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Rice bran oil biodiesel: an alternate fuel for CI engine

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ABSTRACT

Biodiesel is a renewable and environmental friendly alternative fuel which can be used as a substitute for diesel in compression engine without any modifications. Biodiesel can be prepared from vegetable oils and animal fats. This paper presents the experimental results of rice bran oil methyl ester (biodiesel) as fuel in a single cylinder, direct injection, water cooled diesel engine. The performance was measured using electrical dynamometer. The brake thermal efficiency, specific energy consumption, exhaust gas temperature, cylinder pressure, carbon monoxide (CO), unburned hydrocarbon (UBHC) and smoke emissions of the rice bran methyl ester were measured and compared with diesel. According to emission tests, as a result of rice bran methyl ester usage, reduction in CO, UBHC and smoke were observed. The results indicate that the rice bran oil methyl ester can be used directly in compression engine without any modification in the engine.

Keywords: Biodiesel, rice bran oil, engine, performance and emission.

1. INTRODUCTION

Biofuels such as alcohols and biodiesel have been proposed as alternative fuel for diesel engines. In particular, biodiesel has received wide attention as a replacement for diesel fuel because it is biodegradable, nontoxic and can significantly reduce toxic emissions from the engine when burned as a fuel (Agarwal 2007; Cvengros et al. 1996). Biodiesel is an alternative diesel fuel consisting of the alkyl monoesters of fatty acids derived from vegetable oils or animal fats (Abdul Monyem et al. 2001). The reduction of greenhouse gas emissions is considered the main benefit of biodiesel. From an environmental point of view, together with the low CO_2 emissions, the use of biodiesel has been proven to reduce particulate emissions. In the same way, biodiesel can reduce hydrocarbon and carbon monoxide emissions (Lujan et al 2009; Lapuerta 2005; Rakopoulos et al 2006). Significant amount of research has been carried out on the combustion and emission characteristics of diesel engines fueled with biodiesel as a fuel. Kulkarni and Dalai (2006) investigated the engine performance with waste cooking oil biodiesel and found that the emissions produced by the use of biodiesel are less than those using diesel fuels except that there is an increase in NOx. Lawrence et al (2011) performed the performance and emission study on a compression ignition engine using prickly poppy biodiesel blends and reported that the engine runs well in biodiesel blends and releases lesser carbon monoxide and unburned hydrocarbon emissions. Ramadhas et al (2005) 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. Suryawanshi (2006) tested the compression ignition engine with coconut oil biodiesel and found reduction in CO, HC, smoke and PM emissions and slight increase in NOx emission. In this study, biodiesel was produced from rice bran oil and the performance and emission test was conducted in a Kirloskar make, single cylinder direct injection compression ignition.

2. MATERIALS AND METHODS

In this experiment, rice bran oil obtained from rice milling was used for biodiesel preparation. Rice is one of the main food for most of the countries in the world. Therefore the availability of rice bran for oil extraction is renewable in nature. Global production of rice (paddy) was calculated as 604 million tonnes (Mt) in 2004, which can produce around 7.25 Mt of rice bran oil annually (Saravanan et al 2007; Deepanraj et al 2012). Asian countries produce more than 60% of the global rice production. India stands in second place in rice production having capacity to yield nearly 1 Mt of RBO (Saravanan et al 2007;

Table 1
Specification of the engine

Make	Kirloskar
Model	Single cylinder, four stroke, vertical
Bore	87.5 mm
Stroke	110 mm
Displacement volume	661 cc
Speed	1500 rpm
Dynamometer	Electrical dynamometer

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Deepanraj et al 2012). Therefore rice bran oil has the potential to replace almost 0.9% of the world diesel fuel consumption. Biodiesel was prepared by transesterification of rice bran oil with methanol in presence of sodium hydroxide catalyst. The engine used for testing is Kirloskar make, single cylinder, direct injection, water cooled engine coupled with electrical dynamometer. The layout of experimental setup is shown in the Figure 1. Specification of the test engine is given in table 1. The CO and UBHC were measured by AVL gas analyzer and the smoke emission was measured using Bosch smoke meter.

3. RESULTS AND DISCUSSIONS

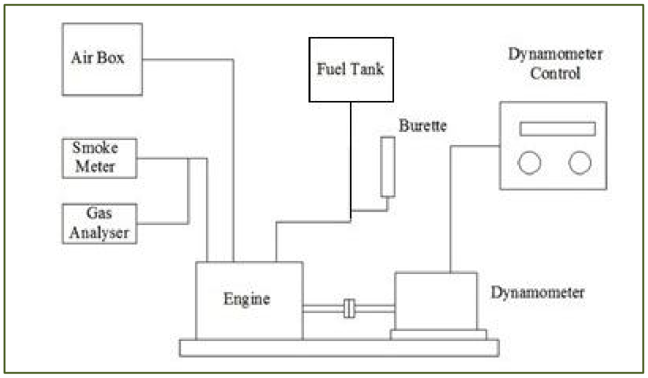

Figure 1
Experimental setup

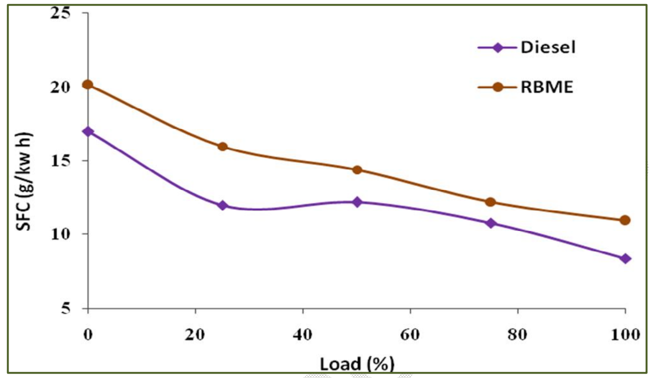

Figure 4
Specific fuel consumption vs Load

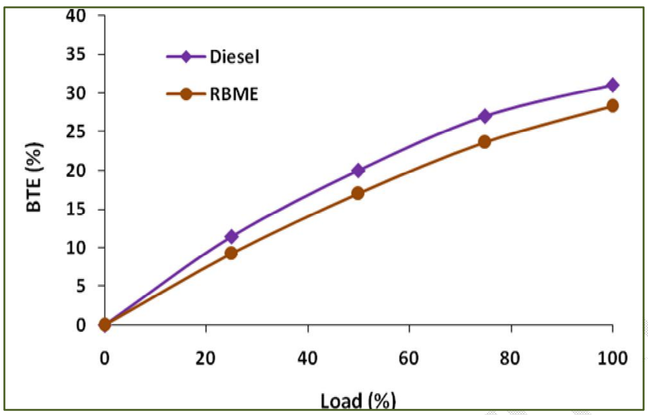

Figure 2
Brake thermal efficiency vs Load

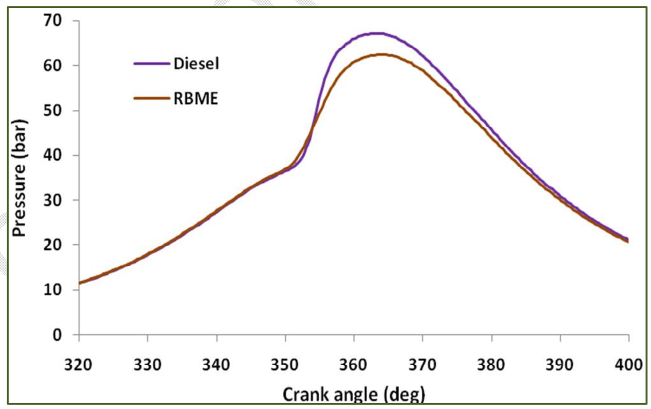

Figure 5
Cylinder pressure vs Crank angle

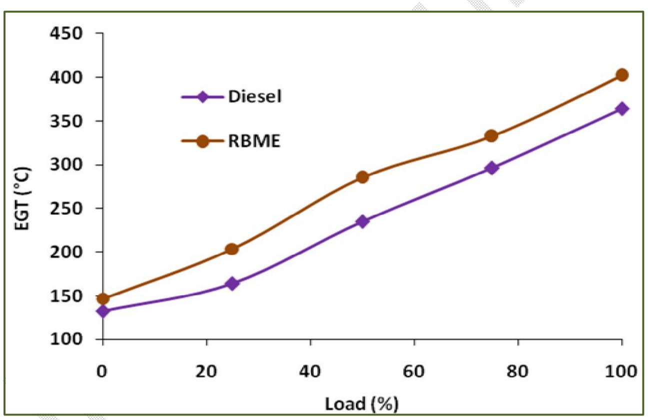

Figure 3
Exhaust gas temperature vs Load

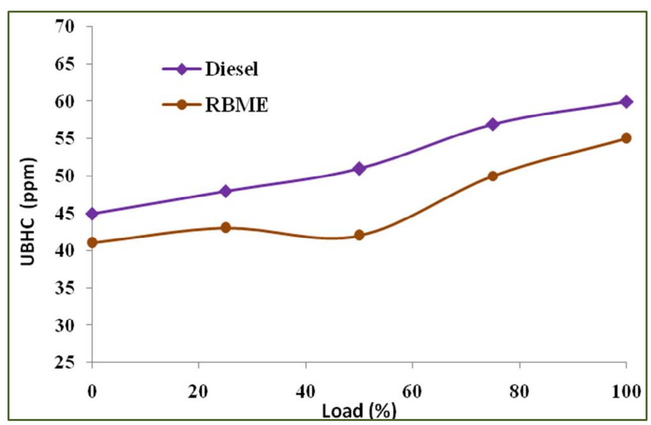

Figure 6
Unburned hydrocarbon vs Load

The variation of brake thermal efficiency (BTE) with respect to load is presented in Figure 2. In all cases, brake thermal efficiency 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. The BTE of the biodiesel is lower than the diesel in all the loads starting from no load to full load. At maximum load, the brake thermal efficiency of the biodiesel fuel is 8.7% lower than diesel and at 50% load the brake thermal efficiency is 15% lesser 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. The variation of exhaust gas temperature (EGT) with respect to load is presented in Figure 3. The exhaust gas temperature increases with increase in load. The rice bran oil methyl ester 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 zero load and minimum load, the exhaust gas temperature of

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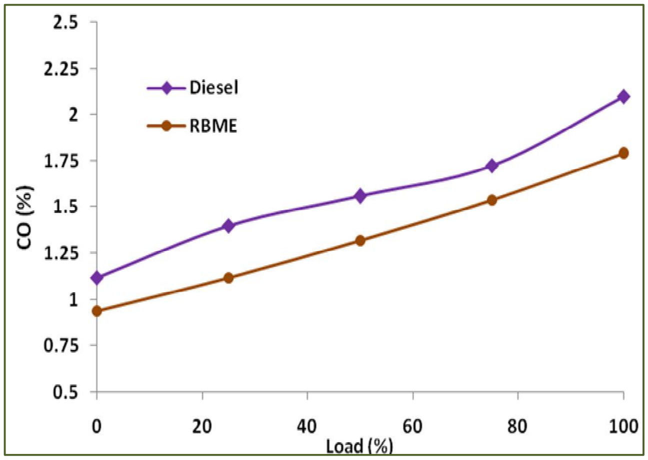

Figure 7

Carbon monoxide vs Load

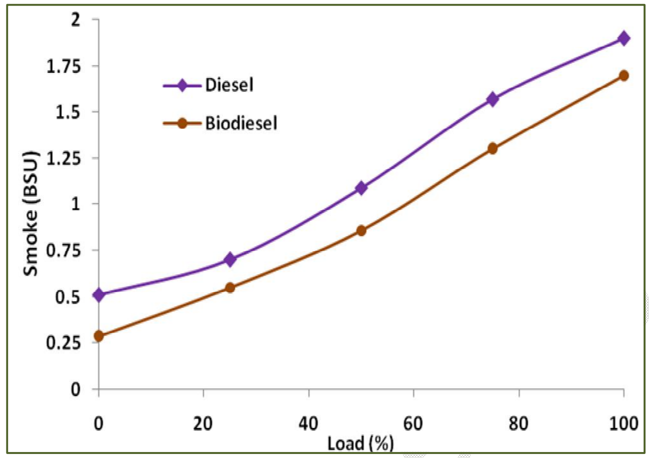

Figure 8

Smoke emission vs Load

biodiesel is 7.45 and 17.54% higher than diesel respectively. The variation of specific fuel consumption (SFC) with respect to load is presented in Figure 4. The specific fuel consumption of rice bran oil methyl ester 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 and 50% load, the brake specific energy consumption is 23% and 15.2% lower than diesel respectively. The variation of cylinder pressure with respect to crank angle is presented in Figure 5. Rice bran oil methyl ester produces a maximum pressure of 62.41 bar, which is 6.9% lower than the diesel fuel. This decrease in pressure of biodiesel may be due to the longer duration of diffusion in combustion process, the cylinder pressure decreases for biodiesel. The variation of unburned hydrocarbon (UBHC) with respect to load is presented in Figure 6. While using biodiesel as a fuel, the unburned hydrocarbon emission decreases. At no load condition, the biodiesel produce 9.2% lower UBHC emission than diesel fuel and at maximum load, it produce 8.3% lower UBHC than diesel. The presence of oxygen in the biodiesel aids combustion and hence the hydrocarbon emission reduced. The variation of carbon monoxide (CO) with respect to load is presented in Figure 7. The CO emission gradually increases with increase in load. The CO emission of rice bran oil methyl ester is lower than diesel for all the load condition. At no load condition, the 20MOME produce 16% lower CO emission than diesel fuel and at maximum load, the same fuel produce 14.76% lower CO than diesel. This is because of the availability of oxygen content in the biodiesel which makes the combustion better. The variation of smoke emission with respect to load is presented in Figure 8. It was observed that the smoke emission increases with increase in load. Rice bran oil methyl ester produces 10.52% lesser smoke emission than diesel at maximum load. Also, at minimum and 50% load, the biodiesel produces 44% and 21.1% lower than diesel respectively.

4. CONCLUSION

Experiments have been conducted on a direct injection diesel engine using diesel and biodiesel. Biodiesel used in the present study was produced from rice bran oil. The use of biodiesel instead of diesel leads to an increase in the brake specific fuel consumption and decrease in brake thermal efficiency, mainly due to the lower heat value compared with diesel. The carbon monoxide, unburned hydrocarbon and smoke emissions reduced significantly with biodiesel as fuel.

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Dhanesh et al.
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