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Experimental determination of suitable ethanol–gasoline blend for Spark ignition engine

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Abstract: - Ethanol produced from biomass has high octane number and good antiknock characteristic, less ozone depletion potential and global warming potential than the pure gasoline, therefore it can be used as a blended fuel with gasoline fuel in the S.I. engine. In this paper the experimental investigation of four stroke petrol engine is carried out to analyze the engine performance and emission characteristics. Engine performance and exhaust emission are determined using different blend ratios of ethanol with gasoline (E0, E20, E40, E60, E80, and E100) to evaluate the most suitable blend. In this study the engine with compression ratio 10:1 is tested using pure gasoline and various blends by varying Brake power at constant engine rpm. Performance tests are conducted for total fuel consumption, brake specific fuel consumption, brake thermal efficiency and exhaust emissions. The exhaust emissions are analyzed for carbon monoxide (CO), and unburned hydrocarbons (HC). The results shows that blending of ethanol with gasoline increases fuel consumption, brake specific fuel consumption, brake thermal efficiencies, while the CO and HC concentration in the emissions of engine exhaust decreases considerably

Keyword – ethanol, gasoline, four stroke petrol engine.

Introduction

Petroleum reserve is limited in the world, and conventional use leads to its depletion, therefore replacement of gasoline by liquied fuel produced form renewable sources is a high priority in many countries worldwide. Ethanol can be produce from ligno-cellulosic material like wood, agricultural, forest residues and municipal waste[1] has potential to be valuable substitute for gasoline fuel, since Ethanol possesses characteristic, properties that have positive influence on engine performance as well as exhaust emissions. The engine shows better performance with reduction in hydrocarbons and carbon monoxide with use of ethanol with gasoline, although there are some drawback with use of pure ethanol, [2] phase stability is main concern when hydrous ethanol is used with petrol, the heating value of ethanol is lower than that of gasoline, however characteristic like auto-ignition temperature and flash point is higher than gasoline which make is easier and safe in transportation and storage[3]. Several additives (oxygenated organic compounds) such as methanol, ethanol, tertiary butyl alcohol and methyl tertiary butyl ether are used as fuel additives[4]. Although having these advantages, due to limitations in technology, economic and regional considerations alcohol fuel still cannot be used extensively. Since ethanol can be fermented and distilled from biomasses, it can be considered as renewable energy under the environmental consideration, using ethanol blended with gasoline is better than methanol because of its renewability and less toxicity.[1] At the present time and instead of pure ethanol, a blend of ethanol and gasoline is a more attractive fuel with good anti-knock characteristics for SI Engines. Due to the high evaporation heat, high octane number and high flammability temperature, ethyl alcohol has positive influence on the engine performance and increases the compression ratio. The low Reid evaporation pressure enable to storage and transportation safely.[3]

Literature Review:

Effect of Ethanol on engine performance and Emissions

Colorado[4] shows the experiment done during the open-loop control of ECU on fuel injection rate in the cold-start period, the fuel injection rate is roughly the same for all fuels (E0 through E40) used. This made the percentage of excess air in the air/fuel mixture of E5, E10, E20, E30, and E40 to be 2%, 4%, 9%, 14%, and 19%, respectively. For E5-E30, the engine can run smoothly. For E40, the air/fuel mixture in the engine was too thin so as to cause engine speed instability. As far as emissions are concerned, E5 and E10 performed almost indistinguishably from the gasoline (E0), while E20 e E40 clearly decreased HC, CO and NO emissions. Therefore, in conclusion, the ethanol content in gasoline for best cold-start emissions was determined to be at least 20 per cent but no greater than 30 per cent.

Lan-bin[5]. In this paper the effects of ethanol and DMC addition to unleaded gasoline on SI engine exhaust emissions at a constant engine load (3 N m) and at five different engine speeds were investigated The ratio of ethanol and DMC was taken (E5, E10,E15, D5, D10, D15). Compared to unleaded gasoline, E10 and D5 blended fuels produced the best results in engine emissions. Using oxygen containing additives increased fuel consumption. The HC emission of E10 and D5 are reduced about 24% and 35%, respectively, and the CO emission by about 61% and 65%, respectively. On the other hand, the CO2 emission of E10 and E5 increased by about 14.8% and 18%, respectively.

The effects of unleaded gasoline (E0) and unleaded gasoline–ethanol blends (E50 and E85) on engine performance and pollutant emissions were investigated in a single cylinder, four stroke, spark-ignition engine at WOT and compression ratios of 10:1 and 11:1Torque with blended fuels (E50 and E85) were generally found to be higher than that of base gasoline (E0) in all the speed range. The lower energy content of ethanol–gasoline fuel caused some increment in brake specific fuel consumption of the engine depending on percentage of ethanol in the blend. A significant reduction in HC emissions was observed as a result of the leaning effect and additional fuel oxygen caused by the ethanol addition. But, HC emissions increased at higher compression ratio due to higher surface to volume ratio.[6]

Ethanol was used as fuel at high compression ratio to improve performance and to reduce emissions in a small gasoline engine with low efficiency. Initially, the engine whose compression ratio was 6/1 was tested with gasoline, E25 (75% gasoline + 25% ethanol), E50, E75 and E100 fuels at a constant load and speed. It was determined from the experimental results that the most suitable fuel in terms of performance and emissions was E50. Then, the compression ratio was raised from 6/1 and 10/1. The engine was tested with E0 fuel at a compression ratio of 6/1 and with E50 fuel at a compression ratio of 10/1 at full load and various speeds without any knock. The cylinder pressures were recorded for each compression ratio and fuel. The experimental results showed that engine power increased by about 29% when running with E50 fuel compared to the running with E0 fuel. Moreover, the specific fuel consumption, and CO, CO2, HC and NOx emissions were reduced by about 3%, 53%, 10%, 12% and 19%, respectively.[7]

The effect of compression ratio on engine performance and exhaust emissions was examined [8] at stoichiometric air/fuel ratio, full load and minimum advanced timing for the best torque MBT in a single cylinder, four stroke, with variable compression ratio and spark ignition engine The fuels containing high ratios of ethanol; E40 and E60 had important effects on the reduction exhaust emissions. The maximum decrease was obtained with E40 and E60 fuels at 2000 rpm engine speed. The average decreases were found to be 11% and 10.8% with E40 and E60, respectively. The better decrease was obtained with HC compared with CO. The maximum decrease in HC emission was obtained using E60 as average of 16.45% at 5000 rpm engine speeds.

By using ethanol–gasoline blend, the peroformance analysis of a spark-ignition engine was experimentally investigated. Sixty percent ethanol and 40% gasoline blend was exploited to test the performance, the fuel consumption, and the exhaust emissions. As a result of this study, it is seen that a new dual fuel system could be serviceable by making simple modifications on the carburetor and these modifications would not cause complications in the carburetor system.[9]

Performance tests were conducted for equivalence air–fuel ratio, fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide (CO), carbon dioxide (CO2) and unburned hydrocarbons (HC), using unleaded gasoline–ethanol blends with different percentages of fuel at three-fourth throttle opening position and variable engine speed ranging from 1000 to 4000 rpm. The results showed that blending unleaded gasoline with ethanol increases the brake power, torque, volumetric and brake thermal efficiencies and fuel consumption, while it decreases the brake specific fuel consumption and equivalence air–fuel ratio. The CO and HC emissions concentrations in the engine exhaust decrease, while the CO2 concentration increases. The 20 vol. % ethanol in fuel blend gave the best results for all measured parameters at all engine speeds.[10]

Experimental investigations have been carried out to performance and emissions of single cylinder four-stroke spark ignition engine at full throttling position of engine and different load conditions is used to different fuels (Gasoline and LPG) at various compression ratios (4.67:1,5.49:1). The test result indicated that LPG fuel have closer performance to Gasoline fuel. However, the brake specific energy consumption shows an improvement with LPG as a fuel replacement. The concentration levels of CO, CO2 and unburnt HC recorded are found to be lower than the gasoline fueled engine.[11]

Table 1 **Property of gasoline and ethanol**

Fuel property	Gasoline	Ethanol
Chemical formula	C_8-C_{14}	C_2H_5OH
Latent heat (kJ\kg)	223.2	725.4
Octane number	88-100	108.4
Boiling point (^oC)	27 - 225	78
Density (Kg/m^3)	765	785
Net lower heating value (MJ\kg)	43.5	2

Experimental setup and test procedure:

The experimental setup consists of Single cylinder Four-stroke petrol engine the detail specification of engine is given in table 1

Table 2 : General specification of test engine

Engine type	Enfield, air cooled, water cooled, spark ignition engine
Number of cylinder	1
Cylinder bore	70 mm
Stroke	60 mm
Rated speed	2800 r.p.m
Rated power	2.5 B.H.P
Compression ratio	10:1
Exhaust gas analyzer	AVL DIGAS
Model no	444

Specification of AVL DiGas
Table 2

Measured Quality	Measurement range
CO	0… 10 % vol
HC	0… 20000 ppm
NOx	0… 5000 ppm

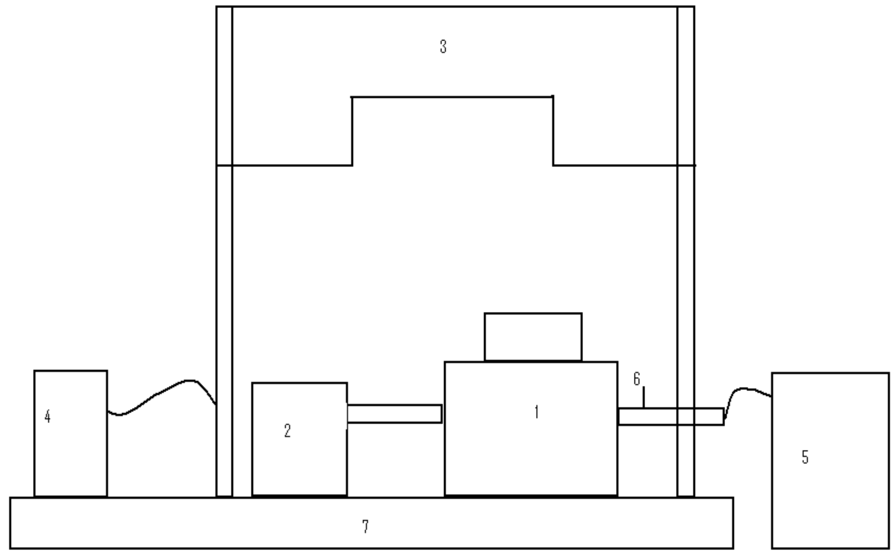

Fig 1. Schematic diagram of experimental set up 1.engine 2. DC motor 3 control penal 4. Water rheostat 5. Exhaust gas analyzer 6.exhaust gas pipe 7. Engine base.

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The engine is equipped with DC Machine and water rheostat in order to apply the required load A series of experiment was carried our using gasoline, ethanol and various blends, All the blends was tested under varying load condition. During each trial engine was started so that engine attains stable condition. Important parameter related to thermal performance of the engine such as fuel consumption, applied load, the ammeter and volt meter reading were measure and recorded . The engine emission parameter like CO, HC and Exhaust temperature was noted and recorded.

Test cases examined

In the experimental study, a single cylinder four stroke spark ignition engine was used. Specification of test engine are given in Table 2. The experiment was conducted at varying the engine load from no load, 440W, 880W, 1320W, 1760W, and 2200 W. The test fuel were gasoline (E0) and gasoline-ethanol blends E20 , E40, E60, E80, E100, the number following E Indicate percentage of volumetric amount of ethanol (99.9% pure). The experiment was performed at 10:1 compression ratio and constant speed 2800 r.p.m. Property of ethanol and gasoline are show in table 3., specific fuel consumption, energy consumption, thermal efficiency, exhaust temperature and pollutant emission was measured during experiment.

Table 3
Properties of gasoline fuel blended with various percentages of ethanol (Average values)

Sample code	% ethanol	%gasoline	Flash point(c°)	Auto ignition temp(c°)	Octane number	Specific gravity
E0	00	100	-65	246	91	0,7474
E20	20	80	-20	279	94	0.7605
E40	40	60	-13.5	294	97	0.7792
E60	60	40	-1	345	100	0.7812
E80	80	20	5	362	104	0.7834
E100	100	0	125	365	129	0.7890

Result and discussion

Effect on Total fuel consumption

Figure shows the effect of the ethanol fuel blending on the total fuel consumption (T.F.C). The T.F.C is s increased as the volume percentage of ethanol fuel is increased in the mixture. This is due to the lower heating value of ethanol compared with gasoline.

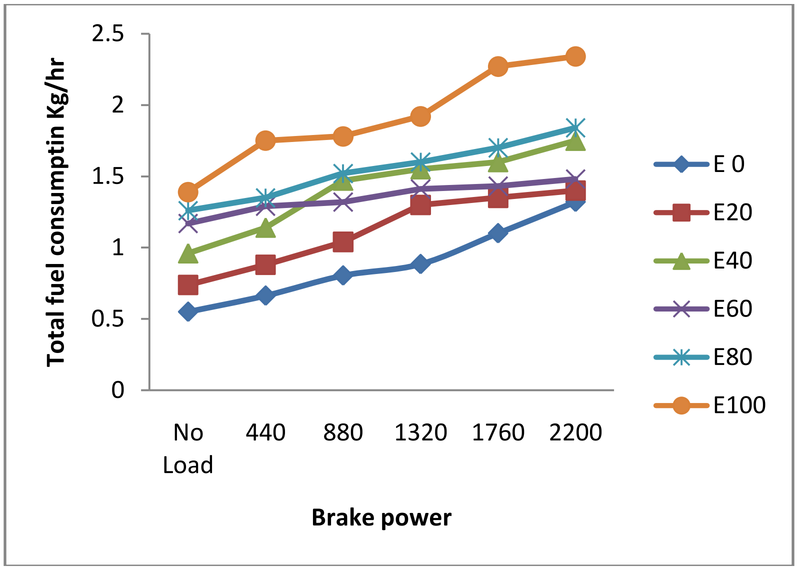

fig 1 . Graph between Brake power versus total fuel consumption

Effect on Brake specific fuel consumption

The variation of BSFC with brake power for different percentage of Ethanol with the gasoline as shown in fig. The additive of Ethanol shows slightly higher BSFC compare to gasoline. This behavior is attributed to the LHV per unit mass of the Ethanol fuel, which is distinctly lower than that of the gasoline fuel. Therefore the amount of fuel introduced in to the engine cylinder for a given desired fuel energy input has to be greater with the Ethanol fuel. The BSFC decreases with the increasing loads. It is inversely proportional to the thermal efficiency of the engine.

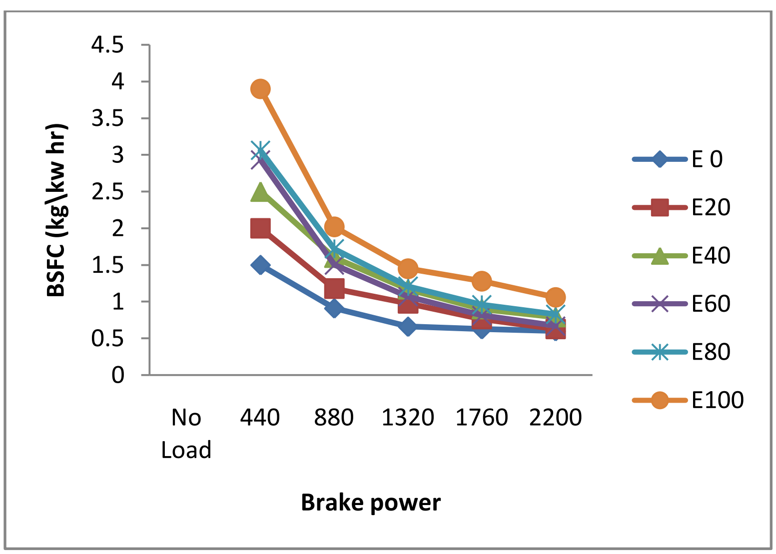

fig 2 Graph between Brake power versus bsfc

Effect on Brake thermal efficiency

The variation of BTE with brake power for different percentage of additives of Ethanol with the gasoline as shown in fig. The additive of Ethanol shows The BTE is higher than the gasoline. The BTE is higher for various additives because of improve combustion efficiency. The brake thermal efficiency is based on B.P and calorific value. of the engine . Brake thermal efficiency gradually increases with increase in percentage of additives. It is observed that brake thermal efficiency is low at low values of B.P and is increasing with increase of B.P for all additives of fuel.

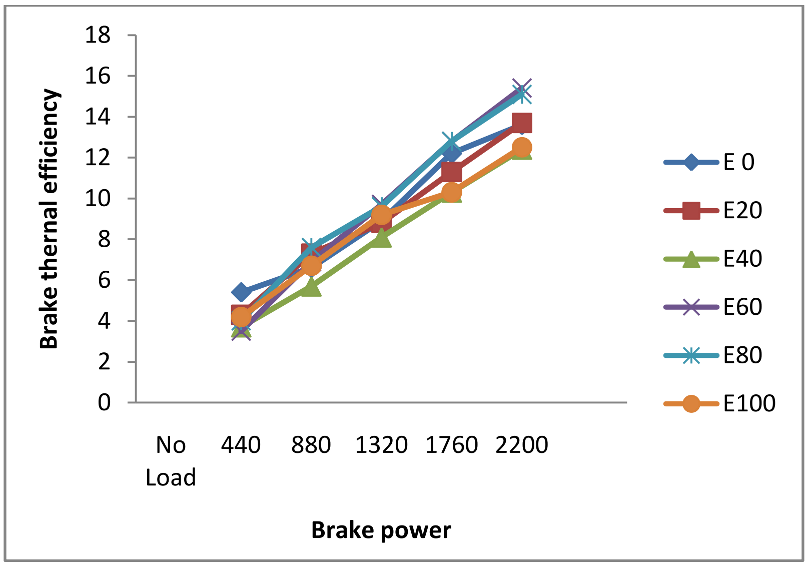

fig3 Graph between Brake power versus BTE

Effect on Carbon monoxide emission (co) emission

It is a product of incomplete combustion due to insufficient amount of air in the air- fuel mixture. When Ethanol containing oxygen is mixed with gasoline, the combustion of the engine becomes better and therefore, CO emission is reduced. fig 1 show the Effect of the ethanol fuel blending on the HC and CO emissions. The concentration of HC and CO is decreased as the volume percentage of ethanol fuel is increased in the fuel mixture. This is due to the reduction in carbon atoms concentration in the blended fuel and the high molecular diffusivity and high flammability limits which improve mixing process and hence combustion efficiency. The stochiometric air–fuel ratio of ethanol is about 2/3 that of gasoline, hence the required amount of air for complete combustion is lesser for ethanol. When the engine condition goes leaner, the combustion process is more complete and the concentration of CO emission gets lower.

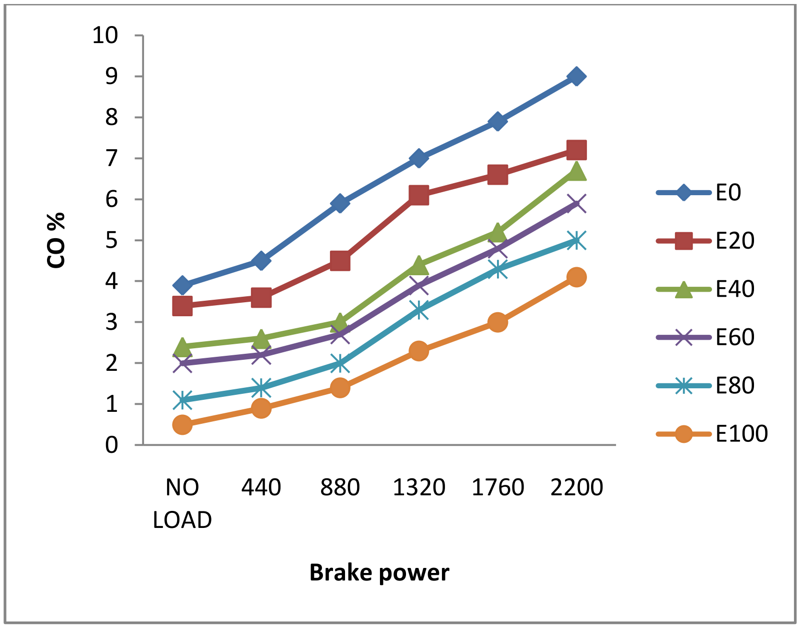

fig 4 Graph between Brake power versus CO

Effect on Hydrocarbon (HC) emission

Rich air fuel ratio with insufficient oxygen prompts the incomplete combustion of fuel as a misfire produces the unburnt hydrocarbon. When ethanol is added to the blended fuel, it can provide more oxygen for the combustion process and leads to the so-called "leaning effect". This indicates that the engine tends to operate in leaner conditions, closer to stoichiometric burning as the ethanol content is increased. Its final result is that better combustion can be achieved therefore the concentration of HC emission decrease as the ethanol content increase.

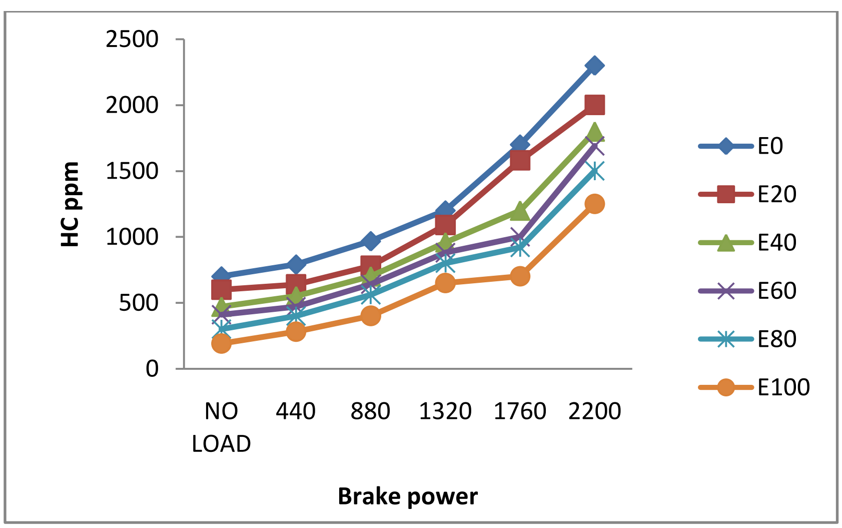

fig 5 Graph between Brake power versus HC

Effect on Exhaust temperature

When ethanol percentage increase exhausts gas temperature decrease show in fig. Exhaust gas temperature is the function of combustion temperature and the temperature of the combustion is depends upon the heating value of the fuel. Heating value of the ethanol is less compared to the gasoline, therefore with the increase of ethanol percentage the combustion temperature decrease as result is exhaust gas temperature decrease.

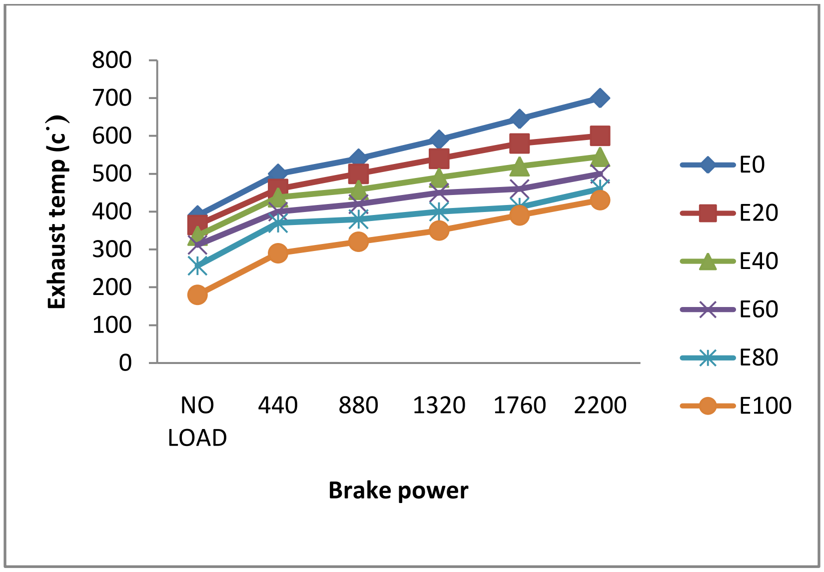

fig 6 Graph between Brake power versus exhaust gas temperature

CONCLUSION

Experiments have been conducted on single cylinder four stroke petrol engines with different percentage of ethanol as additive to gasoline. It is concluded that, the percentage of additive increases the emission characteristics improved .It is observed that the emission values of the HC and CO are decreased when compared with petrol. For the performance it may be concluded that calorific value of ethanol is less (2700kJ/kg) as compare to petrol (44800 kJ/kg). Decrease in calorific value results in higher consumption of fuel for ethanol-gasoline blend as compare to petrol. The brake thermal efficiency increases with increase in percentage of additive. The E60 and E40 gave the best result for all measured parameters at all engine loads Thus ethanol may be used as a additive for gasoline in future. Brake Thermal Efficiency, is increased as the volume percentage of ethanol fuel is increased in the mixture E60 have good thermal efficiency at higher load. As we increase the percentage of Ethanol in fuel Specific fuel consumption increases. This is due to the lower heating value of ethanol compared with gasoline, E60 gives better results as compared to E0 and E20.

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