Performance Characteristics of a Diesel Engine Fuelled with Palm Kernel Methyl Ester and Its Blend with Petrodiesel.

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ABSTRACT

The performance characteristics of a diesel engine fueled with palm kernel methyl ester and its blend with petrodiesel are presented in this paper. The methyl ester (biodiesel) was synthesized from Nigerian palm kernel oil through a direct base catalyzed transesterification process using sodium hydroxide and methanol as the catalyst and alcohol respectively. The produced methyl ester was blended with neat petrodiesel at a ratio of 20% biodiesel to 80% diesel by volume. To establish a baseline for comparison, the engine was first run on diesel. The test results interestingly revealed that the fuel blend (B20) produced higher torque at low and medium engine speeds than neat petrodiesel and unblended methyl ester (B100). It was also observed that petrodiesel developed higher torque and brake power than the unblended methyl ester (B100) at all tested speeds and showed the least brake specific fuel consumption possibly because of its higher heating value.

(Keywords: palm kernel methyl ester, biodiesel, performance characteristics, full load, fuel blend)

INTRODUCTION

Recently, there has been a growing awareness about the implications of the over dependence on fossil fuels as major sources of energy for many decades. This has raised some fears and concern about the possibility of their exhaustion in the near future as well as their impacts on human health and the environment. Most scientists believe that the global warming in recent decades has been caused primarily by the increasing concentration of greenhouse gases coming from human activities like combustion of fossil fuels and deforestation (Ofoh, 2009; EPA, 2007).

The fear of possible exhaustion of fossil fuels and the concern for human health and the environment have become the main drivers for the search for alternative energy sources which are renewable and environmentally friendly. Consequently, methyl and ethyl esters, generally called biodiesel and essentially derived from vegetable oils and animal fats, have been suggested as suitable alternative fuels for diesel engines.

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Biodiesel is the name for a variety of ester-based oxygenated fuels commonly produced through the process of transesterification. Transesterification is a reaction of a triglyceride with an alcohol in the presence of a strong acid or base (alkaline) catalyst to produce a mixture of fatty acids alkyl esters and glycerol as the byproduct. It is called methyl or ethyl ester when methanol or ethanol is used respectively in the production. A number of studies have suggested that biodiesel synthesized from vegetable oils have flow and combustion properties, heating value, octane number, flash point, viscosity, and engine performance characteristics similar to those of petrodiesel and can be used directly or as blend with petrodiesel to run diesel engines with little or no engine modifications (Canakci and Van Gerpen, 2001; Edgar, et al., 2005; Fukuda, et al., 2001; Kinas, et al., 2003).

The potential benefits of pure and blended biodiesel as alternative fuels for diesel engines have been reported in the literature such as, low emission profile, better lubricity and hence prolonged engine life, non-toxicity, biodegradability, renewable sources, and comparable engine performances (Nwafor, 2004; Somerville, 2008; Edgar, et al., 2005; Kegl, 2008; Prasad, et al., 2010). Methyl esters contain no aromatic and sulphur and hence do not produce any sulphurous oxides which are to a large extent, responsible for acid rain (Krishnakumar, et al. 2008).

Many crop oils are being studied as feedstock for the production of biodiesel such as rapeseed oil, soybean oil, groundnut oil, coconut oil, jatropha oil, algae, and palm oil. Palm kernel oil (like palm oil) is derived from oil palm (*Elaesis guineensis* jacq) which is grown in large quantity in this country. It can form a suitable feedstock for sustainable biodiesel project in Nigeria. Palm kernel oil contains 80% saturated fatty acid mainly lauric acid (Lalita, 2004) and this is an important property that enhances fuel ignition quality, oxidation stability and low engine emission (Edgar, et al., 2005). The literature contains more work on the production aspects of methyl ester from palm kernel oil than the engine performance evaluations. Alamu, et al. (2007) carried out a short-term engine test of neat palm kernel methyl ester (biodiesel) during which they monitored only the engine torque and power. The results of their work were very promising. Against this backdrop, it is expedient to carry out more detailed investigations into the potentials of palm kernel methyl ester and its blend with petrodiesel as alternative fuels for diesel engines.

MATERIALS AND METHODS

Materials

The fuels used in this test are the No. 2 diesel (petrodiesel) purchased from fuel station in Owerri, methyl ester (B100) produced from Nigerian palm kernel oil through direct base catalyzed transesterification process and a blend 20% biodiesel and 80% petrodiesel by volume (B20). The palm kernel methyl ester and its blend were characterized in accordance with ASTM methods and the results are shown on Table 1.

Table 1: Physical Properties of Palm kernel Methyl Ester (B100) and Blend (B20).

Property	ASTM No	B100	B20
Density @15°C	D1298	0.865	0.846
Flash Point °C	D93	150	123
Cloud Point °C	D2500	7.5	3.0
Pour Point °C	D97	0.0	-12
Iodine no	D1959	15.35	17.2
Heating valueMJ/kg	D3338	38.6	42.47
Cetane no	D976	54.57	51.2

Test runs were carried out on a 2-cylinder compression ignition engine coupled to a SCHENECK W130 electric eddy current dynamometer. It is a water cooled, direct injection, naturally aspirated four-stroke (RD270) engine with the following specifications:

Bore	95mm
Stroke	85mm
Piston displacement	1205cc
Compression ratio	18
12hour rated output	23.4hp@3000rpm
Torque (Nm)	67/2300
No of cylinders	2

Methods

The engine was started and allowed to idle till the normal operating temperature was attained. The rack was adjusted to full load position and the external load on the engine was gradually increased which resulted to decrease in the engine speed. The engine was run on neat on neat petrodiesel and then its blend and pure biodiesel (methyl ester) Readings of the torque, and fuel consumption rate were taken at every 400rpm interval between 1200rpm and 3600rpm for the various fuels. The results are presented on Table 2-5. The engine was first run on neat diesel and then on pure biodiesel (B100) and its blend with petrodiesel (B20).

RESULTS AND DISCUSSIONS

The results of the engine tests are presented in Tables 2 to 5.

Engine Torque

The engine torque developed at different speeds under full load for the three fuels are presented in Table 2. The values were plotted on Figure 1. It can be observed from the plots that the torque curves for the 3 fuels showed similar trends and they all attained their peak values at the same speed (2400 rpm). Interestingly, the fuel blend (B20) developed higher torque at low and medium speeds than the petrodiesel and neat palm kernel methyl ester as well as the highest 'peak torque'. Since torque represents the ability of an engine to do work, it could be suggested that B20 has a higher load carrying capacity than others, hence a greater potential for heavy duty automotive engines which are usually required to develop high torque at low engine speeds. The engine has a rated torque of 67Nm at 2300 rpm while B20 developed 65.9Nm at 2400rpm. Petrodiesel and the neat methyl ester developed 64.30Nm and 61.40Nm, respectively, at the same speed.

Table 2: Engine Torque (Nm) Variation with Speed at Full Load.

Speed (Rpm)	Petrodiesel	B20	B100
1200	50.30	51.30	49.10
1600	54.40	55.10	54.90
2000	58.70	59.10	59.10
2400	64.30	65.90	61.40
2800	57.50	57.20	57.10
3200	54.20	52.90	52.10
3600	47.20	48.90	46.80

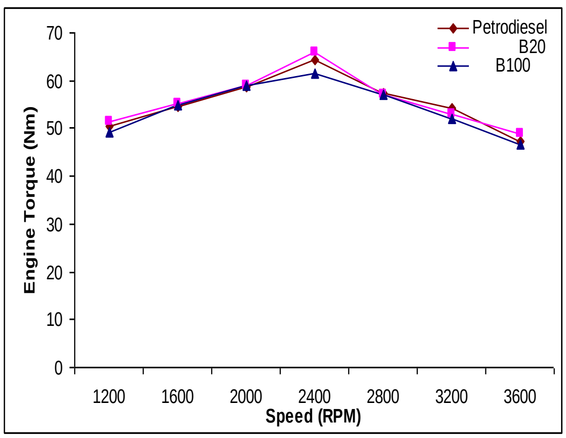

Figure 1: Engine Torque vs. Speed at Full Load.

Brake Power

The brake power values for the three fuels are shown in Table 3 and plotted in Figure 2. The engine brake power curves for the 3 fuels increased with engine speed and coincided up to 2000rpm. They diverged beyond this point and attained their peak values at different speeds. The brake power for B20 attained peak value at higher engine speed than those of petrodiesel and neat palm kernel methyl ester. This is an evidence of its superior full load sustaining capacity at high speeds, and is an imported factor needed for heavy duty haulage trucks.

Table 3: Brake Power Variation with Speed at Full Load.

Speed (Rpm)	Petrodiesel	B20	B100
1200	6.32	6.45	6.17
1600	9.12	9.23	9.20
2000	12,30	12.38	12.38
2400	16.16	16.56	15.43
2800	16.78	16.86	17.33
3200	18.17	17.73	17.46
3600	17.80	18.44	17.65

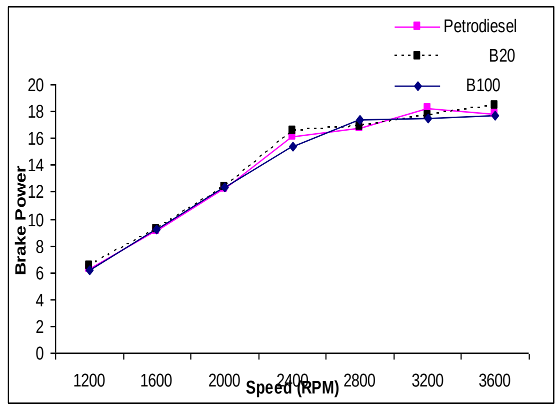

Figure 2: Engine Brake Power vs. Speed at Full Load.

Brake Specific Fuel Consumption

This is a performance criterion that shows the amount of fuel used by the engine to develop one kilowatt shaft power, hence it has a strong correlation with the heating value of fuel. The higher the heating value of a fuel, the lower the brake specific fuel consumption. The results of this test confirmed this because the petrodiesel which has the highest heating value exhibited the lowest brake specific fuel consumption followed by the fuel blend (B20 and then the palm kernel methyl ester. This is in the reverse order of their heating values. It can be observed from Figure 3 that as the engine speed increased, the brake specific fuel consumption decreased to a minimum and then increased. The increase in brake specific fuel consumption to the right could be attributed to the increase in the engine friction power with speed. This demands the burning of more fuel to develop enough power to overcome friction and sustain motion.

Table 4: Brake Specific Fuel Consumption Variation with Speed at Full Load.

Speed (rpm)	Petrodiesel	B20	BI00
1200	0.440	0.483	0.618
1600	0.309	0.343	0.420
2000	0.233	0.260	0.316
2400	0.181	0.197	0.257
3000	0.180	0.203	0.235
3200	0.166	0.196	0.239
3600	0.175	0.200	0.242

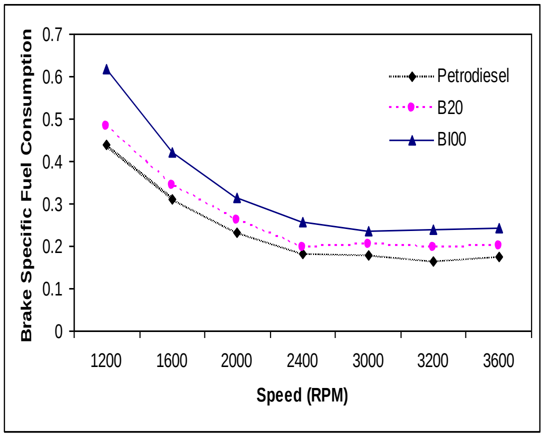

Figure 3: Brake Specific Fuel Consumption vs. Speed at Full Load.

Brake Thermal Efficiency

This is a performance criterion that relates the brake power with the energy input to the engine. It is essentially affected by the heating value of fuel. As shown on Figure 4, the brake thermal efficiency of petrodiesel exceeded those of palm kernel methyl ester (B100) and its blend (B20) at all tested speeds under constant engine load condition. It was observed that brake thermal efficiency is highly correlated with brake specific fuel consumption, the lower the brake specific fuel consumption, the higher the brake thermal efficiency.

Table 5: Brake Thermal Efficiency Variation with Speed at Full Load.

Speed (Rpm)	Petrodiesel	B20	B100
1200	18.63	16.68	13.03
1600	26.38	23.49	19.16
2000	34.96	31.00	25.46
2400	45.13	40.80	31.31
2800	46.04	39.66	34.27
3200	48.97	41.05	33.68
3600	46.43	40.31	33.24

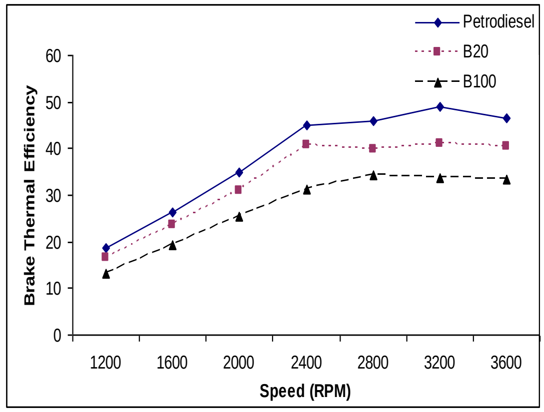

Figure 4: Brake Thermal Efficiency vs. Speed at Full Load.

CONCLUSION

Based on the results of this engine full load performance tests, it could be concluded that; Methyl ester from Nigerian palm kernel oil and its blend with petrodiesel are suitable alternative fuels for modern diesel engines. This is evident from the very close similarity of their performance curves with those of petrodiesel in terms of trend and magnitude.

The fuel blend (B20) has greater potential for heavy duty automotive and marine engines than neat methyl ester (B100) and petrodiesel. This is because of its better torque performance at low and medium engine speeds as well as better load sustaining capacity at higher speeds. Petrodiesel has better fuel economy and brake thermal efficiency than the neat palm kernel methyl ester (B100) and its blend (B20).

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SUGGESTED CITATION

Igbokwe, J.O. and O.O. Obiukwu. 2013. "Performance Characteristics of a Diesel Engine Fuelled with Palm Kernel Methyl Ester and Its blend with Petrodiesel". *Pacific Journal of Science and Technology*. 14(2):75-79.

Pacific Journal of Science and Technology