Investigation of Effect of Ethanol Blends on Performance Parameters of I.C. Engine

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Abstract— **Alcohols, basically ethanol is considered as a leading alternative fuel for automotive application because of its ability to reduce the air pollution and cost of the fuel. This project investigates the effect of lower ethanol gasoline blends (up to 30% by volume) on performance and emission characteristics of the single cylinder four stroke S.I. engine. Tests were carried out for power, fuel consumption and exhaust emissions for CO and HC atgenerator speed of 1200 rpm to 1500 rpm. Results werecompared with the pure gasoline.**

Keywords:Alternative Fuels, Ethanol, Ethanol blends, Performance Parameters, S.I. Engine.

I. INTRODUCTION

Due to rapid depletion of the reservoirs of the fossil fuels, world turns towards the alternative options. There are different types of petroleum based alternative fuels like bio-diesel, bio-ethanol, natural gas, hydrogen etc. Ethanol is one of them, which can be produced from "cellulosic biomass", such as trees and grasses. Ethanol (CH_3CH_2OH) is made up of a group of chemical compounds whose molecules contain a hydroxyl group -OH bonded to a carbon atom. The most attractive properties of ethanol as a SI engine fuel are high octane number, flame speed and latent heat of vaporization as compared to gasoline. Additional oxygen content of the ethanol improves the combustion due to its leaning effect.The addition of ethanol to gasoline results in the enhancement of the octane number of blended fuels and changes the distillation temperature, apart from reducing the engine emissions.

Currently India's Industrial and Transportation sector is heavily dependent on Fossil fuels. Nearly 70% of India's fossil fuel demand is met by importing from other countries. Thus we lose a large amount of foreign currency. Prices of Fuels will continue to rise due to their limited availability. Our only alternative is to switch to alternate fuels. Use of Ethanol as a fuel is seen as a major breakthrough in India by many. Presently India is self- sufficient in Ethanol production andunlike other countries India produces Ethanol from molasses of sugarcane thereby eliminating the conflict with food crops. Indian government has allowed 5% blending of Ethanol of with Petrol and it is widely practiced in major metropolitan cities of the country. However studies suggest that about 30% ethanol by volume can be used in any standard SI Engine without any major modifications. [2]

The present cost of ethanol (Rs.40) is low as compared to petrol (Rs.80) due to the manufacturing and processing required. Maharashtra has 92 ethanol manufacturing plants with a production capacity of 88.58 crore liters. This capacity is enough to meet the requirement of the state.

II. LITERATURE REVIEW

M-Al-Hasan[1]used a 4 stroke, 4 cylinder SI engine (type TOYOTA, TERCEL-3A), concluded that ethanol addition results in an increase in B.P., B.T.E. & fuel consumption while B.S.F.C and equivalent A/F ratio decreases.American Coalition for Ethanol (ACE)[2]had tested and compared the performance and the cost of different ethanol blends with standard unleaded petrol. The test was performed on 3 different models of General motors, Ford and Honda. The 3 engines showed a lower MPG for E10, E20, E30 without any modifications or technical problems and it was concluded that "In general, the more ethanol used, the lower the cost per mile". A. F. Kheiralla, Mohamed M. El-Awad et al…[3]comparedblends of fuel with unleaded gasoline. Fuel properties of tested ethanol gasoline blends such as density and viscosity increased continuously and linearly with increasing percentage of ethanol while, heat of vaporization decreased with decreasing percentage of ethanol. They tested blends Octane rating based on Research Octane Number (RON) which increased continuously and linearly with increasing percentage of ethanol.Thus they concluded that even though the properties of fuel show deviations it can still be used as an effective fuel for automobiles.Shane Curtis, Mark Owen et al…[4] conducted research to determine the effect of ethanol blending on the performance and emissions of internal combustion engines that are calibrated to run on 100% gasoline. Experimental tests were performed on an engine using pure gasoline, E10 and E20. The results of the study show that E10 can be used in internal combustion engines without any negative drawbacks. The fuel conversion efficiency remains the same, while CO emissions are greatly reduced. E20 decrease the fuel conversion efficiency and brake power of an engine, but still reduces CO emissions.

From the above literature survey we can conclude that ethanol can be used as fuel and ethanol addition results in an increase in B.P., B.T.E and reduction in CO, HC emission. Even though the addition of ethanol increases fuel consumption (which is not desirable) but still remains as an economical option.

III. EXPERIMENTAL SETUP

A. *Equipment:*

1) Engine

4 Stroke Single Cylinder Bajaj Discover DTS-i Engine was used to carry out the experiment.

Fig. 1 Engine

Following are the specifications of the engine.

Make : Bajaj Auto Ltd.

Type : Bajaj Discover DTS i engine

Engine capacity : 135cc

Displacement : 134.21cc

Max. Power : 9.64 KW @8500 rpm

Max. Torque : 11.88Nm @ 6500 rpm

Medium of cooling : Air

Clutch : Wet, Multi-plate clutch

2) Electric Dynamometer

An Electric dynamometer was used to measure B.P. of the following specification.

Power rating : 3.5 KW

Rated speed : 1500 rpm

3) Exhaust gas analyzer

Exhaust gas analyzer device was used to determine the CO and HC emissions from exhaust of S.I. engine.

4) Tachometer

Tachometer was used to measure rotational speed of output shaft of gear box.

B. *Preparation of Ethanol Blends and determination of its properties:*

The ethanol used in this experiment was colorless and of 99.9% purity. Gasoline was used as reference fuel in this study. Blends preparations were done by mixing gasoline and ethanol into a container on volumetric basis.The different Ethanol blends used in the experiment are listed in the Table 3.1. Determination of Fuel properties were carried out at Chemistry lab in the college. Each fuel sample was evaluated to determine the specific gravity, viscosity and calorific value which is mentioned in the Table 3.2. Various apparatus were employed in the determination of these fuel properties. Specific gravity was measured using electric digital balance, Calorific value was measured using bomb calorimeter, Viscosity was measured using Viscometer.

Ethanol was blended in gasoline in concentration of 10%, 20%, 30% and these blends are known as E10, E20 and E30.

Table No.1 Types of Blends

Abbreviation	Constituents
Gasoline	100% gasoline (reference fuel)
E10	90% gasoline + 10% ethanol
E20	80% gasoline + 20% ethanol
E30	70% gasoline + 30% ethanol

Table No.2 Properties of Ethanol Blends

Fuel	Viscosity (mm^2/sec)	Calorific value(KJ/Kg) C.V	Specific Gravity S.G.	Cost (Rs.)
Gasoline	0.4872	43021.56	0.7023	80
E10	0.5383	42246.407	0.7157	76
E20	0.6007	40536.388	0.7244	72
E30	0.6614	38866.239	0.7331	68

The addition of Ethanol to Petrol resulted in decrease in calorific value of the blends but the viscosity and specific gravity of fuel increases with increasing percentage of ethanol.

C. *Fabrication:*

The following things were fabricated for preparation of the test rig and suitable attachments were added.

1) Foundation Frame

A C-channel (3 inch) rectangular frame was fabricated according to our requirements. Size of C channel was kept sufficient enough to sustain dynamic load of the set up. Fabrication of frame was done as per professional standards.

Fig. 2 Foundation Frame

2) Sub-Frame

A sub-frame of sufficient strength fabricated to mount the Engine and Dynamometer on foundation frame.

Dimensions:

Small frame: 205x190mm

Big frame: 260x345mm

Fig. 3 Sub-Frame

3) Vibration Pads

Four vibration pads eachof capacity of minimum 150 kg were attached to the base of the foundation frameto absorb dynamic vibrations generated during running of the Engine.

Fig. 4 Vibration Pads

4) Flange Coupling

A Cast Iron standard size flange coupling was purchased and turning, facing, drilling, boring, tapping operations were performed to modify it according to our required dimensionsto couple the output shaft of gearbox to the dynamometer shaft.

Fig.5 Flange Coupling

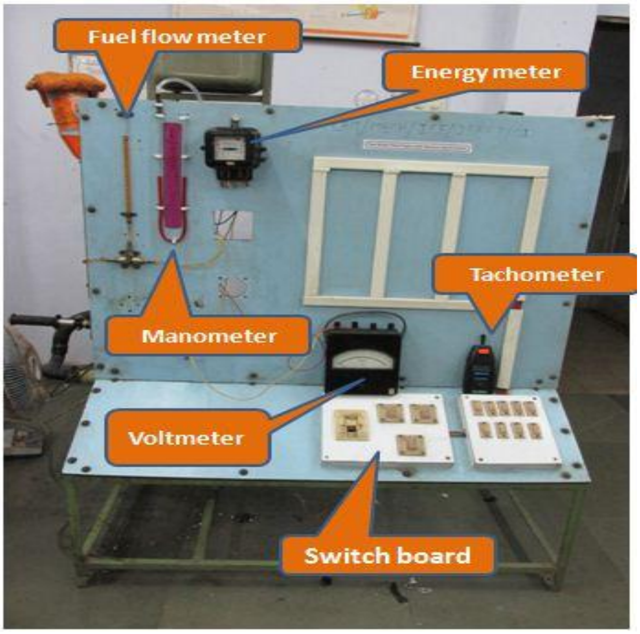

Fig. 6 Experimental Setup

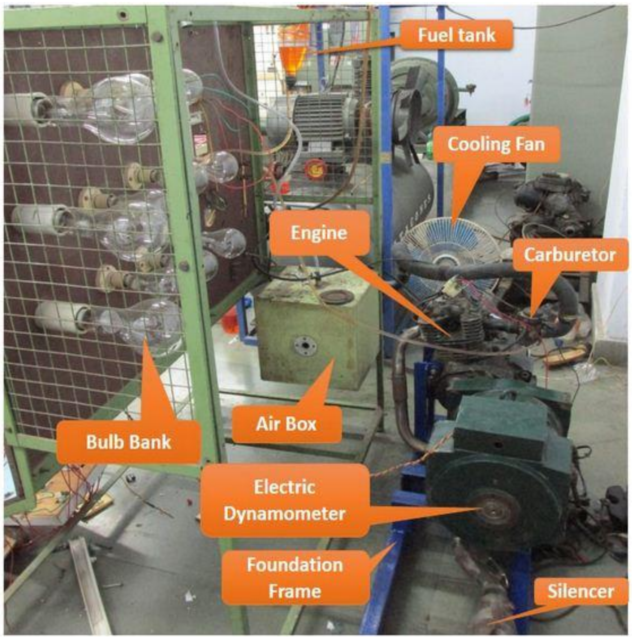

Fig. 7 Experimental Setup

IV. METHODOLOGY

Step 1: Test rig consisting of engine, electric dynamometer, orifice meter, fuel flow meter was prepared.

Step 2: E10, E20, E30 blends were prepared (on volumetric basis) and specific gravity, viscosity, calorific values were obtained.

Step 3: The engine wasallowed run at required fuel flow and speed for about 5 minutes in order stabilize the engine.

Step 4: Readings for calculating B.P., B.S.F.C, Emissions (CO and HC) weretaken at different loads and different speeds.

Step 5: Comparison of performance parameters and emission characteristics for all blends were done.

V. RESULTS AND DISCUSSION

The output power, fuel flow, manometric pressure and rpm were measured. The brake power, brake specific fuel consumption and brake thermal efficiency were calculated and the following graphs were obtained.

Brake Power (B.P.)

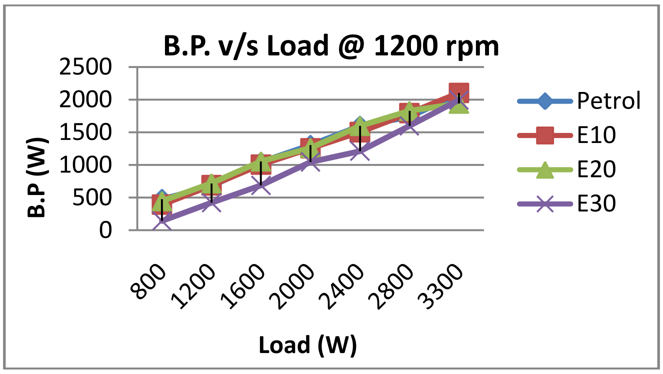

Fig. 8 Effect of ethanol blending on B.P. at 1200rpm

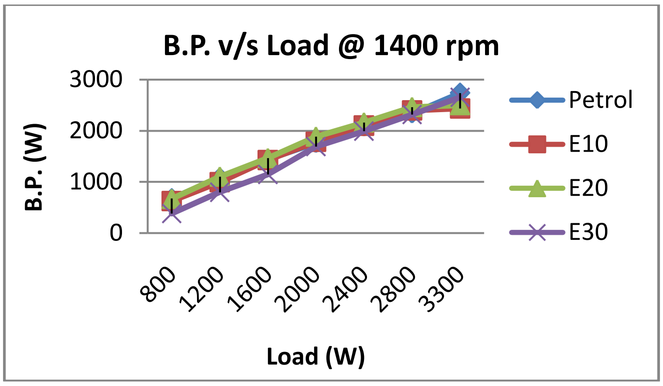

Fig. 9 Effect of ethanol blending on B.P. at 1400 rpm

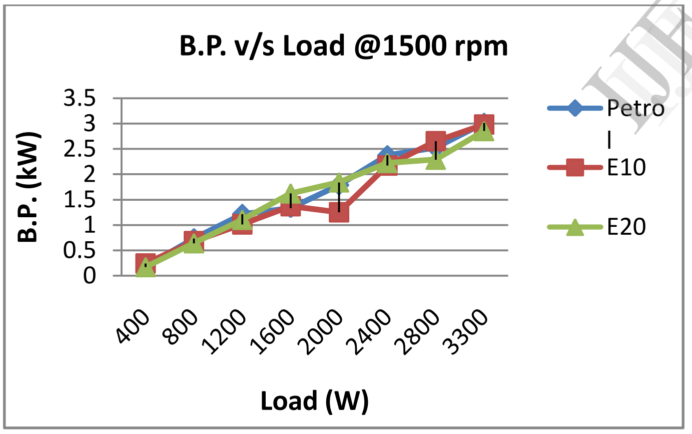

Fig. 10 Effect of ethanol blending on B.P. at 1500 rpm

Fig. 8, 9, 10 show that the Brake power obtained by E10 and E20 are close to petrol while it decreases for E30.

Fig. 8, 9, 10 give us an overall idea of how the engine runs and produces power after addition of ethanol to petrol. For E10 it can be observed that the power output is similar to that of petrol and in some cases the power output is even more than petrol. Addition of ethanol makes a significant impact as the load and speed of the engine increases.

In case of E20 it can be observed that the power output is same or decreases not more than 9% in the worst case. An overall average we can say that the power drop is within 3%, which is a very small number. Such power differences in case of an I. C. Engine can also be observed as the operating conditions change. It can be said that the power drop is negligent and similar to that of petrol.

E30 is a blend consisting of higher percentage of ethanol, it can be seen that at no loads the engine was not holding a stable rpm. As the engine was loaded the, it stabilized and enabled us to take proper readings. It can be seen that the power drop is significant in case of E30. At 1500rpm the engine was not running stable, even under loaded conditions hence it, was not possible to take constant readings from the engine.

Brake Specific Fuel Consumption (B.S.F.C.): Fuel consumed for one kilowatt power generation in one hour is defined as brake specific fuel consumption. Fuel consumption increases with increase in load but brake specific fuel consumption decreases with increase in load as it is function of fuel consumption and brake power.

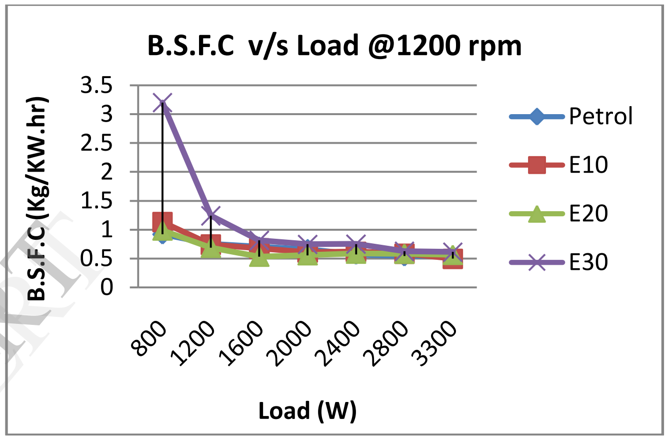

Fig.11 Effect of ethanol blending on B.S.F.C. at 1200 rpm

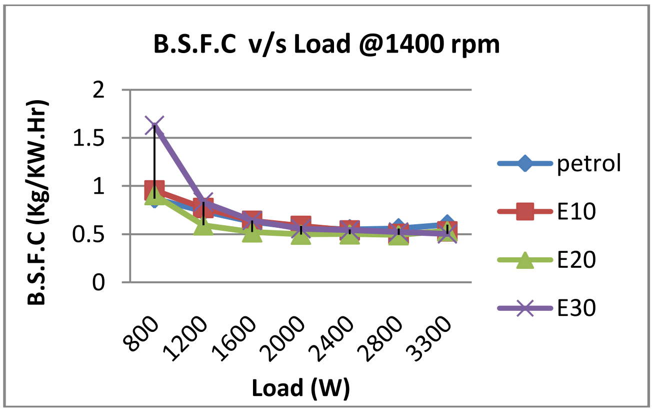

Fig.12 Effect of ethanol blending on B.S.F.C. at 1400 rpm

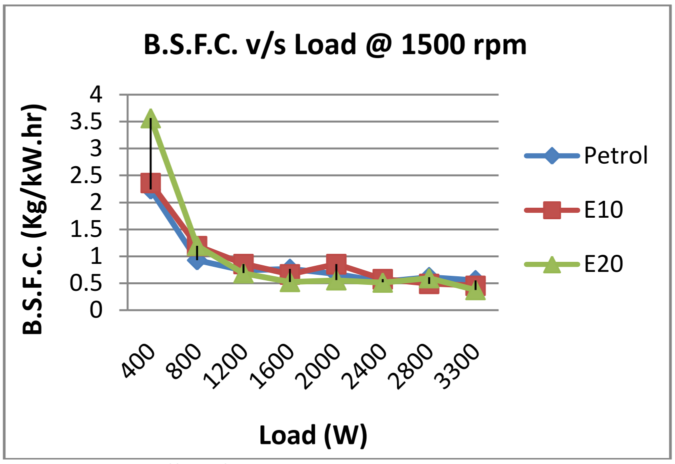

Fig. 13 Effect of ethanol blending on B.S.F.C. at 1500 rpm

Fig. 11, 12, 13 show that B.S.F.C. is maximum for E30 at low loads and minimum for E20. B.S.F.C. for petrol and E10 are almost same.

For E10 the B.S.F.C. is almost same as that of petrol but in case of E20 it is almost same as that of petrol and E10 at lower loads but decreases as the load on the engine increases. From the same it can be seen that in spite of decreasing calorific value of the fuel the B.S.F.C. decreases, this can be credited to the better combustion of fuel inside the combustion chamber. The oxygen content in ethanol leads to better mixing of the mixture as well as the combustion of the fuel. The various parameters like atomization of fuel and mixing is also affected due to the low vapor point of ethanol. These factors help the ethanol blend to better mix with the available air and the higher burn rate or flame speed of ethanol help it burn more efficiently than only petrol.

Brake Thermal Efficiency (B.T.E.): Thermal efficiency is function of calorific value and brake power. We discussed effect of calorific value and presence of oxygen with in blend. The presence of oxygen to particular level gives you complete combustion which compensates the effect of calorific value.

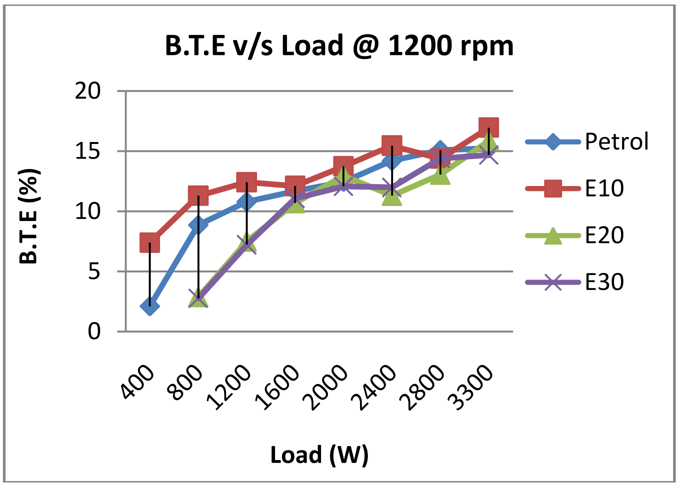

Fig.14 Effect of ethanol blending on B.T.E. at 1200 rpm

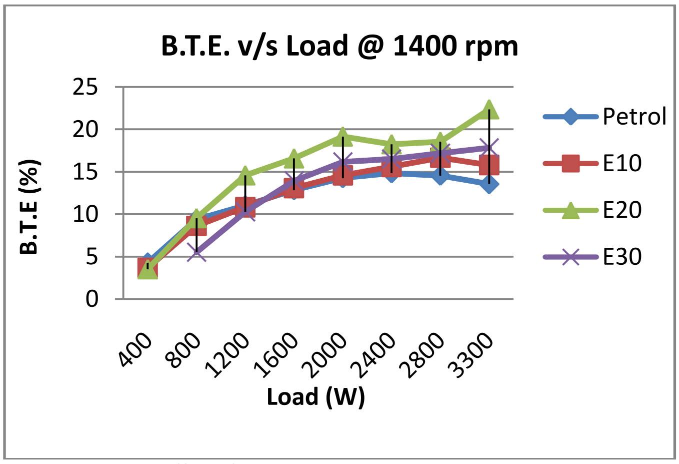

Fig.15 Effect of ethanol blending on B.T.E. at 1400 rpm

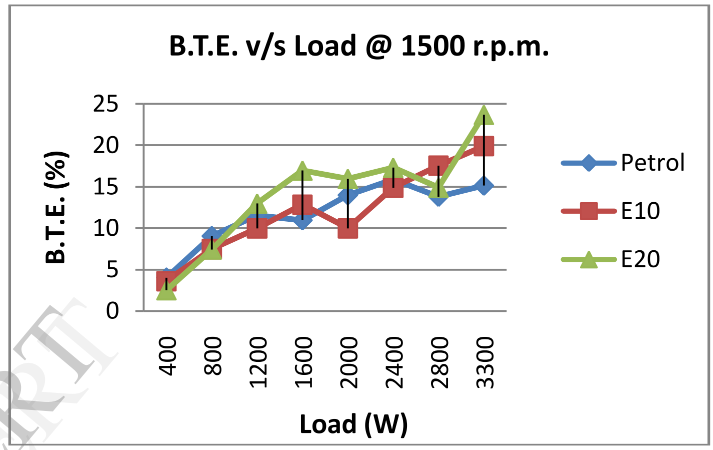

Fig.16 Effect of ethanol blending on B.T.E. at 1500 rpm

Fig. 14, 15, 16 show that the higher B.T.E. is obtained for E10 at 1200 rpm and E20 at 1400 and 1500 rpm. Maximum B.T.E. obtained was 23.7% for E20 at 1500 rpm.

From the above graphs it can be seen that, the B.T.E. of ethanol blends is more than that of the petrol on an average. Its lower or same at low loads and low speeds, but as the loads and the speeds increase the B.T.E. increases. As ethanol has lesser impurities like sulfur and other elements, its more pure and thus burns more efficiently. This with the oxygen help in better combustion of the fuel and hence the entire fuel's heat can be better used up in the engine.

From the graphs it can be observed for E20 overall the B.T.E. is more than other fuel blends tested in the experiment. Also the higher heat of vaporization of ethanol helps it to maintain the operating temperature of the engine and prevent issues like overheating as well as other phenomenon like detonation and knocking which may be caused due to higher combustion chamber temperatures.

CO: Carbon monoxide is product of incomplete combustion of fuel. Formation of carbon monoxide indicates loss of power, result of oxygen deficiency in combustion chamber. Thus an increase in oxygen content with increasing percentage of ethanol results in more complete combustion due to which CO emissions are reduced. This is validated by the graphs obtained.

Fig. 17, 18, 19 show that CO emission decreases with increase of percentage of ethanol in the blends. Minimum CO emissions were found for E30.

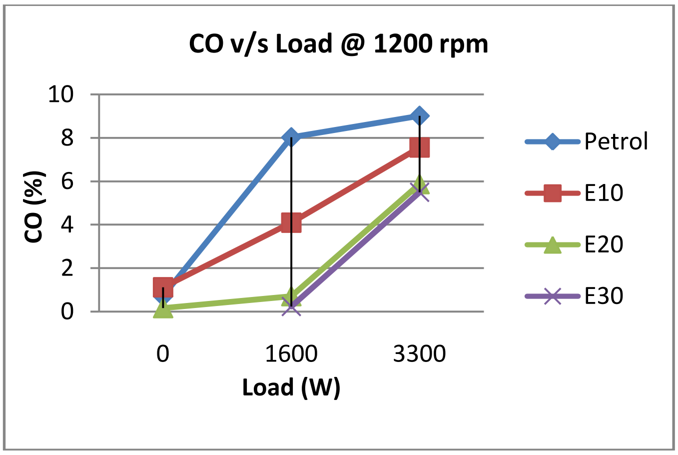

Fig.17 Effect of ethanol blending on CO Emission at 1200 rpm

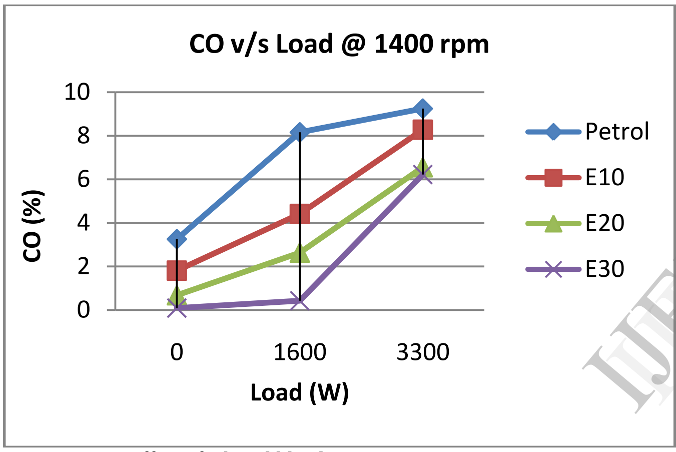

Fig.18Effect of ethanol blending on CO Emission at 1400 rpm

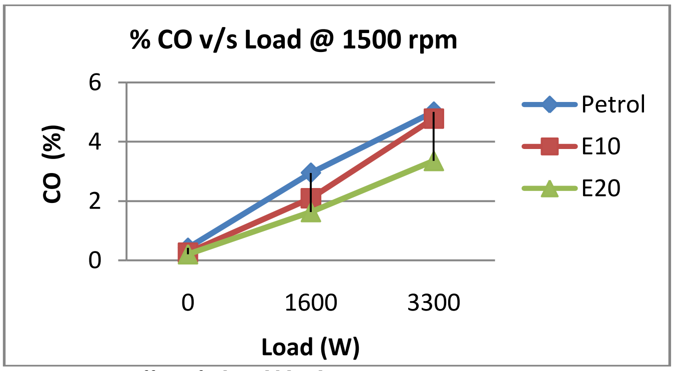

Fig.19 Effect of ethanol blending on CO Emission at 1500 rpm

HC: Hydrocarbon is also product of incomplete combustion of fuel. The formation of hydrocarbon is due to lack of complete air supply. HC emission indicate power loss, higher the hydrocarbon emission higher the power loss resulting into less brake thermal efficiency. Addition of alcohol gives you lesser hydrocarbon emission eliminating need of after burner and other devices. When gasoline tested of engine the HC emission was significantly high. But with addition of ethanol, hydrocarbon emission lowered down significantly.

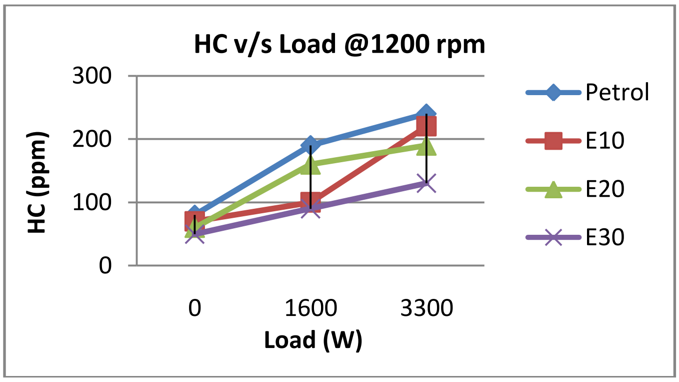

Fig.20Effect of ethanol blending on HC Emission at 1200 rpm

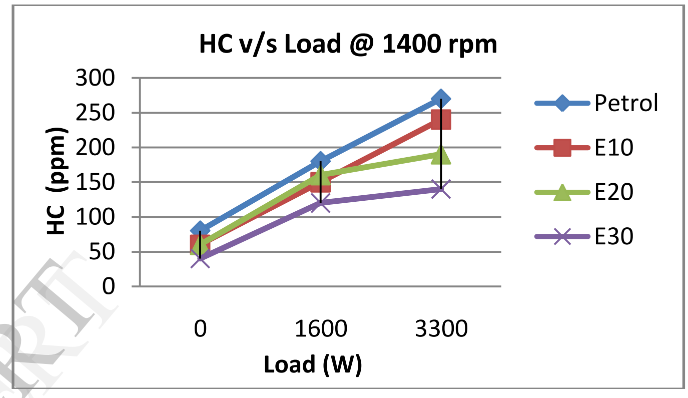

Fig.21Effect of ethanol blending on HC Emission at 1400 rpm

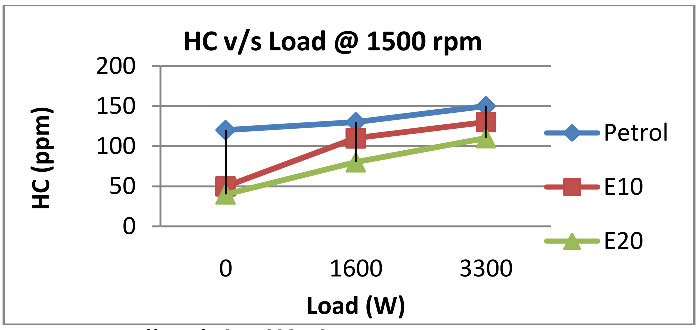

Fig.22 Effect of ethanol blending on HC Emission at 1500 rpm

Fig. 20, 21, 22 show that HC emissions also decrease with increasing percentage of ethanol there by causing less pollution.

VI. CONCLUSION

Brake Power at different loads is almost same for petrol, E10 and E20 while it decreases for E30 Minimum B.S.F.C. is obtained for E20. Maximum B.T.E. (23.7%) is obtained for E20 at 1500 rpm. HC and CO emission reduced for all the blends since oxygen in the fuel helps in better combustion, CO gets converted in to CO_2. Minimum HC and CO emissions are obtained for E30. At 1500 rpm Engine was unstable for E30 thus, it was not possible to take observations and hence we can conclude that E30 cannot be directly used.

From the observation of all graphs we conclude that **E20** gives more B.P., less B.S.F.C., more B.T.E., less emission of CO and HC as compared with petrol, E10 and E30 also it is cost effective compared with petrol hence **E20** is the most efficient and economical ethanol blend and can be directly used for a 4-Stroke S.I. engine without any modifications.

VII. ACKNOWLEDGEMENT

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