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Effect of Fuel Injection Pressure, Isobutanol and Ethanol Addition on Performance of Diesel-Biodiesel Fuelled D.I. Diesel Engine

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Abstract

Biodiesel with additives is generally preferred for improvement of performance and emission characteristics of diesel engines. Higher fuel injection pressure is effective in improving the performance and reducing emissions. In the present work, Isobutanol and ethanol as additives to the diesel-biodiesel blends was investigated experimentally in a direct injection diesel engine. Isobutanol (A1) and Ethanol (A2) were added 5%-10% by volume to diesel-biodiesel blends and the performance and emissions characteristics at different injection pressures viz. 200, 225, 250 and 275 bars were studied.From the results, it was found that nozzle opening injection pressure could be increased up to 250 bar, as a result of which brake thermal efficiency and fuel economy of the engine were improved. Further, Carbon Monoxide (CO) emissions opacity was reduced significantly. However, Nitrogen Oxide (NO_x) emissions decrease in some blends marginally.

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Keywords: D.I.-Direct Injection; Biodiesel-Fish oil Methyl Ester; Emissions; Performance

I. INTRODUCTION

Fuel injection pressure and additives play an important role in diesel engine performance. Higher injection pressure decreases the diameter of fuel particles. This results in better fuel-air mixtures, improved combustion, and performance characteristics. High pressure injection with small orifices can achieve lean combustion, better fuel atomization and evaporation with improved emissions. [1- 5] Recent studies show that additives have become indispensable tools for performance and emission improvement of the engines. In that, oxygenates like ethanol, isopropanol, isobutanol and isopentanol improved the performance parameters and reduced particulate matter significantly. [6- 8].Gasoline-ethanol blends with additives such as cyclooctanol, cycloheptanol increase brake thermal efficiency with reduction in CO, CO2 and NOx. [9]. Present work attempts to investigate performance, emission characteristics of diesel engine with isobutanol and Ethanol as additive to the diesel-biodiesel blends at different injection pressures from 200 bars to 275 bars. Isobutanol has higher energy density and lower Reid Vapor Pressure (RVP) than diesel and hence it can be used as a potential fuel additive to motor gasoline and diesel fuels.

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II. MATERIALS AND METHODS

1. Experimental Set-up

Fig.1 shows the engine used for the investigation. It is a computerized, single cylinder, four stroke naturally aspirated, direct injection, water cooled diesel engine. Its specifications are shown in Table 2. The engine is directly coupled to an eddy current dynamometer. The engine and the dynamometer are interfaced to a control panel with a computer control. Engine soft, version 2.4, is used for recording the test parameters and for calculating the engine performance characteristics. The engine is coupled with computer controlled electronic variable injection system to increase/decrease the injection pressures as shown in fig.1

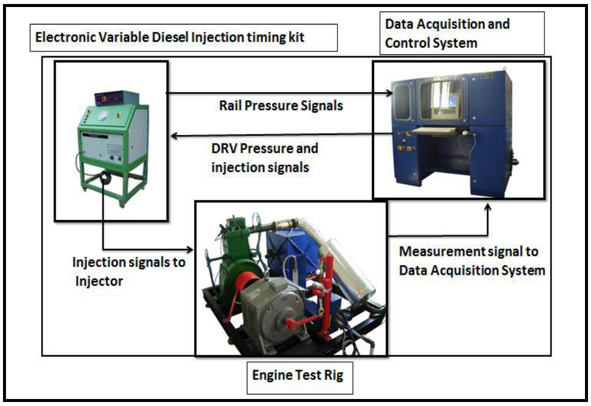

Figure1. Test Engine with fuel flow system

2. Test Fuels

For experimental investigation, biodiesel derived from fish oil is mixed with diesel in varying proportions such as 10%, 20%, and 30% by volume. To these blends, Isobutanol and Ethanol are added 5%, 10% by volume as additive. The blends are designated as B10, B20, B30 (B20 indicates biodiesel 20%, A1 10% isobutanol, 10% Ethanol 10% and remaining diesel by volume respectively). Table1 1 shows the properties of isobutanol and Ethanol. Table.2 compares the properties of diesel, fish biodiesel (B100).

Table 1 Properties of Isobutanol and ethanol

Name of the fuel sample→ ↓ Characteristics	Isobutanol	Ethanol
Flash point, open cup, °C	37.7	9
Specific gravity, 20/20°C	0.8030	0.45
Viscosity at 20°C (Centipoises)	3.95	1.87
Auto ignition temperature, °C	440	425
Surface tension at 20°C, ((dynes/cm)	22.94	19.4
Heat of combustion, kJ/kg	36162	28959

Table 2. The properties of diesel, fish biodiesel (B100) and biodiesel with additive

S.No	Name of the fuel sample→ ↓ Characteristics	Diesel	B 100	B100 IB10
1	Kinematic viscosity(C.S)	3.15	10.15	8.56
2	Density(g/cm^3)	0.83	0.896	0.85
3	Flash point(°C)	60	141	115
4	Fire point(°C)	63	172	142
5	Lower calorific value(KJ/kg)	42500	37250	36800

3. Experimental Procedure

The experiments were conducted at a rated engine speed of 1500 rpm with an injection timing of 27^0 before Top Dead Center (TDC). The engine was allowed to run till the steady state is reached. Then it was loaded by 0%, 25%, 50%, 75% and 100% of rated load. At each load, the injection pressure was varied from 200 to 275 bars with an interval of 25 bars.

The first stage of experiments was performed with pure diesel and the second stage of experiments was conducted using various blends of diesel-biodiesel with isobutanol as an additive with same injection pressures and same operating conditions as those of first stage. The performance and combustion parameters were recorded online. The exhaust emissions CO, CO_2, NO, NO_x, CxHy were recorded by a flue gas analyser (FGA533).

III. RESULTS

1. Performance & Emission analysis

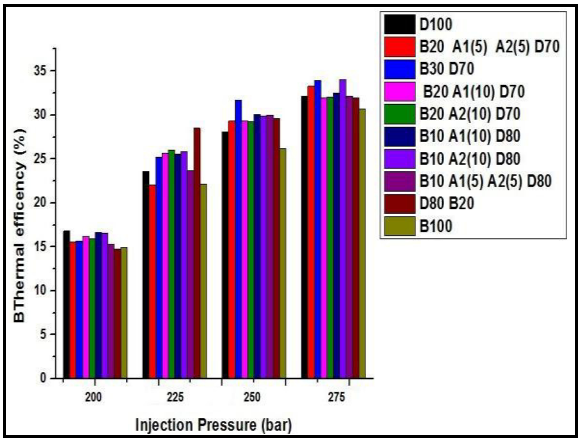

Figure 2 BTE vs. Injection Pressure

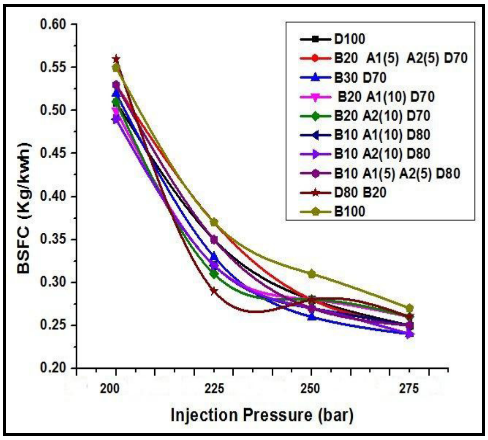

Figure 3 bsfc vs. Injection Pressure

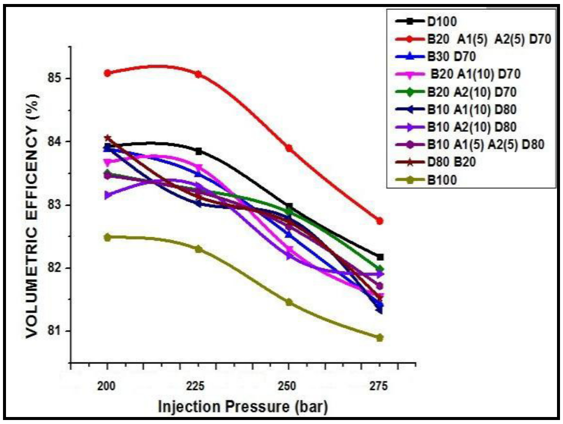

Figure 4 Volumetric Efficiency vs. Injection Pressure

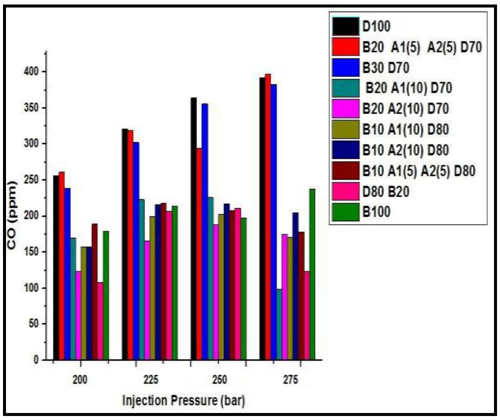

Figure 5 CO vs. Injection Pressure

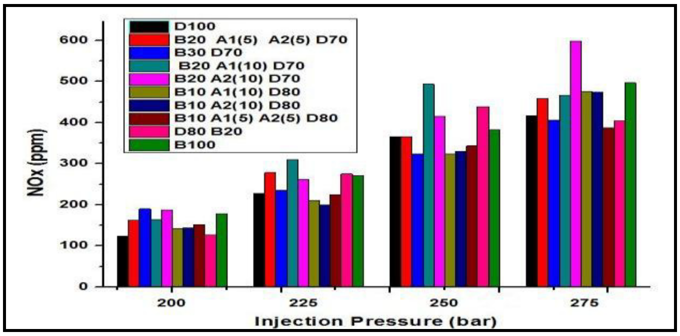

Figure 6 NOx vs. Injection Pressure

IV. CONCLUSIONS

Brake thermal efficiency is more with blends than with conventional diesel fuel. Maximum Brake thermal efficiency obtained is 33.5% with a blended fuel of (B20 A1 (5) A2 (5) D70) while it is 28% with conventional diesel. Brake specific fuel consumption increases by using blends with isobutanol and ethanol as additive which however decreases with increase in injection pressure. Indicated thermal efficiency is also increasing or we can say more as compared to the pure diesel (D100). We can say the blends like B20 A1 (5) A2 (5) D70, B10 A2 (10) D80 were showing more ITE 26.3% where the D100 have 24.9%. In case of volumetric efficiency for blend B20 A1 (5) A2 (5) D70 is more as compare to conventional diesel fuel. It may due to the presence of additives like Isobutanol and Ethanol. Cylinder pressure increases with increase in injection pressure, in case of blended fuels. CO emissions and smoke density can be decreased significantly, by using blended fuels with isobutanol as additive. Further they are found to decrease with increase in injection pressure. NO_x emissions were decreased marginally by using blended fuels with isobutanol and ethanol as additives. However, they are found to increase with injection pressure.

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