Gasohol Engine Performance with Various Ignition Timing

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ABSTRACT

Experimental research has been conducted on the effect of ignition timings on the characteristics and performance of gasohol engines such as power, torque, specific fuel consumption, and thermal efficiency. The fuel used in this research is pure gasoline and a mixture of 50% bioethanol (BE50). The results show that the ignition timing that gives the maximum effect occurs at the top and bottom dead points of 9 degrees for gasoline and 12 degrees for BE50 fuel. Furthermore, the maximum power is obtained at 6,500 rpm, and at an ignition time of 12 degrees BTDC the maximum power generated is 4.63 hp, while for an ignition time of 9 degrees BTDC the power generated is 3.38 hp which occurs at 6500 rpm. These results indicate that there is an increase in power of 6.4%. Moreover, the results also show that for optimal gasoline conditions, the amount of energy consumed at an engine speed of 7000 rpm is around 15705.78 kcal/hour, and for BE-50 it is around 12582.03 kcal/hour, where there is a reduction of about 25.44 %. However, in general, it can be seen that during optimal ignition, there is a saving in fuel consumption in the gasoline-BE50 mixture, while at the same time producing a fairly large thermal efficiency. These results indicate that BE50 has the potential to be used as an alternative fuel in small gasoline engines.

Keywords: *Bioethanol, engine power, fuel consumption, ignition timing, thermal efficiency, torque*

I. Introduction

The increase in industrial activity and the increasing world population cause fuel consumption to increase so that it interferes with air quality and causes an energy crisis [1], [2]–[4]. This makes the need for environmentally friendly alternative fuels very crucial [3], [5]. Therefore, the researchers conducted many studies and found that bioethanol is one type of alternative fuel that can be applied to internal combustion engines (ICdisE) and at the same time to overcome the fuel energy crisis [4], [6], [7]. The raw material for bioethanol used in this study is sourced from coconut sap water which is processed through natural fermentation and fractional distillation [8], [9]. Furthermore, the production cost is relatively cheap because it only requires distillation equipment, unlike the transesterification or esterification process which is more expensive and need more equipment. Moreover, it requires a long process with a lot of equipment.Bioethanol is one type of alternative fuel that is converted from bioenergy plants and biomass [10], and with a high octane number, it has the opportunity to be used as an alternative to gasoline [11]. In addition, bioethanol has

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greenhouse gas emissions and lower production costs, as well as a more profitable future evolution that makes bioethanol and its mixtures have great potential to be used as renewable fuels, especially in ICE [12]. On the other hand, a lot of research has been done on the production of bioethanol and its application to machinery [13], [14] and it was found that ethanol fuel is suitable for internal combustion engines but is more focused on diesel engines [15]–[17]. In addition, a recent study on the effect of a mixture of ethanol and gasoline on NOx emissions [18] and their effect on fuel properties and fuel efficiency for blending ethanol and gasoline have also been applied to the ICE and resulted in very good performance improvements [8], [19].

On the other hand, studies on the application of bioethanol (BE5, BE10, BE15, and BE20) by modifying the ignition timing constant on the ICE have been carried out [20]. From the results of the study, it was found that there was an increase in the octane number for all variations of gasoline bioethanol mixtures and reduced carbon monoxide and unburned hydrocarbon gas emissions. Furthermore, for BE30 with different ignition timing variations, it was also found that emission reduction achieved by increasing the ignition timing further advanced the ignition timing resulting in a significant reduction in NOx emissions [21], [22].

However, it is unfortunate because there are no results from the above research that have revealed the effect of the use of a mixture of bioethanol and gasoline on a stationary SI engine including combustion characteristics, performance, and exhaust emissions. Therefore, this study aims to reveal scientific information about the performance of bioethanol fuel and its mixture with gasoline on the performance of stationary ICE, including power, torque, SFC, and thermal efficiency (ηth).

II. Material and Methods

This study uses pure gasoline and a mixture of gasoline with 50% Bioethanol (BE50). The results of testing the fuel properties can be seen in Table 1.

Table 1. Comparison of the main properties of fuel

Properties	Gasoline	BE-50
Molecular formula	C_7H_{18}	C_2H_5OH
Molecular weight	100-105	46.07
Research octane number (RON)	95.5	120-135
Auto-ignition temperature (ºC)	257	423
Specific heat (kJ/kg K)	2.4	2.0
Density at 15 ºC (g/ml)	0.739	0.79
Viskosity at 20 ºC (mPa)	1.19	0.37-0.44

In addition, this experiment used a variable speed test with a wide-open throttle accompanied by a load setting on the water brake dynamometer to get the expected engine speed [10]. The research scheme can be seen in Figure 1. The test begins with checking the engine performance on the ignition timing BTDC 9 degrees, 12 degrees, and 15 degrees. The engine is operated with an engine speed of 4000 rpm to 7500 rpm accompanied by cooling from the fan to avoid overheating. The next step is to increase the engine speed until a half-open throttle condition is achieved accompanied by loading by adjusting the water flow opening through the water brake dynamometer to 7500 rpm and then observing the load (N) and time (s). The first test used pure gasoline and after that, it used a BE50 mixture where the combustion time was increased every 3 degrees.

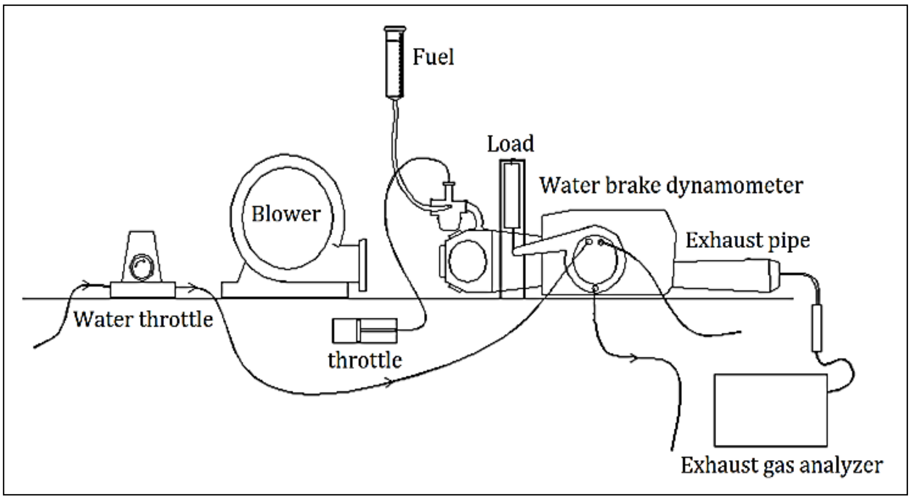

Fig 1. Experimental scheme

III. Results and Discussions

A study on the comparison of the effect of gasoline-BE50 mixture and variations in ignition timing on the performance of the ICE has been carried out. The results showed that there were changes in engine performance parameters, including; torque, effective engine power, thermal efficiency (ηth), specific fuel consumption, and energy consumption.

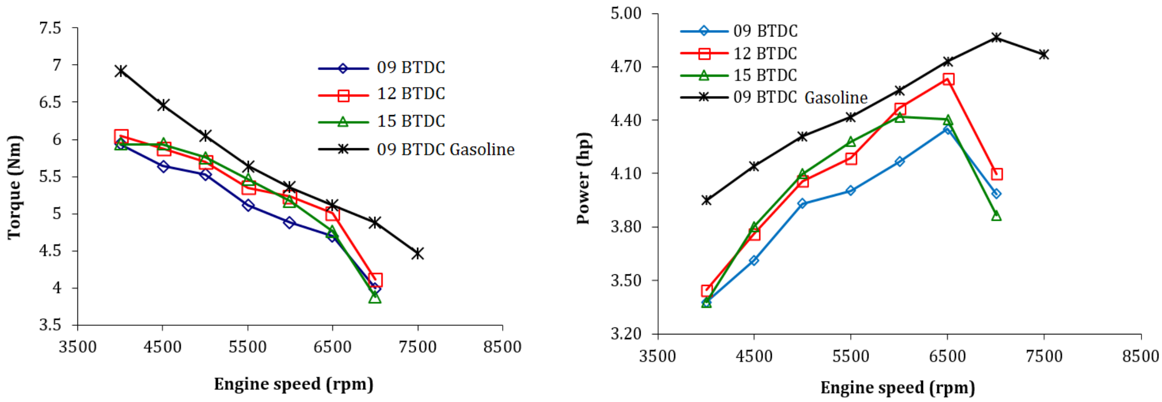

Fig 2. Comparison of torque (left) and engine power (right)

Figure 2 shows the maximum torque achieved at 12 degrees BTDC ignition time is 6.05 N.m and for 9 degrees BTDC ignition timing is 5.93 N.m, and these results indicate that there is an increase in torque of 1.97%. Meanwhile, when compared to gasoline, there was a decrease in torque from 6.93 N.m to 6.05 N.m, or an average decrease of 7.54%. These results indicate that more bioethanol content in gasoline causes a decrease in power. This analysis is possible because the specific energy and heat (see Table 1) contained in the BE50 fuel mixture are very low. Furthermore, the large hydrogen mass content in bioethanol has the potential to increase the strong attractive force with oxygen so that it has the potential to produce H2O molecules and become a coolant in the combustion chamber. This is very reasonable because from Figure 2 it can be seen that the maximum power is obtained at 6,500 rpm, and at an ignition time of 12 degrees BTDC the maximum power generated is 4.63 hp, while for an ignition time of 9 degrees BTDC the power generated is 3.38 hp which occurs at 6500 rpm. These results indicate that there is an increase in power of 6.4%. On the other hand, when compared to the power produced by gasoline under standard conditions, there is a decrease in power from 4.86 hp to 4.63 hp, or an average decrease of 7.55%.

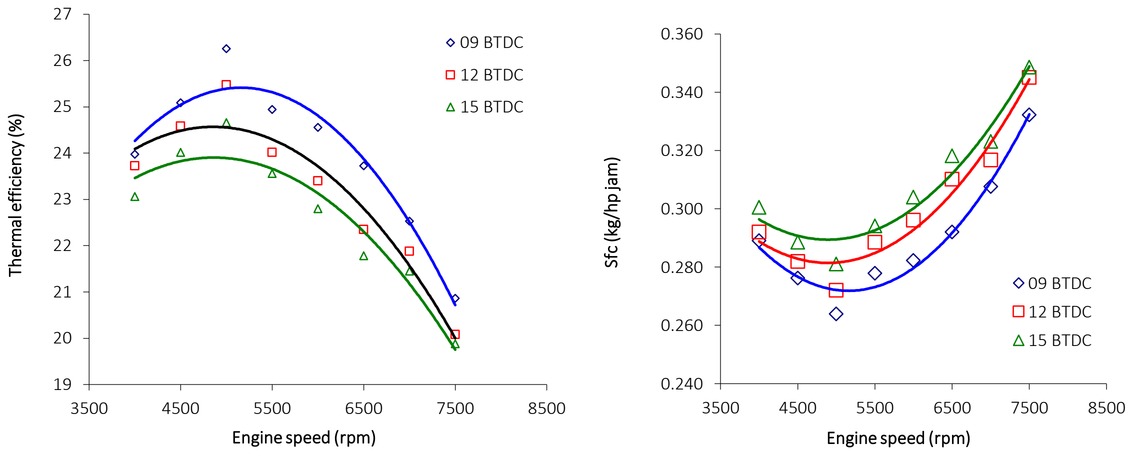

Fig 3. Variations in thermal efficiency (left) and specific fuel consumption (right) at different engine speeds

On the other hand, thermal efficiency is a parameter of the amount of energy used in the converted fuel to produce optimal work (N). Figure 3 shows that the highest thermal efficiency is obtained at 9 degrees, while the smallest is at 15 degrees. This result proves a phenomenon where the spraying of fuel into the combustion chamber at an ignition time of 9 degrees BTDC becomes more effective for generating power. This is very possible because, during the compression process and the ignition timing just before reaching the top dead point, the mass of material that can react in the combustion stage becomes less. This result is confirmed and indicated by the amount of specific fuel consumption with a low ignition timing of 9 degrees.

In addition, Figure 3 (right) also shows that the lowest SFC occurs at the ignition timing of 9 degrees when compared to fuel consumption at other positions. This is what causes the thermal efficiency to be greater. In addition, the results of the study also found that the maximum thermal efficiency was achieved at an ignition timing of 12 degrees BTDC accompanied by the maximum power generated (see Figure 4). While the minimum thermal efficiency is at 9 degrees BTDC ignition time. On the other hand, it can be seen that although the ignition time of 9 degrees BTDC is less than that of gasoline, the BE-50 has the highest thermal efficiency. This phenomenon is influenced by the lower calorific value of BE50 which is around 8427.86 kcal/kg so that energy consumption with BE50 is reduced. Moreover, this indicates that at the correct ignition timing, the air-fuel ratio is achieved, and this is triggered by the increased reactivity of the many hydrogen atoms in bioethanol. This analysis is very possible and is by previous research which states that atomic reactivity has the potential to increase the reaction speed of the fuel molecules to increase the energy contained in the fuel [23], [24].

On the other hand, from Figure 4 it can be seen the impact of changing the ignition timing on the amount of energy consumed (EC). For optimal gasoline conditions, the amount of energy consumed at engine speed of 7000 rpm is around 15705.78 kcal/hour, and for BE-50 it is around 12582.03 kcal/hour, where there is a reduction of about 25.44%.

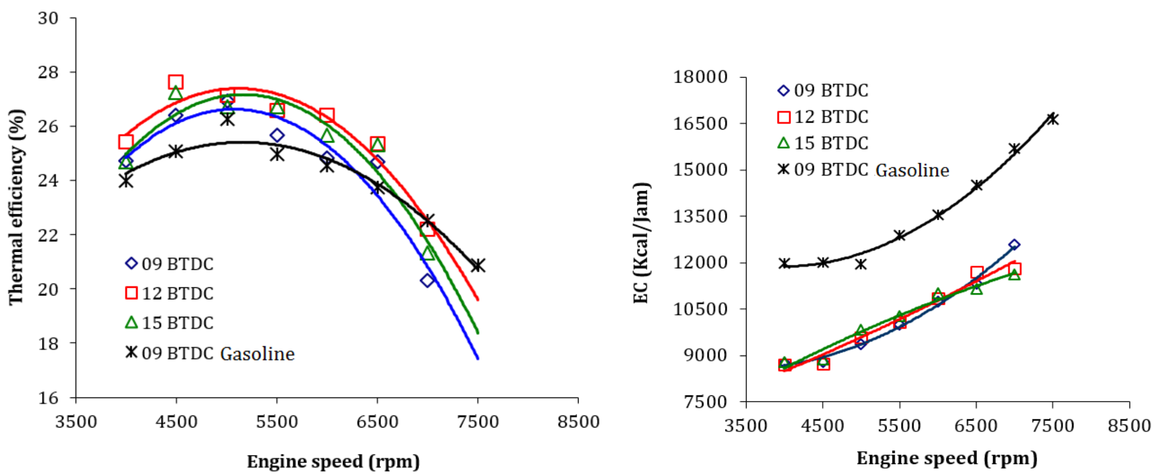

Fig 4. Comparison of thermal efficiency (left) and energy consumption (right) at different engine speeds

IV. Conclusions

An analysis of the effect of ignition timing of various degrees on the performance of gasoline-bioethanol-fueled gasoline engines has been carried out, and there are some very important practical findings. The optimal ignition timing for gasoline engines is 9 degrees, while for bioethanol the optimal ignition timing is 12 degrees BTDC. Furthermore, the improved performance of the BE50-petrol mixed fuel engine proves that the BE50 can be used as an alternative fuel by changing the ignition timing. As for the BE-50, the ignition timing must be changed to 12 degrees BTDC where the skepticism needle in the carburetor is in position one from the bottom to produce an optimal power of 4.63 HP at 6500 rpm, and an optimal torque of 6.05 Nm at 4000 rpm.

To get the maximum benefit from bioethanol, further research is needed using bioethanol with a higher blend content of 80 to 95% bioethanol (BE80-BE95) or 100% bioethanol (BE100) on SI engines with engine speeds of around 5000 to 8000 rpm. Several studies have found that without modification [25], the bioethanol-fueled SI engine produces different performance [26], so it can be tried to modify the engine with different loading and compression ratio variations.

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