EXPERIMENTAL INVESTIGATION ON PERFORMANCE COMBUSTION AND EMISSION CHARACTERISTICS OF BIODIESEL WATER EMULSION WITH CETANE IMPROVER (DEE) IN DI DIESEL ENGINE

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Abstract

Investigating the combustion, emission and performance characteristics of bio-diesel water emulsion on diesel engine which works on direct injection. The amount of fuel consumed, and exhaust released by the diesel engine with biodiesel water emulsion fuel were observed. Here we use 5\%, 10\%, 15\% water mixed with B20 biodiesel blend and constant diethyl ether (DEE) 1\%. These components are mixed in an electric mixer to make blending fuel. This experiment details about the usage of emulsion fuel to the diesel fuel in a diesel engine. The five different engine load condition are 0kg, 4.5kg, 9kg, 13.5kg, and 18kg with a constant speed of 1500rpm and the data is taken at each engine load. The three parameters such as engine performance, combustion, and emissions parameters at different load condition were observed and tabulated. The data that is observed at a different load of 5\%, 10\% and 15\% water biodiesel emulsion is plotted for performance comparison and emission characteristics checking. The results justify that emulsion fuel releases less exhaust temperature than the existing diesel fuel. 15\% water mixed with biodiesel will reduce the NO\textsubscript{X} significantly.

Keywords: biodiesel water emulsion, emulsion fuel, emission, fuel consumed, NO\textsubscript{X}

INTRODUCTION

The need of diesel was growing for Transportation and power generation, the searching for fuel alternates has impossible to stop. So this leads to biofuel. Due to the higher viscosity of bio-

oil, direct use in a diesel engine is not possible so by transesterification it is converted into biodiesel [1]. Without modification in the engine, biodiesel could be used [2]. The several features of biodiesel are lubrication is better, the flash point is higher, exhaust emission is lower and some disadvantages are higher smoke and NO\textsubscript{X} emission [3-4].cold flow properties added will improve oxidation stability[5].water emulsified biodiesel reduces NO\textsubscript{X}
and smoke[6-7].10%,20%,30% composition water in biodiesel blend reduces smoke and NO\textsubscript{X} [8].13% of water in diesel engine reduces NO\textsubscript{X}, smoke, and specific fuel consumption,[9].brake thermal efficiency improved by 10%,20% biodiesel with water and decreases NO\textsubscript{X} [10]. From the above papers, the analysis has done on performance, emission and combustion characters using neet biodiesel. So this paper briefly investigates performance, emission, and combustion of emulsification of biodiesel by 5%, 10%, and 15% water in biodiesel. And compared with diesel characters.

**PREPARATION OF NERIUM-WATER EMULSION**

The first step was transesterification of Nerium oil. At the end of transesterification, Nerium oil is converted into a methyl ester. This reaction involves adding of 4grms of NaOH catalyst per litre of Nerium oil with 250 ml of methanol and resulting methoxide is obtained. And mixture is heated up for 2 hours at 70 °C and settle for 8 hours in a beaker. Then glycerol is settled at bottom and biodiesel is at the top layer. From that glycerol is drained off. Then the biodiesel is washed with distilled water. Then obtained a product is Nerium biodiesel. Then biodiesel is emulsified with 5%, 10%, and 15% of water are added to B20 blend.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Diesel</th>
<th>Biodiesel with 5% water</th>
<th>Biodiesel with 10% water</th>
<th>Biodiesel with 15% water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (kg/m\textsuperscript{3})</td>
<td>860</td>
<td>878</td>
<td>890</td>
<td>895</td>
</tr>
<tr>
<td>Calorific value (kJ/kg)</td>
<td>43500</td>
<td>37455</td>
<td>36405</td>
<td>34945</td>
</tr>
<tr>
<td>Flash point</td>
<td>80</td>
<td>180</td>
<td>185</td>
<td>190</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(\textdegree)</th>
<th>48</th>
<th>57</th>
<th>54</th>
<th>52</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cetane Number</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXPERIMENTAL SET-UP**

The engine test setup used is shown in figure 1. The setup consists Kirloskar diesel engine TV 1, single cylinder, 4 strokes, eddy current type dynamometer loading type diesel engine. It fuel flow rate is measured by calibrated burette. The instruments are provided to measure combustion pressure and crank angle. Combustion analyzer analyzed heat release rate. The AVL DI GAS 444N (Five gas analyzer) is to measure the emissions of CO, HC, CO\textsubscript{2}, O\textsubscript{2}, and NO\textsubscript{X} content. The AVL 437C SMOKE METER is used to measure the opacity of smoke. The exhaust gas temperature of 0%, 25%, 50%, 75%, and 100% load with emulsified fuel and compared with diesel fuel. The injection timing was det to 23° before TDC and a constant speed of 1500 rpm. The consumption of fuel is measured for 10cc of fuel.
consumed. The power developed is measured by voltmeter and ammeter. The analysis of combustion like rate of heat release, peak pressure, cumulative heat release was calculated from crank angle-pressure diagram and heat release diagram. The specifications of the engine are

Table 1: Specification of Engine

<table>
<thead>
<tr>
<th>T1</th>
<th>Engine cooling water inlet</th>
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</thead>
<tbody>
<tr>
<td>T2</td>
<td>Engine cooling water outlet</td>
</tr>
<tr>
<td>T3</td>
<td>Calorimeter water inlet</td>
</tr>
<tr>
<td>T4</td>
<td>Calorimeter water outlet</td>
</tr>
<tr>
<td>T5</td>
<td>Calorimeter exhaust gas in</td>
</tr>
<tr>
<td>T6</td>
<td>Calorimeter exhaust out</td>
</tr>
<tr>
<td>F1</td>
<td>Fuel in</td>
</tr>
<tr>
<td>F2</td>
<td>Fuel out</td>
</tr>
<tr>
<td>F3</td>
<td>Engine cooling water 200lbh</td>
</tr>
<tr>
<td>F4</td>
<td>Calorimeter water 100lbh</td>
</tr>
<tr>
<td>PT</td>
<td>Pressure transmitter</td>
</tr>
<tr>
<td>N</td>
<td>Crank angle encoder</td>
</tr>
</tbody>
</table>

RESULT AND DISCUSSION

PERFORMANCE CHARACTER

BRAKE THERMAL EFFICIENCY

The brake thermal efficiency variation is shown in fig 2. The increase in load increases brake thermal efficiency. It is because of water emulsified Nerium biodiesel calorific value. The combustion process of biodiesel is influenced by flash point and poor volatility. The brake thermal efficiency of the emulsified fuel is less than that of diesel fuel. Among the Nerium biodiesel emulsifier, 10% water in biodiesel emulsion shows higher brake thermal efficiency of 33.76% and it is 1.46% less than diesel fuel. The brake thermal efficiency of 5% and 15% are 32.45% and 29.76% respectively.

BRAKE SPECIFIC FUEL CONSUMPTION

The brake specific fuel consumption has shown in fig 4. Increase in load decreases the brake specific fuel consumption for all test fuels. It is found from
the result 15% Nerium biodiesel water emulsion having greater brake specific fuel consumption than that of diesel and other emulsified fuels of Nerium biodiesel. The brake specific fuel consumption for 5%, 10% and 15% at full load are 0.29 kg/kWh, 0.3 kg/kWh and 0.35 kg/kWh respectively. Whereas for diesel is 0.24 kg/kWh. This due to the energy content of biodiesel is lower.

Fig 4 Variation of brake specific fuel consumption with brake power

COMBUSTION CHARACTERS
PRESSURE VS CRANK ANGLE

The variation peak pressure with crank angle is shown in fig 5. The 15% water in biodiesel water emulsion has a higher peak pressure at its full load condition than the diesel. This is due to increase in ignition delay period by vaporization of water in combustion, which turns premixed combustion period increases for emulsified fuel, which leads to high peak pressure. The peak values for 5%, 10%, 15% are 73.64 bar, 73.21 bar, 74.06 bar and for diesel 74.8 bar. From this it is clear that 5% and 10% water have less peak pressure when compared with diesel.

HEAT RELEASE RATE

Fig 5. Variation of pressure with crank angle

The heat release rate is affected by higher ignition delay period because of vaporization of water in the combustion chamber. As delay period increases for emulsion fuel which increases premixed combustion period and leads to higher heat release rate. The variation of heat release rate is shown in fig 6. The graph shows that the heat release rate is higher for 15% water in Nerium biodiesel emulsion for full load conditions. The heat rejection rate for 5%, 10%, 15% are 33.40 J/°C, 39.24 J/°C, 45.09 J/°C respectively at its full load, and for diesel is 41.32 J/°C at its full load.

EMISSION CHARACTERS
CARBON MONOXIDE (CO)

Fig 6. Variation of heat release rate with crank angle

Fig 7 shows the variation of CO with brake power. This shows increase in load increases the CO emission. From the graph it is found the CO emission at full load for 15% is less than the diesel fuel. Since CO emission depends on carbon contents incomplete combustion. The 15% water in biodiesel shows nearly 0.153% CO emission whereas diesel releases 0.182% CO emission. And all the test fuels have shown less than the diesel fuel. The 5% and 10% test fuels show 0.175% and 0.163% respectively.

HYDROCARBON EMISSION
Fig 8 variation of hydro carbon with brake power
The variation of HC emission with brake was shown in fig 8. It seems from the graph that 5% water in Nerium biodiesel is lesser than the diesel HC emission, where as the other test fuel have higher HC emission when compare to diesel. The HC emission for 5%, 10% and 15% are 120ppm, 154ppm and 157ppm at full load condition respectively and for diesel 122ppm at full load condition. This is because of micro explosion of the emulsified fuel. Reduce in HC emission increases combustion process.

NOx EMISSION

Fig 9 shows the variation of NOx with respect to brake power. The increase in load increases the NOx emission for all test fuels. The more oxygen molecule in the fuel is the reason for increase of NOx at full load condition. It is shown in the graph that all the test fuel has decreased NOx emission compared to the diesel fuel. From that 15% water in nerium oil biodiesel emulsion shows less NOx emission. The NOx emission for 5%, 10%, and 15% are 1626ppm, 1371ppm, and 1261ppm respectively at full load condition. And NOx emission for diesel is 1812ppm. The reduction in NOx emission is due to low peak combustion temperature and water content in the emulsified fuel.

SMOKE EMISSION

Fig 10 variation of smoke with brake power

The variation of Smoke emission with brake power is shown in fig 10, from the graph increase in load increases smoke emission. The smoke emission of the all test fuel is higher than the diesel fuel. Among the test fuels 10% water in nerium oil biodiesel shows less smoke when compared with 5% and 15% emulsion fuels. The 10% emulsion fuel opacity value was 85.5% where as for diesel it is 68.7%.

CONCLUSION

This paper reported a detail study of performance, combustion and emission characters of 5%, 10%, and 15% water emulsified Nerium oil biodiesel in direct injection diesel engine and compared with diesel fuel. The results are followed below:

1. The brake thermal efficiency decreased for all the emulsified fuel when compared with diesel.
2. The brake specific fuel consumption increases for all the test fuels compared with diesel.
3. The maximum values of peak pressure were observed for 15% water emulsified biodiesel at full load condition.

4. The heat release was maximum at 15% water emulsified and compared with diesel.

5. The carbon Monoxide emission of 15% is less than the other test fuels at full load condition and all the test fuel shows less CO emission compared to diesel.

6. The hydrocarbon emission was also found to be less for 5% water in biodiesel emulsified fuel when compared to diesel.

7. The NOX content decreased by 33.33% for 15% water in emulsified fuel at full load when compared with diesel.

**REFERENCE**


