The Comparison of Fuel Consumption for Small Gasoline Engine Fuelled by Commercial Gasoline Fuel in Thailand on Different Conditions

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Abstract

This research aimed to study the Comparison of Fuel Consumption for Small Gasoline Engine Fuelled by Commercial Gasoline Fuel in Thailand on Different Conditions, as produced by small gasoline engine performance testers. The researchers used Gasoline, Gasohol 95, E20 and E85 with Honda GX 200 engine. The test machine consisted of (1) a brake pump and brake calipers, (2) Drive Shafts and Levers Load pressure gauge, (3) Speed sensor of engine, and (4) Fuel cylinder of each type and oil shutoff valve. Digital display all these devices was installed on the same structure as the engine used in the test. The test was conducted at the constant engine speed 2,500 and 3,600 rpm, with a load at 2 Nm and 4 Nm. The performance test results revealed that the workload 2 Nm with the brake specific fuel consumption of gasoline, gasohol 95, E20 and E85showed gasoline having the lowest fuel consumption. The used oil was most cost effective and cost saving with gasohol E85 and 4Nm workload. Specific fuel consumption of E20 and gasohol had the lowest fuel consumption. It was the most cost effective. Based on the tests at engine speed of 3,600 rpm constant load at 2Nm and 4Nm, the performance results of the engine performance were at 2Nm workload. Of the specific fuel consumption of gasoline, gasohol 95, E20 and E85. gasohol 95 had the lowest fuel consumption. It was the most cost effective. At 4Nm workload, the specific fuel consumption of gasoline had the lowest fuel consumption. It was found that the used oil gasohol E20 was the most cost effective.

Keywords: Small gasoline engine, brake specific fuel consumption, brake thermal efficiency, cost effective

1. Introduction

Commercial fuel in Thailand is in two types: diesel and gasoline. The current situation of oil is likely to diminish in production and consumption with higher prices. For this reason, "ethanol" is an alternative fuel from plants like cane and cassava added for mixture of gasoline. Thailand has four types of gasoline with classifieds from ethanol mixture as follows (1) Gasoline without ethanol blends, (2) Gasohol 91 and Gasohol 95 with 10% ethanol blends, (3) Gasohol E20 with 20% ethanol blends, and (4) Gasohol E85 with 85% ethanol blends (Cary, 2017).

Gasoline is used for transportation in the group of passenger cars with gasoline engine, and motorcycles including boats or small water vehicles. Moreover, the group of agriculture engines uses gasoline in water pumps, sprayers, small generators and aquatic animal oxygen fillers for the transport sector. However, the varied prices of gasoline in Thailand result in different ethanol mixtures that affect power and fuel consumption. Most people in the agricultural sector do not know or understand various blends of fuel for efficiency in use and cost.

The research was an attempt to study the performance of a small gasoline engine and compare fuel consumption of a small gasoline engine fuelled by commercial gasoline fuel in Thailand on different conditions. It was expected that the research findings will help people in the agricultural sector to choose the right fuel for their job and save fuel costs.

2. Literature Review

Venkatesan (2016) reported the study on the effect of using unleaded gasoline and additives blends on spark ignition engine (SI engine) performance and exhaust emission. A four- stroke, single cylinder SI engine was used in conducting the study. Performance tests were conducted for fuel consumption, volumetric efficiency, brake thermal efficiency, brake power, engine torque and brake specific fuel consumption, while exhaust emissions were analyzed for carbon monoxide (CO), Hydrocarbon (HC), and Oxides of nitrogen (NOx) using unleaded gasoline and additives blends with different percentages of fuel at varying engine torque condition and constant engine speed. The result showed that blending unleaded gasoline with additives increased the brake power, volumetric and brake thermal efficiencies and fuel consumption. The CO and HC emissions concentrations in the engine exhaust decreased while the NOx concentration increases. The addition of 5% isobutanol and 10% ethanol to gasoline gave the best results for all measured parameters at all engine torque values.

Tanmee et al (2012) researched into vehicle fuel consumption and emission in Thailand regulations, as cited by Economic Commission for Europe (ECE). Gasoline-ethanol fuel consumption was investigated in Bangkok metropolis. The vehicle's on-board diagnosis (OBD) data were collected from mass of air flow rate into an engine read from mass air flow sensor and oxygen sensor. By applying mass of air flow rate in the combustion equation, the fuel consumption rate was determined. Phahonyothin Road with different time conditions was explored this study. The different gasoline-ethanol fuel types: E10, E20 and E85 were carried out on SUV car. The investigation revealed that the fuel consumption of E85 was 18.79% and E20 was 0.56% higher than E10. In addition, the carbon dioxide emission from E85 was 60.61% and E20 was 3.75% less than E10. Moreover, the energy efficiency for E85 was 8.29% and E20 was 3.75% better than E10. Overall of fuel economy, E85 was the best at 23.28% and 2.11% for E20, costing less than E10.

Sritram et al (2012) studied modification of the injection control system and performance tests of motorcycle engine in using gasohol E85. The results showed that the engine using ethanol-gasoline blend (E85) with a proper air-fuel ratio can gain the brake torque and power closed to normal gasoline engine. However, the brake specific fuel consumption was higher than that of the gasoline engine. The study showed the possibility of engine modification in using alternative fuel of ethanol-gasoline blend E85.

3. Experimental setup and method

3.1 Engine and apparatus

The engine is Honda GX 200 with 4 stroke gasoline single cylinder SI engine. Engine has been widely used in group of agriculture for water pump, sprayer, small generator and aquatic animal oxygen fillers for transport sector. Specifications of the engine shown in table 1.

Table 1: Engine Specifications

Engine	Specifications
Series	Honda GX 200T
Description	Four strokes, Single cylinder air cooled engine
Maximum torque	11.9 Nm @ 2500 rpm
Maximum power	3.9 kW @ 3600 rpm
Bore x stroke	68 mm × 54 mm
Displacement	196 cc
Fuel	Gasoline or Gasohol E10
Net weight	16 kg.

The engine was loaded by a prone brake dynamometer to create load to the engine. The master cylinder in the brake system increased brake force with the load control valve. The engine load was loaded on a load cell and displayed on the digital monitor. The speed of the engine was measured with rpm sensors and a stopwatch was used to time each fuel consumption. Data on spent time was calculated for brake specific fuel consumption. The experimental setup was shown in Figure 1.

Figure 1: Experimental Setup
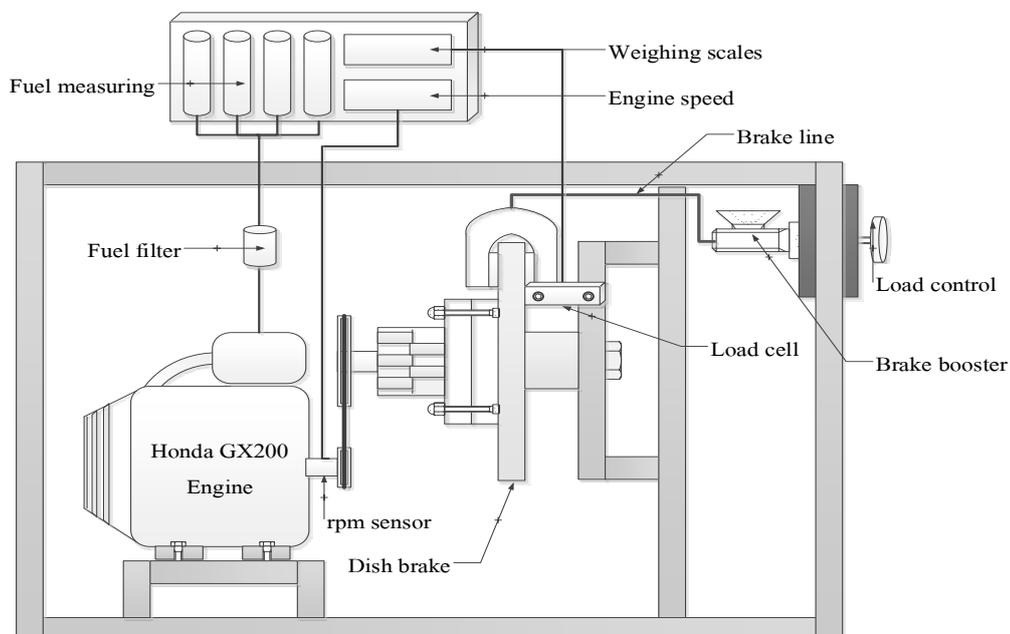
3.2 Fuel Test

The pure fuels used in this study were Gasoline with classifieds from the ethanol mixtures as follows (1) Gasoline without ethanol blends, (2) Gasohol 91 and Gasohol 95 with 10% ethanol blends, (3) Gasohol E20 with 20% ethanol blends, and (4) Gasohol E85 with 85% ethanol blends. These fuels are a commercial fuel in Thailand (Padol et al., 2012). The gross heating value and density Gasoline and Gasohol fuels are given in Table 2.

Table 2: Gross Heating Value and Density of Gasoline Commercial Fuel in Thailand

Properties	Gasoline	Gasohol 95	E20	E85
Gross Heating Value (MJ/Kg)	45.97	44.13	42.23	32.91
Density (kg/m^3)	0.734	0.748	0.748	0.766

3.3 Experimental Procedure

The data on engine specifications from Table 1 showed maximum torque maximum power at 2,500 rpm and 3,600 rpm, respectively. These engine speeds were best performances. This research experimented with the constant engine speed at 2500 rpm and 3600 rpm, and controlled the engine load with two engine torques of 2 and 4 Nm as corresponding to brake mean effective pressure (BMEP). The test started at a constant speed with gasoline for 5-10 minutes to a steady state. The engine was loaded slowly with the engine speed maintained at 2500 rpm until its display showed the load cell force as prescribed. Fuel consumption was timed at 2 ml and recorded when the engine stayed at a constant speed; the same test was performed at 3600 rpm. After gasoline being exhausted, the same test was performed with Gasohol 95, E20 and E85, respectively. The test matrix was calculated for brake specific fuel consumption and brake thermal efficiency by Equations 2 and 3 (Jackkapan, 2015).

$$P_b = 2\pi N T_b$$
(1)

$$BSFC = \frac{\overset{\circ}{m}f}{BP}$$
(2)

$$BTE = \frac{1}{BSFC \times Q_{HV}} = \frac{BP}{\overset{\circ}{m}f \times Q_{HV}}$$
(3)

Where $BSFC$ is Brake specific fuel consumption (g/kW.s), BTE is Brake thermal efficiency (%), $\overset{\circ}{m}f$ is Fuel consumption (g/s), BP and is the quantity of specialist and Q_{HV} is Heating value (MJ/kg)

4. Result and Discussion

4.1 Brake specific fuel consumption

Brake specific fuel consumption (BSFC) is the flow rate of fuel per brake power of engine that shows ability of the engine to burn fuel resulting from heating value of fuel. BSFC can be calculated from Equation 1. The result of gasoline, gasohol 95, E20 and E85 fuels are given in Figure 2.

Figure 2: Brake Specific Fuel
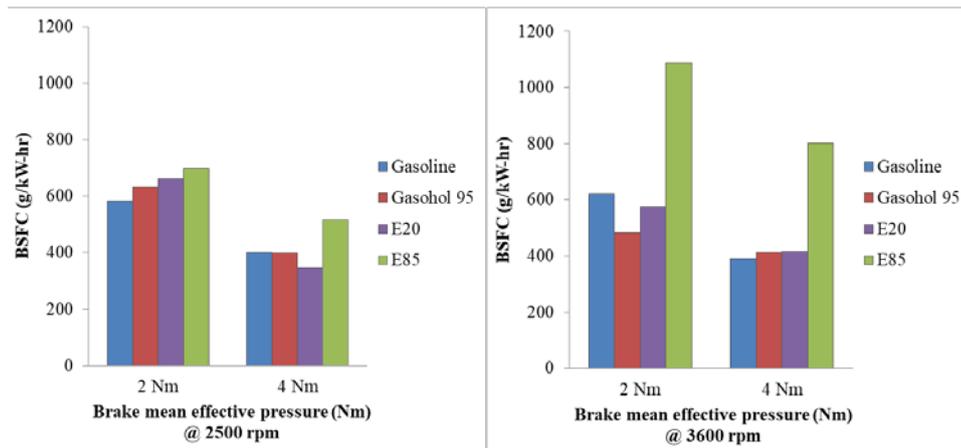
Consumption

Figure 2 presents BSFC of the engine at 2,500 and 3,000 rpm, using 4 types of fuel at two engine torques of 2 and 4 Nm. In the 2,500 rpm case at 2 Nm load engine, BSFC of Gasoline, Gasohol 95, E20 and E85 were increased by 582.03 g/kW-hr, 630.95 g/kW-hr, 662.65 g/kW-hr and 696.53 g/kW-hr, respectively. This behavior is attributed to the HHV per unit mass of the ethanol fuel which was less than Gasoline by 30% (Tanmee et al., 2012). In Case 4 Nm., BSFC of E20 was the lowest by 347.66 g/kW-hr. The latter case was Gasohol 95 and Gasoline at 397.94 g/kW-hr and 399.77 g/k W-hr, considered to have a similar value. The last one was E85 with BSFC by 516.09 g/kW-hr. As shown in Figure 2, BSFC decreased as the engine torque increased. It was a normal consequence of the behavior of the engine. The most amount of fuel was lost with friction of moving internal parts (Jackkapan et al., 2015; Mario et al., 2016).

The high engine speed 3,600 rpm at 2 Nm of Gasohol 95 BSFC was the lowest by 481.89 g/kW-h. The latter case was E20 and Gasoline by 574.47 g/kW-hr and 621.14 g/kW-hr whereas E85 showed the highest result by 1,089.05 g/kW-hr. This can be explained by the lowest of heating value of E85 as mentioned above. In Case 4 Nm., BSFC of Gasoline, Gasohol 95, E20 and E85 were increased by 390.02 g/kW-hr, 412.13 g/kW-hr, 416.46 g/k W-hr and 800.70 g/kW-hr.

The result of BSFC engine speed compared by 2,500 and 3,600 rpm indicated that BSFC of Gasoline, Gasohol 95 and E20 represented the group of few ethanol blends with similar BSFC, whereas BSFC of E85 was greatly increased with high engine speed. The combustion at high speed engine decreased the ability to charge intake air and O_2 into combustion chamber Mario et al., 2016). The amount of O_2 in ethanol molecular boosted O_2 in E85. Therefore the amount of O_2 was sufficient for combustion to make equal power with Gasoline. Consequently, the amount of E85 fuel was increased.

4.2 Brake Thermal efficiency

Brake thermal efficiency (BTE) is defined as brake power of a heat engine as a function of the thermal input from the fuel. It is used to evaluate how attained prominence of an engine converts the heat from a fuel to mechanical energy. The BTE can be calculated by Equation 2 for the result of gasoline, gasohol 95, E20 and E85 fuels as shown in Figure 3.
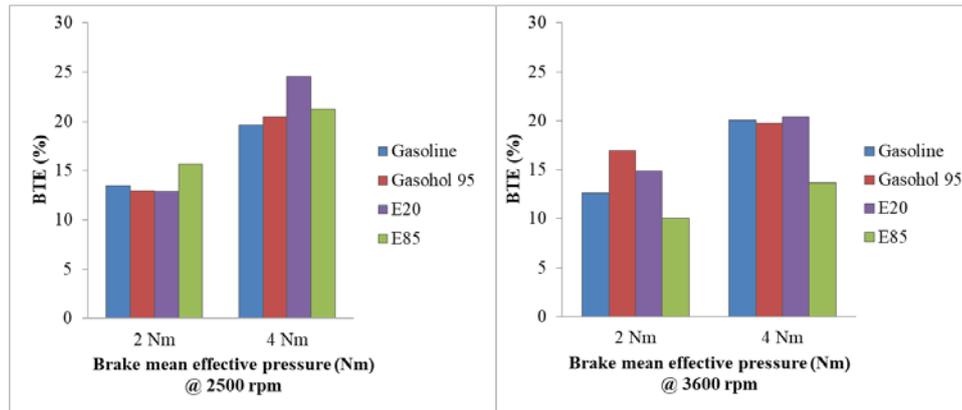
Figure 3: Brake Thermal Efficiency

Figure 3 presents BTE of the engine at 2,500 and 3,000 rpm, using 4 types of fuel at two engine torques of 2 and 4 Nm. In the 2,500 rpm case at 2 Nm load engine, BTE of Gasoline, Gasohol 95, E20 and E85 were decreased by 13.45 %, 12.92 % and 12.86 %, respectively. On the other hand, BTE value of E85 was the highest, ostensibly by 15.70 %, pointing to the behavior of E85 as an engine converting the heating value from E85 to mechanical energy. In Case 4 Nm., BTE of E20 was the highest by 24.51 %, followed by E85, Gasohol 95 and Gasoline by 21.19 %, 20.49 % and 19.5889512 %, respectively.

The high engine speed 3,600 rpm at 2 Nm of Gasohol 95 BTE was the highest by 16.92 %, followed by E20, Gasoline and E85 by 14.83 %, 12.60 % and 10.04 %, respectively. In Case 4 Nm., BTE of Gasoline, Gasohol 95 and E20 had BTE with similar values about 20 % whereas E85 was at its lowest by 13.66 %. In addition, BTE was the effect of BSFC in the lower thermal efficiency of ethanol fuel caused by relative air-to-fuel ratio (Ob et al., 2016). In E85 combustion, ethanol fuels were operated in the slightly lean conditions.

4.3 Cost Economy

The experiment used a commercial fuel in Thailand and data on fuel consumption as mentioned earlier. Cost economy was calculated with price of fuel average in 1 year (2017): Gasoline at 34.56 bath/liter, Gasohol 95 at 27.45 bath/liter, E20 at 24.94 bath/liter and E85 at 20.24 bath/liter (Cary, 2017).

Figure 4: Cost Economy
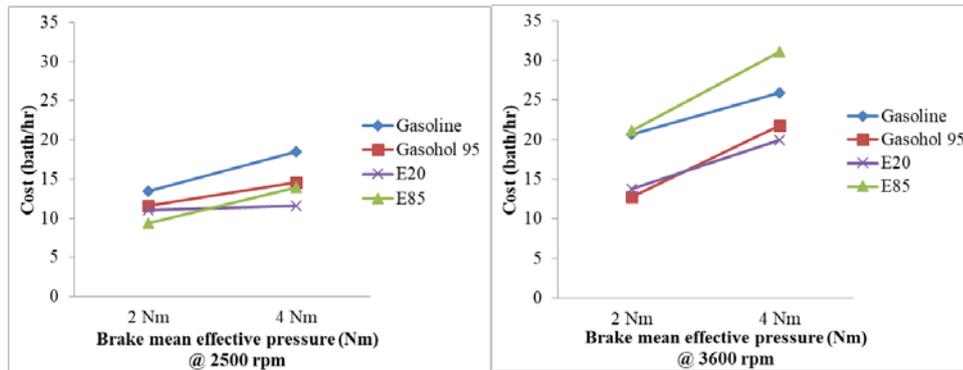
The fuel selection in each type for accuracy of engine power will help users to reduce costs. Figure 4 shows cost economy with the use of any type of fuel. In case of engine speed 2,500 rpm at 2 Nm engine load, the lowest cost was E85 by 9.38 bath/hour, followed by E20, Gasohol 95 and Gasoline at 11.01 bath/hour, 11.55 bath/hour and 13.43 bath/hour, respectively. In Case 4 Nm, the lowest cost was E20 by 11.56 bath/ hour, followed by E85, Gasohol 95 and Gasoline at 13.90 bath/ hour, 14.56 bath/ hour and 18.45 bath/hour, respectively. As for the other engine speed 3,600 rpm at 2 Nm engine load, it was found that the lowest cost was Gasohol 95 at 12.70 bath/ hour, followed by E20, Gasoline and E85 at 13.75 bath/hour, 20.64 bath/ hour and 21.12 bath/ hour, respectively. In Case 4 Nm, the lowest cost was E20 at 19.94 bath/hour, followed by Gasohol 95, Gasoline and E85 at 21.72 bath/hour, 25.92 bath/ hour and 31.06 bath/ hour, respectively.

5. Conclusion

The study on Comparison of Fuel Consumption for Small Gasoline Engine Fuelled by Commercial Gasoline Fuel in Thailand at Different Conditions warrants yielded the following results:

5.1 The fuel with blended ethanol on increased ratios had effect on BSFC of engine. The blended fuel had lower heating value than that of Gasoline. It was also an effect on BTE of Gasohol as lower than Gasoline. However, the moderate ethanol blended ratios in Gasohol 95 and E20 resulted in better combustion. The amount of O_2 in ethanol molecular made combustion more efficient than Gasoline in specific conditions.

5.2 Fuel consumption of E20 and E85 resulted in the lowest cost at 2,500 rpm whereas E20 and Gasohol 95 had their lowest cost at 3,600 rpm. The engine can work well with the use of gasohol.

6. Acknowledgments

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