Determination of Performance Characteristics of Petrol/Bio-Ethanol Blends for Spark Ignition (Si) Engines

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Abstract- Performance characteristics; fuel power (FP), brake thermal efficiency (BTE), brake power (BP) and Specific fuel consumption (SFC) of blended (petrol/bio-ethanol) fuels were studied and compared with neat petrol. The blends were; E05, E10, E15 and E20 for 5%,10%, 15% and 20% bio-ethanol respectively. The performance parameters were measured based on short standard engine tests performed on a Cortina petrol engine test bed, a four stroke engine, and variable speed SI engine with an eddy current dynamometer and Tachometer. The result showed that E05 and E10 were the optimum blending ratios for bioethanol and petrol. It can be concluded from these results that E05 and E10 are the most suitable blends for use in four stroke SI engines.

Keywords- Bio-ethanol, Petrol (gasoline), Blended fuel, Performance parameters and SI engines.

1. Introduction

The increase in energy demand, climate change and the environmental concern of global warming coupled with increasing price of petroleum products in the international market have greatly increased the interests in the source for alternative fuels such as biofuels and biofuel blends for use in internal combustion engines. The alternative fuels that have received the greatest attention in recent times for use in compression ignition engines are bio-ethanol and biodiesel [1]. Bio-ethanol is made by fermenting any biomass that is rich in carbohydrates such as corn, sweet potatoes, cassava, millet, guinea corn, sugar cane, waste products from biomass etc [2, 3]. It is a clean, colourless liquid with a distinctive, sweet smell. It is low in toxicity and causes little environmental pollution if splits [4]. Apart from energy benefits, the growth of crops for energy production also has a positive influence on rural economies [4-9]. It has been shown that bio-ethanol/ petrol mixtures in various ratios can be effectively used as a substitute to neat petrol to reduce the consumption of conventional petroleum [10, 11]. It can be used as a neat fuel (100%) in special petrol engines or as a mixture to gasoline in the common petrol engines. It has become a common practice in many parts of the world to use various blends of bioethanol and petrol in flexible fuel vehicles (FFV); Sweden (5%), Australia (10%), Canada (10%) , Brazil (25%) and USA (up to 10%) [12- 14]. Maher et al reported a significant increase in power output of engines using ethanol-gasoline blends [15]. Furthermore, a study at Southern Illinois University also showed that biofuels blends slightly increased the specific fuel consumption and engine power [16]. Chen et al also reported an improvement in efficiency of combustion using ethanol-unleaded gasoline blends, because ethanol provides additional oxygen to facilitate combustion [17].

The use of bio-ethanol blends or pure bio-ethanol helps in improving the air quality during the use of old engines because it reduces the amount of carbon (ii) oxide and other nitrogen oxides produced by the engines [4,5,11,18]. In USA the common bioethanol/ petrol mixtures are 10% (E10) and 85% (E85) whereas in Brazil, the readily available mixtures are gasoline type C and its high octane variants which contains 20% (E20) to 25% (E25) bio-ethanol [11].

2. Materials and Methodology

In this study, bio-ethanol was prepared from agricultural materials (such as maize, sweet potatoes, cassava, millet, guinea corn and sugar cane) and purified to 99.43% using standard methods. Gasoline used in the study was purchased from local filling stations. The mixtures/blends were obtained by mixing 5%, 10%, 15% and 20% of bio-ethanol in gasoline as E05, E10, E15 and E20 respectively.

Table 1. Some properties of the Ethanol, gasoline and its blends

Blends	Specific gravity (SG)	Calorific Value (CV) J/Kg
Gasoline	0.7625	4.64×10^7
Ethanol	0.7900	3.00×10^7
E05	0.7640	4.54×10^7
E10	0.7650	4.38×10^7
E15	0.7660	4.27×10^7
E20	0.7670	4.18×10^7

The Cortina petrol engine test bed, a four stroke engine, was set to an idle speed that was lower than 750 RPM, which was the chosen starting speed for the tests. The engine was allowed to run at that speed for some time to warm it up to a uniform temperature. Preliminary checks to ensure that the engine could work smoothly without any hitch were carried out with 1 litre neat petrol. The engine was throttled to the first desired speed of 750 RPM which was measured with the aid of a Tachometer. It was allowed to run at this speed and the time required for consumption of 150cm^3 of fuel was read by the use of a stop clock, the brake speed and balancing load were also noted. Load at the dynamometer was increased gradually until the spring balance read zero. The load was noted.

The above procedure was repeated at engine speeds of 1050 RPM, 1350 RPM and 1700 RPM for E05, E10, E15 and E20 blends. After this, the engine accessories were turned down beginning with unloading to switching off the engine.

The test procedures for derivations of the performance parameters were conducted using facilities at the Department of Mechanical Engineering, University of Nigeria, Nsukka, Enugu state, Nigeria under the supervision of Mr. E.O. Nwaehujor the Chief Technologist and his staff. The specific gravities (S.G.) and calorific values of the neat and blended fuels were determined at the quality control department of Benue Cement Company PLC., Gboko Benue State, Nigeria.

3. Results and Discussion

3.1. Brake Thermal Efficiency (BTE)

The rate at which brake thermal efficiency (BTE) varies with indicated engine speed is shown in Figure 1. It would be observed from this figure that the BTE was highest for E05 at engine indicated speed 750 RPM followed by E10. E20 had the lowest brake thermal efficiency at this engine indicated speed. At engine indicated speed of 1050 RPM; E10 had the highest brake thermal efficiency, followed by E05. E20 had the lowest brake thermal efficiency at this engine indicated speed. At 1050 RPM engine indicated speed, the brake thermal efficiency of E10 increased sharply while that of E15, petrol, E20 increased slightly. The brake thermal efficiency of E05 decreased sharply at this speed.

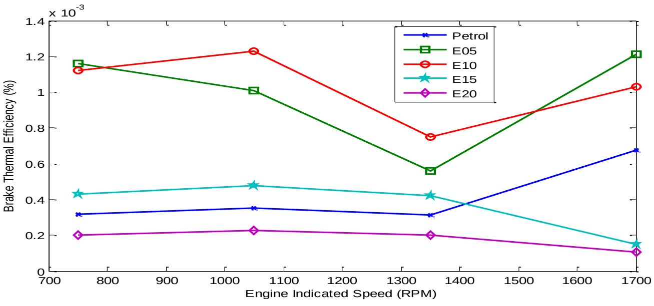

Fig. 1. Brake thermal efficiency characteristic of petrol and some blended bio-ethanol/PMS ratios

At the engine indicated speed of 1350 RPM; BTE of E10 was highest followed by E05. It would be observed that there was a sharp decrease in BTE for E10 and E05. There was only a slight decrease in brake thermal efficiency for E15, petrol and E20. The sharp decrease may have been a result of increase in mechanical friction [19]. The increase in engine indicated speed from 750 RPM to 1350 RPM did not have much effect on the thermal brake efficiency for E15, petrol and E20. At the engine indicated speed of 1700 RPM, there was a sharp increase in BTE for E10, E05 and petrol. There was a sharp decrease in BTE for E15 with only slight decrease in brake thermal efficiency for E20. At these selected experimental speed, E05 and E10 had higher brake thermal efficiency than petrol with E05 as the optimum blending ratio.

At the engine speed of 1050 RPM there was a peak (maxima) in brake thermal efficiency of E05, E10, E15 and E20. The BTE sharply declines especially for E05 & E10 and only a slight decrease was noticed for E15, petrol and E20, then a minimum BTE occurs at 1350 RPM for E05, E10 and petrol. For E15 and E20 there was continues decrease in BTE.

3.2. Specific Fuel Consumption (SFC)

The effect of variation of engine indicated speed on the specific fuel consumption is shown in Figure 2. From this figure it would be observed that at the engine indicated speed of 750 RPM, E20 had the highest specific fuel consumption followed by petrol. E05 had the lowest specific fuel consumption. When the engine indicated speed was increased to 1050 RPM, the specific fuel consumption of petrol, E05, E15, E10 and E20 decreased slightly. At the engine indicated speed of 1350 RPM, the specific fuel consumption (SFC) of petrol, E15, E05, E10 and E20 increased slightly.

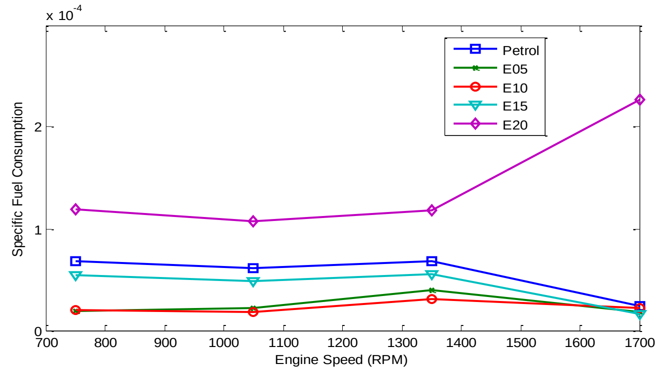

Fig. 2. Specific fuel consumption characteristics of petrol and some blended ratios of bio-ethanol/PMS ratio

When the engine indicated speed was increased to 1700 RPM, there was sharp drop in specific fuel consumption, with E15 having the lowest followed by E05, and E20 having the highest followed by petrol. Considering the SFC at the different engine indicated speed selected for this experiment, it would be observed that E15 will be the optimum blend.

3.3. Fuel power (FP)

The change of fuel power with engine indicated speed is shown in Figure 3. From the figure, it would be observed that the fuel power was higher for E20 at 750 RPM and E10 had the lowest fuel power at 750 RPM. At the engine speed of 1050 RPM, the fuel power ratings of the blended bio-ethanol and the neat petrol (gasoline) were the same as at 750 RPM.

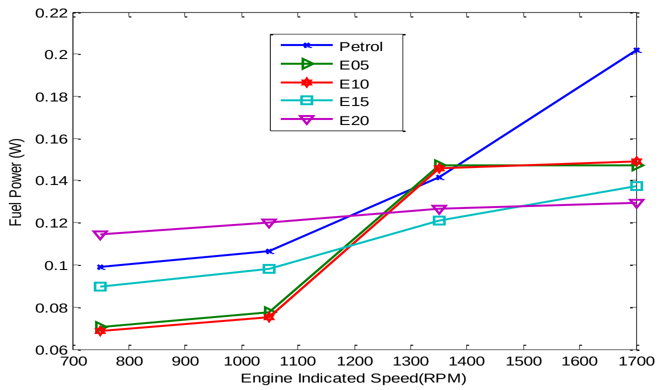

Fig. 3. Fuel power characteristics of petrol and some blended bio-ethanol/PMS ratios

At a higher speed 1350 RPM the fuel power of E05, E10 and petrol increased sharply with the fuel power of E05 becoming highest and followed closely by E10. The fuel power of E15 also increased slightly.

The range of engine indicated speeds used did not have very significant effect on the fuel power of E20.

When the engine indicated speed was increased to 1750 RPM, the fuel power of petrol increased sharply above all the blended bio-ethanol/PMS ratios. E15 and E10 were not affected by the increase in engine speed. The fuel power of E20 was not significantly affected by the increase in engine speed in the range used. As the fuel power increases, the brake thermal efficiency of an engine decreases [20]

3.4. Brake Power

Figure 4 shows variation of brake power in (W) with engine speed. It would be seen that the brake power of E05 was highest at the engine indicated speed of 750 RPM followed by E10. Neat petrol was higher than only E20. When the speed was increased to 1050 RPM, the brake power of E10 increased to the highest position and the brake power of E05 decreased to the second place. The brake power of E20 showed only slight changes in the range of engine speeds used. At the speed of 1700 RPM, the brake power of E10, E05, and petrol increased significantly with E05 having the highest brake power followed E10 and then neat petrol. The brake power of E15 and E20 decreased at that engine indicated speed.

From this result, it would be observed that the optimum brake power of E05, E10 would be 1750 RPM while E15 would be 1050 RPM, and the brake power of E20 not affected significantly by the range engine speed used.

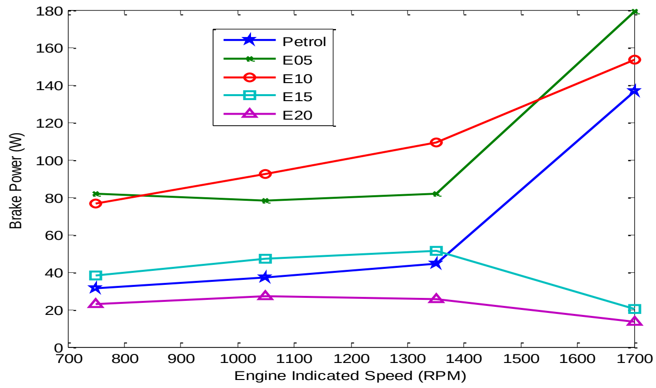

Fig. 4. Brake Power Characteristics of Petrol and some blended bio-ethanol/pm ratios

4. Conclusion

Performance characteristics of neat and blended fuels were studied using performance parameters such as specific fuel consumption (SFC), brake thermal efficiency (BTE), brake power (BP) and fuel power (FP). BTE of E05, E10 and E15 were higher than neat fuel (petrol) at lower acceleration speed of 1350 RPM. At 1700 RPM, the BTE of E05, E10 were higher than sole fuel (petrol), while the BTE of E20 was fairly constant at the tested speeds. The specific fuel consumption of neat fuel (petrol) was higher than E05, E10, and E15 at all the acceleration speeds studied. The SFC of E20 was however higher than the sole fuel (petrol). The fuel power of neat fuel (petrol) was higher than E05, E10 and E15 at 750 RPM and 1050 RPM. E20 had the highest fuel power within this acceleration speed. At the highest acceleration speed used, (1700RPM) the fuel power of petrol was higher than E05, E10, E15 and E20 which is consistent with the findings that as the BTE of the engine increases the fuel power decreases [21].The fuel power of E20 was fairly independent on the engine speed range studied. The brake power of E05, E10 were higher than petrol at all the speeds studied. At acceleration speed higher than 1350RPM, the brake power of E15 and E20 decreased.

Considering all these parameters, one would conclude that the optimum blending ratios for bio-ethanol/PMS ratios are E05 and E10.

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