Performance Comparison between Carburator and MPFI Spark Ignition Engines for Differen Ethnanol Blends

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Abstract— This paper presents, the performance comparison between carburetor and Multi-point Fuel-Injection (MPFI) spark ignition (SI) engines for different blends of gasoline-ethanol. Ethanol from biomass is an ecologically sustainable fuel for automobile engines. In this work, tests were conducted on both carburetor and MPFI SI engines under different loads for all blends. For each blends reading were taken for varying load. The analyses were conducted using gasoline-ethanol blends with the volumetric ratio of 0% to 50% with an increment of 5% ethanol. The performance parameters such as air-fuel ratio, brake thermal efficiency, volumetric efficiency, fuel consumption and mechanical efficiency were done for both the engine under condition. The results show that at 20% ethanol blend with gasoline both the engine gives better performance. However, the MPFI SI engine provides better results than the carburetor SI engine.

Key words: Carburetor, Ethanol, Engine, Gasoline

I. Introduction

In current scenario the main energy source is fossil fuels. All kinds of vehicle engines work with fuels produced from fossil fuels. Fossil fuels reserves in the world are limited and expected to be exhausted in next 40 years. Due to the continuing increases in the cost of fossil fuels and pollution due to combustion of fossil fuels, demands for development of alternative clean energy source have been increased. Ethanol contains an oxygen atom therefore it provides a better antiknock value and it can be considered as a partially oxidized fuel. Ethanol has a higher octane number and higher heat of vaporization than gasoline. Ethanol is one of the important alternative fuel sources, especially ethanol from sugarcane. To reduce the import of crude oil, the government has set the renewable energy plan which aims to increase the use of ethanol in gasoline from 5% to 10% by the year of 2016.

Alcohols have been suggested as an engine fuel almost since automobile was invented. Among the various alcohols, ethanol is known as the most suited fuel for SI engines. According to [1], the vapor pressure of pure ethanol is low. In [2], it was presented that instead of pure ethanol, a blend of ethanol and gasoline is a more attractive fuel. The authors in [3] have investigated the engine performance and pollutant emission of an SI engine using ethanol-gasoline blends (E0, E5, E10, E20 and E30). In [4], experimentally and theoretically effects of ethanol addition to gasoline on an SI engine performance and exhaust emissions has been presented. In [5], a review on SI engine performance has been analyzed using biogas. In [6], performance and emission analysis of our stroke twin spark single cylinder SI engine fuelled with gasoline and CNG has been presented.

However, from the above literature it has been found that the comparison between the MPFI and carburetor SI engines using blends of ethanol and gasoline is not performed still. Hence, this paper this work was carried out.

II. Difference between Carburetor and MPFI SI Engine

Multi-point fuel-injection (MPFI) is used to specify a technology used in gasoline/petrol engines. The MPFI system is a system which uses a small computer to control the car's engine. A petrol car's engine usually has three or more cylinders or fuel burning zones. So in case of an MPFI engine, there is one fuel ±injector installed near each cylinder that is why they call it multi-point (more than one points) fuel injection. Carburetor was one chamber where petrol and air was mixed in a fixed ratio and then sent to cylinders to burn it to produce power. This system is purely a mechanical machine with little or no intelligence. It was not very efficient in burning petrol; it will burn more petrol than needed at times and will produce more pollution. MPFI emerged an intelligent way to do what the carburetor does. In MPFI system, each cylinder has one injector (which makes it multi-point). Each of these injectors is controlled by one central car computer. This computer is a small micro-processor, which keeps telling each injector about how much petrol and at what time it needs to inject near the cylinder so that only the required amount of petrol goes into the cylinder at the right moment [7].

III. Experimental Setup

The properties of ethanol and the calculations for finding out the theoretical property of different blends can be found in literature. Hence, here it was not presented. In this paper, two identical engines one carburetor SI engine and MPFI SI engine was selected for testing purpose. Both engines are the three cylinders, four stroke, and MARUTI 800 engine. The compression ratio for both the engines is same (8.7).

The engine specification of the carburetor SI engine test rig and MPFI SI engine are same and it is shown below:

- General details – three cylinder, four stroke, spark ignition, water cooled, Carburetor type SI MARUTI 800 engine
- Bore = 68.5 mm, stroke = 72 mm
- Piston displacement = 796 cc
- Compression ratio = 8.7:1
- Maximum output = 37 HP @ 5000 RPM

IV. Results and Discussions

A load test was done with gasoline and its blends with ethanol as fuel on both of the engines. The formulas used for finding out the performance factors of both the engines are same and presented below:

Brake power

$$BP(kW) = \frac{W * N * 0.736}{C} \quad (1)$$

where, W = Spring balance reading in kg, N = speed of the engine in rpm, C = constant = 1000

Mass of fuel consumption

$$mfc(kg/hr) = \frac{X_{cc} * 0.72 * 3600}{1000 * T} \quad (2)$$

where, X = burette reading in cc, 0.72 = density of gasoline in gram/cc, T = time taken in seconds

Specific fuel consumption

$$Sfc(kg/kWhr) = \frac{mfc}{BP} \quad (3)$$

Actual volume of air sucked into the cylinder

$$V_a(m^3/hr) = C_d * A * \sqrt{2gh} * 3600 \quad (4)$$

where, $H(m) = \frac{h}{1000} * \frac{\delta w}{\delta a}$ meter of water

A = area of orifice = π d2/4 in m^2, d = 20 mm, h = manometer reading in mm, δw = density of water = 1000 kg/m^3, δa = density of air = 1.193 kg/m^3, C_d = co-efficient of discharge = 0.62, g = acceleration due to gravity = 9.81 m^2/s

Swept volume

$$V_s(m^3/hr) = \frac{\pi d^2}{4} * L * \frac{N}{2} * 60 * 3 \quad (5)$$

where, d = diameter of the bore = 0.0685 m, L = length of the stroke = 0.072 m, N = speed of the engine in rpm

Volumetric efficiency

$$\eta_v(\%) = \frac{V_a}{V_s} * 100 \quad (6)$$

Brake thermal efficiency

$$\eta_{bth}(\%) = \frac{BP * 3600}{mfc * C_v} * 100 \quad (7)$$

where, C_v = calorific value of gasoline = 44000 kJ/kg

Mechanical efficiency

$$\eta_{mech}(\%) = \frac{BP}{IP} * 100 \quad (8)$$

where, IP = indicated power in kW

Air-Fuel ratio

$$A/F = \frac{\dot{m}_a}{\dot{m}_f} \quad (9)$$

Where, $\dot{m}_a$ = mass of air in kg, $\dot{m}_f$ = mass of fuel in kg

The performance tests were carried on the MPFI SI engine as well as an identical carburetor SI engine and investigated the performance for all blends at different loads. From the investigation, it was concluded that the 20% ethanol blend with gasoline gave the best result for both the engines. At the 20% ethanol blend with gasoline, MPFI engine gave the better result compared to the carburetor engine. Because there is such a short duration (time and length) after fuel injection for evaporation and mixing to occur, it is essential that port injectors spray very tiny droplets of fuel.

Figs. 1 to 4, shows the comparison between the MPFI and carburetor SI engines for various performance parameters such as fuel consumption, specific fuel consumption (SFC), brake thermal efficiency, and mechanical efficiency respectively.

A. Mass of fuel consumption

Fig. 1 shows the comparison of performance of MPFI SI engine and Carburetor SI engine. In this investigation, we have compared for pure gasoline and 20% ethanol blend with gasoline. The mass of fuel consumption is lower for MPFI SI engine for both gasoline and E20 blends compared to Carburetor SI engine.

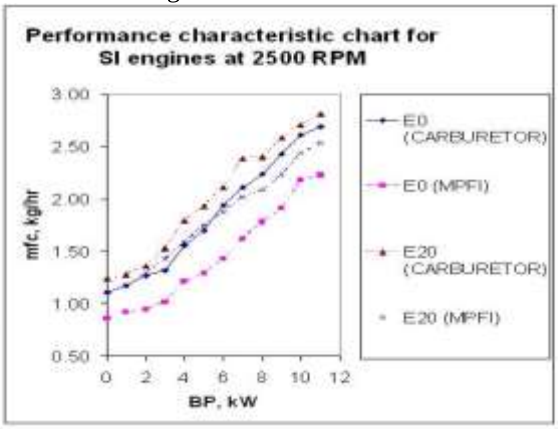

Fig. 1: The effect of E0 and E20 on mass of fuel consumption for SI engines

B. Specific fuel consumption

The comparison for specific fuel consumption for both engines is shown in Fig. 2. The specific fuel consumption for MPFI SI engine is lower compared to Carburetor SI engine. Because fuel is injected directly into the cylinder, hence fuel loss in intake manifold can be avoided.

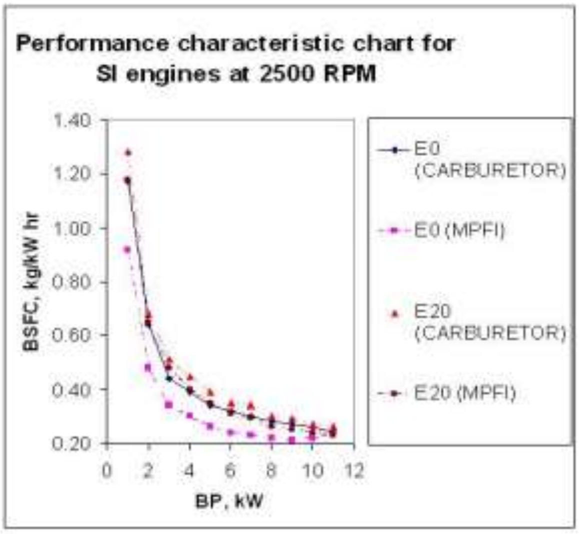

Fig. 2: The effect of E0 and E20 on specific fuel consumption for SI engines

C. *Brake thermal efficiency*

Fig. 3 shows the comparison of MPFI SI engine and Carburetor SI engine for pure gasoline and 20% ethanol blend with gasoline. The comparison shows that the brake thermal efficiency is higher for the MPFI SI engine than Carburetor SI engine. Because Electronic Control Unit of MPFI engine injected only the minimum necessary value of fuel to the cylinder as the load demands, so higher thermal efficiency.

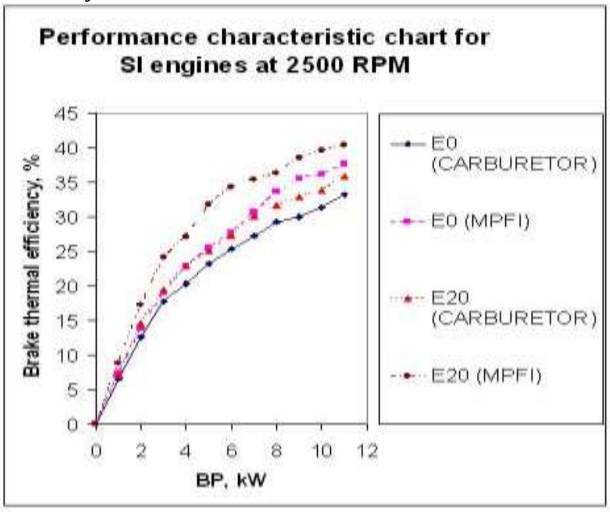

Fig. 3: The effect of E0 and E20 on brake thermal efficiency for SI engines

D. *Mechanical efficiency*

As shown in the Fig. 4, mechanical efficiency is lower for MPFI SI engine than Carburetor SI engine for both the blends. As the overall efficiencies (brake thermal efficiency) is higher for MPFI engines (as already shown). At same loss the output from the MPFI engine is higher. So, all efficiency is higher.

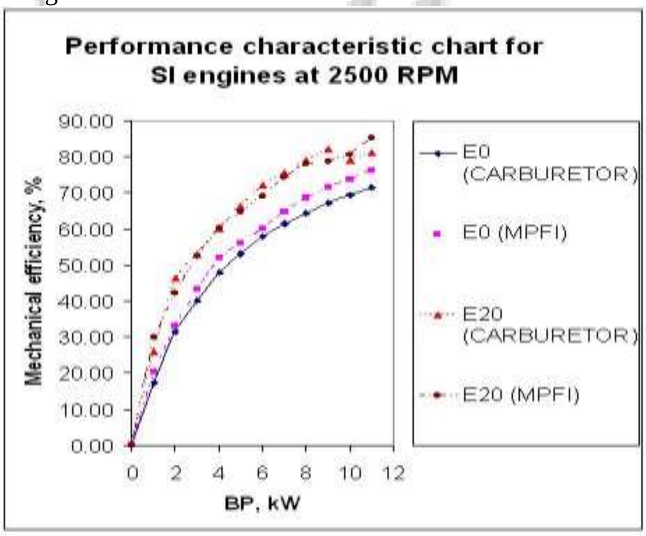

Fig. 4: The effect of E0 and E20 on mechanical efficiency for SI engines

The experimental performance is on MPFI SI engine and on identical Carburetor SI engine shows that MPFI SI engine gave a better performance compared to the identical type Carburetor SI engine for all loads and for all ethanol blends with gasoline. Hence we recommended the use of 20% ethanol blend with gasoline to MPFI engine.

V. CONCLUSIONS

The experimental test was performed to measure the performance parameters for MPFI and carburetor SI engines with different ethanol blends with gasoline. The following conclusions are made:

– The performance of MPFI engines is always better than the Carburetor SI engine for all ethanol blends with gasoline.
– The results show that the performance parameters for MPFI SI engine are better and recommended it for the automobile vehicles.
– Using MPFI engine is advised using ethanol as a fuel for complete combustion resulting in less pollution.
– The experimental results shows that 20% ethanol blend with gasoline gives the best performance for both MPFI as well as the Carburetor SI engine.

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