CONVERSION OF DIESEL ENGINE INTO CERAMIC HOT SURFACE IGNITION ETHANOL ENGINE

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ABSTRACT

A four-stroke single cylinder Compression Ignition(C I) Engine is converted into a ceramic hot surface ignition ethanol engine to reduce the emission. Ethanol is blended with diesel along with some agro waste coconut oil. In this, the performance and emission characteristics of the modified engine is analysed and compared to the base engine. The glow plug is coated with a Partially Stabilized Zirconium (PSZ), Piston crown is coated with Aluminium Oxide (Al_2O_3) and 50% of the clearance volume is reduced by grinding the top of the engine block. Due to high auto ignition temperature of ethanol, a pre heater is introduced. This experiment is effective not only in reducing smoke density and fuel consumption but also increase in engine output. Ethanol is renewable and oxygenated bio-based fuel; therefore it has enough potential to reduce PM emissions when used in compression Ignition Engine. It leads to reduction in the emission of CO_2 and other toxic gases which are harmful to the environment. Many researches completed for using ethanol as an alternative fuel but it is not completely achieved in India. This is due to problems in refilling stations, problems in engine while using ethanol and lower rate of ethanol production. Hence this experiment is conducted to troubleshoot the problems while using ethanol as an alternative fuel in CI engines.

Key words: Ethanol, Agro waste, Ceramic coating, Partially Stabilized Zirconium, Aluminium Oxide, Pre-Heater.

1. INTRODUCTION

The toxic gases released from vehicles will affect environment and living things. These toxic gases cause ozone depletion and global warming. Using of bio ethanol as a fuel will reduce CO_2 emissions, green house effects and other toxic gases when compared to other fuels such as diesel and petrol [1].Ethanol is an alternative renewable fuel produced from agricultural wastes. Ethanol-Diesel emulsion is a technique that can be used in Compression Ignition Engines. This technique will reduce the CO_2 life cycle and other PM emissions [2].In Ethanol-Diesel blend, higher the ratio of ethanol lower the emission of toxic gases. Addition of ethanol will slightly increase NOx emission because of low cetane number but other emissions are generally reduced [3].Ethanol has high auto ignition temperature than diesel therefore it will reduce efficiency. In order to overcome this, ethanol should be injected into the combustion chamber at high temperature. Hence a certain amount of temperature should be maintained before injecting ethanol [4].For obtaining hot surface, ceramic coatings can be used. Ceramics have higher thermal durability and lower thermal conductivity which controls the temperature distribution and heat flow. Coating of ceramics such as Partially Stabilized Zirconium (PSZ) improves the fuel efficiency up to 5 to 6% at all loads and speed. Burning of alcohol in diesel engine with ceramic coating will leads to complete combustion and lower emission [5].The temperature of combustion chamber can be increased by creating a thermal barrier. The piston, cylinder head, exhaust and inlet valve can be coated with Aluminium Oxide (Al2O3) by plasma spray method. Thus a thermal barrier was provided with that coating and high temperature is maintained in combustion chamber [6].By pre-heating the inlet air, vaporization can be easier and in turn complete combustion is achieved [7].

Addition of butanol results an increase in pressure peaks were by a combination of compensating effects: increase in the amount of premixed combustion and increase in the flame speed [8]. The modified single cylinder engine operated with alcoholic-diesel blended fuels worked with improved engine performance compared to neat diesel fuel operation .In diesel and alcohol fuelled blends in diesel engine, the BTE showed increasing trend with increased blend ratio of alcohol in diesel up to 20%. However blends beyond 20% were not considered due to reduced engine power and increased brake specific fuel consumption because of lower calorific value of the butanol. Compared to neat diesel, butyl alcohol-diesel blended fuels showed improved performance in terms of increased BTE.HC, CO and smoke emissions reduced with increased alcohol concentration in diesel fuel while they increased with increased loading conditions However NO_x emissions increased with increased butanol content in diesel fuel. Ignition delay, combustion duration, peak pressure and heat release rates increased with increased alcohol content in the diesel fuel. This experimental work showed the capability of alcoholic fuels which are renewable energy sources to replace diesel [9]. During the usage of fuel blends, the emission of smoke is immensely high when the engine is cold and running at higher speeds, the low emission is observed when the engine is hot and running at lower speeds [10].The usage of coconut oil in as a blend has increased the lubricating property. A higher coconut oil concentration there is a slight reduction in power output, which is directly proportional to the difference in the fuel's calorific value [11].

2. EXPERIMENTAL SETUP

This Project involves the Conversion of Diesel Engine into Ceramic Hot Surface Ignition Ethanol Engine. A stationary four stroke diesel engine is modified as shown in Fig.1 by the process characteristics of glow plug by providing constant current supply to the glow plug for maintaining hot surface on the engine during its working period and decreasing cylinder bore length by grinding the surface which increases the compression ratio. Due to the corrosion capacities of alcohols, various material coating is used inside the engine to resist the erosion. Ethanol has very high auto ignition temperature; hence a pre heater is used to increase the temperature of intake air. In normal diesel engine, the glow plug is constituted in the way of providing heating at colder condition when self-starting of the engine faces struggle, we have changed the purpose of glow plug into full time heating of the engine surface by using glow plug relay which turn on and off at various time intervals relative to the glow plug temperature by means of 12V DC supply and further more modification includes increasing the compression ratio of engine from 24:1 to 25.6:4, and then providing ceramic coating to glow plug and piston crown in order to withstand the high temperature.

Partially Stabilized Zirconium (PSZ) and Aluminium Oxide (Al_2O_3) is coated in the glow plug heating rod (Fig.4) and piston crown (Fig.5) respectively. Partially stabilized zirconium dioxide (PSZ) is a new non-metallic structural material that combines hardness, reduced fragility, and chemical inertness with high chemical stability in aggressive environments throughout a wide temperature range (up to 1400 °C). Aluminium coatings are surface coatings of metals which display excellent corrosion resistance and also withstand high heat, humidity and chemical attacks. The ceramic coating is accomplished by plasma coating or plasma spray process as shown in Fig.2 and Fig.3 . The Plasma Spray Process is basically the spraying of molten or heat softened material onto a surface to provide a coating. The cylinder bore is reduced by surface grinding method as shown in Fig.7. Surface Grinding is a manufacturing process which moves a grinding wheel relative a surface in a plane while a grinding wheel contacts the surface and removes a minute amount of material, such that a flat surface is created as shown in Fig.8.

The ratio of tested bio fuel blends is shown in Fig.6. The n-butanol additive is added for uniformly mixing of fuels. The engine is running at constant speed of 1250rpm. The engine is rushed to increase uniform speed after which it is steadily stacked. The investigations are directed at six force levels. For each heap condition, the engine is run for in any event 10 minutes after which information is gathered. The examination is rehashed multiple times and the normal worth is taken. A dynamometer is utilized for estimating the intensity of engine yield 5-gas analyzer is utilized for estimating the outflows of CO, HC, NO_x and smoke density of the engine. A fuel utilization meter is utilized for estimating the brake explicit fuel utilization of the engine. The main measurement methods used for the determination of exhaust gas temperatures include resistance temperature sensors and thermocouples.

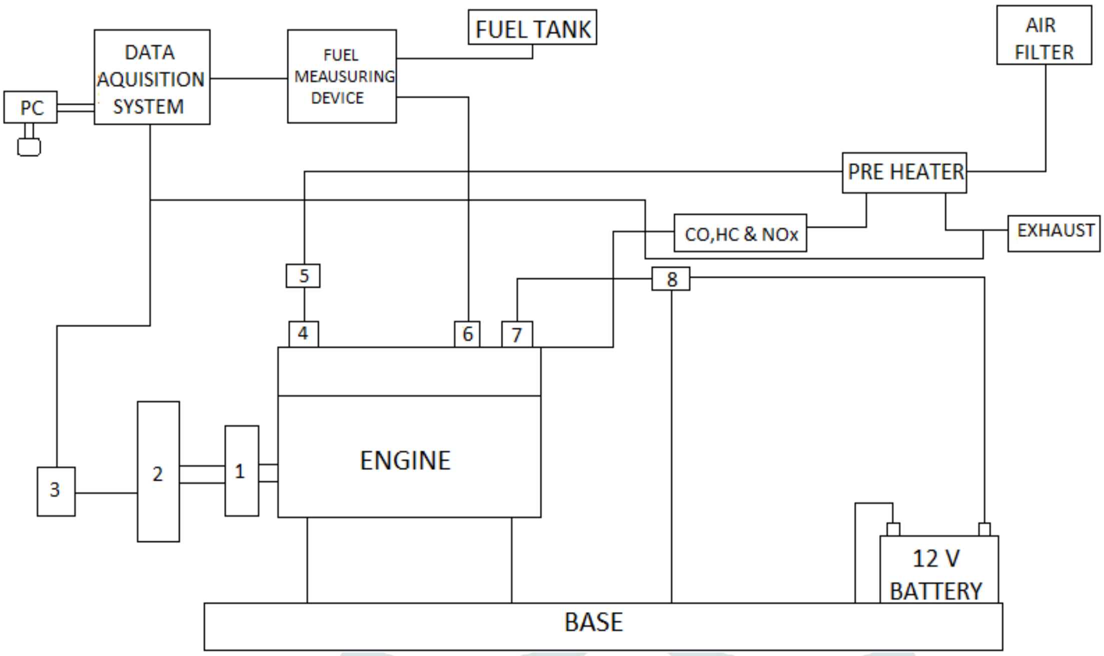

Fig.1 Surface Ignition Engine

1. Flywheel
2. Dynamometer
3. RPM Measuring device
4. Air stabilizing tank
5. Digital air flow meter
6. Fuel Injector
7. Coated Heater
8. Glow Plug Relay

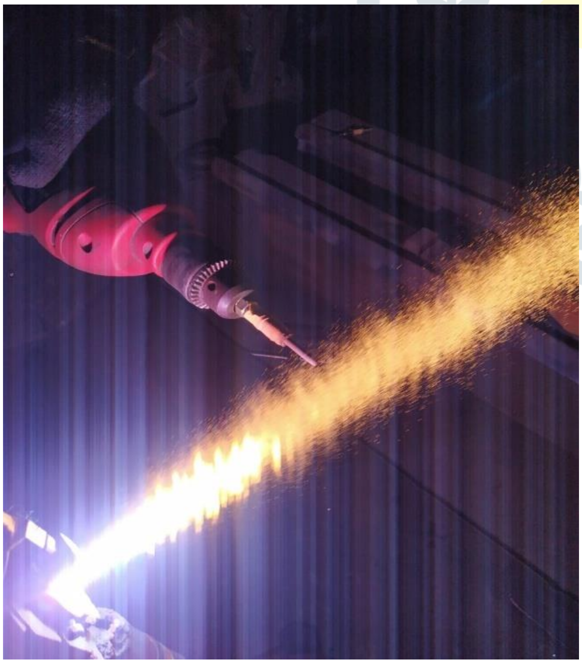

Fig.2 PSZ Plasma coating on glow plug heating rod

Fig.3 Al2O3 Plasma coating on piston crown

Fig.4 PSZ Coated on glow plug heating rod

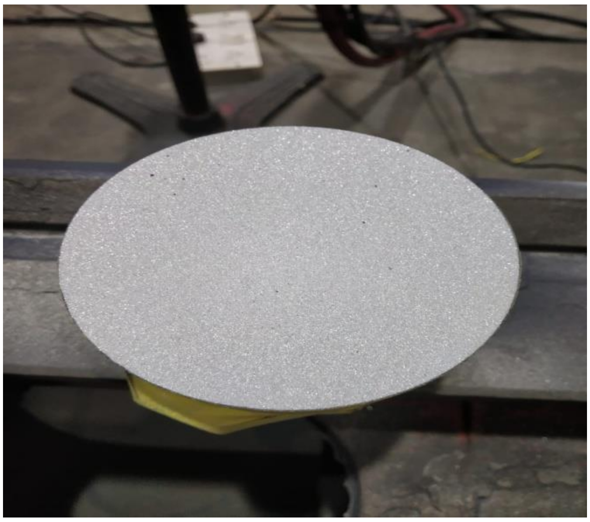

Fig.5 Al_2O_3 Coated on piston crown

Fig.6 Tested bio fuel blends

Fig.7 Surface Grinding

Fig.8 Grinded Engine Bore

Table.1 Specifications of Surface Ignition Engine

Engine Type	4 Stroke SIE
No of Cylinder	One
Bore Diameter	86 mm
Stroke Length	77 mm
Engine Displacement	445.3 cc
Compression Ratio	24+/-1:1(+1)
Max. Engine power	6.62 kW at 3400 rpm
Max. Torque	23 Nm at 2000 rpm
Idling Speed	1250 rpm
Method of Cooling	Forced air and oil cooled

Table.2 Properties of Fuel

Properties	**Diesel**	**Ethanol**	**Agricultural waste Coconut oil**
Chemical formula	$C_{12}H_{23}$	C_2H_5OH	$C_4H_8NNAO_2$
Calorific value (kJ/kg)	42500	19700	38100
Viscosity at 25°C (mPa s)	2.8	1.040	4.1
Flash point (°C)	78	17	115.5
Boiling point (°C)	180-330	78.5	95-99
Auto ignition temperature (°C)	230	365	171
Cetane number	45	5-15	56
Density (Kg/m^3) at 25°C	837	784.9	886.2
Surface tension (N/m) at 25°C	0.023	0.022	0.034

3. RESULTS AND DISCUSSIONS:

The modified CI Engine is compared with base engine .Alternative fuel evaluation is compared based on performance of engine and its effects on environment. The impact of ethanol fuel addition to diesel fuel in Surface Ignition Engine is evaluated by the parameters such as, brake specific fuel consumption, brake thermal efficiency, temperature of exhaust gas, emissions of CO, HC, NO_x and smoke density.

3.1. Brake Specific Fuel Consumption:

Brake specific fuel consumption (BSFC) is a measure of fuel consumed to produce unit brake power. The Fig 9 represents the variations in brake specific fuel consumption of the engine with pure diesel (D100) and other blended fuels with respect to brake power. The graphical variations clearly show that the increase in ethanol addition to diesel increases the brake specific fuel consumption. This is due to the low calorific value of the ethanol than diesel. The main reason is that oxygen content in ethanol does not contribute to heat generation during combustion.

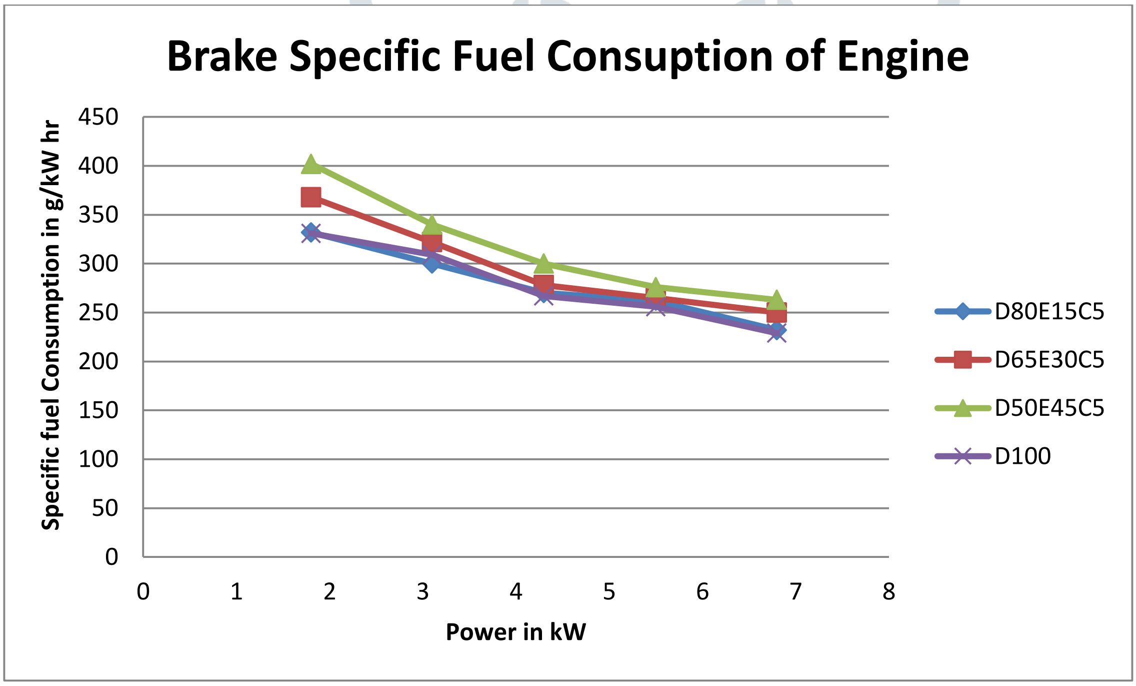

Fig.9 SFC Vs Brake Power

3.2. Brake Thermal Efficiency:

Fig.10 shows the variations of brake thermal efficiency of the engine with pure diesel (D100) and blended fuels with respect to brake power. From the graph, we can figure out that with increase in brake power, the brake thermal efficiency also gradually increases for both blended and pure diesel and the maximum brake thermal efficiency is observed at 5.5 kW for D50E45C5.

The graph also shown that with increase in ethanol addition, the brake thermal efficiency also increases because ethanol contains more oxygen by mass compared to baseline diesel which results in better combustion of fuel and hence increases the efficiency.

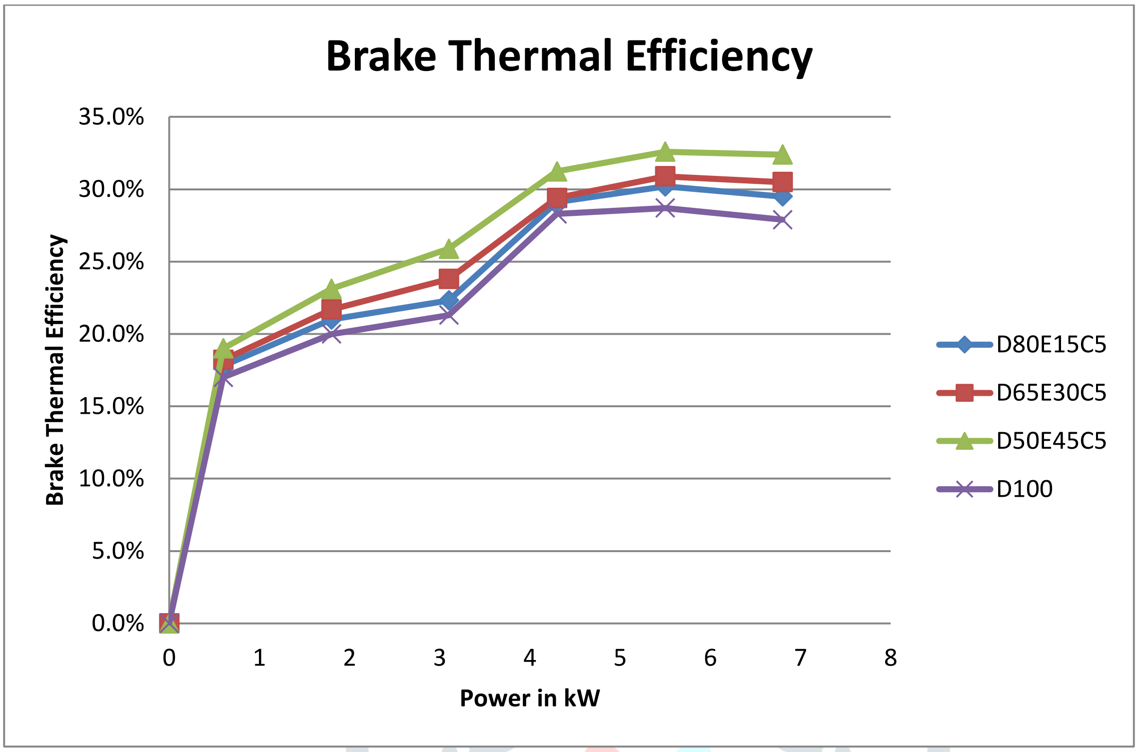

Fig.10 Brake Thermal Efficiency Vs Brake Power

3.3. CO Emission:

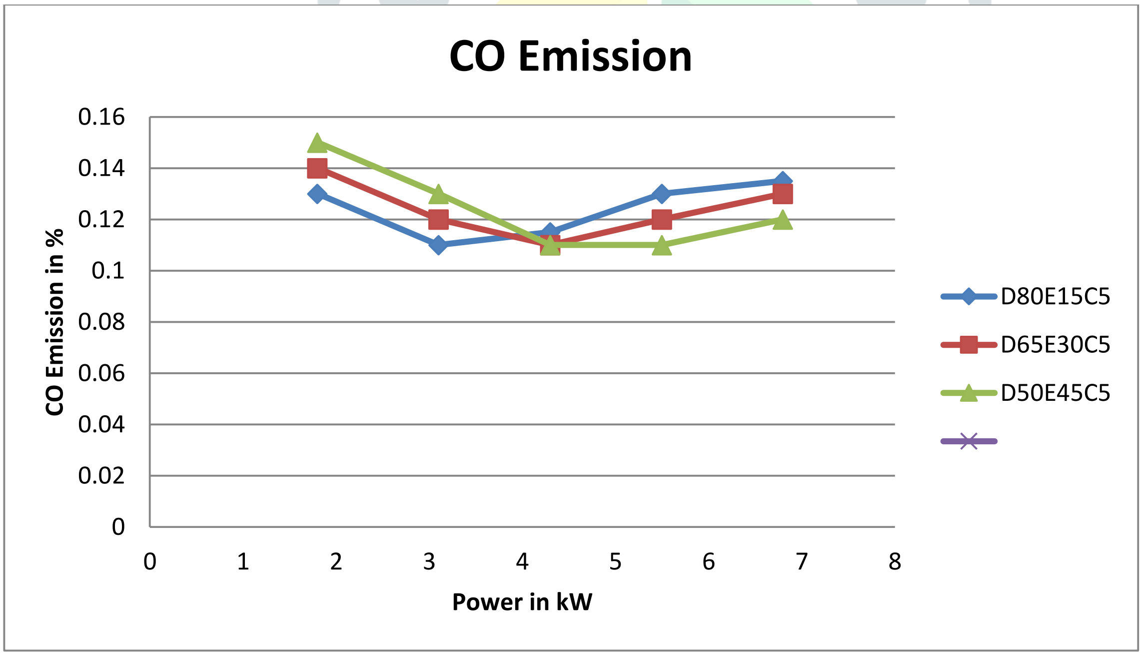

Fig.11 CO Emission Vs Brake Power

Fig.11 shows the variation of CO emission for different blended fuel with respect to brake power. Insufficiency of oxygen in the fuel leads to the formation of CO. when CO has no oxygen to oxidize, then it will remain as CO instead of oxidizing into CO_2. Due to the enormous amount of oxygen content in ethanol, the CO emission is reduced as the addition of ethanol is increased. The figure shows that the D50E45C5 produces less CO emission compared to other blended fuels.

3.4. HC Emission:

Fig.12 shows the variation of HC emission for different blended fuel with respect to brake power. The unburned hydrocarbons are caused by the ineffective combustion of air fuel mixture. When the ethanol is blended with diesel, it provides enough oxygen to produce efficient combustion. So the addition of ethanol as a supplementary fuel to the diesel engine reduces the HC emission. The graph indicates the blends of D65E30C5 and D50E45C5 produce less amount of HC emission compared to baseline pure diesel. It also shown the increase in HC emission for D50E45C5 when power is increased, it may be happened due to non-uniform combustion at full load condition.

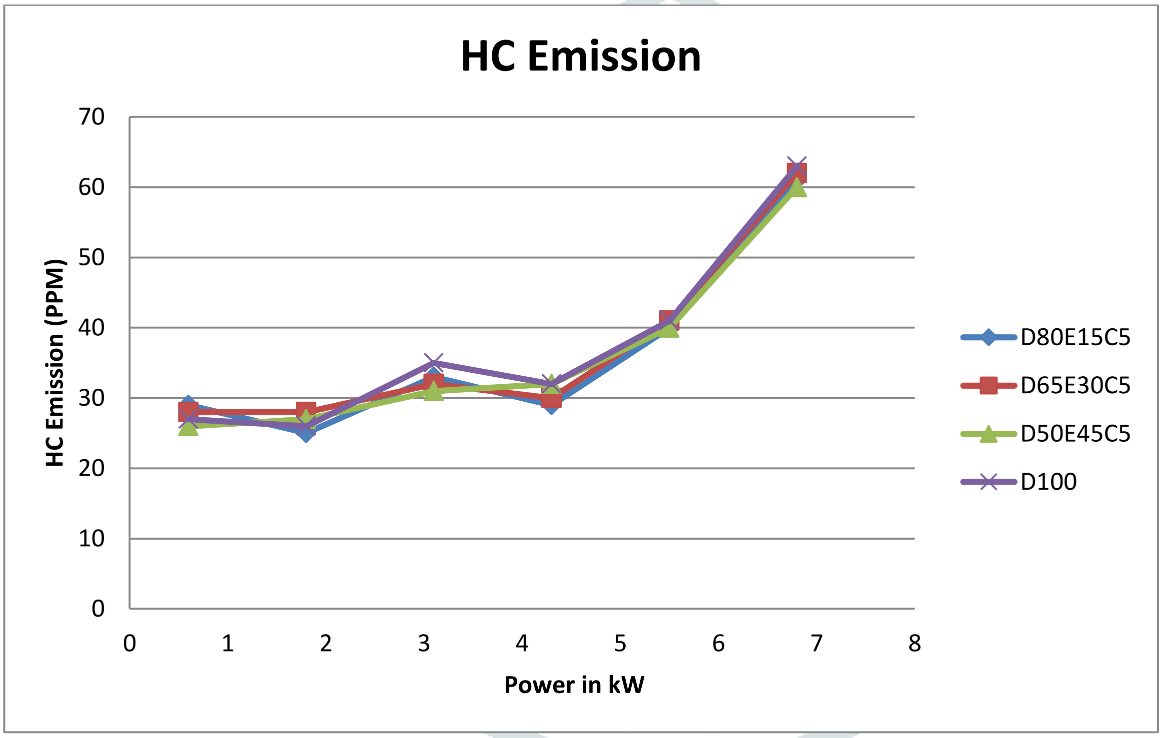

Fig.12 HC Emission Vs Brake Power

3.5. NO_x Emission:

Fig.13 shows the variation of NO_x emission for the different fuel blends with respect to brake power. The oxides of nitrogen (NO, NO_2) coming out from the muffler after the combustion of fuel is popularly known as NO_x. The graph shows that the NO_X emission is lower for D50E45C5 compared to other fuel blends. High combustion efficiency and high latent heat of vaporization of ethanol leads to the low emission of NO_x at E45 blend.

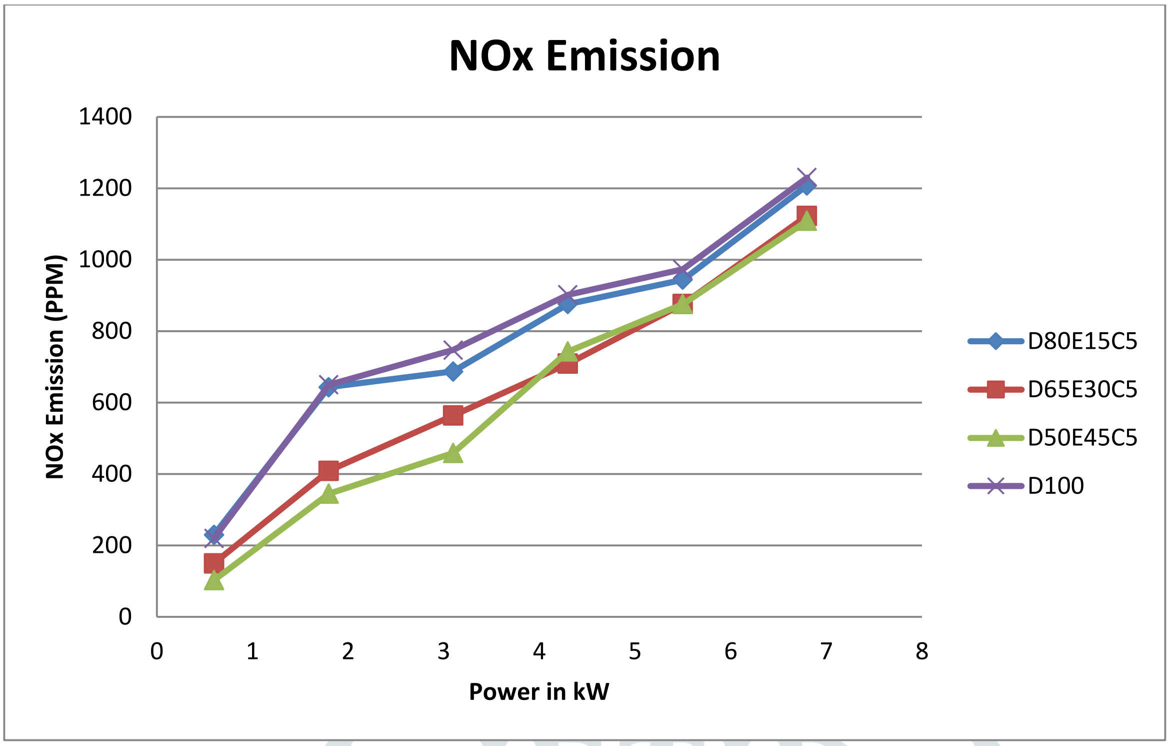

Fig.13 NO_x Emission Vs Brake Power

3.6. Smoke Density:

Fig.14 shows the variation of smoke density for different blended fuel with respect to brake power. Smoke emission is possible if there is a fuel rich zone at high temperature and pressure. The figure shows that there is a reduction in smoke emission because of the ethanol addition. The presence of oxygen in ethanol hinder the oxidation soot nuclei and reduces the fuel rich zone formation during combustion which results in reduction of smoke.

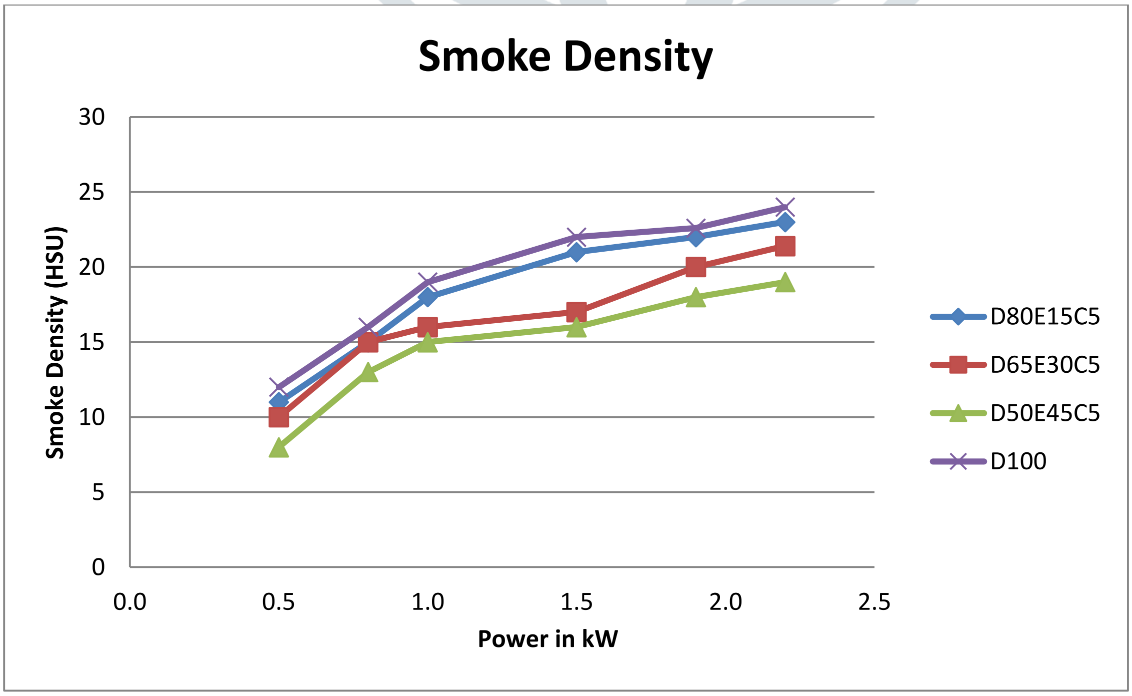

Fig.14 Smoke Density Vs Brake Power

4. CONCLUSION:

A detailed experimental analysis for finding out the emission characteristic of ethanol in comparison with base diesel was carried out. This experimental study investigated that the ethanol fuel can be a suitable alternative fuel of Surface Ignition Engine. A noticeable improvement observed in terms of brake thermal efficiency, combustion efficiency and brake specific fuel consumption. It is found that n-butanol is a suitable additive for mixing the ethanol with diesel. Unfortunately, the brake specific fuel consumption increased as the ethanol added to diesel due to lower calorific value of ethanol. The decrease in emission observed with fuel blends. Harmful gases such as NO_x, HC, CO and smoke density is reduced at D55E45C5. The NO_x formation is decreased because ethanol absorbs heat during Combustion due to its high latent heat of Vaporization. Ceramic coating provides complete combustion which results a reduction in smoke density. This study was concluded that the modifications done in the CI engine is the main reason for the efficient output at D55E45C5 blended fuel ratio.

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