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Full Length Research Paper

Performance analysis of IC engines with bio-diesel jatropha methyl ester (JME) blends

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Petroleum products resources are limited and their consumption rate is increasing very fast with technological development since the last two decades. The emissions from the usage of these petroleum products pollute the environment considerably. Jatropha oil is one of the renewable energy resources which are easily available in India. This study investigates the percentage substitution of jatropha methyl ester blends to diesel as fuel for automobiles and other industrial purposes. The study details the analysis of the performance and emission characteristics of the jatropha methyl esters and its comparison with petroleum diesel. The tests were carried out on a 3.7 KW single cylinder, direct injection and a water-cooled diesel engine. The fuels used were neat jatropha methyl ester, diesel and different blends of the methyl ester with diesel. The experimental result shows that 20% of the blend shows better performance with reduced pollution. The analysis shows that jatropha methyl ester blended biodiesel is a good substitute for pure diesel.

Key words: Jatropha methyl ester, water-cooled diesel engine, performance, emission characteristics.

INTRODUCTION

Bio-diesel is a renewable fuel for diesel engines derived from natural oils like vegetable oils. Bio-diesels can be used as fuel at varying concentrations with petroleum based diesel with little or no modification in existing diesel engines (Sanjib and Anju, 2005; Heywood, 1998). It is produced from raw vegetable oil by a chemical process, which removes glycerol from the oil. Jatropa is a low cost seeds with high oil content, small gestation period, which grows on good and degraded soils, as well as areas with low and high rainfall. The seeds are harvested in dry season. Jatropha can yield up to 10 times the amount of oil as other sources of biodiesel. It is a perennial crop, lasting up to 50 years without replanting. In fact the “cake” (portion of the seed left over after extracting the oil) is full of nitrogen compounds making it an excellent source of organic fertilizer. After 4 or 5 years of treatment with this “cake” the soil of this originally non-agricultural land will be suitable for planting food crops or trees for reforestation.

The Jatropha plant bears fruit from the second year after its plantation and the economic yield stabilizes from the fourth or fifth year onwards. The plant may live for more than 50 years with an average effective yielding time of 50 years. The economic yield can be considered as 0.75-2.0 kg/plant and 4.0 to 6.0 tons per ha, per year depending on the agro-climatic zone and agricultural practices. The cost of plantation has been estimated at Rs.20, 000 a hectare inclusive of plant material, maintenance for one year, training, overheads and the like. A selling price of Jatropha seeds at Rs.12 a kilo

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Table 1. Specifications of CI engine.

Max. BP	3.7kW (5 H.P)
Speed	1500 rpm
Bore	80 mm
Stroke	110 mm
Orifice diameter	20 mm
Compression ratio	16.5:1

gram would be an economically attractive proposition for farmers. India has vast stretches of degraded land, mostly in areas with adverse agro climatic conditions, where species of Jatropha can be grown easily. The use of 11 million hectare of wasteland for Jatropha cultivation can lead to generation of a minimum of 12 million jobs. India with its huge waste/non fertile lands, has taken a well-noted lead in Jatropha cultivation, and commercial production is what the industries have to focus on for sustainable development.

Properties of Jatropha:

Specific gravity: 0.87 to 0.9
Kinematic viscosity at room temperature (m^2/sec): $0.14*10^{-4}$
Dynamic viscosity (N-sec/m^2): $12.5*10^{-3}$
Cetane number: 46 to 70
Flash point °C: 150
Fire point °C: 158
Calorific value (kj/kg): 40105
Pour point °C : -15 to 13

EXPERIMENTAL PROCEDURE

Description

The engine used, is a four stroke vertical single cylinder diesel engine. The Mechanical brake drum is fined to the engine flywheel and mounted on a frame and its features 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 (Table 1).

Procedure

(1) The fuel level and lubrication oil levels were checked and a three way cock is opened to allow the flow of fuel into the engine.
(2)The cooling water is supplied to the engine cooling water jacket and to the brake drum.
(3)The electrical power is supplied to the panel instrumentation.
(4)The engine is de-compressed by a decompression lever provided on the top of the engine head.
(5)The engine is unloaded by removing the weights from the hanger and started by cranking.
(6)The experiment is repeated for different loads and
(7)The above steps 6 and 7 are repeated for different blends of fuels

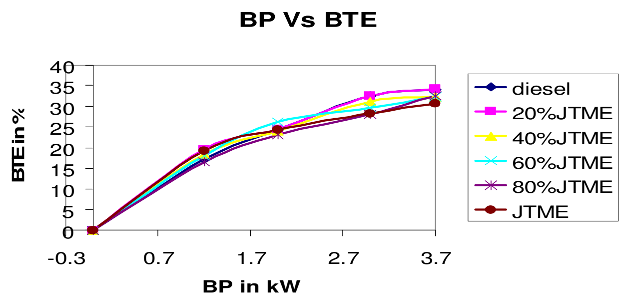

Figure 1. Comparison of brake thermal Efficiency for JTME/diesel blends.

The readings noted are:

(1) Spring balance reading in kg-f (S).
(2) Time taken for 10cc fuel consumption in seconds (t).
(3) Manometer reading (hw).

Experimental results

On comparing bio diesel with diesel, the following was obtained:

(1) BTE slightly decreases
(2) SFC slightly increases
(3) HC reduces
(4) CO reduces
(5) NOx increases
(6) CO_2 increases

PERFORMANCE ANALYSIS

Performance properties are slightly lesser for biodiesel compared to diesel. Accordingly, they improve injection process and ensure better atomization of the fuel in the combustion chamber (Heywood, 1998). Biodiesel can be blended in any ratio for better performance and the increased lubricity makes for a better running of vehicles. Results of the experiments in the form of brake power, brake thermal efficiency, specific fuel consumption for different load conditions for various blends of jatropha methyl esters are compared with the petroleum diesel in the form of graphs.

Brake thermal efficiency

From Figure 1, it is observed that the brake thermal efficiency is low at low values of BP and increases with increase of BP for all blends of fuel (Raheman and Phadatare, 2004). For a blend of 20% the brake thermal efficiency is high at low BP values when compared with other blends of fuel and is very close to diesel at high values of BP. Hence at the blend of 20% of methyl ester the performance of the engine is good.

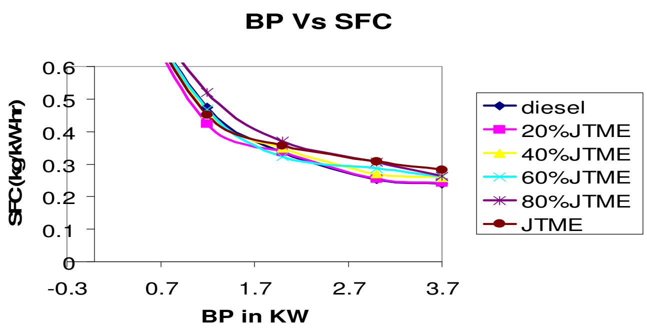

Figure 2. Comparison of Specific Fuel Consumption for JTME/diesel blends.

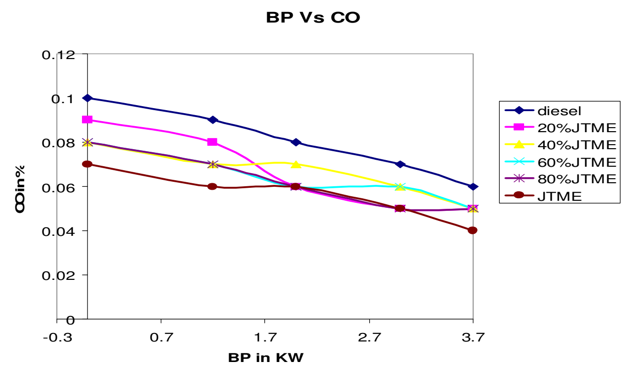

Figure 3. Comparison of CO for JTME/diesel blends.

Specific fuel consumption

From the Figure 2, it is observed that the methyl ester shows higher SFC compared to diesel as calorific value is less (Suresh et al., 2008). It was observed that 20% blend is having comparable closer values with diesel. However SFC was higher for all the other blends. The SFC decreases with the increasing loads and it is inversly praportional to the thermal efficiency of the engine.

EMISSION ANALYSIS

Emission characteristics are improved for biodiesel compared to conventional diesel except oxides of nitrogen, which is slightly higher than diesel. Biodiesel runs in any conventional unmodified diesel engine and yields approximately equal performance as petroleum diesel (Vivek, 2004; Srivastava and Madhumita, 2008). Basically the engine just runs like normal except for the odour. Trasesterified vegetable oils have lower viscosities than the parent oils (Mehar et al., 2004). 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 the vehicle (Sharma and Singh, 2008). Results of the experiments in the form of carbon monoxide (CO), Nitrogen oxides (NOx) and Smoke density for different load conditions for various blends of jatropha methyl esters is compared with the petroleum diesel in the form of graphs.

CO emission

The comparison of various levels of carbon monoxide (CO) emissions with break power for diesel, with different blends of jatropha methyl esters are shown in Figure 3. From the figure, it was observed that CO decreases with increasing load for all the blends of Jatropha methyl esters. If percentage of blends of Jatropha methyl esters increases, CO reduces (Magin et al., 2008). The concentration of CO decreases with the increase in percentage of Jatropha Methyl Esters (JTME) in the fuel. This may be attributed to the presence of O_2 in JTME, which provides sufficient oxygen for the conversion of carbon monoxide (CO) to carbon dioxide (CO_2). It can be observed that blending 20% JTME with diesel results in a slight reduction in CO emissions when compared to that of only diesel.

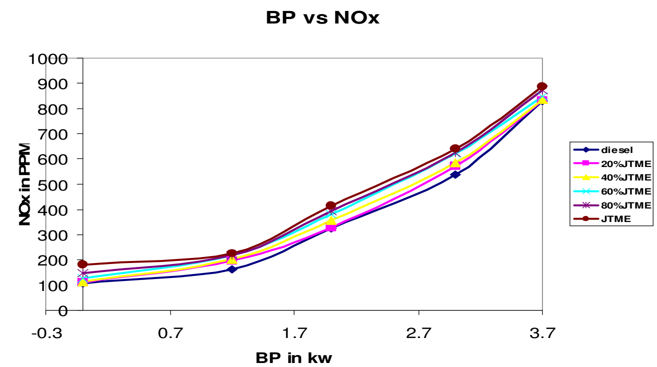

Figure 4. Comparison of nitrogen oxides for JTME/diesel blends.

NOx emission

From Figure 4, it was observed that NOx increases with increasing load for all the blends of jatropha methyl esters. If percentage of blends of jatropha methyl esters increases, NOx increases. It can be seen that NOx emissions increase with increase in percentage of JTME in the diesel-JTME fuel blend. The NOx increase for JTME may be associated with the oxygen content of the JTME, since the fuel oxygen may augment in supplying additional oxygen for NOx formation. Moreover, the

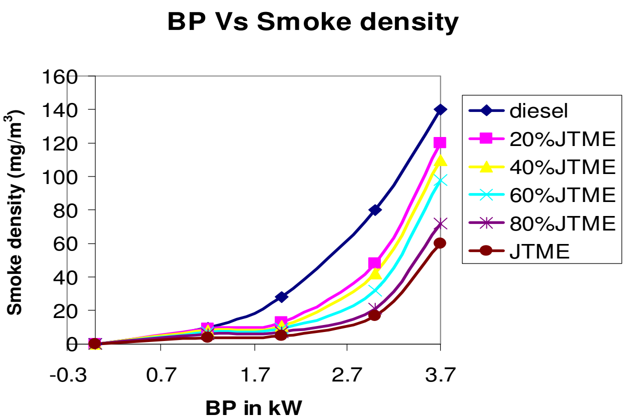

Figure 5. Comparison of smoke density for JTME/diesel blends.

higher value of peak cylinder temperature for JTME when compared to diesel may be another reason that might explain the increase in NO_X formation (Sagar and Rajendra, 2010).

Smoke density

The comparison of smoke density for diesel, neat JTME and blends are shown in Figure 5. From the figure, it was observed that smoke density increases with increasing load for all the blends of jatropha methyl esters. If percentage of blends of jatropha methyl esters increases, smoke density decreases. Because of increasing the load, the fuel entering into the cylinder increases in that proper oxygen is not allowed because the smoke density is high for the diesel.

Conclusion

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

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 as follows:

(1) CO emissions are less compared with diesel

(2) NOx emissions for biodiesel and blended fuel are slightly higher than that of diesel

(3) From this analysis it can be concluded that 20% JTME gives better performance with reduced pollution.

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