International Journal of Research in Advent Technology, Vol.2, No.7, July 2014
E-ISSN: 2321-9637

Experimental Studies on the Performance and Emission Characteristics of a Diesel Engine Fuelled with Crude Rice Bran Oil Methyl Ester and its Diesel and Kerosene Blends

Dhruva D[1], Dr. M C Math[2],
Department of Thermal Power Engineering VTU PG CENTRE MYSORE [1, 2], VTU Belgaum, Karnataka, India.
Email: d.dhruva@ymail.com[1],mcmath1018@yahoo.com[2]

Abstract-This paper studies the effect of utilizing crude rice bran oil methyl ester (CRBOME) and its blends with diesel and domestic kerosene oil on a single cylinder direct injection diesel engine. In this work short term performance and emissions test on diesel engine were carried out using CRBOME and its diesel and kerosene oil blends. In the first place B20, B40, B60, B80 blends were prepared by varying the amount of methyl ester and conventional diesel blend. In the second place methyl ester, diesel, kerosene blends were prepared. Diesel proportions in the blends is reduced by adding domestic kerosene oil in the proportions of [Methyl ester: Diesel: Kerosene] 20:75:5, 40:50:10, 60:25:15, 80:0:20. The engine tests were carried at 0%, 25%, 50%, 75% and 100% rated loads by keeping speed constant (1500rpm). The brake specific energy consumption (BSEC in MJ /kW-hr), brake thermal efficiency (BTE %) and exhaust emissions were evaluated to determine the optimum fuel blends. The results show that B20 and B20 K5 have minimum BSEC of 27 MJ / kW-hr and 22.48 MJ / kW-hr respectively at 100% rated load. B20 has maximum BTE [28.81%] at 75% rated load. B100 and B80 K20 have minimum CO emission of 0.02% and 0.03% respectively at 0% load. B100 and B80K20 have minimum UNBHC emission of 5 ppm and 8 ppm at 0% load. B100 has a maximum NO_X emission [774 ppm] at 100% rated load. B20 K5 has a minimum NO_X emission [210 ppm] at 0% load.

Index Terms- Crude rice bran methyl ester, Diesel, Domestic kerosene oil.

1. INTRODUCTION

Edible and non-edible vegetable oils have been used as an alternative to conventional diesel oil. The use of neat vegetable oil in diesel engine causes engine related problems such as injector choking and piston ring sticking, severe engine deposits [1] due to increased viscosity and low volatility of vegetable oils. Considerable research has been done on biodiesel and their performance in unmodified diesel engines [2]. Several studies have noted that biodiesel has lower energy content and different physical properties than diesel oil. This may cause changes in engine performance [3]. Studies also show that biodiesel fuelled engines have similar performance and combustion characteristics as that of diesel oil [4]. The use of biodiesel in conventional diesel engine results in considerable reduction in emission of carbon monoxide (CO), unburnt hydrocarbons (UNBHC).

The objective of this study was to investigate the performance and emission characteristics of direct injection diesel engine operating on crude rice bran methyl ester [B100] and blends with conventional diesel oil [B20, B40, B60, B80] engine test are also conducted on domestic kerosene oil and its blends with conventional diesel oil and crude oil methyl ester [B20K5, B40K10, B60K15, B80K20]

2. MATERIALS AND METHODS

In the first stage, crude rice bran oil was treated with methanol (15% v/v) in presence of H_2SO_4 (0.5 % v/v) as an acid catalyst. In the second stage, the sample which has lowest FFA from first stage is treated with methanol (7% v/v) in presence of H_2SO_4 [0.5% v/v] as an acid catalyst to bring the FFA level of crude rice bran oil below 1% (0.4%). In the final stage, the sample which has FFA level less than 1% (0.4%) is treated with methanol (25% v/v) in presence of NaOH (0.5 w/v) as alkaline catalyst. Maximum yield of 94% was obtained at the optimized process parameters.

A single cylinder direct injection diesel engine was used in this work. Table 1 shows the specification of the engine.

Table 1.1 Specifications of the engine

Type	Four stoke
Make	Kirloskar AV-1
Bore	80 mm
Stroke	110 mm
Swept volume	553 cc
Cylinder capacity	624.19 cc

Dynamometer	Electrical, Swinging Field Resistive Loading
Cylinder pressure	By Piezo Sensor, Range: 500 psi
Compression ratio	16:1 to 25:1
Rated power	3.75 kW @ 1500 RPM
Loading type	Direct current generator, Voltage 140V, Max current 23 amps
Torque, Fuel Flow	By transducers and Digital Sensors
Cooling system	Water cooled

The engine was operated with B20 [20% methyl ester and 80% diesel], B40 [40% methyl ester and 60% diesel], B60 [60% methyl ester and 40% diesel], B80 [80% methyl ester and 20% diesel], and finally with B100 [100% methyl ester]. The engine was run in no load condition and its speed was kept constant [1500rpm]. Then it was gradually loaded. The experiments were conducted at 0%, 25%, 50%, 75% and 100% rated load. For each load condition the engine was run for at least 5mints. The experiments were replicated twice under all conditions. The performance were evaluated in terms of brake specific energy consumption (BSEC) and brake thermal efficiency (BTE) as a function of load. The results are shown in Fig.1.1 to Fig.1.10.

3. RESULTS AND DISCUSSION

3.1 Effect load on BSEC

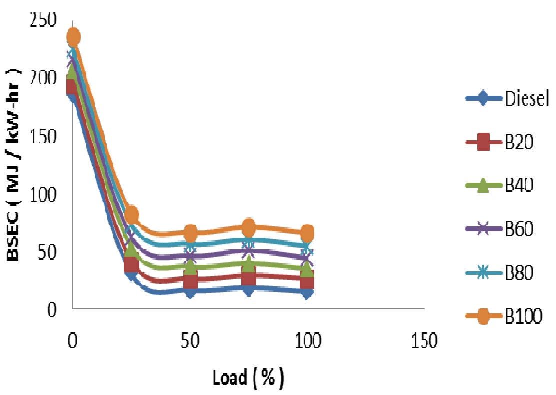

Fig. 1.1: Effect of load on Brake Specific Energy Consumption when diesel engine has run on B20, B40, B60, B80, B100 and diesel.

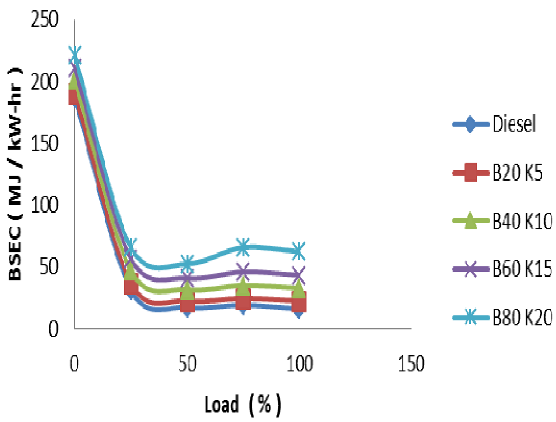

Fig. 1.2: Effect of load on Brake Specific Energy Consumption when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel.

Fig. 1.1 shows that the effect of load on BSEC when diesel engine has run on B20, B40, B60, B80 and B100 respectively. Fig.1.1 and Fig.1.2 indicates that with increases in the percentage of load on the engine BSEC has decreased from no load to full load for all the samples. The decreases in BSEC is high at part loads [0 to 20%] and low at high loads. Sample B20 has similar BSEC as that diesel in all load ranges. BSEC has increased with the increases in percentage of methyl ester in blends. B100 has maximum BSEC as compared to all other samples. This may be due to the factor of lower calorific value of B100. B20 [195.72MJ/kW-hr] has BSEC 4.73% higher than that of diesel [186.46MJ/kW-hr] whereas B100 [236.02MJ/kW-hr] has BSEC 21% higher than that of diesel at 0% load. B20 has minimum BSEC [27MJ/kW-hr] which is 40.74% higher than that of diesel [16MJ/kW-hr] at 100% rated load. All samples have minimum BSEC at 100% rated load.

Fig.1.2 shows the effect of load on BSEC when diesel engine runs on B20K5, B40K10, B60K15, and B80K20. Fig.1.2 indicates that BSEC decreases with increase in the percentage of load on the engine, the decrease is high at part load but low at high load. Fig.1.2 also indicate that B20K5 (20% biodiesel, 5% Kerosene, 75% diesel) has minimum BSEC than B40K10 (40% biodiesel, 10% domestic Kerosene, 50% diesel), B60K15 (60% biodiesel, 15% Kerosene, 25% diesel), B80K20 (80% biodiesel, 20% Kerosene, 0% diesel).B20 K5 has minimum BSEC of 22.48MJ/kW-hr which is 28.83% higher than that of diesel and 16.74% lower than B20 at 100% rated load. 17% decrease in BSEC was observed by replacing 5% diesel with kerosene in B20. B80 K20 has maximum BSEC (220.68MJ/kW-hr) which is 15.51% higher than that of diesel and 1.97% lower than that of B80 at 0 load. Fig.1.2 also indicates that BSEC increases with increase in the percentage of methyl ester in the blend.

3.2 Effect of load on Brake Thermal Efficiency (BTE)

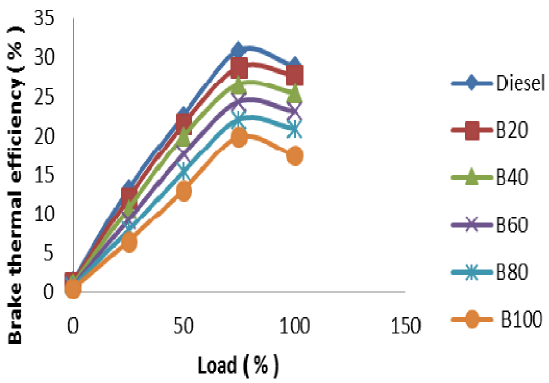

Fig. 1.3: Effect of load on brake thermal efficiency when diesel engine has run on B20, B40, B60, B80, B100 and diesel.

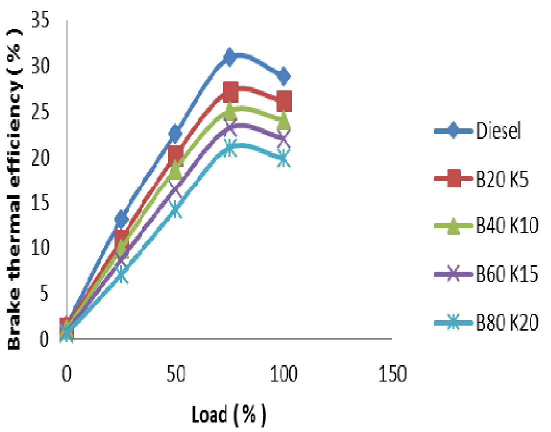

Fig. 1.4: Effect of load on brake thermal efficiency when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel

Fig. 1.3 shows that the effect of load on BTE when diesel engine has run on B20, B40, B60, B80, B100 and diesel. Fig.1.3 shows that B20 has maximum BTE and B100 has minimum BTE at all loads. B20 has minimum BTE (28.81%) which is 6.82% lower than that of diesel at 75% rated load. B100 has minimum BTE (19.85%) which is 35.8% lower than that of diesel at 75% rated load. B20 has minimum BTE (12%) which is 8.54% lower than that of diesel at 25% rated load. Fig.1.3 also indicates that BTE decreases with increase in the percentage of methyl ester in the blend.

Fig. 1.4 shows that effect of load on diesel engine fuelled with B20K5, B40K10, B60K15, B80K20 and diesel which also indicates that B20K5 has maximum BTE than all other samples at all loads. B20K5 has maximum BTE (27.26%) which is 11.84% lower than diesel and 5.4% lower than that of B20 at 75% rated load. Replacing 5% diesel with kerosene, 5.4% decrease in BTE was observed at 75% rated load. B80K20 has minimum BTE (7.06%) which is 46.2% lower than diesel oil at 25% rated load. Fig.1.4 indicates that BTE decreases with increase in the percentage of kerosene in B40, B60, B80 blends. Thus may be due to lower calorific value of kerosene.

3.3 Effect of load on CO emission

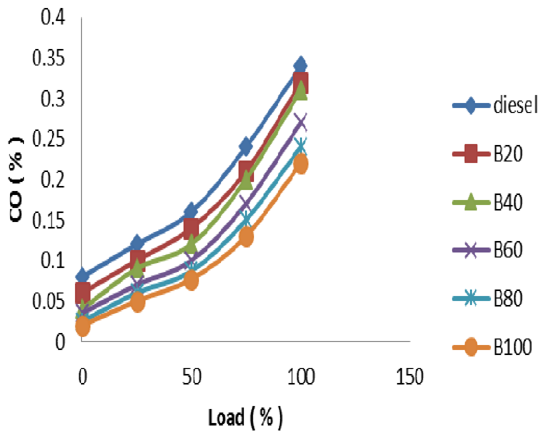

Fig. 1.5: Effect of load on CO emission when diesel engine has run on B20, B40, B60, B80 and diesel

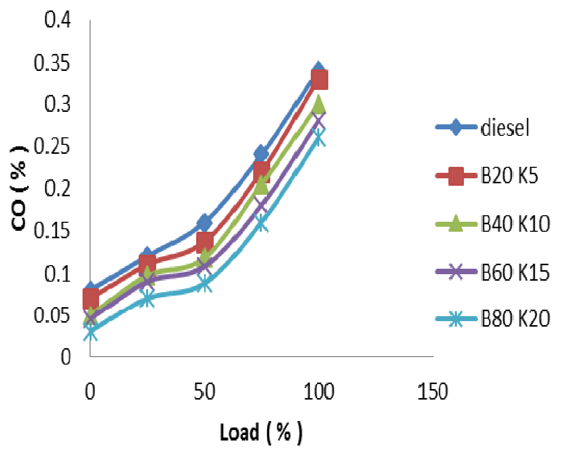

Fig. 1.6: Effect of load on CO emission when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel

Fig. 1.5 shows the effect of load on CO emission when diesel engine runs on B20, B40, B60, B80, B100 and diesel. Fig. 1.5 indicates that CO emission increases with increase in percentage of load and decreases with increase in percentage of ester. B100 has minimum CO emission at all loads. B20 has maximum CO emission (0.32%) which is 6% lower than that of diesel at 100% rated load. B100 has minimum CO emission (0.02%) which is 75% lower than that of diesel at 0 load.

Fig. 1.6 shows the effect of load on CO emission when diesel engine runs on B20K5, B40K10, B60K15, B80K20 and diesel oil. Fig. 1.6 indicates that B80K20 has minimum CO emission than all other samples at all loads. B20K5 has maximum CO emission (0.33%) which is 3% lower than diesel and 3% higher than B20 at 100% rated load. B80K20 has minimum CO emission (0.03%) which is 63% lower than diesel and 17% higher than B80 at 0 load.

3.4 Effect of load on unburnt hydrocarbons (UNBHC) emission

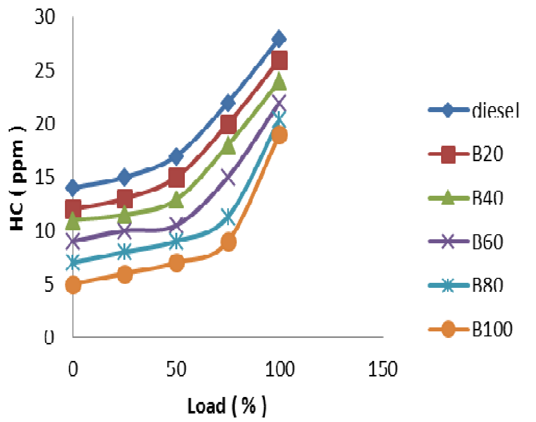

Fig. 1.7: Effect of load on UNBHC emission when diesel engine has run on B20, B40, B60, B80 and diesel

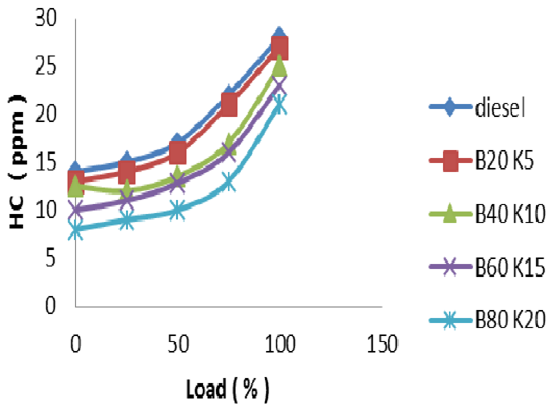

Fig. 1.8: Effect of load on UNBHC emission when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel

Fig. 1.7 shows the effect of load on UNBHC emission when diesel engine runs on B20, B40, B60, B80, B100 and diesel. Fig. 1.7 indicates that UNBHC emission increases with increase in percentage of load and decreases with increase in percentage of ester. B100 has minimum UNBHC emission at all loads. B20 has maximum UNBHC emission (26ppm) which is 7% lower than that of diesel at 100% rated load. B100 has minimum UNBHC emission (5ppm) which is 64% lower than that of diesel at 0 load.

Fig. 1.8 shows the effect of load on UNBHC emission when diesel engine runs on B20K5, B40K10, B60K15, B80K20 and diesel oil. Fig. 1.8 indicates that B80K20 has minimum UNBHC emission than all other samples at all loads. B20K5 has maximum UNBHC emission (27ppm) which is 3.6% lower than diesel and 3.7% higher than B20 at 100% rated load. B80K20 has minimum UNBHC emission (8ppm) which is 43% lower than diesel and 12.5% higher than B80 at 0 load.

3.5 Effect of load on NO_X emission

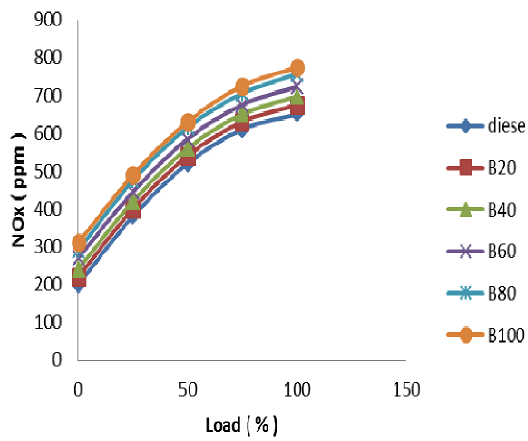

Fig. 1.9: Effect of load on NO_X emission when diesel engine has run on B20, B40, B60, B80 and diesel

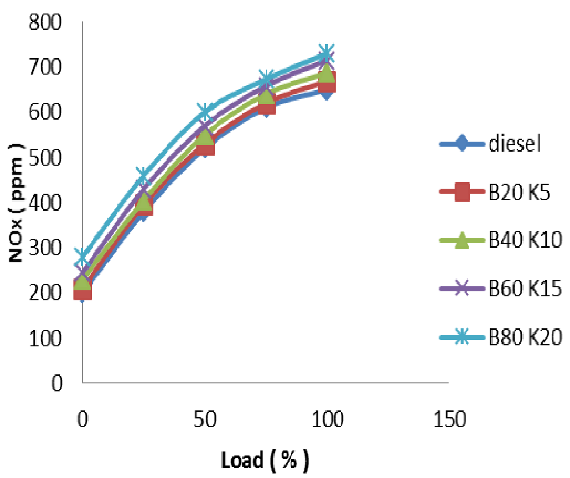

Fig. 1.10: Effect of load on NO_X emission when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel

Fig. 1.9 shows the effect of load on NO_X emission when diesel engine has run on B20, B40, B60, B80, B100 and diesel. Fig. 1.9 indicates that NO_X emission increases with increase in the percentage of ester. B100 has maximum NO_X emission at all loads. B20 has minimum NO_X emission (220ppm) which is 9% higher than diesel oil (200ppm) at 0 load. B100 has maximum NO_X emission (774ppm) which is 16% higher than diesel oil (650ppm) at 100% rated load.

Fig. 1.10 shows the effect of load on NO_X emission when diesel engine has run on B20K5, B40K10, B60K15, B80K20 and diesel. Fig.1.10 indicates that B80K20 has maximum NO_X emission than all other samples at all loads. B20K5 has minimum NO_X emission (210ppm) which is 5% higher than conventional diesel oil and 5% lower than B20 at 0 load. B80K20 has maximum NO_X emission (730ppm) which is 11% higher than conventional diesel oil and 3.6% lower than B80 at 100% rated load.

Conclusion

The following conclusions are derived based on the investigation carried out on a single cylinder direct injection diesel fuelled with crude rice bran oil methyl ester and their diesel and kerosene oil:

1. Three stage transesterification process was successfully used to convert high free fatty acid crude rice bran oil into methyl esters.
2. Methyl ester can be blend up to 20% with conventional diesel oil without loss of power and efficiency. Higher proportions of methyl ester in the diesel blends lead to decrease in efficiency.
3. Domestic kerosene oil from 5% to 10% can be used without appreciable changes in efficiency as compared to methyl esters and diesel blends.
4. Considerable reduction in CO and UNBHC emissions have observed with methyl ester and its diesel and kerosene blends.
5. Appreciable raise in NO_x emission was observed with methyl ester and its diesel and kerosene blends.
6. Biodiesel blends cost can be reduced by replacing diesel proportion in the blends by using kerosene.

REFERENCES

[1] Kemp, W.H. (2006). Biodiesel Basics and Beyond – A Comprehensive guide to production and use for the home and farm. Aztest Press; Ontario, Canada.

[2] Graboski, M.S.; McCormick, R.L.; (1998). Combustion of Fat and Vegetable oil Derived Fuels in Diesel Engines. Progress in Energy and Combustion Science 24, 25-164.

[3] Murayama, T.; Fujiwara, Y.; and Noto, T.; (2000). “Evaluating waste vegetable oils as a proceedings of the institute of Mechanical Engineering., Journal of Automobile Engineering, 214 (Part D), pp. 141-148.

[4] Aravinda and Ashok Kumar, S.; (2000). “Vegetable oils for diesel engines: a comparative study”, Indian Journal of Transport Management, 24 (12), pp. 782-92.