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Experimental studies to improve IC engine performance through magnetization of fuel mixture of gasoline and bioethanol

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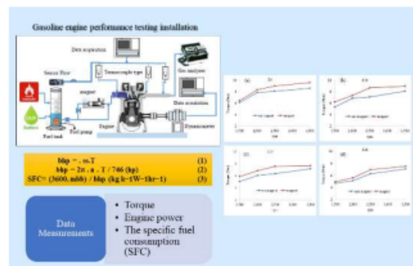
Abstract

Research related to the magnetization of fossil fuels is currently believed to be able to improve the quality of combustion due to the cluster decluster effect on the fuel. Fossil fuels are finite and non-renewable. Meanwhile, non-fossil energy, especially bioethanol, despite having more environmentally friendly exhaust gas emissions and higher octane rating than gasoline, has a lower calorific value than gasoline. To overcome this deficiency, the fuel magnetization of a mixture of gasoline and bioethanol is carried out. The fuel is used in 4 stroke injection motorcycles. Furthermore, the performance of the 4-stroke injection motorcycle was observed. the fuel mixture without magnetization was used as a control variable. The intensity of the electromagnetic field used is less than 2,000 Gauss, this is different from previous analysts. As a result, the magnetized motorcycle experienced an increase in torque of 4.48 – 7.30%, power of 4 – 9.90%, and a decrease in SFC of 6 – 9.20%.



Keywords: Magnet; Bioethanol; Torque; Power; SFC

1. Introduction

Various studies have been carried out to improve the quality of fuel so that combustion becomes more efficient and environmentally friendly. Among them the use of alternative fuels such as bioethanol. The use of bioethanol can reduce the impact of vehicle exhaust emissions and on the other hand can substitute for fuel. The use of ethanol as a fuel is based on the nature of pure ethanol which is quite flammable and has a large net heat-burn of 21 MJ liter (approximately 2 / 3 of the net heat-burn of gasoline. On the other hand, the magnetization of the fuel in the engine can increase the combustion efficiency and reduce emission of combustion products [1 – 3]. What happens when bioethanol fuel is magnetized? To answer this question, the purpose of this study is to analyze the magnetization of bioethanol on the performance of gasoline engines, especially motorcycles.

R.C. Costa and J.R. Sodré conducted a study using an injection system, Hydrous Ethanol (6.80% water) and Ethanol Blending (E22) 4 stroke engine and 4 valves at different engine speeds (1,000 – 7,000) rpm. The results showed that using Hydrous Ethanol was better than E22 fuel. Maximum power is 53 kW at 6,000 rpm while the E22 has 50 kW at 6,000 rpm. Sfc Hydrous Ethanol is 54% more wasteful than using a mixture of gasoline and ethanol fuel. The thermal efficiency of hydrous ethanol fuel is higher than that of E22 (14.10%) [4]. Monasari *et al.* conducted research on engine performance using fuel types E10, E100, 90% ethanol 10% water, 80% ethanol 20% water at 5,000 rpm engine speed, variations in the position of throttle. The results showed that the power and torque on the E100 were higher than the E10. The water content in the fuel affects the amount of power or torque produced. SFC in the E100 will increase compared to the use of E10, while the heat efficiency of the E100 fuel and 90% ethanol content is higher than the use of E10 fuel [5].

Ugare *et al.* examined the use of various magnets including neodymium and a mixture of Neodymium-iron-Boron which produces a magnetic field intensity of 1,000 – 13,000 Gauss in a 1 cylinder 4 stroke gasoline engine. The result is that a magnet with an intensity of 5,000 Gauss can reduce fuel consumption by up to 12% and exhaust emissions of HC, CO, and NOx by 22%, 7%, and 19%, respectively. The cause of the structure of the hydrocarbon atoms changed from cluster to decluster [6]. Chawere *et al.* reported that the hydrogen atom has two structures, namely para hydrogen which has opposite electron spins and ortho hydrogen which has unidirectional electron spins. According to him, fuel in the form of ortho hydrogen is more reactive to oxygen, so that the combustion becomes better, this research has not been proven in practice in the field [7]. Mariaca *et al.* doing blending (besin + bioethanol) on a gasoline engine the results showed that the E40 mixture was the most efficient, due to a 2.50% decrease in SFC and a reduction in hydrocarbon (HC), carbon monoxide (CO) and carbon dioxide (CO_2) emissions, respectively 52.88%, 73.66%, and 9.72% respectively, while the emission of nitrogen oxides (NO) increased by 10.62% [8].

2. Materials and Methods

The material used in this study is bioethanol from cassava with a content of 98% and Pertamina fuel with an octane number of 90 as a bioethanol mixture. the test engine is a 125cc motorcycle. The engine performance test is carried out using a dynamometer with the scheme shown in Fig. 1. The parameters measured in this test are torque, engine power at various percentages of the mixture, while the specific fuel consumption (SFC) is measured using a measuring cup. Measurements were made in the engine speed range of 1,500 – 6,000 rpm. The magnitude of the magnetic field used the strength of the magnetic field used is 647 Gauss, 847 Gauss, 1,068 Gauss, and 1,419 Gauss. As a control is an engine without fuel magnetization.

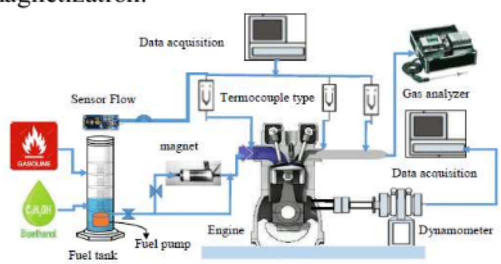


Fig. 1 Gasoline engine performance testing installation.

The tools and materials used in this study are specified in Tables 1 and 2. The composition of a mixture of gasoline and bioethanol E0, E10, E15, and E20. Other tools, namely the combustion quality improvement device and a 12 V battery voltage source. Motorcycle performance testing using a dynamometer connected to data acquisition. The research begins with the calibration of the required equipment, inspection of diesel engine components such as: lubricating oil, lubricating oil filter, fuel filter, parameters observed are Torque, power and fuel consumption. The test starts by starting the engine at 1,000 rpm and then holding it for ± 10 minutes to get a normal engine working temperature. After the machine is operating normally, data retrieval begins. Data collection is done by looking at the measuring instrument and taking notes on the note sheet.

Table 1 Engine specification [9].

Engine Type	4 stroke SOHC, air cooled
Diameter × Stroke	52.40 × 57.90 mm
Cylinder Volume	125cc
Compression ratio	9.50 : 1
Maximum Power	7 kW / 8,000 rpm
Maximum Torque	9.60 Nm / 5,500 rpm
Engine oil	0.84 liter
Transmission System	CVT Automatic
Tipe Kopling	dry, Centrifugal Automatic
Ignation System	TCI / Fuel Injection

Table 2 Fuel specification [10].

Property	Gasoline	Bioethanol
Formula (liquid)	C_8H_{18}	C_2H_5OH
Molecular weight (g mo1^{-1})	11.15	46.07
Density (kg m^{-3})	765	785
Viscosity (cSt)	9.79	6.89
Heat of vaporization (kJ kg^{-1})	305	840
Specific heat (kJ kg^{-1} K^{-1}) liquid	2.40	1.70
Specific heat (kJ kg^{-1} K^{-1}) vapour	2.50	1.93
Lower heating value	44,000	26,900
Stoichiometric air-fuel ratio by mass	14.60	9
Research octane number	92	108.60
Motor octane number	85	89.70
Enthalpy of formation (MJ k mol^{-1}) liquid	259.28	224.10

Data processing

Power (break horse power) Brake horse power is the power generated from the engine output shaft [11].

$$bhp = \omega.T \quad (1)$$

$$bhp = 2\pi \cdot n \cdot T / 746 \text{ (HP)} \quad (2)$$

with:

T = Torque (Nm)

n = rotation of the waterbrake dynamometer shaft (rps)

Fuel consumption is the amount of fuel used by the engine for a certain unit of time. While sfc (specific fuel consumption) is the amount of engine fuel consumption during a certain unit of time to produce effective power [12]. If in the test data is obtained regarding the use of fuel m (kg) in s (seconds) and the power produced is bhp (HP), then the fuel consumption per hour is: Power (end horsepower), Brake horsepower is the power generated of the engine output shaft.

Specific fuel consumption (specific fuel consumption)

$$SFC = (3{,}600 \cdot mbb) / bhp \text{ (kg k}^{-1}\text{W}^{-1}\text{hr}^{-1}) \quad (3)$$

with :

mbb = fuel consumption per unit time (kg hr^{-1})

s = fuel consumption time (seconds)

sfc = specific fuel consumption (kg k^{-1}W^{-1}hr^{-1})

3. Results and Discussion

Fig. 2 shows the results of the torque test (Nm) of the Honda Beat 125cc gasoline motor with gasoline as a fuel mixture and bioethanol with variations in the bioethanol mixture of 0% (E0), 10% (E10), 15% (E15), and 20% (E20). The x-axis direction is the rotational speed (rpm) and the y-axis direction is the torque (Nm). It appears that the increase in torque is proportional to the increase in engine speed until it reaches the maximum value so that the amount of fuel entering the combustion chamber is greater as a result of which the fuel energy is converted into mechanical energy (torque) generated through the combustion process is greater. After reaching the maximum value, the torque produced by the engine decreases because the time available for combustion at high rpm is very short. However, the graph above does not show a decrease in torque, this is because the engine speed has not reached a critical or maximum speed due to the limited capabilities of the testing equipment in the laboratory. The phenomenon of the maximum torque value at a certain rotation is due to the increase in torque due to an increase in engine speed is limited by the time available for combustion at high speed is shorter and due to an increase in mechanical losses [9].

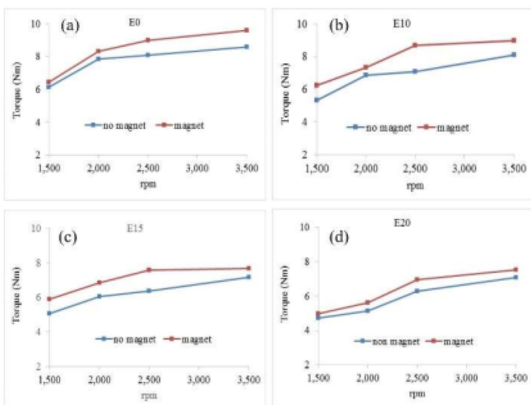


Fig. 2 Graph of the relationship between Torque and rpm.

Fig. 2(a) shows the variation of gasoline fuel 100% without magnetization produces the highest torque of 8.57 Nm at a rotational speed of 3,500 rpm, while the magnetized one, the torque is 9.20 Nm, an increase of 7.30%. Fig. 2(b) shows the variation of gasoline fuel 10% without magnetization produces the highest torque of 8.15 Nm at a rotational speed of 3,500 rpm, while the magnetized one has a torque of 8.66 Nm, an increase of 7.10%. Fig. 2(c) shows the variation of gasoline fuel 15% without magnetization produces the highest torque of 7.17 Nm at a rotational speed of 3,500 rpm, while the magnetized one has a torque of 7.67 Nm, an increase of 6.97%. Fig. 2(d) shows the variation of gasoline fuel 20% without magnetization produces the highest torque of 7.07 Nm at a rotational speed of 3,500 rpm, while the magnetized one, Torque is 7.52 Nm, increased by 4.48%, ability that similar to many works [13, 14]

The increase in torque due to fuel magnetization is due to the magnetic field affecting the molecular structure of the hydrocarbons contained in the fuel causing the breakdown of the hydrocarbon chain into smaller parts or the fuel molecules changing from cluster to de cluster. In addition, the arrangement of the fuel atoms is parallel to the direction of the given external magnetic field or the fuel molecules are neatly arranged, so that it will be easier to react with oxygen obtained from the outside air and produce a more complete combustion. Complete combustion will result in increased torque.

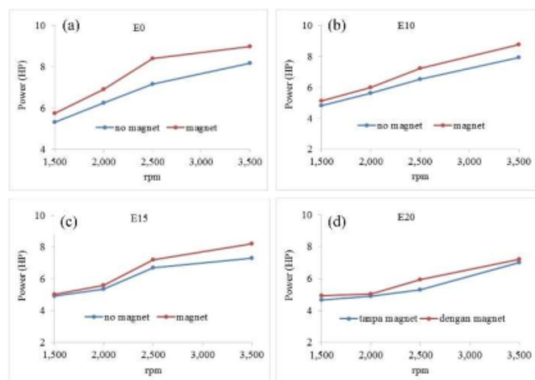


Fig. 3 Graph of the relationship between power and rpm.

Fig. 3 shows the results of testing the power (HP) of the Honda Beat 125cc gasoline motor with a mixture of gasoline and bioethanol fuel. Variations of bioethanol mixture 0% (E0), 10% (E10), 15% (E15), and 20% (E20). The x-axis direction is the rotational speed (rpm) and the y-axis direction is the power (HP). It appears that the increase in power is proportional to the increase in engine speed. This is caused by the greater the frequency of rotation, the more work steps are experienced at the same time, so the power is greater. The power is transmitted to the piston which works back and forth in the engine cylinder. So, in the engine cylinder, energy changes from the chemical energy of the fuel by the combustion process to mechanical energy in the piston.

Fig. 3(a) Shows the variation of gasoline fuel 100% without magnetization produces the highest power of 8.17 HP at a rotational speed of 3,500 rpm, while the magnetized, torque is 8.98 HP, an increase of 9.90%. Fig. 3(b) shows a variation of 10% gasoline fuel without magnetization producing the highest power of 7.94 HP at a rotational speed of 3,500 rpm, while the magnetized one has a torque of 8.46 HP, an increase of 6.54%. Fig. 3(c) shows the variation of gasoline fuel 15% without magnetization produces the highest torque of 7.51 HP at a rotational speed of 3,500 rpm, while the magnetized one, the torque is 8.25 HP, an increase of 9.85%. Fig. 3(d) shows the variation of gasoline fuel 20% without magnetization produces the highest torque of 7.20 HP at a rotational speed of 3,500 rpm, while the magnetized one, Torque is 7.52 HP, increased by 4%.

The increase in power due to fuel magnetization is due to the magnetic field affecting the molecular structure of the hydrocarbons contained in the fuel causing the breakdown of the hydrocarbon chains into smaller parts or the fuel molecules changing from cluster to de cluster. the viscosity of the fuel decreases so that when it is injected into the combustion chamber it can form finer droplets of mist. With these conditions, the process of mixing air and fuel is more homogeneous and more efficient flammable, then the fuel burning time is getting shorter. This is because at an increasing rotational speed, the time required to burn the fuel mixture is getting shorter so that the pressure in the combustion chamber increases and produces greater power. The results of this test also turned out to be the same as the results of tests carried out by Khedvan [15], which states that the amount of power influenced by the torque factor and engine speed. If the torque and engine speed is high, it will get high power as well. So, the higher the torque, the higher the power.

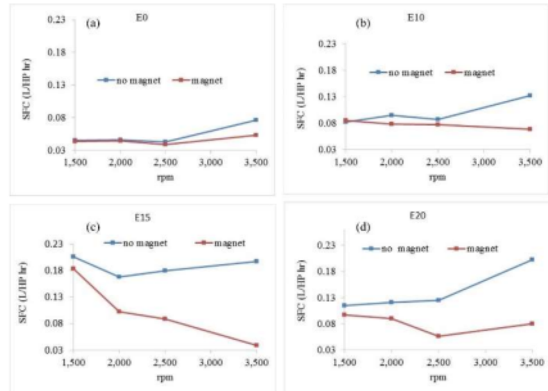


Fig. 4 Graph of the relationship between Torque and rpm.

Specific Fuel consumption (SFC) is a measure of the fuel consumption used to run an engine for a certain period of time for each power generated. Fig. 4 presents a graph of the relationship between how efficiently fuel is supplied to the engine to be used as power output with various engine speed variations. The larger the engine speed indicates the load on the engine is also large, this will relate to how much fuel can be used to power the engine. If the SFC is low, it indicates efficient fuel consumption.

Fig. 4(a) shows the variation of gasoline fuel 100% without magnetization produces the largest SFC of 0.076 liter $HP^{-1}hr^{-1}$ at a rotational speed of 3,500 rpm, while the magnetized, torque is 0.069 liter $HP^{-1}hr^{-1}$, decreased by 9.20%. Fig. 4(b) shows a variation of 10% gasoline fuel without magnetization resulting in the highest SFC of 0.133 liter $HP^{-1}hr^{-1}$ at a rotational speed of 3,500 rpm, while the magnetized SFC, 0.126 liter $HP^{-1}hr^{-1}$, decreased by 9.02%. Fig. 4(c) shows a variation of 15% gasoline fuel without magnetization resulting in the highest SFC of 0.1981 liter $HP^{-1}hr^{-1}$ at a rotational speed of 3,500 rpm, while the magnetized SFC, 0.175 liter $HP^{-1}hr^{-1}$, decreased by 7.89%. Fig. 4(d) shows a variation of 20% gasoline fuel without magnetization producing the highest SFC of 0.202 liter $HP^{-1}hr^{-1}$ at a rotational speed of 3,500 rpm, while the magnetized one, SFC 0.188 of liter $HP^{-1}hr^{-1}$, decreased by 6% ability that similar to many works [16].

It can be seen at a low speed of 1,500 rpm, the SFC value using a magnet is almost the same as that without using a magnet. This indicates that at low rotation the use of magnets does not see the benefits. At high rotation the use of magnets shows a much different SFC value. This means that the use of magnets has a significant effect on the mass flow rate of the fuel which can be converted into engine output power at high rpm. The use of magnets is intended to cause ionization in the fuel. The ionization process is needed so that the fuel can more easily bind oxygen during the combustion process and reduce unburned hydrocarbon products resulting from the fuel combustion process. This is due to the size of the molecular structure of the fuel will change into smaller bonds due to magnetization. This smaller molecular size will directly result in the easier combustion process in the combustion chamber. In other words, the magnetization process can cause more complete combustion and use of fuel to be more efficient.

4. Conclusion

At low to medium speed there is an increase in torque and power generated by the engine from all types of mixed fuel tested compared to gasoline fuel. The greatest torque and power are obtained in mixed fuels with a percentage of 15% bioethanol. The performance of gasoline engines (motorcycles) with a mixture of gasoline-bioethanol fuel (E0, E10, E15, E20) and being magnetized causes

a. Engine torque increased by 4.48 – 7.30% and
b. The average engine power increased by 4 – 9.90%,
c. SFC decreased by 6 – 9.20%

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