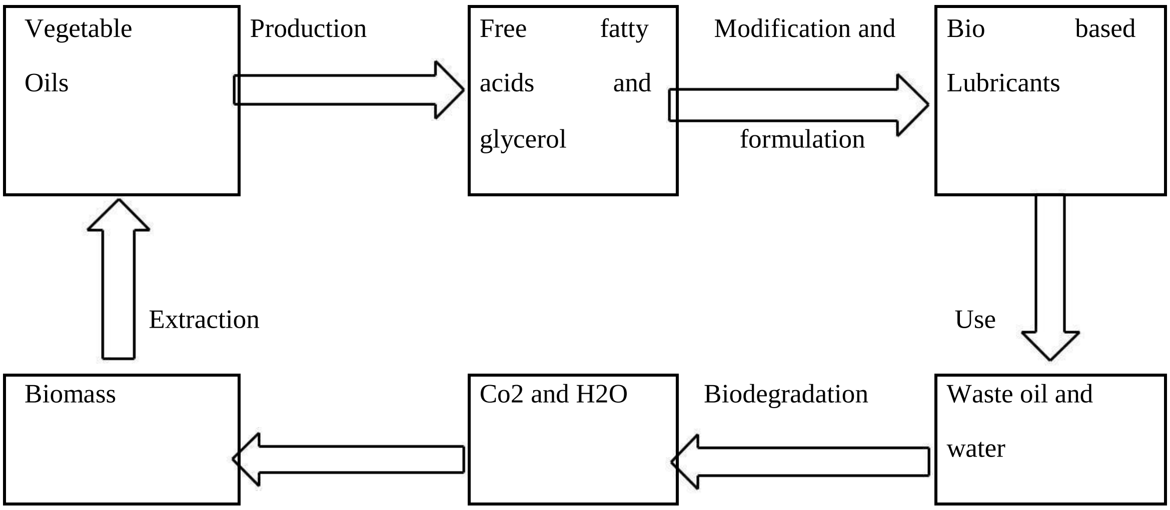

Fig.1 Life cycle of the bio-lubricants

There are two ways to use vegetable oil as a bio-Lubricant, either by directly blending vegetable oil with commercial lubricant or converting the vegetable oil into fatty acid methyl ester (FAME) to be used as lubricant additive for internal combustion engines.

Palm oil, uses and extraction: Palm oil, like all oils and fats is made up of glyceridic materials with some non glyceridic materials in small quantities. Palm oil is usually orange-red to brownish or yellowish-red in colour. It is extracted from the mesocarp of fruits of oil palm tree (Elaeis guineensis). The oil palm fruit, a drupe, prolate spheroid in shape varies between 20 and 50mm in length and could be as large as 25mm in diameter. Palm oil is basically used for domestic purpose like cooking. Recently, palm oil has become the 2nd most consumed oil all over the world.

Fig.2 Palm Fruit and Seeds

Method of extraction

Fresh palm fruits are found in bunches in the trees. These fruits are collected, harvested and then sent to the palm oil mills. The oil is extracted from the flesh of each and every individual fruit present in the bunch by processing them. The seed which is present in the centre of the fruit is called as the kernel. Oil is also extracted from these seeds by crushing them in the crushing mills. After the extraction of oil from both the seeds and fruit, the left out pulp is pressed along with the crushed kernel to form palm kernel cake or expeller.

III.EXPERIMENTAL DETAILS

The material and chemicals used in the study are as follows:

Palm Oil, Lubricant oil of grade SAE 20W-50, Methanol, Potassium hydroxide, phenolphthalein indicator. The instruments used to carry out the study are:

Redwood viscometer, Cleveland open cup tester, Magnetic stirrer, 50ml. and 250ml. conical flask, Burette, 250ml. Beaker, water bath, Agitation apparatus, Wear and friction testing apparatus.

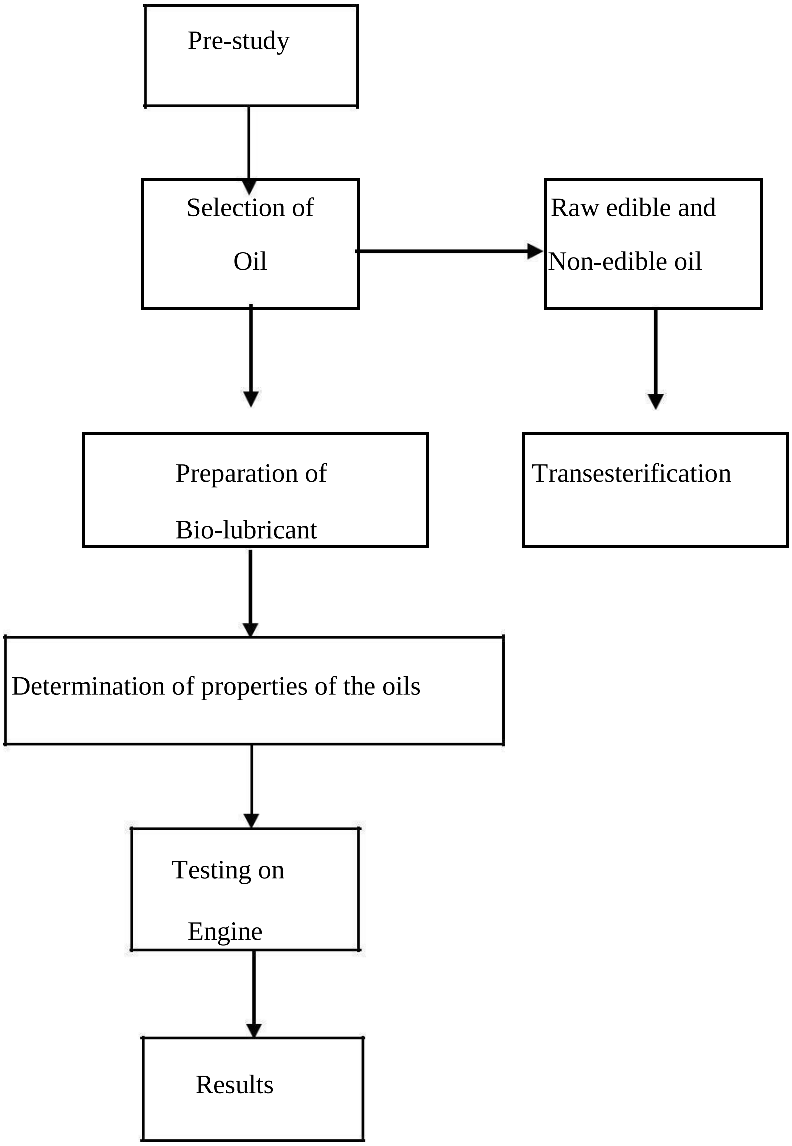

Fig.3 Flow chart representing the process in which work in done

The following steps were followed as methodology:

Density: An empty beaker was weighed and the weight recorded, then 50 cm^3 of the sample was poured into the beaker and weighed. From the sample weight obtained, the density was determined by taking the ratio of the weight of the oil to the known volume (50 cm^3) in SI units according to the equation below

$$\text{Density} = \frac{\text{Sample weight}}{\text{Sample volume}}$$

Viscosity: The viscosity of the oils was calculated using Redwood apparatus.

[1] Level the apparatus by using spirit level and adjusting the levelling screws.

[2] Clean the oil cup thoroughly and place the ball valve in its position.

[3] The cup must be filled with the given sample of oil up to the mark.

[4] Fill the heating bath with water up to the marked level.

[5] Heat the oil sample in the cup until the required temperature is attained.

[6] Place the gravity bottle just below the oil jet and lift the ball valve.

[7] Note down the time taken for collecting 50cc of the given oil in seconds.

[8] Continue heating the water bath and repeat the experiment for every 5^0C rise in temperature at different temperatures by finding the time taken for the collection of 50cc oil each time and tabulate the readings.

Flash and Fire point: These were found using Cleveland open cup apparatus. The procedure for identifying the flash and fire point is listed below

- Clean the oil cup thoroughly and fill it with the given sample of oil up to the given mark.
- Insert the thermometer into the oil cup through the clamp. The thermometer indicates the oil temperature.

A. Connect the heater to the mains through autotransformer and adjust the rate of heating.

B. The oil sample is tested for the flash point with at least flame for every 20C rise in temperature.

C. When the oil gives a momentary flash on the application of the test flame the corresponding temperature is recorded as the flash point of the oil.

D. Repeat the experiment with fresh oil sample three times to increase the accuracy.

Determination of acid value:

(a) Reagents

Weigh 1 g of phenolphthalein and dissolve in 100 mL of ethanol. Weigh accurately 4.0 g of sodium hydroxide and place it in a 1000-mL volumetric flask. Make up to the mark with water. Prepare a mixture of ethanol and diethyl ether (1:1, v/voil). Neutralize with sodium hydroxide titrant and add 1.0 mL of phenolphthalein indicator until pink colouration is observed. Freshly prepare the solution.

(b) Standardization of sodium hydroxide titrant

Weigh accurately 0.6 g of potassium hydrogen phthalate, previously dried to constant weight at 105℃, and place it in a 250-mL conical flask, then add 50 mL of water. Shake it well. Add 2 drops of phenolphthalein indicator. Titrate the solution with the sodium hydroxide titrant until pink colouration can be observed. Towards the end of titration, potassium hydrogen phthalate should be completely dissolved.

Chemical Modification of oils:

Vegetable oil can be chemically modified by various unit processes.

This modified vegetable oil was used as lubricating oil and as base oil in formulating bio based grease.

The chemical modification is a two-step process:

Esterification: This process is used to reduce the free fatty acid content in the oil in by mixing it with the alcohol in the presence of acid catalyst.

Transesterification: Transesterification reaction is the transformation of an ester, a triglyceride (vegetable oil) into another ester in the presence of acid or base as a catalyst. In the production of biodiesel, the products are mixtures of fatty esters (biodiesel) and glycerol.

CH2 – OCOR1 R1COOR CH2 – OH

Catalyst +

CH – OCOR2+3ROH ⟶ R2COOR +CH – OH

\+

CH2 – OCOR3 R3COOR CH2 –OH

Fig.4 Transesterification reaction for producing esters from oil (triglycerides)

Main parameters ruling esterification are amount of catalyst (W/Woil), molar ratio of alcohol to oil, temperature of reaction, time of reaction.The formation of esters by transesterification of vegetable oil requires oil, 15% of methanol & 5% of sodium hydroxide as catalyst on mass basis. For the equilibrium of the reaction 50^{o}C temperature was kept. From 1litre of palm oil 850ml of palm oil methyl ester was obtained.

Preparation of Lubricant Samples

There were three different types of lubricant samples. The lubricant SAE 20W-50 was used as a base lubricant and for comparison purpose. The blended samples were prepared by mixing of 10%, 20% and 30% palm oil with SAE 20W-50. The samples were mixed with the base lubricant using magnetic stirrer and agitation apparatus for 45 minutes for homogenization. The amount of each sample prepared was around 1 Litre.

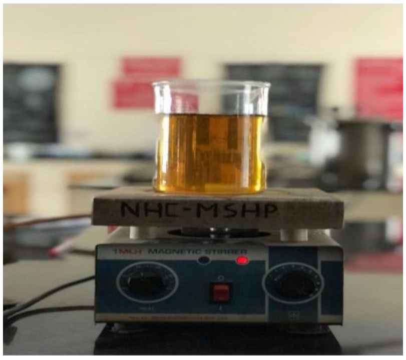

Fig.5 Magnetic Stirrer Heater

Fig.6 Agitation Apparatus

IV RESULTS AND DISCUSSION

The effects of palm oil lubricant on diesel engine was investigated and characterized. The result provides the better understanding of the properties of the palm oil such as viscosity analysis, thermal characteristics such as flash point, fire point and engine emissions. These were compared with the conventional mineral oil

Table 1: Blending proportions of the Different oils with the mineral oil

Sample	Using Palm oil (ml)	
	Vol. of Palm Oil	Vol. of SAE Oil
B0	0	1000
B10	100	900
B20	200	800
B30	300	700

Characterization of the palm oil and mineral oil

Table 2. Properties of the oils

Properties	Palm oil	SAE 20W-50
Density (kg/m^3)	875	880
Flash point (ºC)	323	215
Fire Point (ºC)	352	232
Absolute Viscosity (Ns/m^2)	0.00876	0.00979

Comparison of the Properties of the Blended oils with the mineral oil

Table 3. Properties of the Blended oils with mineral oils

Properties	10% blend	20% blend	30% blend	SAE 20W-50
Density (kg/m^3)	840	840	860	880
Flash point (ºC)	243	247	268	215
Fire Point (ºC)	254	265	275	232
Absolute Viscosity (Ns/m^2)	0.00722	0.00851	0.00876	0.00979

Density

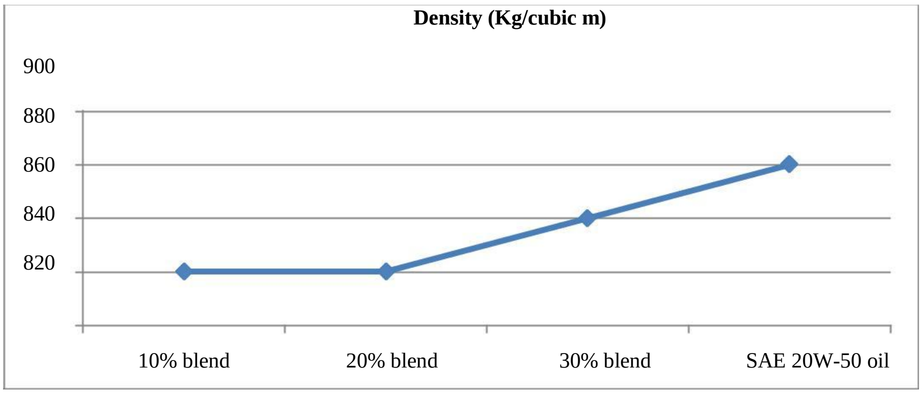

Fig.7 Density of different blends and Mineral Oil

Flash and Fire point: The flash and fire point of the mineral oil was observed to be 215 ˚C and 232 ˚C respectively. The flash and fire point of palm oil blends was found to be higher than mineral oil as shown in the graph. The test was conducted on the blends and mineral oil using the Cleveland open cup apparatus to find the values.

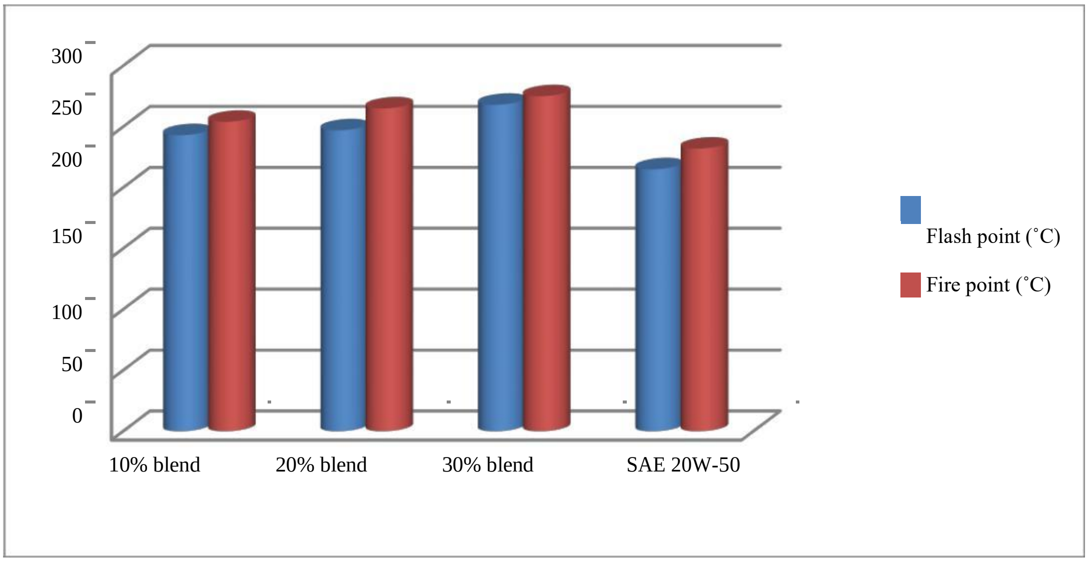

Fig.8 Flash and Fire Points of different blends and Mineral Oil

Viscosity: Viscosity is the most important property of lubricating oil. The figure shows the comparison of viscosity of palm oil blended lubricants and mineral oil. It can be concluded that viscosity of palm oil blended lubricants is slightly lower than the mineral oil. Redwood Viscometer was used to find the viscosity of various blends and mineral oil.

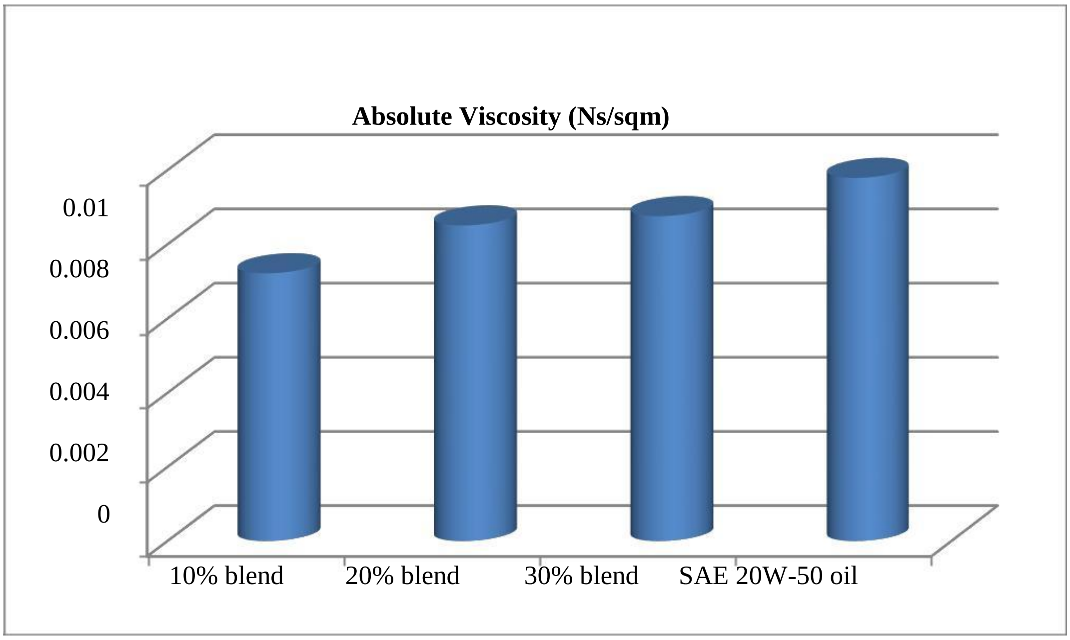

Fig.9 Absolute Viscosity of different blends and Mineral Oil

Effect of lubricant prepared on Engine performance and emission

All the three samples prepared along with the mineral oil was tested on the engine for any change in the performance i.e., power output and emission characteristics and were compared. The specification of the engine used for the test is given below

Table 4. Specification of the engine

Brand	Piaggo Ape
Engine Type	Single cylinder diesel engine
Displacement	395
Max. Torque	22.2 Nm @ 2000 rpm
Max. Power	8.04 bhp @ 3400 rpm
Cooling Type	Air-cooled

All the sample were run for approximately 3 hours. An optimum load of 5kg was maintained for the calculation of the brake power. After testing the engine was made to cool for some time and the oil was drained from the engine crankcase.

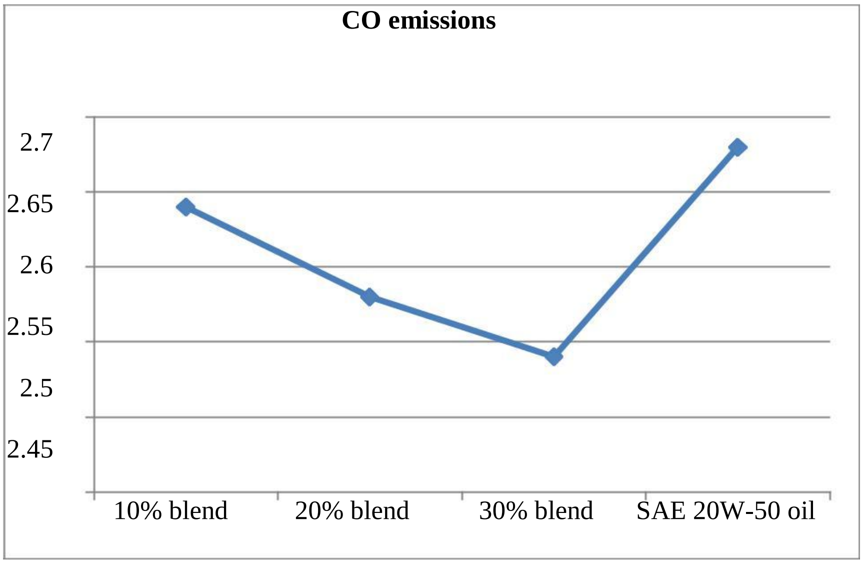

Fig.10 Comparison of CO emissions

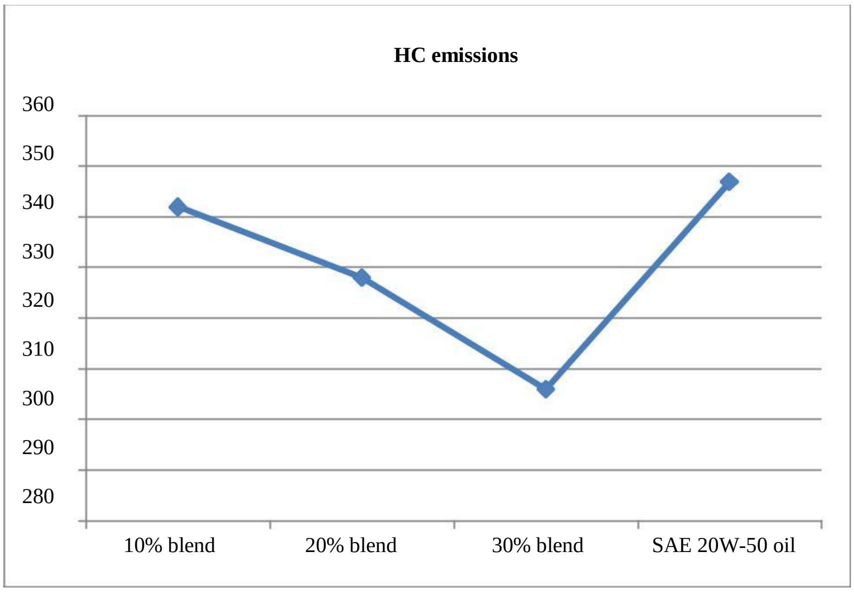

Fig.11 Comparison of HC emissions

From the above graphs it is seen that the emission characteristics of the blended samples and the mineral oil shows similar results. Although, bio lubricant oil blends show a little lesser emission levels than mineral oil.

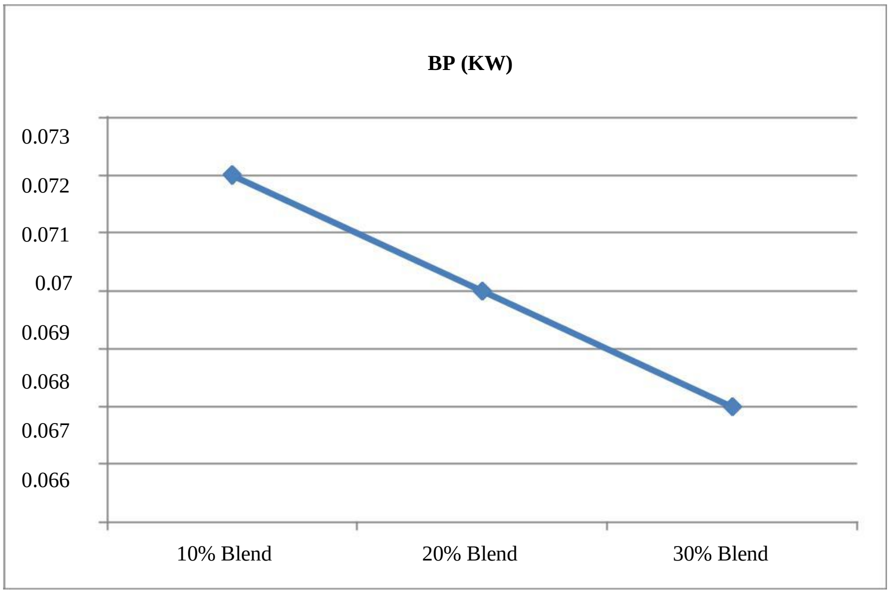

Fig. 12 Comparison of BP in KW of the obtained samples

V CONCLUSION

The objective of this study was to compare the bio-based lubricants with the petroleum mineral oil. The sources for the lubricant such as neem and coconut oil were selected from the by reviewing the journals, reports, papers etc.

Based on the observation and results obtained it is clear that the blended lubricant oil of palm oil has a slide edge over the conventional mineral oil depending upon the comparison of the properties and various other aspects. Since their viscosity is little less compared to the conventional mineral oil. All the samples were tested in engine for any change in the performance and mainly the emission respectively.

Of all the samples prepared 20% blend lubricant shows better characteristic compared to the conventional mineral oil. While selecting a lubricant one must look mainly towards the viscosity and other thermal properties, but also the impacts caused by these products should also be considered, which would not only affect the environment but also economic and social outcomes.

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