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Comparative Analysis of Performance and Emission Characteristics of Diesel and Bio-Diesel as A Fuel in VCR Engine

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***Abstract:** The concerns on climate change, the high energy prices and the dwindling oil reserves and supplies have necessitated a strong interest in the research of alternative fuel sources. Biodiesel is an alternative renewable fuel that has gained massive attention in recent years. Studies on the physical properties of biodiesel have shown that it is completely miscible with petroleum diesel. Since the combustion of biodiesel emits particulate matter and gases which is lower than petrodiesel, combustion of biodiesel and biodiesel blends have shown a significant reduction in particulate matter and exhaust emissions. In this review paper, the use of pure biodiesel or biodiesel blends in terms of performance and exhaust emissions has been studied in comparison to petroleum diesel mineral diesel. Combustion duration for biodiesel blends was shorter than mineral diesel.*
***Keywords:** Neem biodiesel, Global warming, Transesterifications, Pour point , Break power, Emission Characteristic.*

I. INTRODUCTION

Depletion of fossil fuels and environmental awareness has developed the need to find alternatives to diesel fuels which plays a major role in the industry and the economy of any country. Biomass and especially vegetable oils are seen to be an efficient solution on an international scale. This non-toxic resource could be produced at small scale, which could provide energy in a decentralized manner. The carbon emissions produced during the combustion of these oils are the ones which was fixed by the plant, therefore vegetable oils don't increase the global balance of CO2. Nowadays great progress has been made to improve the way vegetable oils are used. The use of vegetable oils in unmodified engines leads to many problems in long term usage. Three major drawbacks of vegetable oils adversely affect the performance of the engine namely high viscosity, poor volatility and polyunsaturated character. The high viscosity of vegetable oils implies inefficient pumping and spray formation. Therefore, air and fuel are not optimally mixed and combustion is incomplete. Furthermore, the low volatility of vegetable oils and their ability to polymerize (due to unsaturation) lead to lots of carbon deposits, injector coking and piston ring sticking. To eliminate these issues, many different processes were developed to make these oils adapt to modern engines. They allow the vegetable oils to attain properties very close to mineral diesel. These processes include direct use by blending, microemulsion, pyrolysis, transesterification etc.

Transesterification (alcoholysis) is a chemicalreaction between triglycerides present in the vegetable oils and primary alcohols in the presence of a catalyst to produce monoesters. The long and branched-chain triglyceride molecules are transformed into monoesters and glycerine. Several experimental investigations have been carried out by researchers around the world to evaluate the engine performance of different biodiesel blends. Generally, a slight power loss, reduction in torque and increased basic were observed in the see of biodiesel fuelled engines. Altin et all. studied the effect of sunflower oil, cottonseed oil, soyabean oil and their methyl esters in a single cylinder, fourstroke direct injection diesel engine. They observed a slight 3 reductions in the torque and power produced and increased basic in the case of biodiesel fuelled engines. Similar results were reported by Kaufman and Ziejewski and Antolin et al for sunflower methyl ester; Clark et al., Mcdonald. for soybean esters; Peterson et al. for rapeseed oil methyl ester etc. Carrarettoal. Carried out investigations on six cylinders direct injection diesel engine. The increase of biodiesel percentage in the blend involves a slight decrease of both power and torque over the entire speed range. In particular, with pure biodiesel, there was a reduction by about 3% maximum power and about 5% of maximum torque. Moreover, with pure biodiesel, the maximum torque was found to have reached a higher engine speed. However, Al-widyan et al reported slightly increased power and lower basic for waste oil biodiesel fuelled engines.

Rahman and Phadatre reported average of 6% increased brake power output for a Karanja oil biodiesel up to 40% blend (B40) and with a further increase in the biodiesel percentage in the blend, engine power reduced. Rahman et al.evaluated the performance of biodiesel blends at different compression ratios and injection timings of the engine. For the same operating conditions, the performance of the engine was reduced with an increase in biodiesel percentage in the blend.However, with the increase in compression ratio and advances in injection timing, this difference was reduced and the engine performance became comparable to diesel. Nabi et al. investigated the performance and emission characteristics of Neem oil biodiesel blends in a DI engine and reported a reduction in emissions including smoke and CO, while NOx emission was increased with diesel-NOME blends in comparison to conventional diesel fuel.With EGR 15% NOME-diesel blend showed better BTE and lower NOx in comparison to mineral diesel.

II. BIODIESEL CHARACTERISTICS

Important properties of Neem oil biodiesel blends used in the study are compared with mineral diesel . 7.5% Neem oil biodiesel blend is within specified ASTM limit and compare with 100%pure diesel. but the viscosity of neat biodiesel was higher than specified ASTM limit of 5 CST at 40o C. Calorific value of biodiesel and blend is lower than mineral diesel. The density of biodiesel and blend is close to mineral diesel.

The indicative Properties are as follows:

S.NO.	Property	Unit	Value
1.	Density	g/cm^3	0.82084
2.	Calorific Value	Kcal/kg	10500
3.	Ceatane Number		47.53
4.	Flash point	Deg C	147
5.	Kinematic Viscosity@40C	Mm^2/S	2
6.	Kinematic Viscosity@100C	Mm^2/S	NA

A. Setup for Experimentation

It was used for delivering signals of crank angle with a resolution of 0.5° crank angle. A TDC marker was used to locate the top dead centre position in every cycle of the engine. The signals from the charge amplifier, TDC Four-stroke, single-cylinder, constant-speed, water-cooled, direct injection diesel engine (Make: Kirloskar Oil Engines Ltd. India; Model: DM-10) was used to study the effect of Neem oil biodiesel blends on performance and emissions of the engine. The detailed specifications of the engine are given in Table 2.

The engine operated at a constant speed of 1500 rpm. The inlet valve opens 4.5° before TDC and closes 35.5° after BDC. The exhaust valve opens 35.5° before BDC and closes 4.5° after TDC. The fuel injection pressure recommended by the manufacturer is in the range of 200-205 bars. This engine consists of a gravity-fed fuelling system with an efficient paper element filter, force-feed lubrication for the main bearing, large-end bearings and camshaft bush; run-through or thermo-siphon cooling system (Figure 1). A piezoelectric pressure transducer (Make: Kistler Instruments, Switzerland; Model: 6613CQ09-01) was installed in the engine cylinder head to acquire the combustion pressure–crank angle history. Machining for installation of the pressure transducer was done in the cylinder head and the engine main shaft was coupled with a precision shaft encoder (Make: Encoder India Limited, Faridabad). Signals from the pressure transducer were amplified using a charge amplifier. The high-precision shaft encoder marker and shaft encoder were acquired using a high-speed data acquisition system (Make: Hi-Techniques, USA; Model: NASDAQ). Engine tests are done at 1500±3 RPM, for 200 bar fuel injector pressure for diesel, 100% Neem oil biodiesel (NB100) and 20% blend of Neem oil biodiesel with mineral diesel (NB20).

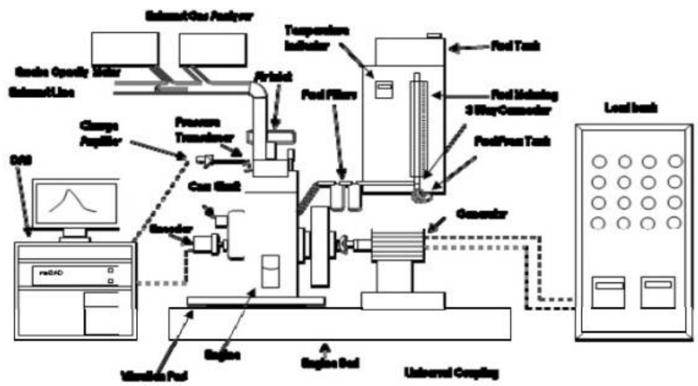

Figure 1: Schematic of Experimental Setup

Table 2 - Specifications of the engine used

Manufacturer	Kirloskar Oil Engine Ltd., India
Engine type	Vertical, 4-stroke, single cylinder, constant speed, direct injection, water cooled, compression ignition engine Model DM-10
Rated power	7.4 kW at 1500 rpm
Bore/stroke	102/ 116 (mm)
Displacementvolume	0.948 L
Compressionratio	17.5
Start of fuelinjection	26° BTDC
Nozzle openingpressure	200– 205 bar
BMEP at1500 rpm	6.34 bar

The cylinder pressure data were acquired for 50 consecutive cycles and then averaged to eliminate the effect of cycle-to-cycle variations. All tests were carried out after the thermal stabilization of the engine. Exhaust gas opacity was measured using a smoke opacimeter (Make: AVL Austria, Model: 437). The exhaust gas composition was measured using an exhaust gas analyzer (Make: AVL India, Model: DIGAS 444).It measures CO2, CO, HC, NO and O2concentrations in the exhaust gas. Experiments were conducted at 200 bars of fuel injection pressure to compare the performance of 20% and 100% biodiesel blends with mineral diesel. BSFC for NB100 and NB 20 is higher than mineral diesel (Figure 2(a)). BSFC was observed to be increased with the increasing proportion of biodiesel in the fuel. The Brake thermal efficiency of pure biodiesel was highest among the fuels used. All the blends showed higher thermal efficiency than mineral diesel (Figure 2(b)). Exhaust gas temperature for biodiesel blends is lower than mineral diesel (Figure 2(c)). But depression in exhaust gas temperature is not proportional to the quantity of biodiesel in the fuel. Lower exhaust gas temperature is caused by better thermal efficiency.

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III. ENGINE EMISSIONS

The emissions of CO increase with increasing load (Figure 3 (a)). Higher the load, richer fuel-air mixture is burned, and thus more CO is produced due to lack of oxygen. At lower loads, CO emissions for biodiesel blends are close to mineral diesel. At higher load, the biodiesel blends show a significant reduction in CO emission. All the biodiesel blends exhibit lower HC emissions compared to mineral diesel (Figure 3(b)). This may be due to better combustion of biodiesel blends due to the presence of oxygen. An increase in the emission of NO was observed in comparison with mineral diesel for the biodiesel fueled engines (Figure 3(c)). The smoke opacity for biodiesel blend fueled engines was lower than mineral diesel at all loads (Figure 3(d)).

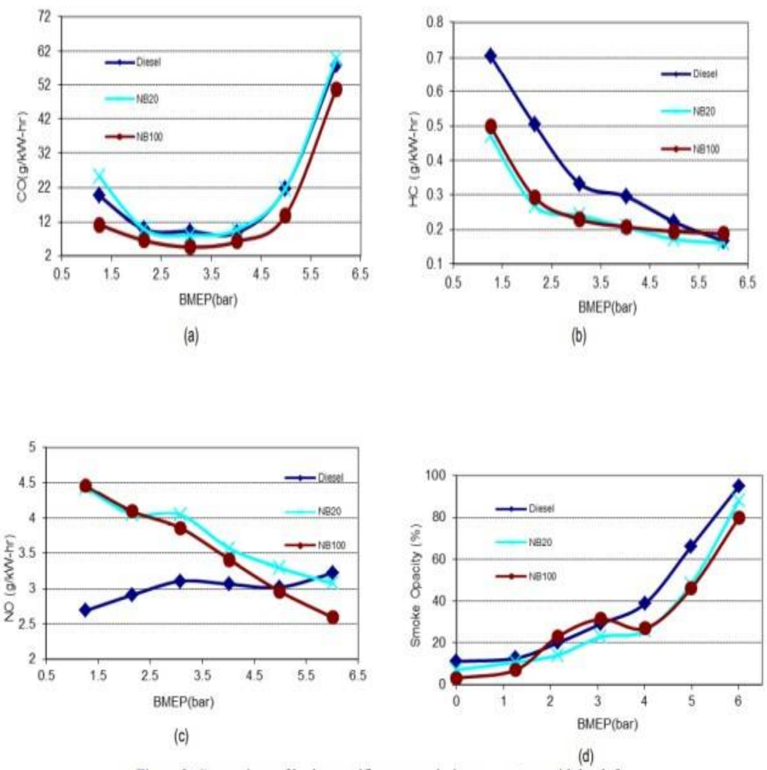

Figure 3: Comparison of brake specific mass emission parameters with load for (a) CO, (b) HC, (c) NO emissions, and (d) Smoke opacity

IV. COMBUSTION ON CHARACTERSTICS

A. In-cylinder Pressure vs. Crank Angle Diagram

The variations in the in-cylinder pressure with the crank angle for 7.5% bio-diesel and 100% purediesel blends at different engine operating conditions with a baseline data of mineral diesel are shown in figures 4(a)-(c). From these figures, it can be noticed that at higher engine loads, pressure trends are almost similar for all the fuels. 7.5%biodiesel blend shows delayed pressure rise w.r.t. mineral diesel at lower loads. For 100% purediesel start of pressure rise is comparable with mineral diesel. t all engine loads, combustion starts earlier for 100% purediesel than mineral diesel while for 7.5% biodiesel blend, the start of combustion is delayed w.r.t. to mineral diesel. Ignition delay for all fuels decreases as the engine load increases because the gas temperature inside the cylinder is higher at high engine loads, thus reduces the physical ignition delay. The start of combustion reflects the variation in ignition delay because fuel pump and injector settings were kept identical for all fuels. Figure 5(a) shows the maximum cylinder pressure at different loads for different blends. It shows that, at all engine loads, the peak pressure for the 7.5% biodiesel blend is higher than mineral diesel. The peak pressure for 2% biodiesel is higher because of the shorter ignition delay and fast burning of accumulated fuel. Figure 5(b) shows the crank angle, at which the peak cylinder pressure is attained for all fuels under different engine operating conditions. It can be observed that with increasing engine load, peak cylinder pressure shifts away from TDC (Figure 5(b)).

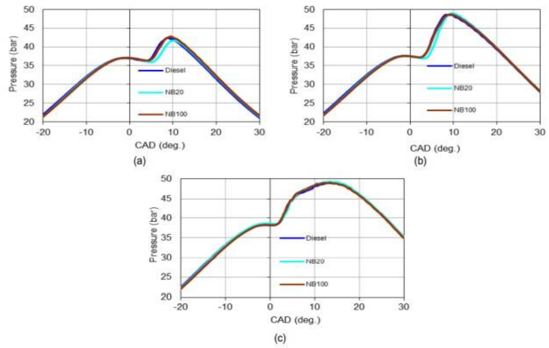

Figure 4: Comparison of in-cylinder pressure at: (a) 0, (b) 3, (c) 6 bar BMEP

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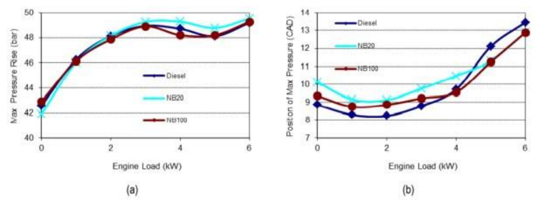

Figure 5: Variation of (a) Maximum cylinder pressure and, (b) Max pressure crank angle for rated load

Crank angle for mass fraction burn

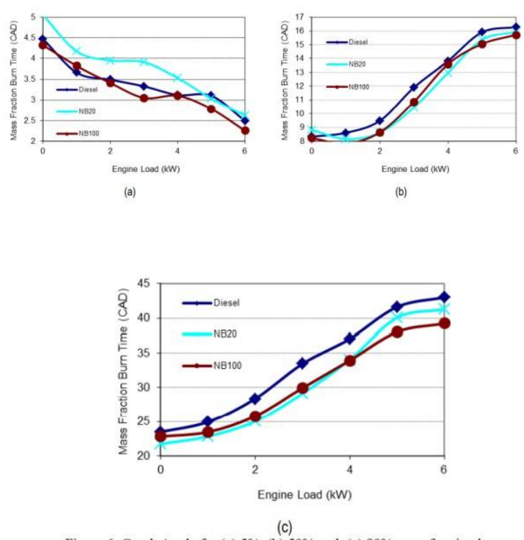

Figure 6: Crank Angle for (a) 5%, (b) 50% and, (c) 90% mass fraction burn

Figure 6(a) shows the crank angle for the 5 percent mass fraction burned. This figure shows that 5 per cent of fuel burns earlier for 100% biodiesel. This is due to the earlier start of combustion for biodiesel, as suggested earlier. 7.5% biodiesel blend shows delayed start of combustion w.r.t. to mineral diesel which indicates delay in the start of combustion due to higher viscosity of biodiesel. For 100% biodiesel delay due to higher viscosity is compensated by a higher cetane number of biodiesel.

Figure 6(b) shows the crank angle degree for 50 per cent mass fraction burned at different engine load conditions. Biodiesel blends take less time for 50% combustion as compared to mineral diesel. Figure 6(c) shows the crank angle degree for 90 per cent mass fraction burned at different engine load conditions. Biodiesel blends take less time for 90% combustion as compared to mineral diesel.

V. CONCLUSIONS

Neem oil biodiesels and its blends were characterized by measuring its density, viscosity and calorific value. Performance emission and combustion characteristics of this biodiesel and its blends were measured in a constant speed direct injection engine. Brake specific fuel consumption for biodiesel and its blends was higher than mineral diesel but brake thermal efficiency of all the biodiesel blends was lower than mineral diesel. Brake specific CO2, CO and Hydrocarbon emissions for biodiesel fuelled engine operation were lower than mineral diesel but NO emissions were higher for biodiesel blends. Combustion 12 started earlier for higher biodiesel blend fuelled operating conditions but the start of combustion was slightly delayed for lower blends of biodiesel in comparison with mineral diesel. Combustion duration for biodiesel blends was shorter than mineral diesel.

Blends of NEEM OIL and diesel have a potential to substitute the conventional fuel but with some advantage there is also some disadvantage that we discussed below. These blends can be used in a diesel engine without any modification.

Mechanical efficiency at CR 18 increase terrifically with increasing load for sample 2 and sample 3. It is also noticed that mechanical efficiency more increase for sample 3 that is 7.5% of NEEM OIL CR 18 mechanical efficiency decrease with increasing

A. Neem Oil

BTE remains almost constant or little bit decrease with increase load for sample 2 and sample 3 as compared to sample 1.

Initially fuel consumption is low for sample 2 and sample 3 as compared to sample 1 but after increasing load specific fuel consumption remains same for all sample. Overall we can say that less fuel consumption for sample 2 and sample 3 by diesel engine as compared to sample 1 that is pure diesel.

Almost same brake mean effective pressure for all sample but at CR 18 notable increase in pressure for sample 3 and sample 2 as compared to sample 1 with increasing load.

Nearly same brake power for all CR, only little bit deflection are noticed.

For CR 18 higher torque is available for sample 3 10% biodiesel and sample 2 as compared to sample 1 but for in CR 18 7.5% is little bit high torque for sample 1 pure diesel as compared to others.

B. Emission Conclusion

The CO emission is minimum for all samples at CR 18 as compared to other sample of other CR so it is best suitable for CR 18. But if we compared sample wise CO emission goes minimum at CR 18 for sample 3 as compared to other samples.

All sample emission is minimum at CR18 but for SAMPLE 2 at CR 18 initial emission is much minimum as compared to other then gradually increase

There is very less NOx emission for sample 2 7.5% biodiesel and Sample 2 at CR 18 as compared to any other sample of any CR.

HC Emission is minimum for sample 1 pure diesel at CR18 and CR 18 and maximum HC emission for sample 3 at CR 18.

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