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Study of premix combustion flame characteristics with magnetic field induction

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Abstract

This study aims to study the effect of magnetic field induction on the characteristics of a fire resulting from the combustion of a mixture of methanol and biodiesel fuel *calophyllum* mixed with *inophyllum*. Further research on premix combustion flames due to magnetic field induction. As time goes by, petroleum is currently running low, therefore alternative biofuels are needed. One type of non-food vegetable oil is Jatropha *calophyllum inophyllum* oil, besides not being consumed, it can also be processed into biodiesel as fuel. To get a more effective and efficient flame, you can apply a magnetic field effect to the fire, especially in terms of the burning rate of the flame. The experimental research method is to heat the *calophyllum* biodiesel *inophyllum* until it is in the form of steam, then flow it to the burner which will then be given air whose mass flow is regulated. Then the fire is ignited and the mass of the air flow is enlarged until the fire is extinguished until it is extinguished. Two magnets are placed between the burners by varying the direction of the magnetic field N-S, N-N and the results of this study are the shape of the flame. The resulting fire is more transparent, clearer and more visible. The direction of the N-S magnetic field causes a higher temperature than the direction of the N-N magnetic field. The height of the flame is affected by the direction of the magnetic field, the stronger the N-S magnetic field. The magnetic field can affect the burning speed of the biodiesel flame. In a poor mixture (ϕ <1) in the presence of a magnetic influence, the rate of fire is lower without the influence of a magnetic field, but in a rich mixture (ϕ > 1) in the presence of a magnetic influence, the rate of fire is higher than without the influence of a magnetic field. This is due to the influence of magnets that induce oxygen. Oxygen is paramagnetic, so it can be attracted by magnetic fields.

Keywords:
Premixed combustion rate, calophyllum inophyllum , biodiesel, magnetic field effect

1 Introduction

The depletion of fossil fuel reserves and the negative impact of their use on the environment has increased the development of alternative fuels, including biodiesel. Biodiesel is a renewable fuel, environmentally friendly and non-toxic, does not contain sulfur and aromatic compounds [1] . Energy sources used as alternative forms of energy are biofuels, bioethanol and biodiesel as substitutes for gasoline and diesel. One of the energy sources used as a substitute for diesel fuel is biodiesel (an energy source made from plants and animals). The concept of using biofuels in diesel engines is not radical. A novel idea, an inventor named Rudolph Diesel demonstrated his first development of a Compression Ignition (CI) diesel engine using peanut oil as fuel at the World's Fair in Paris in 1900 [2] . What Rudolph Diesel does not only offer advantages in terms of exhaust emissions, but also reduces the world's dependence on imported petroleum, supported by the local agricultural industry and increased agricultural income [3] . As an example, studies on the production of *Calophyllum Inophyllum* Methyl Ester (CIME) and its implementation as a fuel in partial or single fuel modes have been carried out in various parts of the world, especially in Indonesia, India and Malaysia [4] .

Research on premix combustion has been carried out using conventional fuels [5] . Emissions of Nitrogen Oxides (NOx) under certain conditions can be reduced if the conventional combustion system is replaced with a premixed system [6] . If the speed of the reactants is the same as the speed of fire propagation, then the fire (reaction zone) will be silent [7] . Premix combustion requires a state of rest because it affects the stability of the flame. The stationary state of combustion occurs when the speed of the reactants is equal to the speed of the flame. In the pre-mixed combustion test, the stationary combustion condition occurs at an equivalent ratio = 1. The preheating temperature is 20 to 100 °C, the laminar flame speed increases with the addition of the given preheating temperature [8] , premixed combustion test Use of a cylindrical type Bunsen burner in vegetable oil biodiesel shows that the laminar rate will decrease if the equivalent ratio is increased until an explosion occurs [9] .

The shape of the flame and the direction of the flow of combustion products and oxygen change due to the direction of the magnetic force. Therefore, the flame can be controlled by applying a magnetic field which can also improve the combustion characteristics. That only non-uniform magnetic fields can interact with the flame, and small laminar flames are more affected by a mixture or partially mixed flame [10] . Fuel ionization is another new technique that has not been widely explored by researchers. Liquid fuels mostly contain hydrocarbons which have strong properties [11] . In this study, electro magnets were placed around a laminar burning methane flame to create a gradient magnetic field (a high downward gradient of the square of magnetic flux density) [12] . The flame interacts with the electromagnetic field through the ions and electrons in the fuel. So far, this studies have been conducted to observe the flame of conventional gaseous fuels such as methane and some liquid fuels such as methanol. This study aims to study the effect of magnetic field induction on the characteristics of a fire resulting from the combustion of a mixture of methanol and biodiesel *calophyllum* pre-mixed with *inophyllum*.

2 Materials and Methods

C. inophyllum oil consists of free fatty acids, glycerides, sterols, terpenoids, steroids, *calophyllolids*, *inophyllolids* and *calophyllic acid*. Nyamplung oil has properties almost equivalent to petroleum diesel and fulfills various engine combustion parameters such as heat release, ignition delay, peak pressure and time of peak pressure [13] .

This research was conducted by testing the combustion characteristics of Methanol fuel with biodiesel. Fuels are shown in Table 1 Percentage methanol and biodiesel calophyllum Inophyllum.

Table 1. Percentage methanol and biodiesel *calophyllum Inophyllum*

Fuel	Percentages
M0B100	0% methanol + 100% biodiesel calophyllum Inophyllum
M10B90	10% methanol + 90% biodiesel calophyllum Inophyllum
M20B80	2 0% methanol + 80% biodiesel calophyllum Inophyllum
M30B70	30% methanol + 70% biodiesel calophyllum Inophyllum

Prior to examining the combustion characteristics, biodiesel was tested to determine the heating value (American Society for Testing and Materials (ASTM) D240), density (ASTM D1298), viscosity (ASTM D445) and flash point (ASTM D93).

Fuel is supplied to the Bunsen burner via a pump syringe which is heated to 200-400 °C in a pipe. Air is supplied to the Bunsen burner by the compressor through a pipe. Fuel vapor and air mix in the mixing chamber and ignite in the Bunsen burner. The flame on the Bunsen burner is affected by magnetic induction and then recorded using a camera for analysis.

2.1 Research Tool Schematic

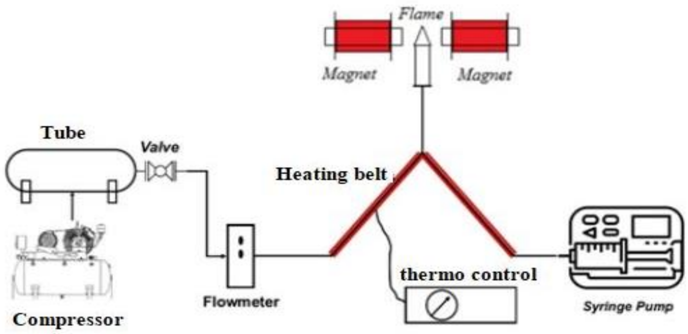

Fig. 1. Laminar speed and flame test equipment.

In Fig. 1 is the test equipment used in this study, with the specifications of the air compressor 3/4 Pk Horsepower: 3/4 HP electric power: 500-Watt tank capacity: 10 liters airflow capacity: 120 liters/minute, flow rate air 1.5 liters/minute, fuel flow rate 15-10 ml/hour, magnetic distance to burner is 0.6 mm. The image of the flame is taken when it is stable and then given a magnetic field.

From the flame, we obtain the height (h) and flame angle (α) measured in the inner flame cone, as shown in Fig. 2.

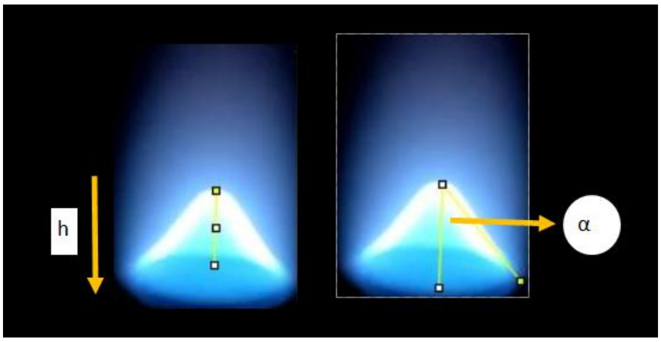

Fig. 2. Testing the height and angle of the flame.

From the data obtained, the laminar combustion velocity can be calculated using Eq. [5] .

$$SL = V.\ \sin\alpha \qquad (1)$$

where SL is laminar burning speed (cm/s), V is speed of reactants (cm/s), α is flame angle

$$V = \frac{Q\ Air + Q\ Fuel}{A} \qquad (2)$$

where V is speed of reactants (cm/s), Qair is airflow (ml/min.), Qfuel is fuel discharge (ml/min.), A is cross-sectional area of the bunsen burner (cm^2).

Experimental tests were carried out at equivalent ratios ϕ = [0.6] [0.8] [1] [1.2] [1.4] where the ratio equation is defined in Equation [8] .

$$\phi = \frac{(Qfuel/Qair)\ actual}{(Qfuel/Qair)\ stoic} \qquad (3)$$

3 Results and Discussion

The different orientations of the magnetic poles have different effects on the burning speed. The repulsion of the magnetic poles has less effect than the attraction of the magnetic poles. Repelling magnetic poles, in Fig. 3 is an illustration of the orientation of the magnetic field on a flame.

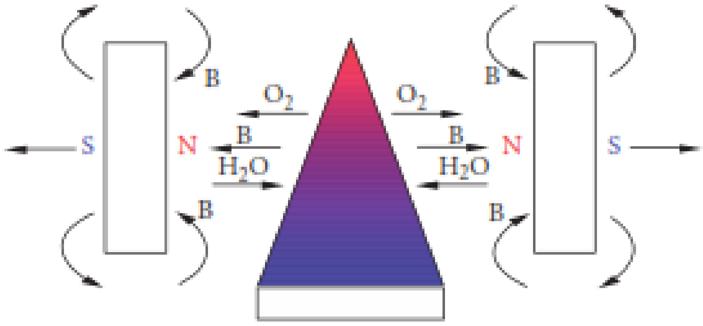

Fig. 3. Orientation of the direction of the magnetic field on the flame.

NS produces a higher combustion rate than NN because NS pumps more heat that H_2O brings to the flame while NN removes H_2O which carries product heat out of the flame [14] .

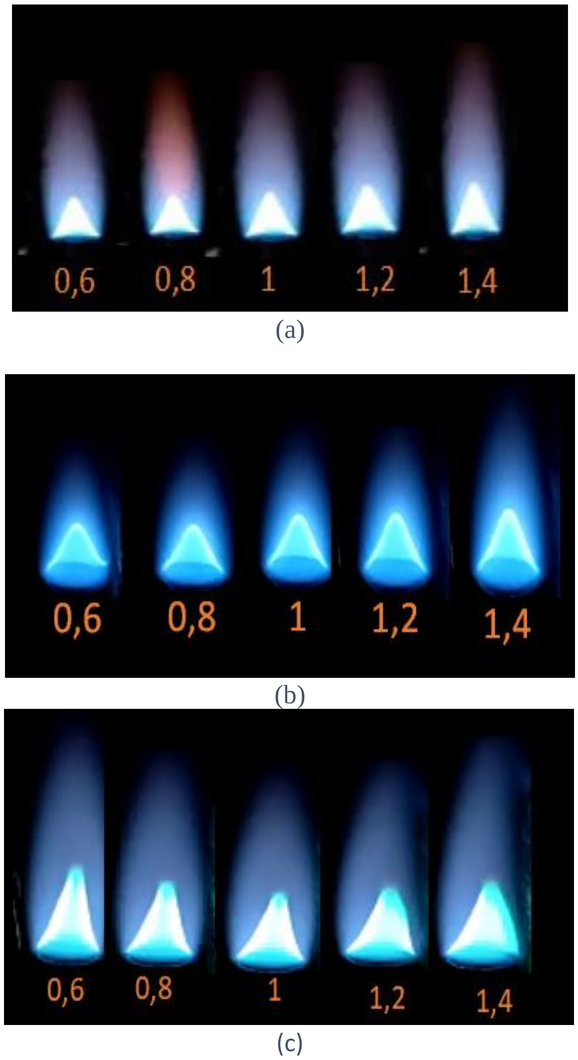

Fig. 4. Stability and flame form of pre-mixed biodiesel equivalent to: (a) without magnet, (b) NN magnets, and(c) NS magnets.

Fig. 4 shows that it is faster at the NS pole. The change in combustion speed due to changes in the direction of the magnetic poles in biodiesel is getting bigger, this shows that heat is the product of H_2O being pumped by magnets is an important factor in biodiesel combustion to overcome the increasingly strong intermolecular attractions.

Temperatures are at various equivalence ratios and magnetic field orientations. Combustion speed shows the rate of combustion reaction, namely the rate of heat release. Although the nature of the magnetic field increases the temperature of the flame, the higher the flame speed increases the biodiesel results in a decrease in temperature. This maybe because some of the heat is taken to vaporize biodiesel which is more difficult to evaporate due to the stronger attraction and polarity of the molecules as shown in Fig. 5.

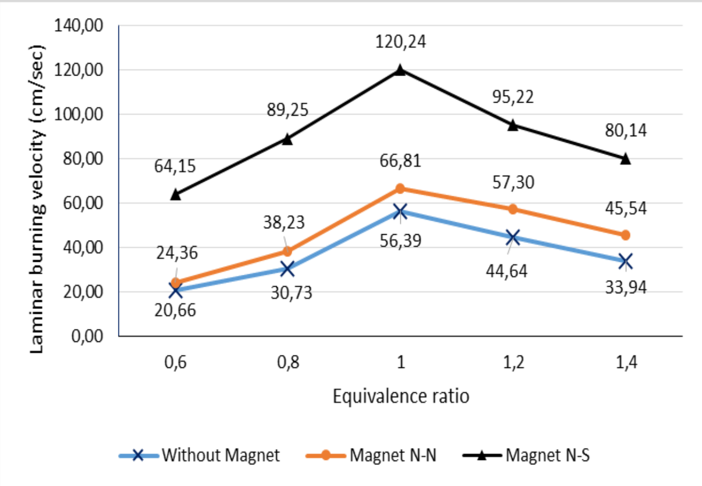

Fig. 5. The laminar burning velocity of biodiesel versus the equivalence ratio in the orientation of a magnetic field and without a magnetic field.

The results of the study of the laminar burning rate of biodiesel *calophyllum inophyllum* in Fig. 5 show that the laminar flame speed increases and decreases with increasing equivalent ratio and magnetic field. This tendency is the same as research on burning other hydrocarbons such as petro diesel, palm oil methyl ester, CH_4, and ethyl-benzene [8] .

The magnetic field has a greater effect and shortens the flame on biodiesel. This case happens because the magnet makes the electrons more energetic so the reaction speed can increase.

From Fig. 5 and from several previous studies it is known that the magnetic field has the power to affect the magnetic poles of electrons in molecular bonds, which means it affects the spin of electrons in molecules. The second role is that the magnetic field can change the rotation of the hydrogen protons in the fuel from para to ortho [15] [16] [17] [18] .

Thus, the combustion reaction can take place more quickly. The change from para to ortho is more pronounced in premixed biodiesel combustion where the laminar combustion speed increases higher due to the stronger electrical polarity of the biodiesel [16] and applies to almost all biodiesel that has more oxygen content.

Biodiesel molecules are more diffusive because they are less polar, so the diffusion time is shorter. By changing the proton spin to ortho and providing electron spin energy to biodiesel due to a magnetic field, the reaction time is shortened, so the reaction zone becomes thinner. The third role of the magnet is to attract paramagnetic molecules in the event of burning oxygen and repel diamagnetic molecules in H_2O which carry heat. The magnetic field can affect the burning speed of the biodiesel flame. In a poor mixture (ϕ <1) in the presence of a magnetic influence, the rate of combustion is lower without the influence of a magnetic field, but in a rich mixture (ϕ > 1) in the presence of a magnetic influence, the rate of fire is higher than without the influence of a magnetic field.

4 Conclusion

Experimental study on the combustion of premixed. The strength of the magnetic field increases the speed of the laminar combustion of calophyllum biodiesel inophyllum. The orientation of the magnetic poles plays a role in transporting O2 because the magnetic field binds oxygen in biodiesel fuel and maximizes the transport of heat carried by H2O in reaction products which greatly determines stability in achieving combustion.

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