Experimental Investigation On Performance, Emission And Combustion Characteristics Of A LHR Single Cylinder Diesel Engine Operating On Deccan Hemp Biodiesel And Diesel Fuel

Sateeshkumar¹ Prakash.S.Pati² Dr.Omprakash Hebbal³
¹M.Tech Student ²Associate Professor ³Professor
1,2, ³Department of Mechanical Engineering

PDA College of Engineering, Gulbarga, Karnataka/(INDIA)


Abstract— In this present investigation deccan hemp oil,a non-edible vegetable oil is selected for the on a diesel engine and its suitability as an alternate fuel is examined. The viscosity of deccan hemp oil is reduced first by blending with diesel in 10/90%, 20/80%, 30/70%, 100/0% on volume basis. Performance parameters of brake thermal efficiency, exhaust gas temperature and were determined at various values of brake power (BP) Investigations were carried out to evaluate the performance of a low heat rejection (LHR) diesel engine consisting of air gap insulated piston with 3-mm air gap, with supermi (an alloy of nickel) crown and air gap insulated liner with supermi insert with different operating conditions of deccan hemp oil based bio diesel with varied injection timing and injection pressure. The effect of void ratio, temperature of catalyst, space velocity on the reduction of oxides of nitrogen (NOx) in the exhaust of the engines was studied. Exhaust emissions of smoke and oxides of nitrogen (NOx) were determined at various values. For ascertaining the validity of result obtained, pure deccan hemp oil from investigation it has been established that, upto 20% of blend of deccan hemp oil without heating and any engine modification.

Key words: Crude Vegetable oil, Non-edible oil ; LHR engine Deccan hemp oil.

I. INTRODUCTION

The concept of LHR engine is to minimize the heat loss to the coolant by providing thermal resistance in the path of the coolant by which energy can be gained. Several methods adopted for achieving LHR to the coolant are i) using ceramic coatings on piston, liner and cylinder head ii) creating air gap in the piston and other components with low-thermal conductivity materials like supreme , cast iron and mild steel etc. Investigations were carried out by various researchers on ceramic coated engines, and reported brake specific fuel consumption (BSFC) was improved in the range 5-9% and pollution levels decreased with ceramic coated engine. Investigations were carried out with air gap insulated piston with nimonic crown with pure diesel operation, and reported brake specific fuel consumption was improved by 3%. The idea of using vegetable oil as fuel has been around from the birth of diesel engine. Rudolph diesel, the inventor of the engine that bears his name, experimented with fuels ranging from powdered coal to peanut oil. In view of the above, the major thrust in engine research during the last one or two decades has been on development of LHR engines. Several methods Renewable Energy adopted for achieving LHR to the coolant are (i) using ceramic coatings on piston, liner, and cylinder head (ii) creating air gap in the piston and other components with low thermal-conductivity materials like supermi, cast iron and mild steel, and so forth.

Ceramic coatings provided adequate insulation and improved brake-specific fuel consumption (BSFC) which was reported by various researchers conducted investigations of LHR engines with varying degree of insulation such ceramic coated engine, air gap-insulated piston engine, and air gap-insulated liner engine with pure diesel operation and reported improvement in the performance of the engine with LHR version of the engine

II. MATERIALS AND METHODS

The extraction of biodiesel is carried out by base catalyzed transesterification method.

A. Extraction of biodiesel from crude Deccan hemp oil:

To a one liter of crude deccan hemp is heated up to 70°C. 300 ml of methanol & 5-7gms sodium methoxide of (catalyst) is added and the mixture is maintained at 65-70°C is about 1½ hours and stirred continuously. The mixture is allowed to settle for 20-30 min until the formation of biodiesel and glycerin layers. The glycerin is removed from the bio-diesel in a separating funnel. The bio diesel produced from Deccan hemp biodiesel is ready to use.

B. Transesterification:

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification Physical and chemical properties are more improved in esterified vegetable oil because esterified vegetable oil contains more Cetane number than diesel fuel. These parameters induce good combustion characteristics in vegetable oil esters. So unburnt hydrocarbon level is decreased in the exhaust. It results in lower generation of hydrocarbon and carbon monoxide in the exhaust than diesel fuel. The vegetable oil esters contain more oxygen and lower calorific value than diesel. So, it enhances the combustion process and generates lower nitric oxide formation in the exhaust than diesel fuel.

\[
\begin{align*}
\text{C} & \quad \text{CH}_3\text{OCOR}' & \text{CH}_2\text{OH} & \text{R'COOCH}_3 \\
\text{C} & \quad \text{CH}_2\text{OH} & \text{CH}_3\text{OH} & \text{R'COOCH}_3 \\
\text{C} & \quad \text{CH}_2\text{OH} & \text{CH}_3\text{OH} & \text{R'COOCH}_3 \\
\text{Triglycerides} & \quad \text{Methanol} & \text{Glycerol} & \text{Methyl Esters}
\end{align*}
\]

Fig. 2.2: Transesterification process
C. The Properties of Diesel and Deccan hemp Biodiesel:
The different properties of diesel fuel and Deccan hemp biodiesel are determined and shown in table 2.1 after transesterification process the fuel properties like kinematic viscosity, cv, density, flash and fire point get improved in case of biodiesel. The calorific value of Deccan hemp 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

<table>
<thead>
<tr>
<th>Properties</th>
<th>D10 0</th>
<th>B10</th>
<th>B20</th>
<th>B30</th>
<th>B100</th>
<th>Apparatus Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kinematic Viscosity At 40°C (Cst)</td>
<td>4.98</td>
<td>5.32</td>
<td>6.58</td>
<td>9.46</td>
<td>51.85</td>
<td>Redwood Viscometer</td>
</tr>
<tr>
<td>Calorific Value (KJ/Kg)</td>
<td>4230</td>
<td>4220</td>
<td>4201</td>
<td>4130</td>
<td>3754</td>
<td>Bomb Calorimeter</td>
</tr>
<tr>
<td>Density (Kg/M³)</td>
<td>840</td>
<td>840</td>
<td>840</td>
<td>865</td>
<td>913</td>
<td>Hydrometer</td>
</tr>
<tr>
<td>Flash Point (°C)</td>
<td>51</td>
<td>62</td>
<td>70</td>
<td>80</td>
<td>155</td>
<td>Pensky-Martien’s Apparatus</td>
</tr>
<tr>
<td>Fire Point (°C)</td>
<td>57</td>
<td>75</td>
<td>83</td>
<td>94</td>
<td>165</td>
<td>Pensky-Martien’s Apparatus</td>
</tr>
</tbody>
</table>

Table 2.1 Fuel properties

III. EXPERIMENTAL SETUP
The experimental setup enables, study performance, combustion and emission characteristics. The experiments have been carried out on a DI compression ignition engine for various blends of Deccan hemp biodiesel with diesel (DHB10%, DHB20%, DHB30%, and DHB100) with varying brake power. The experiment is carried out at constant compression ratio of 17.5:1 and constant injection pressure of 200 bars by varying brake power.

Fig. 3.1: Photograph of engine setup

<table>
<thead>
<tr>
<th>Manufacture</th>
<th>Kirlosker oil engines Ltd, India</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>TV-SR, naturally aspirated</td>
</tr>
<tr>
<td>Engine</td>
<td>Single cylinder, DI</td>
</tr>
<tr>
<td>Bore/stroke</td>
<td>87.5mm/110mm</td>
</tr>
<tr>
<td>Compression Ratio</td>
<td>17.5:1</td>
</tr>
<tr>
<td>Speed</td>
<td>1500r/min, constant</td>
</tr>
<tr>
<td>Rated power</td>
<td>5.2 kW</td>
</tr>
<tr>
<td>Working cycle</td>
<td>4 stroke</td>
</tr>
<tr>
<td>Injection pressure</td>
<td>200bar/23 def TDC</td>
</tr>
</tbody>
</table>

Table 3.1: Engine specification

IV. RESULT AND DISCUSSIONS
The following tables gives the complete information of both performances and combustion characteristic of CI engine the experiments are conducted for variable load like 0,1,2,3,4, and 5.2 kW at rated speed with injection pressure of 160 bars. The engine is connected to computer all the data stored in computer with the help of engine software and exported in the below graphical form

Fig. 4.1: Variation of break thermal efficiency with break power
Fig 4.1 the variation of break thermal efficiency with break power for diesel, Deccan hemp oil and their blends are shown in Fig Break thermal efficiency of 30% blend is very close to diesel for entire range of operation. Maximum break thermal efficient of 50% blend is 24.61% against 24.61% of diesel oil which is lower by 0.041%. We can say that break thermal efficiency of 30% blend is well comparable with diesel. Break thermal efficiency of other blends follows in the order of 20% 100% blend and neat Deccan hemp oil

Fig 4.2: Variation of Break Specific Fuel Consumption
Fig 4.2: The variation of specific fuel consumption with brake power for diesel, and deccan hemp biodiesel oil and it’s blend are shown in Fig 4.2 Specific fuel consumption for deccan hemp biodiesel blends are higher than diesel for certain lower loads, but for higher loads, consumption rate remains almost constant as evident from the graph Fig 4.3 the comparisons of exhaust emission temperature with brake power for diesel, and other blends of Deccan hemp biodiesel are shown in Fig the exhaust
emission temperature of all the biodiesel are higher than the diesel as it is evident from the graph. The exhaust gas temperatures for 100% diesel and 10% 20% 30% 100% blends for varying loads can be observed and stated as they are slightly parallel to each other. The exhaust gas temperature of all the blends and 100% diesel increase as the load increases. It is observed that, at full load the exhaust gas temperature is maximum, this is because; at full load the chemically correct ratio of air and fuel is used, due to chemically correct ratio of air and fuel, high heat is generated inside the cylinder.

decan hemp biodiesel is higher than all other blends for entire operating range and the maximum value is 0.77 % volume occurs at rated load.

**Fig 4.3: Variation of Exhaust Temperature with Break Power**

**Fig 4.4: Variation of carbon monoxide emission with brake power**

Diesel fuelled LHR engine and higher by about 1.64 % and 12.22% than conventional engine fuelled with diesel and biodiesel. This reduction in the cylinder pressure may be due to lower calorific value and slower combustion rates associated with biodiesel fuelled LHR engine. However the cylinder pressure is relatively higher than the diesel engine fuelled with diesel and biodiesel. It is noted that the maximum pressure obtained for LHR engine fuelled with biodiesel was closer with TDC around 2 degree crank angle than LHR engine fuelled with diesel. The fuel-burning rate in the early stage of combustion is higher in the case of biodiesel than the diesel fuel, which bring the peak pressure more closely.

**Fig 4.5: Variation of hydrocarbon emission with brake power**

Fig 4.5 indicates and unburned HC emissions of Deccan hemp biodiesel blends compared with diesel for different engine loads. It is seen that CO emissions of fish-oil biodiesels are higher than that of diesel and HC emissions of fish-oil biodiesel blends, except B100, are higher than that of diesel, however B100 fuel produced lower HC emissions than the diesel. The presence of higher CO and HC emissions indicate the chemical energy of the fuel which is not utilized during combustion process. In this study the unburned HC, CO, NOx, emissions and smoke density, increased by 1.8%, 14.6%, 1.65% and 34.2% with use of Deccan Hemp biodiesel B100 at full load condition respectively when compared with diesel.

**Fig 4.6: Variation of carbon dioxide emission with brake power**

Fig 4.6: The Variation of carbon dioxide emission with brake power for diesel, Deccan hemp biodiesel and their blends. The carbon dioxide emission blend 20% and 30% are up to 3.09 and 3.06 kW is same. The 20% blend is increases at 3.09 and 4.07kW and finally at maximum load both are same. Compared to all blends carbon dioxide emission is decreases in diesel oil.
Fig 4.7: Variation of NO\textsubscript{x} emission with brake power

Fig 4.7: The variation of NO\textsubscript{x} emission with brake power for diesel, deccan hemp biodiesel and their blends. NO\textsubscript{x} Emission of 30% blend is lower compared with other blends followed by 20% blend. However smoke emission of 30% blend is higher than that of diesel. Smoke emission at maximum load for 10%, 20%, 30% and 100% blends are 309, 360, 350, and 330 ppm against 200 rpm of diesel oil. For 20% of blend smoke emission is on higher side for entire range of operation and maximum emission of 112 rpm occurs at maximum load.

Fig 4.9: Variation of crank angle with cylinder pressure

Fig 4.9: In a CI engine the cylinder pressure depends on the fuel-burning rate during the premixed burning phase, which in turn leads better combustion and heat release. The typical variation of cylinder pressure with respect to crank angle. The cylinder pressure in the case of biodiesel fuelled LHR engine is about 4.7% lesser than the

Fig 4.10: Comparison of heat release rate with crank angle is shown in Fig 4.9, at maximum load for both LHR-D100 and NE-D100. It is observed that the premixed burning is more dominant with diesel expected. Deccan hemp biodiesel shows lower heat release rate during premixed burning phase compared to diesel. The high viscosity and poor volatility of result in poor atomization and fuel air mixing rates. Hence, more burning occurs in the diffusion phase.

Fig 4.11: The variation of cumulative heat release rate with crank angle is shown in Fig 4.10. The diesel and blend values are same in all loads expect 10% blend. The two main phases of the combustion process, premixed and diffusion are clearly seen in the rate of heat release curve. If all heat losses (due to heat transfer from the gases to the cylinder walls, dissociation, incomplete combustion, gas leakage) are added to the apparent heat release characteristics, the fuel burn characteristics are obtained.

V. COMPARISON OF DECCAN HEMP BIODIESEL PERFORMANCE AND EMISSION WITH NORMAL ENGINE AND LHR ENGINE

Fig 5.1: The variation of break thermal efficiency with brake power for normal engine with LHR engine of diesel, and Deccan hemp are shown in Fig 5.1. The maximum break thermal efficiency for LHR diesel engine is 28% and normal diesel is 26% and for LHR Deccan hemp 100% bio diesel is 25%. And normal 100% biodiesel is 24% and LHR diesel is having maximum break thermal efficiency compare with normal diesel engine.

Fig 5.2: The variation of break specific fuel consumption with brake power for normal engine and LHR engine of diesel and Deccan hemp biodiesel are shown in Fig 5.2. The LHRD100 is having minimum break specific fuel consumption at maximum load 0.3 kJ/kW-h at 5.07 kW. The NDH100 and LHRDH100 having same specific fuel consumption at entire operating load. The NDH100 is having maximum specific fuel consumption of 4.8 kJ/kW-h, at 5.08 kW load.
Experimental Investigation On Performance, Emission And Combustion Characteristics Of A LHR Single Cylinder Diesel Engine Operating On Deccan Hemp Biodiesel And Diesel Fuel

Fig 5.3: Variation of Carbon Monoxide Emission with Brake Power

Fig 5.4: Variation of hydrocarbon emission with brake power

Fig 5.5: Variation of hydrocarbon emission with Brake power

VI. CONCLUSION

Experimental investigation is carried out on a single cylinder DI- LHR diesel engine to compare the suitability of Deccan hamp biodiesel as an alternate fuel. Then the performance and emission characteristics of blends are evaluated and compared with diesel and optimum blend is determined. For conformation its available results are compared with the results of normal engine Deccan hemp biodiesel available in literature for similar work. From the above discussion, the following conclusions are follows.

- The properties of biodiesel is satisfies the important properties like; density, viscosity, flash point, fire point and calorific value is 0.91 time that of diesel
- Deccan hemp biodiesel can be directly used in diesel engines without any engine modifications.
- Engine works smoothly on Deccan hemp biodiesel with Performance comparable to diesel operation.
- The maximum break thermal efficiency, minimum BSFC of neat deccan hemp oil are respectively 1.58% lower.
Specific fuel consumption is nearer to diesel oil at minimum loads and increases at maximum loads. Minimum BSFC of 10% blend 20% blend and 100% blend are 0.33 kg/kW-h, 0.336 kg/kW-h, and 0.388 kg/kW-h against 0.28 kg/kW-h of diesel oil.

- The exhaust gas temperature of all blends and diesel increases with increases of operating loads.
- Brake thermal efficiency of 30% blend is equal to diesel compared to other blends
- Combustion characteristics are all blends of deccan hemp biodiesel is almost same as that of diesel.
- The emission characteristics like CO, HC are increases and CO2, NO, levels are decrease against diesel oil.
- Performance of LHR deccan hemp biodiesel is validated as results are in well comparison with results normal engine deccan hemp biodiesel.
- Form the above conclusions deccan hemp biodiesel is suitable for normal engine and as well as LHR engine also.

REFERENCES


