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Experimental investigation of injection timing on the performance and exhaust emissions of a Rubber seed oil blends with pure diesel fuel in constant speed diesel engine

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ABSTRACT

An experimental study is conducted to evaluate the use of rubber seed oil blends with diesel at proportions of 40%, 60%, 80% by volume (B40, B60, B80) in a constant speed(1500 rpm) direct injected four stroke air cooled single cylinder CI engine. The series of test were conducted at various engine load conditions of 0%, 25%, 50%, 75% and100% at the rated power of 4.4kW. The injection pressure maintained at 220bar and the injection timing of the engine is 21°. As a result of investigation, at the maximum load condition the brake thermal efficiency is higher compared with biodiesel fuel blends where as the brake specific fuel consumption is higher compared with diesel. There is significant reduction in CO_2 and NOx emissions, with reference to the diesel emission. When biofuel volume increases in the biodiesel, the CO and UHC emissions are increased.

Keywords: Biodiesel, Rubber seed oil, Injection timing, Performance, Emission

1. INTRODUCTION

Vegetable oil [3] esters are non–toxic, biodegradable, and renewable alternative diesel fuel. These esters are known as "biodiesel." Many researchers have reveals that the properties of biodiesel are very close to those of diesel fuel. Therefore, biodiesel can be used in diesel engines [1] with or without engine modifications. It has higher cetane number than petroleum diesel fuel, no aromatics, and contains 10% to 11% oxygen by weight [3, 5]. Zhu et al (2012) found that, when the engine injection timing retarded NOx emission was reduced but other emissions like CO, THC, DME and CH_2O were increased. Cenk Sayin et al. (2010) changed the injection pressure and injection timing in the compression ignition engine. The experiment result showed that there were reductions in smoke opacity, CO, THC emissions while NO_x emissions were increased. Jaichandar S. et al (2012), conducted experiments in a single cylinder DI diesel engine using B20 blend (pongamia oil methyl ester) as fuel. The results showed that BTE increased by 5.64 %, BSFC decreased by 4.6%, Nox increased by 11% due to better air-fuel mixing and retarded injection timing. Cenk Sayin and Mustafa Canakci (2009) studied the influence of injection timings the performance and exhaust emissions [2] of a single cylinder diesel engine at 21°, 24°, 27°, 30° and 33° bTDC on using Diesel, B10, B15. Ethanol was used as biofuel. When injection timing changed from 27° bTDC to 21°b TDC, UHC and CO emissions were increased. For 30°b TDC and 33°b TDC, the HC and CO emissions were decreased and NO_2 and CO_2 emissions were increased. Venkanna et al [10] investigated a diesel

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Table 1
The test engine specifications

Bore	87.5mm
Stroke	110.0mm
Speed	1500(constant speed)
Compression ratio	17.5:1
Rated power	4.4 kW
Number of cylinders	One
Type of cooling	Air cooled-eddy Current dynamometer
Injector opening	21°BTDC
Pressure	220 bar
No. of stroke	4 stroke

Table 2
Properties of fuels used in the experiment

Property	*Diesel*	*Rubber seed oil*
Sp. Gravity	0.74	0.82
Viscosity at 40^0C (mm^2/s)	4.15	4.2
Calorific Value (KJ/kg)	42000	37000
Carbon residues (%)	0.12	0.19

engine using rice bran oil/diesel fuel blend (B5, B20, B50, and B100 from 0% to 100% load conditions. When compared with diesel, the NOx emission was increased by 26.27% 35.27%, 43.42%and 45.62% respectively.

2. EXPERIMENTAL SETUP AND TEST PROCEDURE

A single cylinder, four-stroke CI engine is selected to evaluate the performance and emission characteristics using Diesel and Biodiesel as fuel. The specifications of the engine are given in Table 1. The properties of test fuels are given in Table 2. The experimental setup has been shown in Figure 1. Two separate tanks (one for biodiesel, one for diesel) were provided in order to supply fuels to the test engine. An electric dynamometer with capacity of 4.4kW is coupled with test engine. The fuel properties can be found in Table 2. The tests were conducted with the condition of 220 bar injection pressure and 21° BTDC ignition timing. To analyse

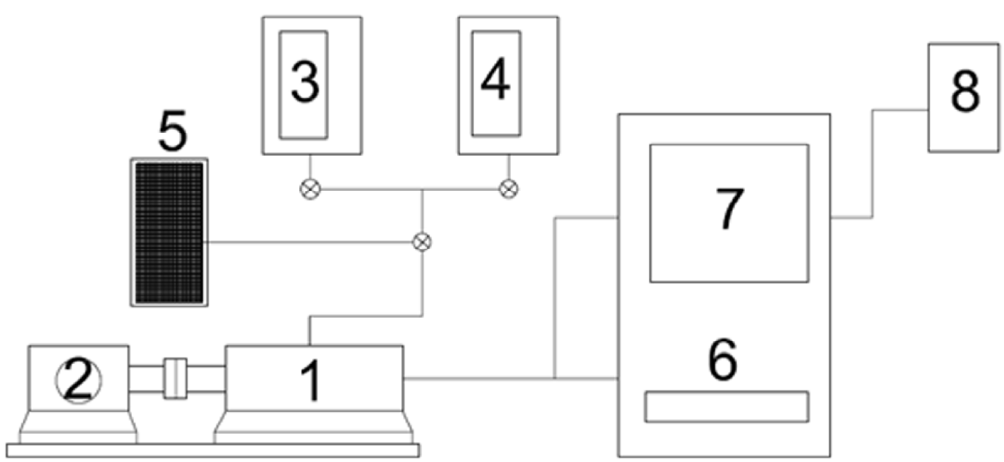

Figure: 1 Experimental setup

the performance and emission characteristics, initially the test was conducted using Diesel to provide baseline data then the test was conducted using biodiesel. The performance test was carried out for 0%, 25%, 50%, 75% and 100% load condition. An AVL model gas analyzer was used to measure carbon dioxide (CO_2) and carbon monoxide (CO) in percentage volume (%vol) and Unburnt hydro carbon (UHC) and Nitric Oxide (NOx) in parts per million(ppm).

1. Engine 2. Alternator 3. Diesel Tank 4. Air inlet 5. Biodiesel tank 6. AVL meter 7. Display 8. Smoke Meter

3. RESULT AND DISCUSSION

3.1. Brake Specific Fuel Consumption (BSFC)

Figure 2 represents the brake specific fuel consumption (bsfc) for diesel fuel and biodiesel [4-5] blends as a function of engine load. The bsfc parameter reflects the engine performance in terms of fuel economy. For the biodiesel blends, lower calorific value compared with diesel fuel because of oxygen content in the

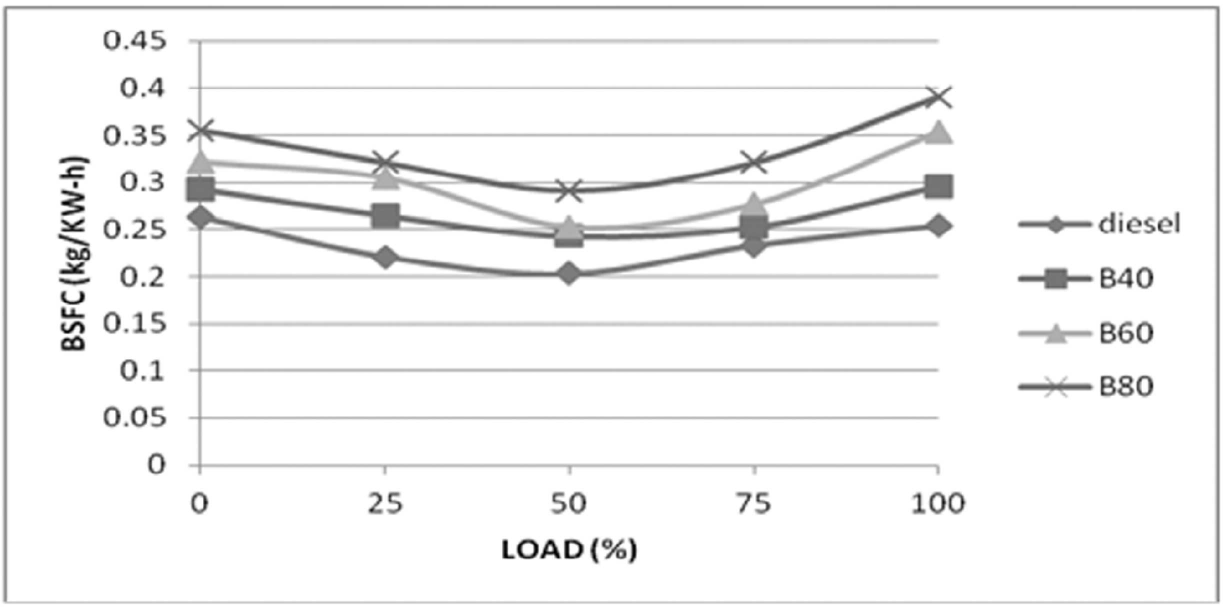

Figure: 2 Brake Specific Fuel Consumption of diesel and biodiesel with respect to load

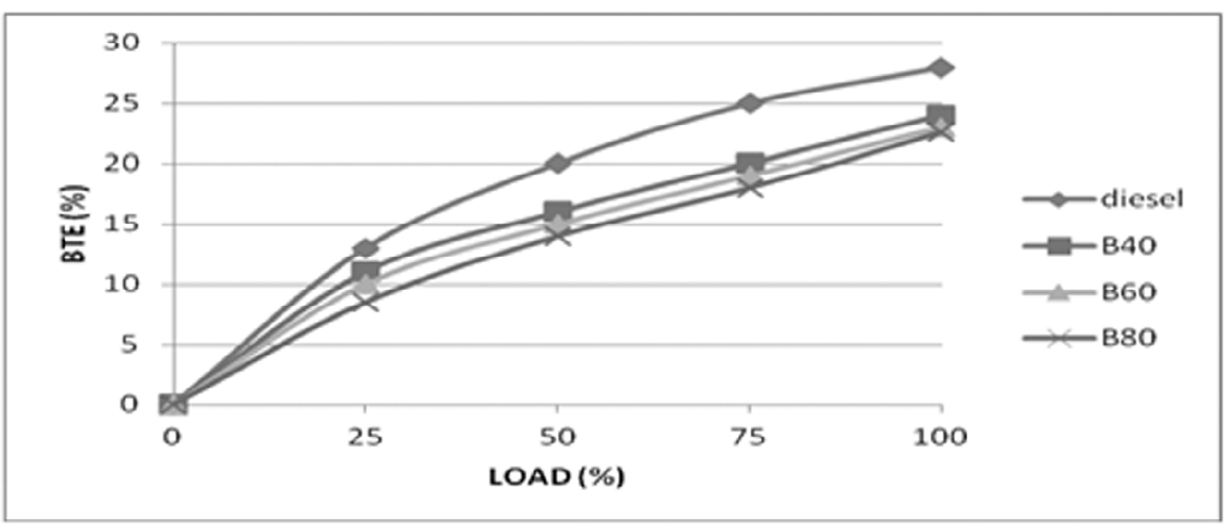

Figure: 3 Brake thermal efficiency of of diesel and biodiesel with respect to load

biofuels. The brake specific fuel consumption (bsfc) of biodiesel is high compared with diesel fuel. The increase in fuel consumption of biodiesel may be attributed to the viscosity of biodiesel which makes the atomization of the biodiesel little difficult. The brake specific fuel consumption of biodiesel is higher than that of diesel. For diesel, the bsfc decreased from 0.26kg/kW-h to 0.25 kg/kW-h from zero to full load condition. The average increase in bsfc compared to diesel fuel is found as 1.2% for B40, 1.4% for B60 and 1.52% for B80 respectively.

3.2 Brake Thermal Efficiency (BTE)

From the figure 3, the brake thermal efficiency for biodiesel is a little lower than the corresponding one for the diesel. It is to be noted that the brake thermal efficiency is the inverse of the product of the brake specific fuel consumption and the lower calorific value. The brake thermal efficiency is decreased 1.14% for B40, 1.3% for B60, B80 with reference to the diesel from zero to full load condition. The decrease in brake thermal efficiency occurred for biodiesel due to lower calorific value and high viscosity.

3.3. Carbon Monoxide Emission (CO)

Figure 4 shows the emission of carbon monoxide of all the tested fuels with respect to load. It is observed that the CO emissions for bio diesel and diesel are very small and CO emission initially decreases or maintaining constant at lower loads Up to 75% and then increases rapidly for all the test fuels. The B80 biodiesel emits large amount of CO emissions compared with other tested fuel because of poor spray characterization. At full load condition, Diesel, B40, B60 emits 1.57%, 1.3%, and 1.12% lower than B80.

3.4. Carbon dioxide (CO_2)

The CO_2 emission increases, when the complete combustion occurs in the combustion chamber. From the figure (), it was observed that Diesel emits higher value of CO2 compared with Biodiesel blends due to the fact that, the blend fuels have a lower elemental carbon to hydrogen than diesel fuel. The CO_2 emission varies from 2.2% to 8% from no load to full load conditions, for diesel. For B40, B60, B80 biodiesel blends, emission decreased by 12.5 %, 22.5%, 10% with respect to diesel.

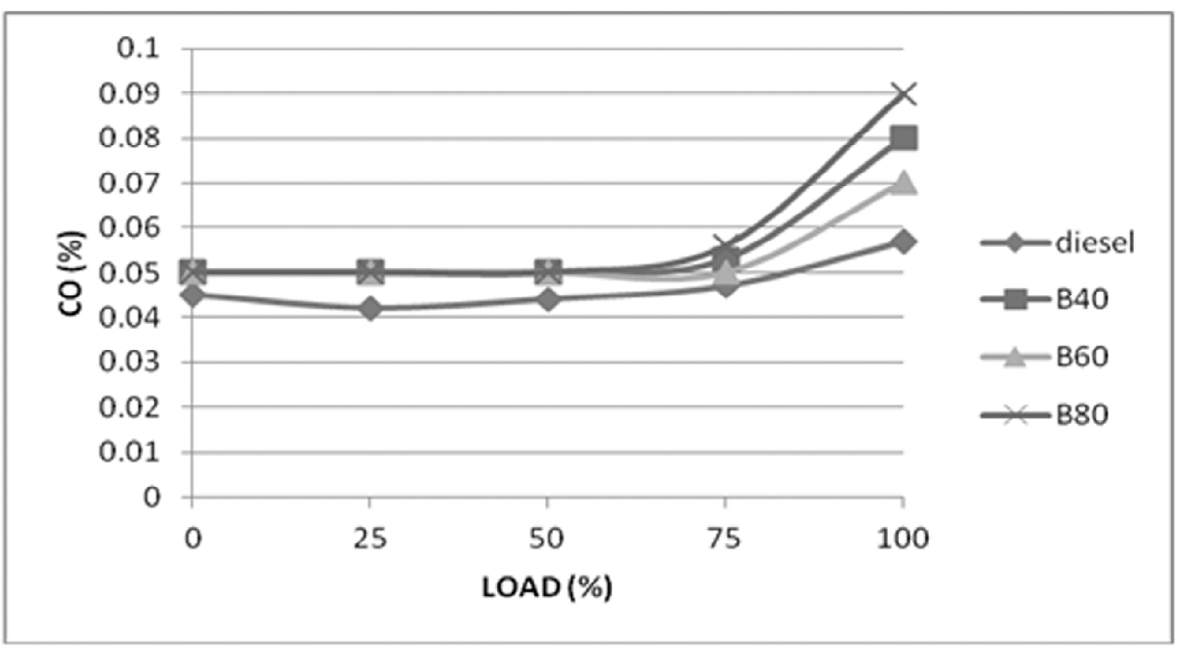

Figure: 4 Carbon monoxide emission of diesel and biodiesel with respect to load

3.5. Nitric Oxide Emission (NO_x)

Figure 6 gives the emission results of biodiesel and diesel for different load condition. The biodiesel have higher number of cetane and lower heating value compared with diesel. High cetane number fuels like diesel have shorter ignition delay which leads to complete combustion [6] smoothly than biodiesel. The Nox formation is reduced in the engine cylinder. The investigations reveal that Nox emissions for were reduced 1.2% for B80, 0.9% for B60 and 0.0.88% for B40 at full load condition with respect to diesel.

4. UNBURNED HYDROCARBON (UHC)

The virtual fuel density, viscosity and peak combustion heating value of the biodiesel blend are the main reason for unburnt hydrocarbon emission. Figure 7 gives the emission results of tested fuels. The graph reveals that the diesel fuel emits [7] less UHC compared with biodiesel. B40, B60, B80 biodiesel blends

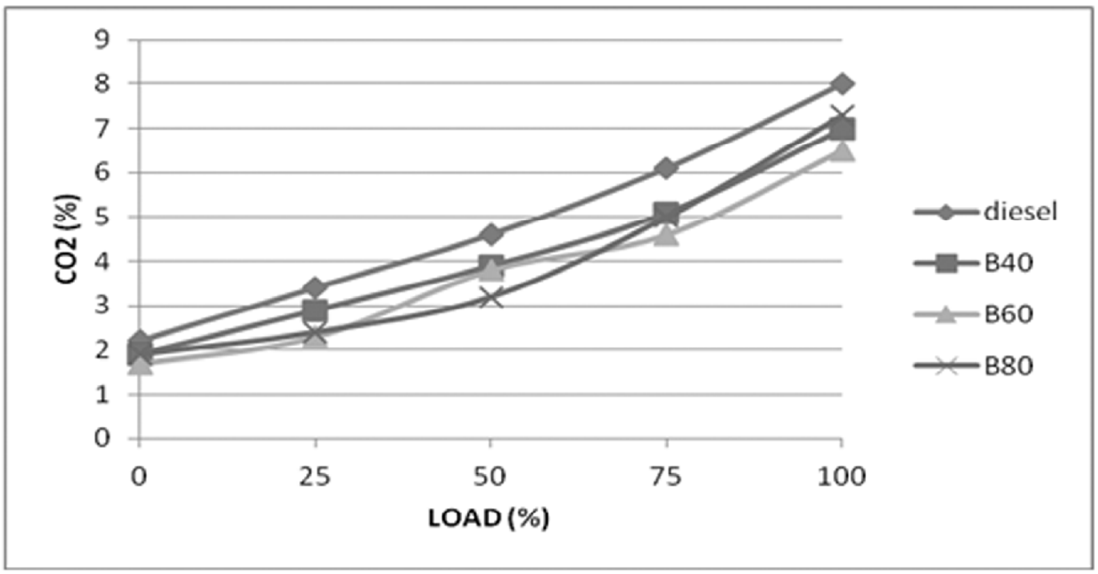

Figure: 5 Carbon dioxide emission of diesel and biodiesel with respect to load

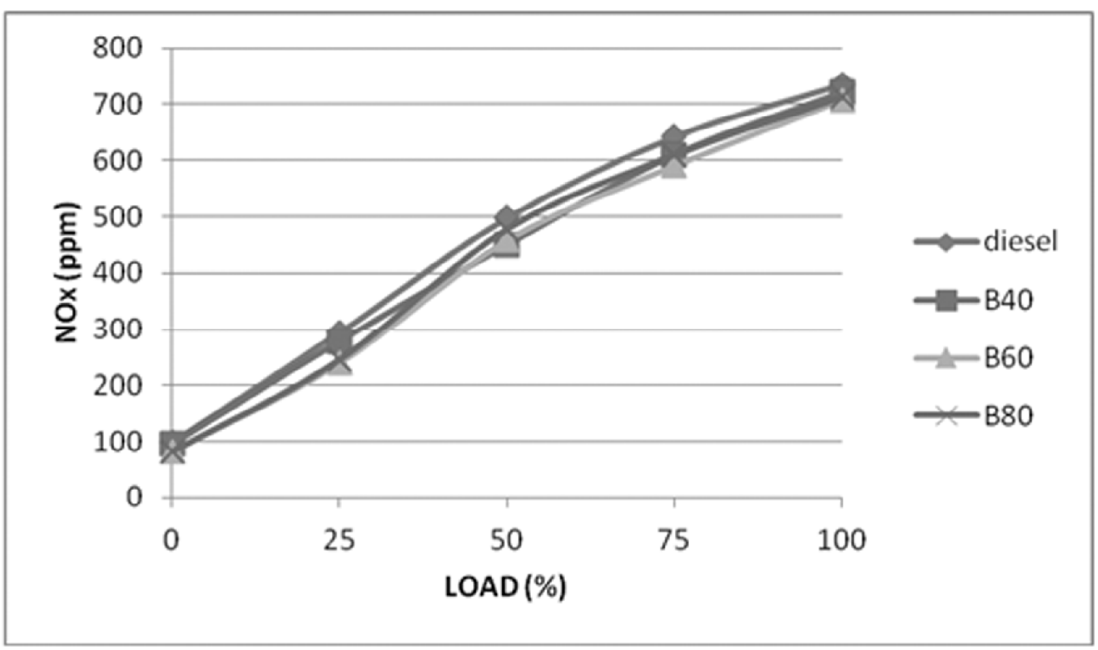

Figure: 6 Nitric Oxide emissions of diesel and biodiesel with respect to load

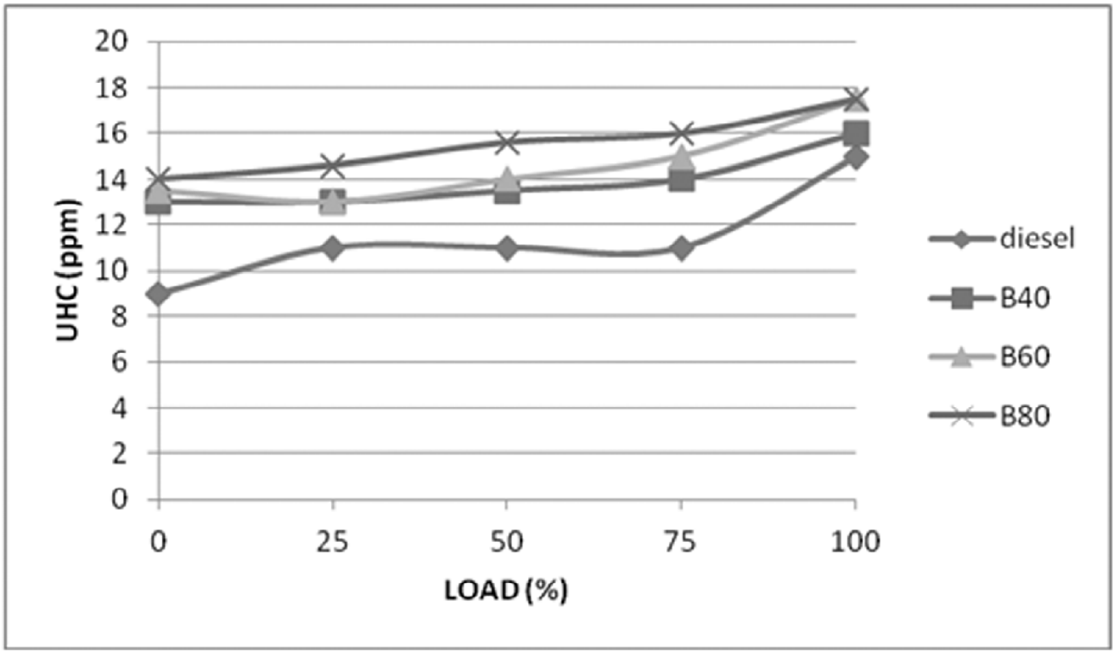

Figure: 7 Unburned Hydrocarbon emissions of diesel and biodiesel with respect to load

emits 1.4%, 1.5% 1.6 % higher than diesel at null load condition and 1.1%, 1.23%, 1.31 % higher at full load conditions.

5. CONCLUSIONS

The experimental investigations on the performance and emission characteristics of a constant speed(1500 rpm) direct injected four stroke air cooled single cylinder CI engine a diesel engine, fuelled with rubber seed oil biodiesel blends at proportions of 40%, 60%, 80% by volume (B40, B60, B80). The following conclusions can be drawn from the analysis of the results obtained during the investigation.

- The use of rubber seed biodiesel in a conventional diesel engine decreases its brake thermal efficiency, the decrease being more with increase in the biodiesel volume in the blends.
- BSFC increases with the volume of biodiesel in the blended fuels.
- CO and UHC emissions are highest for pure diesel and lowest for biodiesel because of higher viscosity.

CO_2 emissions are highest for biodiesel and lowest for diesel

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