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A STUDY OF BIOETHANOL FUEL CHARACTERISTICS IN THE COMBUSTION CHAMBER OF GASOLINE ENGINE USING MAGNETIZATION TECHNOLOGY

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Bioethanol is a renewable energy that can replace gasoline, which will run out in the future. This study investigates the influence of magnetization of bioethanol fuel on the fuel combustion temperature in the combustion chamber of a gasoline motor. The fuel used is bioethanol with a composition of E0 (pure gasoline), E10 (10 % bioethanol+90 % gasoline), E20 (20 % bioethanol+80 % gasoline), E30 (30 % bioethanol+70 % gasoline), E40 (40 % bioethanol+60 % gasoline). The fuel passed through the magnet with a magnetic variation of 647.15 Gauss, 847.25 Gauss, 1419.57 Gauss. The temperature sensor used is a K-type thermocouple. The temperature sensor was inserted in the combustion chamber to measure the combustion chamber temperature. The thermocouple data were recorded in Microsoft Excel on a computer using the LabVIEW program via NI-USB 9213 interface. The temperature data recorded is 400 data/second. The results obtained without exposure to the magnetic field, the lowest peak temperature of 577.1998 °C at E40 and the highest peak temperature of 582.1786 °C at E0. The higher the bioethanol content, the lower the temperature of fuel combustion to the low bioethanol viscosity. The increasing magnetic field strength will increase the combustion temperature; hence the fuel burned quickly and the combustion process is more perfect. The result obtained with the magnetic field exposure, the lowest peak temperature of 577.8347 °C is at E40. The highest peak temperature of 587.36 °C is at E0. The use of a magnetic field in the bioethanol fuel mixture can increase the combustion temperature so that the fuel molecules move freely and the fuel is more easily mixed with oxygen. As more fuel is burned, the combustion of the fuel becomes complete

Keywords: combustion chamber temperature, bioethanol, gasoline engine, magnetic field, thermocouple, LabVIEW

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1. Introduction

The motorcycle is prevalent as transportation in Indonesia because of its high mobility. According to the Indonesian Central Statistics Agency, the number of motorcycles increases, and the latest data for 2019, the number of motorcycles reached 45 % of Indonesia's population. Motorcycles use gasoline, which is not renewable energy, hence one day will run out. Several studies were conducted to find alternative energy. Biofuel is one of the alternative fuels that were widely researched. Several studies were conducted using a bioethanol-gasoline blend, increasing the octane number, oxygen, and reducing heating temperature [1, 2]. High octane numbers increase engine performance and reduce emissions. Fuel temperature affects biodiesel performance and emissions [3–5]. The experiment was reported for the investigation of cyclic variation of combustion parameters [6, 7]. Fuel magnetization reduced 9 % to 30 % of fuel consumption and reduced HC and CO exhaust emissions [8–14]. The fuel magnetization causes an increase in the fuel combustion temperature. Increasing the fuel temperature causes increasing the combustion pressure, so that engine performance increases [15].

2. Literature review and problem statement

Several researchers have investigated biofuel characteristics. They reported that adding bioethanol would improve engine performance. M. K. Akasyah et al. [15] reported that increasing the combustion temperature will increase the combustion pressure that caused the fuel to burn more quickly and increase engine performance. Increasing combustion temperature caused the fuel viscosity decrease that can be easily mixed with oxygen. Hence the fuel can burn perfectly and increase thermal efficiency. Osman Azmi Ozsoysal [16] studied the Otto cycle model and reported that a fraction of the fuel's chemical energy is not fully released inside the engine during the actual combustion process because of the incomplete combustion.

Studies of fuel magnetization have been carried out. The research conducted by Chen et al. [17] reported that the magnetization of the fuel causes increasing molecule vibration. Molecular vibrations make the atom easier to move, hence more easily mixed with oxygen and complete combustion. A study conducted by Jain and Deshmukh using 1,000–1,800 Gauss of magnetic field on a 5 HP diesel engine with variations in load caused a change in fuel molecules motion and decreased 10–30 % of the fuel consumption [8].

Previous studies were conducted to determine the effect of magnetization on the biofuel using the permanent magnet. Unfortunately, vibration and heat can reduce the magnetic field strength of a permanent magnet. The way to overcome that disadvantage is by using an electromagnet with a constant magnetic field as long as the current source is available. All the studies suggest that it is advisable to conduct a study on gasoline using a bioethanol-gasoline blend on a gasoline engine and investigated the effect of magnetization on combustion chamber temperature using electromagnets. The bioethanol mixture in gasoline can reach up to 40 %, which is higher than in the previous study, which only reached 25 % [18].

3. The aim and objectives of the study

The study aims to investigate the influence of magnetic field exposure on bioethanol fuel characteristics.

To achieve this aim, the following objectives are accomplished:

– to explore the combustion temperature of gasoline and bioethanol mixture;

– to explore the combustion temperature of gasoline and bioethanol mixture using the electromagnetic field.

4. Material and method to study bioethanol fuel characteristics in the combustion chamber of gasoline engine using magnetization technology

Fig. 1 shows the flowchart of temperature measurement in the combustion chamber. The gasoline motor used in this research was four-stroke, air-cool, 9.5:1 compression ratio, TCI (Transistorized Controlled Ignition) injection system, 125 cc cylinder volume, 9.6 N·m of the maximum torque at 5,500 r/min, and 7 kW of the maximum engine power at 8,000 r/min. The fuel used is a mixture of bioethanol and gasoline with the composition of E0 (pure gasoline), E10 (10 % bioethanol+90 % gasoline), E20 (20 % bioethanol+80 % gasoline), E30 (30 % bioethanol+70 % gasoline), E40 (40 % bioethanol+60 % gasoline).

The magnetization equipment was installed in the fuel line between the fuel tank and the combustion chamber. The fuel passed through the magnet with the magnetic variations in 647.15 Gauss, 847.25 Gauss, 1419.57 Gauss. The temperature sensor used is a K-type thermocouple. The temperature sensor was inserted in the combustion chamber to measure the combustion chamber temperature. The thermocouple data were recorded in Microsoft Excel on a computer using the LabVIEW program via NI-USB 9213 interface. The temperature data recorded is 400 data/second. The resulting data plotted in the graph were then analyzed to find the combustion temperature for various fuel types. The combustion temperature is compared between the fuel with and without magnets.

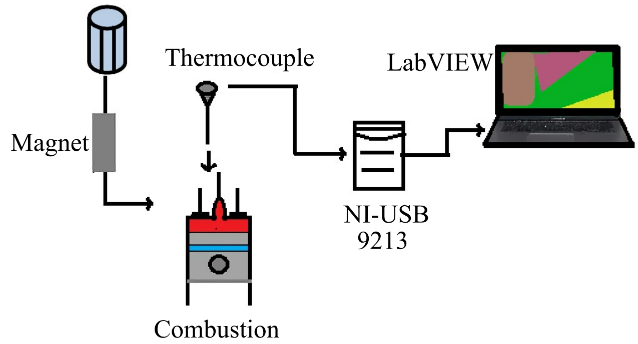
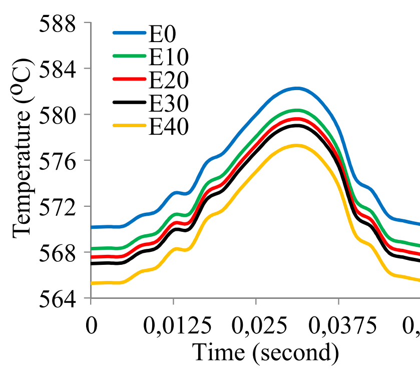


Fig. 1. Flowchart of temperature measurement in the combustion chamber

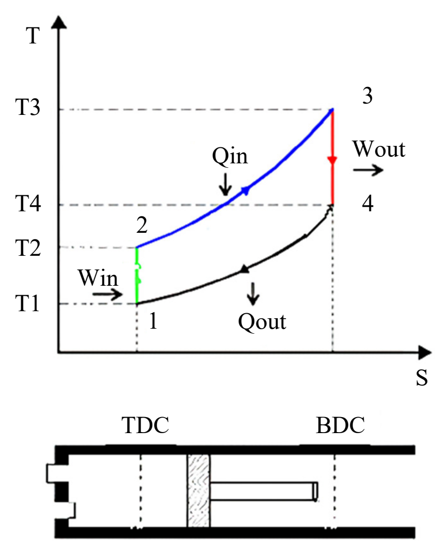
5. Results of investigating the influence of magnetic field exposure on bioethanol fuel characteristics

5. 1. Combustion temperature of gasoline and bioethanol mixture

Fig. 2 demonstrates the characteristic of heat energy of fuel based on the cycles time: *a* – combustion temperature of a different mixture of bioethanol-gasoline; *b* – four-stroke engine process in one cycle occurs in four-piston steps (fuel intake, compression, power stroke, and exhaust).



a



b

Fig. 2. Characteristic of heat energy of fuel based on the cycles time: *a* — Combustion Temperature at Different Fuel; *b* — T-S Diagram

The engine cycle occurs in 0.05 seconds shown in Fig. 2, *a*, starting from the crank angle position of 0° at 0 seconds when the piston is at the top dead center (TDC), then the suction step where the air and fuel mixture flows into the combustion chamber when the piston moves to the bottom dead center (BDC), the crank angle position is 180° at 0.0125 seconds. Furthermore, the compression step occurs when the piston moves up towards the top dead center (TDC) at the crank angle of 360° at 0.025 seconds, where the air and fuel mixture in the combustion chamber is pressed adiabatically so that the temperature and pressure increase. Simultaneously, the spark plugs spark so that the fuel and air mixture ignites, causing the gas temperature and pressure to increase.

The high temperature and pressure gas push the piston to the bottom dead center (BDC) at a crank angle of 540° at 0.0375 seconds. Furthermore, the exhaust step occurs when the piston moves up towards the top dead center (TDC) at the crank angle position of 720° at 0.05 seconds. The fuel combustion in one cycle is shown in Table 1.

Table 1

Engine Cycle

Process	Crank angle (degree)	Time (seconds)
Start	0	0
Suction	180	0.0125
Compression	360	0.025
Power	540	0.0375
Exhaust	720	0.05

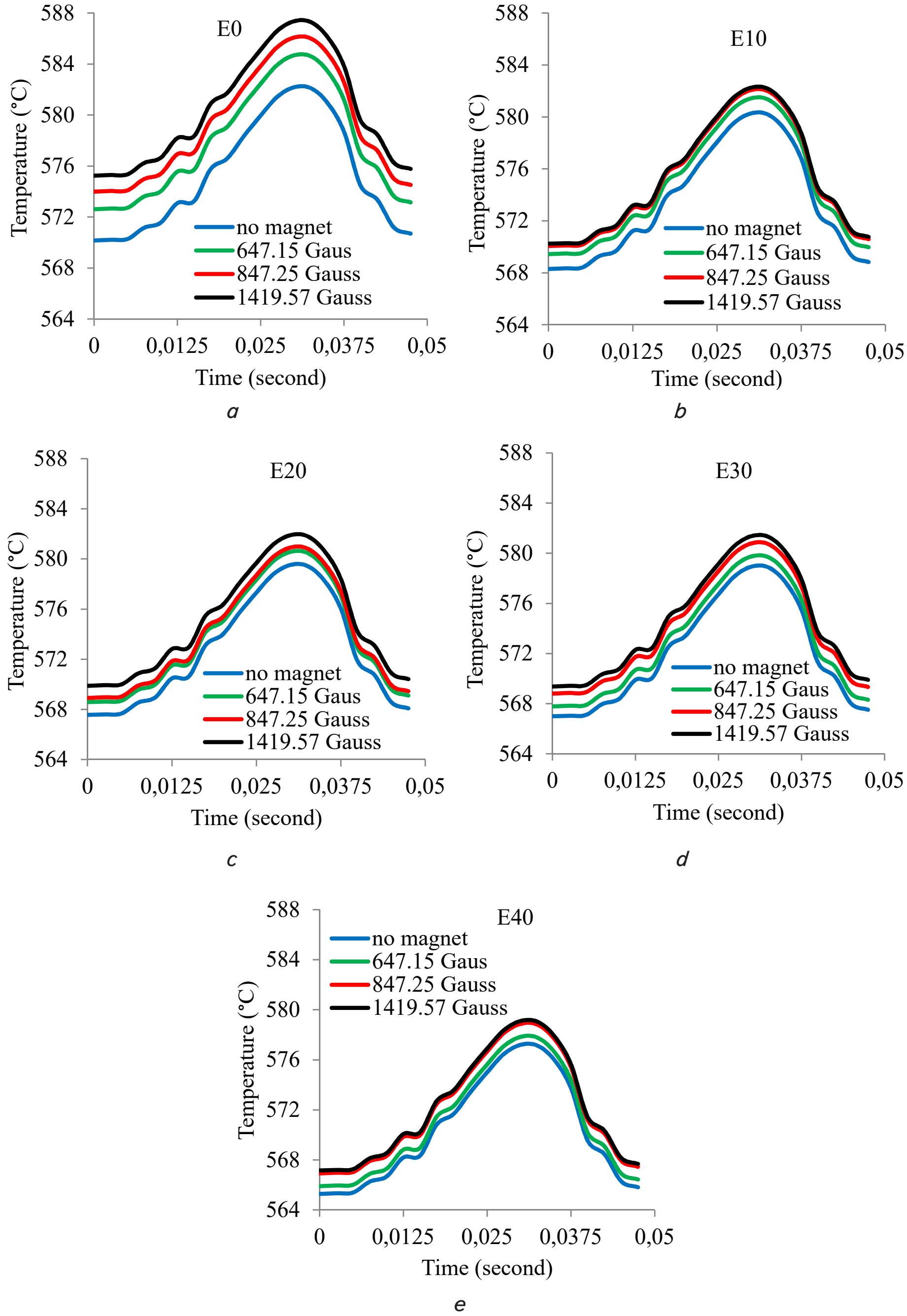


Fig. 3. Combustion temperature on various types of magnet and fuel for: *a* – E0; *b* – E10; *c* – E20; *d* – E30; *e* – E40

5. 2. Combustion temperature of gasoline and bioethanol mixture using the electromagnetic field

Fig. 3 shows the combustion temperature on various types of magnet and fuel for: *a* – E0, *b* – E10, *c* – E20, *d* – E30, *e* – E40. The curve also demonstrated combustion temperature on the cycle time that increasing a magnetic field will increase the combustion temperature.

The curve of pure gasoline and a mixture of bioethanol fuel demonstrates cycles time and temperature. The black, red, green, and blue colors of the curve are related to different magnetization. Meanwhile, E0, E10, E20, E30, and E40 are associated with fuel composition.

Fig. 4 displays the peak temperature combustion at different magnetic field strengths. The solution of E0, E10, E20, E30, and E40 exhibited a different color on the curve.

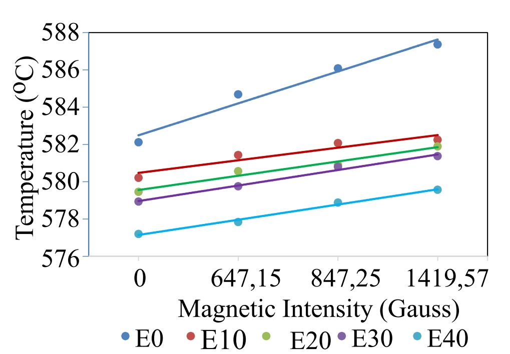


Fig. 4. Peak temperature combustion at the different magnetic field strength

The increasing magnetic field strength will increase the combustion temperature; hence the fuel burned quickly and the combustion process was more perfect. The lowest peak temperature of 577.8347 °C is at E40. The highest peak temperature of 587.36 °C is at E0.

6. Discussion of experimental results

Measuring and storing data were carried out using the LabVIEW program, and the result data can be further analyzed. Fig. 2 demonstrated that the increase in bioethanol composition influenced the reduction of combustion temperature. The peak temperatures in a mixture of bioethanol-gasoline E0, E10, E20, E30, and E40 are respectively 582.2 °C, 580.3 °C, 579.6 °C, 578.9 °C, and 577.2 °C. These peak temperatures were located in point 3 at the T-S diagram shown in Fig. 2, *b*. Based on the peak temperature result, the use of a magnetic field in the fuel can increase the combustion temperature by an average of 5.3 °C for pure gasoline and 2.4 °C for bioethanol mixture. However, the increasing bioethanol content in gasoline fuel decreases the combustion temperature, which influences engine performance [1–3, 17]. Low combustion temperature is related to higher bioethanol content in the bioethanol-gasoline mixture, caused by the low bioethanol viscosity. It will affect the fuel to burn at a low temperature. The viscosity is described as the resistance of the liquid fuel flow [15]. The fuel's high viscosity complicates engine burner ignition, fuel flowing, and atomization [2], hence high temperature is needed for the combustion process. The more bioethanol in the gasoline-bioethanol blend decreases the oil viscosity. The increasing the acid number related to the bioethanol is more reactive than gasoline, which enhances fuel oxidation [2]. Mahabadipour et al. reported that the four-stroke engine cycle starts at the crank angle of 0° at the top dead center (TDC), compression TDC at the crank angle of 360° and ends at 720° [19]. The previous research using Jatropha oil magnetized in a diesel engine reported increasing the magnetic field strength, leading to the higher power of the diesel engine. The magnetic field causes the fuel molecules to move freely, making it easier to burn and the combustion process more completely perfect so that the engine power will be greater [20].

Based on Fig. 3, the magnetic field generates unstable fuel molecules, increasing vibration and reducing the attraction between atoms that influence the fuel molecules mixing easier with oxygen. It also causes more fuel burned during the fuel combustion process. However, the higher the bioethanol content, the lower the combustion temperature. By adding a magnetic field, the combustion temperature was obtained to be higher, so greater thermal efficiency was achieved. The high thermal efficiency indicates more fuel burns and less residual fuel. The vibration hydrocarbon molecule of fuel brings mutual attraction from molecules to be a cluster. In contrast, the fuel magnetization method could work for de-clustering of the molecule. Therefore, the fuel was easy to oxidize and burn [8]. Moreover, the magnetic field can attract and stretch the bonds between molecules in hydrocarbon fuels, even though those bonds are not separated from each other, but bonding strain in the structure will weaken those bonds. The oxygen will easily attract hydrogen and carbon atoms to speed up the reaction during the combustion process.

Previous studies on the magnetization of bioethanol in the diesel engine using a permanent magnet have been done. The present study is the magnetization of bioethanol in the gasoline engine using the electromagnet, which has a constant magnetic field as long as the current source is available. This study's limitation is that bioethanol is made from cassava peel, which may not be available in all countries. Another issue in this study was creating a hole in the combustion chamber for inserting the thermocouple, which keeps it no leakage during generating pressure. The second difficulty was measuring both pressure and temperature at the same time. It is caused by the difficulty of making two holes in the combustion chamber for inserting the temperature and pressure sensor. We suggest that further research should be done on bioethanol gasoline's optimum composition for better diesel engine performance, which is necessary to perform the work effectively, and the effect of the magnetization mechanism on the equipment system. In addition, the effect of magnetization on exhaust gas emissions can be an interesting study in the future.

7. Conclusions

1. The bioethanol mixture in gasoline can reach up to 40 %, which is higher than in the previous study, which only reached 25 %. The combustion temperature was obtained to be 577.2 °C, 578.9 °C, 579.4 °C, 580.2 °C, and 582.1 °C for fuel mixture (E40, E30, E20, E10), and pure gasoline (E0), respectively.

2. The use of a magnetic field in the bioethanol fuel mixture can increase the combustion temperature of 5.3 °C for pure gasoline and 2.4 °C for bioethanol mixture on average. This is caused by the fact that the fuel molecules move freely, are more easily mixed with oxygen and quickly burned as well, and the combustion of the fuel becomes complete.

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