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259. Investigation of CI engine performance and emission characteristics using biodiesel blends with low level addition of alcohol

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Abstract

The researchers are investigating the alternative fuel resource which reduces greenhouse gases effects in the globe. The fuels such as biodiesel, methanol and ethanol derived from natural resources are mostly used in engines as an alternative fuel. In this research paper, Compression ignition (CI) engine performance and exhaust gas emission using biodiesel blend with additive of alcohol have been investigated. The biodiesel-blend of 15% with low concentration 5% of alcohol blend (B15ME5) has been investigated. The engine performance parameters have been investigated on constant rpm and variable loading conditions with 10 equal intervals. The obtained results are compared with the base line (diesel fuel) fuel. The results show that, BSFC of alcohol blended fuel is higher than baseline. It is due to the lower heating value of alcohol fuel. More ever BTE of alcohol blended fuel B15ME5 is found to be increases compared to diesel fuel. However detail discussion on engine performance and exhaust emission will be given in manuscript

Keywords: *"Engine performance, Exhaust emission, Biodiesel-Blend;"*

1. Introduction

The crude oil reservoirs are depleting due to higher exploring rate and rapid urbanization from last decay. Due to higher demand of fuels, it is better to move towards alternative fuels. The fuels are very important for commercial sectors and residential sectors which fulfil the human needs for transportation. Crude oil products are highly responsible for global warming; harmful emission from engine which depleting ozone layer. Cars, logistic trucks and other concerned engine of automobiles, power plant and home furnaces require more fuel as before burning, more fuel are responsible for GHG (greenhouse gases) emissions. Heat released from GHG accelerates to increase sea level due to melting glaciers. The biodiesel and alcohol fuels in known as green fuel because it is extracted from natural feed stocks. The high level blends of biodiesel with additives of methanol and ethanol are investigated by many researchers [1-3]. Alcohols are used as an oxygen enhancer and vegetable oil is added to the diesel–biodiesel–ethanol blend in order to balance the low lubricity of alcohols.

In this study, Diesel fuel (DF) and biodiesel blend with concentration of low level additive of methanol and ethanol (B15ME5) have been used for investigate engine performance parameters and flue gases emissions. The results of B15ME5 are compared with baseline.

2. Experimental setup and research methodology

The experimental results are carried in single cylinder 4-stroke compression ignition (CI) water cooled engine. Detailed test bed engine information is defined in Table-1. The engine is mounted on test bed which is equipped thermocouples, tachometer, flow meter and dynamometer.

Table1. Diesel Engine Test Bed Specification	
Cooling system	Water cooled
Type	Horizontal
Number of cylinders	1
Bore(Piston size)	80mm
Stroke (Piston Displacement)	95mm (477cc)
Compression Ratio	23:1
Starting Method	Manual
Output/rotational speed	8.5PS/2200 rpm(max)

There are two fuel tanks have been used in diesel engine test bed to store the fuel. One is selected for D100 and other is reserved for B15ME5 blended fuel. Both fuel tanks are connected with an engine with single pipeline however flow can be controlled with two separate valves as shown in Figure 1.

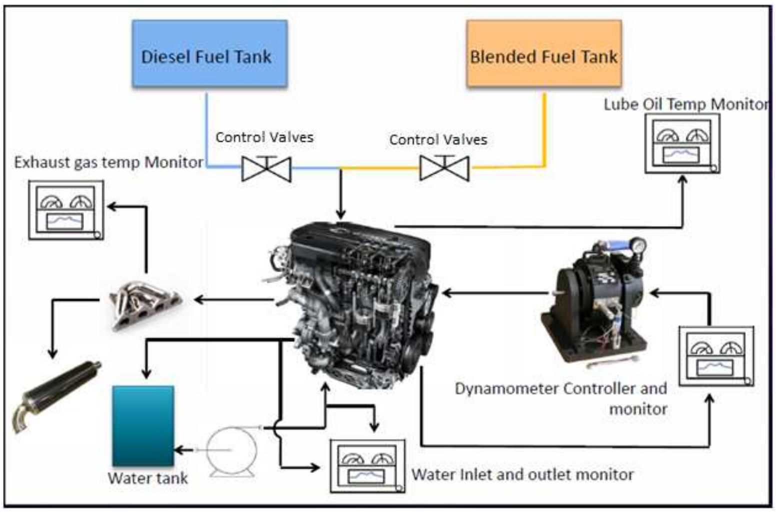

Fig. 1. Schematic diagram of diesel engine test bed

The engine performance parameters are analyzed on variable load and constant speed. The load on engine varies from 0.1 to 2.8 KW at constant speed of 1460 rpm. However 1st data is collected on 0.1 KW engine load at the speed of 1460.Testo 350 XL fuel gas analyser has been used to measure CO, NOx and HC exhaust gas emission. Biodiesel used in this study is extracted from Jatropha. It is produced by trans- esterification process.

3. Engine performance

In this study engine performance parameters have been tested. Brake specific fuel consumption (BSFC), Brake power (BP), Brake thermal efficiency (BTE) and Exhaust gas temperature have been tested. There are two fuel samples have been tested one in diesel fuel (DF) and other is biodiesel blend with additive of methanol and ethanol. The concentration of methanol and ethanol in biodiesel blend is 5% by reducing 5% of biodiesel in blend (D80B15ME5). Biodiesel blend with additive has 80% of diesel fuel, 15% of biodiesel and 2.5% of methanol and 2.5% ethanol by volume. All the results have been carried out on same compression ratio but in variable load and constant speed of engine.

3.1. Brake Specific fuel consumption

The BSFC is defined as the ratio of fuel consumption to engine power. This ratio is used to measure engine fuel efficiency that fuel burns and produce engine power. Some researcher are investigated that biodiesel has higher BSFC than D100. It is because of its lower calorific value [4-6].

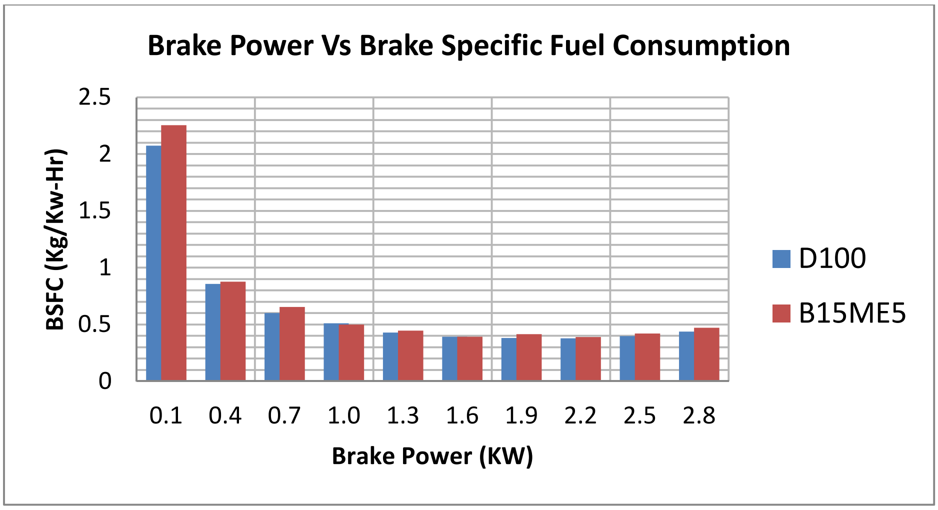

Fig. 2. Results of Brake Specific Fuel Consumption

The BSFC of an engine expressed in terms of Kg/Kw-Hr. It is noticed in Figure-2, the BSFC of B15ME5 is higher than D100 on 0.1KW load condition on engine. It is just because of higher content of oxygen and lower calorific value of the fuel. Due to the highest heating value and the highest density value of diesel fuel than B15ME5, It has been observed that BSFC of B15ME5 is 6.22% higher than D100.

3.2. Brake Thermal Efficiency

Brake thermal efficiency can be determined by the ratio of brake power and fuel supplied in engine. Biodiesel has enhanced combustion because of higher oxygen contents; it enhances the combustion when utilized as a blend. Biodiesel blended with methanol and ethanol is resulted poor combustion because of its lower cetane number. But it is easily blend with biodiesel. It has been observed that by increasing the percentage of the blend with methanol and ethanol calorific value have been decreased; therefore the fuel consumption has been increasing for a same power output. The BTE of D100 and B15ME5 from idling condition to 0.1KW of load on the engine is same. The BTE of B15ME5 fuel has been increased consistently from 1 KW to 2KW of load on the engine. BTE of B15ME5 is slightly higher than that D100. It is due to the reason of increment in the percentage of oxygen contents which help to improve the combustion process.

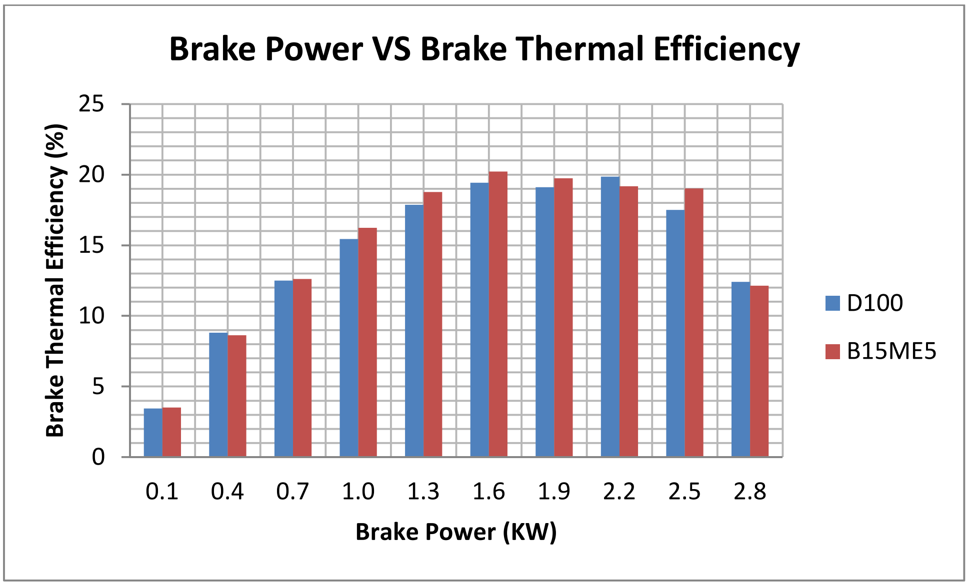

Fig. 3. Results of Brake Thermal Efficiency

Therefore due to a higher percentage of oxygen on helps produce faster combustion process. There are different types of low stoichiometric air/fuel ratios, Ethanol and methanol is one of them. Due to that methanol and ethanol blend with biodiesel lead to leaner combustion.

3.3. Engine exhaust gas temperature

The exhaust gas temperature increases while increases load on engine. The results are carried out on variable load on constant speed of 1460 rpm. Diesel fuel in CI engine produce low exhaust gas temperature on starting loads while B15ME5 produces higher exhaust gas temperature during combustion.

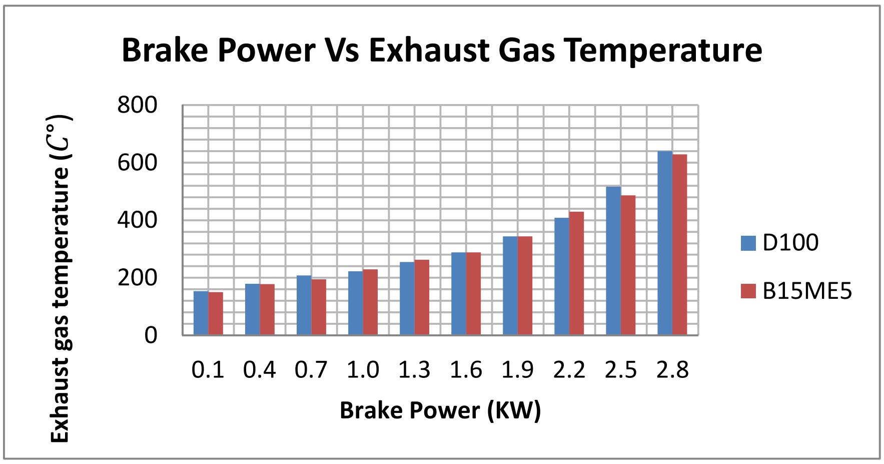

Fig. 4. Results of Engine gas temperature

It has been studied that D100 shows higher exhaust gas temperature from idling to the 0.7KW load on engine. Nevertheless on mid loads from 1.0 Kw to 1.9 KW exhaust temperature of B15ME5 has been increased. But on peak load on engine from 2.2KW to 2.8 KW D100 produces higher exhaust gas temperature. The addition on methanol and ethanol in biodiesel blend enhance the oxygen level and reduces viscosity which helps to produce fine atomization and good combustion.

4. Engine emission

4.1. CO Emission

It has been observed that CO emission of D100 is higher than B15ME5. Higher CO emissions indicate that the fuel is not ignited completely. CO emission from engine is depending on different factors like atomization, variation in engine speed and load, fuel type and design of combustion chamber. By addition of biodiesel blend, methanol and ethanol in diesel fuel reduces CO emission. Because it is helps improves oxygen level in Diesel fuel. It has been also noticed in figure-5, as increment load on engine, difference between the results of D100 and B15ME5 has been reduced.

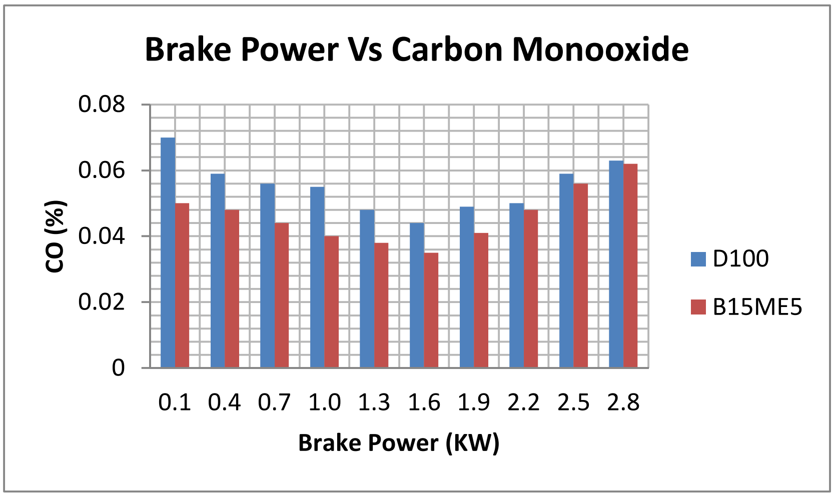

Fig. 5. Results of Carbon monoxide

4.2. HC Emission

The higher HC emission has been observed while D100 is used in CI engine. Higher density, less volatility and poor atomization leads higher HC emission. It has been noticed that, addition of methanol and ethanol on biodiesel blend reduced CO emission. Addition of methanol and ethanol in fuel due to that proper combustion process takes place inside the combustion chamber. On initial loads to the mid loads from 0.1 to 1.6 KW, there is larger difference has been observed whereas on peak load from 2.2 to 2.8 there is no any major difference has been seen in figure-6. The higher temperature of engine reduces the HC emission

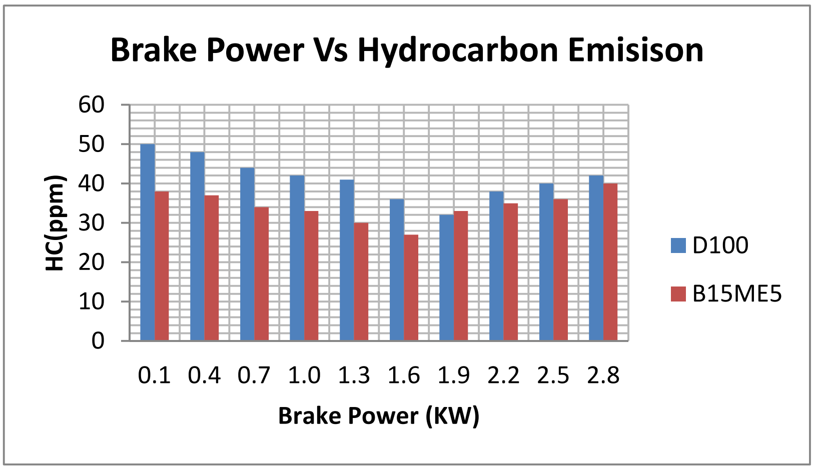

Fig. 6. Results of Hydrocarbon Emission

4.3. NOx Emission

Due to less calorific value of the fuel required more fuel to produce same unit power. The hiher injection of the fuel in CI engine produces higher temperature which leads to higher NOx emission. In this study, form 0.1 to 0.7 KW load on engine produced less NOx emission. But there is no and large difference has been observed. As load increases on engine produces higher exhaust gas temperature which leads to higher NOx emission. In this phenomenon from 1.3 to 2.8 KW load produces higher NOx emission as shown in figure-7.

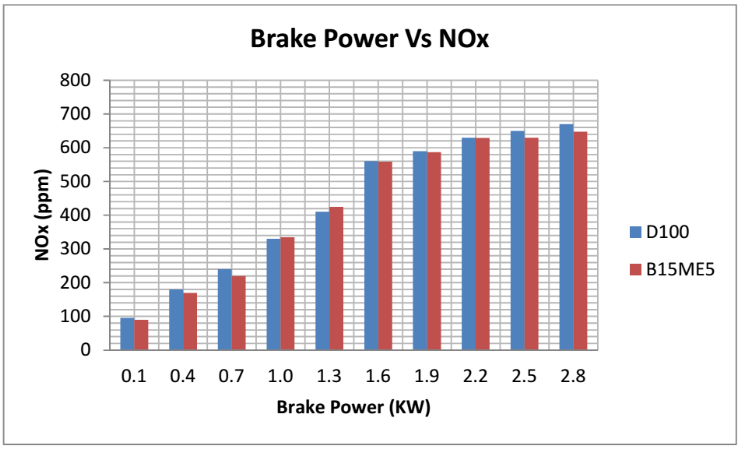

Fig. 7. Results of NOx emission

5. Conclusion

In this study, engine performance parameters BSFC, BTE and exhaust gas temperature have been investigated. Engine exhaust gas CO, HC and NOx emission are also investigated in this work. B15ME5 fuel has used to analysis engine performance and exhaust emission on variable loads and constant speed.

However the results are compared with baseline (D100).

- It has been noted that, BSFC of B15ME5 is 6.22% higher than diesel fuel. It is due to the less density of this fuel. It requires more fuel to produce same unit power output.
- Overall result of BTE shows that, B15ME5 is 2.87% higher than D100. It is because of higher percentage of oxygen available in fuel which helps to produce combustion rich combustion.
- Incomplete combustion may cause of CO emission. In this study, it has been observed that D100 fuel emits 0.091% higher CO emission than B15ME5.
- In this study HC emission also investigated. The result shows that D100 fuel produces 0.7% higher HC emission than B15ME5.
- NOx emission depends on density of fuel, atomization and exhaust gas temperature. In the results of NOx emission show that, on starting load D100 produces higher NOx emission than B15ME5, whereas on peak loads B15ME5 produces higher than D100.

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