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Performance and emission characteristics of CI DI Engine using Jatropha methyl esters and diesel blends

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Abstract: Experimental investigation is carried out to find the thermal performance and emission characteristics of four stroke CI DI, single cylinder water cooled, constant rated speed of 1500rpm engine using blends of Jatropha methyl esters and diesel. Jatropha is a renewable, sustainable and alternative fuel for compression ignition engines. Biodiesel is being used in diesel in the form of blend with diesel. Present study investigates effects of blend ratio and load on engine performances and emissions characteristics of engine. Experimental investigations is carried out to find thermal performance and emission characteristics of diesel engine using Jatropha biodiesel and diesel blends of 20%, 40%, and 60% pure diesel. Results of various blends are compared with pure diesel. Brake specific fuel consumption increases with increase in percentage of biodiesel in the blends and decrease in brake thermal efficiency is observed with the increase in percentage of biodiesel in the blend as compared to diesel. The CO and HC emissions are reduced and NO_x emissions are increased compared to diesel. It is observed that ignition delay is shorter for blends of Jatropha biodiesel and diesel compared to that of pure diesel.

Keywords: Jatropha methyl esters, Biodiesel, blends, emission, engine performance

1.0 Introduction

The use of biodiesel in diesel engine may extend the availability of natural petroleum fuel and reduces the harmful emissions. Biodiesel is a renewable alternate fuel. Increased number of automobiles throughout the world, demand on petroleum fuel is increasing at rapid rate. Looking in to the growth of population and number of automobiles and harmful emissions from the petroleum fuel used automobiles, researchers are thought of finding new alternate energy resources which can be readily stored and used in the existing automobiles without or with minimum modification to engine. To meet the demand of the country, much of the petroleum fuel is imported from the north eastern nations. For the import of petroleum fuels, much of the foreign exchange is spent. Though the other forms of energy are available like wind, solar, coal etc, this energy cannot be used readily in the existing automobiles, due to the storage problems. To satisfy increasing energy demand and to reduce the harmful emissions such as CO, CO_2, NO_x and smoke density, etc and to reduce the use of natural fuels and to prolong the and reserve the natural fuels use of renewable fuel like biodiesel is the alternate source, which is renewable and biodegradable.

To fulfill the rising energy demand and to reduce the use of petroleum reserves, renewable fuel like biodiesel is within the forefront of other technologies. Biodiesel has proved to be a possible alternative for diesel in compression ignition engine. Biodiesel burns like petroleum diesel as it involves regulated pollutants. Diesel fuel can be replaced by biodiesel made from vegetable oils. Biodiesel is now mainly being produced from addible oils like soybean, rapeseed, and palm oils. In developed countries, there is a growing trend towards using modern technologies and efficient bioenergy conversion using a range of biofuels, which are becoming cost wise competitive with fossil fuels [1]. India enjoys some special advantages in taking up plantation of tree-borne oil seeds for production of biodiesel due to large amount of waste land. The use of biodiesel results in substantial reduction of un-burnt hydrocarbon, carbon monoxide and particulate matters. It has almost no sulphur, no aromatics and more oxygen content [2], which helps it to burn fully. Its higher cetane number improves the combustion. In India number of research has been carried out on Jatropha methyl esters. Consumption of edible oil is very high in India, use of edible oil to produce biodiesel is beyond imagination; therefore it is proposed to use non-edible oil for producing biodiesel [3]. Non-edible vegetable oils such as Pongamia, Linseed, Mahua, Jatropha, Simarouba, etc. are potentially effective substitute for diesel. Biodiesel is known as a carbon neutral fuel because the carbon present in the exhaust was originally fixed from the atmosphere [4].

Alternate fuel used are to be technically acceptable, and economically feasible, environmentally acceptable and easily available. Among these alternate fuels, biodiesel and its derivatives received much attention in recent years for diesel engines. Biodiesel is renewable, biodegradable, oxygenated fuel that can be obtained from vegetable oils and animal fat by conversion of the triglycerides to esters via transesterificatioin. Properties of biodiesels are comparable with diesel. It has been reported by many researchers that biodiesel can be used in diesel engines with little or no modification of the engines (5), with comparable performance with that of diesel fuel. Besides it reduces the emissions such as carbon monoxide (CO) and hydrocarbons (HC), and smoke emissions [6, 7]. However, there is an increase in nitrogen oxide (NO_x) emissions [8, 9]. The results vary according to the process of biodiesel production and also with properties of biodiesel. Therefore different biodiesels and their blends were used and tested in diesel engines as well as under different test conditions.
However major disadvantage of biodiesels which include the higher viscosity [10] and flash point cloud point, as well as lower heating value and volatility. For these reasons, it is generally not used in its pure form in the diesel engines. It is usually used as blend with diesel in different percentage volume 10%, 20%, 30%, 40% without modification in existing diesel engine [11]. These biodiesel properties affect on the performance and emissions of the engine. To study effect of biodiesel on engine performance of engine using biodiesel more research is required, in order to ensure that pure biodiesel can be used in diesel engine without modifications.
In this study, all the experiments are conducted without any engine hardware modifications. However, standard diesel engine running at constant speed of 1500 rpm with pre set compression ratio of 17 BTDC and injection pressure of 200 bars is used. The thermal performance and emission characteristics of a diesel engine are investigated by using Jatropha methyl esters and diesel blends.

2.0 Experimental set up:

Experiments are carried out using single cylinder, four strokes, DI, water cooled computerized diesel engine connected to eddy current dynamometer for the present study. The setup includes necessary instruments for measurement of cylinder pressure, injection pressure, and crank angle. The test rig also incorporates exhaust gas analyzer, to measure the exhaust emissions.

The engine is installed with piezo sensor for measurement of pressures. One sensor is placed in the cylinder head to measure the cylinder pressure and other is placed in fuel line near the injector to measure the injection pressure. A continuous water circulation is maintained for cooling the sensors and to maintain the required temperature by using water pump of required capacity. An eddy current dynamometer is connected to measure power output. Mars gas analyzer is used to measure the exhaust emissions.

Experiments are conducted with Jatropha biodiesel and diesel blends having 20%, 40%, 60% and 80% on volume basis at different loads. Performance tests are also carried out on pure diesel as a basis of comparison. The load and percentage of blends are varied and engine and various parameters are measured such as fuel consumption, air flow rate, exhaust gas temperature, and emissions are measured to investigate the behavior of diesel engine. Each time the engine is run for few minutes before the measurements are taken. The experiments are repeated twice and the average value is taken for performance and emission measurements.

Table 1 Technical specification of engine

Model	Kirloskar, TV-1
Type	Vertical single cylinder, 4 stroke, water cooled, DI CI engine
Bore	87.5 mm
Stroke	110 mm
Rated output	3.5 KW
Rated Speed	1500 rpm
Compression Ratio	17
Injection pressure	200 bar

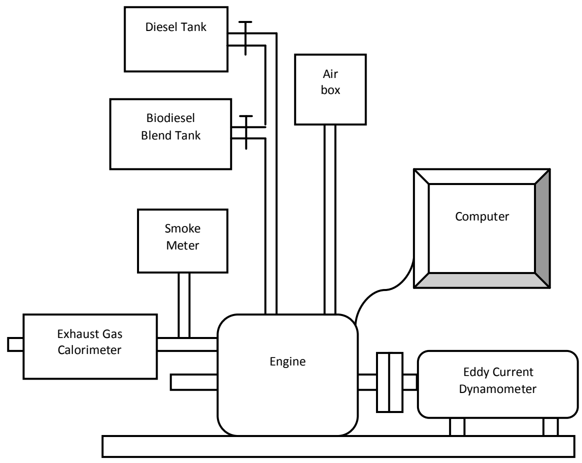

Fig. 1. Experimental setup

3.0 Results and Discussions

Experimental investigation is carried out using biodiesel and diesel blends to find out the effect of various blends on the performance and emission characteristics of the engine. After the engine reached the stabilized working conditions for each test, fuel consumption, torque applied and exhaust temperature are measured from which BSFC, BTE are calculated

3.1 Brake Specific Fuel Consumption

Figure 2 shows the variation of brake specific fuel consumption for all the blends of Jatropha biodiesel blends and pure diesel at various loads. The BSFC increases with load for the blends. The brake specific fuel consumption of B20 is close to that of diesel. BSFC for all the blends is higher than that of diesel; this is because of lower heating value and higher density of biodiesel. Poor atomization and vaporization of the biodiesel blends could be the other reason for higher BSFC.

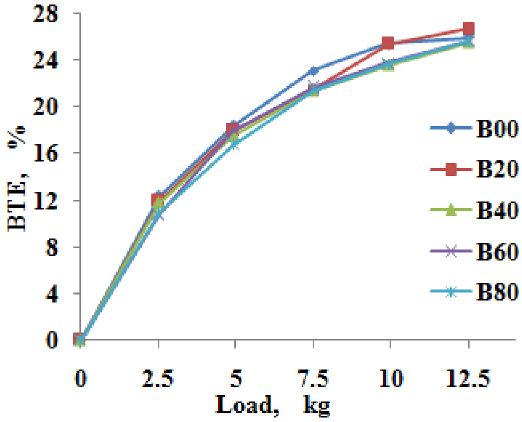

Fig. 3. Influence of blends on thermal efficiency

3.2 Brake Thermal Efficiency

The variation of brake thermal efficiency with load is shown in Fig.3. The brake thermal efficiency is highest for diesel at higher loads. At part load operation the brake thermal efficiency for biodiesel and diesel blends and pure diesel are lesser and comparable. Brake thermal efficiency of biodiesel blends is lesser for biodiesel blends may be attributed to lower volatility, higher viscosity and higher density of Jatropha methyl esters, which effects the mixture formation of the fuel and thus leads to the slower combustion. Among the blends B20 is found to have the maximum brake thermal efficiency of 26.6% at rated load while for diesel it is

26.94% and for B40 it decreases to 25.43 %. It is observed that as the percentage of biodiesel in the bled increases the thermal efficiency decreases.

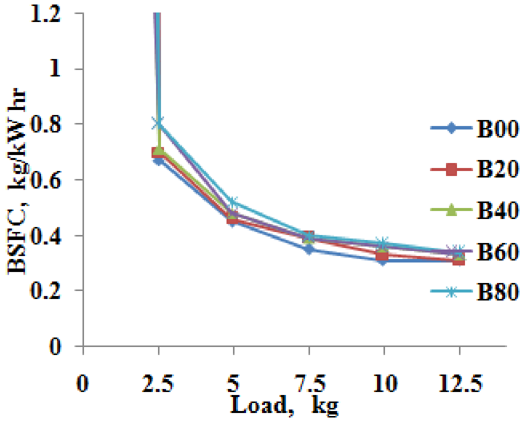

Fig. 2. Influence blends on BSFC

3.3 Carbon Monoxide Emissions:

The variations of CO emission operated with B0, B20, B30, B40, B60 and B80 Jatropha biodiesel and diesel blend and pure diesel at various loads is shown in Fig.4.Emission of carbon monoxide decreases as the load on the engine increases. The emission of carbon monoxide is mainly depends upon the properties of the fuel used. It is observed that engine emits less Carbon monoxide for Jatropha biodiesel blends compared to diesel fuel. The decrease in carbon monoxide may be due to higher cetane number of Jatropha biodiesel and the presence of oxygen in their molecular structure. But as the volume percentage of Jatropha biodiesel in the blend increases the percentage of carbon monoxide emission decreases. For rated load the carbon monoxide for higher volume fraction of Jatropha biodiesel in the blend increases CO emissions compared to pure diesel this may be attributed to incomplete combustion.

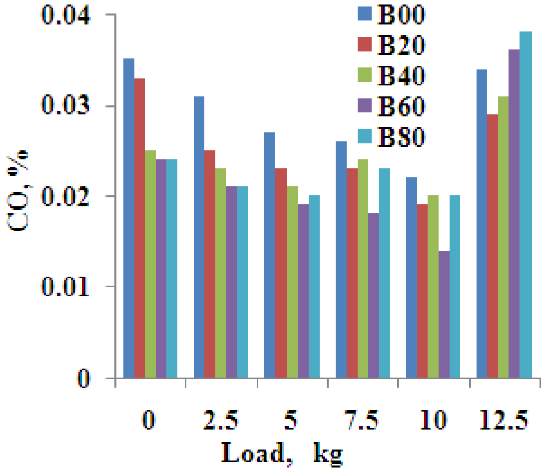

Fig. 4. Influence of blends on CO emissions

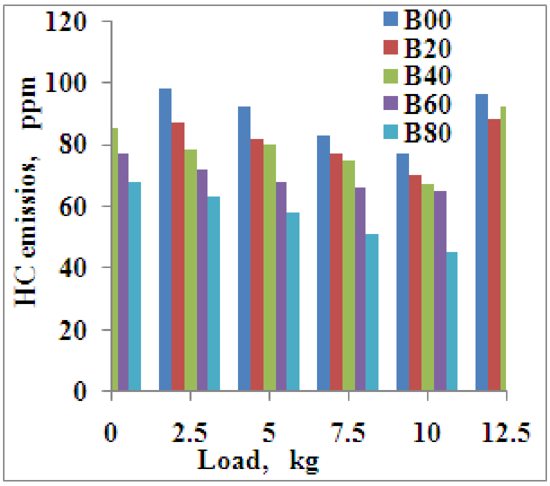

Fig. 5 Influence of blends on HC emissions

3.4 Hydrocarbon Emissions:

The variation of unburned hydrocarbon emissions for varying loads and blends of biodiesel and pure diesel are shown in Fig 5. It is observed that at lower loads with increase in blend ratio, HC emission decreases, which could be attributed to the higher cetane number of biodiesel blends. Another reason for lesser HC emission with the increase in blend ratio is due to oxygen content in Jatropha biodiesel fuel which helps in complete combustion. As the percentage of biodiesel increases emission of hydrocarbon decreases for the blends of Jatropha biodiesel compared to pure diesel fuel which can be attributed to combustion of Jatropha biodiesel blends.

3.5 Nox Emissions:

The oxides of nitrogen emissions of diesel and Jatropha biodiesel blends are shown in figure 6. Results indicate that, for both the Jatropha biodiesel blends as well as for pure diesel, the increased engine load increases NO_x emissions. The formation of NO_x is very much sensitive to the temperature and oxygen availability. Increase in $NO_{x,}$ for biodiesel blend is attributed to higher cetane numbers of biodiesel than that of diesel fuel, and are usually associated with higher NO_x emissions. The NO_x emissions are increases in all the cases of Jatropha biodiesel blends. Despite the shorter ignition delay for jatropha biodiesel blends as compared to diesel NOx emission increases may be due to higher cetane number of biodiesel in the blends. Also may be due to inherent oxygen of biodiesel may improve the combustion efficiency and increases temperature which increases NOx emissions. For rated load NOx emission decreases may be attributed to incomplete combustion of blends due lesser combustion temperature because of increased amount of fuel supply at higher load.

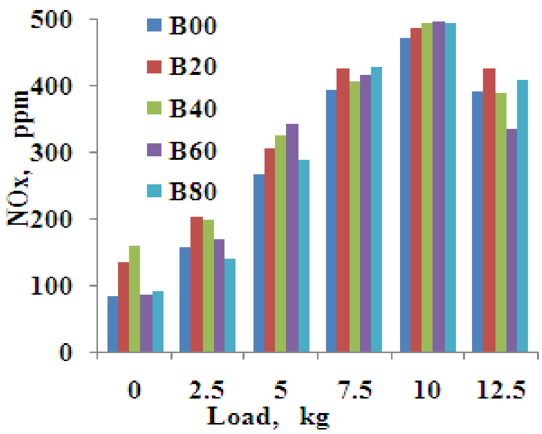

Fig. 6 Influence of blends on NO_x emissions

4.0 Conclusions

Experimental investigations is carried out to investigate thermal performance and emission characteristics of DI CI engine is using Jatropha biodiesel and diesel blends and the following conclusions are made.

The Brake specific fuel consumption is marginally higher than diesel for B20 but closer to diesel may be due to lower heating value of biodiesel in the blends. With increased percentage of biodiesel in the blends increases brake specific fuel consumption.

The brake thermal efficiency for B20 is closer to diesel fuel compared to the higher percentage of biodiesel in the blends.

CO, HC emissions are lesser for biodiesel and diesel blends as compared to diesel.

The NO_x emissions for Jatropha biodiesel and diesel blends are higher in comparison with diesel for all loads and blends.

From all these observations, it could be concluded that the blends of Jatropha biodiesel with diesel up to 20% by volume could be used as fuel for diesel engine with less emissions, without modifying the engine and marginally lesser brake thermal efficiency with reduced emissions which may help in reducing the environmental pollution.

5.0 References

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