ANALYSIS OF THE EFFECT OF NOZZLE HOLE DIAMETER ON CI ENGINE PERFORMANCE USING KARANJA OIL-DIESEL BLENDS

1Mr. Lijo P Varghese, 2Mr. Rajiv Saxena, 3Dr. R.R. Lal
1M.E. [Heat Power & Thermal] Scholar, Department of Mechanical Engg, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India
2Professor, Department of Mechanical Engg, Lakshmi Narain College of Technology, Bhopal, Madhya Pradesh, India
3Professor, AISECT University, Raisen, Madhya Pradesh, India

ABSTRACT

An experimental study was carried out to find out the effect of fuel injector nozzle hole diameter on diesel engine performance using Karanja oil- diesel blends. For this experimental setup a 5.97 KW single cylinder, water-cooled, direct injection diesel engine with dynamometer was used for the experimental work. Engine performance parameters such as brake thermal efficiency (BTE), brake specific energy consumption (BSEC), brake power (BP), total fuel consumption(TFC) and exhaust gas temperature were calculated. These performance parameters were measured using three different size nozzles. One nozzle with holes of .25 mm, .25 mm and .15 mm, second nozzle with all three holes of .4 mm size, third nozzle with all three holes of .6 mm size. Results indicated that brake thermal efficiency decreased with the increase in nozzle size. Brake power increased with increase in nozzle size but with increasing load, brake power reduced. The brake specific fuel consumption increased with increase in nozzle size, with karanja oil – diesel blends having less brake specific fuel consumption but at peak load and with nozzle size of .6 mm, diesel had the least brake specific fuel consumption. Exhaust gas temperature increased with increase in nozzle size and percentage of karanja oil to diesel.

Keywords: diesel, engine performance, karanja oil, nozzle diameter.

1. INTRODUCTION

The consumption of diesel is 4-5 times higher than petrol in India. Due to the shortage of petroleum products and its increasing cost, efforts are on to develop alternative fuels especially, to the diesel oil for full or partial replacement. It has been found that the vegetable oils are promising fuels because their properties are similar to that of diesel and are produced easily and renewably from the crops. Vegetable oils have comparable energy density, cetane number, heat of
vaporization and stoichiometric air–fuel ratio with that of the diesel fuel. None other than Rudolph Diesel, the father of diesel engine, demonstrated the first use of vegetable oil in compression ignition engine in 1910. He used peanut oil as fuel for his experimental engine [1].

Vegetable oils have almost similar energy density, cetane number, heat of vaporization, and stoichiometric air/fuel ratio compared to mineral diesel fuel. However, straight vegetable oils cannot be used directly in engines. Straight vegetable oils or their blends with diesel pose various long-term operational and durability problems in compression ignition engines, e.g. poor fuel atomization, piston ring-sticking, fuel injector coking and deposits, fuel pump failure, and lubricating oil dilution etc.. The properties of vegetable oils responsible for these problems are high viscosity, low volatility, and polyunsaturated character. Several techniques are proposed to reduce the viscosity of vegetable oils such as blending, pyrolysis, micro-emulsion and transesterification etc. Heating and blending of vegetable oils reduce the viscosity but its molecular structure remains unchanged hence polyunsaturated character and low volatility problems exist. It has been reported that transesterification is an effective process to overcome all these problems associated with vegetable oils [2]. There are many vegetable oils which have properties similar to diesel but viscosity is a major factor against their use, they need to be processed before they can be used with diesel, for this nozzle with increased hole sizes were used for testing the performance of CI engine, as processing add to the cost of bio-diesel. If they would be used at normal standard size nozzles, it may lead to the choking of the nozzles.

Vegetable oil can be directly mixed with diesel fuel and may be used for running an engine. The blending of vegetable oil with diesel fuel in different proportion were experimented successfully by various researchers. Blend of 20% oil and 80% diesel have shown same results as diesel and also properties of the blend is almost close to diesel. The blend with more than 40% has shown appreciable reduction in flash point due to increase in viscosity. Some researchers suggested for heating of the fuel lines to reduce the viscosity. Although short term tests using neat vegetable oil showed promising results, longer tests led to injector choking, more engine deposits, ring sticking and thickening of the engine lubricant [3]. Micro-emulsification, pyrolysis and transesterification are the remedies used to solve the problems encountered due to high fuel viscosity. Although there are many ways and procedures to convert vegetable oil into a Diesel like fuel, the transesterification process was found to be the most viable oil modification process [2]. The use of vegetable oils, such as palm, soya bean, sunflower, peanut, and olive oil, as alternative fuels for diesel is being promoted in many countries [4].

Y. He et al. [5] conducted tests with blend of 30% cottonseed oil and 70% diesel on diesel engine. The experimental results obtained showed that a mixing ratio of 30% cottonseed oil and 70% diesel oil was practically optimal in ensuring relatively high thermal efficiency of engine, as well as homogeneity and stability of the oil mixture. For this purpose, a modification of diesel engine structure is unnecessary, as has been confirmed by the literature. High viscosity of cottonseed oil is one of the key problems preventing its widespread application. Deshpande [6] used blends of linseed oil and diesel to run the CI engine. Minimum smoke and maximum brake thermal efficiency were reported in this study. Barsic et al. [7] conducted experiments using 100% sunflower oil, 100% peanut oil, 50% of sunflower oil with diesel and 50% of peanut oil with diesel. A comparison of the engine performance was presented. The results showed that there was an increase in power and emissions. In another study, Rosa et al. [8] used sunflower oil to run the engine and it was reported that it performed well. Blends of sunflower oil with diesel and safflower oil with diesel were used by Zeiejerdki et al. [9] for his experimentation. He demonstrated the least square regression procedure to analyze the long-term effect of alternative fuel and I.C. engine performance. The straight karanja oil blend up to 25% with the petro diesel meets the standard specification. However blending of this oil with petro diesel up to 20% (by volume) can be used safely in a conventional CI engine without any engine modification that could help in controlling air pollution. [10]
2. EXPERIMENTAL SETUP AND METHODOLOGY

A Kirloskar make, single cylinder, water cooled, direct injection diesel engine was selected for the present research work, which is primarily used for agricultural activities and household electricity generations. It is a single cylinder, four stroke, and water-cooled engine. It has a provision of loading mechanically since it is coupled with mechanical dynamometer. The engine can be hand started using decompression lever. The inlet and exhaust valves are operated by an overhead camshaft driven from the crankshaft. The fuel pump is driven from the end of camshaft. The detailed technical specifications of the engine are given in Table 1.

<table>
<thead>
<tr>
<th>Make</th>
<th>Kirloskar Oil Engines Ltd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE</td>
<td>single cylinder, 4 stroke, vertical, water-cooled engine</td>
</tr>
<tr>
<td>Rated Brake Power(kW)</td>
<td>5.968</td>
</tr>
<tr>
<td>Rated Speed (rpm)</td>
<td>1800</td>
</tr>
<tr>
<td>Number of Cylinder</td>
<td>One</td>
</tr>
<tr>
<td>Bore x Stroke (mm)</td>
<td>87.5 x 110</td>
</tr>
</tbody>
</table>

For determining the effect of injector nozzle diameter on diesel engine performance, the size of the nozzle holes were increased using the process of laser drilling. Nozzle is heat treated as a result it cannot be machined using ordinary machining processes. It can be machined by laser drilling and EDM (electric discharge machining). The tests were conducted on nozzles with holes of .4 mm, .6 mm sizes and nozzle with holes of .25 mm, .25mm and .15mm.

![Figure No.1](image)

**Figure No.1** Experimental set-up
(N-SPEED SENSOR, W-LOADING ARRANGEMENT, T1-T6-TEMPERATURE SENSORS, I-INJECTOR)
2.1 The Fuel Properties
The fuel properties of the karanja oil and its blends are furnished.

Table No.2: Fuel properties of Karanja Oil and its Blends

<table>
<thead>
<tr>
<th>Properties</th>
<th>Diesel</th>
<th>Karanja oil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>B5</td>
</tr>
<tr>
<td>Calorific value, KJ/kg</td>
<td>43500</td>
<td>43119</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>0.835</td>
<td>0.837</td>
</tr>
<tr>
<td>Kinematic viscosity at 30°C</td>
<td>2.5</td>
<td>2.78</td>
</tr>
</tbody>
</table>

3. PERFORMANCE CHARACTERISTICS

3.1 Brake Specific Fuel Consumption(BSFC)
The brake specific fuel consumption of engine was increased with increase in the nozzle size, the brake specific fuel consumption was less when using karanja oil and diesel blends with B20 having the least brake specific fuel consumption but at peak loads, while running on diesel fuel, engine had least specific fuel consumption. Nozzle with hole sizes of .25 mm, .25 mm and .15 mm, had the least brake specific fuel consumption while nozzle with all three holes of .6 mm had the highest brake specific fuel consumption. The comparative brake specific fuel consumption for all the three nozzles at various loads is given in the below figures.
3.2 Brake Power (BP)

In general brake power increased with increased in nozzle size, that is a nozzle with all holes of .6 mm produced more brake power compared to the nozzle with all holes of .4 mm, and nozzle with hole sizes of .25 mm, .25 mm and .15 mm. At maximum load condition B20 fuel produced the highest brake power, for nozzles with all holes of .6 mm and .4 mm but nozzle with hole sizes of .25 mm, .25 mm and .15 mm diesel fuel produced the maximum brake power.
Fig. 7 brake power in kW at 50% load for different nozzle sizes

Fig. 8 brake power in kW at 75% load for different nozzle sizes

Fig. 9 brake power in kW at 100% load for different nozzle sizes
3.3 Brake Thermal Efficiency (BTE)

Brake thermal efficiency decreased with increase in the nozzle sizes. At 25%, 50%, 75% load conditions B20 produced the maximum brake thermal efficiency with some exception. But at peak load condition, for all the three nozzles, diesel fuel produced the maximum brake thermal efficiency. Comparative analysis of brake thermal efficiency at various load conditions for different nozzle sizes is given in the below figures.

![Fig.10 BTE at 25% load for different nozzle sizes](image1)
![Fig.11 BTE at 50% load for different nozzle sizes](image2)
![Fig.12 BTE at 75% load for different nozzle sizes](image3)
3.4 Total Fuel Consumption (TFC)

Total fuel consumption increased with the increase in the nozzle hole sizes. The total fuel consumption was less when engine was running on karanja oil-diesel blends but at peak load, the total fuel consumption was less when diesel fuel was used.

Fig. 13 BTE at 100% load for different nozzle sizes

Fig. 14 TFC in kg/hr at 25% load for different nozzle sizes

Fig. 15 TFC in kg/hr at 50% load for different nozzle sizes
4. CONCLUSIONS

With increase in the nozzle size brake specific fuel consumption increased which was least for the B20 fuel but at peak load diesel fuel produced the least brake specific fuel consumption. The exhaust gas temperature increased with increase in nozzle size, with increase in karanja oil-diesel blending ratio, exhaust gas temperature increased but B20 produced less exhaust gas temperature compared to B15 for all nozzle sizes. The brake thermal efficiency decreased with increase in nozzle hole size, karanja oil-diesel blends produced more brake thermal efficiency but at peak load diesel fuel produced the maximum brake thermal efficiency for all the nozzle sizes. Brake power increased with the increase in the nozzle size with some exceptions, at peak load B20 produced the highest brake power at .6 mm nozzle size. The total fuel consumption increased with the increase in the nozzle hole size, karanja oil-diesel blends had less total fuel consumption as compared to diesel fuel. But at peak load, diesel fuel had the least total fuel consumption at all nozzle sizes.
5. REFERENCES

Journal Papers