POWER PERFORMANCE AND FUEL CONSUMPTION OF A SPARK-IGNITION ENGINE USING DIFFERENT BLENDS OF ETHANOL-GASOLINE

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ABSTRACT

The Philippine Government Alternative Fuel Program now mandates a 10% bioethanol blend for commercial gasolines sold at the pumps. Numerous laboratory studies of different kinds of bioethanol in different countries exist but none yet in the Philippines, specifically, in vehicle use. A research was conducted at the UPME-Vehicle Research and Testing Laboratory (VRTL) to investigate experimentally the effects on engine's power performance and specific fuel consumption (SFC) of E5 (5% ethanol), E10 (10%), E12.5 (12.5%), E15 (15%), E20 (20%), E25 (25%) and E30 (30%) ethanol-gasoline blends by volume as compared to neat gasoline (E0). The vehicle was driven in road load simulation at standard Japanese driving cycle while measuring fuel consumption and power developed. Each blend test passed three trials using the AVL Chassis Dynamometer equipped with fuel mass flow meter with temperature control. Test showed positive correlation between mass specific fuel consumption (MSFC) and ethanol amount in the fuel mixture. From 44.68 g/km at E0, it raised continuously to 45.58g/km(E5), 45.79g/km(E10), 45.89g/km(E12.5), 46.11g/km(E15), 46.33g/km(E20), 46.71(E25) and 49.14g/km(E30). Lower energy content of ethanol–gasoline fuel caused an increase in the engine's MCSF or a decrease in mileage in all blended fuels. However, the energy specific fuel consumption (ESFC) gives a better picture of the efficiency on fuel conversion. There was an improved maximum power obtained for E5, E12.5, E20 and E25 of about 1.9%, 0.55%, 1.64% and 3.4% respectively, while E10 and E15 decreased in outputs by 0.78% and 0.32% respectively. These blends show relatively comparable output to neat gasoline due to oxygen content of ethanol outweighing lower heating value. E30 showed the biggest reduction at 3.43% lower than neat gasoline. In general, during the experiment, no significant problem was encountered in the engine performance. This means that all blends tested were suitable to the vehicle (engine) used.

Keywords: biofuel, ethanol, specific fuel consumption

1 INTRODUCTION

The increasing human population and concurrent rising standard of living are predicted to cause shortages of energy and resources in the future. Our country is very fortunate with recent active oil exploration and extraction of previous and new discoveries. However, dependence on petroleum as a main source of energy does not augur well for us. In a few decades, this country's known reserves and even at the other parts of the world which took nature hundred millions of years to make in the earth will be exhausted.

From the viewpoint of energy conservation, many nations including the Philippines are now on the response of using biofuel to be blended in diesel and gasoline (Biofuels Act) to be used in engines. Coconut oil, wheat, sugar beet, corn, straw, wood, and even jatropha, palm oil, talisay and many other organic sources of alcohols are now being utilized and used both on gasoline and diesel engines in response to the campaign.

The Alternative Fuels Program is one of the five key components of the Arroyo Administration's Energy Independence Agenda, which outlines the roadmap that will lead to the country's attainment of 60% energy self-sufficiency by 2010. The government urged motorists to switch to biofuels, stressing its economic benefits not only for the government but also for the consumers. Under the Biofuels Act (RA 9367), local oil companies are now required to sell gasoline pre-blended with 10% ethanol.

According to the DOE, the production and use of bioethanol can serve a variety of needs. On national level, bioethanol can improve the balance of payments by displacing imported petroleum with domestically produced fuel. It may also provide more jobs in rural areas and alternative markets for agricultural commodities. The department pointed out that the use of E10 would mean "better performance, reduced carbon monoxide and unburned hydrocarbon emissions which, in most cases, would improve fuel economy".

Unfortunately, due to different reports from related researches conducted, most of the vehicle owners are still using the conventional gasoline because they are so doubtful on the possible effects (problems or disadvantages) of the biofuel blends on their engine's performance.

If gasoline-ethanol can compete with that of straight gasoline, widespread use of these blends can be possible.

2 EXPERIMENTAL SETUP AND PROCEDURE

The whole experiment was conducted at the Vehicle Research and Testing Laboratory of the University of the Philippines (UP-VRTL). The laboratory houses a chassis dynamometer, mobile emissions analyzer, and a fuel mass flow meter with temperature control among many other things.

2.1 Fuel Properties

Both the neat gasoline and the ethanol were supplied by Petron Corporation, the largest oil company in the country. The ethanol supplied was about 97% ethanol concentration which is the bioethanol supplied to the local oil companies to be blended with their respective gasoline. The following tables 1 and 2 show the properties of the fuels taken from the material safety data sheet and certificate of quality (Petron Corporation), while the heating value shown at figure 1 was measured by the Department of Energy. All of the fuels used were taken from their respective single batches.

Table 1: Neat gasoline properties

PROPERTY	TEST METHOD	RESULT
Appearance	Visual	Clear
Color	Visual	Yellow
Distillation Initial Boiling Point Final Boiling Point	 ASTM D86 ASTM D86	 40.8 211.3
Residue		1.0
RON	ASTM D2699	92.4
RVP	ASTM D6378	53.2

Table 2: Ethanol Properties

PROPERTY	TEST	SPECIFICATION	RESULT
Color	Visual	Dark Violet	Dark Violet
Acidity/Alkalinity	ASTM D6423	6.5-9.0	8.5
Density @ 20°C, kg/m^3	ASTM D4052	Report	788.3
Ethanol Content, %v/v	ASTM D5501	96.9 (min)	97.5
Methanol, %v/v	ASTM D5501	0.5 (max)	0.001
Water Content,%v/v	ASTM E203	0.5 (max)	0.38

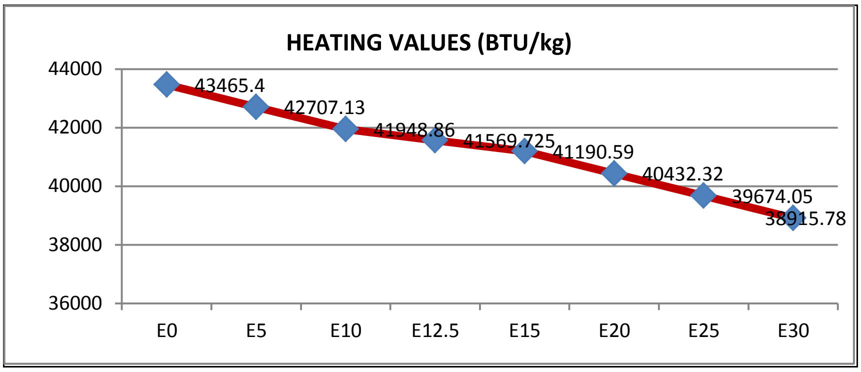

Figure 1: Heating values of different blends of gasoline-ethanol

2.2 Equipment

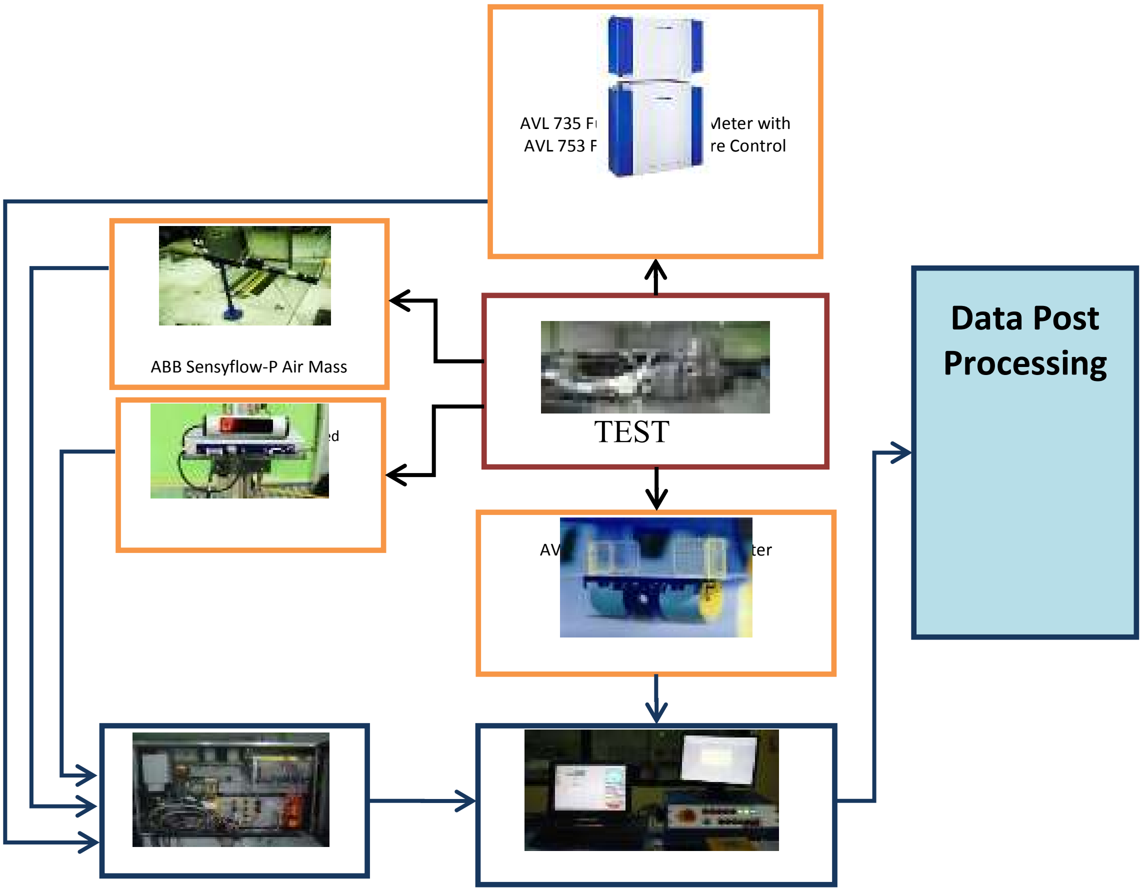

Figure 2: Schematic diagram of the whole test set-up

The gasoline fueled vehicle used was 2004 Honda Jazz that has a 1.7 litre EFI/NA, 10.8 CR with a maximum power of 82 hp/61.2 kW @ 5700 rpm, F/F, 5 speed manual transmission. The oil and oil filter has been replaced and the engine has been flushed twice using an engine flush first and then new engine oil which is the same type the engine will be using throughout the test. An AVL 48" compact chassis dynamometer rated at 150 kW continuous power was used for the vehicle test. It is capable of running in a constant force mode or a road load simulation which simulates the vehicle as if it is running on actual roads. Intake air flow was measured using an ABB Sensyflow-P air mass flow meter.

Figure 3: Vehicle-chassis dynamometer set-up

2.3 Testing Procedures

The testing of the fuels on the vehicle was done in two phases. First was the drive cycle test which consisted of driving the vehicle over a standard drive cycle (Japanese 10-15 drive cycle) and took into account the average values for performance and fuel consumption. A maximum power measurement then follows as the second phase of the test. All of these tests were carried out with the dynamometer set to road-load variable resistance. A neat straight gasoline fuel was also tested using the same procedures at the very start of the test and each new blend was tested required running one drive cycle and maximum power test (3 trials). This is to have a baseline comparison for every blend since the tests for different blends were done in different days with varying environmental conditions and to flush out the engine with neat fuel as well. Although environmental conditions were almost identical during the whole testing period with temperature ranging from 26-29 degrees Celsius and relative humidity at the 70-80% range.

3 RESULTS AND DISCUSSION

3.1 Fuel Consumption

As seen from figures 5 and 6, there is a positive correlation between fuel consumption and the ethanol amount in the fuel mixtures in drive cycle test. From 44.68 g/km at E0, It raised to 45.58 g/km (E5), 45.79 g/km(E10), 45.89 g/km (E12.5), 46.11g/km(E15), 46.33g/km(E20), 46.71(E25) and 49.14 g/km(E30). The heating value of pure ethanol is approximately 34% less than the values of gasoline and it is well known that heating value of fuel affects the MSFC of an engine. The reduced energy content of ethanol–gasoline fuel results to an increase in mass specific fuel consumption of the engine or a decreasing trend mileage as in figure 7.

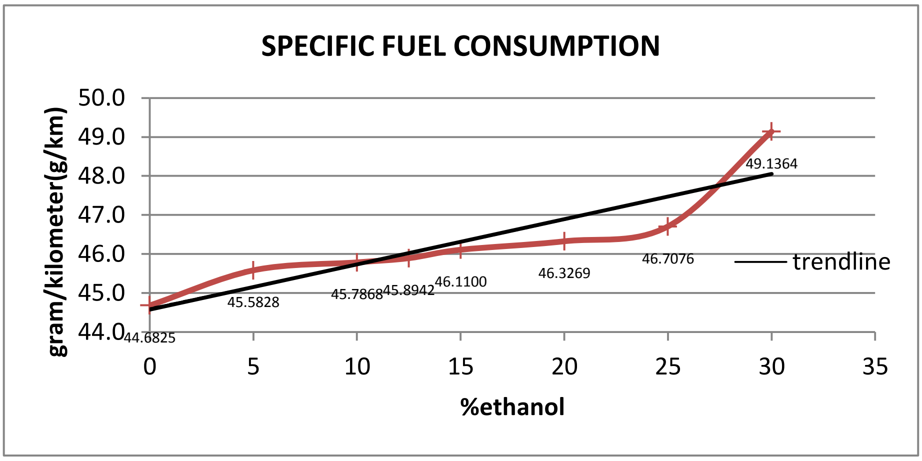

Figure 4: Mass specific fuel consumption vs. ethanol blends

It can be seen at figure 6 that E5 showed slight increase in energy specific fuel consumption by 0.23%, however, an efficient fuel energy conversion at E10 and continuously improving up to E25 (1853.08 BTU/km) in spite of lower heating value of ethanol as compared to gasoline. At E30, an increased in ESFC was seen resulted to a change on trend but still of better energy conversion compared to neat gasoline (1942.14 BTU/km).

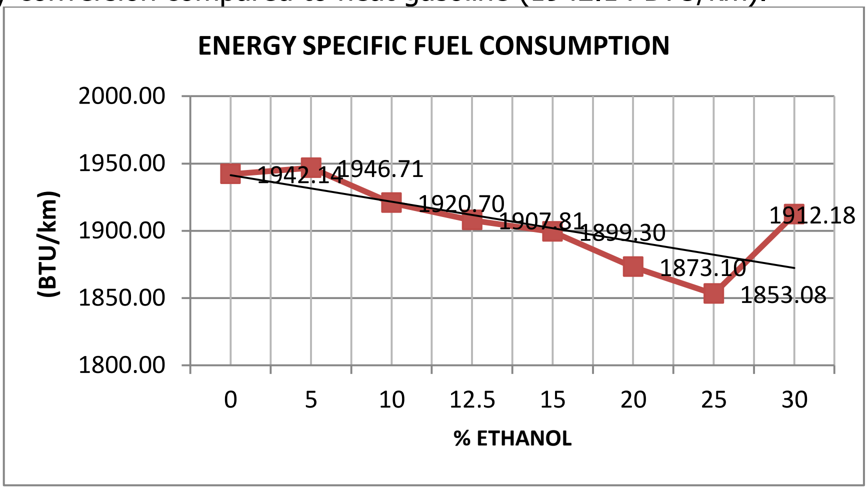

Figure 5: Energy specific fuel consumption vs. ethanol blends

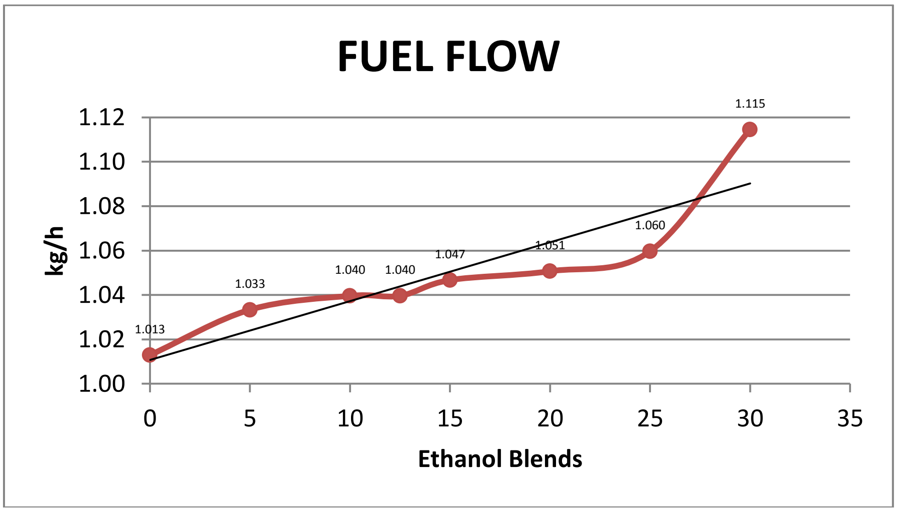

Figure 6: Fuel flow rate in kg/h in increasing trend as ethanol concentration increases

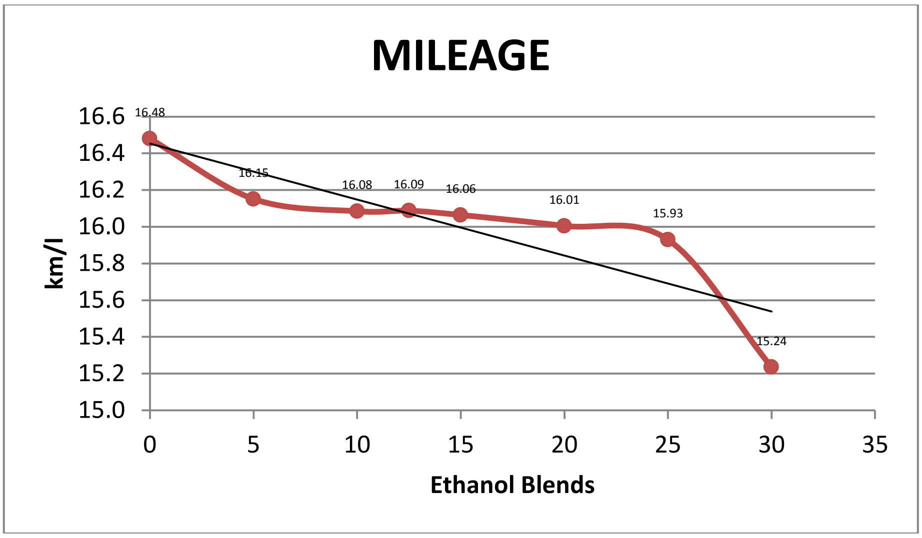

Figure 7: Mileage data showing a decreasing trend in higher ethanol blends

3.2 Maximum Power Measurement

Maximum power test results in figure 6 shows a slight increase in power obtained for E5, E12.5, E20, and E25 of about, 1.9%, 0.55%, 1.64% and 3.4%, respectively, as compared to neat gasoline with 43.6 kW. E10 has only 44.01 kW or 0.48% declined compared to neat gasoline and E30 gives the worst performance at 42.84 kW. Error bars show that the power developed using ethanol is still very comparable to that of neat gasoline.

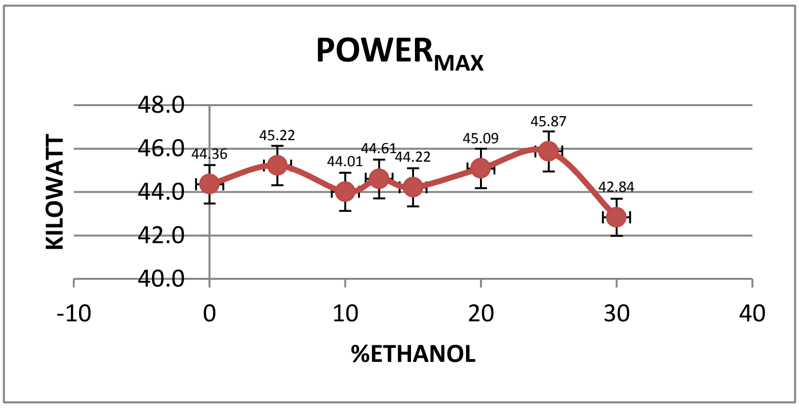

Figure 8: Maximum power developed at different blends

4 CONCLUSION

In relation to the objective set, general results concluded from this study can be summarized as follows:

1. The lower energy content of ethanol–gasoline fuel caused an increase in the specific fuel consumption of the engine and a decrease in mileage in all blended fuels.
2. There is an efficient fuel energy conversion at E10 and continuously improving up to E25 that is possibly due to the oxygenated ethanol (C_2H_5OH) resulting to better combustion.
3. E25 fuel gives the highest maximum power output while and E30 records the lowest. Other blends show relatively comparable output to neat gasoline.

4. In general, during the conduct of experiment, there was no significant problem encountered in the engine especially on performance. This means that all blends tested were all suitable to the vehicle (engine) used.

5 FUTURE WORKS

In order to present a complete picture of the utilization of ethanol-gasoline blended fuel in Spark-ignition engines, the extension of this study on the following factors that may affect performance and emission must be investigated:

1. Ignition timing - The test vehicle Intelligent-Dual Sequential Ignition Technology (i-DSI) may have some effect on the earlier and retarded ignition.
2. Compression ratio – Expected increase in Octane Rating of the gasoline-ethanol blend may suggest a possible change in compression ratio fit for better combustion.
3. Ethanol and gasoline chemical composition – A complete chemical composition analysis for the fuel blends must be conducted.
4. Higher ethanol in blends must be evaluated since at E30, a very obvious change was observed in both the energy specific fuel consumption and power developed.

Furthermore, the effects on the vehicle parts, particularly to the fuel tanks and all fuel lines must be investigated and the cost of fuel as based on its energy utilization.

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