Performance and Emission Characteristics of CRDI Engine with Blends of Cardanol

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Abstract: In this study the performance and emissions tests were conducted on a single-cylinder 3.5kW diesel engine using a non-edible plant-based bio-fuel Cardanol produced from cashew nut shell liquid (CNSL) blend with Honge and diesel. The bio-fuel blends 5C10H85D (5% cardanol+10% Honge+85% diesel), 10C10H80D, (10% cardanol+10% Honge +80% Diesel) 15C10H75D (15% cardanol +10% Honge + 75% Diesel) and 20C10H70D (20% cardanol+10% Honge+70% diesel) were prepared and tested at various loads (0%,25%, 50%, 75% and full load conditions) and compared with baseline diesel at 300 bar, 400 bar and 500 bar injection pressure and 18:1 compression ratio. The experimental results show that at full load, the brake thermal efficiency of 10C10H80D is 28.78% comparably similar to that of diesel is 29.75%. The lower emissions of CO, hydrocarbon except NOx are encouraging to recognize 20C10H70D as an optimized fuel blend for a compression ignition engine. The significant factors of cardanol bio-fuel include its low cost, non-edible, abundance, and it is a by-product of the cashew nut industries.

Keywords: Injection Pressure, biodiesel, blends, Cardanol, Honge oil, Emission

I. INTRODUCTION

The creating economy combined with population development has added to an exponential interest for energy sources. The disappointment of oil based goods to meet these proceeded with essential demands and pollution related issues as a result of far reaching usage of non-renewable sustainable power sources have required the advancement and the adjustment of inexhaustible and eco-pleasing fuel communicated by Kulkarni BM et.al (2008). Increasing familiarity with the utilization of non-renewable energy resources similarly as their negative characteristic impact has actuated excitement for the potential benefits of biofuels, for example, biodiesel, which is a substitute fuel for diesel engines revealed by Pullen and Saeed (2011). Vegetable oils contain many fatty acids. Four fatty acids, namely palmitic, stearic, oleic and linoleic acids, present in higher compositions. The variation of fatty acid content in the biofuel affects the performance and emissions in a compression ignition (CI) engine reported by Dinesh (2017), Suresh Kumar et al. (2008).Presented their results of performance and emission characteristics of a diesel engine fuelled with blends of Pongamiaipinnata methyl ester (PPME) with diesel. The test results revealed that up to 40% biodiesel blend provided better engine performance (BSFC and BSEC) and improved emission characteristics. The blends B40 and B60 showed lower CO and HC and higher CO2 and NOx emissions due to better combustion of fuel blends Chauhan et al. (2012) tested a Kirloskar single-cylinder diesel engine fuelled with biodiesel Jatropha oil to observe its performance, emissions, and combustion characteristics. Das and Ganesh (2003) studied the methods of extraction of CNSL from cashew nut shell. The authors studied the yield of CNSL at low temperature pyrolysis (CNSL-1) and high temperature pyrolysis (CNSL-2). They did not report much difference in properties like ash content, moisture, and density. It was observed that the viscosity changed drastically as the temperature rose from room temperature to higher temperature (60 and 80°C). They noticed a slightly higher calorific value and lower flash point in the case of CNSL-2 compared to CNSL-1 and the 100% miscibility with methanol and diesel showed good indication for blending with these fuels. Mallikappa et al. (2012) conducted an investigation on the performance and emission characteristics of a four stroke double-cylinder CI engine with cardanol biofuel volumetric blends of 0–25%. As the biofuel percentage in the blend increased, reduction in BSEC was obtained. The brake thermal efficiency obtained for cardanol biofuel blends was less than that of diesel. NOx emissions increased with increased proportion of blends and also with higher EGT (exhaust gas temperature). The nominal value of HC emissions was obtained up to B20 and more at B25 due to incomplete combustion.

II. MATERIALS AND METHODOLOGY

2.1 Materials

Honge oil is additionally called Karanja oil. Its plant name is Pongamiaipinnata, has a place with group of Leguminaceae or papilionaceae. Karanja is a medium estimated quickly developing evergreen tree. The time required by the tree to develop ranges from 4 to 7 years and relying upon the extent of the tree the yield of portions per tree is between 8 to 24 kg and the yield of potential per hectare is 900 to 9000 kg/hectare reported by V.S.Yaliwal (2010).Extraction requires the seeds through a screw crusher, for the most part called expellers. The oil is then separated to make it clean enough to process as expressed by C.V. Mahesh (2012). Honge oil collected locally and Cardanol was collected from Adarsh cashew industry Karkala area Karnataka.
2.2 Transesterification

As indicated by Srivastava and Prasad R (2004) there are four distinctive courses through which non-consumable oils can be converted into methyl esters are transesterification, blending, emulsion and pyrolysis out of which transesterification is commonly used. Dharmadhikari et al. (2012) expressed that Free unsaturated fat (FFA) substance should be known for the crude oil. FFA will be determined by basic chemical titration.

2.3 Methodology

One litre of honge oil was warmed in open beaker to a temperature for 100°C to expel water particles present in oil pursued by filtration of oil. The oil was prepared under alkali base catalyzed transesterification method. Since FFA value was observed to be 2.41%. The oil was blended with 300ml of methanol and 6 grams of sodium hydroxide pallets in round bottom flask mixed on a hot plate magnetic stirrer for a one and half hour at 60°C and after that it was permitted to settle down for around 6 to 8hrs to get biodiesel and glycerol. The biodiesel obtained in the process was further washed with water to remove moisture content. Hence pure Honge biodiesel was obtained.

2.4 Properties of biodiesel

Haiter Lenin and thyagarajan(2012), Senthil Kumar et al.(2012) expressed that some of the properties like flash point, viscosity, density, specific gravity and calorific value are needed for using the bio-diesel as vehicular fuel. The Physico-chemical properties such as higher calorific value, density, kinematic viscosity, flash and fire points are determined as per ASTM standards for biodiesel. In this study 4 blends were used 5C+10H+85D(5%Cardanol+10%honge oil+85%diesel), 10C+10H+80D, 15C+10H+75D and 20C+20H+70D

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<th>Sr No.</th>
<th>Diesel (%)</th>
<th>Biodiesel (%)</th>
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<th>Specific Gravity (eSt @ 40°C)</th>
<th>Density (kg/m3)</th>
<th>Calorific Value (kJ/kg)</th>
<th>Flash Point (°C)</th>
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III. EXPERIMENTAL PROCEDURE

The engine tests were conducted on a computerized single cylinder four four-stroke, water-cooled CRDI diesel engine test rig (Fig. 1). It was specifically coupled to a current dynamometer. The engine and the dynamometer were interfaced to a control board, which was associated with an advanced PC, utilized for recording the test parameters can be retrieved when required. The set of experiments were conducted at the designed speed of 1500 RPM and compression ratios of 18:1. The experiments were conducted at no-load. 25% of full load, 50% of full load, 75% of full load and full load with neat diesel and blends Cardanol raw oil and Methyl ester of Honge oil with Diesel as fuel. The exhaust gases are analyzed by using gas analyser.

IV. RESULTS AND DISCUSSION

Initially the experiments were performed for diesel at 300bar, 400bar and 500bar injection pressures and 18:1 and then 4 blends of cardanol honge with diesel were carried out. The engine performance like brake power, brake specific fuel consumption, brake thermal efficiency, and emission like HC, CO and NOx were obtained and then compared the performance of blends with those of D100 at 18:1 compression ratio. Based on the experimental methodology the following results were obtained.

4.1. Brake specific fuel consumption

The variation of BSFC against load for four blends is shown. From the results it was observed that the load increases the brake specific fuel consumption decreases for the fuel samples used in the test. It was observed that 20C+10H+85D blend gives the minimum BSFC of 0.32 kg/kW-hr and minimum BSFC of 0.31 kg/kW-hr for 10C+10H+80D blend and which found to be more than diesel i.e. 0.26 kg/kW-hr at full load. BSFC decreases with respect to load and shows close results to diesel. This may be due to improved combustion, low viscosity and high volatility of the test fuels.

![Fig 1. BSFC at 100% Diesel](image-url)
As shown in the figure 1 it is seen that BSFC variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum BSFC that is 0.26kg/kWh so it has the maximum efficiency compared to diesel at other injection pressure.

The figure 2 shows the variation of Brake specific fuel consumption vs load and this graph is the comparison of B10, B20 oil with diesel oil at different injection pressure. It is observed that B10 oil at 300bar pressure shows the minimum BSFC 0.31 kg/kWh on various loading condition so B10 oil at 300 bar has the value close to that of diesel so B10 oil at 300bar injection pressure can be used as an alternative for diesel.

4.2. Brake Thermal Efficiency

Figure 3 shown in the that BTE variation with respect to load condition and it is observed that diesel at 500 bar pressure shows the maximum BTHE that is 32.72% so it has the maximum efficiency compared to diesel at other injection pressure.

4.4 Hydrocarbon

Figure 5 shown that HC variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum HC that is 51ppm so it has the maximum efficiency compared to diesel at other pressure.
4.5 Carbon monoxide

As shown in the figure 7 it is seen that CO emission with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum CO emission 0.11% so it has the maximum efficiency compared to diesel at other pressure.

4.6 Nitrous oxides

As shown in the figure 9 it is seen that Nitrous Oxide variation with respect to load condition and it is seen that diesel at 300 bar pressure shows the minimum NOx that is 171ppm so it has the maximum efficiency compared to diesel at other pressure.
Fig 10. NOx of B10, B20 & Diesel

The figure 10 shows the variation of NOx vs load and this graph is the comparison of B10, B20 & Diesel oil at different injection pressure. It is seen that B10 oil at 300 bar pressure shows the minimum emission of NOx that is 160ppm on various loading condition so B10 oil at 300 bar gives out less NOx. High temperature and availability of oxygen are the two primary reasons for high NOx formation as nitrogen and oxygen respond at higher temperature and due to high cylinder pressure and temperature at higher loads.

V. CONCLUSION

Honge., Cardano I & Diesel and blending ratios (5%C+10%H+85%D), (10%C+10%H+80%D), (15%C+10%H+75%D), (20%C+10%H+70%D), where C, H & D are Cardanol, Honge & Diesel respectively. We have conducted the experiment using 3 injection pressure which are 300 bar, 400 bar & 500 bar with loading condition of 0%, 25%, 50%, 75% & 100%.

After observing the graph and comparing the values of B10 & B20 with values of 100% diesel oil, we can conclude that in terms of Brake Thermal Efficiency when the values of B10, B20 & Diesel is compared the value of BTH is maximum for B20 at 500 bar pressure 28.78% so it is more efficient. In case of Brake Specific Fuel Consumption when compared the values of B10, B20 & Diesel the value of B10 at 300 bar injection pressure is minimum 0.3 kg/kWh and close to that of diesel value so it is more efficient. In case of Hydrocarbon emission when the value of B20&B10 is compared with Diesel it was seen that the HC emission of B10 at 300 bar pressure is the minimum 160ppm and hence more efficient compared to others.

So by comparing the values of B10, B20 & Diesel we can come to a conclusion that the value of B10 at 300 bar injection pressure have the value close to that of 100% Diesel oil so it can be used as an alternative fuel for diesel.

REFERENCES