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# Experimental Investigation to Evaluate the Performance, Emission and Combustion Characteristics of Diesel Engine with Castor Oil Biodiesel

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***Abstract*** **Biodiesel is one of the environmentally friendly alternative fuels need to be prepared in order to satisfy the increasing need of mineral fuels for transportation, power generation and to endure the machines in mills. Any vegetable oil (edible or non-edible) and animal fatty tissue can be practiced to produce biodiesel. Moisture and free fatty acid content of feedstock is the important properties which affect production and quality of biodiesel. In this subject field Castor oil is used to extract biodiesel. Performance, emission and combustion characteristics of these biodiesel fuel blends such as B10, B20, B30, B50 and B100 are compared with compared with baseline data obtained with conventional diesel in a single cylinder, four stroke, water cooled, and naturally aspirated direct injection (DI) diesel locomotive.**

**Performance characteristics with Castor oil biodiesel blends are compared with mineral diesel. Brake specific fuel consumption (BSFC) for Castor oil biodiesel is found to be higher compare to diesel. While CO and unburned HC for Castor oil biodiesel blends fuelled engine were lower than mineral diesel on an intermediate basis. NOx emission for Castor oil biodiesel was found to be more eminent for all blends. CO2 emission for Castor oil biodiesel fuel was found to be lower for all blends. From heat release rate and pressure curve with respect to crank angle showed the details of combustion characteristics and revealed that combustion was started a little earlier for higher biodiesel blends, however, combustion was found to be a little delayed for lower blends of biodiesel compared to diesel. Results showed that biodiesel obtained from Castor oil can be used as an excellent substitute for fossil fuels.**

***Keywords*: Biodiesel, Performance, Emissions, Castor Oil, Load, BSFC.**

## I. INTRODUCTION

Despite growing demand for fuel, dwindling resources is a crisis for science and technology. Diesel fuel is respected in economy of countries due to it uses in a comprehensive range as heavy-duty transport vehicles, rail transportation systems, agricultural machineries and construction equipment. Motor vehicles contribute significantly to the air pollutions problems. Therefore use of alternative fuels can help in the promotion of environmental protection. Increased consumption of conventional based fuel gives way for the exploration of several alternative fuels. Biodiesel is a promising diesel fuel substitute because it is a clean renewable fuel which can be used in any direct injection engine without the need to redesign the current technology. Biodiesel is produced from transestrification reaction of vegetables oil (fresh or waste) or animal fats with alcohol in presence of a catalyst. However, pure biodiesel is not recommended by scientists for conventional engines due to number of operational deficiencies. Engine modifications are required to use pure bio-diesel which is a costly practice. Therefore, bio-diesels are generally mixed with petroleum diesel at predetermined percentages to create a biodiesel blend. But engine performance differs with the amount of concentration of bio-diesel used.

Torque & Power, Engine Vibration, Fuel Consumption and Emission are some of the standard parameters which determines the quality and performance of the fuel used. Fuel cost and consumption are direct measurements of the economy of using the fuel. Poor fuel performance will lead to frequent maintenance and more often replacement of the engine. Hence, finding an optimum combination of bio-diesel and petro-diesel which gives the best operating characteristics has been a requirement over the years.

## II. EXPERIMENTAL WORK

For this study a single cylinder, four stroke diesel engine, Kirloskar, Model TV1, connected to eddy current type dynamometer for loading, smoke meter to measure smoke and five gas analyzer for exhaust gas evaluation, is employed. It is provided with necessary instruments for combustion pressure and crank-angle measurements. These signals are interfaced to computer through engine indicator for Pθ−PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The setup has stand- alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator Rotameters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency etc.

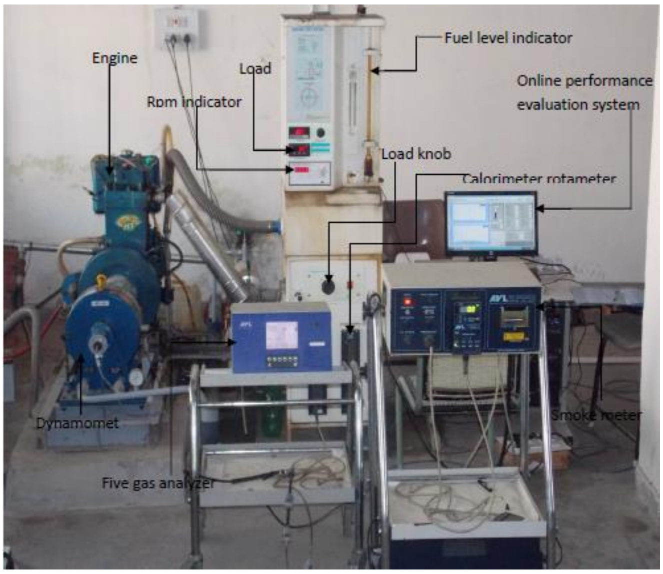


Fig. 1 Engine Setup

The engine was fuelled with pure diesel and mixtures containing 10%, 20%, 30%, and 50% of Castor oil biodiesel. Relative effects of engine operation, emission characteristics and combustion characteristics of the different blends of Castor oil biodiesel with that of diesel under variable loads (0%, 25%, 50%, 75% and 100%) at a constant velocity of 1500 RPM are measured. The main specifications of engine are shown in Table1.

Table 1: Specifications of Test Engine

| | |
|---|---|
| Product | Engine test setup 1 cylinder, 4 stroke, Diesel Engine. |
| Maximum Power | 5.2kW @1500rpm |
| Bore × Stroke | 87.5 × 110 |
| Compression Ratio | 17.5:1 |
| No of Cylinder | 1 |
| Dynamometer | Type Eddy Current |
| Software | EnginesoftLV |
| Pump | Type Monoblock |
| Fuel tank capacity | 15 litres |

## III. RESULTS AND DISCUSSIONS

Figure 2 shows that the variation of brake thermal efficiency with load for different blends. The maximum brake thermal efficiency is obtained 34.39% for B10 among all other blends, which is just 0.18% lower than that of diesel on an intermediate basis. The reduction in brake thermal efficiency for higher blends may be ascribable to the combined result of its lower heating value and increase in fuel consumption.

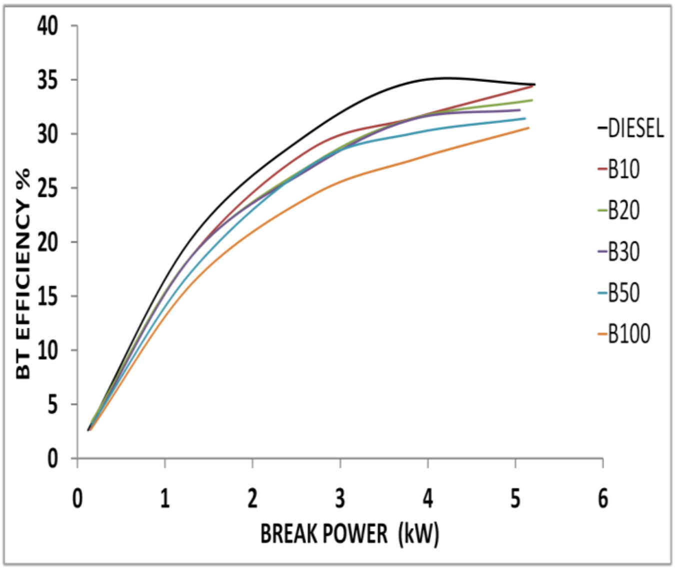


Fig. 2 Variation of Brake power with BT Efficiency

The variation of brake specific fuel consumption with regard to load is given in figure 3. It is obvious from the name that the BSFC of the engine gradually decreases with increase load and then becomes constant up to full load condition. B10 has given lowest brake specific fuel consumption to all other blends however, and it was slightly higher than that of diesel. For higher percentage of biodiesel blends, the BSFC increases.

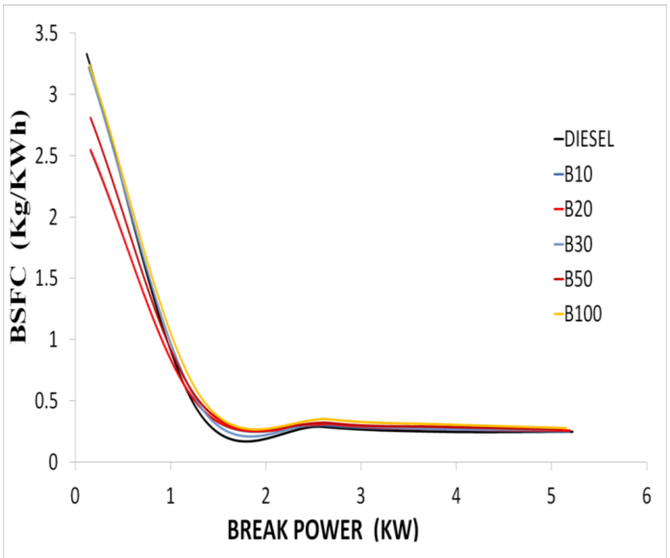


Fig. 3 Variation of Brake power with BSFC

Figure 4 displays that the fluctuation of carbon monoxide emission of the blends and diesel under various loads. The discharge of CO is found to be diminished with increasing load. This increased temperature helps in the oxidation of CO on account that its value decreases. Even so, at full load air-fuel ratio was decreased up to that much limit when sufficient oxygen was not available to oxidize completely that is way higher CO is obtaining. The CO emission of all blends is close to that of standard diesel except B10 which has contributed 0.032% compared to diesel 0.038%, on an intermediate basis.

Variation of unburned hydrocarbon can be seen in figure 5. Substantial reduction in HC emission has been ground with increasing blend ratio of biodiesel in the fuel .All blends except lower blends such as B100 have given high HC. Other blend like B10, B30, B100 and diesel has been given 18ppm, 19ppm, 22ppm and 24ppm of HC emission respectively at full load (100%). These reductions indicate that the better combustion of fuels and thus, HC level decreased significantly.

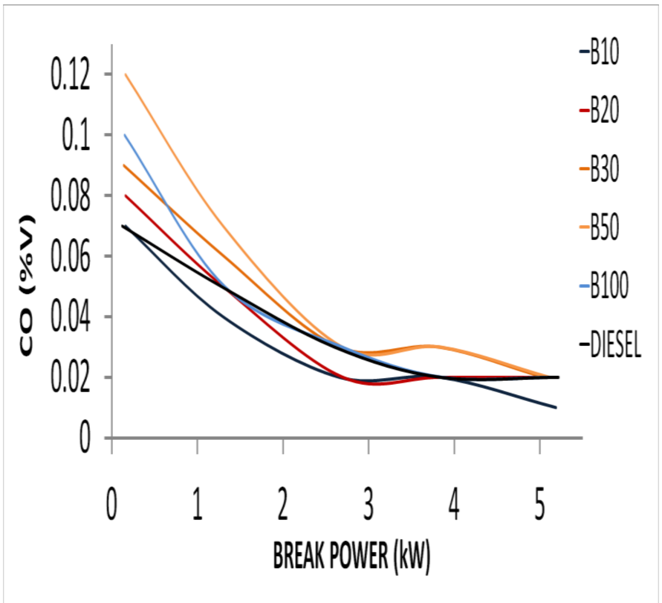


Fig. 4 CO (%V) Vs BP (KW) emission

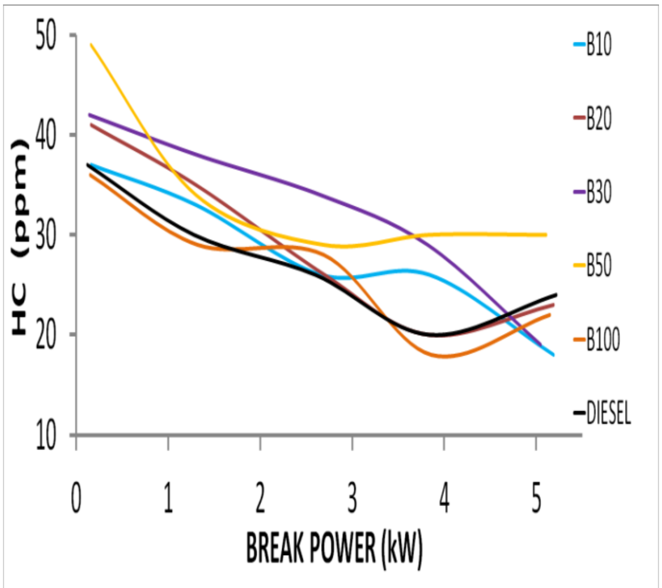


Fig. 5 Unburned HC Vs BP

The NOx emission for biodiesel blends is more eminent than that of conventional diesel except B30, B50 and B100 on average basis. NOx emission from the CNBD blend B20, B30, B50, and B100 is fairly lesser than that of diesel. Only for full load the NOx emission from the blend B10 is higher than that of diesel. While other blends closely follow standard diesel or even gives a lower level of NOx than diesel. The cause of higher NOx emission for blends is due to the high peak temperature.

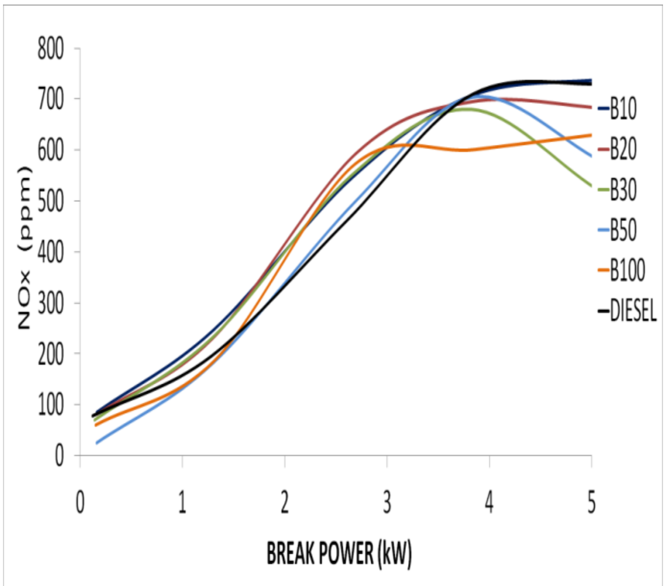


Fig. 6 NOx Vs BP

Percent of CO2 in the exhaust is the direct indication of perfect combustion of fuel in the combustion chamber. Figure 7 shows the variation of CO2 under varying load for different biodiesel blends. All test fuels show increasing trends, CO2 emission with increase in shipment due to increase in accumulation of fuel. CO2 emission for all blends of biodiesel for 50% load to full load is less than diesel this may be due to due to the high presence of oxygen than the diesel.

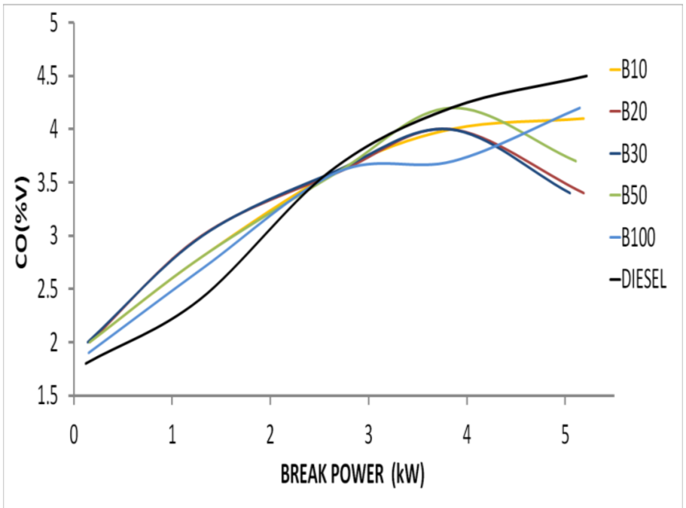


Fig. 7 CO2 Vs BP

Figure 8 shows the variation of in cylinder pressure with crank angle for blends B10, B20, B30, B50 and B100 in comparison of baseline data obtained from standard diesel. Figure 8 shows the increasing trend of incylinder pressure with increase in load. At no load condition all blend shows high peak pressure compare to standard diesel, but as the load increases gradually from no load to full load with equal interval of 25% load, all test fuels shows earlier pressure rise. Blend B100 always shows the higher peak pressure in comparison with other blends and mineral diesel.

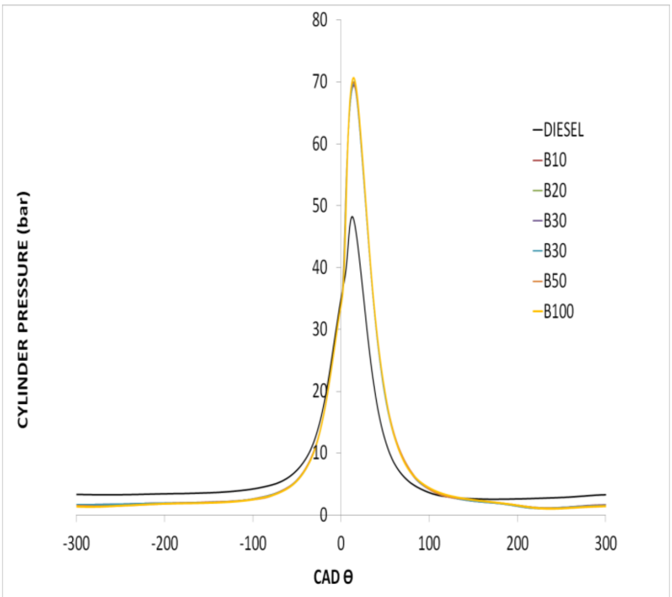


Fig. 8 Incylinder pressure vs. crank angle

Figure 9 shows the heat release rate for biodiesel blends in comparison of standard diesel at different engine operating conditions. Because of the after combustion of fuel variation of heat release occurs. From figure 3.8 it is cleared that the biodiesel blends show identical combustion stages for all loads as diesel. In general, premixed fuel- air mixture burns rapidly after an ignition delay of fuel. Generally, lower blends as B10, B20 and B30 shows the delay in the start of premixed combustion heat release than higher blends as B50 and B100 in comparison of diesel. This is because, in of low blend the concentration of biodiesel is low, that is way fuel does not cause a significant force on certain number, but it touches the air fuel mixture formation due to changes in viscosity and evaporation properties of the fuel.

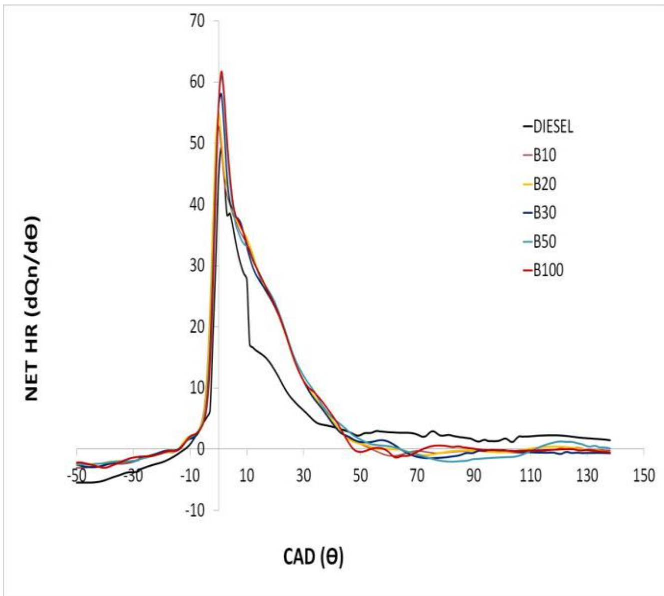


Fig. 9 Heat release rate vs. crank angle

## IV. CONCLUSIONS

- Castor oil biodiesel blend B10 showed 34.39% efficiency only it was almost 0.18 % lower compared to diesel.
- Nearly similar brake specific fuel consumption was obtained with Castor oil biodiesel in comparison of diesel.
- Blending ratio B10 of castor oil biodiesel gave lower CO emission compared to diesel
- Approximate similar value of inbound HC for Castor oil biodiesel blend B100 (26.6 ppm) was observed, to be lower compared to diesel (27.5 ppm) on an average base.
- Castor oil biodiesel blend B50 gave 397.2 ppm of NOx level considerably less than diesel 434.6 ppm of NOx level on average basis.
- Low CO2 emission was found out for Castor oil biodiesel blends compared to diesel, B30 of biodiesel blend gave the lowest value of CO2 compared to diesel. Castor BD B30 and diesel gave 3.2% and 3.3% CO2 respectively.
- Castor oil biodiesel blend B50 showed the highest incylinder pressure than diesel.
- The maximum heat release rate was noticed for only B100 blend of Castor oil gave a considerably high rate of heat release than diesel.

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