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Presentation Investigation of Spark Ignition Engine by means of Blend of Butanol And Ethanol with Gasoline

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ABSTRACT

In an automobile the power developed basically depends upon the fuel used for combustion. Gasoline and Diesel are used in liquid form which is extensively used in the world from last century. These fuels are obtained from crude oil reserves, which is available in limited quantity in the world. This situation will create a problem for energy crises in the future. The fossil fuels are also the big source of air pollution which is having a negative impact on environment as well as on human health.In the present scenario, ethanol is being used as an additive with gasoline in many of the countries of the world. At present in India, 10 percent ethanol mixing with gasoline is mandatory by the Government of India and from the year of 2017, it will be 20 percent. From the past researches it has been found that ethanol is a good replacement of gasoline but is has many disadvantages like: - due to its hygroscopic nature, ethanol damages the internal part to the engine, it effects the metallic as well as non-metallic part of the engine. For overcoming the problems an effort has been made in this study by using butanol as an additive with ethanol gasoline blends because butanol is not hygroscopic in nature and does not rust the internal parts of the engines.In this report, performance analysis of multi cylinder spark ignition engine has been evaluated on ethanol gasoline blend with or without butanol addition. Ethanol was added with gasoline in three different volumetric ratio as 10,20 and 30 percent. Butanol was added in the volumetric ratios of 2.5,5,7.5 and 10 percent with ethanol gasoline and gasoline. Various performance parameters of the engine such as bsfc. BTE, BSEC and EGT have been observed. Exhaust emission such as carbon monoxide, hydrocarbon and oxides of nitrogen has also been observed. The results show that addition of butanol in ethanol gasoline blends had positive effect on the engine performance. Emissions of CO and HC founds to be lower compared to ethanol gasoline blends and gasoline. While NOX emission were on higher side. Overall, additive blends have been performed well and found suitable without any hardware modification of the engine.

Keywords: - SI Engine, Butanol, Ethanol, Biofuel, Brake Horsepower, Gasoline, Brake Thermal Efficiency

INTRODUCTION

The Automobile industry is the largest sector in the world which uses various fuels and are reliable source for transportation and power generation. The power developed by an automobile basically depends upon the fuel used for the combustion. Petrol and Diesel are the basic fuels in liquid form which are extensively used in the world from the last century. These fossil fuels are derived from crude oil, available in limited quantity in the world. The demand of fossil fuel is rising rapidly because of increase in vehicles due to which the resource of crude oil are depleting rapidly. The present situation will create a problem for energy crises in the future. In fact, with a worldwide increase in the number of automobiles and a rising demand of emerging economics demand will probably rise even harder. Transport fuel demand is generally satisfied by the fossil fuel demand. However, resources of these fuels are decreasing, prices of fossil are expected to rise and the combustion of fossil fuels has adverse effects on environment.

The reliance on fossil fuel is increasing day by day but the combustion of these fuels and also effecting the climate of the earth. The greenhouse gasses are increasing due to increase in number of vehicles. Many efforts are made by numerous countries to fix the value of exhaust emissions coming out from the automobiles. Still there is a lot of work to do for accomplishing of the hydrocarbon fuels with same alternative fuels like alcohols, ethers etc. due to their compatible properties with hydrocarbons.

About 75 percent of the total crude oil of India is met through imports. Total import of crude oil by India was about 189.238 MMT which cost about Rs. 8,64, 875 Crore during 2013-14. The total production of crude oil was 37,778 MMT in 2013-14. In recent years, the consumption of crude oil in India has been increasing at an annual rate of 5- 6&. (MoPNG,2014). If the use of alcohol as engine fuel is encouraged in India, then apart from saving foreign exchange, the farmers would be motive to cultivate the crops like potato, sugarcane etc. this will increase the production of alcohol through which the air quality increase.In the future, the air pollution will worsen by transportation because of increasing deforestation and number of vehicles. In a report of world health organization on air

pollution. 13 Indian cities are ranked amongst 20 most polluted cities of the world. State Governments are looking for some substitute for reducing air pollution. Another reason of encouraging the development of alternative fuels for internal combustion engine is the difficulty over the emission problems of gasoline and diesel engines. Joint with other air- polluting systems, the large number of vehicles are a major cause to the air quality problem of the whole nation. A considerable measure of changes have to be made in reducing emission from automobile engine. If a 35 percent improvement made over a period of years. It is to be noticed that amid the same time the number of automobiles in the whole world increasing by 40 percent. However, more enhancement are needed to cut down the ever- increasing air pollution due to automobile population The Government of India (GOI) has approved the National Policy on Bio-fuels on December 24, 2009, The policy empowers the utilization of the renewable energy resources as alternate fuel to supplement transport fuels and it proposes an demonstrative target to replace 20 percent of petroleum fuels consumption with bio- fuels Bio-fuels and biodiesel) by end of 12^{th} Five-Year Plan (2017***) TERI, 2007).***

LITERATURE REVIEW

Bayraktar and Duragun (2005) investigated the effect of LPG on SI engine emission and performance. The result revealed that use of LPG has negative effect on engine performance. Fuel economy and engine structural components when used at the same fuel-air-radio in comparison to gasoline. The exhaust emission of Co and No was reduced by using LPG compared to gasoline.

Murillo et al (2005) experimentally reported the pollutant and performance parameter of two different multi-cylinder spark ignition outboard engines. They found that by using LPG, the specific fuel consumption and power output reduced in comparison to gasoline. In view of exhaust emission use of LPG as a fuel helps in the reduction of CO emission but HC and NOX emission were increased.

Yousufuddin and Mehdi (2008) experimentally investigate the performance and emission characteristics of variable compression SI engine fuelled on LPG. The experimental result showed that by using LPG increased the specific fuel consumption and the brake thermal efficiency and volumetric efficiency of the engine decreased in comparison to gasoline. Exhaust emission of CO and HC were increased in comparison to gasoline.

*Ozxean and Yamin (2008) developed a computer simulation on variable stroke length, single cylinder, 4-stroke LPG fuelled engine. The simulation result revealed that brake torque, power and bsfc increase for all stroke length. At low speed the pollutant level found to be increased while at higher stroke length, it was found to be lowered**.***

Lee et 1l. (2009) investigate the performance and emission characteristics of

2.7.L spark ignition engine on LPG fuelled with Di methyl ether (DME) blends. In this study three different blends of DME with LPG were prepared in the volume of 10,20 and 30 percent DME. The result indicated that with the increase in DME content. Engine torque decreased while bsfc increased compared to LPG. Exhaust gas temperature increased for the blend compared to LPG. Addition of DME content increased the knocking tendency in the engine compared to gasoline. Exhaust emission of HC and NOX increased at low engine speed compared to LPG.

Anish Raman et al. (2014) experimentallyfound the behavior of meth tetra butyl ether on multi cylinder. MPFI spark ignition engine on varying engine speed. Addition of meth tetra butyl ether with gasoline helps in the increment of brake specific fuel consumption and brake thermal efficiency in comparison to gasoline. Emission of Co and HC decreased while CO2 and NOX increased for methyl tetra ether –gasoline blends in comparison to gasoline.

Frkuswt al. (2015) conducted experiments on a 1.4-L multi-cylinder SI engine without catalytic converter fuelled with LPG by varying ignitions timing. It was shown that advancing the ignition timing with LPG results in improvement in brake power and brake thermal efficiency. Advancing the ignition timing increased the emission of NOx and negligible effect of CO emission for LPG fuel. HC emission increased as ignition timing advance for LPG fuelled.

Topgiil (2015) investigated the effects of MTBE blends on engine performance and exhaust emission in a single cylinder, four stroke spark ignition engine. Experimental result showed that MTBE blends provided higher value of brake thermal efficiency and lower value of brake specific energy consumption in comparison to unleaded gasoline. The maximum reduction in CO and HC emission were found with MTBE blends and NO emission was higher for MTBE blends in comparison to unleaded gasoline.

TESTING PROCEDURE

Test Engine

A Hindustan Motor make four stroke, four cylinder MPFI gasoline run engine having 8.5:1 compression ratio selected for the study. The engine is commonly used in Ambassador cars for transportation. The specifications of the selected engine are shown in Table 3.1.

Table 3.1 Specification of Engine

Make	**Hindustan Motor**
Model	Ambassador
Number of Cylinder	4
Bore (mm)	84
Stroke (mm)	82
Displacement Volume (cc)	1817
Coolng System	Water Cooled

Fuels and Their properties

The experiments were carried our using butanol, ethanol with gasoline as engine fuel. The volume percentage of butanol was carried from 2.5-10 percent and used as an additive. The volume percentage of ehatnol was kept from 10-30

percent. The gasoline volume percentage was adjusted per the volume required. Total sixteen blends were prepared for the study.

Gasoline

Gasoline is a hydrocarbon fuel which contains carbon molecular in number varying from 4 to 12. Gasoline is also known as petrol or motor sprit and produced by distillation of crude oil. Gasoline is not miscible with water and its elative density varying from 0.72-0.78. Gasoline octane rating is varying from 84 to 95. It also having negligible amount of oxygen molecule. On burning, gasoline produced black smoke which is highly toxic for human being. For this study, IOCl marked gasoline was obtained from the University's filling station.

Ethanol

Ethanol (CH3CH2OH), an oxygenated organic carbon compound, is also known as Ethyl alcohol. It is a small chain high octane alcohol with molecular weight as 46 and containing 35 percent oxygen. Ethanol has high octane quality for spark ignition applications. The concentration of Ethanol is expressed as degree proof which represents twice the concentration of Ethanol. A 200º proof Ethanol, anhydrous or absolute Ethanol, has 100 percent concentration of Ethanol. Ethanol, on burning does not produce a single trace of black smoke and having a tag of clean burning fuel. Ethanol can be obtained from molasses by fermenting the carbohydrates. During the fermentation, the carbon dioxide is removed after forty hours and a fully fermented material is formed called mash. By distillation, the ethanol vapours are produced from the mash. Alcohol can also be obtained from potatoes. Alcohols are also obtained from fermentation of the vegetable waste material, such as tropical grass, strew etc.

Butanol

Butanol or butalcohol or normal butanol is a primary alcohol surround with four carbon structure and the chemical formula (C4H2OH) . It contains 21.5 percent oxygen and easily miscible with water. Octane rating of butanol is much closer to gasoline, which is very reliable with gasoline. The major benefit of using butanol with gasoline is that it does not damage the internal parts of the engineand also having energy density closed to gasoline. Butanol is a partly clean burning fuel because it produces black smokes lesser than gasoline but higher then ethanol. Butanol commonly produced from bimass such as corn. Grain, potatoes, sugar beeet, grass, grass, plant and tree leaved and also from agriculture waste. Butanol is produced from the fermentation through the acetone butanol ethanol process. The fermentation of Butanol produced one more feed stock that cannot be obtained through ethanl fermentation. The chesse industry produced a waste product known as whey. From the cheese whey, bio fuel can be obtained by butanol fermentation.

Brake Horsepower

The brake horsepower developed by the engine was calculated using the given equation.

BHP = $2\,\pi\,NT/6000C$ ……(3.5)

Where,

BHP = Brake horsepower, kW

T = Torque, N-m

N = Engine speed, rpm

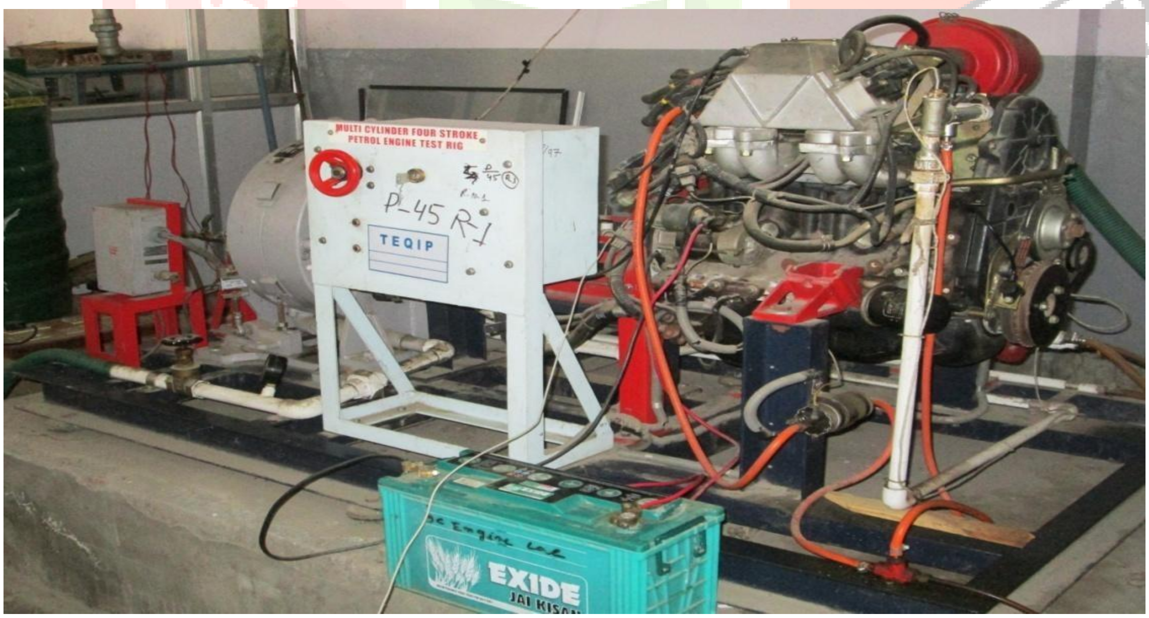

Fig 1 Plate 3.5 Engine Setup

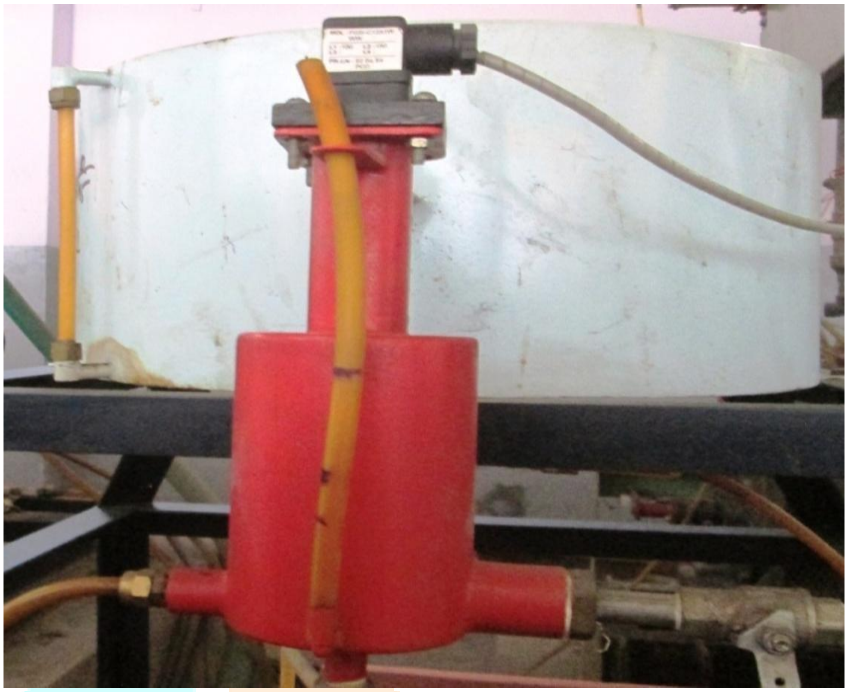

Plate 3.6 : Fuel Consumption unit

RESULTS AND DISCUSSION

The section contains the results of experiment conducted on MPFI engine. Here detailed discussion of engine performance and emission characteristics on multi cylinder spark ignition engine whose specifications are listed in Table 3.1 are described

Stability of blends at room temperature

The stability and homogeneity was checked at room temperature which varied from 28^{0}C to 34^{0}C, lasting from more than 30 days of their preparation. 20 ml samples of different combination of additive/gasoline and ethanol/additive/gasoline were prepared. A total Sixteen were prepared of the tested with butanol as an additive. All tested blends were kept at room temperature for thirty days and then kept in refrigerator for nest thirty days at a temperature of .4^{o}C. It was days observed that tall the tested fuel blends were stable and there was no phase separation shown by the tested fuels.

Fuel Properties

The values of fuel properties such as relative density, gross heat of combustion flash and fire point of the selected fuel types (plate 3.1 (a) to (d) were determined. The observed values of above parameter are presented in Appendix A21 to A 24.

Relative density

The relative density of gasoline and different blend of butanol with and without ethanol and gasoline are shown in the fig. 4.1 (a) to (d). The graphs showed that the relative density of gasoline was observed 0.730. The relative density of gasoline was observed by Koc et al. (2009) is in the range of 0.0690-0.790 and that by Zhang et al.(2015) as 0.730. The relative density of butanel was observed as 0.810 which is similar as reported by **Zhang *et al.* (2015).** The relative density of butanol was also mentioned by **Elfasakhany (2016)** as 0.810. The relative density of all fuel type were observed to be 0.736, 0.738, 0.740, 0.741for E10 blends, 0.743, 0.744, 0. 746, 0.747

for E20 blends and 0.748, 0.749, 0.751, 0.753 for E30 blends with 2.5, 5, 7.5 and 10 percent additive respectively. The value of API gravity is also calculated and presented in appendix A21- A24. It is observed that API gravity is closer to gasoline for all tested fuel type. API gravity of butanol is 30.7 percent lower than gasoline.

Gross heat of combustion

The gross heat of combustion for gasoline and different blends of ethanol with and without butanol additive are shown in the fig. 4.2 (a) to (d). The graphs indication that the gross heat of combustion of gasoline was bserved 42.95 Mj.kg. Canakei et al. (2013) reported the gross heat of combustion of gasoline as 42.60 MJ/kg. The gross heat of combustion of gasoline was reported by Costagliolaet al.(2013) as 42.7 MJ/kg and that by Zhang et. al (2015) was 43.4 Mj.kg. The gross heat of combustion for butanol was found 32.71 MJ/kg/ Varol et al. (2014) reported the gross heat of combustion for butanol as 33 MJ/kg. Zhang et al/ (2015) also reported the gross heat of combustion for butanol was33.1 Mj/kg.

Performance Parameter of the Engine

The performance evaluation of the engine in respect of bsfc, brake thermal efficiency, brake specific energy consumption, exhaust gas temperature and emission of Co, HC and Oxide of Nitrogen (NOX) was carried out under different engine speed. The observed value of above parameters are presented in appendix.

Brake specific fuel consumption

The variation in brake specific fuel consumption (bsfc) with respect to engine speed for gasoline and fuel blends type are shown in fig. 4.4. (a) to (d). From all figures, it is observed that as the engine speed increased for all tested fuels, the bsfc decreased and further increase in engine speed results in increasing bsfc. This may be due to that at high engine speed; engine requires more fuel foe maintaining the engine power. For all tested fuel, the minimum bsfc found at 2500 rpm of the engine speed.

Engine Performance Test Results of Hindustan Motor Make Ambassador Engine on Gasoline Fuel Ambient Temperature: 24 ºC

Engine Speed (rpm)	Brake Specific Fuel Consumption (Kg.kW-h)	Brake Thermal Efficiency (%)	Brake Specification Consumption (MJ/kW-h)	Exhaust Gas Temperature (K)	Carbon Monoxide (%)	rocarbon (ppm)	Oxides of Nitrogen (PPm)
1500	1.07	8.85	45.9	556	0.677	145	275
2000	0.439	16.80	18.9	615	0.587	94	316
2500	0.367	19.10	15.76	654	0.620	84	675
3000	0.594	14.10	25.51	704	0.591	68	1290

Brake Specific Fuel Consumption

Engine Performance Test Results of Hindustan Motor Make Ambassador Engine on 2.5% Butanol Additive – Gaoline Blended Fuel

Ambient Temperature: 24 ºC

Engine Speed (rpm)	Brake Specific Fuel Consption (Kg.kW-h)	Brake Thermal Efficiency (%)	Brake Specification Consuption (MJ/kW-h)	Exhaust Gas Temperature (K)	Carbon Monoxide (%)
1500	**0.844**	**10**	**36**	**527**	**0.590**
2000	**0.530**	**15.9**	**22.63**	**597**	**0.537**
2500	**0.432**	**19.5**	**18.44**	**645**	**0.587**
3000	**0.618**	**13.5**	**26.38**	**602**	**0.541**

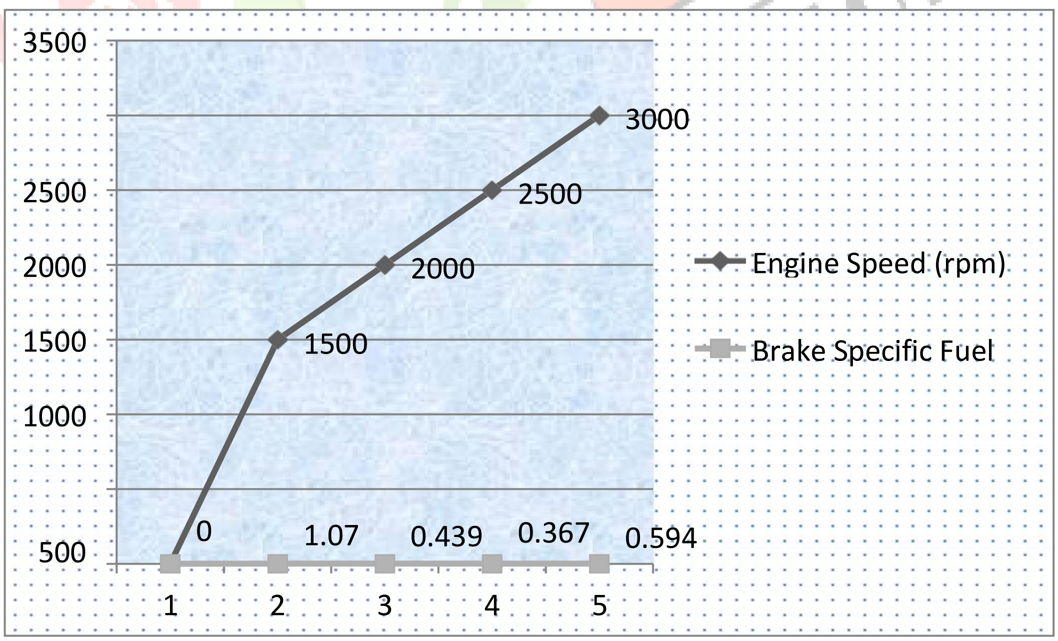

Table-3

Engine Performance Test Results of Hindustan Motor Make Ambassador Engine on 5% Butanol Additive – Gaoline Blended Fuel

Ambient Temperature: 24 ºC

Engine Speed (rpm)	Brake Specific Fuel Consption (Kg.kW-h)	Brake Thermal Efficiency (%)	Brake Specification Consuption (MJ/kW-h)	Exhaust Gas Temperature (K)	Carbon Monoxide (%)
1500	0.864	9.87	36.7	525	0.560
2000	0.587	14.5	24.9	573	0.547
2500	0.396	21.5	16.7	650	0.570
3000	0.551	15.5	23.4	586	0.519

Graphs (3.a)

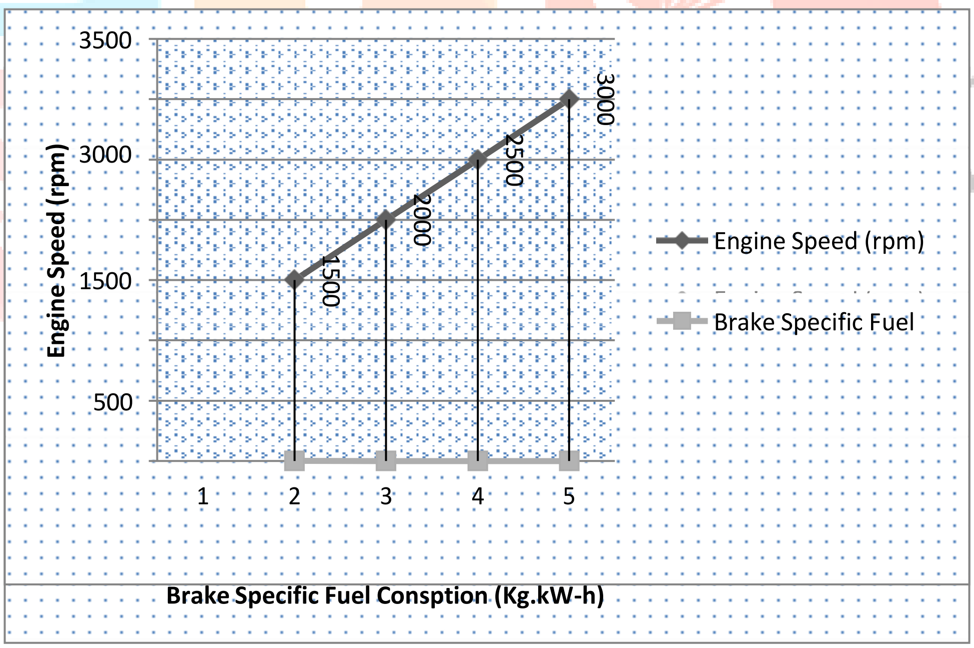

Table-4

Engine Performance Test Results of Hindustan Motor Make Ambassador Engine on 7.5% Butanol Additive – Gaoline Blended Fuel

Ambient Temperature: 24 ºC

Engine Speed (rpm)	Brake Specific Fuel Consption (Kg.kW-h)	Brake Thermal Efficiency (%)	Brake Specification Consuption (MJ/kW-h)	Exhaust Gas Temperature (K)	Carbon Monoxide (%)
1500	0.864	9.86	36.44	515	0.542
2000	0.576	15.3	24.3	576	0.522
2500	0.496	19.8	19.78	637	0.547
3000	0.785	18.1	33.11	618	0.527

SUMMARY AND CONCLUSION

The Hindustan Motor make, four stroke multi cylinder, gasoline start spark ignition engine was tested on gasoline and gasoline ethanol blends with or without butanol additive. All the tested fuel was prepare on volume basis. The properties of the tested fuels were evaluated. Performance and emission evaluation of the engine on tested fuels was conducted. On the basis of the result obtained the following conclusions were drawn.

(I) The blends were prepared on the volume basis. The butanol-gasolineblends were prepared by adding 2.5, 5, 7.5 and 10 percent butanol to gasoline. The ethanol- gasoline blends were prepared by adding 10, 20 and 30 percent of ethanol (200º proof) to gasoline and butanol was used as an additive in the blends. The butanol was added in varying value of 2.5, 5, 7.5 and 10 percent by volume in E10, E20 and E30 blends. All the blends were found stable and there was no phase separation in the temperature range of -4 ºC and 28 ºC to 34ºC even after 30 days of blends formation.

(I) The relative density of ethanol-gasoline blends increase with increase in butanoladdition.

(a) The relative density at 15ºC of gasoline was found to be 0.730 and for E10 blends with butanol additive was found 0.736, 0.738, 0.740,and 0.741 for 2.5, 5, 7.5 and 10 percent respectively.

(b) The relative density at 15ºC of E20 blends with butanol additive was found 0.743, 0.744, 0.746, and 0.747 for 2.5, 5, 7.5 and 10 percent respectively.

(c) The relative density at 15ºC of E30 blends with butanol additive was found 0.748, 0.749, 0752, and 0.753 for 2.5, 5, 7.5 and 10 percent respectively.

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