A COMPARATIVE STUDY ON BIODIESEL BLENDS WITH PURE DIESEL FUEL IN DIRECT INJECTION DIESEL ENGINE WITH AND WITHOUT COATING OF PISTON HEAD

S. Mahalingam¹, S.Saravanan² and K.Naveen³

¹ Department of Mechanical Engineering Sona College of Technology
²,³ Department of Mechanical Engineering Salem-636005, India smahasona@gmail.com

Abstract:

The increasing petroleum product demand and pollution concern ended up with the use of alternative fuels in IC engines. Particularly the esterified alternative fuels with reduced viscosity are being used in diesel engines to improve the combustion efficiency. In this study, both the performance and emission characteristics of a dual fuel such as jatropha and rubber seed oil with various injection pressures has been analyzed experimentally. The coating techniques have also been applied for coating the piston head during the performance and emission analysis. The zirconia stabilized with yittria has been applied over the piston head at various injection pressures such as 200, 220 and 240 bar. The experimental results shows that the brake thermal efficiency, CO were increased and the brake specific fuel consumption was decreased at the injection pressure of 240 bar compared to other injection pressures.

Keywords: Jatropha oil, Rubber seed oil, diesel engine, performance and emission.

I INTRODUCTION

The most suitable solution to tackle the pollution problem due to carbon emissions from automobiles is, using the biofuels produced from the food crops such as jatropha, sunflower oil, rapeseed oil, cotton seed oil, rubber seed etc in an efficient and economical method. Now a days the two major challenges to save the environment from the global warming are the green house gases emitted to atmosphere and the related climate change every year worldwide. Sahoo et al (2009) used Jatropha, Karanja and Polanga oil based methyl esters blended with conventional diesel having sulphur content of less than 10 mg/kg. Ten fuel blends including Diesel, B20, B50 and B100 were tested with different engine speed. BSFC and emission reduced. Edwin Geo. V et al (2010) analyzed the performance, emission and combustion characteristics of a direct injection diesel engine fuelled with rubber seed oil through diethyl ether injection at different flow rates of 100, 150 and 200 g/h. The brake thermal
efficiency rate of 200 g/h. Smoke, hydrocarbon and carbon monoxide emissions were reduced and the NOx emission was increased. Antony Raja. S et al (2011) biodiesel produced from Jatropha oil by transesterification process. The Jatropha oil was converted into jatropha oil methyl ester known as biodiesel prepared in the presence of homogeneous acid catalyst. The values obtained from the Jatropha methyl ester were closely matched to that of diesel. Hariharan V.S and Vijayakumar Reddy.K (2011) the performance of DI diesel engine running at constant speed and with different injection pressures of 170, 190, 210 and 230 bars. The biodiesel of sea lemon oil was blended with the diesel and tested in IC engine to observe the performance and emission characteristics of the engine. The smoke and UHC were reduced with increase in injection pressure, while the BTE increased. Junepyo Cha et al (2013) the effect of two different injection pressures 50 and 100 MPa on combustion and emission characteristics under near-stoichiometric conditions. At high injection pressure (100 MPa), operating range of injection timing was extended by which extremely low NOx emission and significant increase of soot emission was achieved. Metin Gumus et al (2012) the effect of fuel injection pressures (18, 20, 22, and 24 MPa) and mean effective pressure (12.5, 25, 37.5, and 50 kPa) in a direct injection diesel engine fuelled with biodiesel and diesel blends. Increase in injection pressure, decreased BSFC of high percentage biodiesel - diesel blends (B20, B50, and B100), smoke opacity, CO, UHC emissions and increased the emissions of CO2, O2 and NOx. For diesel fuel and low percentage biodiesel diesel blends (B5), the increased or decreased injection pressure causes increase in BSFC values compared to original injection pressure. Purushothaman. K and Nagarajan .G (2009) the effect of injection pressures of 215, 235 and 255 bar on the combustion process and exhaust emissions of a direct injection diesel engine fuelled with 30% orange skin powder diesel solution. At 235 bar injection pressure with 30% solution, better BTE, higher NOx emissions, lower HC, smoke and CO emissions were observed compared to diesel fuel. Cenk Sayin et al. (2010) both of the injection pressure and injection timing were changed in the compression ignition engine decreases the smoke opacity, CO, THC emissions while NOx emissions were increased. Narasima Kumar.S (2014) analyzed a conventional diesel engine and ceramic coated low heat rejection diesel engine with different operating conditions of linseed oil based biodiesel with fixed injection timing and injector opening pressure. Smoke levels decreased and NOx levels increased with engine with LHR combustion chamber with biodiesel operation. Murali Krishna et al (2012) the performance of a medium grade low heat rejection diesel engine of crude rice brawn oil with varied injection pressure and injection timing. Performance of both Conventional engine and LHR engine were improved with advanced injection timing and at higher injection pressure. Peak brake thermal efficiency, NOx increased, smoke levels decreased on LHR engine.Can Hasimoglu et al (2010) a low heat rejection engine for different insulation levels with the cylinder head, valves and pistons of the test engine were thermally insulated with yttoria-stabilized Zirconia (Y2O3–ZrO ). The brake thermal efficiency, BSFC and volumetric efficiency was increased was improved for LHR application. Ihmanshu. V et al (2012) the effect of ceramic
coated diesel engine for the performance and emission and compared with a four-stroke, direct injected, single cylinder, diesel engine without coating at constant speed and different load conditions. Ibtihal Al-Namie et al (2012) the inlet and exhaust valve faces were coated with ceramic materials made of Yttria Stabilized Zirconia and NiCrAl as a bond coat for a thickness of 500 μm by using flame spray method. There was a reduction in the fuel consumption for both coated and uncoated engines about 7.6%. The HC, CO exhaust gases temperature emission increased after coating.

In this present experimental study the esterified jatropha and rubber seed oil blends were used with pure diesel fuel in the engine with ceramic coated piston head. The experiment has been done with different injection pressures and the performance and emission characteristics of the test engine.

II EXPERIMENTAL SETUP AND PROCEDURES

The kirloskar make single cylinder, four stroke, diesel, air cooled engine with constant speed (1500 rev/min) was used to evaluate the performance and emission characteristics. The test engine was attached with an electric dynamometer at the rated power of 4.4 kW and a smoke meter while running the engine and controls the test engine with different load conditions such as 0%, 25%, 50%, 75% and 100%. Intake air consumption was measured using a U tube manometer. The engine was maintained with injection pressure of 240 bar and 24° BTDC ignition timing was maintained during the running of the engine. An AVL model gas analyzer was used to observe the emissions like smoke, CO, UHC, and NOx. The specifications of the test engine are described in table 2.

| Property | Diesel | Rubber seed oil | Jatropha oil | Biodiesel
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<tbody>
<tr>
<td>Sp. Gravity</td>
<td>0.7</td>
<td>0.82</td>
<td>0.96</td>
<td>0.90</td>
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<tr>
<td>Viscosity at 40°C (m²/s)</td>
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<td>4.2</td>
<td>4.4</td>
<td>4.2</td>
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<tr>
<td>Calorific Value (KJ/kg)</td>
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<td>3700</td>
<td>38500</td>
<td>39500</td>
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<td>Carbon residues %</td>
<td>0.1</td>
<td>0.19</td>
<td>0.61</td>
<td>0.26</td>
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</tbody>
</table>

III Result and Discussions

A. Brake Thermal Efficiency (BTE)
Fig. 1. BTE for diesel fuel with and without piston coating

The Figure 1 shows clearly the variation of the BTE of pure diesel for changing engine load conditions. The brake thermal efficiency of the coated piston PWC (Piston With Coating) at 240 bar with 100% load is prominent for the diesel fuel and its BTE is increased to 30% at full load conditions when compared to that of coated and non-coated pistons at different loads. The brake thermal efficiency of the PWOC (Piston With Out Coating) at 220 bar is approaching near to the brake thermal efficiency of the PWC at 240 bar. At 220 bar, the PWC is slightly more in brake thermal efficiency when compared to the PWOC at 240 bar and PWC at 200 bar. The PWOC with 240 bar attained the value between the PWC at 220 bar and PWC at 200 bar. On comparing the values of the two values of the PWC at 200 bar, PWC at 220 bar and PWOC with 240 bar, the brake thermal efficiency is beyond the moderate level which stands between 23% and 26%. The Brake thermal efficiency of the PWOC at 200 bar is minimal as 23% when compared to other coated and uncoated pistons.

B. Brake Specific Fuel Consumption (BSFC)

The variations of BSFC for diesel fuel with different engine loads are shown in the figure 2 during the PWC and PWOC conditions. The BSFC was measured by running the engine with different injection pressures such as 200, 220 and 240 bar, and when the engine load is increased, the BSFC is being reduced. From the graph, for the pure diesel for PWOC at 200 bar, the BSFC varies from 0.56 kg/kW-h at no load condition to 0.39 kg/kW-h at full load condition without piston coating. When the injection pressure was increased to 220 bar for the PWOC, the BSFC is reduced from 0.52 kg/kW-h to 0.37 kg/kW-h. Then the injection pressure was increased to 240 bar for PWOC and the corresponding BSFC varies from 0.48 kg/kW-h to 0.34 kg/kW-h.

Fig. 2. BSFC for diesel fuel with and without piston coating

The experiment was repeated with piston coating at the pressure of 200 bar and the fuel consumption varies from 0.43 kg/kW-h to 0.31 kg/kW-h. Then for the increased pressure of 220 bar for PWC, the BSFC was decreased from 0.4 kg/kW-h to 0.28 kg/kW-h. If the injection pressure is further increased for the PWC at 240 bar, the BSFC was again reduced from 0.37 kg/kW-h to 0.26 kg/kW-h of full load condition. Finally it is shown that the piston head insulated with the Zirconia coating has a very lower amount of BSFC at all load conditions. For the less proportion of Biofuel blends mixed with diesel, the BSFC slightly increased than the diesel fuel. For the PWOC with 200 bar, the BSFC is decreased from 0.63 kg/kW-h at no load condition to 0.45 kg/kW-h at full load condition.

C. Carbon Monoxide (CO)

Figure 3 shows the carbon monoxide emission with the variation of engine loads in constant speed diesel engine. When the
engine load is increased, the CO increased for all tested fuels used in the test engine with different pressures with piston coating and without coating. From the test result for the PWOC at 200 bar the CO is increased from 0.043% at no load condition to 0.08% at full load conditions. If the injection pressure is increased to 220 bar with the PWOC, the CO varies from 0.04% to 0.06% for the entire load conditions.

![Graph showing CO emission with different injection pressures](image)

**Fig. 3. CO for diesel fuel with and without piston coating**

Further increasing the injection pressure at 240 bar the PWOC emits very less which varies from 0.035% to 0.042%. The PWC with 200 bar also emits lesser CO compared to the PWOC at 220 bar pressure because of the higher heating value of the fuel in the combustion chamber. For the increasing of pressure of 220 bar with PWC it varies from 0.033% to 0.05%. This CO emission from 25% to 75% load condition is very closer to that of the PWC at 200 bar pressure. Then the injection pressure is increased with coating up to 240 bar it varies from 0.03% at no load condition to 0.037% for the 100% of full load conditions. From the test result, the PWC at 240 bar emit the lower CO compared to the other injection pressures.

**IV CONCLUSION**

The experimental analysis shows that the single cylinder, constant speed, diesel engine with piston coating gives the better performance. For the variation in the injection pressure along with the different load conditions, the following results were obtained. From the graph, it is found that the brake thermal efficiency of diesel was higher compared to the other biodiesel. The piston coated with the injection pressures 240 bar the BTE achieved maximum of 30% when compared to other injection pressures with and without coating.

Brake specific fuel consumption for with zirconia coating it was reduced from no load to full load condition. Compare to the other pressures with coating 240 bar obtained better performance. Without coating at 200 bar injection pressure shows maximum CO compared to other blends. From the experimental results injection pressure at 240 bar with coating obtained lower CO compared to the other injection pressures.

**REFERENCES**


