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PRODUCTION OF NEEM AND YELLOW OLEANDER SEED OIL BIODIESEL BLENDS AND EVALUATION OF THEIR PERFORMANCES IN A COMPRESSION IGNITION ENGINE

Abdullahi Madu YAMI[1,*], Mudathir Abdulsalam HASSAN[1], Mohammed E. IBRAHIM[1], Yusuf J. SOJA[1]

[1]Department of Mechanical Engineering, Modibbo Adama University Yola, Adamawa State, Nigeria

Abstract

In this study Neem and Yellow oleander biodiesels were blended in some given proportions and characterized. An F165 diesel engine was ran with each blend and its performance parameters evaluated and compared to those obtained when the engine ran on Automotive Gas Oil (AGO). The produced neem oil biodiesel (NOB) and yellow Oleander biodiesel (YOB) were blended together in a percentage ratio of 20:80, 40:60, 60:40 and 50:50 percentages for Neem and Yellow oleander biodiesels respectively. Results show that brake power of the blends is close to that of AGO at lower torques but developed higher power at higher torques (2.69 kWh at 10Nm for N10Y40 and 2.68 kWh for AGO). The blends exhibited close comparison with the AGO in thermal efficiency. The results of the study show a diesel engine perform well with pure biodiesel blends as fuels as it does with fossil AGO, thus new biofuel was produced capable of replacing conventional diesel fuel in the transportation industry.

Keywords: *Automotive Gas Oil, Biodiesel blends, Compression ignition, Thermal efficiency, Total hydrocarbon*

Introduction

The continuous rise in the earth's atmospheric temperature is basically attributed to the greenhouse effects occasioned by increased presence of CO_2 and other air pollutants. Greenhouse gases, such as CO_2, CH_4 and N_2O are major gaseous emissions that bring about global air pollution [1, 2].

The use of fossil fuels is a major cause of greenhouse gases (GHGs) which cause global warming resulting in ozone layer depletion, glaciers melting and environmental pollution. As the world's population increases and corresponding hike in industrial activities to meet up with daily energy demands of people and machines, the level of release of GHGs becomes higher than ever before [1].

The search for alternative sources of energy that is cheap, renewable, and environmentally friendly have recently occupied the energy research space. Seed oil biodiesel, a cheap renewable biofuel with clean burning characteristics, has been found to have the production capacity to reduce the worldwide reliance on petroleum diesel fuels. Research continue to show that biodiesel products from several seed oils have fuel properties equivalent to those of diesel fuel, with lower harmful emissions [3]. In their investigation of the combustion, emission and performance characteristics of Palm steering Biodiesel on a Direct Injection engine, [4] reported higher thermal and mechanical efficiencies of engines ran with biodiesel relative to fossil diesel. The presence of large amount of oxygen molecules in biodiesel structure results in total engine ignition which lowers HC and CO formation [5-7].

*Corresponding author: ibnbatal72@gmail.com

The current study is aimed at determining the physical and chemical characteristics of biodiesel blends produced from neem seeds oil and yellow oleander seeds oil biodiesels and compare the performance of compression ignition engine when run with the different ratios of the blends and automotive gas oil (AGO).

Methodology

Biodiesel blending

A volume by volume mixture of the neem and yellow Oleander biodiesels were blended in the following proportions: N20YO40 (20% neem by volume and 80% yellow oleander by volume); N40YO60 (40% neem by volume and 60% yellow oleander by volume); N60YO40 (60% neem by volume and 40% yellow oleander by volume); and N50YO50 (50% neem by volume and 50% yellow oleander by volume) and are presented in Table 1.

Engine Performance Characteristics

Automotive gas oil was initially used to start the engine and allowed to stabilize and get warmed for 30 minutes. Neem / yellow oleander biodiesel blend was then introduced into the tank and used to flush out the fossil diesel from the engine system. Actual tests Engine performance experiments for engine performance were conducted in accordance with SAE standard (SAE J1349 Revised MAR 2008) as reported in [8]. The machine is a four stroke single cylinder diesel engine test rig which was connected to TD114 IC engine instrument shown in Fig. 1. Table 2 shows the detailed description of the engine. A single oil tank was employed for both the AGO and neem/yellow oleander seed oil biodiesel blends. About 160 ml of neem/yellow oleander biodiesel blend was then loaded into the fuel tank of the test engine and the tests conducted for each value of torque. Three experiments were conducted for each biodiesel blend and the results were averaged to determine the repeatability of the measured data and have an estimate of measured accuracy. After the experiments, the neem/ yellow oleander biodiesel blends were flushed out of the fuel lines and injection system by injecting fossil diesel fuel while keeping the engine running for a while before shutdown. The variations of the engine performance parameters were measured or calculated against varying engine torques and presented as shown in Fig. 6 to 15 respectively.

Table 1. Composition of Neem/ Yellow Oleander Biodiesel Blends

Blend (% x 2)	Neem Oil biodiesel (ml)	Yellow oleander Oil biodiesel (ml)	Total (ml)
N10Y40	32	128	160
N20Y30	64	96	160
N30Y20	96	64	160
N50Y50	80	80	160

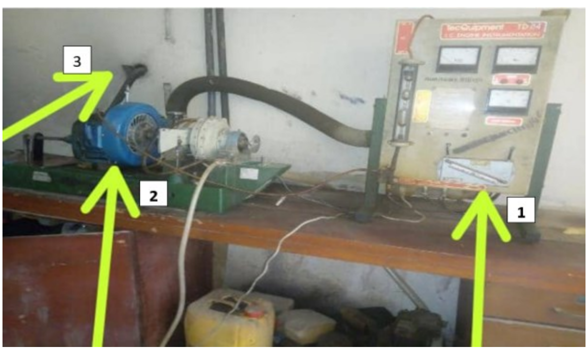

Fig. 1. F165 Diesel engine test rig connected to TD114 IC engine instrumentation: 1 - TD114 IC engine instrumentation; 2 - F165 Diesel engine test rig; 3 - Exhaust pipe

Brake power

The engine was clamped on to a test bed and the shaft connected to the dynamometer rotor. The rotor was coupled by mechanical friction to a stator which is supported in low friction bearings. The stator was balanced with the rotor stationary. The torque exerted on the stator with the rotor turning was measured by balancing the stator with weights. The engine brake power (P_B) was calculated using equation (1) [8].

$$P_B = \frac{2\pi NT}{60} \tag{1}$$

Where: T is the engine's torque (Nm), N the engine's rotational speed (rpm) and P_B the engine brake power

$$\omega = \frac{2\pi N}{60} \tag{2}$$

Where ω is the angular speed in rad/s.

Therefore:

$$P_B = T\omega \tag{3}$$

Brake specific fuel consumption (SFC)

The brake specific fuel consumption (SFC) is the ratio of the engine fuel consumption to the engine output as measured at the flywheel and is calculated by equations (4) and (5) [10]

$$SFC_B = \frac{Mf}{\mathrm{PB}} \tag{4}$$

$$M_f = \frac{8\rho\ \times}{t} \cdot 10^{-6} \tag{5}$$

Where: M_f = fuel consumption rate, kg/s; ρ = density of fuel, kg/m^3, t = time taken, seconds.

Brake thermal efficiency (BTE)

Brake thermal efficiency (η_{BT}) is defined as the actual brake work per cycle divided by the amount of fuel chemical energy as indicated by the fuel's lower heating value. It was calculated using equation 6 [10].

$$\eta_{BT} = \frac{P_B}{M_f \times H_g} \times 100 \tag{6}$$

Where H_g is the lower heating value of diesel fuel (MJkg^{-1}).

Brake Specific energy consumption

Specific energy consumption defines energy used to produce a product [9].

Results and Discussions

Biodiesel blends Characterization

The properties of neem and yellow oleander biodiesel blends and the AGO used in this study are shown in Fig. 2 while their comparison with single stock biodiesel fuels is in Fig 3. Similarly, the average values of the properties of the blends as compared to those of single stock biodiesels and AGO are in Fig. 4 and Fig. 5. It can be seen from the results that, blending the two biodiesel samples resulted in blends with improved properties. The viscosities of the blends ranging from 4.185mm^2/s for N50Y50 blend to the lowest value of 4.128mm^2/s for the N30Y20 blend fall within the 1.9- 6.0mm^2/s limit of ASTM D6751. The biodiesel blends can therefore be said to possess the right viscosities to perform effectively in diesel engines. The higher the viscosity of a fuel, the poorer the atomization of the fuel would be thus, operation of the injection would be less accurate. The average value (4.152mm^2/s) also shows similar trend with reductions of 18.5% and 19.7% of the viscosities when compared to neem and yellow oleander biodiesels. There is a significant reduction in viscosity implying enhanced suitability of biodiesel blends as substitutes for fossil diesel.

The highest flash point recorded for the blends is 129.36ºC, for the N10Y40 blend while the mean is 124ºC. Though their flash points are lower than ASTM D6751 (130ºC minimum) standard, the biodiesel blends are safer than conventional diesel fuel (AGO) with flash point of 68ºC in terms of storage and transportation from the standpoint of fire hazard. They also have better flash points than neem oil biodiesel (98.4ºC) and comparable to yellow oleander oil biodiesel (129.2ºC). The cloud points of the biodiesel blends (highest 12.6ºC for N20Y30) are lower than those of neem and yellow oleander biodiesels but are still higher than that of AGO (6ºC), this implies that cold flow properties improve with blending. There are improvements in pour points of the biodiesel blends in comparison to the values obtained for neem (10ºC) and yellow oleander (8ºC) biodiesels. The lowest value obtained for the biodiesel blends is 8.4ºC for the N10Y40 blend while the highest value is 9.2ºC for the N30Y20 blend. Despite these improvements, the pour points of the biodiesel blends are still higher than that of AGO (- 4ºC) and require anti gelling additives for them to function properly in cold weather conditions. Cetane number, the measure of diesel quality is superb for all the blends, with the lowest value of 53.60 for N30Y20 and better than the fossil diesel fuel, AGO of 51. All the blends also have better cetane values than neem and yellow oleander biodiesel fuels. Blending improved the heating/calorific values of the biodiesels, with the lowest of 40.352MJ/kg for N10Y40 blend which is greater than neem oil biodiesel's 39.33MJ/kg and a highest value of 42.896MJ/kg for N20Y30 blend about equal to value for AGO (43.50MJ/kg). Blending also improved the physicochemical properties when compared to the single stock biodiesels of neem and yellow oleander as can be clearly seen in Fig. 2 and Fig 3.

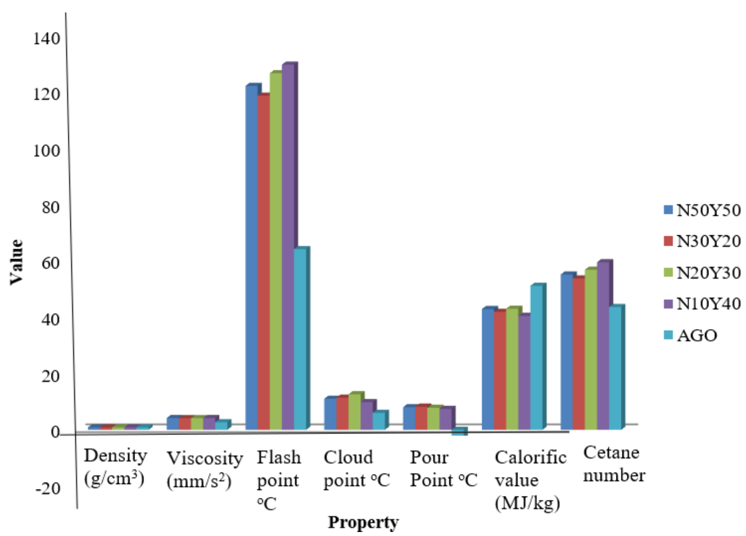

Fig. 2. Comparison of Properties of Neem- Yellow Oleander Biodiesel Blends with AGO

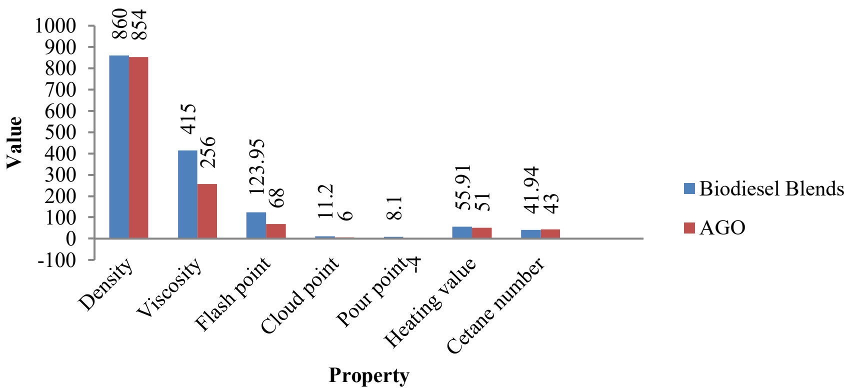

Fig. 3. Comparison of Average Properties of Neem- Yellow Oleander Biodiesel Blends with AGO

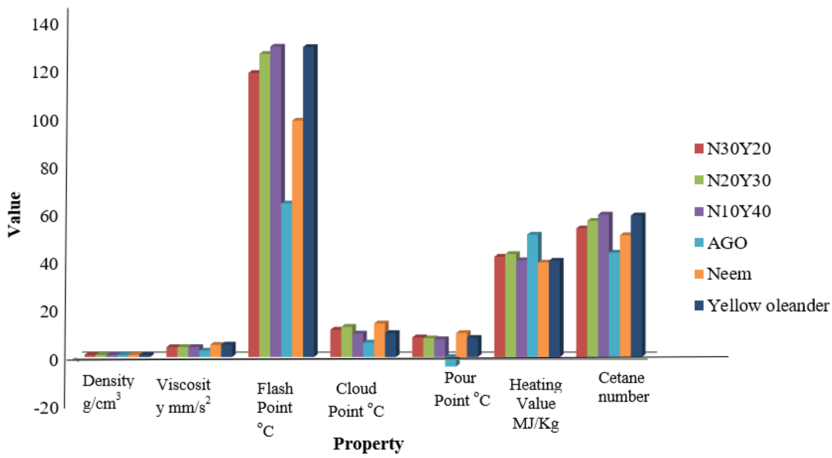

Fig. 4. Comparison of Properties of Neem- Yellow Oleander Biodiesel Blends with Single Stock Biodiesels

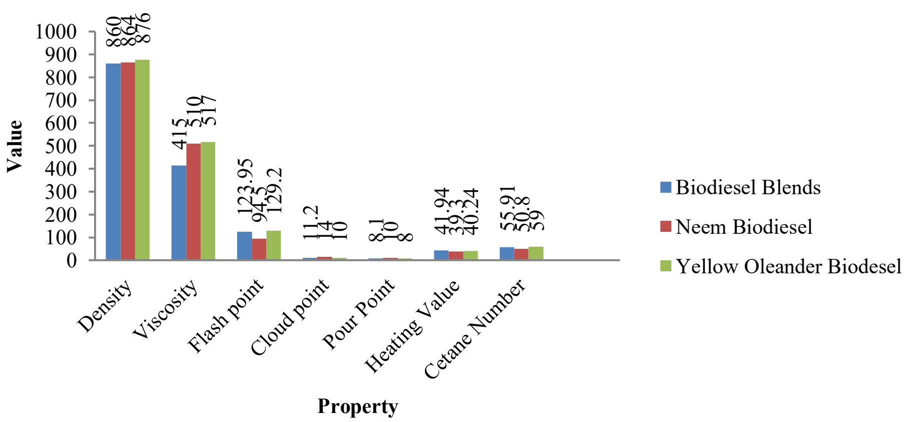

Fig. 5. Comparison of Average values of Properties of
Neem- Yellow Oleander Biodiesel Blends with Single Stock Biodiesels

Engine Performance Evaluation

The results of performance tests of the engine ran with different biodiesel fuels blends when compared with AGO show that brake power increases with increasing torque. Pure biodiesel blends produce slightly higher brake power compared to fossil diesels (AGO) shown in Fig. 6. A similar result was reported by [11] when castor and jatropha pure biodiesel blends were used to run the CI engine. Results from this study show that the highest brake power of 2.69 kW at an operating torque of 10 Nm was achieved when the engine was ran with N10Y40 biodiesel blend. Under the same conditions, AGO and the other biodiesel blends produced 2.68 kW brake power.According to [12, 8], the relative high viscosity of biodiesel increases fuel spray penetration thereby improving air- fuel mixing resulting in high engine power. The high lubricity of biodiesel which reduces friction loss also improves the brake effective power [13]. The mean values of brake power (Fig. 7) at all torques show similar performance with AGO with negligible difference of 0.17% in the case of 4.5N torque.

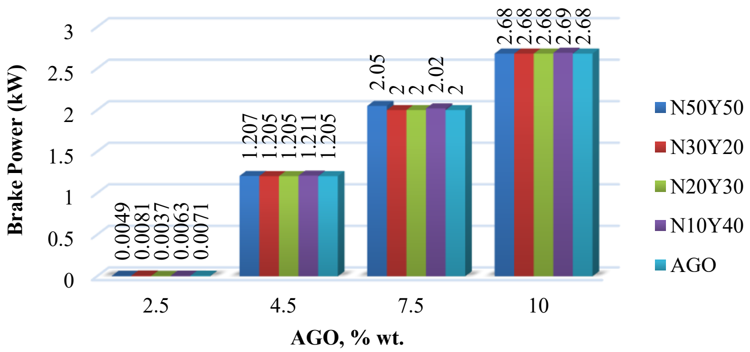

Fig. 6. Comparison of the Brake power of Neem- Yellow Oleander Biodiesel Blends with AGO

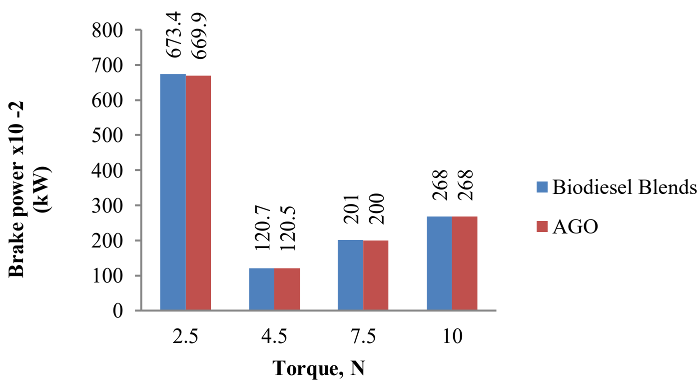

Fig. 7. Comparison of Mean Brake power of Neem- Yellow Oleander Biodiesel Blends with AGO

The fuel mass flow rate for both AGO and biodiesel blends increased steadily with increase in torque due to extra energy required to overcome the increased load shown in Fig. 8. As shown MFR is higher in biodiesel fuel blends than in conventional diesel at all values of torque. A similar trend was reported by [14] . The implication of increased fuel mass flow rate with increase in torque is more energy will be available to the engine to overcome the increased load. However, for the same power output one needs to spend more on fuel when using biodiesel as fuel for diesel.

N10Y40 blend has highest fuel mass flow rates (0.459kg/s, 0.55kg/s, 0.669kg/s and 0.8177kg/s for 2.5Nm, 4.5Nm, 7.5Nm and 10 Nm torques) for all values of torque used in this study.

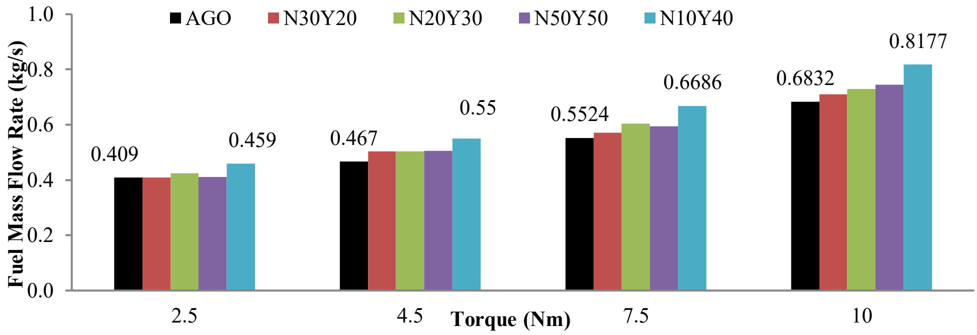

Fig. 8. Comparison of MFR of biodiesel blends to AGO at varying torques

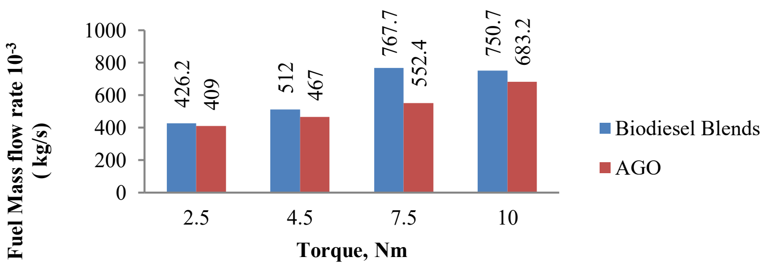

Fig. 9. Comparison of Mean MFR of biodiesel blends to AGO at varying torques

The mean MFR shown in Fig. 9 exhibit an increasing rate with increase in toque up to 7.5N with 39% higher rate than AGO at 7.5N.

The specific fuel consumptions of all the blends and AGO are observed to be decreasing with increasing torque. At full torque, 10Nm the specific fuel consumption of AGO is 254.93g/kWh while the N10Y40 biodiesel blend recorded value of 682.02g/kWh as shown in Fig. 10 and Fig. 11.

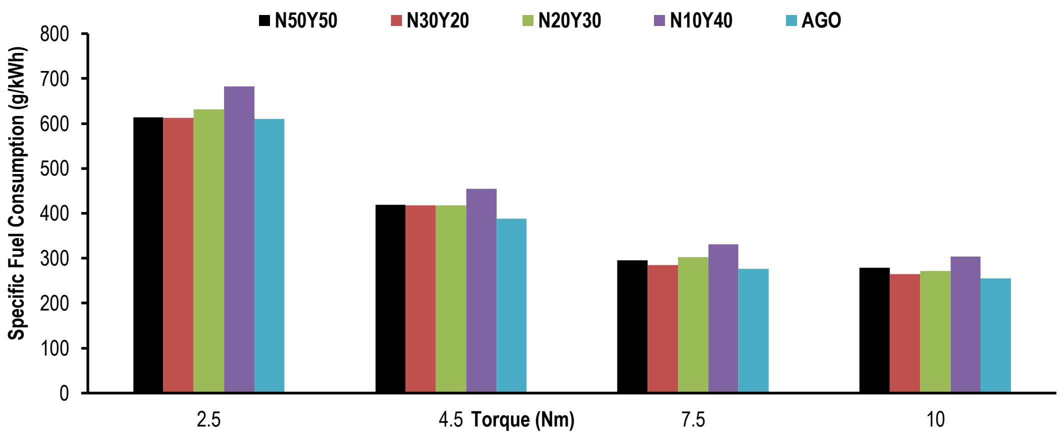

Fig. 10. Comparison of SFC of biodiesel blends to AGO with varying torques

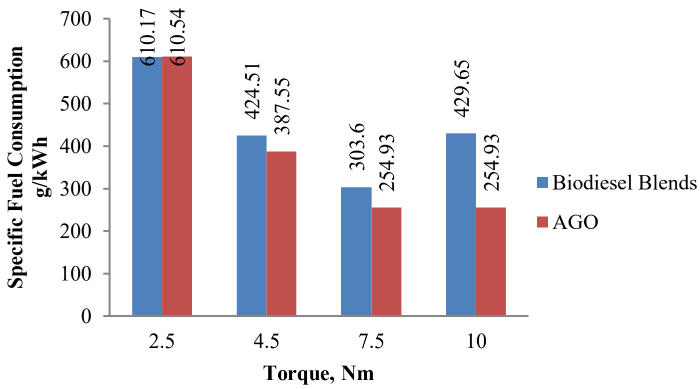

Fig. 11. Comparison of Mean SFC of biodiesel blends to AGO with varying torques

Similar results were reported by [15, 16]. This increase in SFC of the pure biodiesel blends is due to high mass flow rate. Excess oxygen in biodiesel blends engenders complete combustion of the fuel resulting to more fuel entering the combustion chamber. The increase in the SFC of an engine fueled by neem and yellow oleander biodiesel blends can also be attributed to low volatility and high density and viscosity, which affect the mixture formation, leading to slow combustion which results in a high-energy output for the same quantity of neem and yellow oleander biodiesel blends implying that more fuel must be consumed to produce the same power when using diesel fuel [17]. The brake thermal efficiency (BTE) shows how well an engine converts heat energy from fuel to mechanical energy. The effects of varying torque on thermal efficiency in Fig. 12 and Fig. 13 when AGO and biodiesel blends were used to power the engine revealed that the blends exhibited close comparison with the AGO. Lower thermal efficiencies were obtained for biodiesel fuel blends compared to diesel fuel [18].

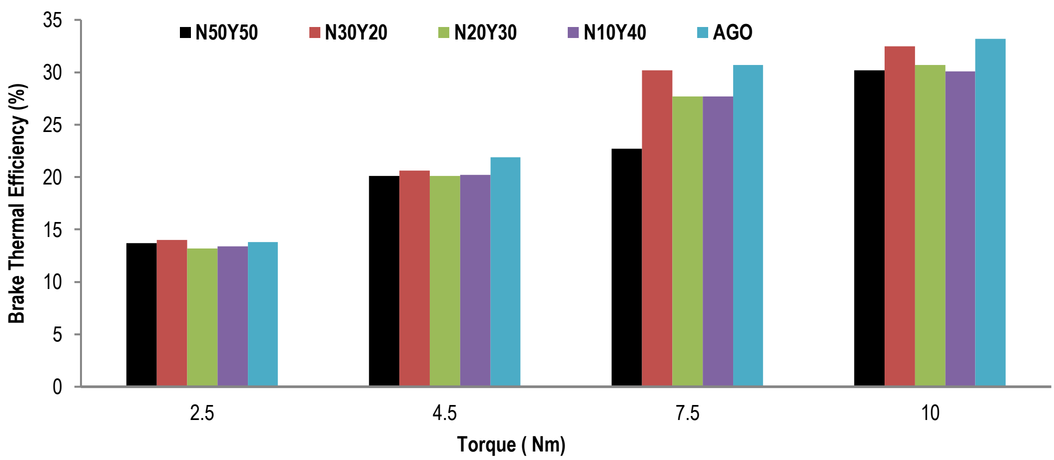

Fig. 12. Comparison of BTE of biodiesel blends to AGO with varying torques

The brake thermal efficiencies increased as the torque was increased for all the blends utilized. The difference in the response of AGO and biodiesels was quite insignificant (1.6% to 5.9% for various torques) even though AGO performed better. The increment in BTE with increase in torque, according to [19] is due to reduction in the heat loss and increases in the power developed with increase in the torque. The N30Y20 blend gave the best thermal efficiencies for all torques with the highest value of 32.5% at the torque of 10Nm. AGO, at this torque gave a thermal efficiency of 33.2%. The lowest efficiency recorded (30.1%) was in the N10Y40 blend. The lower values of BTE for the biodiesel blends could be explained by their lower calorific values which resulted in low power output.

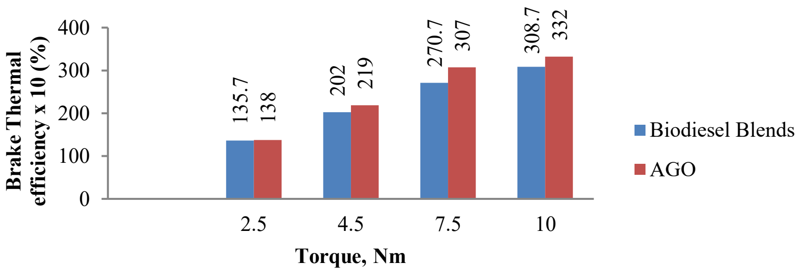

Fig. 13. Comparison of BTE of biodiesel blends to AGO with varying torques

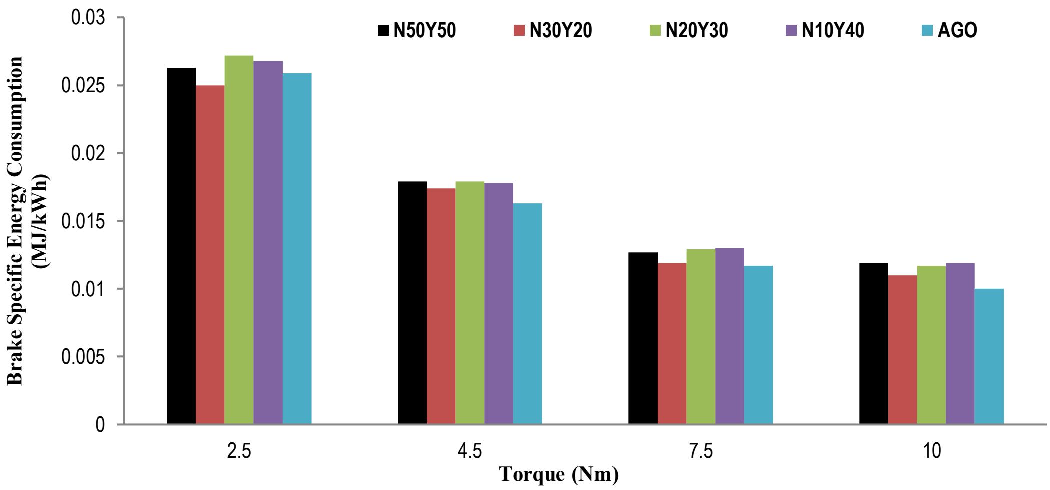

Fig. 14. Comparison of BSEC of biodiesel blends to AGO at varying torques

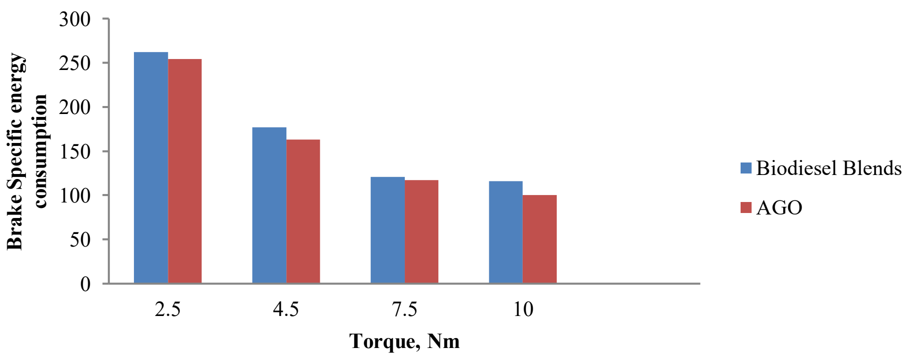

Fig. 15. Comparison of Mean BSEC of biodiesel blends to AGO at varying torques

There was decrease in BSEC with increase in engine torque for both fuels but with values higher for all the biodiesel blends at all levels of torque compared to corresponding diesel values (Fig. 14). A similar trend was observed by [19, 20 and 21] when neat biodiesel (B100) was used to run a CI engine. All the biodiesel blends have BSEC higher than AGO. Among the biodiesel blends, N20Y30 blend gave the highest BSEC (0.0272 MJ/kWh) while N30Y20 gave the lowest value (0.0250 MJ/kWh). This can be attributed to high mass of biodiesel consumed by the engine at a particular instant. In Fig. 15, the blends mean show similar reduction in BSEC with increasing torques all indicating higher BSEC for the blends, 16% and 8% higher than AGO for 10N and 4.5N torques.

Conclusion

Neem and Yellow oleander biodiesels were blended, characterized used to run a diesel engine and the performance characteristics determined. From the results, the following conclusions can be drawn:

1. The properties of the blends satisfy international (ASTM) standards for biodiesels.
2. Engine performances with Neem- Yellow oleander biodiesel blends are in close agreement with its performances with (AGO).
3. Pure biodiesel blends can be used to run compression ignition engine without any engine modification

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