EXPERIMENTAL INVESTIGATION ON DIESEL ENGINE TEST RIG WITH ETHANOL-BIODIESEL-DIESEL BLEND

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Abstract— *Due to depletion of Conventional fuels, the alternative fuels namely biodiesel, diesohol have received much attention for power generation and transportation all over world. Unstable nature of Ethanol–Diesel blends led to study blends of Ethanol-biodiesel–diesel for stability. The blend with maximum permissible percentage of Ethanol for reasonable stability is selected for performance and emission studies in Single cylinder, 4-stroke, and water cooled stationary C.I. engine. It is found that a blend of 25% Ethanol, 15% Biodiesel and 60% Diesel is the most suitable for maximum replacement of Diesel. Engine performance under optimum injection pressure condition is investigated and it showed similarity in performance with diesel and emit reduced emissions.*

Index Terms— Ethanol-Biodiesel-Diesel (EBD) blend, diesel

I. INTRODUCTION

The major part of all energy consumed worldwide comes from fossil sources (petroleum, coal and natural gas). However, these sources are limited, and will be exhausted by the near future. The fossil oil reserves in the world are depleting at an alarming rate, Over 85% of our energy demands are met by the combustion of fossil fuels and the demand for oil is growing many-folds each year as oil provides energy for 95% of transportation [1]. Due to depletion of Conventional fuels, the alternative fuels namely biodiesel, diesohol have received much attention for power generation and transportation all over world.

In particular, biodiesel has received wide attention as a replacement for diesel fuel because it is Bio-Degradable, nontoxic and can significantly reduce exhaust emissions and overall life cycle emission of carbon oxides (CO_2) from the engine when burned as a fuel.

Many researches investigate that the use of biodiesel in diesel engines can reduce hydrocarbon (HC), Carbon Monoxide (CO) and Particulate Matter (PM) emissions, but Oxides of Nitrogen (NO_x) emission may increase [17].

The oxygen content of biodiesel is an important factor in the NO_x formation, because it causes to high local temperatures due to excess hydrocarbon oxidation. The increased oxygen levels increases the maximum temperature during the combustion, and increases NO_x formation. Biodiesel has some disadvantages, such as higher viscosity and pour point, and lower volatility compared with diesel. The poor cold flow property of biodiesel is a barrier to the use of biodiesel– diesel blends in cold weather [20]. Methanol or Ethanol might be expected to improve low temperature flow properties. Including ethanol in biodiesel–diesel blends increases the oxygen contents, which may further improve the PM emissions. The Emulsification Technique is applied to reduce NO_x emission and to promote the combustion efficiency for fossil fuels [9]. Hence, emulsions of biodiesel are considered to curtail emissions of NO_x from burning biodiesel.

II. EQUIPMENT AND EXPERIMENTS

1.Experimental fuels The biodiesel produced from Jatropha oil is prepared by a method of alkaline-catalyzed transesterification. The ethanol is an analysis-grade hydrous ethanol (99.9% purity). Due to diesel and ethanol have poor miscibility, when the volume fraction of ethanol in blend is more than 10%, a few of oleic acid is necessary as a solvent (Biodiesel) additive to maintain the blend stable and uniform at room temperature for 45 days.

In this study, Ethanol, biodiesel and diesel are blended volumetrically with different percentage of ethanol (E), biodiesel (B) and diesel (D) respectively. The different blend ratios of EBD with stability are shown in Table1. The table shows that the E10B10D80 blend has maximum stability but for the maximum replacement of conventional fuel (diesel), E25B15D60 blend is used. For example, E15B20D75 blend represented the 15% Ethanol, 20% Biodiesel or Jatropha Methyl Ester (JME) and

75% High Speed Diesel (HSD) by volume. The unstable and stable blends are shown in Fig. 1 and Fig. 2 respectively with respect to time.

2. Experimental setup and procedure

The engine used is a Kirloskar AV1-5 hp@ 1500 rpm, vertical, single cylinder, naturally aspirated, four stroke, water-cooled, 16.5:1 compression ratio, direct injection diesel engine with a bowl in piston combustion chamber. The maximum engine power is 3.7 kW at 1500 rpm with the liquid fuel injection; a high pressure fuel pump is used, having a single-hole injector nozzle. The time is measured for the fuel flow of 20 cc for each measurement. A Kistler piezoelectric transducer is installed for monitoring the cylinder pressure coupled with Kistler charge amplifier. Cathode Ray Oscilloscope is used to record the measured data. Exhaust emissions (NO_x, HC, CO) are measured by AVL Disgas 4000 gas analyzer. The schematic diagram of test setup is shown in Fig. 3.

Table 1: Stability of EBD blends with respect to time.

S.No	ETHA-NOL	BIO-DIESEL	DIESEL	SEPARATION-TIME	STA-BILITY
1.	15	5	80	1 Day	Unstable
2.	10	10	80	Till date	Stable
3.	5	15	80	Till date	Stable
4.	25	5	70	10 Minute	Unstable
5.	20	10	70	18 Days	Unstable
6.	15	15	70	Till date	Stable
7.	10	20	70	Till date	Stable
8.	5	25	70	Till date	Stable
9.	35	5	60	10 Minute	Unstable
10.	30	10	60	15 Days	Unstable
11.	25	15	60	Till date	Stable
12.	20	20	60	Till date	Stable
13.	15	25	60	Till date	Stable
14.	10	30	60	Till date	Stable
15.	5	35	60	Till date	Stable
16.	40	10	50	2 Hours	Unstable
17.	45	5	50	15 Minute	Unstable

Fig.1.*Stable blends of EBD fuels*

Fig.2.*Unstable blends of EBD fuels*

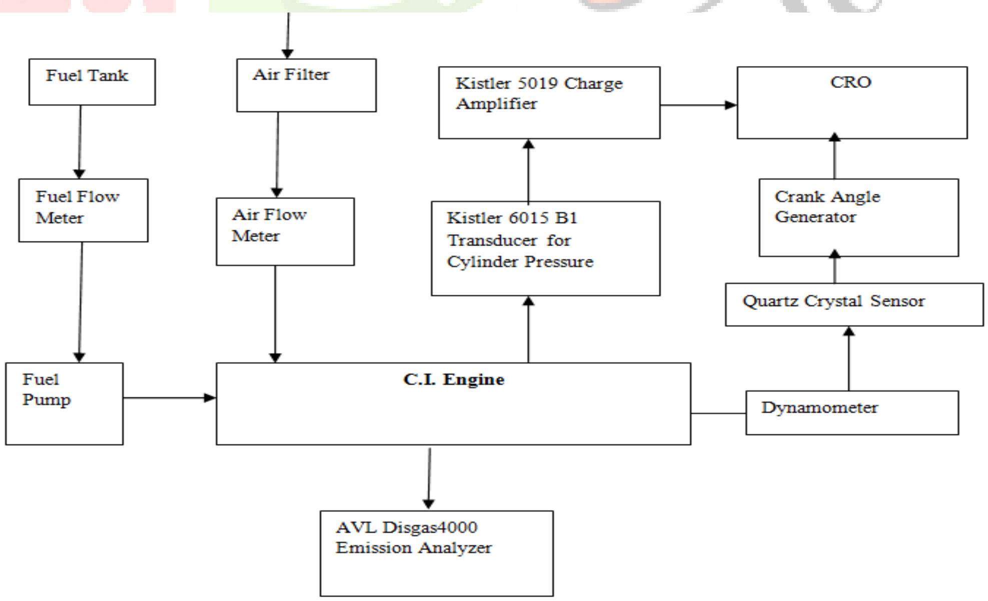

Fig.3.*Schematic diagram of test rig*

The engine is started with diesel fuel and warmed up. The warm up period ended when the cooling water temperature is stabilized. Then the fuel consumption, exhaust temperature and exhaust emissions such as NO_x, HC and CO are measured. The E25B15D60 blended fuel is used at different injection pressures such as 190, 200, 210, 220 and 230 kgf/cm^2 in the existing engine for obtaining the optimum injection pressure. The experiment is carried out by E25B15D60 blended fuel at different engine loads and optimum injection pressure. To evaluate the performance and emission parameters, important operating parameters such as engine speed, power output and fuel consumption are measured. Significant engine performance parameters such as Brake Specific Fuel Consumption (BSFC) and Brake Thermal Efficiency (BTE) for diesel and the E25B15D60 blended fuel are calculated.

III. RESULTS AND DISCUSSION

1 Determination of optimum injection pressure

The optimum injection pressure was found among the 190, 200, 210, 220 and 230 kgf/cm^2 injection pressures on the basis of BSFC and BTE curves. Fig.4 showed that at the 200kgf/cm^2 injection pressure, the brake specific fuel consumption was minimum and the brake thermal efficiency was maximum in comparison to 190, 210, 220 and 230 kgf/cm^2 injection pressures. So all the results were investigated at optimum injection pressure (200 kgf/cm^2).

2 Brake specific fuel consumption and brake thermal efficiency

The Brake Specific Fuel Consumption is greater for E25B15D60 blended fuel than the conventional diesel fuel for all loads. This may be due to lower heating value than diesel and resulted that to generate the same amount of power, more quantity of fuel is required as shown in Fig.5. Brake thermal efficiency of diesel and E25B15D60 blended fuel increases with increasing load as shown in Fig.6. The maximum value of brake thermal efficiency at optimum injection pressure for diesel as well as EBD fuel are 21.94% and 23.0% at 2kW load respectively. The brake thermal efficiency of ethanol-biodiesel-diesel blend is higher than that of diesel due to higher energy content of fuel.

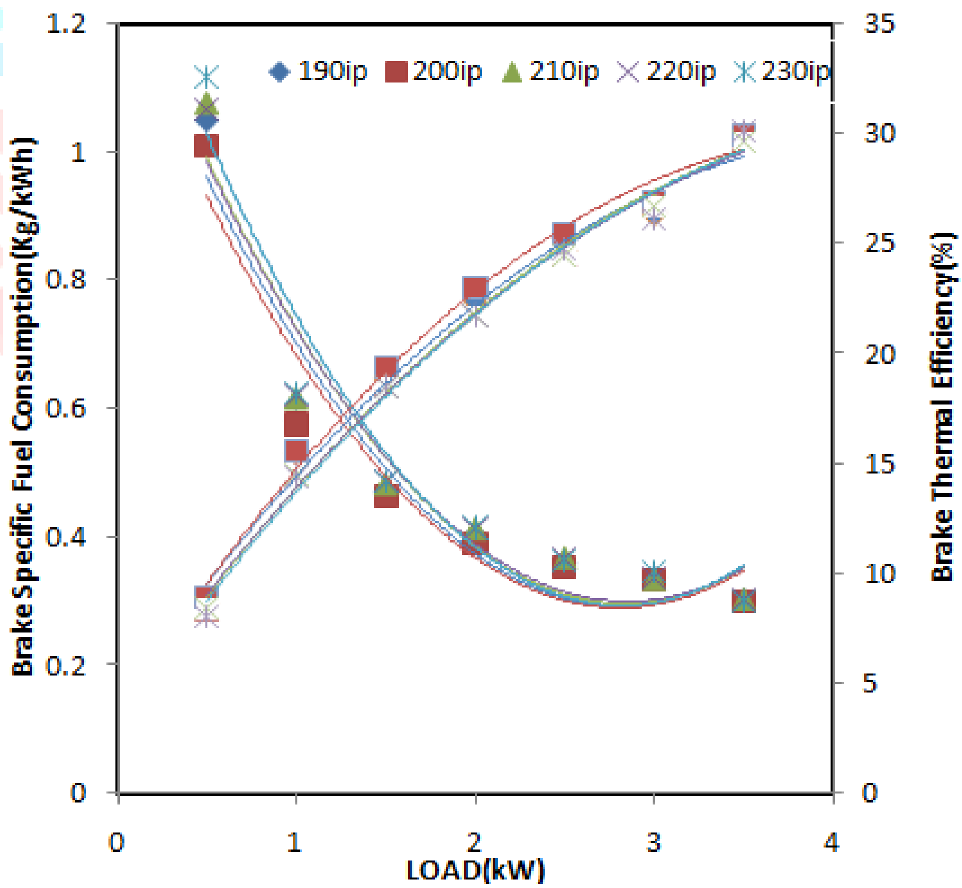

Fig. 4 *Effect of Load on BSFC and BTE at different injection pressures*.

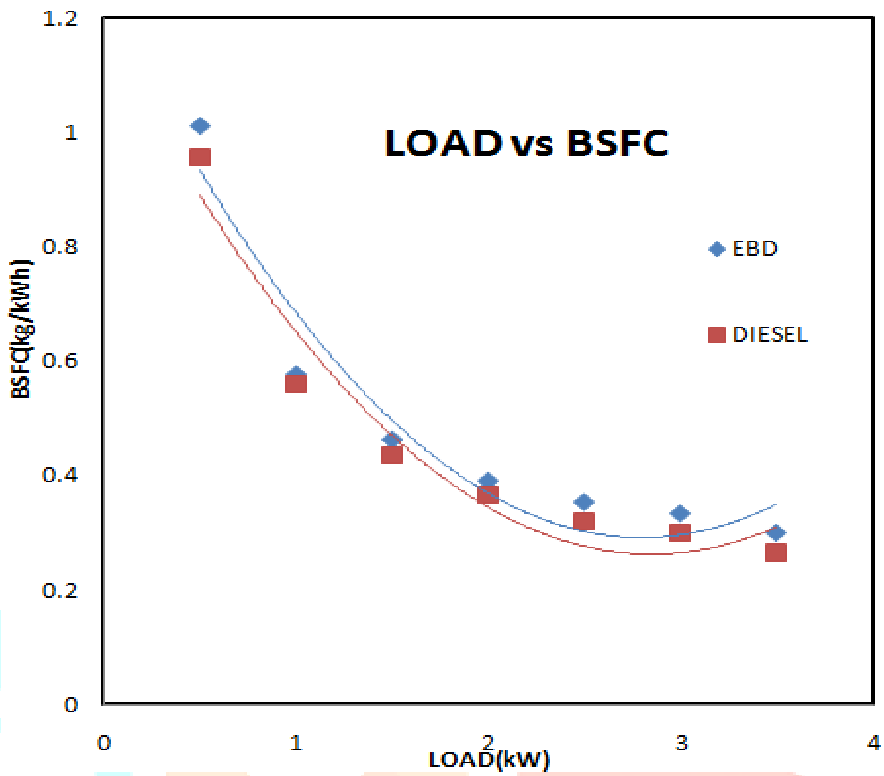

Fig. 5 *Effect of Load on Brake Specific Fuel Consumption.*

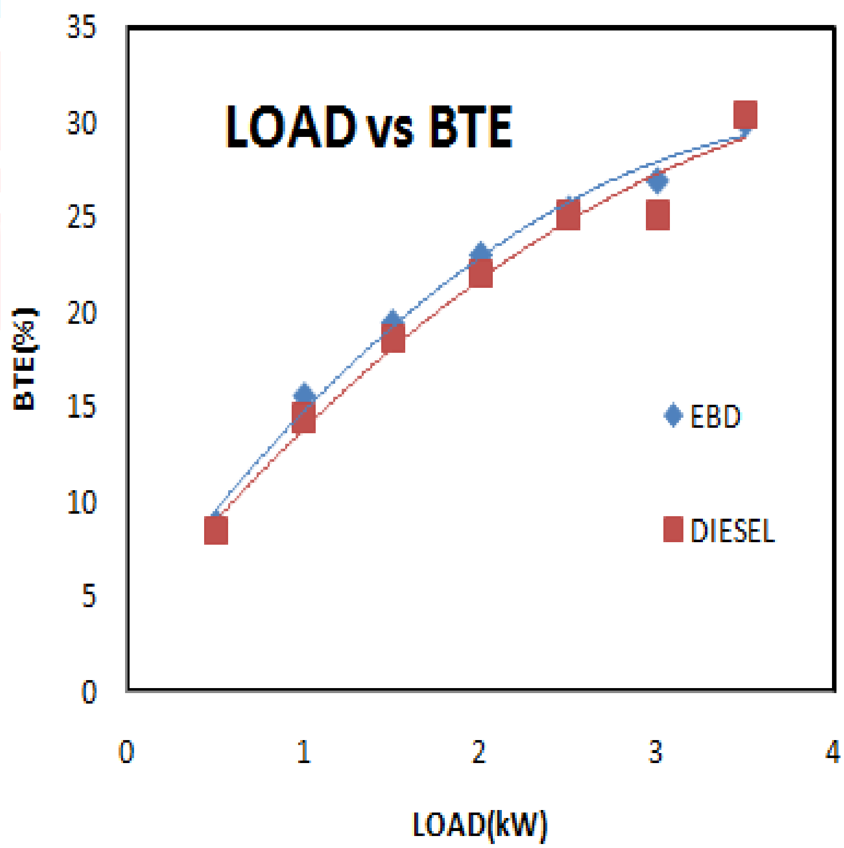

Fig. 6 *Effect of Load on Brake Thermal Efficiency*

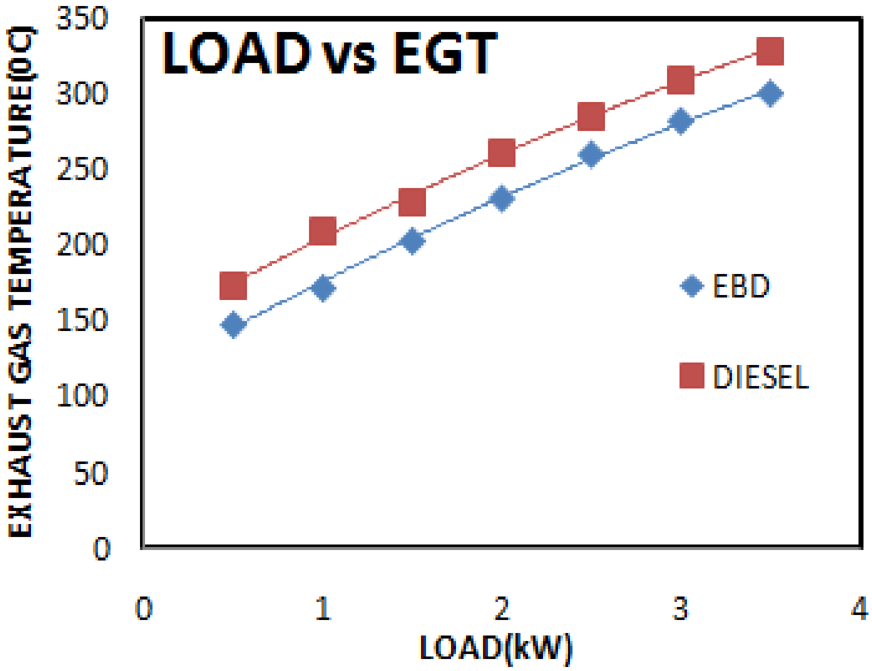

Fig. 7 *Effect of Load on Exhaust Gas Temperature*

3 Exhaust Gas Temperature

The exhaust gas temperature increases with load due to the generation of heat increased and time available for heat transfer being the same (constant speed engine), resulting in increased exhaust gas temperature. Fig.7 shows that the exhaust gas temperature for ethanol-biodiesel-diesel blend was less than the exhaust gas temperature for diesel throughout the all loads due to the complete combustion as a result of better atomization of the fuel by nozzles with the lower viscosity of EBD fuel.

4 Emission Analysis

Oxides of Nitrogen (NO_x)

NO_x formation in an engine is a function of reaction temperature, available oxygen and duration of availability. NO_x formation increases with higher temperatures, longer high-temperature combustion periods and greater availability of oxygen. When the proper amount of oxygen is available, higher the peak combustion temperature and more NO_x formed. Variation of oxides of nitrogen as a function of load for diesel as well as ethanol-biodiesel-diesel blend at an optimum injection pressure is shown in Fig. 8. It is clear from the trend that NO_x emissions are minimum at no load conditions for both the fuels and then tend to increase with higher load. Higher NO_x concentrations are obtained for ethanol-biodiesel-diesel blend as compared to diesel due to higher temperature and availability of free oxygen.

Carbon Monoxide

The variation of CO emission for ethanol-biodiesel-diesel blended fuel under various engine loads is shown in Fig. 9. Carbon monoxide is formed when the insufficient oxygen is available in the combustion chamber to complete the proper combustion or to vaporizing the fuel during combustion. The CO emissions of ethanol-biodiesel-diesel blended fuel are higher than the diesel fuel at all loads. The CO emission of ethanol-biodiesel-diesel blended fuel is much higher at no-load or idle stage due to insufficient oxygen in the combustion chamber and it was very close to the diesel fuel at higher load due to increasing in operating temperature and proper mixing of fuel.

Hydrocarbon

The variation of HC emission for ethanol-biodiesel-diesel blended fuel under various engine loads is shown in Fig. 10. The trend of HC emission for the blended fuel shows that it increases at no-load condition and then decreases to a 50%-60% load and again increases at full load condition due the incomplete combustion and lower cetane number of the ethanol-biodiesel-diesel blended fuel.

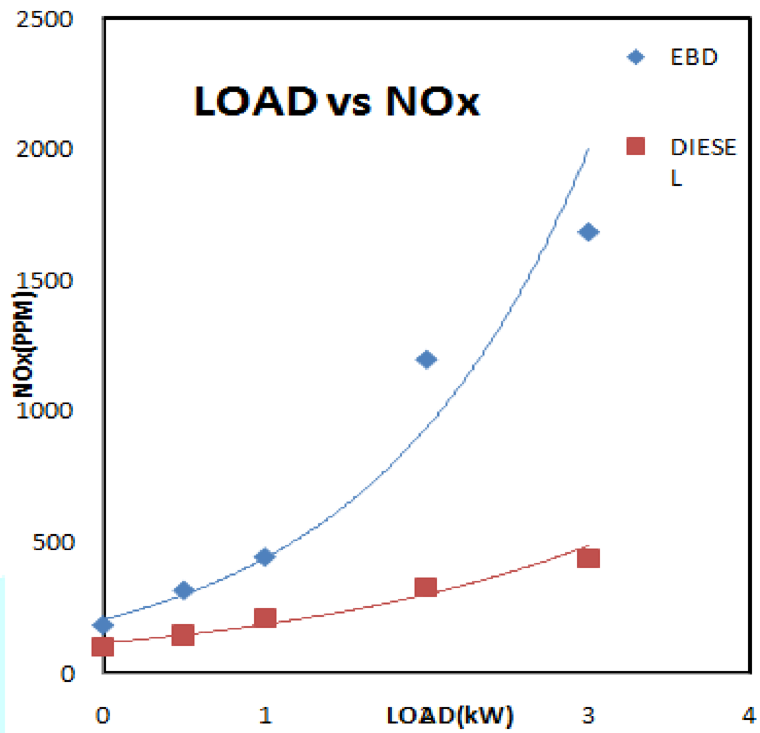

Fig. 8 *Variation of NOx with load*

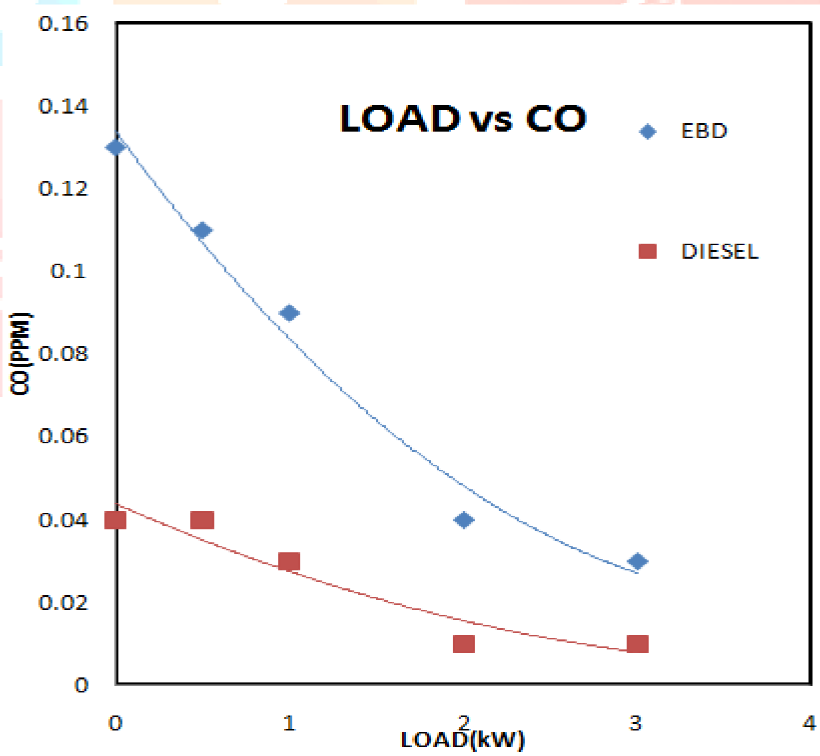

Fig. 9 *Variation of CO with load*

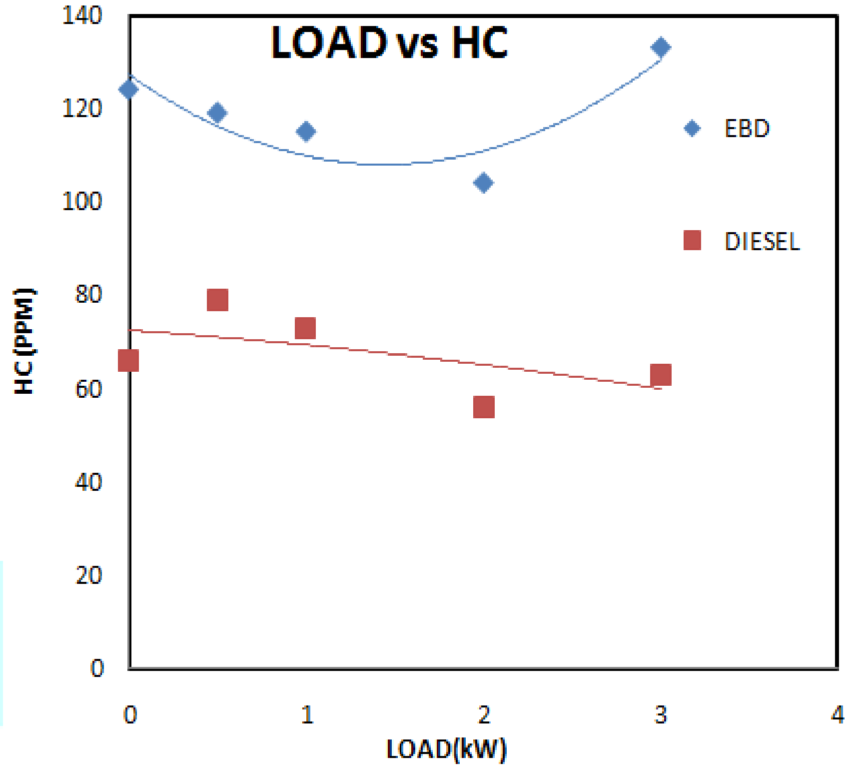

Fig. 10 *Variation of HC with load*

IV. CONCLUSION

The performance and emission characteristics of a naturally aspirated single cylinder 4-stroke water cooled direct injection diesel engine using ethanol-biodiesel-diesel blended fuel were studied and the conclusions of the test results shows that the brake specific fuel consumption is higher than that of diesel and the brake thermal efficiency increases 4.83% at 2kW load. As for the emissions of the blend, it was found that CO, HC and NO_x increased up to 200% to 300%, when compared to those of diesel.

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