Using blended Fuel of Ethanol and Petrol Analyze Performance of a Multi - Cylinder Spark Ignition Engine

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Abstract: ***The purpose of this study is to experimentally determine the optimal blend rate of ethanol - gasoline fuels in order to maximize brake thermal efficiency of a commercial SI engine. In this study, the engine performance, in term of brake torque and brake specific fuel consumption, has been investigated with variation of volumetric mixing ratio between 87.5 - octane gasoline and 99.5% - purity ethanol (E0, E10, E20, E30, E40, and E50). The experiment has been conducted at different engine speeds and percentages of intake - throttle opening. The tests were performed at constant compression ratio. The experimental results indicated that the appropriate ethanol - gasoline mixing ratio can enhance engine torque output, especially at low engine speed. The brakes thermal efficiency is maximum when the engine operates with a speed of 2000 - 2500 rpm, using E40 and E50 fuels. This paper also provides a guideline for suitable ethanol - gasoline blend rate at certain engine load and speed.***

Keywords: Ethanol; Ethanol - gasoline blends; SI engine; Performance

1. Introduction

The dominant use of fossil fuel for energy production is rapidly depleting the reserves of petroleum based fuels. The fast decrease in the future availability of fossil fuel and the need for reducing the emission from the fuel used has increased the need for the utilization of regenerative fuels (Janet al., 2007). Internal combustion engines conventionally run on petrol and diesel fuels which are fossil fuels and whose production and combustion result in the emission of gases that have adverse effects on human health and environment. The greenhouse gas emission from the combustion of petrol and other hydrocarbon fuels have been identified as the major cause of climate change and global warming (Igbo we et al., 2015). These environmental concerns and the desire to be less dependent on fossil fuel have intensified worldwide effortful production of biodiesel from vegetable organic materials and bioethanol from starch and sugar producing crops (EPA 2007). The limited nature of oil resources has made studies on alternative energy sources much more important in internal combustion engines in which oil products are used as energy source (Kannan et al., 2011; Fahd et al., 2013).

Biofuels such as bioethanol, a colorless liquid with mild characteristic odor can be produced by fermentation ofbiomass crops such as wheat, sugar beet, sugar cane, corn, raffia trunk, wood and wood - like plants (Parket al., 2012; Guido et al., 2013). Using bioethanol as fuel for spark ignition engine Has some advantages over petrol such as better anti - knock characteristics, better emission characteristics, improved brake thermal efficiency and volumetric efficiency (Al - Hassan, 2003; Jitendra et al., 2013). However, the oxygen content in ethanol reduces the heating value of theblends produced with petrol (Nwufo et al., 2013).

From the literature review we have observed that in the previous years studies done on the Performance Characteristics Of A Multi Cylinder MPFI Spark Ignition Engine. Finally it can be concluded that by the useof Ethanol–Petrol Blended Fuels, hydrogen –petrol blends, We can maximize the torque or power at a specific loading condition and pollutants can be minimized. Further researches are ongoing in the given area.

2. Experimental Setup

The setup consists of a four cylinder, four stroke, Multi Cylinder SI engine (Detailed specifications listed in Table: 1) connected to eddy current dynamometer for loading. The schematic diagram of the experimental setup is shown in fig.1.

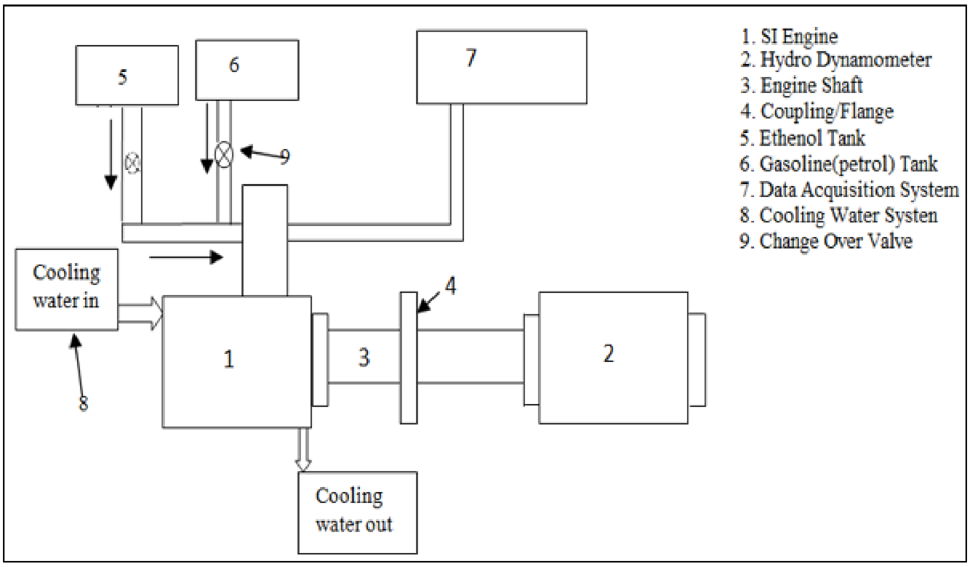

Figure 1: Schematic Diagram of the Experimental Setup

Table 1: Technical specifications of test engine

Characteristics	Value
Type of engine	4 E - FE DOHC 16V
Make	Maruti Wagon R
Volume V, cm3	1332
Compression ratio	9, 8
Torque Ms, Nm	124
Fuel	Gasoline/Ethenol
Ignition system distributor	TCCS – II, Toyo Denso

3. Materials

The fuels used in this test are petrol purchased from nearest fuel station in Ghaziabad, UttarPradesh, India. Bioethanol produced from various feedstocks through fermentation and distillation processes; Blends ofthe produced bioethanol and petrol at different proportions. The ratios of the fuel blend used in the experiments were determined based on the suggestions provided in previous studies. The percentages of blending are given intable2.

The petrol, ethanol and its blends were characterized in accordance with American Society for Testing and Materials (ASTM) methods and their properties as reported by Nwufo et al., 2013 are given on table3.

Table 2: Composition of bioethanol/petrol blended sample used

Sample code	% Ethanol	% Petrol
E10	10	90
E20	20	80
E30	30	70
E40	40	60
E50	50	50

Table 3: Properties of Bioethanol Fuel Blended with Petrol

Properties	Petrol	E10	E20	E30	E40	E60	Bioethanol
Density (kg/m^3)	747.7	750.8	760.5	778.2	779.2	781.2	789.0
Vapour Pressure (kpa)	36	39	39	38	35.6	31	9.5
Flash Point (^{0}C)	- 65.0	- 40.0	- 20.0	- 15.0	- 13.5	- 1.0	12.5
Heating Value (MJ/kg)	44.4	44.22	42.08	40.48	38.50	35.84	29.78
Auto - Ignition Temperature (K)	519	533	552	552	567	618	638

The blends were prepared right before the experiments in order to ensure homogeneity and were thoroughly mixed in a mixer to prevent phase separation. Test runs were carried out on a multi cylinder four stroke engine coupled to a hydraulic dynamometer.

4. Experimental Procedures

At the first stage tests were performed at different engine loads. The experiments were conducted at six different speeds viz.2000rpm, 2500rpm, 3000rpm, 3500rpm, 4000rpm, 4500rpm while maintaining a constant load. The engine is coupled to ahydro dynamometer through which load is applied. A fixed 23° BTDC injection timing and 18.0 compression ratio were used throughout the experiments. In all tests the engine was allowed to warm up for 15min to reach equilibrium. This was determined by monitoring the exhaust and coolant temperatures. The data measured during the tests included engine speed, brake power and fuel consumption.

5. Results and Discussion

5.1 Engine torque (Nm)

Fig.2 shows the variation of engine torque of all fuel samples with respect to engine speed. It can be seen that torque increases steadily with speed up to a maximum value and then falls with further increase in speed. This is due to the mechanical friction loss and lower volumetric efficiency of the engine at higher engine speed. The engine torque developed by petrol and E20 fuels were higher than that developed by other fuel samples. The maximum torque was recorded at very close engine speeds for the different fuel samples which is shown in figure below. The reason for reducing torque with ethanol blended fuel may be attributed to the lower calorific value of the bioethanol fuel.

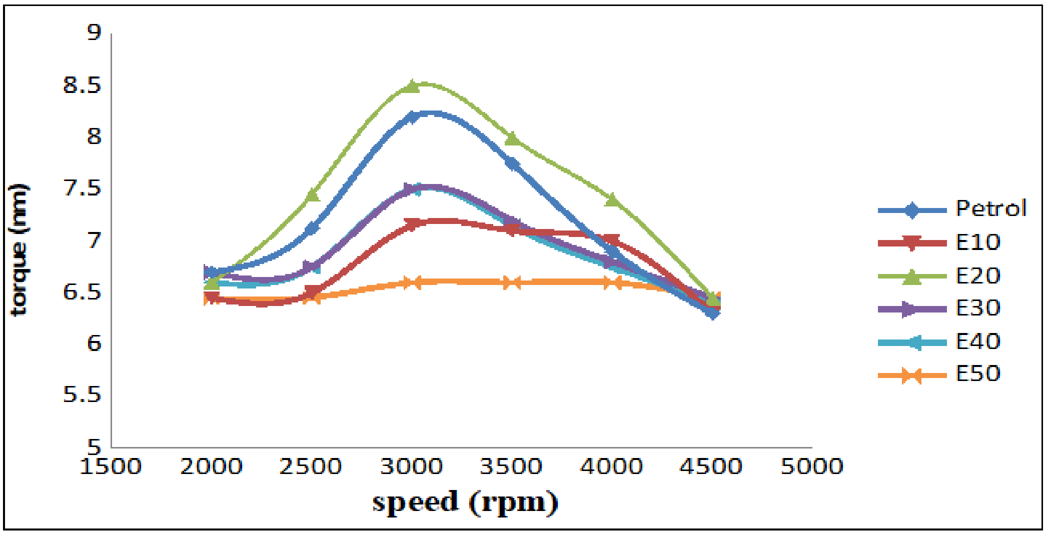

Figure 2: Variation of Engine Torque with Engine Speed for Different Fuels

5.2 Brake Power (kW)

The brake power values of all fuel samples are shown in fig.3**.** The engine brake power increased steadily with increase in engine speed.

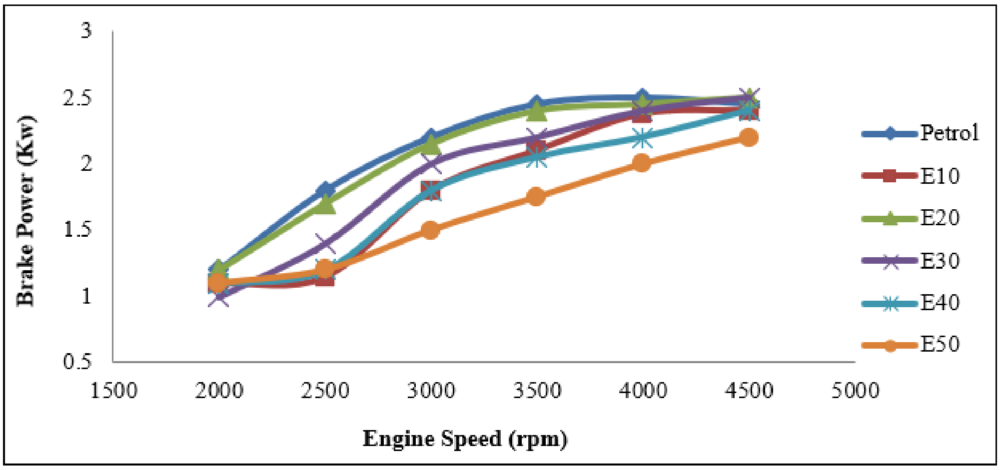

Figure 3: Variation of Brake Power with Engine Speed for Different Fuels

The maximum brake power of the engine was recorded at different engine speeds for the different fuel samples and it was 2.5kW, 2.375kW, 2.45kW, 2.4kW, 2.4kW and 2.2kW at approx 4000rpm for petrol, E10, E20, E30, E40 and E50 respectively. The lower brake power values of higher ethanol blends compared to petrol can be attributed to their lower calorific values.

5.3 BMEP (kpa)

The BMEP is highly correlated with engine torque as can be seen on fig.4. Petrol and E20 developed the highest BMEP at the same speed of 3000rpm as the engine torque.

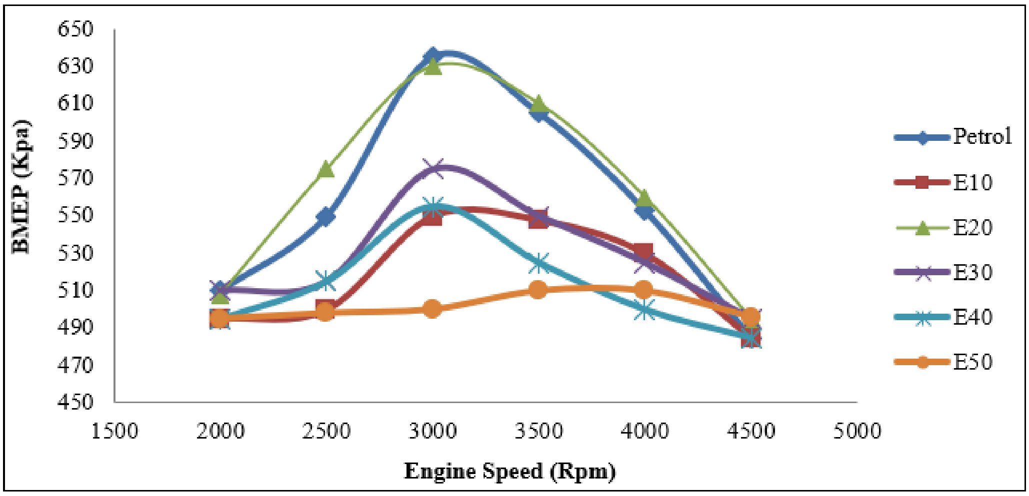

Figure 4: Variation of Brake Mean Effective Pressure with Engine Speed for Different Fuels

5.4 Brake Thermal Efficiency (%)

The effect of ethanol – petrol blend on the brake thermal efficiency of the test engine is shown in Fig.5. The brake thermal efficiency increased steadily with increase in engine speed up to a maximum value then decreases with further increase in engine speed. The decrease in brake thermal efficiency at higher engine speed is due to lower combustion efficiency attributed to reduced time for complete combustion.

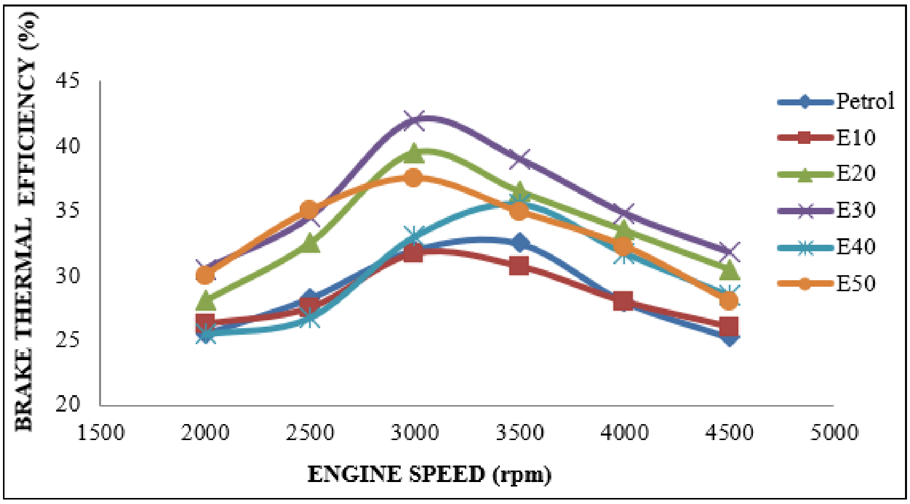

Figure 5: Variation of Brake Thermal Efficiency with Engine Speed for Different Fuels

5.5 BSFC (kg/kWh)

BSFC is the ratio between mass flow of the tested fuel and effective power and depends on the relationship among volumetric fuel induction, fuel density and lower heating value. Fig.6 shows the variation of BSFC for all fuel samples with respect to the engine speed. It shows that brake specific fuel consumptions of E10, E40 and E50 are higher while that of E20 and E30 are lower compared to that of petrol. The minimum BSFC of 0.248kg/kWh, 0.273kg/kWh, 0.217kg/kWh, 0.228kg/kWh, 0.262kg/kWh and 0.282kg/kWh was obtained for petrol, E10, E20, E30, E40 and E50 respectively.

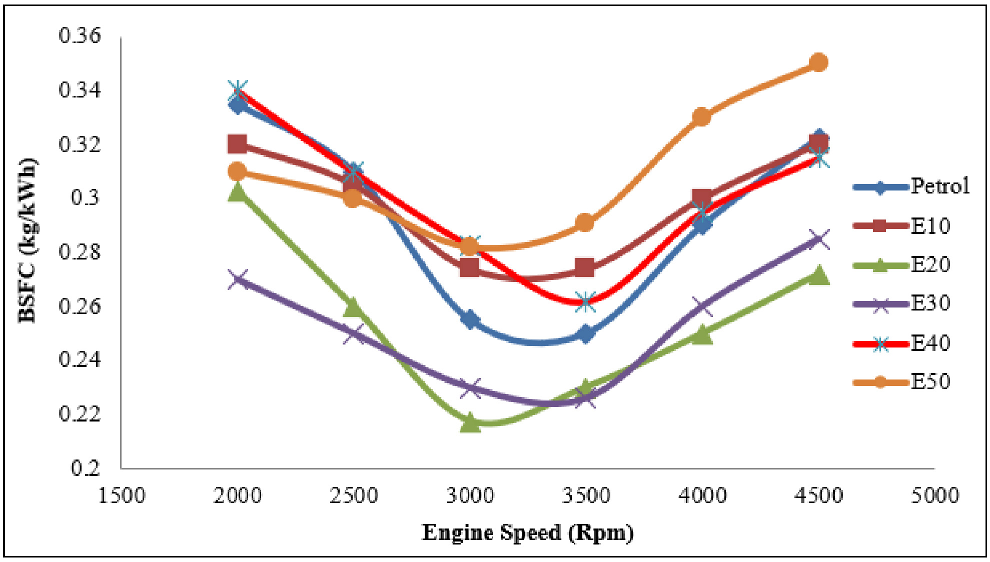

Figure 6: Variation of BSFC with Engine Speed for Different Fuels

6. Conclusions

The following conclusions have been drawn from the present work:

- By adding ethanol to petrol at various proportions, the octane number of the produced blends is increased. This leads to increase in compression ratio and power output thus brake thermal efficiency of the blends increases.
- Addition of ethanol to petrol has the tendency of increasing flame speed which will enables the optimization of the spark timing of ethanol blends. This will improve the engine performance with the use of high volume of ethanol in the blend. Thus the use of higher blends should be encouraged for better environment; however the spark timing has to be retarded.
- By addition of ethanol the torque developed by the engine is improved.

In all, ethanol and its blends with petrol exhibited performance characteristics trends similar to that of petrol thusconfirming them as suitable alternative fuels for spark ignition engines.

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