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Performance and emission characteristics of mahua oil biodiesel on a compression ignition engine

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Abstract

The performance and emission characteristics of a mahua oil biodiesel was evaluated on a Kirloskar make, single cylinder, water cooled diesel engine. The brake thermal efficiency, exhaust gas temperature, specific energy consumption, carbon monoxide, unburned hydrocarbon and smoke emissions of the mahua oil biodiesel were measured at various loads and compared with diesel. Mahua oil biodiesel produces higher specific fuel consumption and lower engine efficiency than diesel. On other side, the carbon monoxide, unburned hydrocarbon and smoke emissions were reduced than diesel. From the results, it has been identified that the mahua oil biodiesel can be used directly in diesel engine without any modificationst.

1. Introduction

Environmental degradation of petroleum products and their non-renewable nature has led to a world-wide search for renewable and greener alternatives in internal combustion. Vegetable oils are one of such alternatives, which have the advantage of reducing most of the regulated emissions such as carbon monoxide, unburned hydro carbons, nitrogen oxides and soot in reciprocating engines [1, 2]. Vegetable oils are renewable source of energy with an energy content close to diesel. The major problem faced in utilizing vegetable oils as CI engine fuel is their higher viscosity, ranging from 10 to 20 times higher than that of diesel fuel. This higher viscosity results in poor fuel atomization, incomplete combustion and carbon deposition on the injector and the valve seats causing serious engine fouling [3]. The higher viscosity of vegetable oils can be reduced through the processes like blending, pyrolysis, transesterification, micro-emulsification, etc.

Many researchers investigated the potential of biodiesel as an alternate fuel in diesel engine in last several years [4-7]. Ramadhas et al [8] investigated a diesel engine using rubber seed oil biodiesel blends and found that the lower blends increases the efficiency of the engine and lowers the fuel consumption compared to the higher biodiesel blends. Muralidharan and Vasudevan [9] performed performance, emission and combustion analysis using waste cooking oil biodiesel blends on a variable compression ratio engine and found that longer ignition delay and reduction in carbon monoxide emission. Gumus and Kasifoglu [10] studied the performance and emissions of a diesel engine without any modification, using neat apricot seed kernel oil biodiesel and its blends with diesel fuel and found that lower concentration of apricot seed kernel oil methyl ester in blends give a better improvement in the engine performance and exhaust emissions. Deepanraj et al [11, 12] conducted the performance and emission study on a compression ignition engine using palm oil biodiesel and its blends with diesel and reported that the engine runs well with biodiesel and blends and releases lesser carbon monoxide and unburned hydrocarbon emissions. Ilkilic et al [13] studied the performance and emission characteristics of a single cylinder diesel engine using safflower oil biodiesel blends and found that the CO, smoke and particulate matter emissions were reduced compared to diesel and the NOx and HC emissions were increased.

The aim of the present study is to investigate the performance (brake thermal efficiency, specific fuel consumption, and exhaust gas temperature) and emission (carbon monoxide, unburned hydrocarbon and smoke) characteristics of a single cylinder diesel engine using mahua oil biodiesel.

2. Materials and Methods

Mahua oil used in this experiment for preparing biodiesel was purchased from local market in Vellore and the diesel was purchased from local petrol bunk. Biodiesel was prepared by transesterification of mahua oil with methanol in presence of sodium hydroxide catalyst [11-15]. The properties of mahua oil biodiesel prepared are given in table 1.

Table 1. Properties of diesel & biodiesel

Property	**Diesel**	**Mahua oil biodiesel**
Calorific value (MJ/kg)	42.8	39.2
Density (kg/m^3)	840	910
Viscosity (cSt)	3.6	5.9
Flash point (°C)	63	130
Fire Point (°C)	75	150

Experiments were carried out on a single cylinder, vertical, naturally aspirated, four stroke, constant speed, water cooled, direct injection diesel engine. The layout of experimental setup is shown in the figure 1. Specification of the test engine is given in table 2.

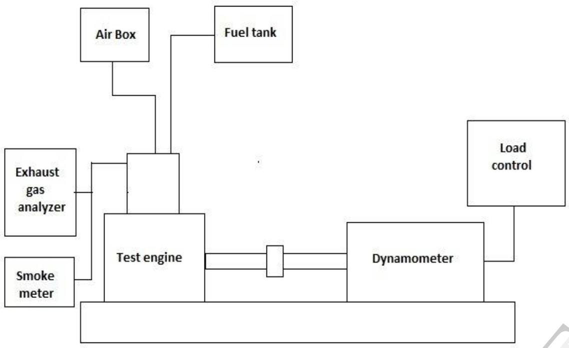

Fig. 1. Experimental setup

Table 2. Specification of the engine

Make	Kirloskar
Model	TV-1
No. of cylinders	One
No, of strokes	Four
Bore	87.5 mm
Stroke	110 mm
Displacement volume	661 cc
Speed	1500 rpm
Cooling	Water cooling
Dynamometer	Eddy current dynamometer

The engine was coupled with eddy current dynamometer for loading. The mass flow rate of intake air was measured using an orifice meter connected to a manometer. A surge tank was used to damp out the pulsations produced by the engine, for ensuring a steady flow of air through the intake manifold. The fuel consumption rate was determined using the glass burette and stop watch. The engine speed was measured using a digital tachometer. The carbon monoxide and unburned hydrocarbon emissions were measured by AVL gas analyzer and the smoke emission was measured using Bosch smoke meter. The exhaust gas temperature was measured with k-type thermocouple.

3. Results and Discussions

Figure 2 shows the variation of brake thermal efficiency (BTE) with respect to load. BTE has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load. In all the loads, starting from no load to full load of the engine, the BTE of mahua oil biodiesel is lower than the diesel. At maximum load, the brake thermal efficiency of the biodiesel fuel is 16.44% lower than diesel. This is due to poor mixture formation as a result of low volatility, higher viscosity and higher density of biodiesel compared with diesel.

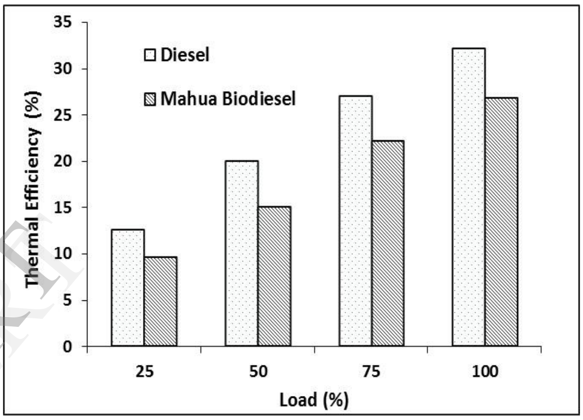

Fig.2. Brake thermal efficiency vs. Load

Figure 3 shows the variation of specific fuel consumption (SFC) with respect to load. The SFC of mahua oil biodiesel is higher than that of diesel in all loads. This is due to the effect of higher viscosity and poor mixture formation of biodiesel. At maximum load, the specific fuel consumption of biodiesel is 23.21% higher than diesel.

Figure 4 shows the variation of exhaust gas temperature (EGT) with respect to load. The mahua oil biodiesel produces higher exhaust gas temperature than diesel because of oxygen in the biodiesel which enables the combustion process and hence the exhaust gas temperature is higher. At maximum load, the exhaust gas temperature of biodiesel is 12% higher than diesel.

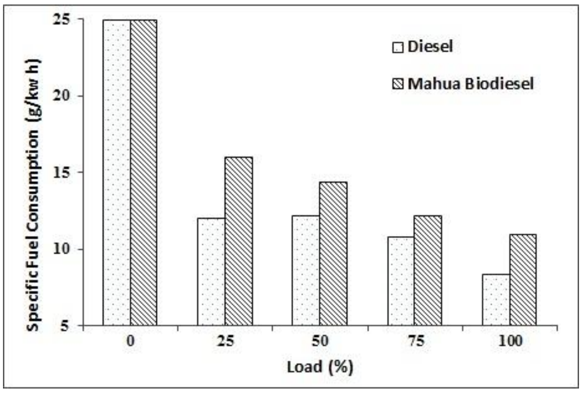

Fig.3. Specific fuel consumption vs. Load

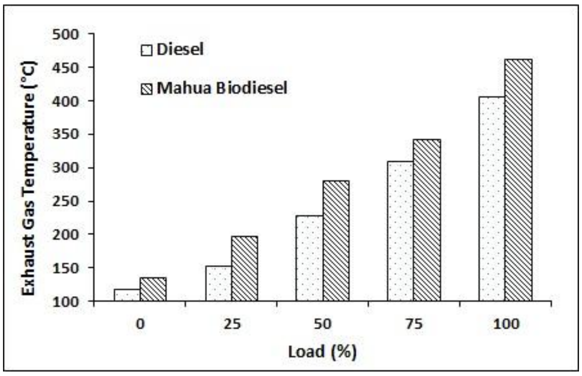

Fig.4. Exhaust gas temperature vs. Load

Figure 5 shows the variation of carbon monoxide (CO) with respect to load. The carbon monoxide emission increases with increase in load. For all the loads, The CO emission of mahua oil biodiesel is lower than diesel. At maximum load, the carbon monoxide emission of mahua oil biodiesel is 8.15% lower than diesel. This is because of the availability of oxygen content in the biodiesel which makes the combustion better.

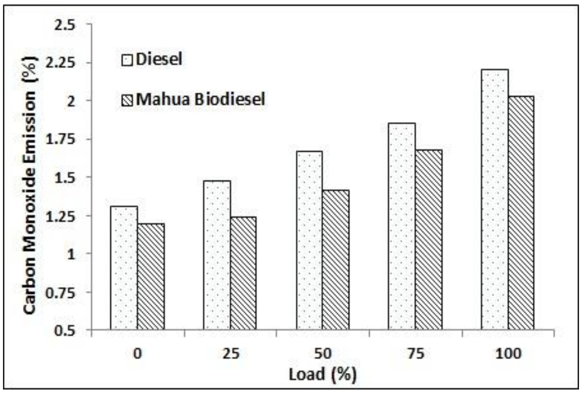

Fig.5. Carbon monoxide emission vs. Load

Figure 6 shows the variation of unburned hydrocarbon (HC) with respect to load. The unburned hydrocarbon emission decreases with biodiesel fuel. . At maximum load, the unburned hydrocarbon emission of mahua oil biodiesel is 19.7% lower than diesel. The presence of oxygen in the biodiesel aids combustion and hence the hydrocarbon emission reduced.

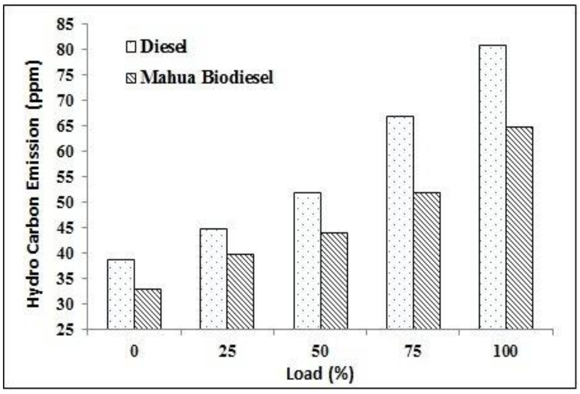

Fig.6. Hydro carbon emission vs. Load

Figure 7 shows the variation of smoke emission with respect to load. It was observed that the smoke emission increases with increase in load. Mahua oil biodiesel produces 23.08% lesser smoke emission than diesel at maximum load.

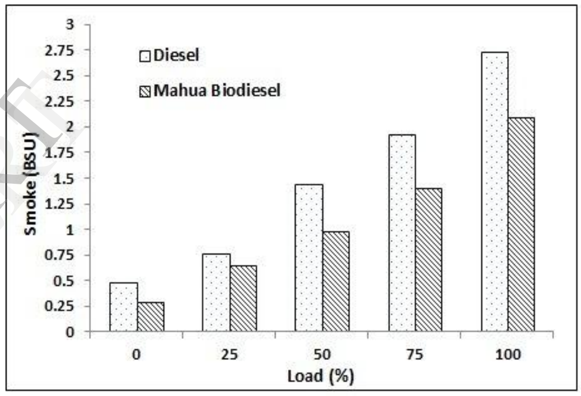

Fig.7. Smoke emission vs. Load

4. Conclusion

Experiments have been conducted on a single cylinder, Kirloskar make, direct injection diesel engine using diesel and mahua oil biodiesel. The use of biodiesel instead of diesel leads to an increase in the specific fuel consumption and decrease in brake thermal efficiency, mainly due to the lower heating value compared with diesel. The carbon monoxide, unburned hydrocarbon and smoke emissions reduced significantly with biodiesel as fuel.

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