PERFORMANCE AND EMISSION CHARACTERISTICS OF AL_2O_3 COATED LHR ENGINE OPERATED WITH MAHUA OIL BIODIESEL BLEND

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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. Biodiesel can be prepared from vegetable oils and animal fats. But the application of biodiesel in diesel engine will decrease the engine's efficiency and increase the specific fuel consumption. Application of ceramic coatings in engine will help to solve these problems. This paper presents the experimental results of mahua oil biodiesel blend in an Al_2O_3 ceramic coated compression ignition engine. The brake thermal efficiency, specific fuel consumption, carbon monoxide, unburned hydrocarbon and oxides of nitrogen emissions of both diesel and mahua oil biodiesel blend were measured before and after coating and the results are described in this paper.

Keywords: *Mahua oil, biodiesel, ceramic coating, low heat rejection.*

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1. INTRODUCTION

Compression ignition engine commonly called diesel engines are well known for its effective operation in both industrial and transportation sector. In this connection care to be taken to study the energy conservation phenomenon for effective utilization of available fuel and also to find an alternate fuel for diesel It is a known factor that, engines loses a portion of its energy developed throughout combustion and in other thermodynamic processes [1]. To minimize these losses, an attempt is made to study a low heat rejection concept as one of the measures. In low heat rejection engines, the effective utilization of generated heat takes place due to insulation of both piston and cylinder [2-4]. At the same time, the problems associated with high combustion temperatures involved with low heat rejection engines are resolved. Heavy exhaust blow-down energy and high NOx emissions are two among them, which leads to decrease in thermal efficiency and inability to achieve emission legislation levels.

Bio diesel is a diesel fuel substitute produced from renewable sources such as vegetable oils, animal fats and recycled cooking oils. Chemically, it is defined as the mono alkyl esters of long chain fatty acids derived from renewable lipid sources. Bio diesel is typically produced through the transesterification reaction of a vegetable oil or animal fat with methanol or ethanol in the presence of a catalyst to yield glycerine and bio diesel (Chemically called methyl or ethyl esters) [5-7].

Significant amount of research has been carried out on the performance and emission characteristics of conventional and LHR diesel engines fueled with biodiesel as a fuel. Kulkarni and Dalai [8] 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. Ramadhas et al [9] 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 [10] 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. 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. Krishnan et al [13] investigated the effect of AlSi graphite particle coating on piston in a diesel engine and observed significant improvement in the thermal efficiency using diesel as fuel. Balkrishna et al [14] investigated the performance and combustion characteristics on a single cylinder low heat rejection engine using diesel and multi-blend biodiesel. They reported that Al_2O_3 coated engine gave better performance than conventional diesel engine interms of brake power, engine efficiency and specific fuel consumption.

In this present study, biodiesel was produced from mahua oil and the performance and emission test was conducted in a Kirloskar make, single cylinder direct injection compression ignition with and without Al_2O_3 coating.

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 [15-18]. The properties of diesel, mahua oil and mahua oil biodiesel prepared are given in table 1.

Table -1: Properties of diesel and biodiesel

Property	Diesel	Mahua oil	Mahua oil biodiesel
Viscosity (cSt)	3.6	18	5.9
Density (kg/m^3)	840	932	910
Calorific value (MJ/kg)	42.8	36.3	39.2
Flash point (°C)	63	207	130
Fire Point (°C)	75	228	146

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 2. The mass flow rate of intake air was measured using an orifice meter connected to a manometer.

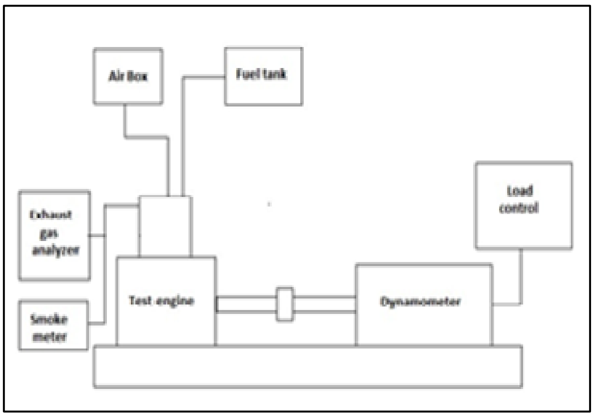

Fig-1: Experimental setup

Table-2: Specification of the test 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

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 exhaust gas temperature was measured with k-type thermocouple. The CO and UBHC were measured by AVL gas analyzer. The piston, cylinder head, inlet and outlet valve of the engine was coated with a nano ceramic material Al_2O_3 through plasma spray process. Engine performance and emission tests were carried out with and without ceramic coating.

3. RESULTS AND DISCUSSIONS

The variation of brake thermal efficiency with respect to load is shown 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 brake thermal efficiency of the biodiesel is lower than the diesel in all the loads starting from no load to full load in both conventional and LHR engine. But in the aspect of LHR engine, the diesel and biodiesel blended fuel gave higher efficiency than the conventional engine. Compared to conventional biodiesel engine, the brake thermal efficiency of LHR biodiesel engine is 13.41% higher at maximum load condition.

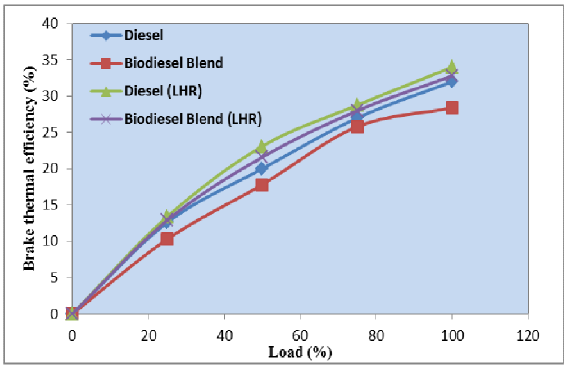

Fig-2: Variation of brake thermal efficiency with load

The variation of specific fuel consumption with respect to load is shown in figure 3. The specific fuel consumption of mahua oil biodiesel blend 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 of conventional engine, the specific fuel consumption of biodiesel is 8.09%

higher than diesel. But in the aspect of low heat rejection engine, the diesel and biodiesel blend are gave lower specific fuel consumption than the conventional engine. Compared to conventional diesel engine, the specific fuel consumption of diesel and biodiesel blend in LHR engine are 9.52% and 10.41% higher at maximum load condition.

The variation of carbon monoxide emission with respect to load is presented in figure 4. The carbon monoxide emission gradually increases with increase in load. The carbon monoxide emission of biodiesel blend is lower than diesel for all the load condition. This is because of the availability of oxygen content in the biodiesel which makes the combustion better. At maximum load, the carbon monoxide emission of diesel and biodiesel blend in low heat rejection engine is 13.21 and 12.88% lower than the conventional engine respectively.

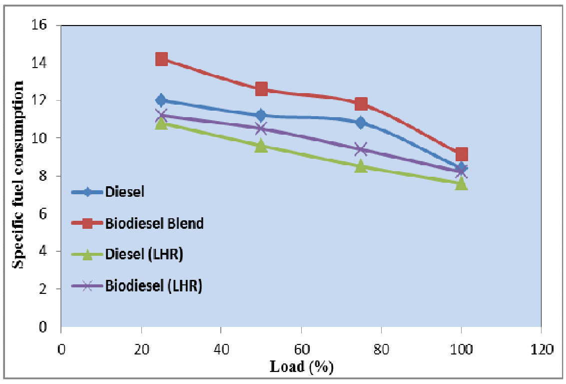

Fig-3: Variation of specific fuel consumption with load

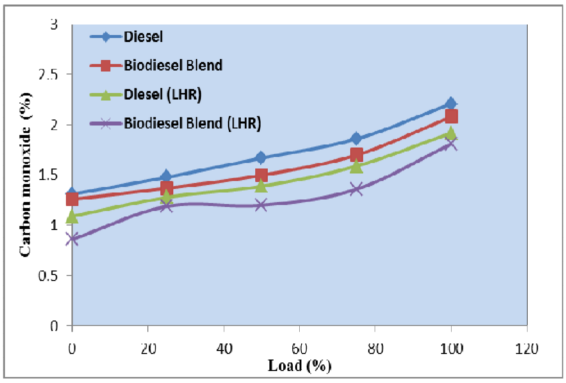

Fig-4: Variation of carbon monoxide with load

Figure 5 shows the variation of hydrocarbon emission of the engine with respect to load. Hydrocarbon emission is low in LHR engine when compared with conventional engine for all the test fuels. The decrease in the hydrocarbon in the LHR engine may be due to the increase in after combustion temperature due to decrease in heat rejected to cooling and heat loss to atmosphere due to the nano ceramic coating. In LHR engine unburned hydrocarbons were added to the combustion. Thus the results clearly indicate that the ceramic coating lowers the hydrocarbon emission compared with uncoated engine. The decrease in hydrocarbon emission may be also due to the more oxygen content in the biodiesel, which helps for complete combustion. At maximum load, the unburned hydrocarbon emission of diesel and biodiesel blend in low heat rejection engine is 14 and 17.1% lower than the conventional engine respectively.

The variation of oxides of nitrogen emission with respect to load is presented in figure 6. The oxides of nitrogen emission gradually increase with increase in load. An increase in the temperature of after combustion process causes an increase in oxides of nitrogen emission. Compared to conventional diesel engine, the oxides of nitrogen emission in the low heat rejection is more because of an increase in after combustion temperature due to the ceramic coating. Biodiesel blend used in both conventional and low heat rejection engine produce more oxides of nitrogen because of their higher oxygen content than diesel fuel.

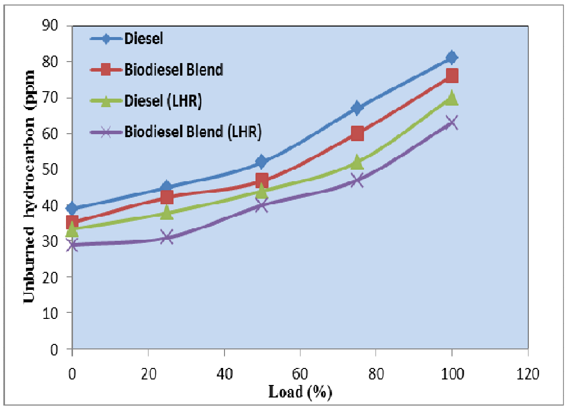

Fig-5: Variation of hydrocarbon emission with load

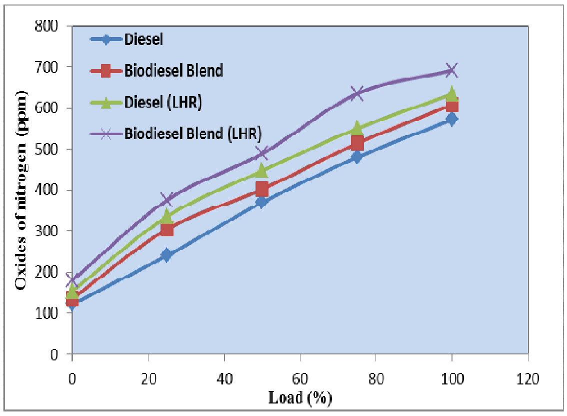

Fig-6: Variation of oxides of nitrogen with load

CONCLUSIONS

The experimental study was carried out with diesel and 50% mahua oil biodiesel blend. The ceramic coating was done on the piston surface, cylinder head and valves of the engine to convert the conventional engine into low heat rejection engine. It was observed that the heat transferred to the coolant and surrounding was reduced well due to the thermal barrier coating. The specific energy consumption of LHR engine with biodiesel was higher than LHR engine fueled with diesel fuel, but lower than the conventional engine operations. The high operating temperature during combustion in low heat rejection engine makes the combustion process to nearly a complete combustion. At maximum load the carbon monoxide and unburned hydrocarbon emission level decreases for LHR engine fuelled with biodiesel blend. The reduction in carbon monoxide and unburned hydrocarbon emission level is due to the high combustion temperature and availability of oxygen in biodiesel blend.

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