EMISSIONS AND PERFORMANCE CHARACTERISTICS OF DIESEL ENGINE FROM BLENDS OF KARANJA METHYL ESTER AND DIESEL

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ABSTRACT

This paper presents the results of investigations carried out in studying the fuel properties of karanja methyl ester (KME) and its blend with diesel fuel from 20 to 100% by volume and in running a diesel engine with these fuels. Engine tests have been carried out with the aim of obtaining comparative measures of Brake power, specific fuel consumption and emissions such as CO₂, CO, HC, smoke density and NOx to evaluate and compute the behaviour of the diesel engine running on above mentioned fuels. The reduction in exhaust emissions together with increase in brake power, brake thermal efficiency and reduction in specific fuel consumption make the blends of karanja esterified oil (B20) a suitable alternative fuel for diesel and could help in controlling air pollution.

INTRODUCTION

Energy is an essential and vital input for economic activity. Building a strong base of energy resources is a pre-requisite for the sustainable economic and social development of a country. Indiscriminate extraction and increased consumption of fossil fuels have led to the reduction in underground-based carbon resources. Biofuels will mitigate the vulnerability and the adverse effects of use of fossil fuels. Several developed countries have introduced policies encouraging the use of biofuels made from grains, vegetable oil or biomass to replace part of their fossil fuel use in transport in order to achieve the following goals; to prevent environmental degradation by using cleaner fuel, to reduce dependence on imported, finite fossil supplies by partially replacing them with renewable, domestic sources and to provide new demand for crops to support producer income and rural economics.

Karanja can grow in humid as well as subtropical environments with annual rainfall ranging between 500 and 2500 mm. This is one of the reasons for wide availability of this plant species. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red kernels. The yield of kernels per tree is reported between 8 and 24 kg. The kernels are white and covered by a thin reddish skin. The composition of typical air dried kernels is: Moisture 19%, Oil 27.5%, and Protein 17.4%. The present production of karanja oil approximately is 200 million tons per annum. The time needed by the tree to mature ranges from 4 to 7 years and depending on the size of the tree the yield of kernels per tree is between 8 and 24 kg.

India is a tropical country and offers most suitable climate for the growth of karanja tree. It is found in abundance in rural areas and forests of entire India, especially in eastern India and Western Ghats. As the tree of karanja is naturally found in forests, there are so far no reports on adverse effects of karanja on fauna, flora, humans or even on environment but that is a different area of research. Karanja oil has been reported to contain furanoflavones, furanoflavanols, chromenoflavones, flavones and furofuranoketones which make the oil non-edible and hence further encourages its application for biodiesel production.

Fatty acids composition of Karanja oil

Table 1 Composition of Karanja oil

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Fatty acids</th>
<th>Composition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Palmitic (C16:0)</td>
<td>11.6</td>
</tr>
<tr>
<td>2</td>
<td>Stearic (C18:0)</td>
<td>7.5</td>
</tr>
<tr>
<td>3</td>
<td>Olate (C18:1)</td>
<td>51.5</td>
</tr>
<tr>
<td>4</td>
<td>Linoleic (C18:2)</td>
<td>16.0</td>
</tr>
<tr>
<td>5</td>
<td>Linolenic (C18:3)</td>
<td>2.6</td>
</tr>
<tr>
<td>6</td>
<td>Arachidic (C20:0)</td>
<td>1.7</td>
</tr>
<tr>
<td>7</td>
<td>Eicosonic (C20:1)</td>
<td>1.1</td>
</tr>
<tr>
<td>8</td>
<td>Behenic (C22:0)</td>
<td>4.3</td>
</tr>
<tr>
<td>9</td>
<td>Lignoceric (C24:0)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

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Transesterification

Transesterification (alcoholysis) is the chemical reaction between triglycerides and alcohol in the presence of catalyst to produce mono-esters. The long and branched chain triglyceride molecules are transformed to mono-esters and glycerin. Transesterification process consists of a sequence of three consecutive reversible reactions. That is, conversion of triglycerides to diglycerides, followed by the conversion of diglycerides to monoglycerides. The glycerides are converted into glycerol and yielding one ester molecule in each step. The properties of these esters are comparable to that of diesel. The overall transesterification reaction can be represented by the following reaction scheme.

\[
\text{Triglyceride + ROH } \leftrightarrow \text{Diglyceride + ROH} \leftrightarrow \text{Monoglyceride + ROH} \rightarrow \text{Glycerol + RCOOR}
\]

Triglyceride Methanol Glycerol

BIODIESEL

Where R, RII, & III are long chain hydrocarbons. Stoichiometrically, three moles of alcohol are required for each mole of triglyceride, but in practice a higher molar ratio is employed in order to displace the equilibrium for getting greater ester production. Though esters are the desired products of the transesterification reactions, glycerin recovery also is important due to its numerous applications in different industrial processes. Commonly used short chain alcohols are methanol, ethanol, propanol and butanol. The yield of esterification is independent of the type of alcohol used. Therefore, the eventual selection of one of these three alcohols will be based on cost and performance considerations. The methanol is used commercially because of its low price. Alkaline hydroxides are the most effective transesterification catalysts as compared to acid catalysts. Potassium hydroxide and sodium hydroxide are the commonly used alkaline catalysts. Alkaline catalyzed transesterification of vegetable oils is possible only if the acid value of oil is less than 4. Higher percentage of FFA in the oil reduces the yield of the esterification process.

Experimental Procedure

Specifications of CI Engine

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAKE</td>
<td>Kirloskar</td>
</tr>
<tr>
<td>TYPE</td>
<td>vertical, water cooled, single cylinder, 4-stroke, compression ignition engine</td>
</tr>
<tr>
<td>MAX. BP</td>
<td>3.7kW (5 H.P)</td>
</tr>
<tr>
<td>SPEED</td>
<td>1500 RPM</td>
</tr>
<tr>
<td>BORE</td>
<td>80mm</td>
</tr>
<tr>
<td>STROKE</td>
<td>110mm</td>
</tr>
<tr>
<td>ORIFICE DIA</td>
<td>20mm</td>
</tr>
<tr>
<td>COMPRESSION RATIO</td>
<td>16.5:1</td>
</tr>
</tbody>
</table>

Description

The engine is four stroke vertical single cylinder diesel engine. The Mechanical brake drum is fined to the engine flywheel and are mounted on a frame and futures mounted on anti-vibrations. The panel board is provided with 3 way cock, digital temperature indicator with selector switch, digital RPM indicator and U-tube manometer.

Performance Analysis

Results of the experiments in the form of brake power, brake thermal efficiency, specific fuel consumption for different load conditions for various blends of karanja methyl esters compare with the petroleum diesel in the form of graphs.

Brake Thermal Efficiency (BTE)

From the fig.1, it is observed that the BTE is slightly lower than the diesel for karanja methyl ester and its blends only B20 blend is slightly higher than diesel. The BTE is nearly same for karanja methyl ester because of nearer calorific value.

The brake thermal efficiency is based on brake power(bp) of the engine. This efficiency gives an idea of the out put generated by the engine with respect to heat supplied in the form of fuel. For CI engine brake thermal efficiency gradually increases with increase in bp.

From the fig.1, it is observed that brake thermal efficiency is low at low values of bp and is increasing with increase of bp for all blends of fuel.

![Figure 1 Comparision of Brake Thermal efficiency with blends of KME and diesel](image-url)
Emission Analysis

Emission characteristics are improved for biodiesel compared to conventional diesel. Bio-diesel runs in any conventional unmodified diesel engine and yields approximately equal performance as petroleum diesel. So basically engine just runs like normal except odour. Trasesterified vegetable oils have lower viscosities than the parent oils. Accordingly they improve injection process and ensure better atomization of the fuel in the combustion chamber. Bio-diesel can be blended in any ratio for reduced emissions and the increased lubricity makes for a better running of vehicle.

Results of the experiments in the form of carbon monoxide (CO), Carbon dioxide (CO$_2$), Nitrogen oxides (NOx), Hydrocarbons (HC) and smoke density for different load conditions for various blends of karanja methyl esters compare with the petroleum diesel in the form of graphs.

CO Emission

From fig.3, it is observed that CO decreases with increasing load for all the blends of Karanja methyl esters. If percentage of blends of Karanja methyl esters increases, CO reduces. The concentration of CO decreases with the increase in percentage of KME in the fuel. This may be attributed to the presence of O$_2$ in KME, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO$_2$).

HC Emission (in PPM)

From fig.5 it is observed that hydro carbon (HC) increases with increasing load for all the blends of Karanja methyl esters. If percentage of blends of Karanja methyl esters increases, HC reduces. The hydrocarbon emissions are inversely proportional to the percentage of KME in the fuel blend. A significant difference between KME and diesel operation can be inferred. The diesel oil operation showed the highest concentrations of HC in the exhaust at all loads. Since KME is an oxygenated fuel, it improves the combustion efficiency and hence reduces the concentration of hydrocarbon emissions (HC) in the engine exhaust.

NOx Emission (in PPM)

From fig.6, it is observed that NOx increases with increasing load for all the blends of karanja methyl esters. If percentage of blends of karanja methyl esters increases, NOx decreases. It can be seen that NOx emissions decrease with increase in percentage of KME in the diesel-KME fuel blend. The NOx decrease for KME may be associated with the oxygen content of the KME, since the fuel oxygen may augment in supplying additional oxygen for NOx formation. Moreover, the higher value of peak cylinder temperature for KME when compared to diesel may be another reason that might explain the decrease in NO$_x$ formation.

Smoke density

From fig.7, it is observed that smoke density increases with increasing load for all the blends of karanja methyl esters. If percentage of blends of karanja methyl esters
increases, smoke density decreases. Because of increasing the load the fuel entering in to the cylinder increases in that proper oxygen is not allowed for that the smoke density is high for the diesel.

Figure 6 Comparison of Smoke density with blends of KME and diesel

CONCLUSION

Experiment has been done by blending biodiesel (karanja) in different volumes with diesel. The engine performance indicating parameters like brake power, indicated power, brake thermal efficiency, mechanical efficiency, etc., have been observed for various blends at different loads.

It is clear that, at all blending of biodiesel the engine performance is found to be very appreciable. At 20% blending trial particularly at full load and half load conditions the specific fuel consumption and indicated thermal efficiency are very closer to the values obtained without blending. So at some considerable conditions KME blends can be the good substitute of petroleum diesel.

From the experiments conducted, it is concluded that biodiesel and its blends as a fuel for diesel engine have better emission characteristics compared with diesel. More over its impact on environment is very poor when compared with diesel. The NOx, HC,CO and Smoke density emissions are less compared with diesel. Thus KME biodiesel may be the promising fuel for the future

References


Sudipta choudhury and Dr. P.K.Bose “ Karanja oil-its potential and suitability as biodiesel.


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