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Research Article

COMPARATIVE ASSESSMENT OF PERFORMANCE AND EMISSION ANALYSIS OF A DIESEL ENGINE FUELED WITH BIODIESEL PREPARED FROM DIFFERENT SOURCES

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ABSTRACT

Present study experimentally investigates the use of biodiesel prepared from two potential non-edible oil (Karanja and Jatropha) and waste cooking oil in compression ignition engine. Keeping in view the low temperature operability and other durability issues found in pure biodiesel, B-20 blends were experimented in diesel engine. The performance and emission parameter were observed and analyzed. All the B-20 blends showed performance and emission characteristics similar to that of high speed diesel. WCB-20 showed highest NOx emission at full load. Karanja biodiesel blend showed good performance characteristics compared to Jatropha and waste cooking biodiesel blend. The results reveal that all the 20% blending test fuel can be used in compression ignition engine as a supplementary fuel.

INTRODUCTION

The depletion of fossil fuel reserve, strict emission norms imposed by respective government authority due to harmful health effect of pollutant emit from burning of fossil fuel. The limited reserves of fossil based fuel are concentrated in certain regions of the world (Demirbas, 2007). The coming years are going to be very crucial for Indian power resource sector, because India is largely dependent up on other countries for fossil based fuel owing to larger demand and modernization of the country. Energy is an important factor for growth of any country. Major consumer of energy is transportation sector. Energy produced from bio sources, which are renewable and carbon neutral in nature should be exploited for transportation sector for a developing country like India.

The present study was carried out to investigate the comparative assessment of Performance, emission parameters of a direct injection diesel engine run by *jatropha*, karanja and wastecooking methyl ester. A popular blend B20 was used for the present study because of its better wear and durability characteristics. B-20 means, 20% volume of biodiesel mix with 80% volume of high speed diesel. Earlier works also reported B20 blend works better compared to high speed diesel and less carbon and other metal deposits were observed (Agarwal and Das, 2001). Another reason is due to climatic condition, high concentration of biodiesel could hinder smooth engine run due to the poor low temperature operability characteristics. Earlier literature reported, there are more than 350 oil bearing crops available for producing biodiesel (No, 2011). In India, *Jatropha*, Mahua, Rubber, Karanja are popular non-edible feedstocks proved promising for biodiesel production (Ramadhas, *et al.*, 2005; Ghadge and Raheman, 2005; Shahid and Jamal, 2011; Atadashi, *et al.*, 2012). Earlier work reported use of Karanja and *Jatropha* biodiesel in diesel engines (Raheman and Phadatare, 2004; Chauhan, *et al.*, 2012; Chauhan, *et al.*, 2013). In India, edible oil consumption is very high and is used for daily cooking. Most of the edible Most of the edible oil imported from other

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countries, so biodiesel production from such oil is costly and unviable proposal.

MATERIALS AND METHODS

Jatropha and Karanja seeds were collected from a shop Agency Center, Arunachal Pradesh, India. Waste cooking oil was collected from Nana's Restaurant, Nirjuli, and Arunachal Pradesh. Due to more acid value both *jatropha* and karanja oil was pretreated (esterified) with H_2SO_4, then transesterified with methanol to get corresponding methyl esters. After transesterification, the glycerol was separated and biodiesel was water washed and dried for 20 minutes at 110°C for removing moisture from the respective esters. B20 blend of each ester was prepared and used for engine performance and emission analysis. This entire process is represented in (Figs. 1-3). AVL made 'smoke meter' and 'five gas analyzer' were used for the measurements of pollutant emission and opacity of exhaust smoke.

A single cylinder compression ignition engine shown in (Fig. 4) of above given specifications was used for the performance and emission analysis of all the test fuels. The engine was started by hand cracking. Four samples of blends of biodiesel with diesel fuel varying from B-5 to B-20 were prepared. Then the engine was fuelled with prepared blends and various performance and emission characteristics were observed and analyzed. The fuel consumption of the engine was measured. The engine was loaded from no load condition (i.e., 0 KW) to maximum load condition (i.e., 3.04 KW). The brake specific fuel consumption (BSFC), and brake thermal efficiency were evaluated. The exhaust gas emissions namely, HC, CO, CO_2, O_2 and NOX and engine smoke were measured (Table 1).

Fig. 1 Moisture removing.

Fig. 2 Glycerol separation.

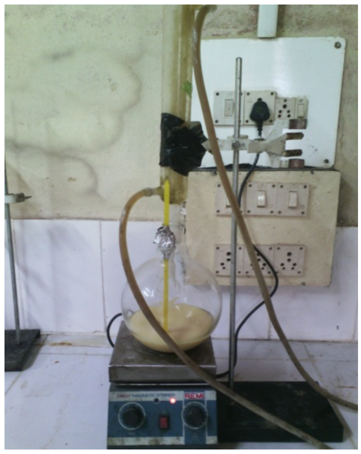

Fig. 3 Trans-esterification reaction.

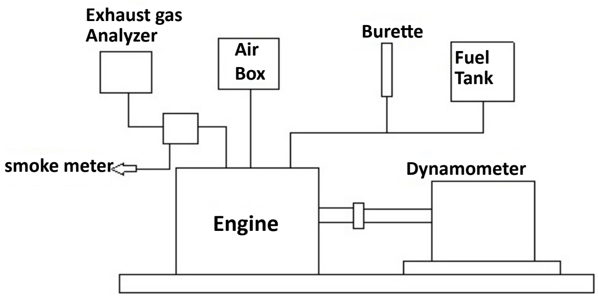

Fig. 4 Experimental setup.

Fig. 5 compares the specific fuel consumption of blends of biodiesel at various brake powers. It was observed that the brake specific fuel consumption of diesel and biodiesel blends decreased with increase in brake power. At maximum brake power, all the blends (i.e., WCB-20, JB-20, and KB-20) and diesel showed almost same value for BSFC. The specific fuel consumption suddenly decreases from no load to 25% load. With further increase in load, the BSFC slightly decreases.

Fig. 6 shows the effect of load level on brake thermal efficiency of high speed diesel and other biodiesel

diesel blends. Biodiesel blends were compared with high speed diesel for fuel performance checkup in terms of brake thermal efficiency. With increase in load level the brake thermal efficiency of all the test

Table 1. Specifications of the test engine

Parameters	Value
Rated power @1500 rpm	3.75 kw
Speed (rpm)	1500
Bore (mm)	87.5
Stroke (mm)	110
Compression Ratio	17.5
Injection timing	23 bTDC

fuel increases. At part load waste cooking biodiesel showed better performance compared to other blends. At full load, the brake thermal efficiency of KB20 and diesel were observed to be 27.12 and 28.96 respectively.

RESULTS AND DISCUSSION

The HC emission from diesel fuel operation at higher loads was significantly higher as compared to the test results using blends of biodiesel as shown in Fig. 7. The maximum HC level was observed with diesel fuel (149 ppm) whereas the minimum HC emission level was achieved with WCB-20 fuel

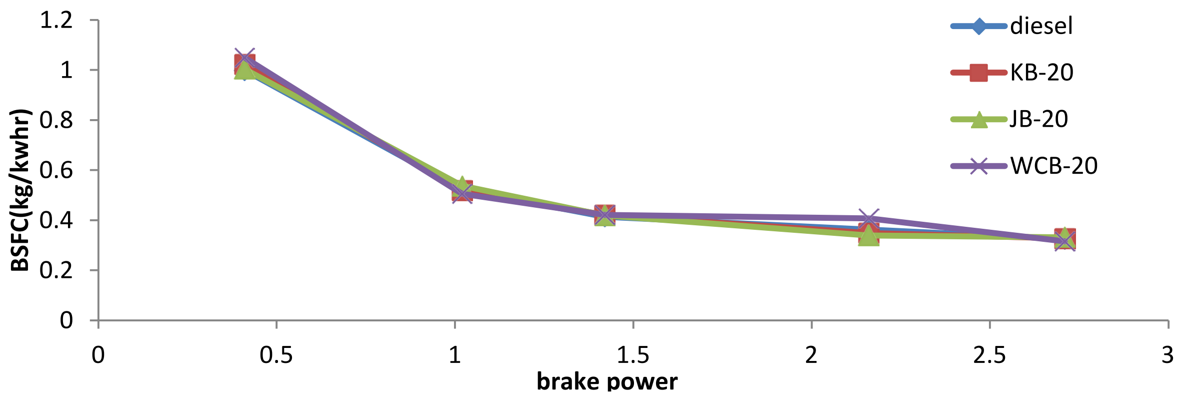

Fig. 5 Effect of brake power on specific fuel consumption.

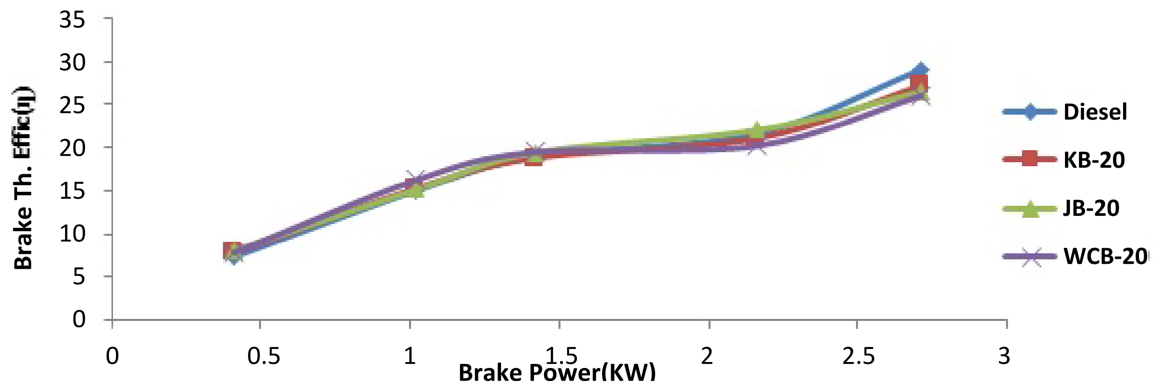

Fig. 6 Effect of brake power on brake thermal efficiency.

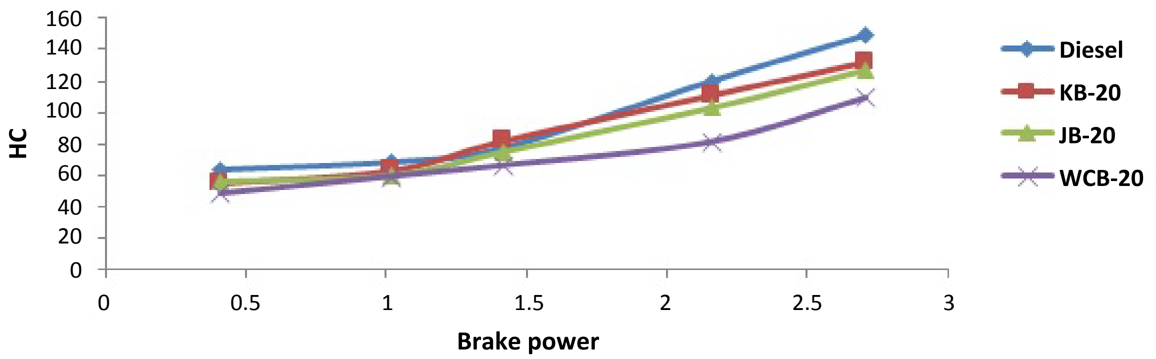

Fig. 7 Effect of brake power on unburned hydrocarbons in exhaust.

(109 ppm) There was a considerable increase in HC emissions with the increase in brake power. This is to be expected because as the load is increased; the fuel quantity injected is increased thereby contributing to increased HC emission.

The oxygen content in the exhaust gas with diesel, blends of biodiesel has been shown in Fig. 8. At part load, the oxygen content in the exhaust gases were lower for blends of biodiesel as compared to neat diesel fuel. As brake power increased the oxygen content for all blends of biodiesel and neat diesel fuels tended to reduce significantly. This was due to utilization of oxygen in the combustion process for more mass of fuel burning.

The CO_2 content in the exhaust gas with diesel, blends of biodiesel is shown in Fig. 9. At the part load the CO_2 content in the exhaust gas were nearly same. It was observed that CO_2 content in the exhaust gas increased for all fuels with increasing brake power. Maximum CO_2 content at maximum brake power was highest for diesel and lowest for *Jatropha* biodiesel.

A plot of CO content in the exhaust gas verses brake power is shown in Fig. 10. At part load the WCB-20 showed good results in terms of CO emissions. With increase in brake power the biodiesel blends (oxygenated fuel) produced less CO compared to high speed diesel.

It can be seen from Fig. 11, NOx emission increases with increase in brake power. With increase in brake power the in-cylinder temperature increases due to the increase in pressure inside cylinder in the compression stroke. As an oxygenated fuel, the oxygen content in fuel in higher temperature combine with nitrogen present in atmospheric air to form more NOx. WCB20 showed exceptional higher NOx emission. Several literatures reported the similar trend with NOx.

Fig. 12 shows the effect of load level on smoke. With increase in load level, the opacity was observed to be increased. This may be attributed to the fact that increases in resistance inside the combustion chamber due to the increase in load. At maximum brake power smoke opacity of diesel was higher compared to other B 20 blends.

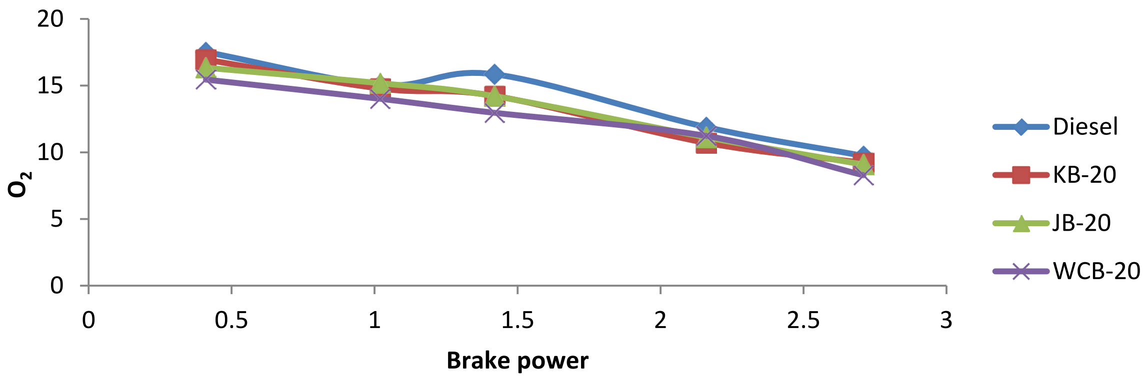

Fig. 8 Effect of brake power on oxygen in exhaust.

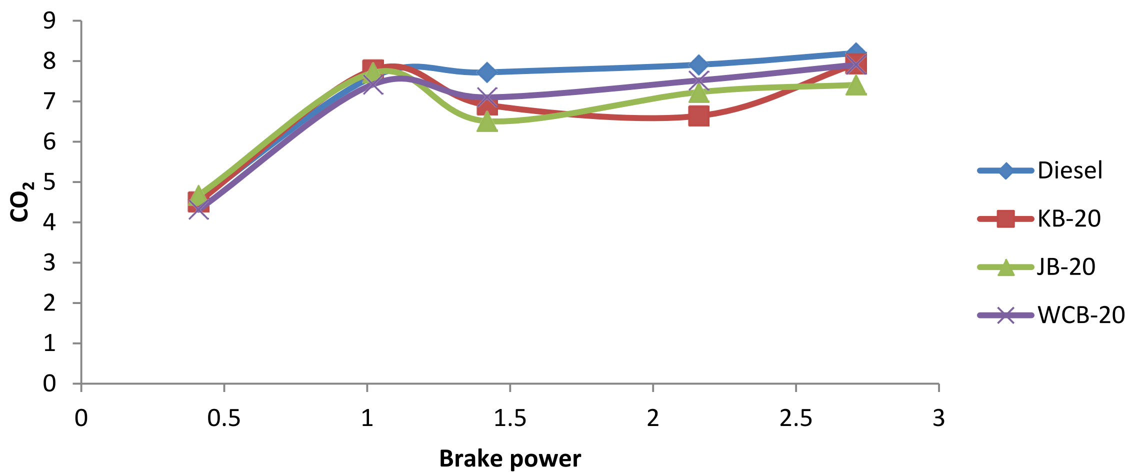

Fig. 9 Effect of brake power on exhaust carbon dioxide.

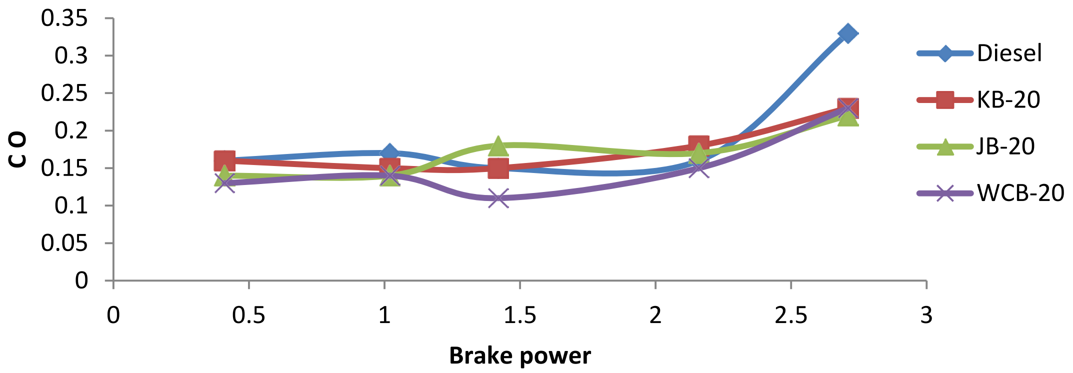

Fig.10 Effect of brake power on carbon monoxide in exhaust.

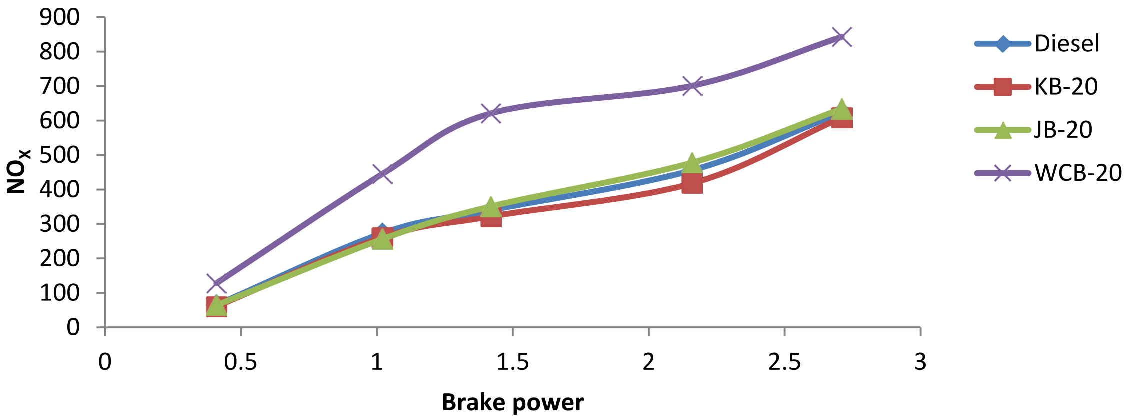

Fig. 11 Effect of brake power on exhaust NOX emission.

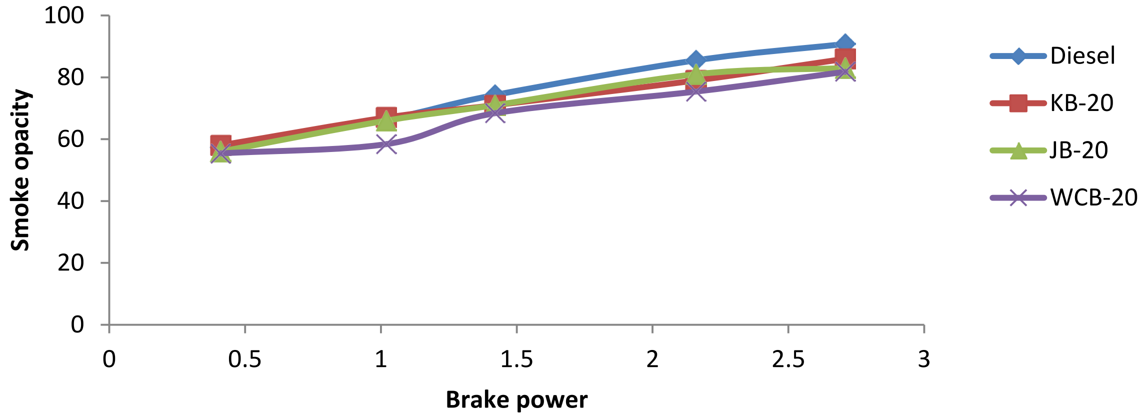

Fig.12 Effect of brake power on exhaust smoke opacity.

CONCLUSIONS

Keeping in view the results from production of all B20 blends and their utilization in diesel engine, the following conclusions are made.

1. Due to higher acid value, *Jatropha* oil and Karanja oil was esterified first with H_2SO_4 and then transesterified to get respective biodiesel. Waste cooking oil was only transesterified for the production of subsequent biodiesel.

2. The BSFC value was almost similar for all the test fuels at maximum brake power. The B.Th. efficiency was higher for diesel fuel than other B20 blends.

3. Except NOx emission of WCB20, other B20 biodiesel blends showed emission results, which are comparable with high speed diesel.

4. Hence, it is concluded that KB20, WCB20 and JB20 can be used in compression ignition engine without any modification in engine hardware.

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