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Experimental Investigations on a Four Stoke Diesel Engine Operated by Jatropha Bio Diesel and its Blends with Diesel

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ABSTRACT

Increasing oil prices, fast depletion of fuels and huge demand for diesel in transport, power and agricultural sectors activates the research and development of substitute energy resources to maintain economic development. One of the best alternatives is Biodiesels obtained from Vegetable oils. The present study focuses on Evaluation of performance and emission characteristics of a single cylinder four stroke diesel engine with Jatropha biodiesel (B100) and its blends (B05, B10, B15, B20 and B25) in comparison to diesel. The performance is compared with diesel fuel, on the basis of brake specific fuel consumption, brake thermal efficiency, exhaust gas temperature and emissions of hydrocarbons and oxides of nitrogen. From the experimental Results it is indicated that B20 have closer performance to diesel. This study reveals that the performance of the engine with Jatropha biodiesel differs marginally from diesel fuel and hydrocarbon emissions are less than diesel. It is also observed that the Jatropha oil biodiesel can be used as a substitute for diesel without any engine modification.

Keywords: Bio Diesel, Performance, Emissions, Hydro Carbons, Jatropa oil.

1. Introduction

In the scenario of increasing industrialization and motorization of the world has led to a steep rise in the demand for petroleum products. If this situation continues there is every chance for the scarcity of petroleum products. A major solution to reduce this problem is to search for an alternative fuels. Vegetable oils can be an important alternative to the diesel oil, since they are renewable and can be produced in rural areas[1]. The inventor of diesel engine Rudolpf diesel predicted that the plant based oils are widely used to operate diesel engine. The bio diesel has great potentials as alternative diesel fuel[2]. But use of pure vegetable oil can cause numerous engine related problem such as injector choking, piston deposit formation and piston ring sticking due to higher viscosity and low volatility[3]. An effective method of using vegetable oils in diesel engine is by modifying the vegetable oils into its monoesters by transestrification4. Transesterification of bio diesel provides a significant reduction[5] in viscosity, thereby enhancing their physical and chemical properties and improve the engine performance.

2. Technical specifications of the engine

In this work experiments were conducted on 4 stroke, single cylinder, C. I engine (Kirloskar Oil Engineers Ltd., India) of maximum power-3. 68 KW with AVL smoke meter and Delta 1600 S gas analyser.

3. Material & Methods

In the present work engine tests were conducted with Jatropha Bio Diesel and its blends (B05, B10, B15, B20, B25 and B100) in comparison to diesel separately to evaluate performance and emission characteristics. The genus name Jatropha4 derives from the Greek jatros (doctor), trophe (food), which implies medicinal uses, hence the plant is traditionally used for medicinal purposes. It is a hardy shrub that can grow on poor soils and areas of low rainfall (from 250 mm a year). Hence it is being promoted as an ideal plant for small farmers. The seeds contain 27-40% oil that can be processed to produce a high quality biodiesel fuel, usable in a standard diesel engine[5]. The various properties of the above bio diesels[6] are presented in table 1.

TABLE I Properties of fuels used

Properties	Jatropha biodiesel	Diesel
Density (kg/m^3)	862	830
Calorific Value (kJ/Kg)	392330	43000
Viscosity @400C (cSt)	4. 8	2. 75
Cetan Number	51	45
Flash Point (^{o}c)	135	74

4. Results and discussions

A. Brake thermal Efficiency

The Figure 1 shows the variation of brake thermal efficiency with break power output. The brake thermal efficiency graph represents very similar trends for all the fuel blends. In general the thermal efficiency depends on the combustion process which is a complex phenomenon that is influenced by several factors such as design of combustion chamber, type of injection nozzle, injection pressure, spray characteristics and fuel characteristics such as cetane number, volatility, viscosity, homogeneous mixture formation, latent heat of vaporization, calorific value etc.

It is evident that diesel fuel has the higher brake thermal efficiency compared to biodiesel and its blends. Due to its higher calorific value the amount of heat produced in the combustion chamber is more, further the combustion is complete and produced higher temperatures. The efficiency of diesel is 29. 18%, Jatropha Bio diesel with B20 blend is 29. 06% and B100 (pure Jatropha biodiesel fuel) is 27. 5%.

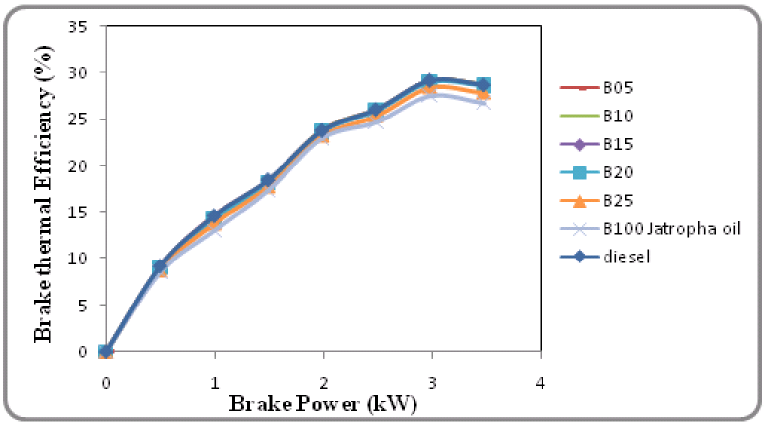

Figure 1. Variation of Brake thermal Efficiency with power output

B. Brake specific Fuel Consumption

The variation of brake specific fuel consumption (BSFC) with break power is shown in Figure 2. The BSFC reduced with the load for all fuel blends. The BSFC for the Jatropha bio diesel and its blends are higher than diesel fuel. The specific fuel consumption is increased by 16. 22% with Jatropha biodiesel compared with the diesel fuel. The BSFC is increased with increasing load because of the injection of less quantity of fuel due to the higher viscosity and lower heating value. The oxygenated biodiesels may lead to the leaner combustion resulting in higher BSFC.

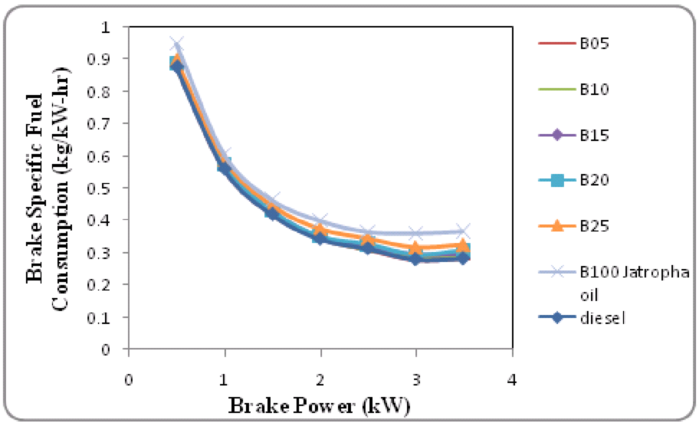

Figure 2 Variation of brake specific fuel consumption with power output

C. Exhaust Gas Temperature

The exhaust gas temperature in the combustion chamber depends on the calorific value, latent heat and viscosity of the fuel injected. The exhaust gas temperature increases with the load for Jatropha bio diesel and its blends. It is observed from the Figure 3 that due to the higher viscosity less quantity of bio diesel is injected into the combustion chamber which forms into leaner mixture and makes the combustion insufficient. This reduces the combustion chamber temperature and in turn exhausts gas temperature. The exhaust gas temperature for the diesel at the rated load is 285^{0}C, for Jatropha biodiesel (B100) is 260^{0}C and for its blend B20 it is 274^{0}C. Though the viscosity for the Jatropha Bio diesel is higher it is compensated by the calorific value.

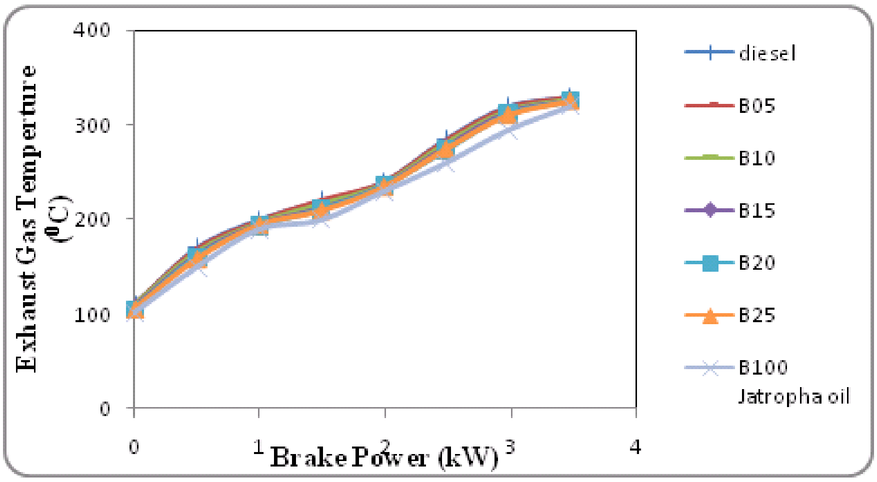

Figure 3 Variation of Exhaust gas temperatures with power output

D. Smoke Density

The variation of the smoke densities with power output is shown in Figure 4.

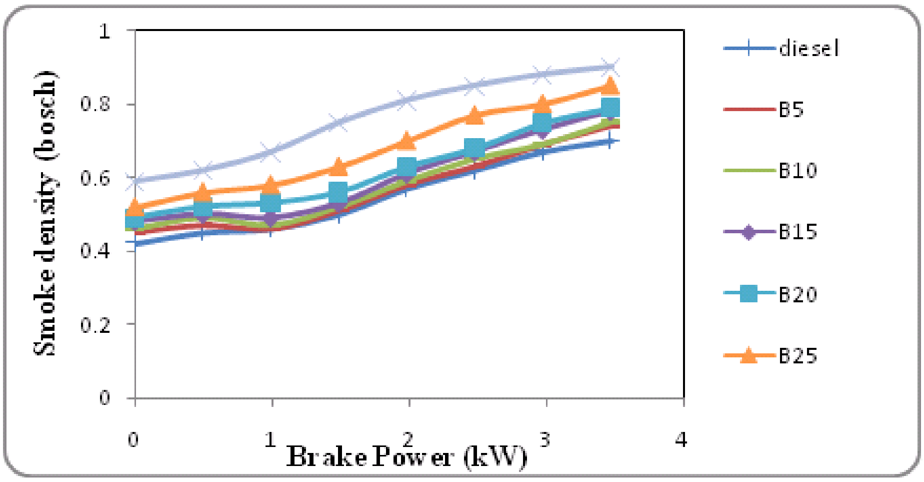

Figure 4 Variation of smoke density with power output

The smoke opacity emissions increased with the increase of engine load. This is compensated up to certain extent due to the absence of aromatics and presence of inherent oxygen molecules in the bio diesel. These oxygen particles helps to promote stable and complete combustion by delivering oxygen to the combustion zone of burning fuel by reducing locally rich region and limit primary smoke formation and lower smoke emissions. Higher smoke emissions at higher loads may be due to poor atomization of bio diesel. Higher viscosity and bigger size fuel molecules result in poor atomization of fuel. When compared to diesel the increase in smoke emissions is 30% for Jatropha biodiesel due its high viscous nature and the increase in smoke emissions is only 10% for Jatropha biodiesel blend (B20).

E. Hydrocarbon emissions (HC Emissions)
The variation of hydrocarbon emissions with break power is shown in Figure 5. The HC emissions depend upon mixture strength i. e. oxygen quantity and fuel viscosity in turn atomization. The HC emissions increase with increasing load as well as increasing the amount of bio diesel. Lower heating value leads to the injection of higher quantities of fuel for the same load condition. More the amount bio diesel leads to more viscosity. Viscosity effect, in turn atomization, is more predominant than the oxygen availability, either inherent in fuel or present in the charge When compared to diesel, the oxygen availability in the bio diesels is more. So the emissions are less than diesel. It is observed from the figure that the decrease in hydro carbon emissions with increase in biodiesel content in the blend and pure Jatropha biodiesel emits fewer hydrocarbons.

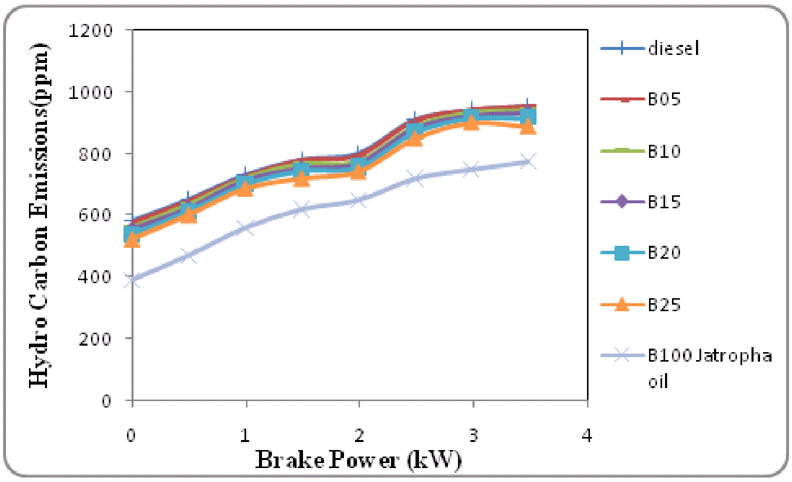

Figure 5 variations of hydrocarbon emissions with power output

F. Carbon Monoxide Emissions (co emissions)
The variation of carbon monoxide emissions for is illustrated in Figure 6. With the higher combustion chamber temperatures, the combustion in the engine is more complete and the oxidation of carbon monoxide is also improved. Hence carbon monoxide present in the exhaust due to incomplete combustion reduces drastically.

Due to the lower calorific value and higher viscosity of bio diesel, the combustion in the diesel engine is insufficient. Thus the temperature produced in the chamber is less and in turn increases the CO emissions. But the oxygen presents in the bio diesel acts as a combustion promoter during the combustion process, which results better combustion and compensate the increase in the emissions.

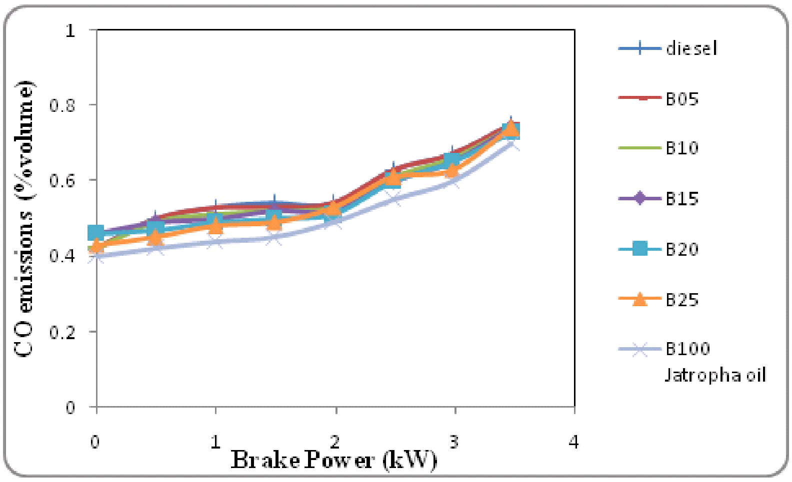

Figure 6 Variation of CO Emissions with Power output

G. Nitrogen oxide Emissions

The variation of Nitrogen oxide emissions oils is illustrated in Figure 7. The NOx emissions are highest for diesel fuel compared to bio diesels and its blends. The percentage decrease in NOx emissions with Jatropha biodiesel (B100) is about 11. 79%.

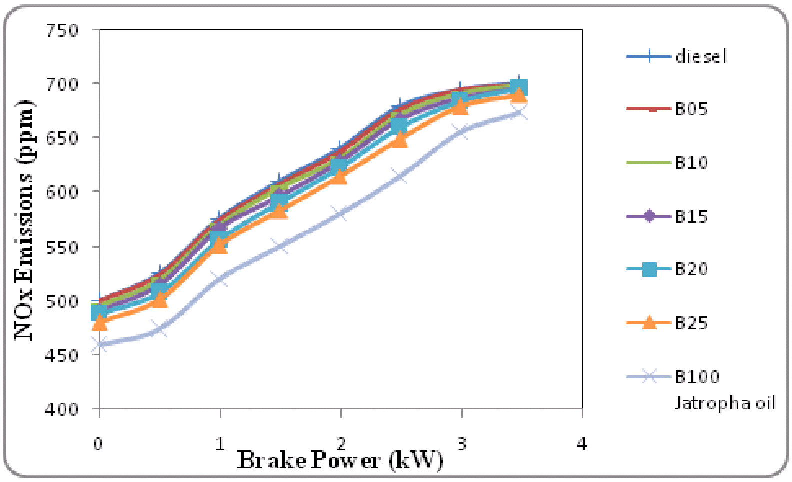

Figure 7 Variation of NOx emissions with power output

5. Conclusions

In the current investigation it is observed that the Jatropha oil biodiesel can be used as a substitute for diesel without any engine modification to reduce the impact on transportation and also reduce the dependency on crude oil imports, and also provide employments in agricultural field.

The conclusions are summarized as follows

1. The brake thermal efficiency of the engine depends majorly on the heating value and viscosity.
2. With the higher combustion rate, the temperature inside the engine and in turn in the exhaust gas temperature increases.
3. The Hydrocarbon emissions are less than diesel fuel as compared with biodiesel.
4. The NOx emissions increase with the higher temperatures in the chamber. With the bio diesels due to its lower heating values and higher viscosity the temperature in the chamber is less and in turn emissions are less than diesel fuel.
5. The above investigations suggest that blend of jatropa bio diesel– B20 is the optimum blend which can produce better values with Pure Diesel for Diesel engines as far as performance and emissions were considered

It is concluded that the Jatropa bio diesel is best oil and the efficiency is also nearer to the diesel. So that it can be used as alternative to diesel.

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