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Preparation, Engine Performance and Emission Characteristics of Ethanol in Single Cylinder Spark Ignition Engine

R. Selvakumar [A], M. Jebaraj[b], S. Manikandan[b], C. Balaji Ayyanar[c]
[a]*Research scholar, Department Of Mechanical Engineering, Anna university, Chennai*
[b]*Assistant Professor, Department of Automobile Engineering, Sree Sastha Institute of Engineering and Technology, Chennai.*
[c]*Assistant Professor, Department of Mechanical Engineering, CIT, Coimbatore.*

Abstract: The current era of the world population is running behind the faster depleting conventional fuel as the population of vehicle is increasing exponentially. There is an increasing need of an alternate fuel to meet the above demand and to reduce the atmospheric pollution caused by the conventional gasoline. In this study, Ethanol prepared by the fermentation of corn is blended with conventional gasoline from 10% to 90% in increments of 10% and a performance test is carried out on a single cylinder petrol engine. The variation of Brake Thermal Efficiency, Mechanical Efficiency, Specific Fuel Consumption and Emission of Carbon Monoxide for different blending ratios of Ethanol is calculated and plotted as graph. The drawback of using ethanol as an alternate fuel is increased emission of Carbon Monoxide. It is found that the most favorable level of performance and emission is obtained at 60% of ethanol blending ratio without any changes in the conventional single cylinder petrol engine.
Keywords: SI engine, ethanol, single cylinder, Engine performance, Emission

1. Introduction

At present time virtually all the world’s transportation and industries’ needs are supplied by the fuel derived from petroleum .the vehicle population continues to increases exponentially. The combustion of petroleum in motor vehicles results unregulated carbon dioxide emissions a prominent green house gas will increase by 65 percent over the current levels causes global warming, acid rain and urban air pollution.

At present more than 70 percent of our country’s energy requirements are met though imports. It is the main reason for the deficit of our budget. Current gasoline consumption in India is 7 – 7.5 billion liters / year. Considering the hard currency saved by avoiding oil importation through the significant displacement of gasoline by alternative fuels and the decrease in the amount of external debt.

21st centuries with its prosperity will bring intricate problems to mankind, one such problem is the fast depletion of fossil fuels and rapid increases in atmospheric pollution. Hence throughout the world, the sharply increasing crude oil prices in the year 1973, 1979, 2002 and 2007 triggered off a frantic search for alternative fuels. although the initial enthusiasm and the impetus of alternative fuel fever, has now abated somewhat and has room for more sober views because of the increasing glut of crude oil and the corresponding slump in prices.

The investigation at present that alcohol has been used as a blended fuel in single cylinder petrol engine to find out the optimum level performance with various blending ratios and consequent emission test without any modification in the conventional engine.

In 2013, there were 2.4 million alternative fuel vehicles sold in the United States, indicating an increasing popularity of alternative fuels. There is growing perceived economic and political need for the development of alternative fuel sources. This is due to general environmental, economic, and geopolitical concerns of sustainability. The major environmental concern, according to an IPCC report, is that "Most of the observed increase in globally averaged temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas concentrations". Since burning fossil fuels are known to increase greenhouse gas concentrations in the atmosphere, they are a likely contributor to global warming.

2. Literature Survey

As the U.S. seeks to become less dependent on foreign oil and to develop clean, renewable energy, it continues to be clear that no one alternative fuel source will be able to meet the nation’s energy demand. In addition to ethanol, biodiesel, and other sources of alternative energy, research has focused on the production of butanol through the fermentation of biomass.

Originally a byproduct of acetone production, butanol experienced a significant increase in demand in the 1920s as an important industrial solvent. The production of butanol by fermentation subsequently declined due to the price of petrochemicals dropping below that of the starch and sugar substrates used in fermentation, combined with the high costs of labor and relatively low yields associated with the intensive batch system. Currently, almost all industrial butanol is produced through a petrochemical process.

In today's search for alternative fuel sources, a reemerged interest in butanol derived from agricultural bio mass has arisen. Butanol has numerous attractive fuel properties. It packs more energy per pound, burns cleaner, and is less hazardous to handle and less flammable than some other alternative fuel sources. An additional advantage of butanol is that it can be mixed with gasoline in any proportion and used as an automotive fuel without engine modification.

During the early nineties, Hans Blaschek, a professor of microbiology and present assistant dean of the college of ACES Office of Research at the University of Illinois at Urbana-Champaign, developed a superior microbial strain to produce butanol from starch. Although it is a better butanol producer than other strains, it cannot accumulate more than 2% butanol in the fermentation medium. Unfortunately, butanol is toxic to the microbes that produce it. Recovery of such a low concentration of butanol by traditional techniques such as distillation has not yet proven to be economical.

Through groundbreaking research funded by C-FAR, great strides have been made in the recovery of butanol from dilute fermentation streams. Nasib Qureshi, a chemical engineer with the USDA National Center for Agricultural Utilization Research, in collaboration with Hans Blaschek and former postdoctoral fellow Thaddeus Ezeji, has devised a method called gas stripping. In this process, gases produced in the fermentation vessel are used to remove butanol from the fermentor on a continuous basis. The aim is to keep butanol levels in the production vessel below 1% so that the microbes survive and continue producing butanol. As a result of this integrated recovery process, the microbes can continue producing butanol without being killed by the toxicity of their own product.

This new recovery process is a major breakthrough in butanol production. Based on these studies, butanol production from agricultural biomass is much closer to being commercialized. [8]

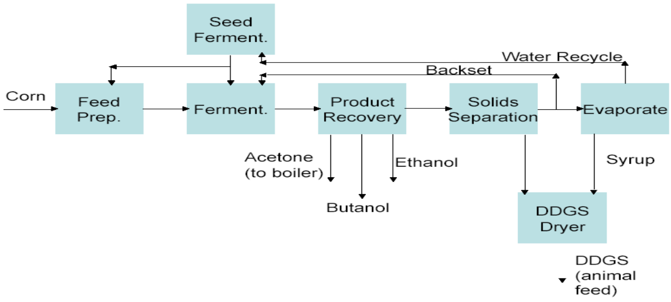
In 1997,A. Abdel Rahman and M.M Osman from Kuwait University conducted investigation on varying the compression ratio of S.I engine working under different ethanol – gasoline fuel blends. The experiments were carried out using a variable compression ratio engine. From their report it is attained that the 10 percent ethanol – gasoline fuel blends increased the maximum pressure over that of pure unleaded gasoline. At higher compression ratio than 8, for fuel blends above 20 percent ethanol, improved the indicated thermal efficiency and the optimum compression ratios were found to be 8, 10, and 12 for 10, 20, and 30 percent ethanol respectively.[10]

In 1986, F.H. Palmer from British Petroleum Company ran a wide range of vehicle performance test on oxygenated fuel blends. From their result, it was found that 10 percent ethanol in gasoline improves the engine power by 5 percentage. The addition of ethanol to lead – free gasoline has resulted in an increase of fuel research octane number by 5 units for each 10 percent ethanol addition. It was further reported that the exhaust emission of carbon monoxide was reduced considerably (by about 30 percent).[11]

In 1986, M.A.S. Hamdan and Jubran have studied the effect of ethanol addition on the performance of gasoline and diesel engines. The performance tests were carried out using different fuel blents of ethanol gasoline. The maximum percentage of ethanol used was 15 percent. From this experiment It was found from that ethanol gasoline blends had a greater effect on engine performance. The best performance was achieved when 5 percent ethanol – gasoline blend was used, with a thermal efficiency increase of 4 percent to 21 percent. However, all their tests were carried out under part load condition. [12]

Y.Yacoub and R.Bata from West Virginia University, USA conducted the test on Waukesha Multi Cylinder spark ignition engine with unleaded test gasoline and high purity straight chain alcohols. Alcohols with carbon number ranging from C_1 to C_5 were individually blended with unleaded test gasoline. According to the investigation, the knock characteristics of an alcohol – gasoline blend were dependent on the type of alcohol in the blend and not solely on its oxygen content. Further adding lower alcohols (C_1, C_2 & C_3) to unleaded test gasoline improved its knock resistance. The result reported that ethanol gasoline blends provides the highest knock resistance improvement among all tested blends, and operate at higher efficiency compared with neat gasoline owing to its higher compression ratio. Similarly most of alcohol – gasoline blends showed reduction in CO, CO_2 emissions. [13]

Test Procedure



The engine was made to run 2000 rpm at different loads using pure gasoline as a fuel. The fuel was supplied from a tank which is connected to a burette with a three way cock. At normal condition, engine consumes the fuel from the tank; the burette level just indicates the level of fuel tank. When the consumption reading was required, the valve was closed and the fuel is consumed by the engine from the burette only. The time for 25CC of fuel consumption was noted down with the help of stop watch. Once the reading was taken the valve was operated again so that fuel flows to engine directly from the tank.

Different fuel blends of pure butanol and pure gasoline prepared and kept in a glass containers. The fuel blends were prepared with 10% up to 90% butanol in increments of 10%. The test was carried out to varying blending ratio up to 90% butanol and 2,4,6,8 Kg load. The test is repeated up to 50% ethanol blend in increments of 10%

In all experiment the following procedure was carried out

- Prepare the fuel blend and fill the fuel tank
- Adjust the engine to run at 2000 rpm.
- Vary the engine load by turning the hand wheel and maintain the constant speed.

The following readings are taken

- Fuel consumption – (By recoding time needed to consume 25 CC of fuel)
- Engine speed
- Load reading
- Percentage of CO
- Unburnt hydrocarbon

Engine Specification

Engine	***: Four stroke single cylinder SI Engine***
Make	***: Enfield make***
Rated power	***: 2.2 KW***
Speed	***: 3000 rpm***
Bore diameter	***: 70 mm***
Stroke length	***: 66.7 mm***
Displacement volume	***: 256 cc***
Compression ratio	***: 4.67: 1***
Lubricating system	***: Splashed type***
Cooling system	***: Air cooling***
Starting method	***: Rope and pulley***

Experimental Set Up

The experiments were carried out on a single cylinder 4 stroke petrol engine of model the largest manufacturer of agricultural usage engines. the engine is provided with air cooling system by means of flat extended surfaces. In this engine splashed lubrication is installed for lubricating purpose. The engine is started by means of Rope and pulley system. The load is applied to the engine by means of brake drum dynamometer.

Test on Engine with Inlet Air Heating

Methodology

The latent heat of vaporization for ethanol is nearly three times higher than gasoline, when quantity of ethanol is increased in gasoline blends, vaporization problem may occur in carburetor. Ice formation may take place at venture throat and fuel nozzle. To avoid this problem, the intake air is to be heated so that we can achieve maximum replacement of ethanol in gasoline. Heat energy can be introduced in intake air, by means of an electric coil heating. By preheating the fuel, phase change may occur which will make interruption in the flow of fuel. To avoid this problem, the air is heated by means of electric coil.

4.2 EXPERIMENTAL SET UP

The experimental setup with inlet air heating by using the electric coil. To preheat the air 60 watts round filament model electric heater is used and thermometer is placed in preheater to measure the inlet air of the engine. The preheater is placed between to carburetor and air filter.

Test Procedure

Under normal conditions, the engine inlet temperature was measured to be 31^{o}C. Hence it was decided to heat the inlet air to 50^{o}C and 60^{o}C. In first, by means of switch control the intake air temperature was raised to 50^{o}C. The same set of procedure was followed as in the previous case. To increase the ethanol acceptance level, it was decided to raise the inlet air temperature to 60^{o}C, some set of reading were taken with different blending proportions of ethanol. The various readings were grafted.

Result and Discussion

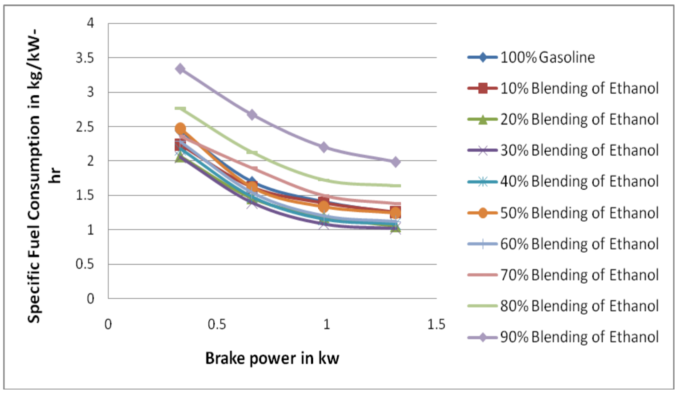


Fig 5.1 Variations of Specific Fuel Consumption for different blending ratio of Ethanol

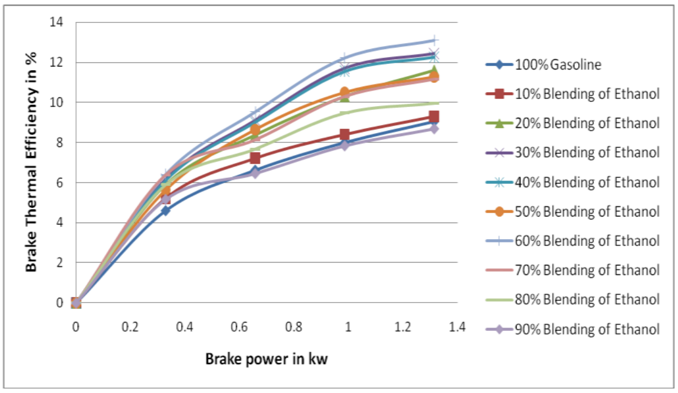


Fig 5.2 Variations of Brake Thermal Efficiency for different blending ratio of Ethanol

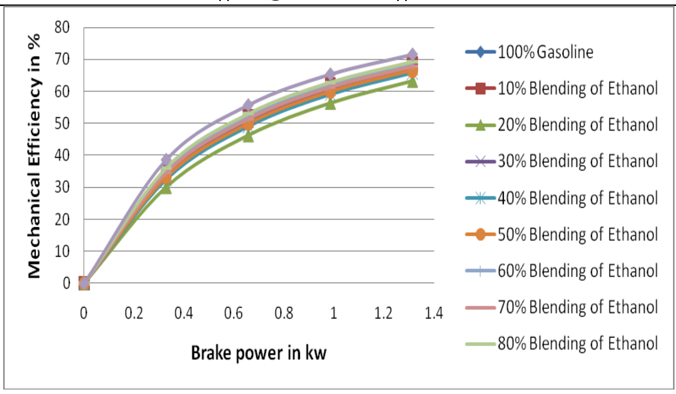


Fig 5.3 Variations of Mechanical Efficiency for different blending ratio of Ethanol

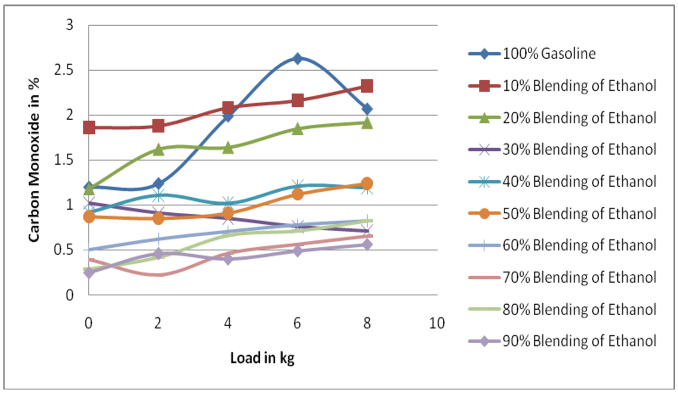


Fig 5.4 Variations of Carbon monoxide emission for different blending ratio of Ethanol

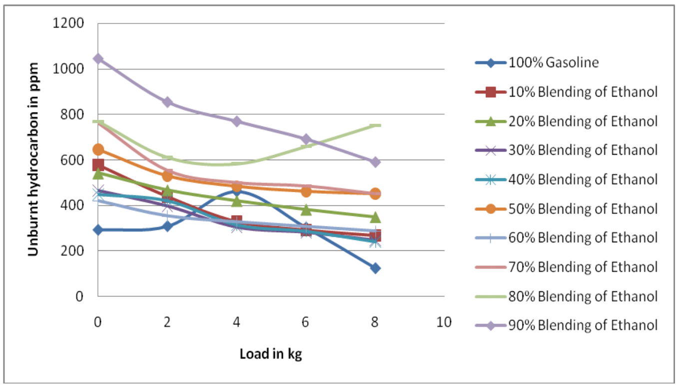


Fig 5.5 Variations of Unburnt hydrocarbon for different blending ratio of Ethanol

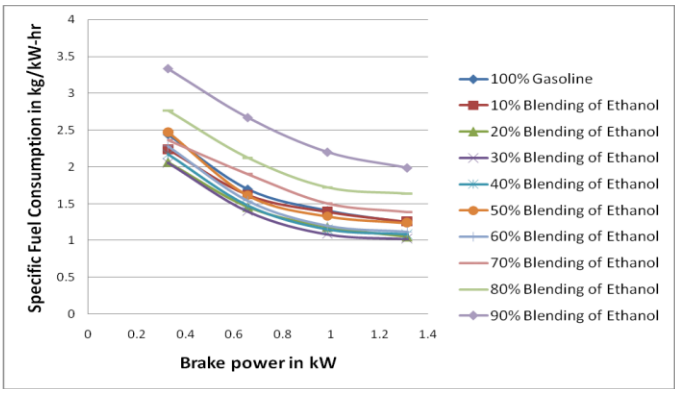


Fig 5.6 Variations of specific fuel consumption VS brake power for different blending ratio of Ethanol

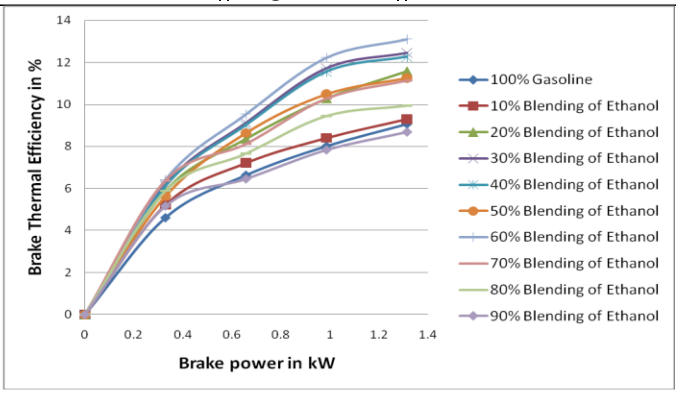


Fig 5.7 Variations of brake thermal efficiency VS brake power for different blending ratio of Ethanol

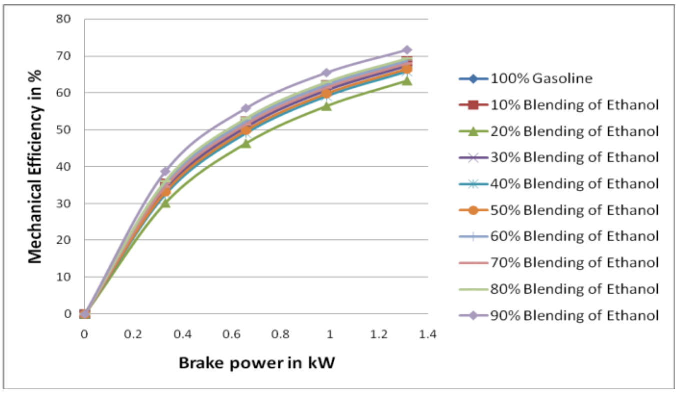


Fig 5.8 Variations of mechanical efficiency VS break power for different blending ratio of Ethanol.

Fig 5.1 shows the variations of Specific fuel consumption of conventional gasoline engine, fueled with neat gasoline and ethanol blended gasoline ranging from 10 – 90 volume percent at different brake power. The engine attained minimum consumption of 1.0224 kg/kW-hr at 30 percent of ethanol blending, which is lower by 17% over neat gasoline engine.

Fig 5.2 shows the variations of Brake thermal efficiency of conventional gasoline engine, fueled with neat gasoline and ethanol blended gasoline ranging from 10 – 90 volume percent at different brake power. The engine attained maximum efficiency of 13.10 percentages at 60 percent of ethanol blending, which is higher by 4.04% over neat gasoline engine.

Fig 5.4 shows the comparison of carbon monoxide emission of conventional gasoline engine; at 60% blending proportion the carbon monoxide emission of ethanol blend fuel is 13% higher.

Fig 5.5 to Fig 5.8 show the comparison curves of Specific fuel consumption, Brake thermal efficiency and Carbon monoxide emission between neat gasolines, 60% ethanol blend.

Conclusion

Based on the present study, the following conclusions were obtained

In a conventional gasoline engine, the gasoline can be replaced by means of ethanol to 90% by volume without any modification in the engine. It is observed that air preheating is required for using ethanol beyond 50% blend with gasoline in conventional engine.

At 60 percent blending, the 14.2 percent increase in brake thermal efficiency when compared with neat gasoline and ethanol blend gasoline respectively. At other blending ratios, the brake thermal efficiency is varied from 8.3 to 37.5 percent higher than neat gasoline operation. There is 4.6 percent of increase in mechanical efficiency when 6.1 percent of increase in mechanical efficiency when 90% ethanol blend is used compared with neat gasoline.

The percentage of carbon monoxide at the lowest value of carbon monoxide percentage at 70% of ethanol blend fuel is 12 percent higher.

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