

Effect of Variation of Loads on the Performance and Emission Characteristics of Blends of Lard Oil Methyl Ester and Diesel on C I Engine

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Abstract— In the present study, Lard oil methyl ester (LOME) has been extracted from pig fats by base-catalyzed transesterification with methanol in the presence of sodium hydroxide (NaOH) as catalyst. The effect of LOME addition to pure diesel on the performance and emission characteristics of direct injection diesel engine has been experimentally investigated by load at a constant Compression ratio. The experimental test results showed that the addition of LOME to diesel decreased the brake thermal efficiency of the engine by 3% and increased the specific fuel consumption by 3% compared to pure diesel. But for B20 blend, carbon monoxide (CO), hydrocarbon (HC), oxides of nitrogen (NOx) and smoke emission are decreased by 20%, 4%, 14%, and 3% respectively as compared to pure diesel at full load of the engine.

Index Terms— Lard Oil Methyl Ester, Diesel, C I Engine, Emission

1 INTRODUCTION

Production and use of fossil fuel in internal combustion engines causes environmental pollution, such as rise in carbon dioxide levels in the atmosphere [1]. The combustion of petroleum leads to emission of CO, SO₂, NO_x etc resulting in global warming, which threaten wild and human life, impacts on the environment and human health. Hence research is going on to find an alternative for diesel fuel. Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines alone or blended with diesel oil [2]. Different animal fats like pork lard, beef tallow, chicken fat, yellow grease and brown grease are used for biodiesel production [3]. Biodiesel is biodegradable and non-toxic and has low emission profiles as compared to petroleum diesel [4]. Hence biodiesel research has become more prominent research.

Biodiesel can be obtained through the esterification process. During this process raw oil is tested for free fatty acid (FFA) content using titration method [5]. If FFA is less than 4% then directly transesterification can be carried out. If it is greater than 4%, more NaOH is added to convert oil to methyl ester. Esterification process is done by employing methanol/ethanol in presence of acid as homogeneous catalyst, among which H₂SO₄ exhibited very promising result [5]. In transesterification reaction, NaOH and Methanol/ Ethanol are mixed in a conical flask till all the methanol/ Ethanol dissolves. Oil is heated in a round bottom three necked flask. Oil is heated up to the boiling point of Methanol/Ethanol.

round bottom flask at that particular temperature. Heating is done for 2 hours and while heating mixture is continuously stirred by magnetic stirrer. Later this is transferred to a separating funnel and it is kept for one day for complete separation of biodiesel from glycerin. Then the methyl ester is separated from the conical flask and subjected to water washing. A small quantity of hot water is added and the biodiesel is water washed. This water washing is done till the mixture becomes clear. Heating the mixture will result in evaporation of water from the fuel sample. This end result is methyl ester which can be used as a fuel in IC engines.

2 Experimental Details

In this work biodiesel is produced and its properties are measured. Experiments are conducted in VCR engine for different blends like diesel B10, B20 and B30 for performance and emission characteristics at three compression ratios at a constant speed of 1500 rpm.

2.1 Transesterification

The biodiesel is produced by transesterification method which was carried out using a round bottom flask of 1 litre capacity, equipped with thermostat, mechanical stirrer, sampling outlet and condensation systems. A freshly prepared 300 ml methanol and 6.5 grams of sodium hydroxide solution are taken in a separate flask. 1000 ml of lard oil is heated to 65°C in the round bottom flask and the solution is mixed with the lard oil which is heated to 65°C. Now the reaction takes place for 2 hours with same temperature of 65°C. After 2 hours, the solution is taken in a separating funnel and kept for minimum 15 hours for proper settling of glycerin. The glycerin collected at the bottom of the funnel is taken out and lard oil methyl ester is washed with hot water to remove soap and glycerin content from the lard oil methyl ester till a clear lard oil methyl ester is obtained.

2.2 Properties of Fuel Samples (Diesel and Blends of LOME)

Table 1 shows the properties of fuel samples. Higher

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Calorific value is found by Bomb calorimeter apparatus. Density is found by using hydrometer. Cannon Fenske Viscometer is used to measure the Kinematic Viscosity. Flash and fire points are found by using Cleveland open cup apparatus.

Table 1. Properties of Diesel and blends of LOME

Properties	Higher Calorific value (kJ/kg)	Density (kg/m ³)	Kinematic Viscosity @ 40°C (cSt)	Flash Point (°C)	Fire Point (°C)
ASTM Standards	D 240	D-4052	D445	D92-05a	D92-05a
Diesel	46363	712.6	2.63	56	58
B10	43630	716.1	2.98	76	78
B20	40902	726.3	3.21	80	82
B30	38170	729.4	3.41	84	86
B100	29980	759.5	4.12	172	174

It is observed that the calorific value of LOME is less than diesel fuel. Viscosity of the blend increases as the percentage of LOME increases in the fuel sample. Density, flash and fire points also increase as the percentage of LOME increases in the fuel sample.

2.3 Engine Setup

The Engine setup consists of a single cylinder, four stroke, water cooled variable compression ratio diesel engine connected to an eddy current type dynamometer for loading. A tilting cylinder block arrangement is used for varying the compression ratio without stopping the engine and without altering the combustion chamber geometry. Temperature sensor arrangements are made in the measurement of exhaust gas inlet and outlet temperatures, water jacket and calorimeter water. The exhaust gas emissions are measured using an exhaust gas analyser and smoke opacity is measured using a smoke meter.

3 Results and Discussion

The experiments were conducted at a constant speed of 1500 rpm for three different compression ratios of 16, 17 and 17.5 at an injection pressure of 200 bar with diesel and LOME blends (B10, B20 and B30). Mass flow rate, load, emissions and smoke opacity readings were recorded for various loads. Engine performance parameters like brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC) were calculated.

3.1. Performance Characteristics

3.1.1. Brake Specific Fuel Consumption (BSFC)

Figure 1 shows the variation of BSFC with respect to varying load for diesel and LOME blends (B10, B20 and B30) for compression ratio 17.5. From the graph it is observed that, as load increases BSFC decreases. This is due to the as percentage of biodiesel in blend increase fuel consumption is more and breakpower is highly [6]. And also as the percentage of biodiesel in the blend increases, BSFC increases. It is due to the lower calorific value of biodiesel and its blends compared to diesel, more amount of fuel is required to produce the same power output [7]. Here among the four loads, BSFC is minimum for a load 12kg. Also as percentage of LOME in the blend increases BSFC also increases.

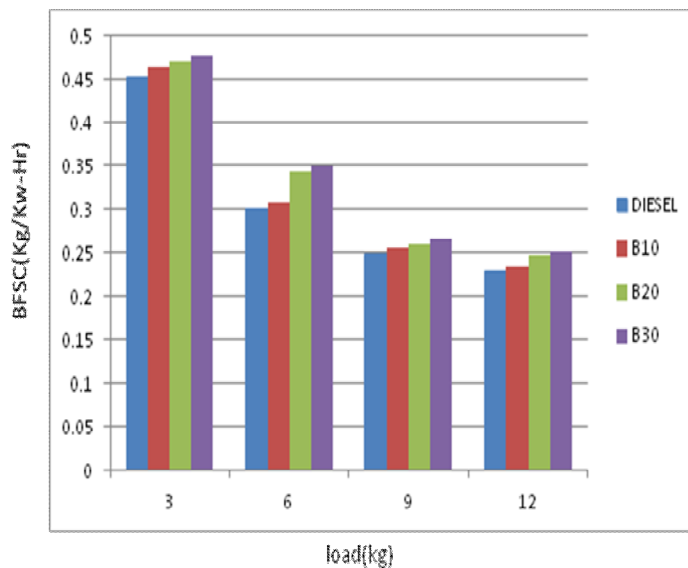


Fig1

3.1.2. Brake Thermal Efficiency (BTE)

Figure 2 indicates the variation of BTE with respect to load for diesel and LOME blends (B10, B20 and B30) at CR17.5. It observed that as Load increases BTE also increases. This is due to this is due to higher viscosity, higher density, and lower calorific value of waste pork lard methyl ester than pure diesel [6]. But as biodiesel in blend increases, BTE decreases. This is due to combined effect of its lower heating value and increase in fuel consumption [9]. BTE is maximum at Load 12kg.

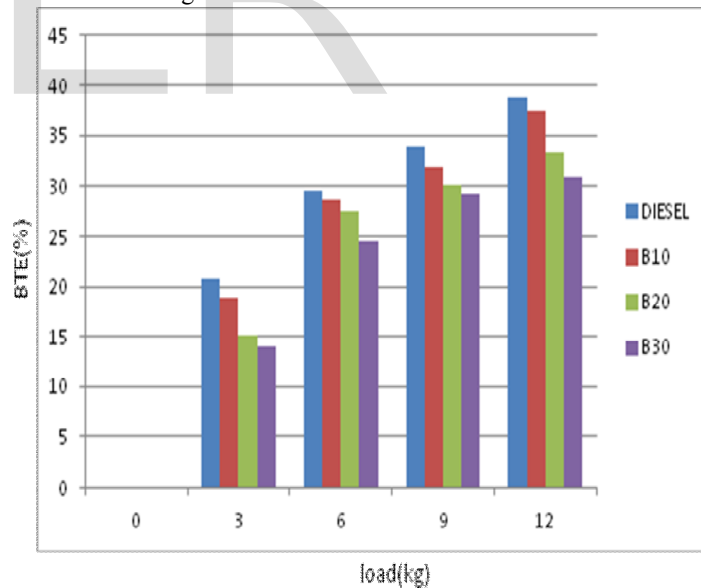


Fig2

3.2. Emission Characteristic

3.2.1. Hydro Carbon (HC)

Figure 3 shows variation of HC with respect to load for diesel and LOME blends (B10, B20 and B30) at a CR 17.5. It is observed that as load increases, emission of hydrocarbon increase. This is due to the presence of fuel-rich mixtures at higher loads [6]. And as percentage of biodiesel in blend increases, emission of HC also decreases. At zero load, emission of HC is less.

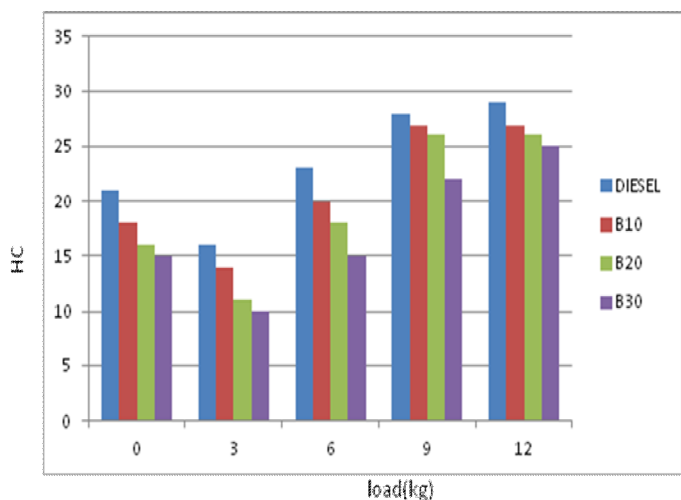


Fig3

3.2.2. Carbon Monoxide (CO)

The variation of CO with respect load for diesel and LOME blends (B10, B20 and B30) at a CR 17.5 is shown in Figure 4. It is observed that as load increased, emission of CO is decreased. This is due to the presence of higher oxygen content in biodiesel [7]. Also as percentage of biodiesel in the blend increased, emission of CO is decreased. At 12k load emission of CO is less.

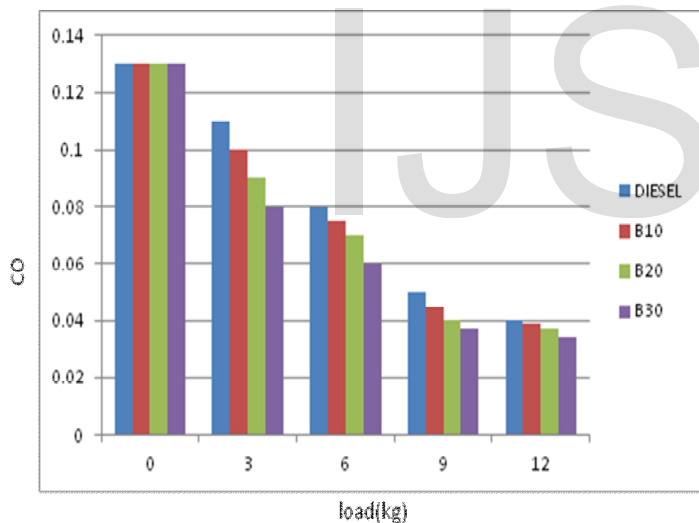


Fig4

3.2.3. Carbon Dioxide (CO₂)

Figure 5 shows the variation of CO₂ with respect to load for diesel and LOME blends (B10, B20 and B30) at a load of 12 kg. It is observed that load increases emission of CO₂ increase. This is due to low calorific value of fuel. As the calorific value of the fuel is low, more fuel needs to be burnt to get equivalent power output. So combustion of more carbon compounds leads to higher carbon dioxide emission. Also as percentage of biodiesel in blend increases, the carbon dioxide emission increase. At load 12kg emission of carbon dioxide is more.

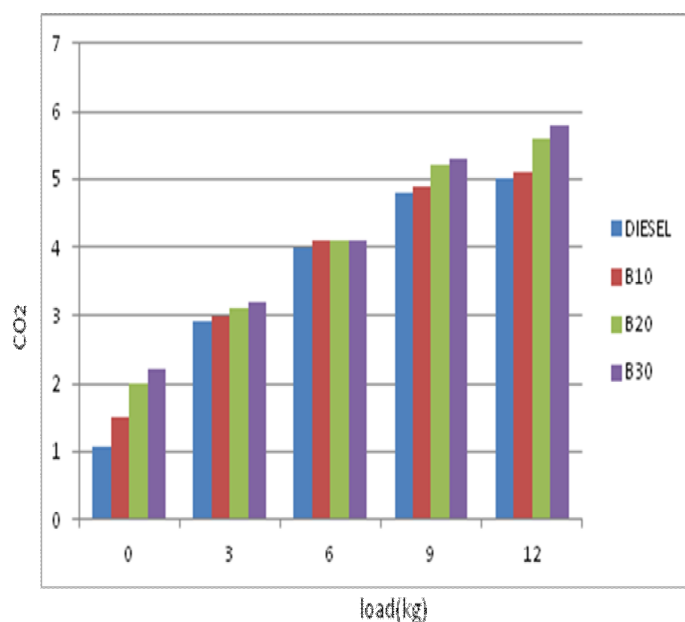


Fig5

3.2.4. Oxides of Nitrogen (NO_x)

NO_x is formed during combustion because of high temperature inside the cylinder. Figure 6 shows the variation of NO_x with respect to load for diesel and LOME blends (B10, B20 and B30) at a CR 17.5. It is observed that as load increases, emission of NO_x also increases. Also as percentage of biodiesel in blend is increased, emission of NO_x also increased. This is due to the availability of excess oxygen in the biodiesel. For blend b30 NO_x is more.

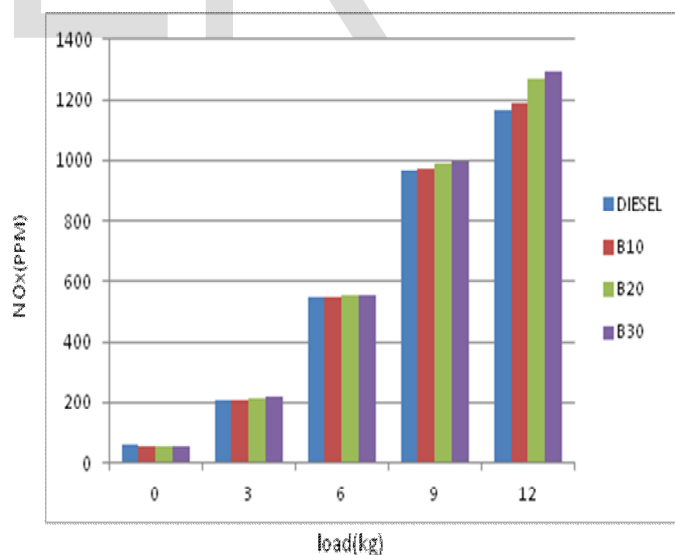


Fig6

4. Conclusions

Following conclusions may be drawn from the present study.

- The performance and emission characteristics are better for LOME blends B20
- As the load increases the BTE increase but BSFC decreases.
- As the percentage of LOME in the blend increases, BSFC increases but BTE decreases.

- As load increases, emissions of HC, CO, CO₂ increase but NO_x decrease.
- As the percentage of LOME in blend increases, emissions of HC, CO and CO₂ decrease but NO_x and smoke opacity increase.

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