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Comparison of Tribological Characteristics of Jatropha Oil and SAE-40 Motor Oil as Two Stroke Engine Lubricants

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Research Article

Abstract

Lubrication in two stroke engines (petrol engines in particular) is achieved by either mixing directly the lubricating oil (mostly mineral oils) with the fuel (petrol), or by injecting correct amount of oil into the crankcase thereby combining with the freshly induced charge (air-fuel mixture). In either of the two cases, mist lubrication phenomenon occurs. Mist-Lubrication here implies that, due to the nature of working principle of two stroke petrol engines, part of the lube oil supplied to the engine for lubrication equally partake in the combustion process thereby adding to the emission components. Quite a number of research works revealed that vegetable based oils burn much cleaner than their mineral based counterparts, and hence, suggest the utilization of the bio-based oils as replacements to the conventionally used mineral based oils. However, the tribological performance of the vegetable oils needs to be considered in choosing them as replacements for the conventionally used mineral oils. This is not only important, but critical, as it translates into the engines operating life. It is a known fact that the cost of wear in automobiles, especially the engine components, is worrisome and that is what this work intended to address. This research is aimed at determining the possibility of substituting the conventionally used mineral/petroleum based lubricant (SAE 40) with Jatropha oil (non-edible vegetable based oil) as two stroke petrol engine lube oil by comparing their tribological characteristics. In this work, the tribological characteristics of SAE 40 motor oil and those of Jatropha oil was determined using Anton Paar pin on disc Tribotester. The tribology test results shows about 2.4% reduction in wear rate with Jatropha oil as lubricant, but the coefficient of friction values were found to be almost the same for both the oil samples.

Keywords
Jatropha oil, Mist-Lubrication, SAE-40 motor oil, Tribology.

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1. Introduction

T Internal combustion engines serve the function of producing mechanical power from the chemical energy stored in hydrocarbon fuels. This is usually actualized by a cycle of processes which continues for the duration over which the power is needed. The tasks involved in the conversion activity begins with an induction process (supplying fresh charge which is a mixture of fuel and air, in to the engine bores), followed by compression of the induced charge through a suitable compression ratio to a high temperature and high pressure condition. The compressed charge is then ignited and the pressure front developed by the expanding gasses as a result of the combustion process pushes the piston down giving rise to a power stroke. When the burning mixture is completely burnt, the exhaust gasses are expelled out of the engine through the exhaust system and the cycle begins again. The upward and downward movement of the piston is termed as the stroke. The four processes involved in the conversion process are used to classify internal combustion engines based on the number of strokes over which the entire cycle is completed. Some engines have the cycle completed in two number of strokes and hence they are named “two stroke engines”, while others have it in four number of strokes hence their name “four stroke engines” (Amsoil 2017).

Bio based oils, in addition to the advantage of being obtained from a renewable (non-depletable) source, as a number of research findings reveal, have significantly less impact on the environment, as compared to the mineral oils. Bio based oils can be obtained from different sources, such as groundnut, soya beans, neem seed, melon seed, mango seed, etc. but it is equally important not to allow the striving for fuel compete with the food demand of the living population. In that regards, non-food seeds were considered to serve the purpose. Jatropha seed is one of the popularly known non-food oil bearing seed having a greater percentage of oil content by weight of the seed. It contains 30 to 40 percent oil, it can grow virtually in almost any type of soil, it is capable of surviving up to three consecutive years of drought and even animal do not eat its leaves (Brooke *et al.*, 2008).

Lubrication in two stroke engines (petrol engines in particular) is achieved by either mixing directly the lubricating oil (mostly mineral oils) with the fuel (petrol), or by injecting correct amount of oil into the crankcase thereby combining with the freshly induced charge (air-fuel mixture). In either of the two cases, Mist lubrication phenomenon occurs. Mist lubrication means the oil too burns along with the petrol. And this causes additional pollution (ME Mechanical, 2016).

Quite a number of research works (such as Sasitorn, 2009) revealed that vegetable based oils burn much cleaner than their mineral based counterparts, and hence, suggest the use of the bio-based oils as substitute to the conventionally used mineral based oils. However, the tribological performance of the vegetable oils needs to be taken into cognizance before choosing them as replacements for the conventionally used mineral oils. This is not only important, but necessary, as it translates into the engines operating life. It is a known fact that the cost of wear in automobiles, especially the engine components, is worrisome and that is part of the reasons that necessitate this study.

Golshokouh *et al.* (2014) reported a study which investigated the friction, wear and viscosity of jatropha oil and an engine/hydraulic oil. The author studied the tribology of the oils using a three ball tribotester at a speed of 1200 rpm, a load of 392 and at 75ºC. Gunam et. al. (2015) reported a study on synthesis of biodegradable lube oil obtained from jatropha oil having a high free fatty acid content. The work was aimed at probing the feasibilty of producing esters of Trimethylopropane (TMP) using Jatropha oil as the source of the free fatty acids. The process of transesterification was used to synthesize the evaluated esters, lubricity of the biolubricant was investigated. It was found that more than 80 percent yield of the biolubricant was achieved, lubricity properties obtained were found to be comparable to the other vegitable oil based lubricants. Bilal *et al.* (2013) also reported a study on extraction and characterization of Jatropha oil for use as a lubricant. Extracted oil was tested for density, acid value, % FFA, viscosities at 40ºC and 100ºC as well as saponification value. A relatively higher %FFA was observed with the extracted Jatropha oil of almost 15%, but this was reduced to 0.44% upon transesterification. The biolubricant produced was found to be comparable to the ISO VG-46 commercial standards for light and industrial gears applications and other plant based bio-lubricant. Rao et. al. (2009) reported a research work conducted on jatropha oil biodiesel and blends as a diesel engine fuel alternative. In the study, the physico-chemical properties of jatropha oil such as the viscosity, carbon residue, flash point, calorific value, specific gravity etc. were determined. Engine performance test was conducted on the various blends of the jatropha biodiesel. The results showed (for jatropha biodiesel) increased exhaust temperature with increase in the power and the amount of jatropha biodiesel. However, there was a reasonable efficiency and lower smoke was seen with diesel blends. Sasitorn, (2009), conducted a study on Gasoline-Jatropha 10 percent blended fuel between carburetor and injection system motorcycle". The study was aimed at comparatively experimenting the 10% Jatropha-gasoline blended fuel in motorcycle engines. The motor cycles used for the experiment were both carburetor and injection systems. The base fuel used was Gasoline of octane number 91. The factors examined and reported in the study were; the engine performances, specific fuel consumptions and emissions. From the findings, the blended fuel exhibits physical stability with the viscosity of the resulting (blended) fuel as well as the free fatty acid slightly increased after keeping it under observation for a period of ten weeks. He then proceeded to test the fuel on the targeted engines and the following results were reported; "the maximum torque and horse power of injection system is 1.62 percent and 2.41 percent reduction compared with Gasoline fuel. For both system the total fuel consumptions increased by 12 percent, while the emissions decreased by 27 percent. There was an indication of slightly increased carbon deposits at the piston head and spark plug".

In this research, the tribological characteristics (Friction coefficient, penetration, wear rate and wear scar) of SAE 40 motor oil and those of Jatropha oil were determined and compared.

2. Material and Methods

2.1 Materials Used

The materials used for this investigation include;

i. Jatropha oil – this was used as obtained from National Research Institute for Chemical Technology (NARICT) Zaria Kaduna state - Nigeria.

ii. A brand of Oando SAE-40 motor oil was used for the study. This is due to the simple fact that it is one of the most commonly use two stroke engines lube oils in the country (Nigeria).

Some of the properties of the two oils are presented in Table 1.

Table 1. Properties for SAE 40 motor oil and Jatropha oil as acquired

Properties	SAE 40	Jatropha oil
Density (kg/m^3)	898.4	920.4
Viscosity index (VI)	165	220.7
Pour point (°C)	9	5

2.2 Methods

The tribological properties (wear and co-efficient of friction) of the two oil samples, as lubricants, were tested and compared using an Anton Paar Tribotester version 6.1.19 (pin on disk type) according to ASTM standard G 99-95a (2000), under the following conditions;

Temperature: - 23ºC (Room temperature at the beginning of the experiment)

Humidity: - 55.00%

Normal Load: - 8.0 N

Linear speed: - 5.2 cm/s

The stationary partner was steel ball 6mm diameter, while the rotating member (disk) was an aluminium-silicon alloy.

The disk was made to rotate against the stationary steel ball which was offset 5mm radius from the center of the rotating disk sample under the above listed conditions. The contact surface was fully lubricated with the oil samples. The Tribotester was run for five minutes and thereafter readings were taken.

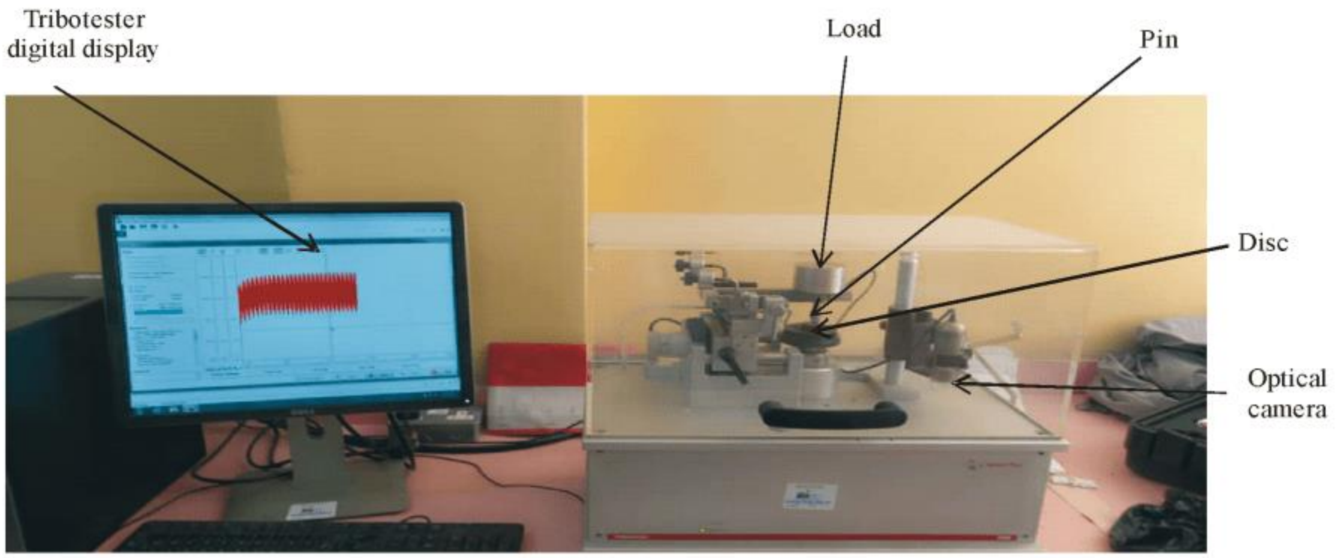

Figure 1 Anton Paar Tribotester version 6.1.19

The testing process was completely automated; the Tribotester captures and analyzes the test surface using an optical camera, does all the calculations for wear, coefficient of friction, penetration and worn track section, and displays the results on a screen as it can be seen in Figure 1.

3. Results and Discussion

Figures 2 and 3 show the tribological characteristics for Jatropha oil and SAE 40 motor oil as generated by the Tribotester.

The red curve represents the coefficient of friction, which appears to have peaked to a value of 0.119 for SAE 40 and 0.140 for Jatropha oil at the beginning of the test. The curve eventually even out after the first minute to a mean value of 0.083 for both the two oil samples.

The grey curve represents the penetration values for the oil samples.

Sample	**Static partner**	**Calculations**
Worn track section : 234822.6 µm2	Worn cap diameter : 0.0 µm	Sample wear rate : 0.02884 mm3/n/m
Young's modulus : 0.0 gpa	Young's modulus : 0.0 gpa	Partner wear rate : 0 mm3/n/m
Poisson ratio : 0.000	Poisson ratio : 0.000	Max Herzian stress : 0 gpa

Start : 0.013	min : 0.013	max : 0.119	mean : 0.083	std. dev. : 0.005

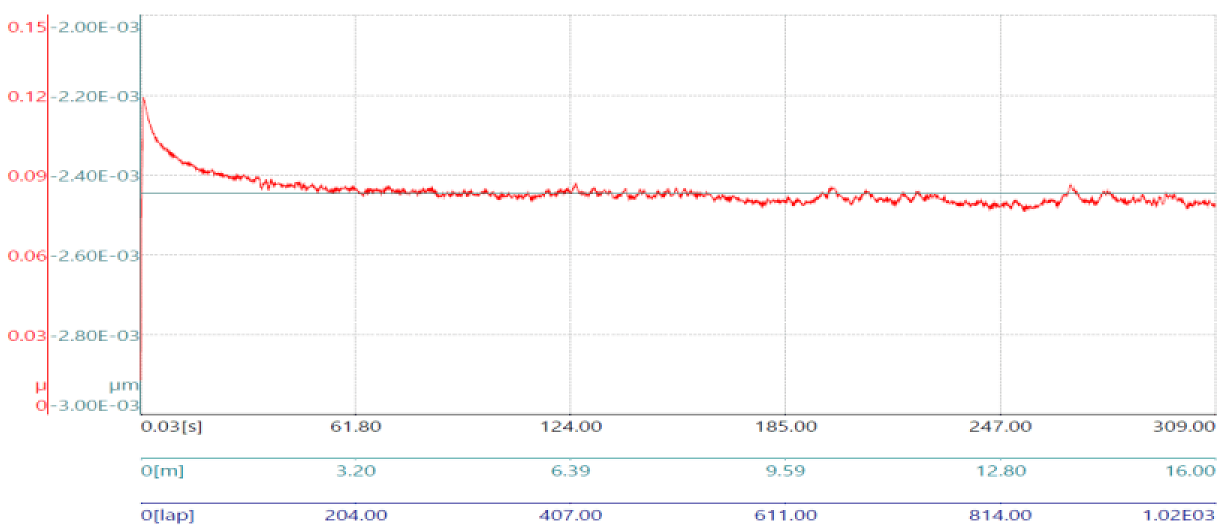

Figure 2: Showing the tribological parameters obtained with SAE 40 as lubricant

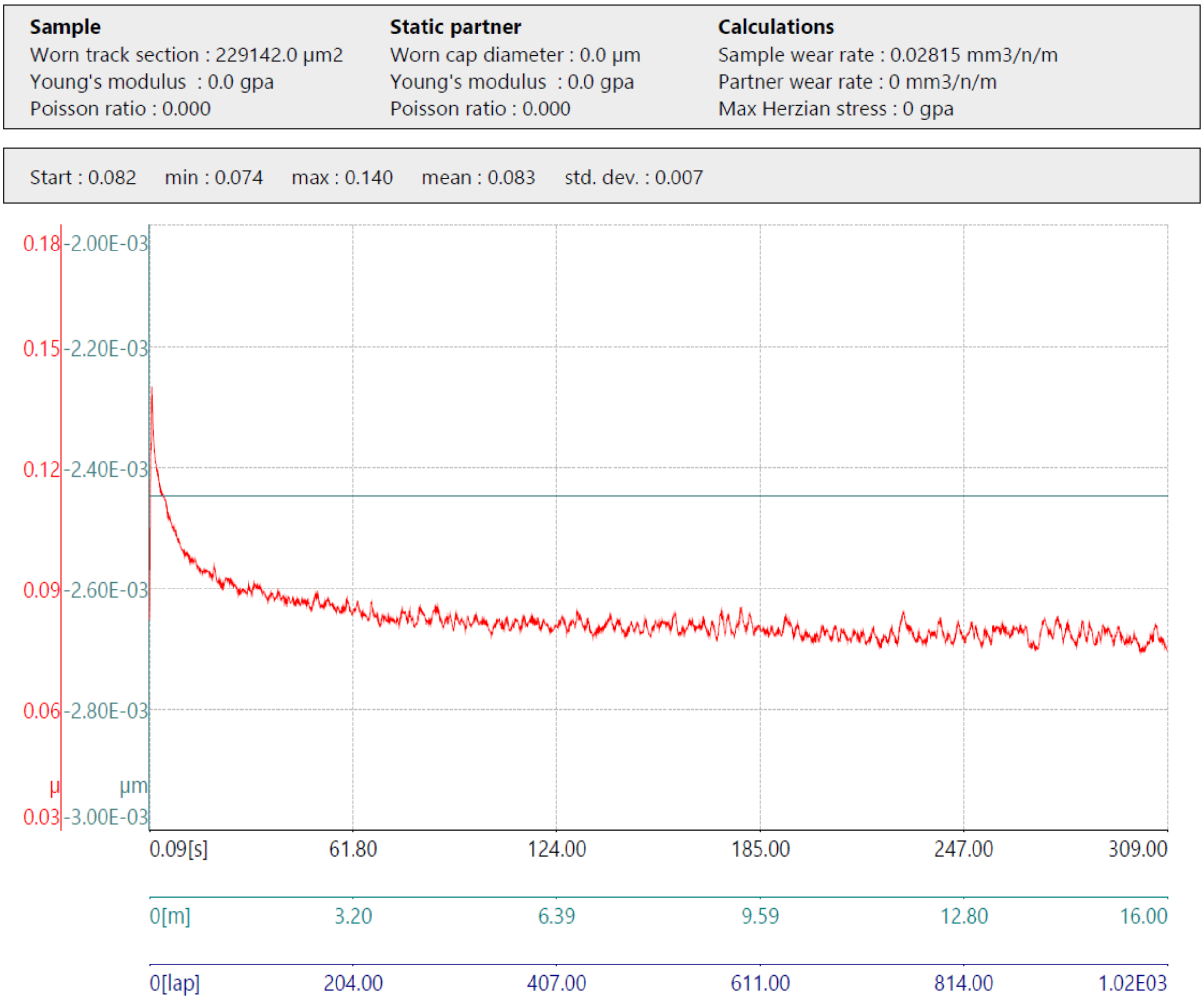

Figure 3: Showing the tribological parameters obtained with Jatropha oil as lubricant

Figure 4 shows the results for coefficient of friction for the two oil samples (SAE 40 motor oil and Jatropha oil) as extracted from the plot of the Tribotester (figures 2 & 3), rounded to three (3) decimal places. From the result, it can be seen that both SAE 40 motor oil and Jatropha oil display similar results for coefficient of friction of 0.083.

Figure 5 shows the wear rate recorded for the two oil samples. In the case of wear properties, Jatropha oil shows relatively less wear rate value of 0.02815mm3/n/m. this is around 2.4% less than that shown with SAE 40 motor oil, which shows a wear rate value of 0.02884mm3/n/m. This could translate to additional 2.4% service life for the engine components with Jatropha oil as the lubricant.

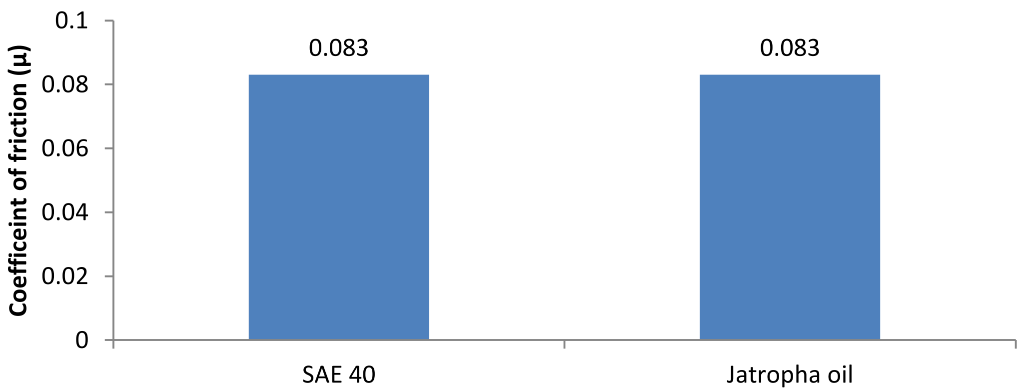

Figure 4: The friction coefficient of the oil samples

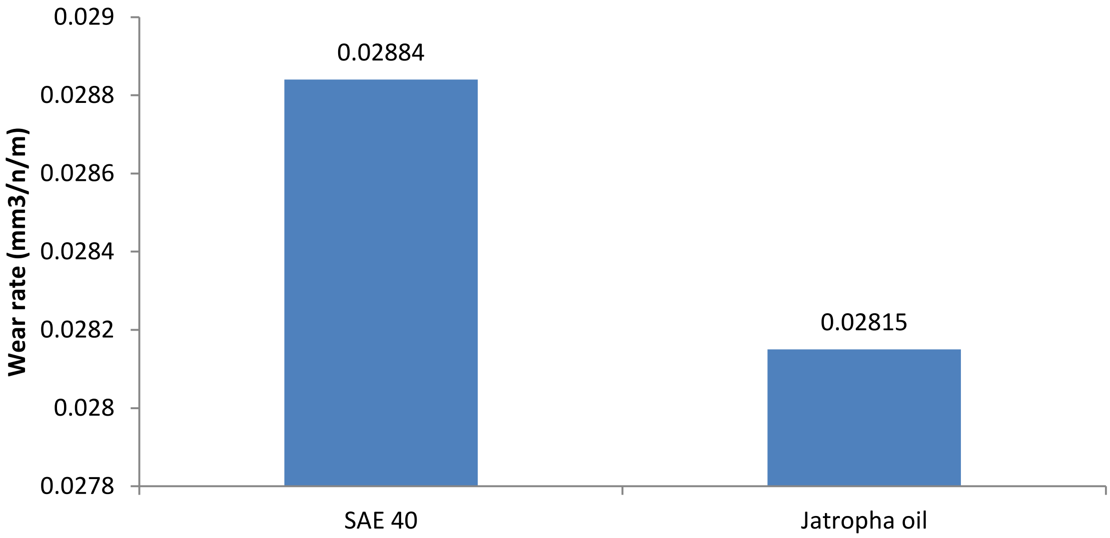

Figure 5: The wear rate recorded for the oil samples

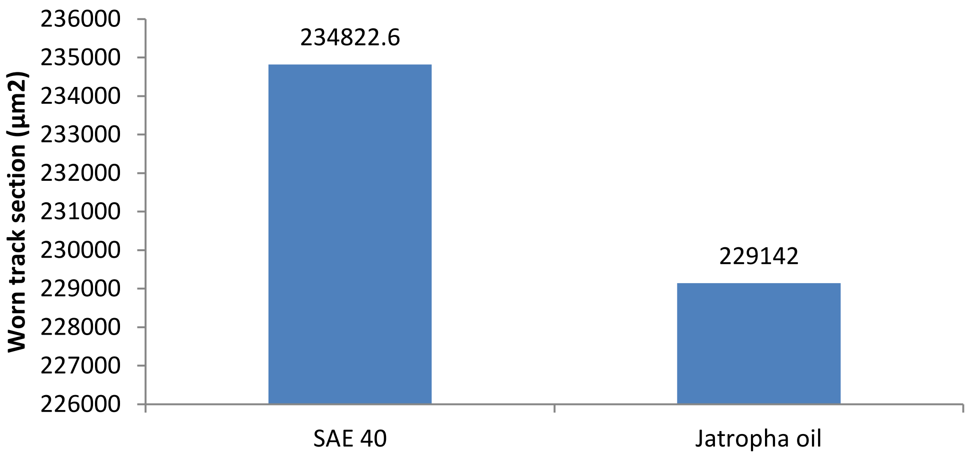

Figure 6: The worn track section recorded for the oil samples

Figure 6 shows the worn track section as observed with the two oil samples. Just like in the case of wear rate results, Jatropha oil shows relatively smaller value for worn track section (229142.0µm^2). This is around 2.4% smaller than 234822.6 µm^2 as observed with SAE 40 motor oil.

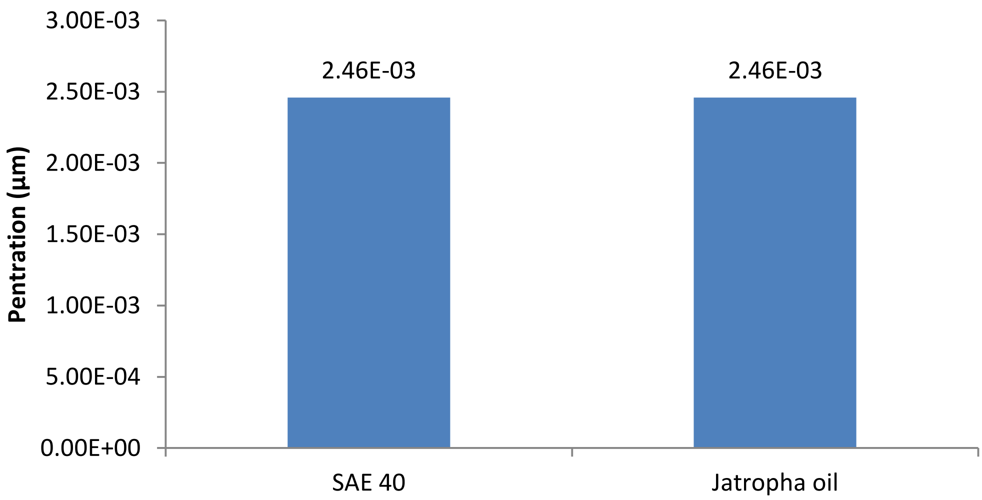

Figure 7: The penetration displayed by the oil samples

Figures 7 shows the penetration values observed for the two oil samples also as extracted from the plot of the Tribotester. The test results show that both SAE 40 and Jatropha oil has similar penetration values as rounded up to three significant figures of 0.00246μm.

4. Conclusion

The test result shows that both SAE 40 and Jatropha oil has almost the same friction coefficient and penetration values of 0.083 and 0.00246 μm respectively. This can be seen in figures 4 and 7. While in the case of wear properties, Jatropha oil shows relatively less wear rate value of 0.02815mm^3/n/m. This is around 2.4% less than that shown with SAE 40 motor oil, which shows a wear rate value of 0.02884 mm^3/n/m (see figure 5). Similar trend is also seen in figure 6, with Jatropha oil showing worn track section of 229142.0μm^2 which is almost 2.4% less than 234822.6 μm^2 as observed with SAE 40 motor oil.

The results, therefore, reveal that the Jatropha oil has better tribological properties than the conventionally used SAE 40 motor oil. It shows 2.4% reduction in the wear rate with Jatropha oil. This translates to the possibility of elongating the engine's service life by 2.4%. Hence it can be concluded based on the findings of this research that Jatropha oil has the Potentials of being used as a replacement for the conventional mineral based motor oil (SAE-40) in two stroke petrol engines.

References

Amsoil. (2017, January 1). *2-4 Stroke Engine Applications and Lubrication Needs*. Retrieved March 10, 2017, from http://www.amsoil.com/newstand/2-and-4-stroke-oils/articles/applications-andlubrication-needs/

Bilal, S., Mohammed-Dabo, I. A., Nuhu, M., Kasim, S. A., H, A. I., & Yamusa, Y. A. (2013). Production of biolubricant from Jatropha curcas seed oil. *Journal of Chemical Engineering and Materials Science*, pp.72-79.

Brooke, B., Stephen, G., Michael, W., & Hwok-Chuen, L. (2008). *Biodiesel Produced from Jatropha Seed Oil.* Grand Rapids: Team 9: oil from the soil.

Golshokouh, I., Syahrullail, S., & Golshokouh, M. (2014). Tribology Evaluation of Jatropha as a New Environmental Source of Lubricant. *European Online Journal of Natural and Social Sciences;Vol.3, No.3 Special Issue on Environmental, Agricultural, and Energy Science.*, pp.343-348.

Gunam, R., M., M. F., Mohd. Ghazi, T. I., Muhammad Syam, A., & Idris, A. (2015). *Synthesis of Biodegradable Lubricant from Jatropha Oil with High Content of Free Fatty Acids.* Selangor Darul Ehsan, Malaysia: Department of Chemical and Environmental Engineering, Faculty of Engineering, Universiti Putra Malaysia.

ME Mechanical. (2016, February 11). *Various Lubrication Systems*. Retrieved March 10, 2017, from ME Mechanical web site: https://me-mechanicalengineering.com/various-lubrication-systems/

Rao, Y. V., Ram, S. V., Hariharan, V. S., Raju, A. V., & P. Nageswara, R. (2009). Use of Jatropha Oil Methyl Ester and Its Blends as an Alternative Fuel in Diesel Engine. *Journal of the Brazilian Society of Mechanical Science and Engineering*, 253-260.

Sasitorn, N. (2009). Comparative study of Gasoline-Jatropha 10 percent blended fuel between carburetor and injection system motorcycle. *Thai National AGRIS Centre*.