EXPERIMENTAL INVESTIGATION ON FOUR STROKE CERAMIC HEATER SURFACE IGNITION C.I. ENGINE USING DIFFERENT BLENDS OF ETHYL ALCOHOL

R.Rama Udaya Marthandan[1], N.Sivakumar[2], B. Durga Prasad[3]
[1]Research scholar,Dept. of Mech. Engg., Sathyabama University,India
[2]Asst. Professor, Sun College of Engineering and Technology, Kanyakumar Dist. , India
[3]Associate professor, JNTU, Ananthapur,A.P,India

ABSTRACT
In this paper an experimental investigation on the performance of surface ignition ceramic heater four stroke CI engine fueled with pure diesel(B0D100E0) and ethanol-diesel blends containing 10%,20%,25% and 30% by volume of ethanol are evaluated. n-butanol (B) additive is used to solubility of ethanol(E) in diesel(D), that acts as a bridging agent through molecular compatibility and bonding to produce a homogeneous blend.The ethanol – diesel fuel affects blend stability, viscosity, lubricity, corrosiveness and safety.The tests are carried out on 10HP ceramic heater surface ignition single cylinder diesel engine under steady state operating conditions.The engine is run at various speeds of 1250rpm and1500 rpm.The relevant parameters such as brake thermal efficiency(BTE), brake specific fuel consumption (BSFC) and emisions are calculated for pure diesel and ethanol-diesel blends by B5D85E10, B5D75E20, B5D70E25and B5D65E30.The Partially Stabilized Zirconia(PSZ) ceramic heater is used to reduce the emissions by 220 ppm of NOx, under half load for the blends of B5D85E10 gives minimum CO emissions and unburned HC emissions by 24 ppm from the engine and improve engine output behavior to 2%.

KEYWORDS: *ethanol,n-butanol,emissions,ceramic heater.*

I. INTRODUCTION

Ethanol is one of the possible fuel for diesel replacement in CI engines[1]. It can be made from raw materials such as sugarcane, sorghum, corn, barley, cassava, sugar beets etc. A biomassbased renewable fuel, ethanol has cleaner burning characteristics, and a high octane rating. The application of ethanol as a supplementary compression-ignition fuel may reduce environmental pollution, strengthen agricultural economy, create job opportunities, reduce diesel fuel requirements and thus contribute in conserving a major commercial energy source[2].
A surface ignition ceramic heater[3] CI engine is able to operate at higher temperature enabling combustion of fuel at complete resulting to increase combustion efficiency. This should increase engine performance, decrease fuel consumption and reduce pollution[4]. Ceramic heater provides instant heat within seconds of turning, which helps save fuel and reduce emissions. It is mounted through the engine head, that heats up and warms air moved over its surface, due to its inherent self-regulating characteristics. Ceramic heater for diesel combustion would represent a simple low cost and easy approach in diesel engine performance[5].
In the C.I engines a premixed fuel air vapor is drawn in during the suction stroke, a single high intense spark passes across the electrode, producing a core of flame from which the combustion spreads to the envelope of mixture surrounding it at a fast rate. The above two methods evidently show that the fuel properties of the first method will not be suitable for the second, and hence if we need to have an engine with multi fuel capability, the nature of combustion should be very different from the above

methods. This is where the concept of surface ignition comes into active consideration. Surface ignition indicates the beginning of combustion from a hot surface. It will be interesting to know that almost all fuels exhibit this property to varying degrees, the alcohols being highly susceptible to this kind of combustion [8].

II. EXPERIMENTAL WORK

A different speeds stationary four stroke surface ignition[8] ceramic heater[9] CI engine is selected for the experiment. The major specifications of the engine are given in Table 1and properties of fuel used are given in Table 2. The engine is connected with dynamometer, air stabilizing tank, diesel and ethanol blends consumption measuring device , exhaust gas analyzer etc[6]. A ceramic heater is fixed inside the cylinder and connected by 12 volt DC battery to heating combustion chamber.Diesel fuel and ethanol-diesel blends with additive by B0D100E0, B5D85E10, B5D75E20, B5D70E25 and B5D65E30 are tested. The ethanol and additive is obtained from the local market. The engine is run on no-load condition and its speeds are adjusted to 1250 rpm and 1500 rpm by adjusting the screw provided with the fuel injector pump. The engine is run to gain uniform speed after which it is gradually loaded. The experiments are conducted at six power levels for each load condition. The engine is run for at least 7 minutes after which data is collected. The experiment is repeated 5 times and the average value is taken. The observations are made during the test for the determination of various engine parameters like Brake specific fuel consumption, Brake thermal efficiency and exhaust emissions[7].

Heat transfer affects engine performance, efficiency, and emissions. The mass of fuel within the cylinder, higher heat transfer to the combustion chamber walls, will lower the average combustion gas temperature and pressure, and reduce the work per cycle transferred to the piston. Thus specific power and efficiency are affected by the magnitude of engine heat transfer [8]. Advances in engine technology by introducing ceramic heater increase the engine output efficiency and reduce the emission parameters[10].

In ceramic heater C.I engine an injection pressure and rate of injection can also offset the adverse effect of ceramic heater as shown in Figure 1. In this new system, decrease in pre mix of combustion due to decrease in ignition delay increases the Brake Specific Fuel Consumption (BSFC). Partially Stabilized Zirconia(PSZ) Ceramic Heater is fitted inside the cylinder, because of its very high fracture toughness among ceramics, it has one of the highest maximum service temperatures (2000^0C) among all of the ceramics and it retains some of its mechanical strength close to its melting point (2750^0C). PSZ ceramic heater is used in diesel engine because of two very notable properties: one is high temperature capability and other is low thermal conductivity. None of the other ceramics possess a thermal conductivity as low as the zirconia. This means that engine using zirconia ceramic heater would retain much of the heat generated in the combustion chamber instead of loosing it to the surroundings [9].

Table 1 Tested engine specifications

Engine type	4-stroke single cylinder engine
Make	Kirloskar
Power	10.0KW
Bore x Stroke(mm)	102x110
Cubic Capacity(cc)	898
Compression ration	18:1
Colling system	Water cooled
Lubrication system	Force feed
Attachment	Ceramic heater(12 V,DC)

Table 2 Properties of blending stocks

Properties	Diesel	Ethanol	n-Butanol
Boiling point (^{0}C)	180	78	117
Flash point (^{0}C)	65	10	35
Density, g/ml at 20^{0}C	0.829	0.789	0.81
Oxygenate (Wt%)	0.84	35	7.5
Carbonate (Wt%)	-	52	25
Hydrogen (wt%)	87	13	74
Viscosity,CS at 40^{0}C	13	1.2	10.3
Cetane number	48	6	40

Figure 1 shows the experimental set up of the work. A dynamometer is used for measuring the power of the engine output. Exhaust gas analyzer is used for measuring the emissions of CO, HC and NOx from the engine.A fuel consumption meter is used for measuring the break specific fuel consumption of the engine, also Data Acquisition System(DAS) is used to calculate all required out put parameters.

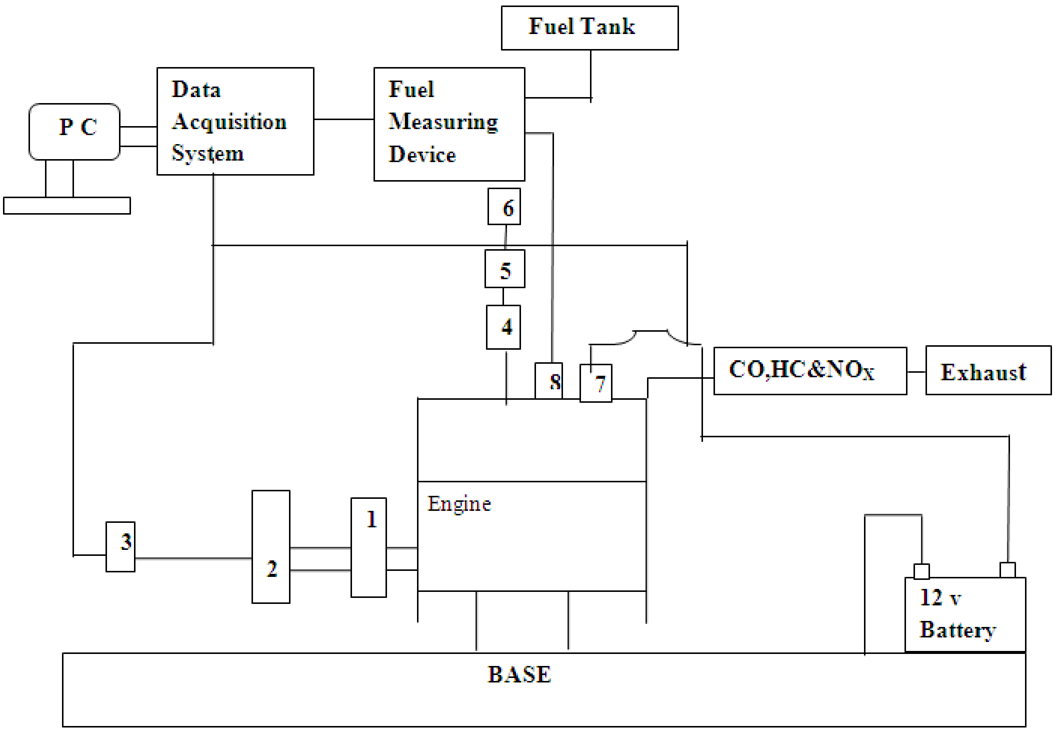

Figure 1 Experimental Setup

1. Flywheel
2. Dynamometer
3. R.P.M. Measuring device
4. Air stabilizing tank
5. Digital air flow meter
6. Air filter
7. Ceramic heater
8. Injector

III. RESULTS AND DISCUSSIONS

The experimental tests were carried out on the surface ignition ceramic heater four stroke CI engine using pure diesel and ethanol- diesel blends with n-butanol additive at different speeds. The relevant parameters such as engine torque and fuel consumption of the engine were recorded and the brake specific fuel consumption, brake thermal efficiency were also calculated at 1250 rpm and 1500 rpm.

The engine emissions of CO, unburned HC and NOx were analyzed using the exhaust gas analyzer. The results were obtained by data acquisition system and are shown as follows. The ratio of ethanol-diesel blends gives various fuel consumption according to the percentage of ethanol present in the diesel fuel. If more ethanol is added with diesel, gives more fuel consumption.

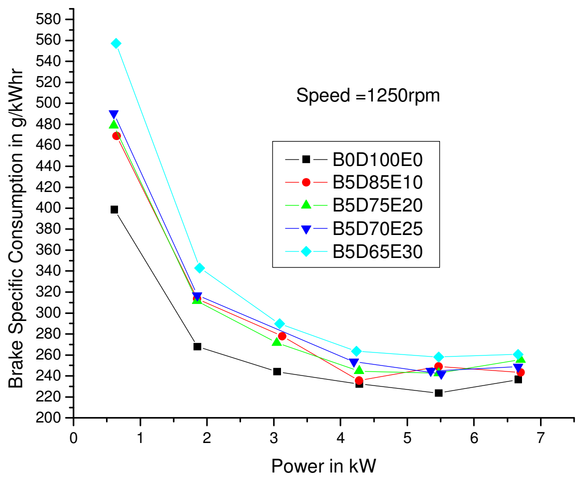

Figure 2 BSFC of the engine for 1250rpm

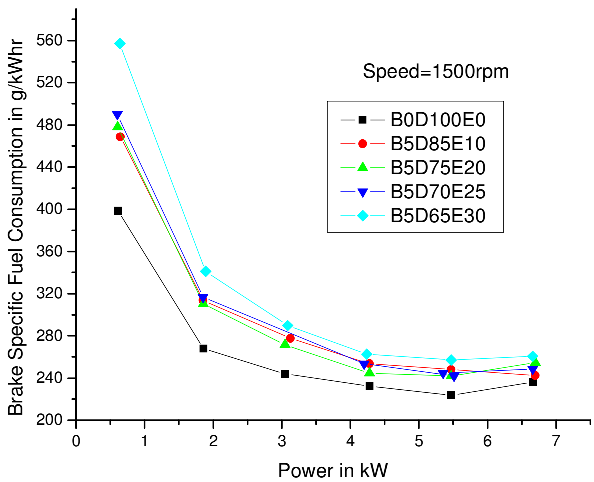

Figure 3 BSFC of the engine for 1500 rpm

Figures 2 and 3 show the BSFC of the engine. When the engine runs at 1250 rpm on different engine loads, for the blends of B5D65E30, the BSFC is increased by 4% for the blends of B5D85E10 BSFC is decreased by 1.2% for maximum engine load and the blends of B5D75E20 BSFC is average by 2.5% up and down. The results show the trends of the increase of fuel consumption with the increase percentage of ethanol in the blends.
When the engine runs at 1500 rpm , for the blends of B5D65E30, the BSFC is increased at all engine load conditions.The blends B5D70E25 give 3.25% less BSFC next to pure diesel fuel.However, BSFC is high at minimum power for all fuel ratios. This increase of fuel consumption is due to the lower heating value of ethanol than that of pure diesel[4].

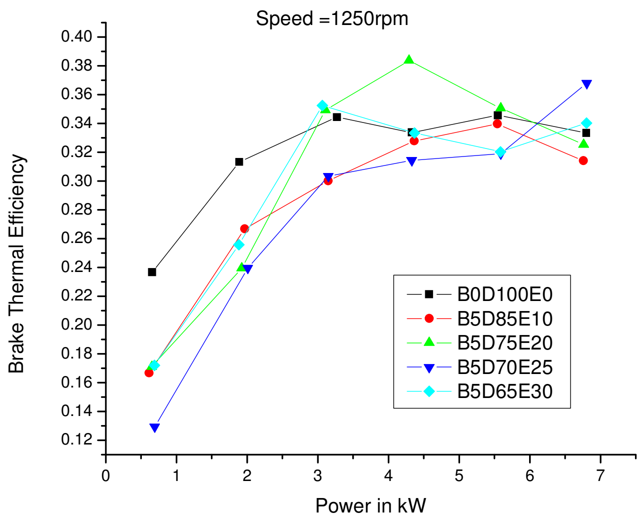

Figure 4 BTE of the engine for 1250 rpm

Figures 4 and 5 show the results of the break thermal efficiency(BTE) of the engine.When the engine runs at the speed of 1250 rpm for the blends of B5D70E25 the BTE is increased by 2.5%, and at average load BTE is increased for the blends of B5D65E30 by 3.4%. These results show the difference of the break thermal efficiencies between the blends and diesel are relatively small at 1500rpm.When the engine runs at the speed of 1500 rpm the break thermal efficiency is increased for the blends of B5D75E20 and B5D70E25 by 5% at high load and 2.5% at low load.The exhaust emissions are measured in terms of Corbon Monoxide (CO),Hydrocarbons(HC) and Oxides of Nitrogen (NOx) emissions. The results for diesel fuel as well as ethanol-diesel blends are given below. The oxygen content of the blended fuels would help to increase the oxygen to fuel ratio in the fuel at rich regions. The resulting more complete combustion leads to reduction of CO in the exhaust. If the percentage of ethanol in the blends increased, NOx emission is reduced. This is because of the air-fuel ratio in the case of ethanol-diesel blends, is lower as compared to diesel alone. The latent heat of vaporization of ethanol lowers at same temperature resulting in lower NOx emissions[7].

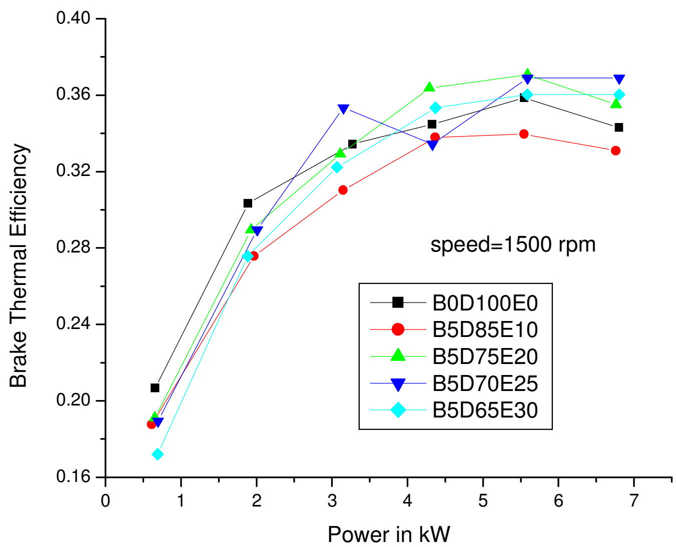

Figure 5 BTE of the engine for 1500 rpm

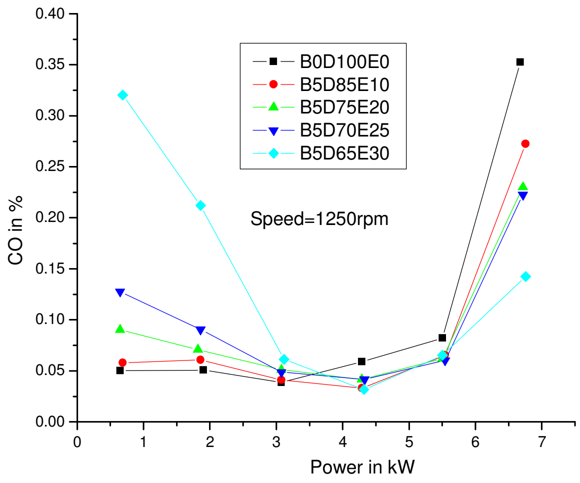

Figure 6 CO emissions for 1250 rpm

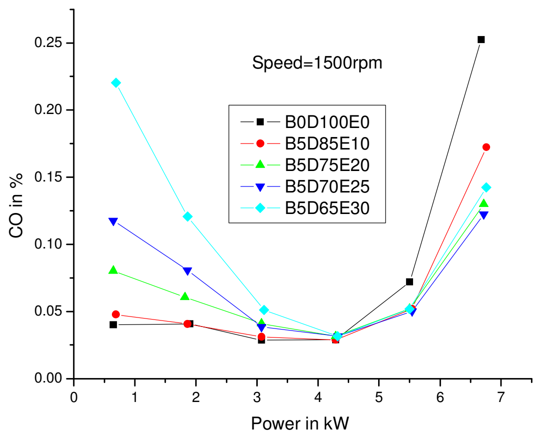

Figure 7 CO emissions for 1500 rpm

Figures 6 and 7 show the CO emissions of the engine. The CO emissions from the engine fuelled by the blends are higher than those fuelled by pure diesel at minimum loads. The higher percentage of the ethanol gives more CO emissions upto half load. For higher engine loads which are above half load , the CO emissions became lower than that fuelled by diesel for all the blends for all speeds by 0.01% to 0.07%. Upto half load the varition of CO emissions between pure diesel and B5D85E10 is only 0.05% for the speed of 1500rpm. At average load CO emission is same for 1500rpm and 0.01% to 0.02% different for 1250rpm. The percentage of ethanol in the blends increased the percentage of CO emission reduced. The emission reduced with the use of 10%, 20%, 25% and 30% ethanol-diesel blends as compared to diesel alone. This is due to the concept that ethanol has less carbon than diesel. The same fuel dispersion pattern as for diesel, the oxygen content of the blended fuels would help to increase the oxygen in fuel ratio in the fuel rich regions. This results in more complete combustion which leads to reduced CO in the exhaust smoke by ceramic heater engine.
The reduction of CO emissions at full load is due to the more complete combustion. The phenomenon is due to the oxygen element contained in ethanol. When the engine working above its half load, the temperature in the cylinder is high, which makes the chemical reaction of fuel with oxygen easier and the combustion becomes more complete for two different speeds.
The level of unburned hydro carbons (HC) in exhaust gases is generally specified in terms of the total hydro carbon concentration expressed in parts per million(ppm) carbon atoms.

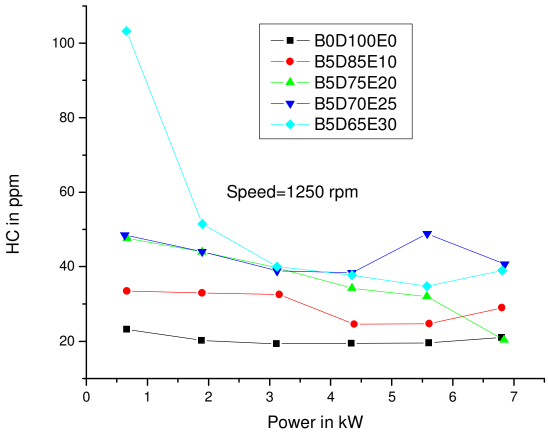

Figure 8 HC emissions for 1250rpm

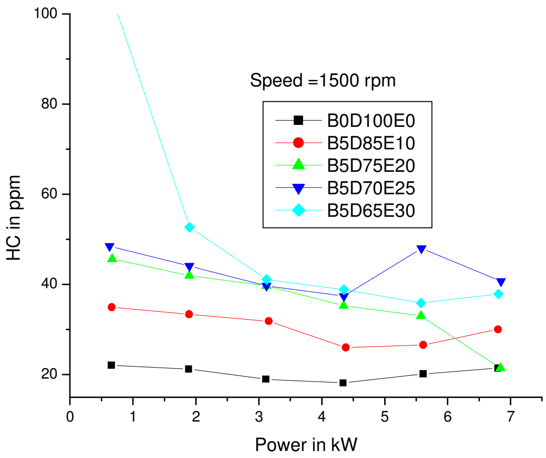

Figure 9 HC emissions for 1500rpm

Figures 8 and 9 show the HC emissions of the engine. More percentage of ethanol gives more HC emissions for all speeds. For the blends of B5D85E10 the HC is reduced by 5 to10ppm from pure diesel at1250rpm and 7 to 12.5ppm at 1500rpm. This is due to the high temperature in the ceramic heater engine cylinder to make the fuel be easier to react with oxygen when the engine runs on the top load and high speed. Figure 9 shows that the results of unburned HC emissions from the engine for the blended fuels are all higher when the engine runs at the speed of 1500rpm.

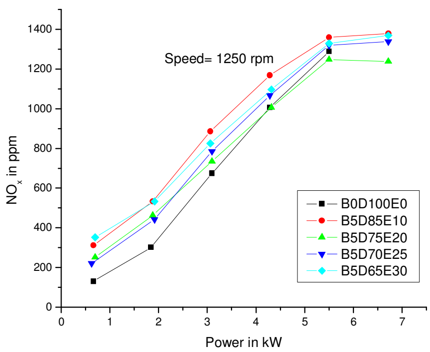

Figure 10 NOx emissions for 1250rpm

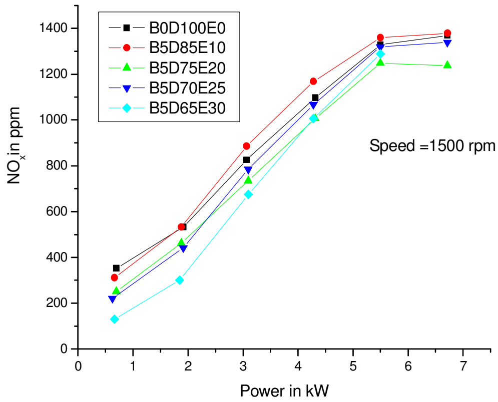

Figure 11 NOx emissions for 1500rpm

Figures 10 and 11 show the NOx emissions of the engine. When the engine runs at the speed of 1250 rpm NOx emission is minimum for pure diesel and more for1500rpm. The NOx emission is more for the blends of B5D85E10 at 1500rpm by 20%. The blends B5D70E25 give average NOx for all working conditions. The NOx emissions from the enigne are higher than those of diesel. NOx emissions are increased for all blends and speeds when the load is incerased. For low load NOx is minimum due to the fuel air mixture with spread in composition about stoichiometric burns.During the mixing controlled combustion phase the burning mixture is likely to be closer to stoichiometric by the help of ceramic heater. When the engine runs at 1500rpm the NOx is reduced by 40% for the blends of B5D75E20. This is because the air-fuel ratio in the case of ethanol-diesel blends is lower as compared to diesel alone. The latent heat of vaporization of ethanol is minimum for the same temperature in minimum NOx emissions[7].

IV. CONCLUSIONS

An experimental investigation was conducted on the blends of ethanol - diesel fuel using ceramic heater surface ignition single cylinder CI engine.The tested blends were from 10% to 30% of ethanol by volume and also with 5% of the additive of n-butanol.The engine was operated with each blend at different power and different speeds of 1250 rpm and 1500 rpm.

The Experiment showed that the n-butanol was a good additive for mixing diesel with ethanol blends.

Using ceramic heater improved engine performance to 2% and controlled the emissions and reduced unburned HC by 7.5ppm.

The brake specific fuel consumption is slightly increased by 62g/Kwhr for B5D65E30 and 58g/Kwhr for B5D70E25 blends at 1250 rpm and 60g/Kwhr for B5D65E30 at 1500 rpm.

The break thermal efficiency is increased for the blends of B5D75E20 by 2% and B5D65E30 by 2.5% at the speed of 1250 rpm. When the engine runs at 1500 rpm the break thermal efficiency is increased for the blends of B5D75E20 by 5% at high power and B5D70E25 by 2.5% at low power.

The higher percentages of the ethanol give more CO emission by 70.34% maximum.At half load CO emission is average.For higher engine loads which are above half of the engine load , the CO emission becomes lower than that fuelled by diesel for all the blends for the speed of 1250rpm. CO emission is same for all blends at half load and 5% CO emission is increased at low and high load at the speed of 1500 rpm.

The blends of B5D85E10 the HC emission is reduced by 20ppm. When the engine runs at the speed of 1500 rpm, the HC emission becomes less as the loads increased. Less emission for B0D100E0 and B5D85E10 by 24 ppm and 10 ppm respectively.

NOx emission is reduced for the blends of B0D100E0 and B5D70E25 by 100ppm at the speed of 1250 rpm. When the engine runs at 1500 rpm the NOx is reduced for the blends of B5D65E30 upto half load of the engine by 220 ppm.

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Authors

R. Rama Udaya Marthandan is working as a Professor and HOD at Sun College of Engineering and Technology, Kanykumari District, INDIA. He received the M.E. degree in Mechanical Engineering from Annamalai University in 2000. He is a Head of the Department of Mech. Engg. He is a life member of ASME and ISTE. His research interests include Alternative Fuels and IC Engine.

N. Sivakumar is working as an Assistant Professor at Sun College of Engineering and Technology, Kanykumari District, INDIA. He received the M.E. degree in Mechanical Engineering from Anna University: Chennai in 2004. He is a life member of ISTE. His research interests include Finite Element Analysis.

B. Durgaprasad is working as an Associate Professor at JN Technical University, Ananthapur, Andhra Pradesh, INDIA. He received his Ph.D. in the area of surface ignition IC engine from JNTU in 2000.