Experimental Investigation on Use of Honge (Pongamia) Biodiesel on Multicylinder Diesel Engine at Part Load

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Abstract— Biodiesel is a fatty acid alkyl ester which is renewable, biodegradable and non toxic fuel which can be derived from any vegetable oil by transesterification process. Biodiesel has become a key source as a substitution fuel and is making its place as a key future renewable energy source. Biodiesel derived from vegetable oils are quite promising alternative fuels for diesel engines. Use of vegetable oils in diesel engines leads to slightly inferior performance and higher smoke emissions due to their high viscosity. The performance of vegetable oils can be improved by modifying them through the Transesterification process. In the present work, the performance of single cylinder direct injection diesel engine using honge as fuel was evaluated for its performance, emission and combustion characteristics. The properties of honge thus obtained are comparable with ASTM biodiesel standards. The produced honge biodiesel was tested for their use as a substitute fuel for diesel engine. Tests have been conducted at different varying load of biodiesel, at 60% throttle. The performance parameters elucidated includes brake thermal efficiency, specific fuel consumption, torque, also emission characteristics against varying Brake Power (BP) and combustion characteristics against crank angle.

Keywords: Honge biodiesel, diesel engine, transesterification, performance, combustion, emission characteristics

I. INTRODUCTION

The world is presently confronted with the double crises of fossil fuel depletion and Environmental degradation. Indiscriminate extraction! And lavish consumption of fossil fuels has led to reduction in underground-based carbon resources. The sky rocketing oil prices exert enormous pressure on our resources and seriously affect our economy.

The fact that petroleum based fuels will neither be available in sufficient quantities nor at reasonable price in future has revived interest in exploring alternative fuels for diesel engines. The search for an alternative fuel, which promises a harmonious correlation with sustainable development, energy conservation, management, efficiency and environmental preservation, has become highly pronounced in the present context. Renewable energy technologies fit well into a system that gives due recognition to decentralization, pluralism and local participation. Thermodynamic tests based on engine performance evaluations have established the feasibility of using a variety of alternative fuels such as Compressed Natural Gas, Biogas, Alcohols, and Vegetable oils etc. For the developing countries of the world, fuels of bio-origin can provide a feasible solution to the crisis. The fuels of bio-origin may be alcohol, vegetable oils, biomass, and biogas. Biodiesel is a nonpetroleum-based fuel defined as fatty acid methyl or ethyl esters derived from vegetable oils or animal fats and it is used in diesel engines and heating systems. Thus, this fuel could be regarded as mineral diesel substitute with the advantage of reducing greenhouse emissions because it is a renewable resource. However, the high cost of biodiesel is the major obstacle for its commercialization, the biodiesel produced from vegetable oil or animal fat is usually more expensive than petroleum-based diesel fuel from 10 to 40%. Moreover, during 2009, the prices of virgin vegetable oils have nearly doubled in relation to the early 2000. This is of great concern to biodiesel producers, since the cost of feedstock comprises approximately 70-95% of total operating costs at a biodiesel plant. Compared to neat vegetable oils, the cost of vegetable oils is anywhere from 60% less to free, depending on the source and availability.

Still further if Honge are poured down the drain, resulting in problems for wastewater treatment plants and energy loss, or integrated into food chain by animal feeding, causing human health problems, and their use for biodiesel production offers solution to a growing problem of the increased waste oil production from household and industrial sources all around the world.

Used cooking oil is one of the economical sources biodiesel productions. However, the products formed during frying, such as free fatty acid and some polymerized triglycerides, can affect the Transesterification reaction and the biodiesel properties.

Commercial Biodiesel does have standards which must be met, just like commercial petro diesel does. The ASTM Standard for Biodiesel is ASTM 0 6751. When made to this standard, Biodiesel is a very high quality fuel which is superior to petro diesel in every way, except cold weather performance.

II. THE PROPERTIES OF DIESEL AND HONGE BIODIESEL

<table>
<thead>
<tr>
<th>Fuel samples Properties</th>
<th>Diesel</th>
<th>Honge biodiesel</th>
<th>Apparatus used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel density in g/L</td>
<td>828</td>
<td>855</td>
<td>Hydrometer</td>
</tr>
<tr>
<td>Kinematic viscosity at 40°C in cSt</td>
<td>4.6</td>
<td>5.60</td>
<td>Redwood viscometer</td>
</tr>
<tr>
<td>Flash point in °C</td>
<td>51</td>
<td>56</td>
<td>Abies apparatus</td>
</tr>
<tr>
<td>Fire point in °C</td>
<td>57</td>
<td>63</td>
<td>Abies apparatus</td>
</tr>
<tr>
<td>Calorific value in kJ/g</td>
<td>42600</td>
<td>37,120</td>
<td>Bomb calorimeter</td>
</tr>
</tbody>
</table>

Table 1: Fuel properties
The different properties of diesel fuel and Honge biodiesel are determined and given in Table 1. After Transesterification and Esterification process the fuel properties like kinematic viscosity, calorific value, and density, flash and fire point get improved in case of biodiesel. The calorific value of Honge biodiesel is lower than that of diesel because of oxygen content. The flash and fire point temperature of biodiesel is higher than the pure diesel fuel this is beneficial by safety considerations which can be stored and transported without any risk.

III. EXPERIMENTATION

A. Engine components

The various components of experimental, photograph of the experimental set up is shown in Fig. 1.

<table>
<thead>
<tr>
<th>Sl.No</th>
<th>Component</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Engine</td>
<td>Tata Indica V2, 4 Cylinder, 4 Stroke, water cooled, Power 39KW at 5000 rpm, torque 85 NM at 2500 rpm, stroke 79.5mm, bore 75mm, 1405 cc, CR22</td>
</tr>
<tr>
<td>2</td>
<td>Dynamometer</td>
<td>eddy current, water cooled</td>
</tr>
<tr>
<td>3</td>
<td>Temperature</td>
<td>eddy current, water cooled</td>
</tr>
<tr>
<td>4</td>
<td>Piezo sensor</td>
<td>Range 500 PSI</td>
</tr>
<tr>
<td>5</td>
<td>Air Box</td>
<td>MS fabricated with orifice meter and manometer</td>
</tr>
<tr>
<td>6</td>
<td>Load indicator</td>
<td>Digital, Range 0-50 Kg, Supply 230VAC</td>
</tr>
<tr>
<td>7</td>
<td>Engine Indicator</td>
<td>Input Piezo sensor, crank angle sensor, Input Piezo sensor, Communication RS 232, Crank angle sensor, No. No. of channel 2</td>
</tr>
<tr>
<td>8</td>
<td>Software</td>
<td>IC Enginepro Measurement and Automation</td>
</tr>
<tr>
<td>9</td>
<td>Temperature Sensor</td>
<td>Type RTD, PT100 and Thermocouple Type K</td>
</tr>
<tr>
<td>10</td>
<td>Fuel Flow transmitter</td>
<td>DP transmitter, Range 0-500 mm</td>
</tr>
<tr>
<td>11</td>
<td>Air flow transmitter</td>
<td>Pressure transmitter,</td>
</tr>
<tr>
<td>12</td>
<td>Load sensor</td>
<td>Load cell, type strain gauge, Range 0-50 Kg</td>
</tr>
</tbody>
</table>

Table 2: Technical specifications of the Tata indicaV2 diesel engine

IV. RESULT AND DISCUSSIONS

A. Introduction

This chapter consists of three types of experimental analysis, first one is performance characteristics like brake thermal efficiency, specific fuel consumption, torque against brake power, second one is combustion characteristics like pressure, and heat release rate, mass burned fraction, rate of pressure rise against crank angle, and finally third one is emission characteristics like carbon monoxide (CO), carbon dioxide (CO2), unburned hydrocarbon (HC), smoke opacity.

B. Performance, emission and combustion characteristics of Honge bio-diesel and diesel on diesel engine:

1) Variation of torque with brake power.

Fig 4.2.1: Variation of torque with brake power

Fig 4.2.1 shows the variation of torque with brake power for biodiesel and diesel. Variation of torque for different biodiesel and pure diesel at a particular engine break power is within a very narrow range. In case of both biodiesel and pure diesel, initially the torque rises sharply with increase in engine break power. Further variation of torque with break power remains almost constant. Further increase in break power causes decrease in torque.

2) Variation of brake thermal efficiency with brake power.

Fig 4.2.2: Variation of brake thermal efficiency with brake power

The fig 4.2.2 gives the comparison between the brake thermal efficiency of the engine when run with biodiesel and with diesel. The brake thermal efficiency is plotted as a function of brake power (kW). It has been observed that the brake thermal efficiency increases when the engine is run with biodiesel. The maximum value of brake thermal efficiency for diesel & pure diesel is at 27% and 32%. The brake thermal efficiency is almost constant between range of 25% to 30%, and it decreases sharply with further increase in part load. Brake thermal efficiency of biodiesel is lower than diesel.
3) Variation of brake specific fuel consumption with brake power.

The fig 4.2.3 shows the variation of the brake specific fuel consumption versus brake power when diesel is used as fuel and it is compared with brake specific fuel consumption when biodiesel is used as fuel. This may be due to the lower calorific value of Honge methyl ester compared to the diesel value. In the load range of 0 to 2 kW specific fuel consumption of biodiesel is higher, as load increases biodiesel comparable with that of diesel.

C. Emission characteristics of multi cylinder diesel engine.

1) Variation of carbon monoxide with brake power.

Figure 4.3.1 shows variation of carbon monoxide emission (CO) with brake power for diesel and biodiesel, for part load of the engine. It is observed that the biodiesel emits less amount CO than diesel at all load condition. The percentage of CO emission is as shown in fig 4.3.1 respectively. CO emission is 0.03 for diesel and biodiesel is 0.01 respectively lower than diesel at part load condition due to poor spray characteristics and improper mixing. At full load CO emission of diesel is 0.03%.

2) Variation of carbon dioxide with brake power.

The fig 4.3.2 gives the variation of carbon dioxide emission with brake power when biodiesel and diesel is used as fuel. The carbon dioxide emission is found to increase at all power outputs when biodiesel is used. The results show the increases in CO2 emission as the power output increases as compared with the std. gasoline operation.

3) Variation of unburnt hydrocarbons with brake power.

The fig 4.3.3 shows variation of hydrocarbon (HC) emission with brake power for diesel and biodiesel at part load of the engine. At part load condition HC level of biodiesel and diesel is respectively 4ppm, 13ppm. HC level of biodiesel is lesser than diesel fuel respectively at part load condition due to high viscosity that leads to bigger fuel droplets and hence non-uniform mixing with air.

4) Variation of opacity with brake power.

Smoke formation occurs at the extreme air deficiency. Air or oxygen deficiency is locally present inside the diesel engines. It increases as the air to fuel ratio decreases. Experimental results indicate that smoke emissions are increased with increase in the part load as the formation of smoke is strongly dependent on the load. Fig 4.3.4 shows variation of smoke emissions with biodiesel and diesel with the part load. Since at higher part loads better combustion may take place inside the engine cylinder trying to reduce the smoke emissions. Fig 4.3.4 shows the smoke values of diesel and biodiesel at part load operation. For diesel operation the smoke values reduced because of the atomic bounded oxygen which helps in better combustion, thus reducing the smoke.
D. Combustion characteristics of multi cylinder diesel engine

1) Variation of cylinder pressure with crank angle.

Fig. 4.4.1: Variation of cylinder pressure with crank angle

Fig 4.4.1 shows the test results comparison of cylinder pressure v/s crank angle. The cylinder pressure was found significantly higher for sole fuel. This is due to the low heat rejection to the cylinder walls. The increase in cylinder pressure is due to increase in trapped gas temperature in the combustion chamber. Further for diesel the pressure rise is found to be 82 bars when compared with biodiesel which is having a pressure of 62-65 bars at varying load.

2) Variation of mass fraction burned with crank angle.

Fig. 4.4.2: Variation of mass fraction burned with crank angle

3) Variation of cumulative heat release with crank angle.

Fig. 4.4.3: Variation of cumulative heat release rate with crank angle

Variation of cumulative heat release rate with crank angle is shown in the fig 4.4.3. From the graph it is observed that diesel fuel has higher cumulative heat release rate compared to biodiesel. This is due to the cumulative effect of slight delay in start of dynamic fuel injection and a longer ignition delay compared to neat biodiesel. Maximum cumulative heat release rate for biodiesel is recorded as 0.39 kJ at 397 degree CA. Diesel has maximum cumulative heat release rate of 0.74 kJ at 400 degree CA.

4) Variation of net heat release with crank angle.

Fig. 4.4.4: Variation of net heat release rate with crank angle

The variation of net heat release rate with crank angle is shown in fig 4.4.4. The net heat release rate in more for biodiesel as compared to the diesel fuel. Diesel has high net heat release rate of 32.98 kJ at 366 degree CA compared to biodiesel of 27.77 at 429 degree CA. This is due to higher calorific value, Cetane number and good atomization because of low viscosity.

5) Variation of rate of pressure rise with crank angle.

Fig. 4.4.5: Variation of rate of pressure rise with crank angle

Variation of rate of pressure rise with crank angle shown in fig 4.4.5 the combustion starts in the pre ignition region where the rate of pressure raise increases slightly and then again decreases to a small extent. Near TDC the rate of pressure rises is high for both biodiesel and diesel. The maximum rate of pressure rise recorded for biodiesel is 1.9 at 340 degree CA and for diesel are 5.56 at 366 degree crank angle.

6) Variation of mean gas temperature with crank angle.
Fig. 4.4.6: Variation of mean gas temperature with crank angle

Variation of mean gas temperature with crank angle is shown in fig 4.4.6 at low load condition i.e. at 10%. Maximum mean gas temperature is more for diesel as compare to neat biodiesel. During premixing phase mean gas temperature slightly increases and again decreases, later near TDC maximum temperature noted for diesel is 1824.64 °C at 383 degree CA and for neat biodiesel is 1121.56 °C at 373 degree CA. This is due to lower calorific value and lower Cetane number of biodiesel compared to diesel. Another reason would be lower viscosity of diesel results good atomization and hence proper air fuel mixture gives better combustion results leads to attainment of high temperature.

V. CONCLUSIONS

Experiment conducted on a four cylinder four stroke TATA INDICAV2 DIESEL ENGINE to compare the suitability of Honge biodiesel as an alternate fuel. Then the performance and emission characteristics of biodiesel are evaluated and compared with diesel and optimum results are obtained. For conformation its available results are compared with the results of normal engine, Honge biodiesel available in literature for similar work. From the above discussion, the following conclusions of the project are as follows.

- Neat Honge oil is converted into biodiesel using transesterification process.
- Characterization of Honge biodiesel is carried out, the specific gravity and calorific value of biodiesel is less than that of diesel.
- Viscosity of the neat Honge oil is at higher values. However viscosity of biodiesel is well comparable with diesel.
- Engine is producing the desired brake power at different speed compared with that of diesel.
- Brake thermal efficiency of biodiesel is lower than diesel.
- In the load range of 0 to 2 kW specific fuel consumption of biodiesel is higher, as load increases biodiesel comparable with that of diesel.
- Mean gas temperature of combustion chamber for a complete cycle for burning of biodiesel is lower than that of diesel.
- Smoke, unburnt hydrocarbon, carbon monoxide, carbon dioxide emissions are a little lower than that of diesel due to low temperature of mean gas temperature.
- The mass burnt fraction for a Honge completes after 17 degree of top dead center. However that of diesel is prolonged 27 degree CA, which attributes to higher emission.
- Cumulative heat release rate and mean gas temperature has same trend of biodiesel and diesel.

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mahua oil ” pet engineering college, department of mechanical engineering, vallioor, India department of mechanical engineering, nagercoil, India. International journal of environmental sciences volume 3, no 1, 2012 copyright by the authors - licensee ipa- under creative commons license 3.0


