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Performance and Emission Characteristics of CI Engine by Varying Injection Pressure & Timing Using Rice Bran Oil Biodiesel Blends

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Abstract— *Global interest in increasing the usage of alternative fuels in internal combustion engines continues to be strong due to environmental concerns and the limited availability of conventional fossil fuel in future. Latest interest has focused on the use of bio-derived fuels in diesel engines.*

Vegetable oils and their derivatives are alternative diesel fuels and rice bran oil is one of the most important oil in terms of availability. Keeping this in mind a research work has been carried out to investigate the effect of injection timing and injection pressure on a diesel engine with rice bran vegetable oil. In the present research, the effect of injection timing and injection pressure on performance and emission parameters of a direct injection diesel engine fueled with preheated rice bran vegetable oil is investigated. The injection timing is varied from 23° to 21° Crank Anglebefore Top Dead Centre (CA bTDC) and injection pressure is varied from 200 bar to 210 bar. The tests are carried out in all combinations of injection timing and injection pressure at full load using preheated rice bran oil as fuel and combustion, performance and emission parameters are measured. The values of combustion, performance, and emission parameters are favorable at 21°CA bTDC of injection timing and 210 bar of injection pressure except for NOX. The NOX is found higher at 21°CA bTDC of injection timing and 210 bar of injection pressure which is not desired. Except NOX, all the other parameters are found to be promising at 21°CA bTDC of injection timing and 210 bar of injection pressure.

Keywords— *Rice bran oil, transesterification, bio-diesel, CI engine, emission characteristics.*

I. Introduction

Biodiesel which can be derived from vegetable oils are good alternative fuel for diesel since they are renewable and environment friendly. Investigations were carried out with different types of edible and non-edible vegetable oils to conform their ability to replace the diesel fuel.

Rice bran oil is extracted from rice bran which is a thin layer between the rice and outer husk. The rice production is a renewable process, hence the rice bran oil extraction is also a renewable one. Based on the worldwide rice production it has been estimated that rice bran oil has the potential to replace 0.9% of the world's diesel requirement.

Rice bran oil biodiesel was derived from refined rice bran oil by transesterification process and engine performance and emission test were conducted. The FFA content of refined oil is less than 3%, hence it can be converted into biodiesel by base catalyzed reaction alone.

Previous research works on biodiesel reveal that B20 will be on optimum fuel blend for CI engine. Blending of biodiesel with diesel reduces the property differences such as viscosity, density and also emission cold weather performances etc. In present work we are decided to carry out the performance and emission analysis using rice oil biodiesel blends such as B20, B40, B60, B80, B100 with injection pressures 180,190,200 bar with injection timing 21°, 23°, 25° BTDC.

II. Experimental Procedure

2.1 Preparation of Biodiesel Blends

One litre of rice bran oil was taken in a conical flask. The oil in the flask was then heated on a heating plate up to a temperature of 60°C. 2 gms of Potassium hydroxide (KOH) as base catalyst and 250 ml of methanol was then mixed with the oil. The preheated oil mixture was then heated at a constant temperature of 60º C for 2 hours and stirred at 400 RPM. After 2 hours of constant stirring the mixture was poured into a separating funnel for glycerol to settle down.

After 2days settled down glycerol was separated and removed.Remaining is methyl ester (biodiesel) of rice bran oil (Yield 90%) which was further purified by washing with hot distilled water for removal of excess KOH, methanol and water.

2.2 Properties of Biodiesel Comparison with Diesel

Property parameters	Diesel	Rice bran oil biodiesel
Density at 15 ºC, g/cm³	0.822	0.882
Viscosity at 40 ºC, mm²/s	3.4	4.63
Flash point, ºC	71	165
Auto-ignition temperature,ºC	225	320
Pour point, ºC	1	3
Cetane Number	45	52
Net heating value, MJ/kg	42	40

III. Experimental Setup

3.1 Engine Performance Evaluation

Evaluation of the engine performance is described as

- Specifications of the engine
- Engine performance evaluation procedure
- Performance Parameters evaluation

3.1.1 Experimental testing engine

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Fig. 3.1. Photograph of testing engine.

3.1.2 Specifications of the engine

Engine type: Four stroke, Single cylinder vertical water cooled diesel engine

TABLE 3.1. Specifications of the engine.

Make & Model	Kirloskar TV-1
Rated power	5.2 Kw
Rated speed	1500 rpm
Bore dia (D)	87.5 mm
Stroke (L)	110 mm
Compression ratio	17.5:1
Dynamometer Arm length	0.195

3.1.3 Engine performance evaluation procedure

Initially the experimentation was performed with diesel and then with blends of rice bran methyl ester (B25, B50, B75 andB100). Fill the diesel in fuel tank. Initially adjust the compression ratio of the engine to a ratio of 17.5:1. Start the water supply and set cooling water flow for engine at 7lit/min. Also ensure adequate water flow rate for dynamometer cooling. Supply the diesel to the engine by opening the valve provided at the burette and the engine was allowed to run at no load, then 20% load was applied and the readings were note at 200bar and 23ºbtdc.Repeat the experiment for 40%, 60%, 80%, 100% load. Then the biodiesel blends B25, B50, B75 and B100 were used and the readings were noted. After that the injection pressure and the injection angle were altered to 210bar and 21ºbtdc and the biodiesel blends of B25, B50, B75, and B100 were used and the readings were noted for various loads. At the end of the experiment bring the engine to no load condition and turn off the engine and after few minutes turn off the water supply.

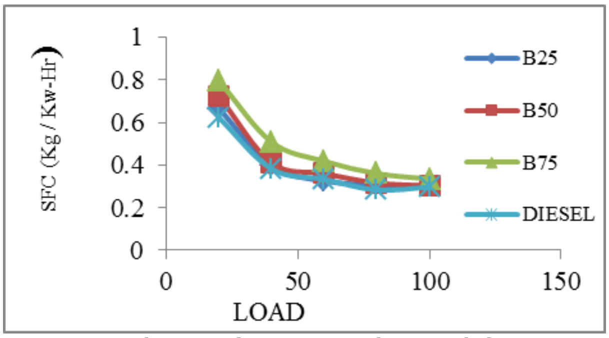
IV. Results and Discussion

The performance and emission analysis of a constant speed engine at various loads using Diesel, Rice bran oil biodiesel and its blends were carried out at 200 bar & 23º btdc and 210 bar &21º btdc. The results were discussed below.

4.1. Performance Analysis at 200 BAR & 23º BTDC

4.1.1 Specific fuel consumption (SFC)

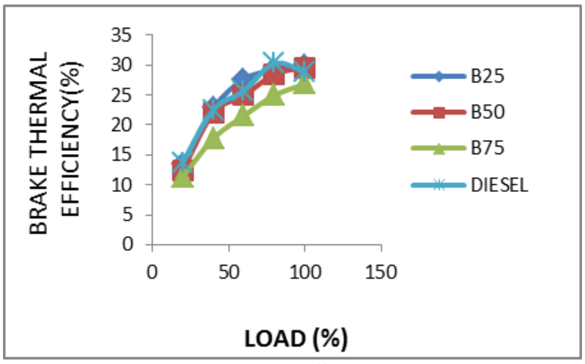
The Specific fuel consumption decreases with increase in load. The SFC for biodiesel and its blends were higher than diesel at all loads. The minimum SFC (0.301 Kg/Kw-hr) was observed at B25 which was slightly higher than that of diesel (0.297 Kg/Kw-hr) at full load.



Graph 4.1. Load V_S SFC at 200 bar & 23º btdc.

6.1.2. Brake thermal efficiency (BTE)

Brake Thermal efficiency increases with increase in load for biodiesel and its all blends. The maximum brake thermal efficiency 30.29% for diesel at 80 % load and the maximum brake thermal efficiency 29.89% for B25 at full load among the biodiesel blends were observed.

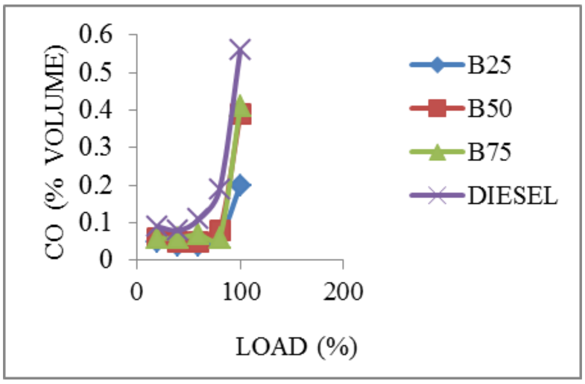


Graph 4.2. Load V_S Brake thermal efficiency at 200 bar & 23º btdc.

4.2. Emission Analysis at 200 BAR & 23º BTDC

4.2.1. Carbon Monoxide (CO)

The CO emission was lower for biodiesel and its blends than diesel at all loads. The minimum CO 0.04 % emission for B25 was noted. The CO emission was slightly fluctuated among all loads but it was increased in value at full load for diesel and biodiesel and its blends. The maximum CO 0.56 % emission for diesel was noted at full load.



Graph 4.3. Load V_S CO at 200 bar & 23º btdc.

4.2.2. Hydrocarbon (HC)

The HC emission was found to be higher for biodiesel and its blends than that of the diesel fuel. The maximum HC

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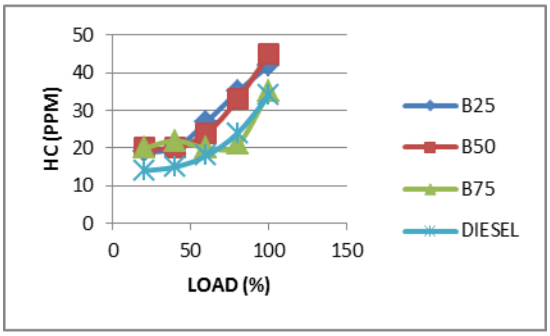
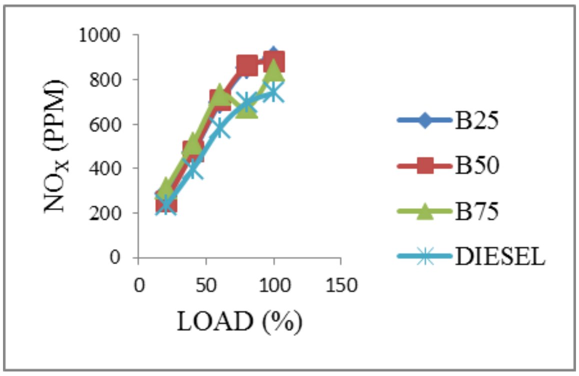
emission (45 PPM) was noted for B50 at full load. The HC emission was slightly fluctuated for B75 among all loads but for remaining biodiesel blends it was increased with increase in load.



Graph 4.4. Load V_S HC at 200 bar & 23º btdc.

4.2.3. Oxides of Nitrogen (NO_X)

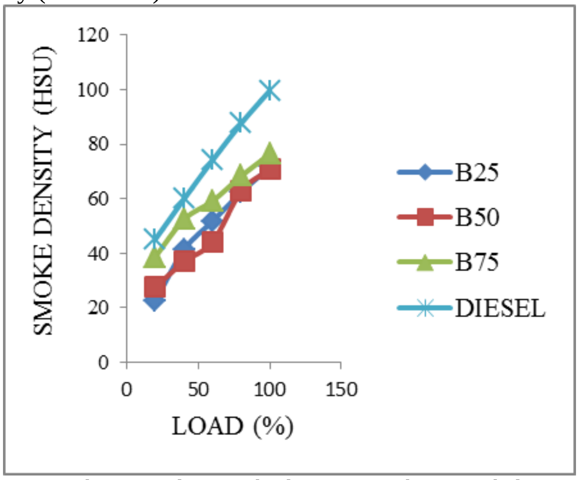
The maximum NO_X emission of biodiesel and its blends was higher than that of diesel for all loads. The maximum NO_X emission (899 PPM) for B25 at full load was observed. The NO_X emission increases with increase in load for diesel and biodiesel its blends except for B75 at 80% load.



Graph 4.5. Load V_S NO_X at 200 bar & 23º btdc.

4.2.4. Smoke density

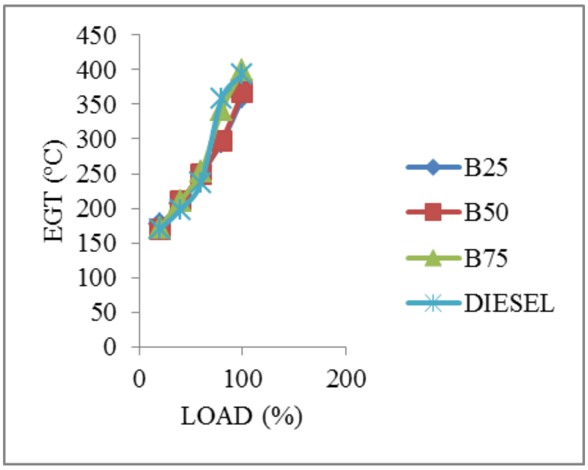
It was found that the smoke density increases with increase in load. The smoke density of biodiesel and its blends were lower than that of diesel at all loads. The maximum smoke density (99.7 HSU) was noted for diesel at full load.



Graph 4.6. Load V_S Smoke density at 200 bar & 23º btdc.

4.2.5. Exhaust Gas Temperature (EGT)

It was found that the EGT increases with increase in load for diesel, biodiesel and its blends. It was observed that the maximum EGT (404 ºC) for B100 at full load.

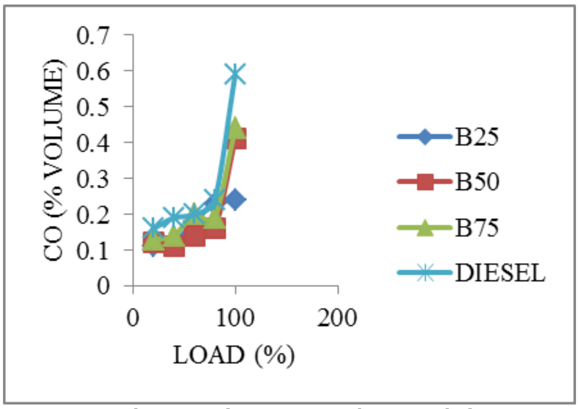


Graph 4.7. Load V_S EGT at 200 bar & 23º btdc.

4.3. Emission Analysis at 210 BAR & 21 º BTDC

4.3.1. Carbon monoxide (CO)

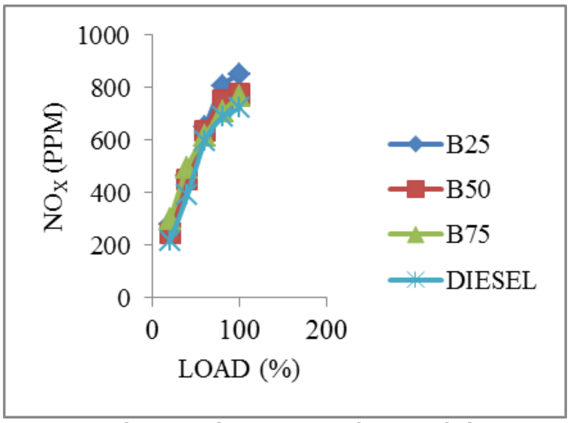
The maximum CO emission (0.59%) was observed for diesel at full load. The CO emission was higher for diesel than biodiesel and its blends. The CO emission was slightly fluctuated for B50 at 40% load and for B75 at 80% load but it was increased in value with load for diesel and biodiesel and its blends.



Graph 4.8. Load V_S CO at 210 bar & 21º btdc.

4.3.2. Oxides of nitrogen (NO_X)

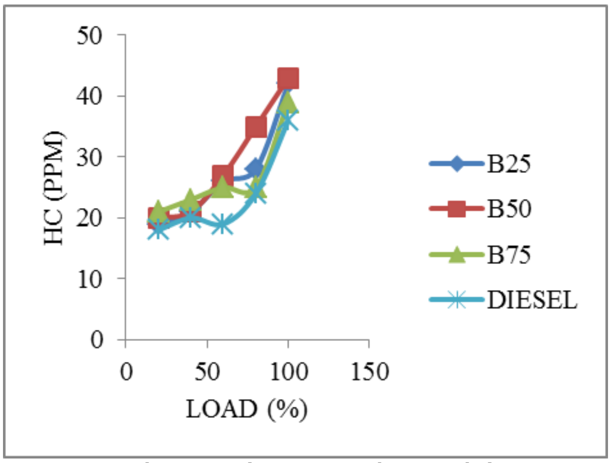
The NO_X emission increases with increase in load for diesel, biodiesel and its blends at all loads. The NO_X emission was higher for biodiesel and its blends than that of diesel. The maximum NO_X emission (850 PPM) was found for B25 at full load. When compared with 200 bar & 23ºbtdc the NO_X emission values were decreased for most of the biodiesel and its blends and diesel.



Graph 4.9. Load V_S NO_X at 210 bar & 21º btdc.

4.3.3. Hydrocarbon

The HC emission for biodiesel and its blends increases with increase in load at all loads but for diesel it was fluctuated at 60% load. The maximum HC emission (45 PPM) was found for B100 at full load. The HC emission of biodiesel and its blends were higher than that of diesel at all loads.



Graph 4.10. Load V_S HC at 210 bar & 21º btdc.

V. CONCLUSIONS

Present work is done to study the production, engine performance and exhaust emission characteristics of rice bran methyl ester. Based on the results of the present work, following conclusions are drawn:

1. Biodiesel Production: Single stage base catalyzed transesterification was performed with potassium hydroxide (KOH) as base catalyst.

2. Engine performance and exhaust emission comparison of blends of Rice bran methyl ester with diesel:

At 200 Bar & 23º btdc

(i) The maximum brake thermal efficiency 30.29% for diesel at 80 % load and the maximum brake thermal efficiency 29.89% for B25 at full load among the biodiesel blends were observed.

(ii) The SFC for biodiesel and its blends were higher than diesel at all loads. The minimum SFC (0.301 Kg/Kw-hr) was observed at B25 which was slightly higher than that of diesel (0.297 Kg/Kw-hr) at full load.

(iii) The maximum NOX emission of biodiesel and its blends was higher than that of diesel for all loads. The maximum NOX emission (899 PPM) for B25 at full load was observed.

(iv) The CO emission was lower for biodiesel and its blends than diesel at all loads. The minimum CO 0.04 % emission for B25 was noted.

(v) The HC emission was found to be higher for biodiesel and its blends than that of the diesel fuel. The maximum HC emission (45 PPM) was noted for B50 at full load.

(vi) The smoke density of biodiesel and its blends were lower than of diesel at all loads. The maximum smoke density (99.7 HSU) was noted for diesel at full load.

At 210 Bar & 21º btdc

(i) When compared with injection parameters at 200 bar & 23º btdc the NOX emission was reduced and CO, HC emission were increased.

(ii) Based on the experimental investigation the blends of rice bran methyl ester can be used as fuel in diesel engine without making any modification to the engine.

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