EXPERIMENTAL AND EMISSION ANALYSIS OF ESTRIFIED RUBBER SEED OIL WITH DIESEL IN DIRECT INJECTION CONSTANT SPEED DIESEL ENGINE

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Abstract

The demand of resources and fuels for the technological development is increasing day by day. In order to keep the pace of development high we need to think about some alternate fuel which would help overcome the demand keeping in mind the resources for the future generation. An alternate fuel needs to be developed and researched upon which could help us get a greener and better tomorrow. In this study the experimental tests on a single cylinder diesel engine using esterified rubber seed oil bleeds with diesel are conducted. The performances parameters thermal efficiency (BTE) and brake specific fuel consumption (BSFC) are analyzed with different inlet pressures (180 bar, 200 bar, 220 bar) and various load conditions. Also emission analysis of hydrocarbons (HC) and Nitric Oxide (NOx) has been carried out. It was found that the thermal efficiency of engine is increased at the pressure of 220 bar and considerable reduction of HC, NOx was absorbed.

Key words: Diesel engine, esterification, emission, rubber seed oil, Exhaust gas analyzer.

I. INTRODUCTION

There is a need to search and find ways of using alternative fuels, which are preferably renewable and also emit low levels of gaseous and particulate pollutants in internal combustion engines. Internal combustion engines play a major role in transportation, industrial power generation and various other operations. Fuels like vegetable oils, bio-diesel, alcohols, natural gas, biogas, hydrogen, liquefied petroleum gas (LPG), etc. are being investigated by researchers for engine applications. One such most researched biodiesel is rubber seed oil in combination with diesel.

According to previous researches the various types of biodiesel can be commercially produced from the refined edible vegetable oils such as palm oil, sunflower oil and soybean oil, etc. by using a process known as alkaline-catalyzed etherification. This method used for the biodiesel production consists of acid-catalyzed pretreatment followed by an alkaline-catalyzed transesterification. In the previous researches important properties of methyl esters of rubber seed oil were compared with other esters and diesel. Pure rubber seed oil, diesel and biodiesel are used as fuels in the compression ignition engine and the performance and emission characteristics of the engine were analyzed. As per the researches it was shown that the lower blends of biodiesel had increased the brake thermal efficiency of the engine and had reduced the fuel consumption too. The exhaust gas emissions could also be reduced with an increase in the biodiesel concentration. The results after various experiments had proved that the use of biodiesel (produced from unrefined rubber seed oil) in compression ignition engines is also a viable alternative to diesel. [1]

As per the research from various other scholars it is being found that usage of pure vegetable oils in diesel engines results in higher smoke levels and lower thermal efficiency as compared to that of diesel. But this problem can also be tackled by inducting a gaseous fuel in the intake manifold along with the air. During the experiment firstly hydrogen was used as the inducted fuel and rubber seed oil, rubber seed oil methyl ester and diesel was used as main fuels in a dual fuel engine. It was noticed that the peak pressure and maximum rate of pressure rose with the hydrogen induction in the intake manifold. The change in the heat release rate indicated an increase in the combustion rate with hydrogen induction in the intake manifold. After the experiment it was concluded that hydrogen can be inducted along with air in order to reduce smoke levels and improve thermal efficiency of Rubber seed oil and its bio-diesel fuelled diesel engines. [2]

In one of the other experiments performed, the engine test bed procedure was opted for testing the coking of Direct Injection diesel engine injector nozzles.

The injector nozzles were examined for the effect of using neat rubber seed oil biodiesel and blend with diesel oil as fuel and the results were compared. The effects of the fuels on various engine components and the exhaust gases emitted such as Hydrocarbon, Carbon Monoxide, Smoke and Brake Specific Fuel Consumption were investigated. After the experiment it was found that the performance and emissions of B5 fuel was comparable with the performance obtained by diesel fuel. It was also noted that the use of B100 resulted in significantly higher in the BSFC; higher emissions. The experiment concluded that the usage of pure rubber seed oil and B5 reduced deposits on the cylinder head but Rubber seed biodiesel increased the sedimentary deposits on the piston. [3]

In another experiment conducted, the major property of the crude rubber seed oil that it has very high free fatty acids was used. Using these free fatty acids, the methyl esters were produced by the transesterification process. In the experiment the important properties of methyl esters of rubber seed oil were compared with diesel. The experiment involved usage of three fuels - diesel, blends of biodiesel & diesel and neat biodiesel. The various fuels were tested in a single cylinder, water cooled four stroke diesel engine and the performance and emission characteristics of the engine were analyzed. The results from the experiment gave proof that the rubber seed oil based biodiesel can be used as a fuel in compression ignition engine without any major engine modification and it is a suitable alternative to diesel. [4]

Table 1. Properties of Fuels

Properties	Diesel Fuel	Rubeer Seed Oil	Biodiesel
Sp. Gravity	0.74	0.82	0.81
Viscosity at 40°C (mm^2/s)	4.15	70.2	20.14
Calorific Value (KJ/kg)	42000	37000	41000
Carbon residues%	0.12	0.45	0.36

II. EXPERIMENTAL SETUP

A constant speed single cylinder (1500 rpm) direct injection diesel engine coupled with eddy current dynamometer was used to study the performance a biodiesel engine with 10% rubber seed oil along with 90% of diesel. The experiment was carried out for various injection pressures viz. 180, 200, 220 bar and the thermal efficiency of the engine was obtained at various load conditions. The exhaust gases composition was measured using AVL based exhaust gas analyzer. This analyzer measures the amount of NOx and HC released at various conditions.

III. ENGINE CONDITIONS

An internal combustion Diesel engine of the following specifications was being used for the experimental analysis for the given biodiesel sample.

Bore:	95.5 mm
Stroke:	130.0 mm
Speed:	1500 rpm
Compression ratio:	16:1
Rated power:	4 HP
Number of cylinders:	One
Type of cooling:	water cooled - eddy current dynamometer
Injector opening pressure:	180 bar
No. of stroke:	4 stroke

IV. RESULTS AND DISCUSSIONS

A. Performance Analysis

In this study the two performance parameters such as brake thermal efficiency and specific fuel consumption (SFC) was considered to test the engine and plotted in Fig. 1 and 2.

a. Brake Thermal Efficiency

On comparison of the thermal efficiency values based on the different injection pressures at various load conditions was plotted as shown in Fig. 1, in which at 220 bar pressure maximum efficiency was obtained about 27% at all different load conditions. The minimum thermal efficiency was obtained about 21% at 180 bar of pressure and the efficiency obtained at 200 bar of pressure is not as high as 220 bar but is much closer to 180 bar. So with respect to Brake thermal efficiency, injection pressure most suitable is 220 bar.

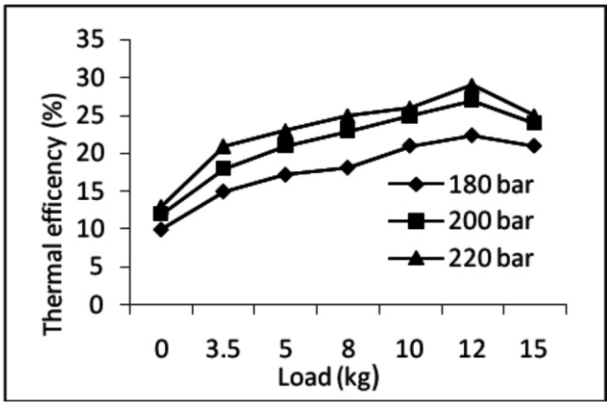

Fig. 1. The variations of thermal efficiency with changing load conditions

b. Brake Specific fuel consumption (BSFC):

The specific fuel consumption is important parameter in all internal combustion engines. In this experiment the brake specific fuel consumption was found for the different injection pressures. The engine was tested for another two injection pressures such as 200 bar, 220 bar along with the normal injection pressure of 180 bar. From the Fig. 2, the BSFC is lower at 220 bar and higher at 180 bar at all load conditions. At 200 bar the BSFC was higher than that of at 180 and 220 bar at zero load condition. But it was lower than 180 bar and higher than that of at 220 bar at the full load condition.

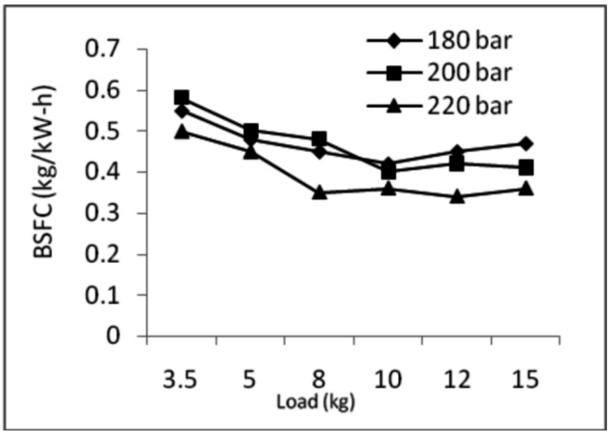

Fig. 2. The variations of brake specific fuel consumption with changing load conditions

B. Emission Analysis

When the oxygen content is increased in bio fuel, the complete combustion takes place in chemically correct ratio, which is called as stochiometric air-fuel ratio. In this experiment two emission parameters were considered to test the engine such as unburned hydrocarbon (HC) and nitric oxide (NOx). These parameters were shown in Fig. 3 and 4.

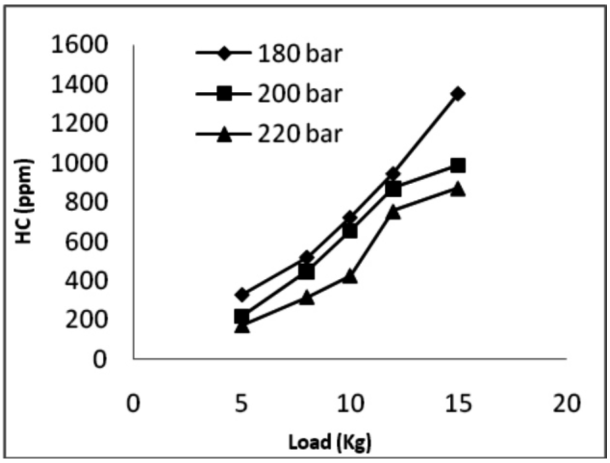

Fig. 3. The variations of hydro carbon emission with changing load conditions

a. Hytrocarbon (HC)

On comparison of the amount of Hydrocarbons (HC) released in the exhaust on different injection pressures at various load conditions from Fig.3, it was found that at zero load conditions, the amount of HC released is almost the same for all injection pressures. But, as the load on the compression injection engine increases, the amount of HC's released increases drastically when the injection pressure is 180 bar. At 220 bar of pressure, the amount of HC's released is comparatively very less and suitable for the environmental emission limits. At 200 bar of pressure, the amount of HC's released stays close by to the amount of HC's released at 220 bar of pressure. Minimum amount of HC's are emitted at 220 bar of pressure, but the 200 bar of pressure is also acceptable.

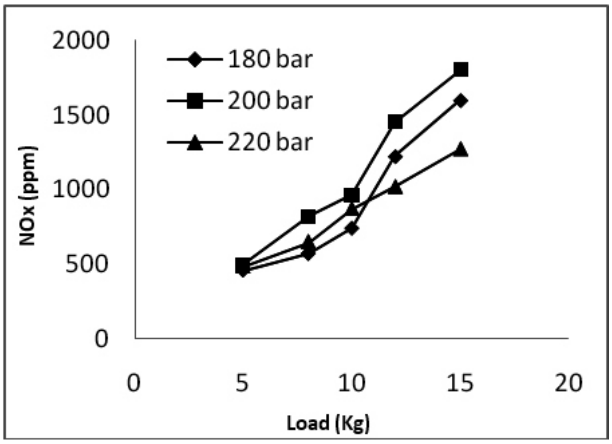

Fig. 4. The variations of Nitric oxide emmision with changing load conditions

b. Nitric Oxide (NOx)

From the amount of NOx released in the exhaust on different injection pressures at various load conditions from the Fig. 4, it was found that at zero load conditions, the amount of NOx released is almost the same for all injection pressures. But, as the load on the compression injection engine increases, the amount of NOx released increases drastically when the injection pressure is 200 bar. At 220 bar of pressure, the amount of NOx released is comparatively very less and suitable for the environment. At 180 bar of pressure, the amount of HC's released stays very close by to the amount of NOx released at 200 bar of pressure. Minimum amount of NOx are emitted at 220 bar of pressure.

V. CONCLUSION

The present study was carried on an unmodified diesel engine which was converted to run on a biofuel. The main objective of the present investigation was to study the performance analysis of Biofuel at different inlet pressures and various load conditions. According to the experimental analysis it was concluded that at 220 bar of injection pressure, maximum thermal efficiency is obtained in the internal combustion diesel engine and at 180 bar minimum thermal efficiency is obtained over all load conditions. At 200 bar of injection pressure, the thermal efficiency remains in the moderate region.

The amount of HC's emitted in the exhaust of the engine should always be low as it signifies the amount of un-combusted fuel. As per the analysis it was found that at 180 bar of inlet pressure the amount of HC's was maximum. The amount of HC's obtained at 200 bar of pressure was moderately low. The amount of HC's emitted at 220 bar of pressure was found to be minimum and most economic.

The amount of NOx emitted in the exhaust of the engine should always be low as it is very harmful for the environment and results in global warming. As per the experiment conducted, it was noted that at 200 bar of pressure maximum amount of NOx gasses were evolved and at 220 bar of inlet pressure the amount of NOx evolved is minimum, keeping the amount of NOx evolved at 180 bar a little high but lower than that at 200 bar.

Considering all the three parameters i.e. the thermal efficiency, amount of NOx, and amount of HC at all load conditions we can state that the most moderate inlet pressure can be around 220 bar for an internal combustion engine running on biofuel.

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