EXPERIMENTAL STUDY ON PERFORMANCE AND EMISSION CHARACTERISTICS OF N-BUTANOL – GASOLINE MIXTURE IN IC ENGINE

[1]Jestino Jes Sebastian, [2]Sandhya M
[1]PG Student, Dept. of Mechanical Engineering, Govt.Engineering College Thrissur, India
[2]Assistant Professor, Dept. of Mechanical Engineering, Govt.Engineering College Thrissur, India

***Abstract*—**Butanol or butyl alcohol can be used as a blend for IC engine, which is designed for use with gasoline without modification. Butanol can be produced from biomass (bio-butanol) as well as fossil fuels (petro-butanol). Both petro-butanol and bio-butanol have the same chemical properties. Butanol is less corrosive than ethanol and has higher energy content than ethanol and closer to that of gasoline. In comparison with ethanol, butanol is less prone to water contamination. As a result, it could be distributed using the same infrastructure used to transport gasoline. It can be used a sole fuel in SI engines, or it can be mixed with gasoline and used. There were four types of butyl alcohol, and they all have the same chemical composition, consisting four carbon atoms ten hydrogen atoms and single oxygen and have identical chemical pattern.

To meet the present requirements of the automotive industry there is continuous search of improve the performance, exhaust emission, and life of the IC engines. Blending butanol with gasoline changes the properties of the fuel and alerts the engine performance and emission characteristics. This is because heat which is released at a rate because of combustion of the compressed charge in the combustion chamber gets changed with respect to change fuel properties.

***Keywords*—IC engines, Bubtanol-gasoline blend, Emission and performance charectristics.**

I. INTRODUCTION

Rising fuel prices and increased oil consumption along with the lack of sustainability of oil-based fuels have generated an interest in alternative, renewable sources of fuel for internal combustion engines, namely alcohol-based fuels. Currently ethanol is the most widely used renewable fuel with up to 10% by volume blended in to gasoline for regular engines or up to 85% for use in Flex-Fuel vehicles designed to run with higher concentrations of ethanol. Ethanol can also be used as a neat fuel in spark-ignition (SI) engines or blended up to 40% with Diesel fuel for use in compression-ignition (CI) engines. Ethanol was introduced as a replacement for methyl tertiary butyl ether (MTBE) when it was realized that MTBE leaked onto the ground at filling stations resulting in the contamination of enormous quantities of groundwater. Ethanol is biodegradable, less detrimental to ground water, and has an octane number much higher than gasoline as well as having a positive effect on vehicle emissions. However, there are several drawbacks to ethanol. While ethanol is soluble in gasoline, additives are required to ensure its solubility in diesel fuel especially at lower temperatures and addition of ethanol to diesel fuel can reduce lubricity leading to wear problems in fuel pumps. Due to the lower cetane number of ethanol, cetane enhancing additives are usually required to improve ignition delay and reduce cyclic irregularities. Perhaps most important of all is that ethanol has a much lower flash point than diesel fuel and higher vapors formation potential which can lead to safety issues in confined spaces.

Butanol is a viable alternative to ethanol and offers several benefits over ethanol. Ethanol is fully miscible in water and thus cannot be transported using existing fuel supply pipelines. An analysis of corn-based butanol as a transportation fuel showed that, on a life-cycle basis, the use of corn butanol could result in fossil energy savings of 39%–56% when compared with the use of gasoline and greenhouse gas emission reductions of 32-48%. In addition, several companies have announced production of bio-butanol [2] including Cobalt Technologies which recently began producing a 12% blend of bio-butanol with gasoline from non-food feedstock.

Depletion of fossil fuel is forcing us to find out alternative fuels. Depletion and rise in demand of these fuels increased its cost. Today the fossil fuel price controls the world economy. This will greatly affect the economic growth of developed and developing countries that has no fossil fuel sources. Fossil fuels used by these countries are mainly for the power production and the transporting purposes. Use of fossil fuels resulted in degradation of environmental health. Internal Combustion Engines are the main consumer of these fuels. Combustion of fossils fuels in the engine exhausted greenhouse gases. Greenhouse gases are the main cause behind the global warming and climate change. Both the developed countries and the developing countries are in a track to reduce the greenhouse gases. In this scenario, the investigation and use of alternate fuels source is a main concern of the countries. For each research they need to find out better combustion, performance, and lower emission characteristics.

N-butanol [1] or butyl alcohol can be used as a fuel for IC engine, which is designed for use with gasoline without modification. N`-butanol is less corrosive than ethanol and has higher energy content than ethanol and closer to that of gasoline. In comparison with ethanol, n-butanol is less pro`ne to water contamination. As a result, it could be distributed using the same infrastructure used to transport gasoline. It can be mixed with gasoline and used. There were four types of butyl alcohol, and they all have the same chemical composition, consisting four carbon atoms, ten hydrogens, and a single oxygen. It also has identical chemical pattern C_4H_{10}O [3]. They differ each from others with respect to their structure. The chemical structure of different butanol is given below:

However, when the latent heat of vaporization of these fuels are considering, n-butanol is less attractive than gasoline. For port fuel injection systems, when the fuel vaporizes in the inlet port, it affects a temperature decrease in the intake charge. Therefore, fuels of higher latent heat of vaporization have larger decrease in temperature of intake charge with complete vaporization in the intake port. This increases the density of combustible mixture and increases thecharge mass. Furthermore, the cost of n-butanol productionis higher in comparison with ethanol[4,5]. Through these experiments, our intention is to find out the effects of butanol in an IC engine. We expect to have lower emission and high brake thermal efficiency.

II. BLEND PREPARATION

The blend has prepared by direct volume mixing.Different volumes [6,8] of butanol by percentage has taken to the experiment. 4, 8 and 12 percentage of butanol mixed with 96, 92 and 88 percentages of pure gasoline with the help of measuring flask. Mixing done carefully due to the highly evaporative and explosive nature of gasoline.

Take 4% by volume of butanol into the measuring flask. Pour the measured butanol into a can. Take 96% by volume of pure gasoline into the measuring flask. Mix the measured gasoline with butanol in the can and shake it well. Now the blend is ready for the experiments. Repeat the above procedure for next samples.

III. ENGINE PERFORMANCE TEST

Experiments to be done by performing load test in SI engine test rig. The test rig consists of Maruti Suzuki 800cc engine with MPFI injection system. Engine consists of three cylinders and water cooled cooling system. Engine is equipped with fuel measuring tube and sensors to analyze the performance. The test rig is equipped with digital display unit which shows load acting on engine. Engine is connected to the computer to analyze performance while running. Engine is coupled with hydraulic dynamometer. Load acting on engine is measured by load cell present in dynamometer.The engine specifications are shown in table 1.

Table 1: Engine specifications

Make	MARUTI 800CC ENGINE
Number of cylinders	3
Number of strokes	4
Fuel	Petrol
Cooling system	Water cooled
Power	27.6 kw at 5000 rpm
Torque	59nm at 2500rpm
Stroke length	72mm
Bore	66.5mm
Compression ratio	9.2

IV. EMISSION TEST

Emission test is done using AVL dye gas analyzer. Three copper constantan thermocouples were fitted to measure the temperatures at the inlet of the cooling water, at the outlet of the cooling water and the exhaust. These thermocouples were calibrated [7]. A separate fuel tank was fitted for easy filling of the fuel and cleaning.CO, HC, and NOx emission of different blends were found and tabulated.

V. CALORIFIC VALUE

Bomb Calorimeter is used to check the calorific value of fuel samples. It consists of C200 (Calorimeter) and RC 2 (constant water temperature bath). The amount of heat released when water after combustion is condensed is called higher calorific value [9]. The amount of water after combustion is vapor state is called lower calorific value.

Procedure- Gelatin tube weight is measured and filled with fuel sample [10]. The mass of fuel is calculated by subtracting weight of gelatin with weight of gelatin filled with fuel. Gelatin capsule is placed inside the crucible of bomb calorimeter with end of cotton wick touching the capsule. After filling the bomb with 2ml water the lid of bomb is closed and the bomb is filled with oxygen at 30 bar pressures. Place the bomb inside calorimeter carefully by touching the three knobs inside calorimeter and close the calorimeter. Manually enter the weight of fuel, calorific value of cotton wick (50 J per cotton) and calorific value of gelatin (weight of gelatin×18847 J/g) in calorimeter. Place the bomb inside calorimeter carefully by touching the three knobs inside calorimeter and close the calorimeter. Water is automatically filled in the calorimeter and we get the calorific value after 10 minutes. It should be noted that forceps should be used while handling cotton wick and gelatin capsule.

VI. SCHEMATIC DIAGRAM

The schematic diagram of experiment setup is shown in figure 1;

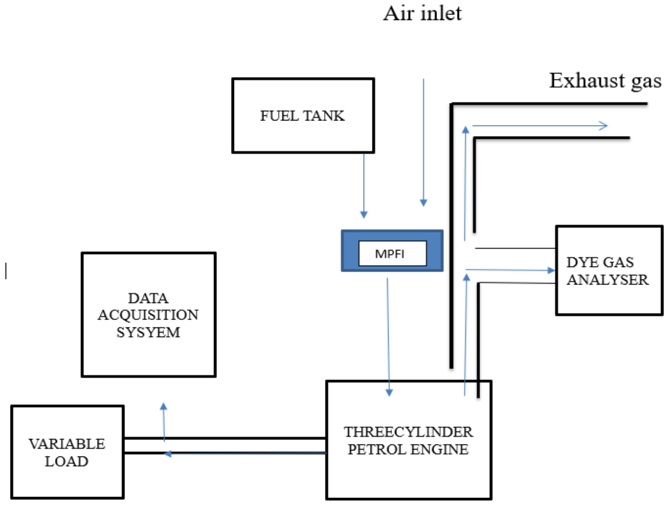

Fig. 1: Schematic diagram

VII. RESULTS AND DISCUSSIONS

We found a better combustion of the air fuel mixture due to the presence of the extra oxygen in the butanol. Better combustion gave much more heat to the engine. So, in order to reduce the high exhaust temperature, we can use lean mixtures to the cylinder inlet. Due to the better combustion of the charge, the emissions will be reduced. And which can even result to better engine performance with improved efficiency. The graphs from the experiments are plotted below;

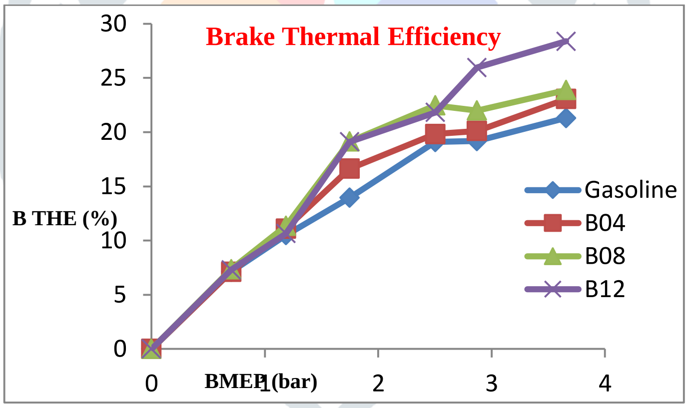

Fig.2 Brake thermal efficiency v/s BMEP

Consider figure 2, the brake thermal efficiency of the blend is higher than that of the pure gasoline. At low BMEP range the efficiency is almost same for gasoline, B04 and B08. The increase in the thermal efficiency is due to the presence of oxygen, which leads to better combustion of the charge. This results in more power output. In other words,added butanol produce lean mixture, that increases the relative air fuel ratio to a higher value and make the burning more efficient. If we increase the butanol content it results in lower efficiency and consequently higher HC emissions. It is due to the lower latent heat of vaporization of butanol. The latent heat of vaporization of butanol is 118 kJ/kg at 118 ^{0}C while gasoline has 380- 500 kJ/kg at 25- 215 ^{0}C.

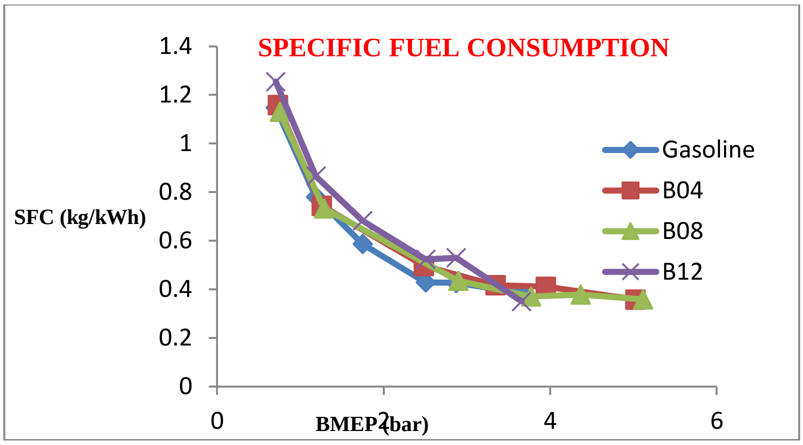

Fig.3 specific fuel consumption v/s BMEP

In the third figure, the specific fuel consumptions are almost similar for both the blend and pure gasoline. As the BMEP increases, SFC decreases. SFC for the blend is slightly greater than that of the pure gasoline. This change is due to the change in the density of the charge. The density of the charge increases with the increase in the percentage of the butanol added.

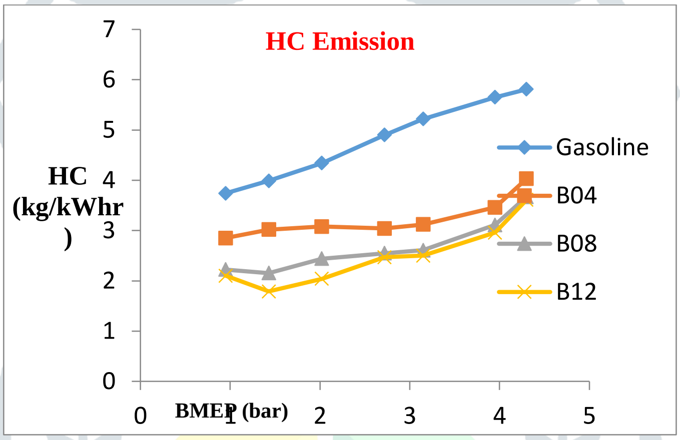

Fig.4 HC emission v/s BMEP

As the percentage of butanol increases, emission of the hydrocarbon reduces in the fourth figure. It is due to the presence of oxygen in the butanol. Presence of oxygen helps to increase the rate of combustion. It further reduces the number of unburned hydrocarbons. Emissions are lower due to greater knock resistance of the fuel allowing higher compression ratios to be used and that knock resistance was mainly a function of the oxygen content of the blend.

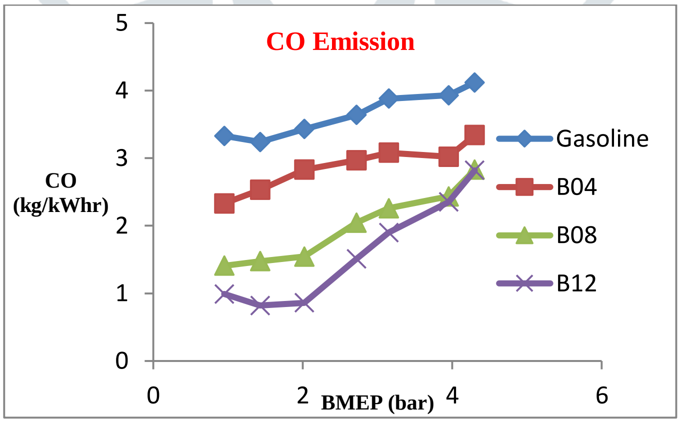

Fig.5 CO emission v/s BMEP

Consider figure 5, CO emission decreases with the increase of the butanol content in the mixture. It is due to the presence of oxygen in the butanol. It consists of 21.1 % of oxygen. This oxygen also will take part in the combustion process. This further reduces the CO emission. The change in the CO emission is due to the leaning effect caused by lower stoichiometric air fuel ratios of the fuels due to their partially oxidized nature.

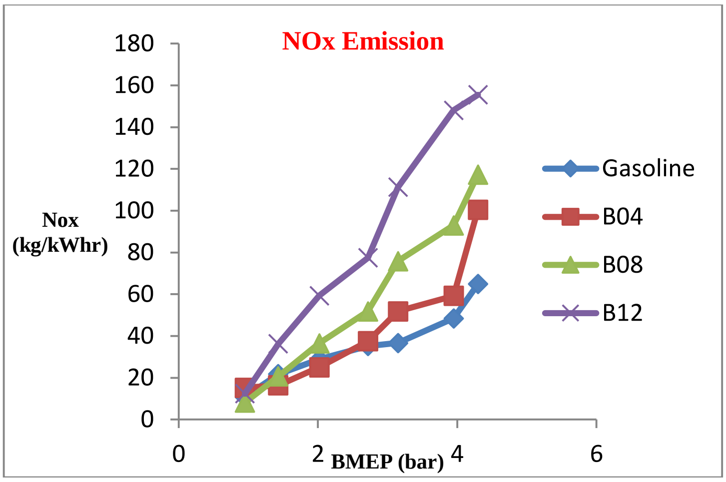

Fig.6 NOx emission v/s BMEP

In figure 6, emission of NOx is higher for the blends. It is due to the increase of the combustion temperature, which is caused by the presence of oxygen in the butanol. As the amount of the butanol increases percentage of the oxygen content will be increased. This will result in the production of NOx. The higher NOx emission is due to the lower enthalpy of vaporization and higher flame temperature. Higher flame temperature is obtained due to the lower energy density of the butanol.

VIII. CONCLUSION

The emissions characteristics of butanol was experimentally investigated using a three-cylinder spark ignition engine. Pure gasoline, B04, B08 and B12 (denotes 4, 8, 12 percentage by volume of butanol in the mixture) were tested in the engine. The various parameters like Brake mean effective pressure (BMEP), Specific fuel consumption (SFC), Brake thermal efficiency and emission characteristics were found. It's clear from the analysis, that the emissions of CO and HC were reduced by increasing the butanol content. On the same time the increase in the NOx content were noticed. As the amount of butanol increased SFC and brake thermal efficiency were increased. Butanol added to the blend produces lean mixture, that increases the relative air fuel ratio to the higher value and makes the burning more efficient. The higher NOx emission is due to the lower enthalpies of vaporization and higher flame temperature. Higher flame temperature is obtained due to the lower energy density of the butanol.

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