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Performance and Emission Characteristics of Neem Oil Methyl Ester and Its Blends with Diesel Fuel

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ABSTRACT: In this research an analysis of the results of utilization of bio-diesel blends on diesel engine performance and its emissions. The bio-diesel fuels were produced from refined neem oil via the reversible reaction (transesterification) process and was tested on a Perkins 4:108 diesel engine fitted on a stable condition engine test bed. The engine is afour cylinders, water-cooled, and four-stroke CI engine. The investigation was performed to test the biodiesel performance and emission of engines with different blends at different load conditions . The engine was tested in a series of fixed operating conditions at engine speeds of 1200, 1400, 1600, 1800 and 2000 rev/min and engine loads of 20%, 40%, 60%, 80% and 100%.The performance variables evaluated comprises of brake torque (Nm) ,fuel consumption (kg/s), brake power (kw), specific fuel consumption and fuel thermal efficiency. It was observed that biodiesel and blends have lower thermal efficiency than standard diesel, the BSFC decreases with the increase in engine speed until minimum BSFC is found at 1400 rpm and then increases with increase in engine speed until 2000 rpm and the brake power of the engine with standard diesel was higher than for biodiesel. Carbon monoxide (CO) was lower on operation with biodiesel blends, but Nitrogen Oxide (NOx) have higher emissions on operation with biodiesel blends.From the analysis, the optimum performance was obtained in B20 blend which indicated better fuel qualities and engine performance.

Key words: Neem oil, biodiesel, Engine performance,Compression Ignition, Diesel Engine.

I. INTRODUCTION:

Due to the increment in the costs of petroleum products, devitalization of the globe crude oil resources and the numerous surroundings issues correlated with the utilization of traditionalpetroleum established fuels, the requisite to realizefeasibleand environmentally-safereplacement has emerged/materialized (Amenaghawon et al., 2013; Hosseini and Shah, 2009; Mohan and Reddy, 2012). Biodiesel is considered as a possible replacement and future fuel for diesel engine due to the predicted scarcity of fossil fuels, increase in the price of the petroleum and due to the great molecular comparison between bio-diesel and petroleum-based diesel, this substitute fuel has a prospect of realizing the technological essentials of diesel fuel [26].

Biodiesel, as defined by the American Society for Testing and Materials (ASTM), is a fuel consisting of mono-alkyl esters of long chain fatty acids obtained from vegetable oils or animal fats.It is a domestic, clean-burning, sustainable liquid fuel that can be utilized in compression ignition engines instead of petroleum based diesel with slight or no alteration. The predominant biodiesel production process- transesterification, generally entails the reaction of an alkyl-alcohol with a long chain ester linkage in the presence of a catalyst to yield mono-alkyl esters (biodiesel) and glycerol. Distinct types of catalysts such as base, acid or lipase are used in transesterification for biodiesel integration, but the base-catalyzed reaction is the utmost common in the industry due to easier, faster and cheaper processing (Hassan et al., 2013). The conventional catalysts used for transesterification are homogeneous and heterogeneous catalysts. The biodiesel industry is predominated by adoption of homogeneous catalysts (such as KOH, NaOH and CH_3ONa) because of their easy usage and short time needed for transformation of triglycerides to biodiesel (Demirbas 2008; Sharma et al., 2011).Nevertheless, the use of homogeneous catalysts requires neutralization and separation from the final reaction products leading to a series of surrounding issues such as production of waste water and corrosion challenges (Georgogianni et al., 2009). Among heterogeneous catalysts which have been investigated, calcium oxide a solid base catalyst shows high prospective result in transesterification process with high oil conversion (Liu et al., 2008).

The frequently used alcohols for the transesterification include methanol and ethanol. Methanol is applied most frequently, due to its low cost and its physical and chemical advantages (Demirbas, 2005). Another advantage of using methanol is the segregation of glycerine, which can be obtained via decantation process (Nagi et. al., 2008).

Biodiesel can be produced by use of neem oil as a feed stock, as neem trees are mostly found in different region of the country. A mature neem tree produces 30 to 50 kg fruit every season. The neem seed has high oil content of 39.7 to 60%. Neem oil can be obtainable without shortage of feed stock and with lower cost. It consists of high percentage of monounsaturated fatty acids (C16:1, C18:1), a low amount of polyunsaturated acids (C18:2, C18:3) and a reserved amount of saturated fatty acids (C16:0, C18:0). The above qualities of neem oil and its fatty acid composition makes it to be a useful renewable source for biodiesel production (Radha et al., 2011; Muthu et al., 2010).

Engine performance testing of biodiesel is essential for assessing its significantqualities. Different analysts have studies the properties of a biodiesel from soybean oil in diesel engines and established that particulate matter (PM), CO, and soot mass emissions decreased, while NOx increased. Labeckas and Slavinskas [3], studied the performance and exhaust emissions of rapeseed oil methyl esters in direct injection diesel engines, and established that there were lower emissions of CO, $CO_2$and HC.Raheman et al. (2004) examined the fuel characteristics of karanja methyl esters blended with diesel from 20% to 80% by volume. It was found that B20 (a blend of 20% bio-diesel and 80% petroleum diesel) and B40 (a blend of 40% bio-diesel and 60% petroleum diesel) could be used as an appropriate alternative fuel to petroleum diesels because they apparently produced less CO, NOx emissions, and smoke density.Similar results were reported by Kalligeros et al. [4], for methyl esters of sunflower oil and olive oil when they were blended with marine diesel and tested in a stationary diesel engine. The purpose of this research was toevaluate the biodiesel produced and its blends in diesel engine, itsperformance and the emission properties of the diesel engine.

II. EXPERIMENTAL TEST ANALYSIS

The performance of the biodiesel produced by the transesterification process was evaluated on a Perkins 4:108 diesel engine fitted on a steady state engine test bed.The test engine and dynamometer were controlled by a microprocessor system equipped with data acquisition and logging. Sensors were fitted to the engine and the dynamometer to measure significant variables and send the data to the control system. The sensors measured engine load, engine speed, inlet air temperature, exhaust gas temperature, lubrication oil temperature, fuel consumption and the cooling water temperature. The system allows for highly precise measurement of the main exhaust emission components.

The engine was tested in a series of steady state operating conditions at engine speeds of 1200, 1400, 1600, 1800 and 2000 rev/min and engine loads of 20%, 40%, 60%, 80% and 100%. The performance variables measured include--brake torque (Nm), fuel consumption (kg/s), brake power (kW), specific fuel consumption and fuel thermal efficiency. The engine is four cylinders, water-cooled, naturally aspirated and four-stroke CI engine. The engine has the following specification represented in table 1. The investigations were carried out with standard diesel fuel, biodiesel and blends. The ambient temperature and pressure were observed. A short check run was done in order to ensure that all indispensable accomplices were in the functioning order before the verified/real trial.

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Table.1.Test Engine specifications

Components	Values
ENGINE	Four stroke diesel engine
Type	Perkins 4:108
Bore	79.735mm
Stroke	88.9mm
Swept volume	1.76litres/cycle
Compression ratio	22:1
Maximum BHP	38
Maximum speed	3000rpm
Number of cylinder head	4
Diameter of exhaust	$1^{1}/_{2}{}''$
Length of exhaust pipe	$36''31'$
Capacity	112kw/150hp
Maximum speed	7500rpm
KW	(N_m x rev/min)/9549.305
Capacity	50-100 cc
Orifice size	58.86mm
Coefficient of discharge	0.6

III. ENGINE PERFORMANCE/TEST ANALYSIS

A. Variation of engine speed with torque.

The variation of engine torque against speed for biodiesel, biodiesel blends and standard diesel at full load is shown in Fig.1. It can be observed that the torque decreased as the engine speed increases. This could be as a result of increase in the fuel temperature and reduction in the viscosity and the lubricity. It was also observed that the engine yields the highest torque in the speed range of 1200 to 1400 rpm, while the lowest torque was obtained in the range of 1900 to 2000 rpm. However, the torque of the engine with standard diesel was higher than for biodiesel and its blends. The reason for the reduction of torque with bio-diesel can be attributed to the lower calorific value of the biodiesel. Similar result was obtained by Abdullah et al., (2011).

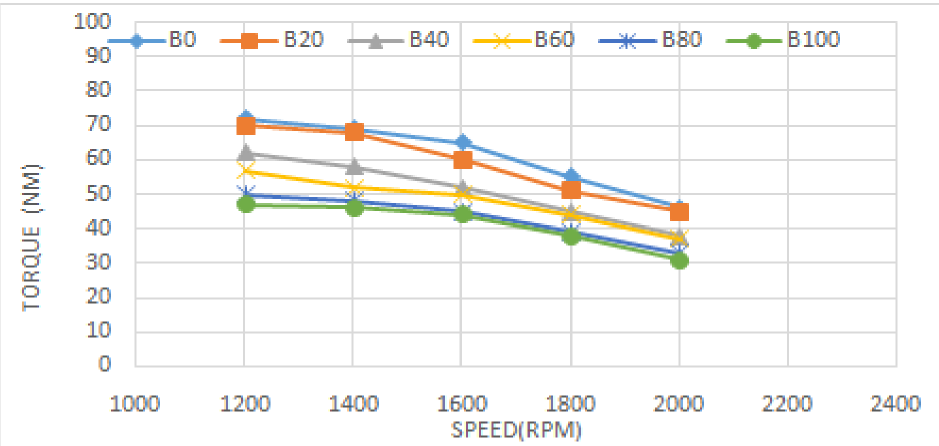

Fig.1. Variation of torque with engine speed for standard diesel and biodiesel blends

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B. Variation of engine speed with brake thermal efficiency (BTE)

The variation of brake thermal efficiency with brake power for neem biodiesel blends for a conventional engine is presented in Fig.2 .The brake thermal efficiency of the engine gradually increases with increase in engine speed .The maximum thermal efficiency for standard diesel and biodiesels was noticed to occur at 1400 rpm after attaining the maximum value (1400 rpm), it then decreased. This was as a result to the fact that, initially with the rise in engine speed, the torque produced by the engine increased, consequently efficiency increases, but at higher speed, more amount of fuel was injected into the engine cylinder per cycle and as a result to higher engine speed this fuel does not have enough time to burn completely which reduced the efficiency of the engine. It was also observed that biodiesel and its blends have lower thermal efficiency than standard diesel. This may be attributed to their oxygen content and high cetane number of the biodiesel.

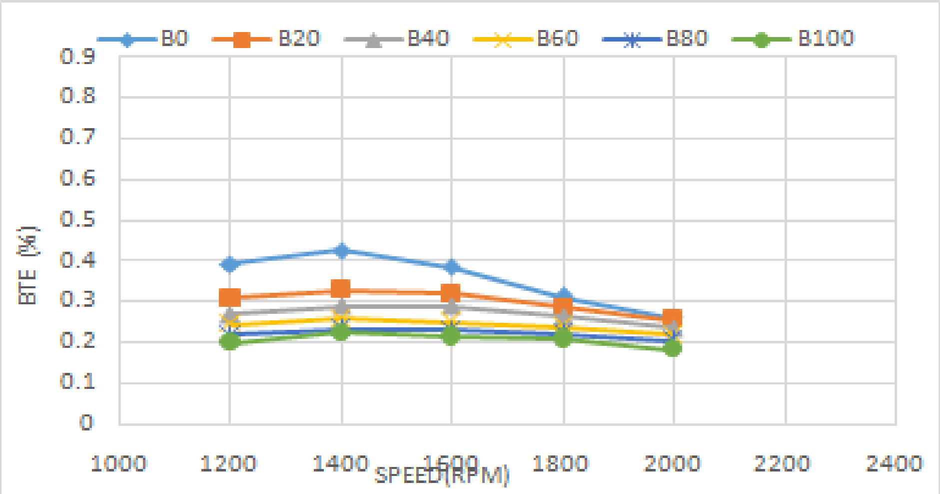

Fig.2. Variation of brake thermal efficiency with engine speed for standard diesel and biodiesel blends

C. Variation of engine speed with brake specific fuel consumption (BSFC).

Figure 3 shows the variations in the BSFC in g/kWh for both standard diesel and biodiesels with respect to the engine speed. From the result, it showed that fuel consumption increased when using biodiesel, but this trend was weakened as the amount of biodiesel reduces in the blend fuel with diesel, this is in agreement with observation made by Xue et al., (2010). B100 has the upmost BSFC. This increase could be as a result to the collective outcomes of the higher fuel density, higher fuel consumption and lower brake power due to lower calorific value of the biodiesel. The result from the below figure also indicates that the BSFC reduced with the rise in engine speed until minimum BSFC is established at 1400 rpm and then increases with increase in engine speed until 2000 rpm.

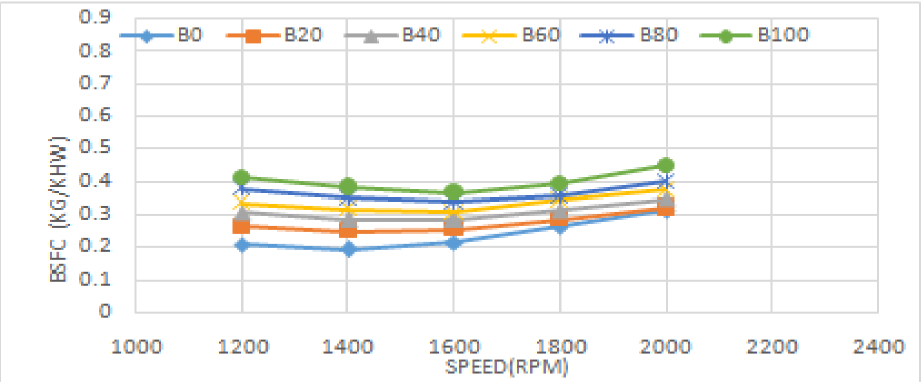

Fig.3. Variation of brake specific fuel consumption with engine speed for standard diesel and biodiesel blends.

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Fig.4. Variation of brake power with engine speed for standard diesel and biodiesel blends

D. Variation of engine speed with break power (BP).

From Fig.4, it could be observed that brake power increases as the speed increases and decreased after attaining a maximum speed of 1600rpm. This is could be ascribed to reduction in lubricity at higher speed. The brake power of the engine with standard diesel was higher than biodiesel. This is could be due to the fact that biodiesels have lower calorific values than standard diesel, both torque and brake power is reduced. This is in agreement with results obtained by Abdullah et al., (2011). Furthermore, the brake power of B20 is proportionate with that of standard diesel and this was as a result decrease in biodiesel content of B20.

E. Variation of CO emission with load

The variation of CO emission with load is shown in Fig.5.It can be observed that CO emissions for biodiesel operation was significantly lower than those for standard diesel operation because biodiesel has both a higher cetane number and a higher oxygen content which contribute to a shorter ignition delay period which is important in reducing CO emission. It can also be noticed that CO emission level decreases with increasing biodiesel content as compared with the diesel.

F. Variation of NO_x emission with load

The variation of NOx emission with respect to load for diesel and biodiesel blends is presented in Fig.6. The result showed that the diesel fuel have lower NO_x emission than blends of biodiesel (higher NO_x emission).It can also be that NO_X emissions increased with increase in biodiesel content. This is may be ascribed to higher oxygen content and cetane number in biodiesel. As the engine load increases, the NO_x emission increases for biodiesel due higher combustion chamber temperature and higher fuel consumption.

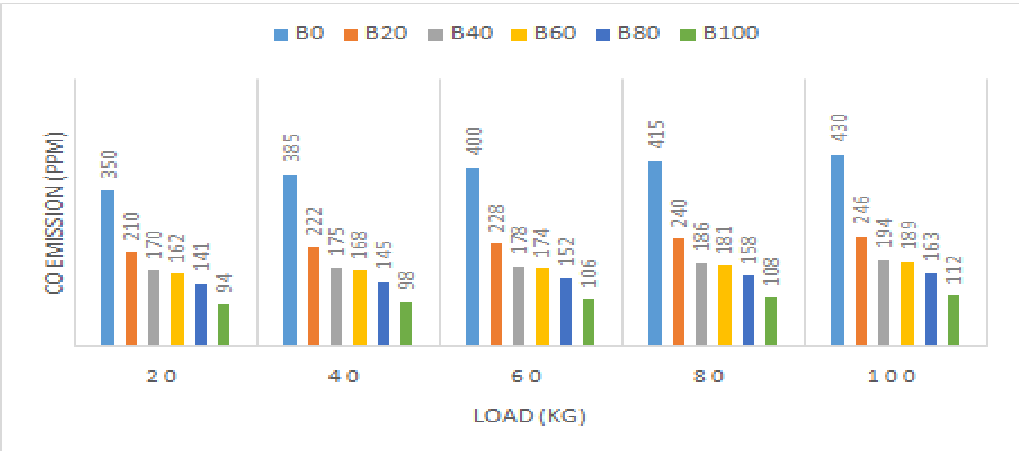

Fig.5. Variation of CO emission with load for standard diesel and biodiesel blends

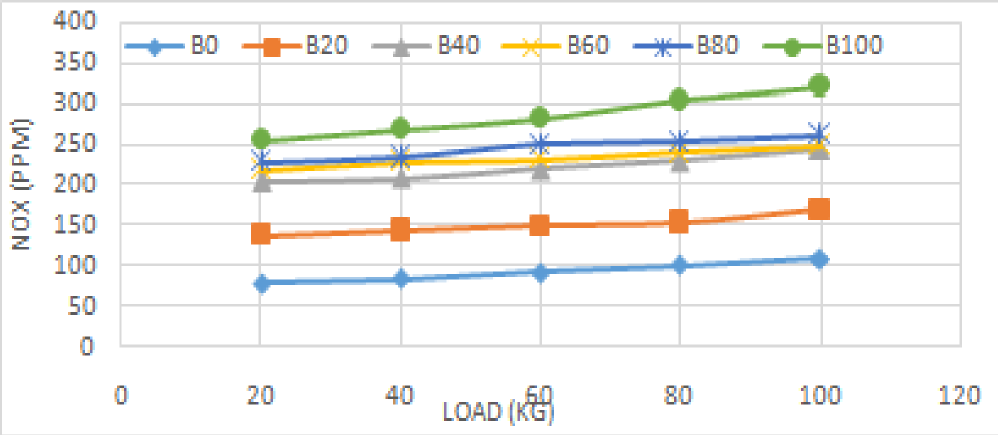

Fig. 6. Variation of NO_X with load for standard diesel and biodiesel blends

G. Variation of HC emission with load

The variation of HC emission with load is presented in Fig.7 .It can be seen that the biodiesels produced relatively lower HC emissions compared to standard diesel which indicates that HC emission reduces with increase in biodiesel content which may be attributed to the attainability of oxygen in biodiesel, which eases better combustion. It can also be observed that HC emission for biodiesel increases with increase in engine load which may be due to high fuel consumption.

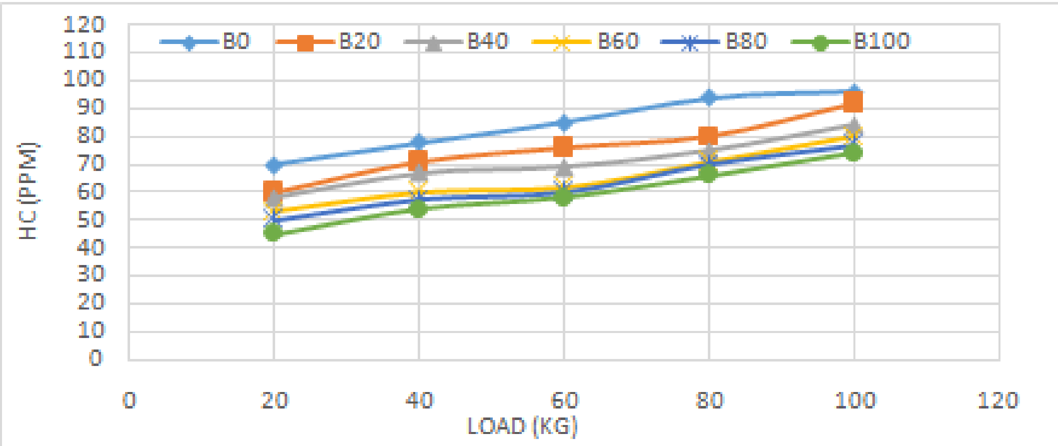

Fig.7. Variation of HC emission with load for standard diesel and biodiesel blends

5.1 Conclusions

The research was investigated to evaluates the production of neem oil methyl ester via transesterification means and performance of neem biodiesel blends with neat diesel in a single cylinder four stroke diesel engine under unstable load states of engine operations.From the above observation, it can be concluded that 20% blend of neem biodiesel with petroleum diesel can be used as a replacement fuel without any engine alteration. This helps to decrease 20% need on petroleum diesel.B40, also shows suitable results similar to B20.It can also be observed that diesel fuel have lower NO_X emission than blends of biodiesel (higher NO_X emission), CO emissions for biodiesel operation was significantly lower than those for standard diesel operation. From the combustion investigation, it was established that B20 was as good as quality diesel.

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