PERFORMANCE & EMISSION CHARACTERISTICS OF CI ENGINE USING BLENDS OF ETHANOL AND BIODIESEL WITH DIESEL

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Abstract: - This paper is based on experimental investigation of performance and emissions of CI engine. Due to exponential growth in industrialization the demand for conventional automotive fuels is also increased sharply which adversely affects not only the economy but also the environment. This makes the search for an alternative fuel more important today. In this research the blends of ethanol & biodiesel with diesel in varying proportions are used. The performance& emission levels has been investigated under the various parameters like Brake Thermal efficiency, BSFC, BSEC, Smoke density, HC, CO & exhaust temperature. The experimental results show that the BE20 fuel gives the best performance in comparison to conventional diesel fuel along with fairly reduced exhaust emission.

Keyword: IC engine, Diesel, Blends, Fuel Properties, Engine performance & emission

Introduction:-

The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. Indiscriminate extraction and lavish consumption of fossil fuel have led to reduction in underground based carbon resources. The search for alternative fuels, which promise a harmonious correlation with sustainable development, energy conservation, efficiency and environmental preservation, has become highly pronounced in the present context. The fuels of bio origin can provide a feasible solution of this worldwide petroleum crisis.(1)The Biodiesel is described as fuel comprised of mono- alkyl ester of long chain of fatty acid derived from vegetable oil or animal fats. Biodiesel and ethanol can produce from feed stocks that are generally considered to be renewable. Since the carbon in biodiesel originated mostly from CO_2 in the air, the full cycle CO_2 emission for biodiesel contributes much less to global warming than

fossil fuels. Although biodiesel cannot entirely replace petroleum based fuel, biofuel and diesel fuel blend can be used on existing to achieve both environmental and energy benefits. Ethanol is a low cost oxygenated with high oxygen content (35%) that has been used in ethanol – diesel blend. The use of ethanol in diesel fuel can yield significant reduction of particulate matter (PM) emission for motor vehicles. Therefore, in this research the possible use of higher percentage of biodiesel in an unmodified diesel engine being used. (2) It is important for an alternative diesel fuel to be technically acceptable economically competitive and easily available. Among these alternative fuels, biodiesel and its derivative have received much attention in recent year for diesel engine. It has similar property to those of fossil diesel. It has been reported by the result of many studies that biodiesel can used in diesel engine with little or no modification with almost the same performance and emission (3). The results vary according to the base of vegetable oil or animal fats, the process of biodiesel production as well as biodiesel fuel properties, therefore different biodiesel and their blend with various fuels were tested in diesel engine with different engine as well as test condition (4).

On the other hand, disadvantage of biodiesel include the higher viscosity and pour point as well as lower calorific value and volatility. For all above reason, it is generally not accepted that blend of standard diesel fuel with 10% or up to 20% biodiesel can be used with existing diesel engine without any modification. (4) Many engine performance and emission test have been conducted using biofuel such as ethanol as supplementary fuel. (5) Ethanol – methyl ester blend fuel was used in diesel engine by Ali et al (6).It was reported that engine performance with methyl ester and ethanol blend was similar to that with diesel. However it also reported that blending ethanol with biodiesel had advantage of reducing the viscosity as well as reducing crystallization of biodiesel.

The main objective of this investigation is to improve the fuel characteristic of biodiesel by using extender to utilize pure biodiesel in diesel engine; the ethanol was selected for this purpose. The effect of soyabean oil obtained biodiesel -ethanol and biodiesel-diesel blend fuel on engine performance and exhaust emission were investigated in single cylinder, four stroke cycle, direct injection unmodified diesel engine and experimental result were compared with those of standard diesel engine.

2) EXPERIMENTAL SETUP AND PROCEDURE

2.1) Test fuels and experimental apparatus:-

This research investigates the impact of biodiesel blend with ethanol and diesel fuel on engine performance and exhaust emissions. The biodiesel was tested as B20, BE20 & E-diesel fuel mixture forms. The main purpose of blending ethanol with biodiesel as a solvent additive is to research the possibility to use blended fuel with high percentage of biodiesel in an unmodified diesel engine.

The alkaline catalyzed transesterification reaction was carried out with 0.25v/v ethanol (6:1) molar ratio and 0.3% w/v KOH. Briefly, soyabean waste oil was heated to above 100^{o} C to evaporate possible existed water in oil. The oil was set at 60^{o}C temperature on a heating plate prior to starting the reaction. A fixed amount of freshly prepared ethanol solution of selected catalyst KOH were added into the reactor and mixed. The reaction was carried out at 60^{o} C for 2 hour the mixture was allowed to settle overnight before removing the glycerol layer from the bottom in separating funnel to get the ester layer on the top separated as biodiesel.

The fuel properties of BE20 were quite similar to conventional diesel fuel in its main characteristics Table 1 shows the property of different fuel compared with diesel.

FUEL	CALORIFIC VALUE (KJ/KG)	DENSITY(g/ml)	FLASH POINT	VISCOSITY (37.8^{o} c)	CETANE INDEX
Biodiesel	33540	0.884	78	4.5	45
Diesel	42700	0.84	68	2.84	48
Ethanol	27000	0.79	14	-	5-8
B20	38680	0.864	78	3.34	50
BE20	40684	0.834	58	2.48	46

Table (1) technical properties of biodiesel, diesel fuel, ethanol, B20 fuel and BE20 fuel

The addition of direct mixing of ethanol to diesel fuel changes the physicochemical properties of the blends. By using ethanol density, kinematic viscosity, low calorific value and aromatic fractions of blends decrease. Simultaneously, H/C ratio and oxygen content of blend are enhanced, which has favorable effect on the ignition and combustion of the blends. Some of the properties of the biodiesel, diesel fuel (DF), ethanol, 20% biodiesel and 80% diesel fuel (B20), and 80% biodiesel and 20% ethanol (BE20) are represent above Table1

A single- cylinder, four stroke, water cooled, and naturally aspired direct injection diesel engine was used. The basic specification of the engine is shown in Table 2. The combustion system of the diesel engine was a direct injection, medium swirl type. The specification of DC machine is presented in Table 3. A schematic diagram of engine setup is shown in Figure 1. The test was stared firstly with diesel fuel and when the engine reached the operating temperature, it was loaded with DC machine the engine loaded at wide open range of load (500-3000 watt). The fuel consumption was measured with burette with 10ml volume and a stopwatch. The mass flow rate (kg/hr) was calculated from volumetric flow and fuel density.

Table 2 Basic technical specification of the test engine

Items	Specification
Model	Kirloskar Av1
No of cylinder	1
Bore	8cm
Stroke	11cm
Power	5hp
Compression ratio	16.5:1
Speed	1500 rpm

Table 3 Technical specification of DC machine

Items	Specification
Model	Samson D.C machine
Volt	150
Power	4.6 KW
Current	40 Amp
Speed	1500 rpm

Table 4Technical specification of EGA

Items	Specification
Company	AVL DIGAS 444
CO	0 - 10%
HC	0 – 20000(ppm)

2.2) Experimental procedure:-

The exhaust gas temperature was measured by using thermometer located downstream of exhaust valve. The tests were performed at unsteady state condition since some fluctuation may occur in engine operation especially in on-road conditions. Many of the studies of internal combustion engine have focused on steady- state performance and emission. However, the daily driving schedule of automotive and truck engine is inherently related to unsteady operation, whereas the most critical condition encountered by engine are met during transient that making the studies of transient engine operation an important scientific objective. Similarly, a work results, the literature indicated that depending on engine load, the pressure variation in the

cylinder exhibit different type of behavior. The tests were performed at unsteady state test the fuels were tested in random order and each test repeated 3 times. The results of 3 repetitions were averaged to decrease the uncertainty. An Exhaust gas analyzer was used for measuring exhaust emissions. Before taking the measurement the gas analyzer instrument was calibrated and its probe was inserted to the exit of exhaust pipe. By mean of the instrument ambient temperature (^{o}C), CO (%), HC (ppm) is measured and calculated.

It was aimed in this study to investigate the ethanol as an additive to pure biodiesel that derived from Waste Fry Oil (WFO - soya bean) and determine the engine performance and exhaust emission characteristic in direct injection diesel engine.

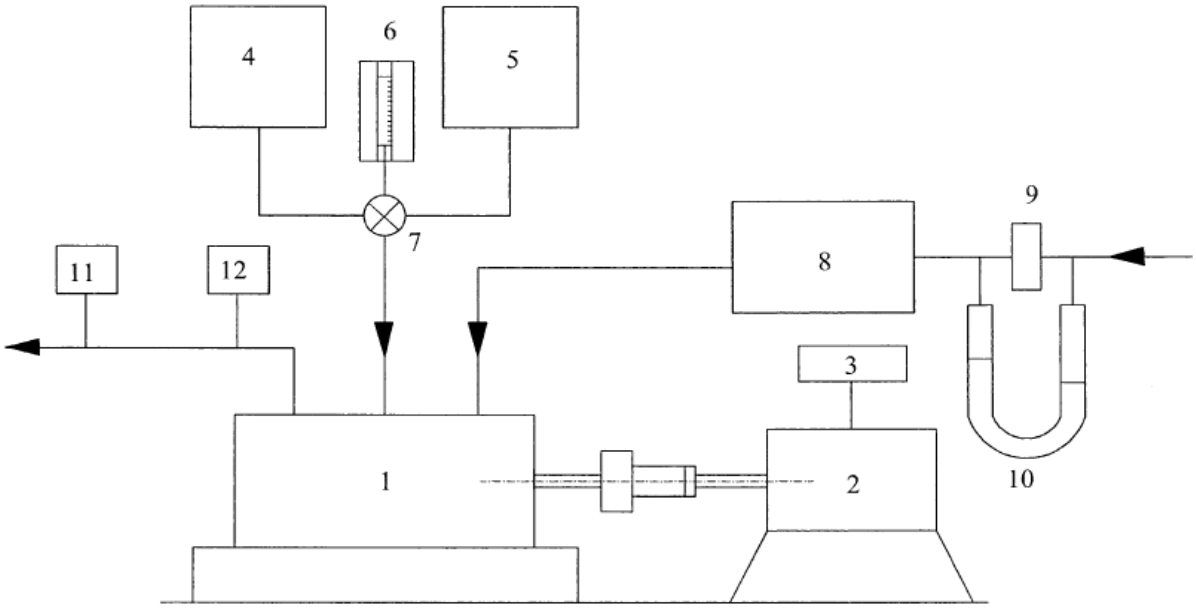

Fig1 Schematics diagram of experimental setup

(1) Engine; (2) Electrical load bank; (3) voltmeter, ammeter; (4) Diesel fuel tank; (5) Biodiesel fuel tank; (6) Burette;(7) Two way valve;(8) Air box; (9) Orifice plate; (10) U tube manometer;(11) Smoke meter; (12) EGA

3). Result and discussion:-

It is important to emphasize that the blend fuel and the diesel fuel that was used as reference were evaluated under the same conditions, analyzing the performance and emission of the fuel in varying proportion of load. The value fuel consumption of engine was obtained with B20 and BE20 blends for each evaluated point, matching with engine consuming diesel fuel, shown in fig2. The fuel consumption was obtained at B20, BE20, E- diesel & diesel fuel. The engine fuel consumption for BE20 & Diesel fuel is almost lower than that of B20; E- diesel it's mainly shown in fig 2. BE20 fuel operation showed lower BSFC, than expected, as shown in fig 3

especially at higher loads. Higher BSFC was observed when running the engine with B20 fuel. Average brake-specific fuel consumption for usage of B20 was 39.6% which higher that of diesel fuel and 34.8% higher than that of BE20 and for E-Diesel it was 37.8%. The fuel viscosity had a great influence on brake specific fuel consumption that led to almost similar BSFC result for BE20 and DF which shown in fig 3.

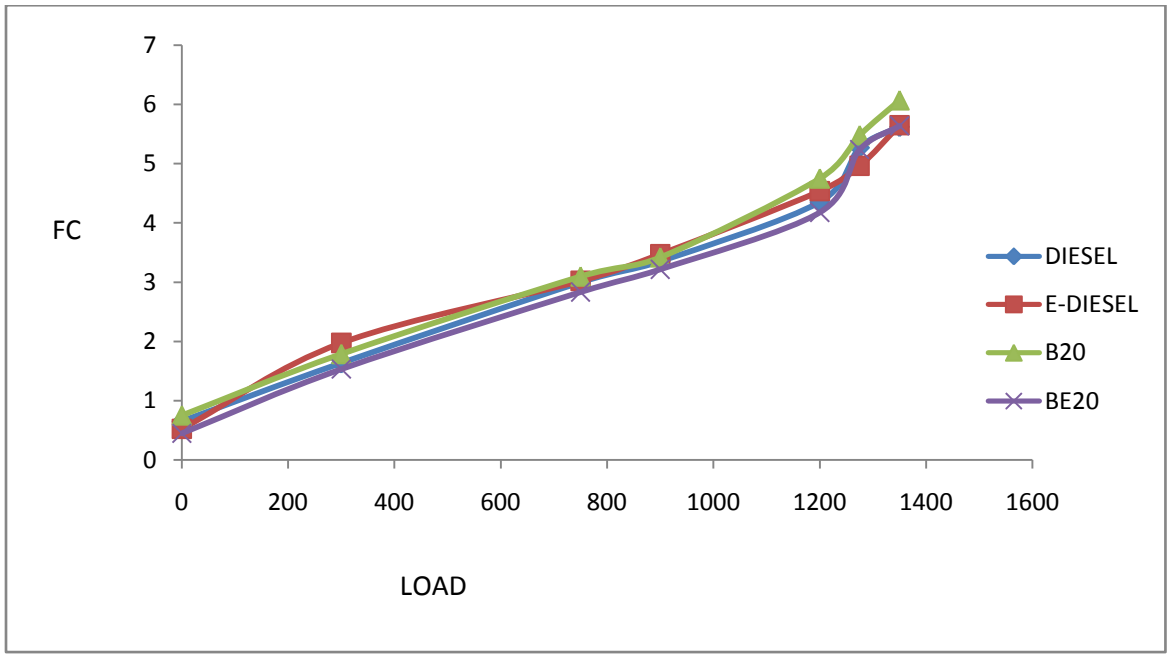

Fig 2 The FC variation at different Brake power for BE20, B20, E-diesel and DF

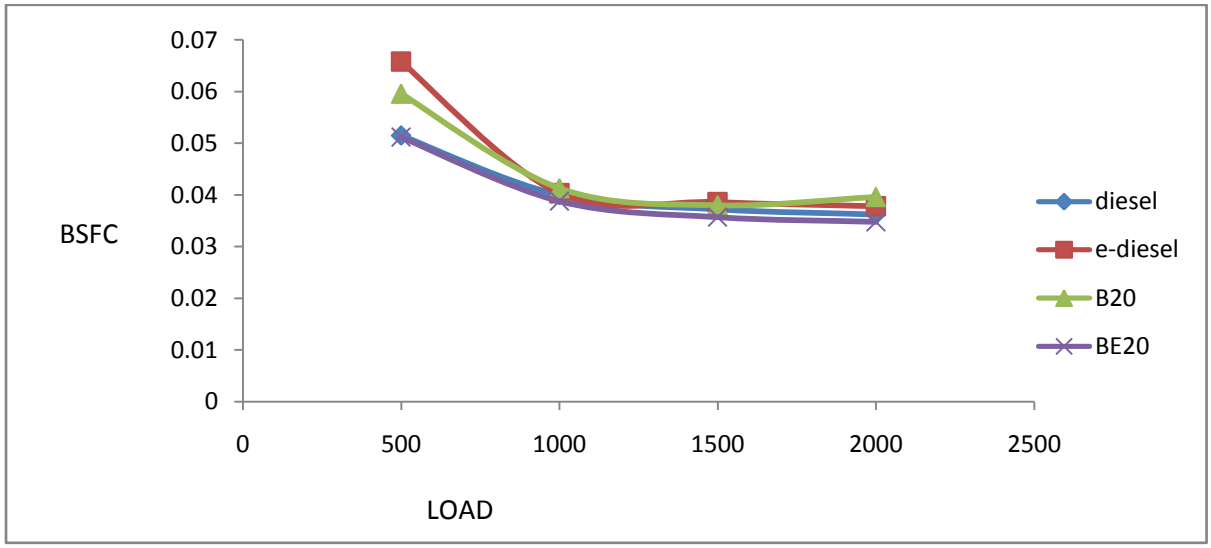

Fig 3 The BSFC variation with different load for BE20, B20, E- diesel, DF

Fig 4 shows the comparison of the brake thermal efficiency with load tested fuels. It can be observed from figure that the brake thermal efficiency was 24.96% for BE20, while those of DF, B20 & E diesel were 23.24%, 23.51% & 24.4% respectively. The brake thermal efficiency of B20 & diesel was lower compared to E- diesel and BE20. This may due to the lower heating value and inferior combustion of biodiesel & diesel. Besides, the brake thermal efficiency of BE20 is higher than that of standard diesel especially at higher load. The possible reason for improved brake thermal efficiency may be more complete combustion, and additional lubricity of biodiesel that contained in BE20.

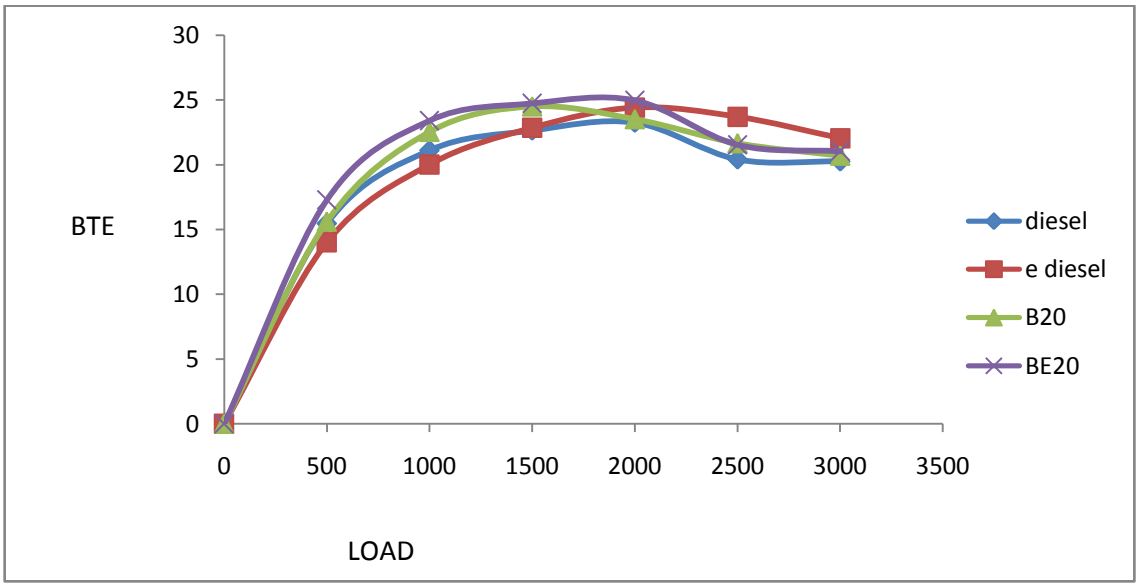

Fig 4 Variation of Brake thermal efficiency with different load for BE20, B20, E-diesel & Diesel

Fig 5 depicts that, the brake specific energy consumption decrease by 25-30% approximately with increase in load. This reserve trend was observed due to lower calorific value with different biodiesels. The brake specific energy consumption (BSEC) mainly shows energy consumption of different fuels. Lower the BSEC lower will the fuel consumption and it's be highly efficient, since fuel consumption and BSEC should be lower of any fuels.

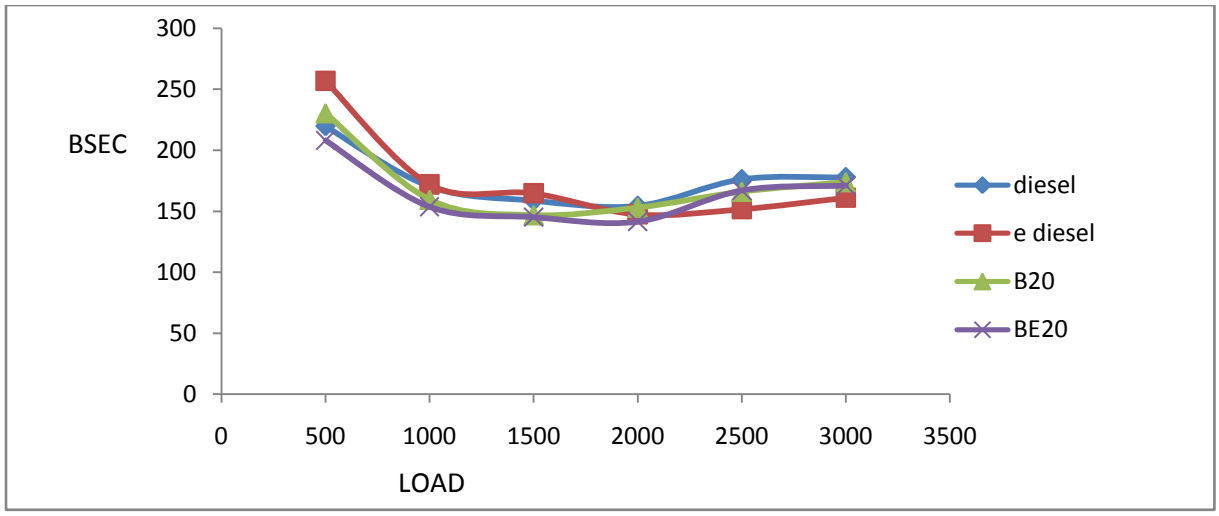

Fig 5 show BSEC vs LOAD

The exhaust gas temperature with BE20 was higher when compared to those of diesel and B20 fuel, E- diesel fuels (Fig 6). In Fig 6, BE20 shows higher temperature different at each load of the engine than the other fuels (B20, E-Diesel & DF). The main reason for large difference between BE20 and Diesel fuel may be improved combustion of BE20 thanks to the ethanol added to biodiesel. An-other reason may be shortened combustion period of BE20 with increased flame velocity. Beside, the temperature for diesel & B20 is quite similar. The exhaust temperature of E- diesel is higher than that of B20 and diesel.

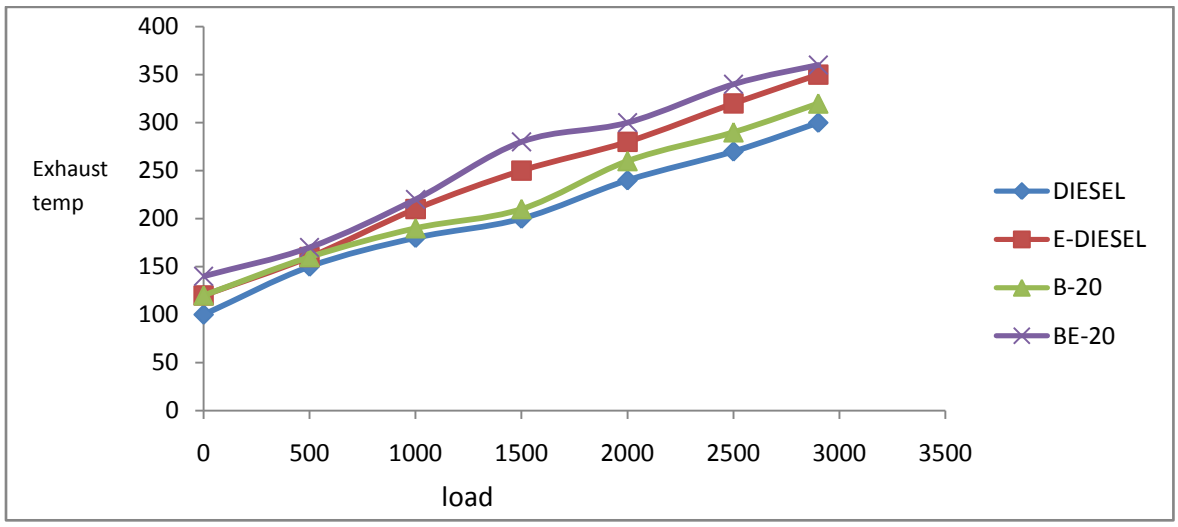

Fig 6 Shows variation of exhaust temperature of different fuels

Fig 7 shows that CO emission by B20, E-diesel, BE20 & diesel. The biodiesel blends, is lower than the ones for the corresponding diesel fuel case. This can be explained by the enrichment of oxygen owing to ethanol and biodiesel addition, in which an increase in the proportion of oxygen will promote the future oxidation of CO during the engine exhaust process.

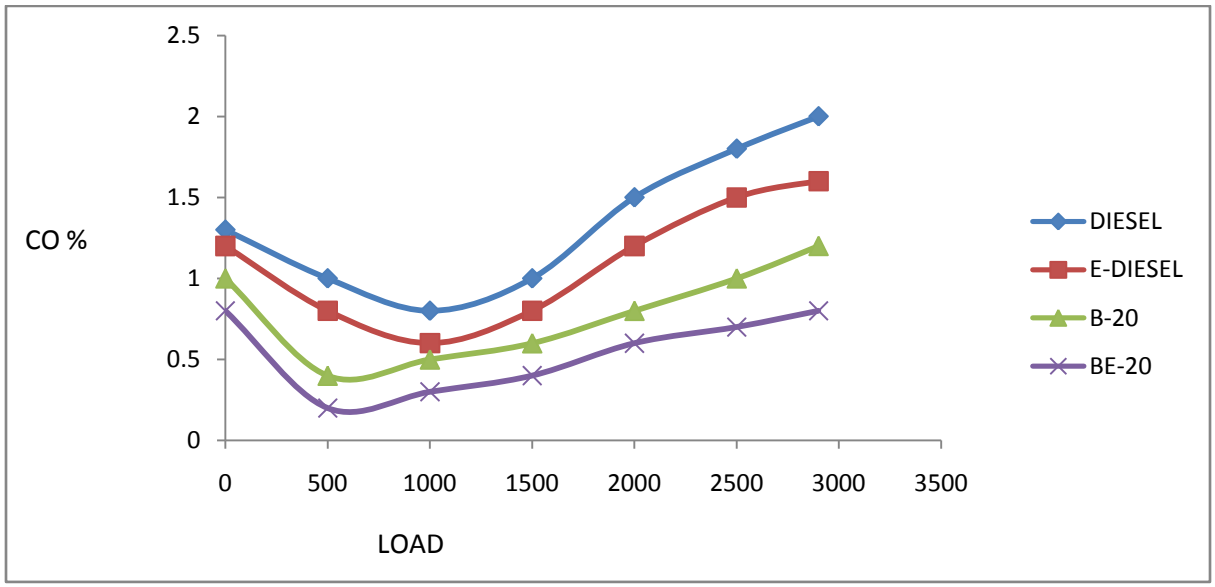

Fig 7 shows the variation of CO emission of different fuels

Fig 8 shows the HC emission of different fuels. It mainly shows that the HC emission of BE20 is lower than that of any fuels since exhaust temperature of BE20 is higher this mainly effect HC emission of fuel. Since diesel shows higher amount of HC emission because it has lower exhaust temperature.

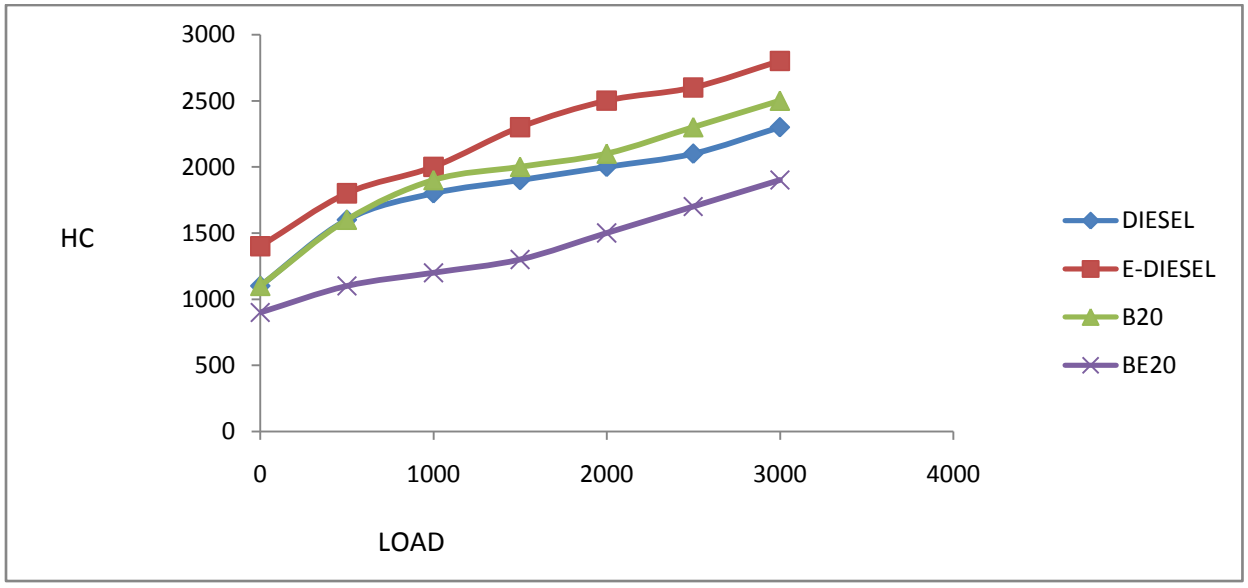

Fig 8 shows HC variation of different fuels

Fig 9 shows the smoke density of different fuels. The smoke capacity of E- diesel & diesel is higher than B20& BE20. Since BE20 smoke density is lower than any fuel due to higher exhaust temperature of BE20 this may result in complete combustion of HC which may result in decrease in smoke density.

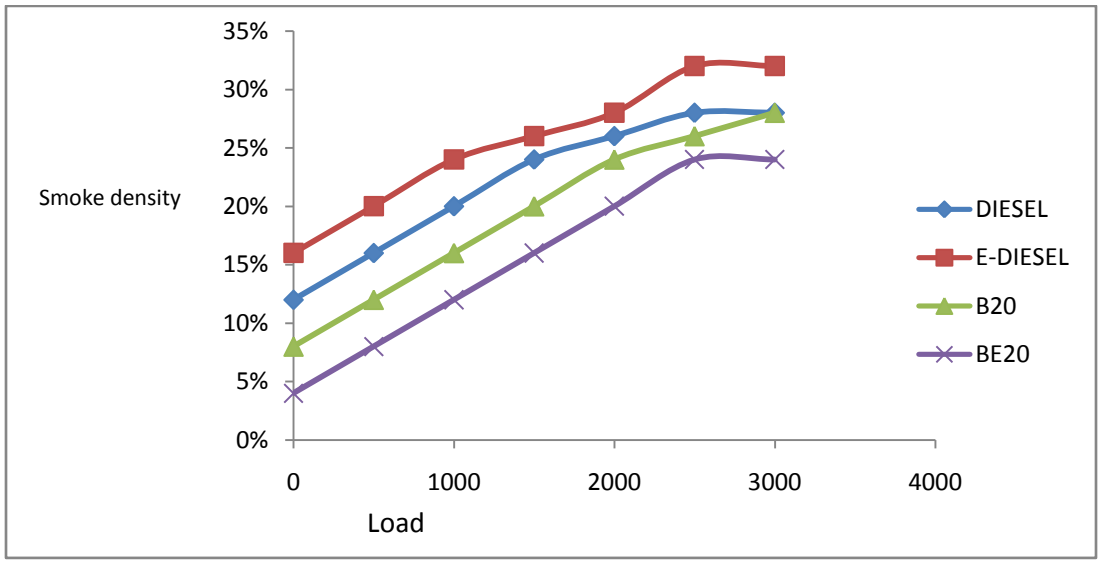

Fig 9 shows smoke density of different fuels

4) Conclusions:-

Blends of biodiesel and ethanol fuel can be used as alternative fuels in convectional diesel engine without any changes.

- Fuel consumption of BE20 is lower than other fuel mainly B20, E- diesel, diesel due the ethanol being used as additives in biodiesel which mainly lower the fuel consumption rates.
- BSFC was lower for BE20 than any other fuels especially lower than E diesel and B20 and was same than that of diesel fuel.
- BSEC for BE20 lower due calorific value is almost same with diesel fuels.
- Brake thermal efficiency of BE20 is higher than any other fuels specially. Diesel has lower BTE than any other fuels
- The highest percentage of exhaust temperature was obtained with blend of BE20 which is helpful in proper combustion.
- The CO percentage of BE20, B20& E-diesel is lower than that of diesel. This may result in lower CO emission with blend of biodiesel.
- The HC emission mainly depends on exhaust temperature of any fuel since BE20 has lower HC emission.

- The smoke density of BE20, B20 is lower than E diesel & diesel due to the lower HC emission.

The main conclusion derived by this research is that using ethanol with biodiesel can potentially remove serious problem revealed with the use of high percentage of biodiesel in operation of unmodified diesel engine. The exhaust emission of BE20 and other biodiesel is reduced and the fuel blend BE20 is about 90% renewable and emission free.

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