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Engine Emission Characteristics Using Jatropha Based Biodiesel

Pravinkumar N. Tank, Brijesh P. Waghela
Mechanical Engineering Department, Dharmsinh Desai University Nadiad, Gujarat, India

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ABSTRACT

Experimental investigation was carried out using Jathroph based oil in naturally aspirated diesel engine. Experiments are performed for pure diesel, pure biodiesel from Jatropha oil and 20% blending of Jatropha oil with diesel. The performance was carried out for three different engine load and emission characteristics were compared together with fuel consumption rate. The comparison of the resulting emission show that there is reduction in the emissions of CO, CO_2 and HC using bio diesel fuel as well as 20% blending of biodiesel and small rise in the NOx. Also there is slight increase in the fuel consumption rate using biodiesel for the current load conditions.

Keywords : Jatropha Oil, Emission Characteristics, Biodiesel

NOMENCLATURE

kW	Kilo watt
HC	Hydro carbon
CO	Carbon monoxide
NO_x	Nitrogen oxides
BD	Bio diesel
RPM	Revolutions per minute

I. INTRODUCTION

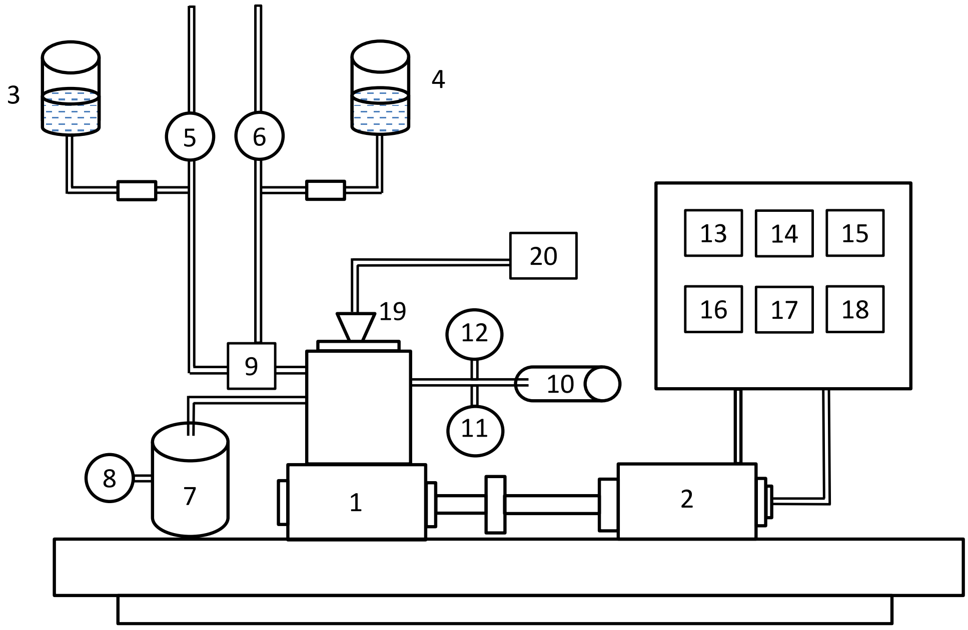
Methyl or ethyl ester of fatty acids from used or fresh vegetable oil and animal fats is what biodiesel is. When burnt, it produces far less pollutants than diesel fuel derived from petroleum, is non-toxic, and biodegradable. After being cleaned to get rid of any remaining contaminants, biodiesel is normally utilised as fuel in diesel engines without requiring any engine changes. Use of biodiesel as fuel for the IC engine is studied by many researchers few of the related literature from them is described below.

Pramanik (2003) used Jatropha curcas oil in CI engine and found significant improvement in the engine performance. Schumacher *et al.* (1993) investigated effect of fuelling a diesel engine with soybean methyl ester/diesel fuel blends. The blends investigated were 10% bio-diesel and 90 % diesel, 20% bio-diesel and 80% diesel, 30% bio-diesel and 70% diesel and 40% biodiesel and 60% diesel. It was observed that bio-diesel and diesel fuel blends effectively reduced particulate matter, unburned hydrocarbon and carbon monoxide. However, it increased emission of oxides of nitrogen. Optimum blend to decrease particulate matter and increase NOx could be 20% bio-diesel and 80 % diesel. Senthil Kumar et al (2003) used methanol to Jatropha oil in the proportion of 3:7. They found better break thermal efficiency using duel fuel and with Jatropha oil compared to blend. Reduction in the smoke and NO was found with Jatropha oil compared to diesel. Scholl and Sorenson (1993) used soybean oil methyl ester fuel in a compression ignition engine. Their findings show that, soybean oil methyl ester works similar to diesel fuel in regards to heat released rate and performance. HC emission produced is lower with the methyl ester fuel and smoke produce is also lower than diesel fuel at optimum working condition. The CO emission changed accordingly. NOx production was directly related to the pressure generated in the cylinder. It was also reported that the variation of injection timing had affected strongly on performance and emission characteristics of CI engine. Suryawanshi and Deshpande (2004) reported that bio-diesel (Pongamia oil methyl ester) and its blends with diesel results in a similar brake thermal efficiency and exhaust gas temperature as compared to pure diesel operation. However, specific energy consumption is slightly higher in case of biodiesel may be due to lower calorific value of biodiesel fuel. There is a significant reduction in smoke and HC emission for all blends of biodiesel compared to diesel at part and full loads. However, NOx emission slightly increased for all blends of biodiesel. Pathak (2004) reported that emission of CO and HC reduced while NOx increases with the increase percentage of Bio-diesel in diesel-biodiesel mixture. He also reported that NOx could be reduced by using de-NOx catalyst. Melissa et al (2007) worked to reduce NOX and suggested two approaches. The first approach is the modification of soy-oil methyl esters by conversion of cis bonds in the fatty acid chains of its methyl esters to their trans isomers and the second one were transesterified of polyol derivatives of soybean oil to form soy methyl polyol fatty acid esters. They found reduction of NOX in proportion to the blending of polyol biodiesel with petrodiesel. Kay and Yashir (2012) have suggested simplified production methods of biodiesel from low quality Jatropha oil with economy and high efficient catalyst.

In the present work biodiesel from the Jatropha oil is tested and compare for the emission characteristics for the complete biodiesel and 20% blending of biodiesel with pure diesel fuel.

II. EXPERIMENTAL TEST FACILITIES

Experimental test facility available was water cooled, naturally aspirated diesel engine running on four stoke. The engine was water cooled capable of producing 6 kW power at 1500 revolutions per minutes. Engine compression ratio was specified as 17.5. Schematic of experimental test set up is shown in Fig. 1. An electric dynamometer was used to supply load on the engine. A turbine type meter connected to large tank was attached to the engine for the measurement of air flow. In order to provide signal at top dead centre, an optical encoder system was created. The engine speed was measured using a digital rpm indicator and a photo sensor. The volumetric fuel flow rate was measured using a burette and stopwatch by noting down difference in the level of fuel consumed for the fixed time interval. Exhaust gas temperature was measured using digital temperature indicator and chromel-alumel thermocouples. Cylinder pressure was measured using a piezo-electric transducer and a high-speed digital data collecting system. An infrared exhaust gas analyser was used for emission measurement of HC, CO, NOX in the exhaust gas. Through the process of trans esterification, Jatropha oil was transformed into its methyl ester. Transesterification is the process of producing glycerol and fatty acid ester by reacting the triglycerides of Jatropha oil with ethyl alcohol in the presence of a catalyst (NaOH). Specified amounts of Jatropha oil, methanol and sodium hydroxide were taken in round bottle flask. The mixture stirred vigorously since Jatropha oil and methanol are immiscible until ester formation begins. The mixture was heated to 65°C and held at that temperature without stirring for 60 minutes. Then it was allowed to cool overnight without stirring. Two layers were formed. Bottom layer consisted of glycerol whereas the top layer was the ester. Compared to vegetable oil ester has the lower viscosity and higher cetane number Experiments were performed initially on the test set up using diesel as the base fuel for getting reference data for the comparison. During the present work, the injection timing was set at 26° before top dead centre. Temperature of cooling water was maintained around 70°C. Engine was made steady state before recording the measurements. Subsequently, experiments were repeated using diesel and methyl ester of Jatropha oil for comparison. During trials various parameters such as temperature of exhaust gases, fuel consumption, ambient temperature, noise level etc. had been measured. Microprocessor based flue gas analyzer was used to find the emissions constituents and with that characteristics of emissions can be analysed.



1. Engine
2. Dynamometer
3. Jatropha oil
4. Diesel tank
5. Burette for Jatropha oil
6. Burette for diesel
7. Air tank
8. Air flow meter
9. Injector
10. Silencer
11. Smoke pump
12. HC/CO Analyzer
13. Stop watch
14. RPM indicator
15. External temperature indicator
16. Coolant temperature indicator
17. Lubricating temperature indicator
18. Rota meter
19. Pressure sensor
20. Data acquisition system

Fig. 1 Experimental test set up

III. RESULTS AND DISCUSSION

1. Performance of engine using biogas based on rate of fuel consumption

Experiments are performed for three different loads 1.4, 2.8 and 4.2 kW and for three different configuration of fuel (i) Diesel (ii) Bio diesel and (iii) 20% blending of biodiesel with diesel. Results of fuel consumption rate for all the tree sets of experiments are shown in Fig. 2. It is seen that as the load increases, fuel consumption rate also increases. The pattern of rate of fuel consumption is similar for all the three fuel configurations like diesel, biodiesel and 20% blending of bio diesel with diesel. However from the graph it is seen that for a given load, rate of fuel consumption is higher with the use of bio diesel. 20% blending of biodiesel also gives higher fuel consumption rate compared to when only diesel is used as fuel. Never the less 20% blending will give lesser fuel consumption rate compared to 100% bio diesel fuel.

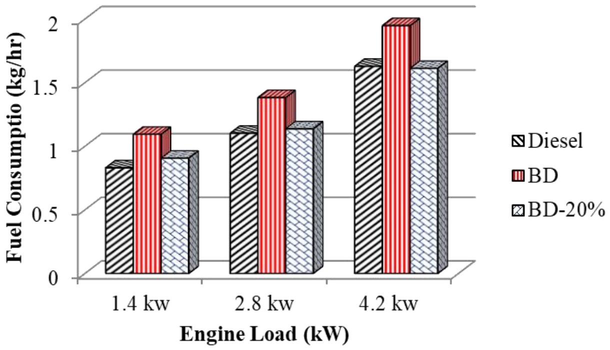


Fig. 2 Fuel consumption rate for different fuel configuration

2. Engine performance using biogas based on the emissions

Engine emissions by performing engine trial using 100% biodiesel and 20% blending of biodiesel with the diesel are compared for the engine emissions with 100% diesel as fuel in diesel engine. Experiments are repeated and readings are taken at the stabilized conditions of the test engine.

2.1 CO_2 emissions

Figure 3 shows CO_2 emissions for all the tree case of fuel blending and load. It shows that the level of CO_2 emissions is higher as the load increases. Further it gives production of CO_2 is reduced using biodiesel. Engine emissions of CO_2 are in between the pure diesel and pure biodiesel fuel with the use of 20% blending of biodiesel. Thus it can be seen the use of biodiesel is advantages for the reduction of CO_2 emissions.

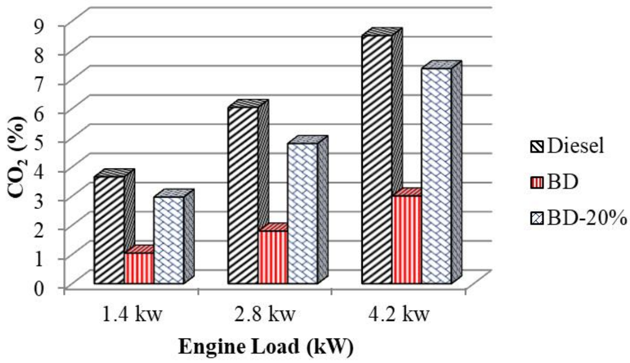


Fig. 3 CO_2 emission for different fuel configuration

2.2 CO emissions

Emissions of CO for different engine load 1.4, 2.8 and 4.2 kW are show in the Fig. 4. Figure 4 shows emission of CO increases with load. It also shows there is decrease in the emissions of CO with bio diesel. For a given engine load CO production is highest for the diesel fuel and lowest for the 20% blending of BD fuel. Therefore use of biodiesel helps reducing CO emission level in CI engine.

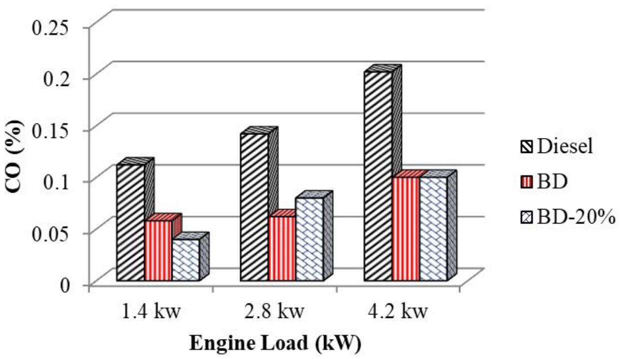


Fig.4 CO_2 emission for different fuel configuration

2.3 HC emissions

Emissions of HC are also measured with gas analyzer. The result for the different conditions of load and using two different biodiesel proportions is show in Fig. 5. The plot shows variation in the production of HC at different load. It is seen that as the load on engine increase, the proportion of HC also increases. For the case of 1.4 kW load rate of HC production is highest for the 100% diesel fuel and lowest for the 20% blending of BD fuel. At the load of 2.8 and 4.2 kW, emissions of HC for 20% BD is in-between the highest CO production for diesel and lowest CO production for 100% biodiesel fuel.

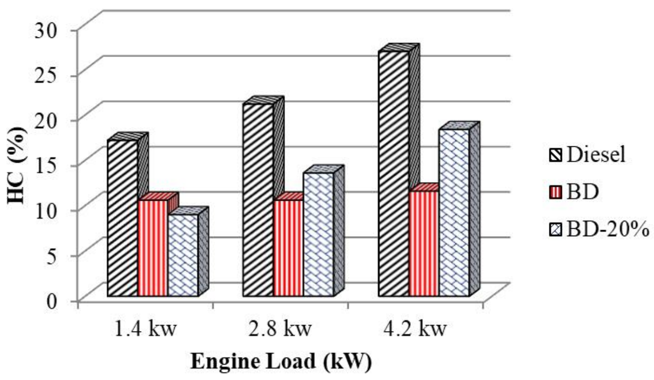


Fig. 5 HC emission for different fuel configuration

2.4 NOx emissions

NOx emissions for different load on the engine and diesel, BD and 20% blending of Jatropha based oil are presented in the Fig. 6. The observation from the graph shows the production of NOx at constant load is affected with the presence of BD. The plot shows production of NOx increase with load on the engine. It also shows NOx emissions is highest for the 100% BD and lowest for the 100% diesel fuel. However it will be in between the two when it is used 20% blending of BD fuel. So use of biodiesel increases slightly NOx production.

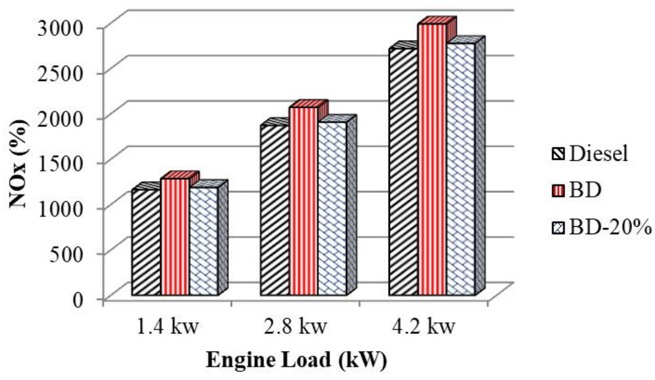


Fig. 6 NOx emission for different fuel configuration

IV. CONCLUSION

Bio-diesel can be thought of as alternative fuel for the IC engine. It can be implemented in the present IC engines without much additional cost, disturbance and with or without minor changes in the engine. Biodiesel not only reduce carbon dioxide emissions, there is also a substantial reduction of unburnt HC, CO_2. Bio-diesel is potentially a green fuel with considerable prospects. Emissions of nitrogen oxides (NOx) tend to be slightly higher for engines using biodiesel. Biodiesel scores well in its contribution to reducing carbon emissions hence its global impact on climate change is low. Following conclusions can be drawn from the present study.

There is reduction of CO_2, CO and HC using 100% Bio diesel and blending of biodiesel in the diesel on propionate basis.

There is increase in the NOx emissions using biodiesels. However proper blending with diesel may reduce the NOx emissions compared to 100% biodiesel.

For a given load there is slight increase in the fuel consumption rate using biodiesel fuel and blending of biodiesel with the diesel compared to pure diesel fuel.

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