ISSN 2347 - 3983
Volume 11. No.2, February 2023
International Journal of Emerging Trends in Engineering Research
Available Online at http://www.warse.org/IJETER/static/pdf/file/ijeter011122023.pdf
https://doi.org/10.30534/ijeter/2023/011122023

Characterization of Premixed Flames with Ethanol Fuel affected Magnetic Field Induction

Deny Tomy Andrianto[1], Muh.Nurkoyim Kustanto[2], Yuni Hermawan[3], Nasrul Ilminnafik[4], Salahuddin Junus[5]
[1] Department of Mechanical Engineering, Jember University
Jember, 68121, Indonesia
*Corresponding Author: nurkoyin@unej.ac.id

Received Date: January 02, 2023 Accepted Date: January 22, 2023 Published Date : February 07, 2023

ABSTRACT

The purpose of this study was to determine the effect of magnetic field induction on the characteristics of premixed ethanol combustion flames. Petroleum reserves will increasingly be depleted if alternative energy is not found. Therefore, various breakthroughs are needed to prevent an energy crisis from occurring. Simultaneously the researchers are also trying to find equipment that can save fuel consumption. To get a more effective and efficient flame, you can apply a magnetic field effect to the burning fire, especially in terms of the rate of burning of the fire. Fuel oil under normal conditions tends to be irregular and grouped together. By providing a magnetic field to induce the fuel oil, the hydrocarbon bonds will break and will make the chemical composition more homogeneous. The experimental research method is to heat ethanol until it is in the form of steam, then flow it to the burner which will then be given air which is controlled by the mass flow. The research began with the manufacture of magnetic induction from carbon steel wrapped in copper wire. Then testing the fuel by providing a magnetic field before the ethanol fuel enters the burner tip. The magnetic field helps the fuel ionization process, this ionization is needed so that the fuel can easily bind oxygen during the combustion process. If the ionization process goes well then the combustion process becomes more complete. In this ionization process, it will result in the formation of positively charged fuel molecules so that during combustion the combustion process will occur more quickly. The magnetic field will generate Far Infrared waves, which will strengthen the positively charged bonds in the fuel structure due to the ionization process and position these bonds in an orderly manner. This makes it easy for oxygen to react with fuel in the combustion process. With the electric motion force will increase the combustion temperature. The increase in temperature is caused by the process of ionization of the fuel due to the magnetic field generated by the electromotive force. The dynamic electromotive force causes the flame to increase when the current is flowing and decrease when the electric current is cut off. The resulting fire is more transparent, clearer and more visible. The direction of the N-S magnetic field causes the temperature to be higher than the direction of the N-N magnetic field. The magnetic field can affect the burning speed of the ethanol flame. In a poor mixture ($\phi < 1$) in the presence of magnetic influence, the rate of fire is lower without the influence of a magnetic field, but in a rich mixture ($\phi > 1$) in the presence of a magnetic influence, the rate of fire is higher than without the influence of a magnetic field.

Key words : Burning speed, premixed, Ethanol, Electromotive Force, Effect of Magnetic Field.

1. INTRODUCTION

Ethanol is an environmentally friendly alternative (renewable) fuel that produces low carbon emissions compared to gasoline or the like (up to 85% lower). Basically, ethanol is made from sweet potatoes, corn or other plantation products and until now there has been no vehicle specifically designed to use 100% ethanol. The use of ethanol in vehicles usually uses 2 types of ethanol, namely ethanol 10 (E-10) which is a mixture of 10% ethanol and 90% gasoline and can be used in all the latest vehicles [1]. In general, the hydrocarbon molecules in fuel compounds will carry out vibrational activity towards the core. In addition, hydrocarbon compounds will tend to attract and attract intermolecular molecules so as to form clustered molecules (clustering). Clustering in this fuel causes the hydrocarbon molecules not to separate from each other when they react with oxygen. There is a rapid chemical reaction between the hydrogen and carbon in the fuel with the oxygen contained in the air. As a result of the clustering effect there is still fuel that has not been burned and turned into UHC (Unburned Hydrocarbon) and carbon monoxide. So to reduce emission levels and increase combustion efficiency, it is necessary to improve the atomization process. One way to improve the fuel atomization process is to apply a magnetic field to the fuel flow [2]. In everyday life, the emergence of an electric field is always accompanied by the emergence of a magnetic field. The use of a magnetic field in the fuel flow is as follows:

1. The magnetic field helps the ionization process in the fuel, this ionization is needed so that the fuel can easily bind oxygen during the combustion process. If the ionization process goes well, fuel consumption will be reduced because the combustion process is more complete. In this ionization

process, it will result in the formation of positively charged fuel molecules so that during combustion the combustion process will occur more quickly.

2. The magnetic field will cause Far Infrared Waves, which will strengthen the positively charged bonds of the fuel molecule structure due to the ionization process and position these bonds in an orderly manner. This makes it easy for oxygen to react with fuel in the combustion process [3].

Research on premixed combustion has been carried out using conventional fuels [4]. Emissions of nitrogen oxides (NOx) under certain conditions can be reduced if the conventional combustion system is replaced with a premixed system[5]. If the speed of the reactants is the same as the speed of flame propagation, (the reaction zone) will be stationary [6]. Premixed combustion requires a stationary state because it affects the stability of the flame. The stationary state of combustion occurs when the velocity of the reactants is equal to the velocity of the flame. In the pre-mixed combustion test, stationary combustion conditions occur at an equivalent ratio = 1. Preheating temperature is 20 to 100 °C, laminar flame velocity increases with the addition of a given preheating temperature [7], premixed combustion test using The cylindrical type Bunsen burner shows that the laminar rate will decrease if the equivalent ratio is increased until an explosion occurs [8].

The shape of the flame and the direction of 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 [9]. That only a non-uniform magnetic field can interact with the flame, and small laminar flames are more affected by mixtures or partially mixed flames [10]. In this study, electro-magnets were placed around a laminar burning methane flame to create a magnetic field (high downward gradient of the square of the magnetic flux density)[8].

The flame interacts with the electro-magnetic field through the ions and electrons in the fuel. So far, studies have been conducted to observe the flames of conventional fuels from gases such as methane and some from liquid fuels such as ethanol [7].

2. RESEARCH METHODS

This research was conducted by examining the characteristics of the combustion of ethanol fuel. Figure 1 shows the laminar and high flame firing speed testers. Fuel is supplied to the Bunsen burner via a pump syringe which is heated at 100-300 °C in a pipe. Air is supplied to the bunsen burner by the compressor through a pipe. Fuel and air vapors mix in the chamber and ignite in the bunsen. The flame on the bunsen is affected by magnetic induction and then recorded using a camera for analysis.

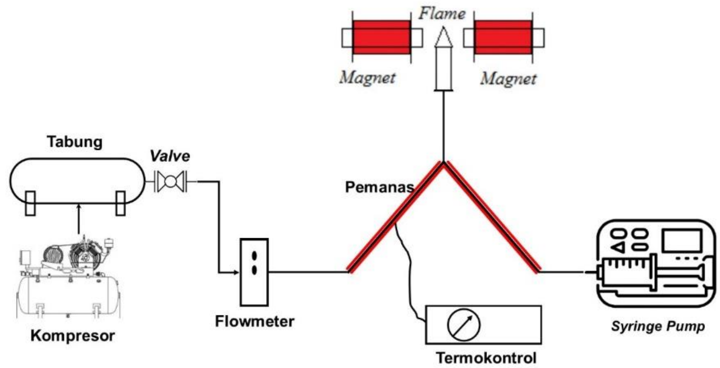


Figure 1: Laminar and flame combustion speed test equipment.

From the observed flame, we obtain the height and angle of the flame measured in the inner flame cone, as shown in Figure 2.

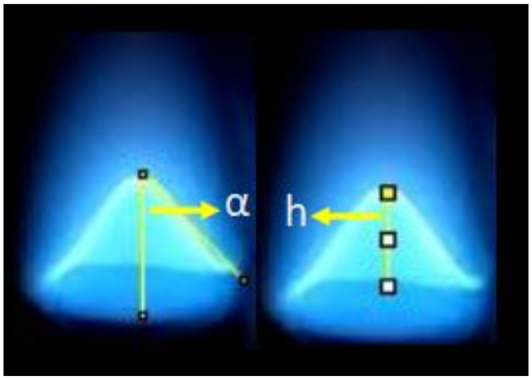


Figure 2: Testing the height and angle of the flame

From the data obtained, the speed of laminar combustion can be calculated using the equation [4].

$$SL = V.\ \mathrm{Sin}\ \alpha \qquad (1)$$

explanation,
SL : laminar burning velocity (cm/s)
V : reactant speed (cm/s)
A : the angle of the flame

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

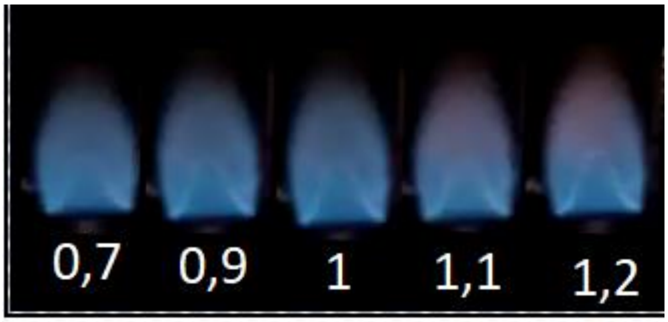
explanation,
V : reactant speed (cm/s)
Qair : air discharge (ml/min.)
Qfuel : fuel discharge (ml/min.)
A : bunsen burner cross-sectional area (cm^2)

Experimental tests were carried out from the equivalent ratio ϕ = 0.7, 0.9, 1, 1.1, 1.3 where the equation ratio is defined in Eq. [9].

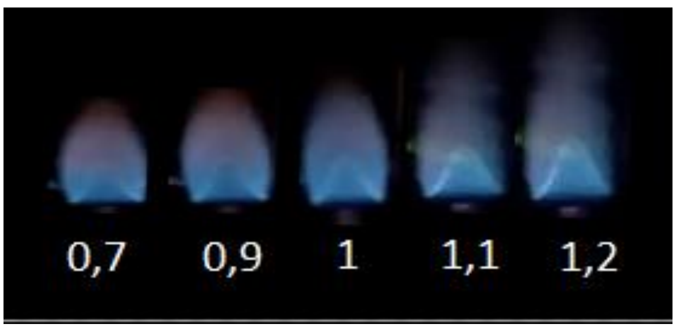
$$\phi = \frac{(Qfuel/Qair)\ actual}{(Qfuel/Qair)\ stoic} \qquad (3)$$

3. RESULTS AND DISCUSSION

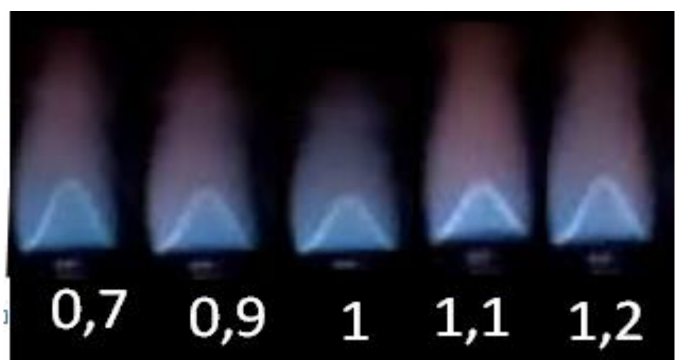
The orientation of the magnetic field poles has a different effect on the burning speed. The repulsion of the magnetic poles will have a smaller effect than the magnetic attraction. Attractive magnetic poles N-S produce a higher combustion rate than N-N because N-S pumps out more of the heat that H_2O brings to the flame while N-N removes H_2O which carries the product heat out of the flame [10].



(a) ethanol flame with an equivalent ratio of 0.7-1.2



(b) ethanol flame with an equivalent ratio of 0.7-1.2



(c) ethanol flame with an equivalent ratio of 0.7-1.2

Figure 3: The shape of an ethanol flame with a ratio of 0.7-1.2: (a) without a magnet; (b) N-N magnets; (c) N-S magnets

It can be seen in Figure 3, that the magnetic influence is faster at the N-S pole. The change in combustion speed changes the direction of the magnetic poles to become larger, this shows that the product heat in the H_2O pumped by the magnet is an important factor in combustion. Burning speed shows the rate of heat release. Although the nature of the magnetic field increases the temperature of the flame, the higher the flame speed, the lower the temperature. Maybe because some of the heat is taken to vaporize the fuel.

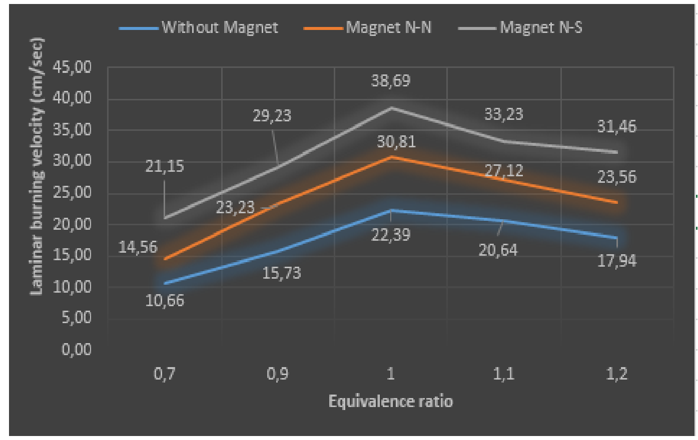


Figure 4: The burning speed of an ethanol laminar flame versus the equivalence ratio in the orientation of a magnetic field and without a magnetic field.

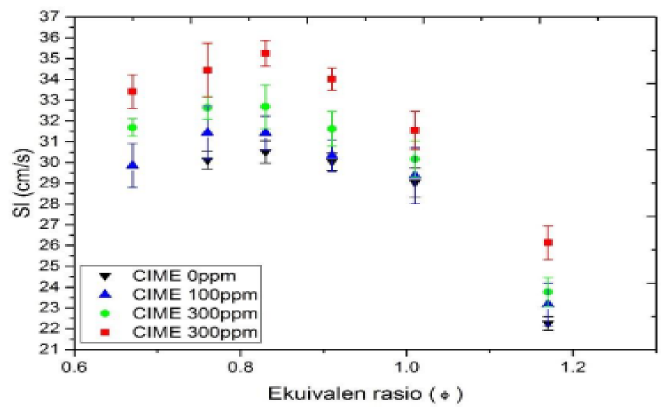


Figure 5: Graph of biodiesel laminar flame velocity and mixtures [9].

The results of the research on the ethanol laminar burning rate were compared with research [9]. The results showed that the laminar flame velocity increased and decreased with increasing equivalent ratio and magnetic field. This trend is the same as research on burning other hydrocarbons such as petrodiesel, palm oil methyl ester, CH_4, and ethyl-benzene [2].

The height of the ethanol burning flame in the orientation of the magnetic field. This shows that the ethanol flame with a magnet is higher than the flame without a magnet because the higher it indicates that the flame tends to be less stable because it has a longer span, the magnetic field has a greater effect and shortens the flame on biodiesel. This happens because the magnet makes the electrons more energetic so the reaction speed can increase.

From several previous studies, it was stated 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 [11][12][13][14][15].

Combustion reactions can take place more quickly. The change from para to ortho is more pronounced in premixed combustion where the laminar burning speed increases higher due to the stronger electrical polarity of ethanol [13]. The role of the magnetic field is to attract paramagnetic molecules in case of combustion is oxygen and repel diamagnetic molecules in H_2O which carry heat.

4. CONCLUSION

The strength of the magnetic field increases the speed of the laminar burning of ethanol through its role in increasing the spin of the electrons and changing the spin of the hydrogen fuel protons. The direction of the magnetic poles plays an important role in the transport of O_2 and the transport of heat carried by H_2O in the reaction product which greatly determines the stability and achievement of combustion. The right combination of field strength and magnetic field direction determines the quality of the burning fire.

REFERENCES

[1] L. Hakim, “Variasi Kuat Arus Dan Arah Medan Magnet Pada Saluran Bahan Bakar Terhadap Unjuk Kerja Motro Bakarc 4 Langkah Dengan Bahan Bakar E-10,” 2014.

[2] A. D. W. I. Utami, P. Sarjana, D. T. Mesin, and F. T. Industri, “Pada Injector Bioethanol Terhadap Karakteristik Semprotan Untuk Aplikasi Pada Mesin Sinjai-150,” 2018.

[3] A. Sudibyo, S. H. Santoso, and A. Nugroho, “Pengaruh Besarnya Medan Magnet Dalam Aliran Fluida Bahan Bakar Terhadap Performance Pembakaran,” vol. 0707017508, no. September, 2013.

[4] D. B.N. Riwu, I. N. G. Wardana, and L. Yuliati, “Kecepatan Pembakaran Premixed Campuran Minyak Jarak - Liquefied Petroleum Gas (LPG) pada Circular Tube Burner,” *J. Rekayasa Mesin*, vol. 7, no. 2, pp. 41–47, 2016, doi: 10.21776/ub.jrm.2016.007.02.1.

[5] S. Bahri La Muhaya, I. Wardana, and D. Widhiyanuriyawan, “Pembakaran Premixed Minyak Nabati pada Bunsen Burner Type Silinder,” *J. Rekayasa Mesin*, vol. 6, no. 1, pp. 45–49, 2015, doi: 10.21776/ub.jrm.2015.006.01.7.

[6] D. H. T. Prasetiyo, N. Ilminnafik, and S. Junus, “The Flame Characteristics of Diesel Fuel Blend with Kepuh (Sterculia Foetida) Biodiesel,” *J. Mech. Eng. Sci. Technol.*, vol. 3, no. 2, pp. 70–80, 2019, doi: 10.17977/um016v3i22019p070.

[7] G. Soebiyakto, I. N. G. Wardana, N. Hamidi, and L. Yuliati, “Premixed Combustion Of Vegetable Oil In A Cylinder With 4 Magnetic Poles,” *J. Southwest Jiaotong Univ.*, vol. 435, no. 122, p. 11090, 2020.

[8] W. Wu, J. Qu, K. Zhang, W. Chen, and B. Li, “Experimental Studies of Magnetic Effect on Methane Laminar Combustion Characteristics,” *Combust. Sci. Technol.*, vol. 2202, no. February, 2016, doi: 10.1080/00102202.2015.1119825.

[9] S. Pambudi, N. Ilminnafik, S. Junus, and M. N. Kustanto, “Experimental Study on the Effect of Nano Additives γAl2O3 and Equivalence Ratio to Bunsen Flame Characteristic of Biodiesel from,” vol. 4, no. 2, pp. 51–61, 2021.

[10] D. Perdana, L. Yuliati, N. Hamidi, and I. N. G. Wardana, “The Role of Magnetic Field Orientation in Vegetable Oil Premixed Combustion,” vol. 2020, 2020.

[11] H. C. Ong, T. M. I. Mahlia, H. H. Masjuki, and R. S. Norhasyima, “Comparison of palm oil, Jatropha curcas and Calophyllum inophyllum for biodiesel: A review,” *Renew. Sustain. Energy Rev.*, vol. 15, no. 8, pp. 3501–3515, 2011, doi: 10.1016/j.rser.2011.05.005.

[12] F. A. El Fatih and G. M. Saber, “Effect of fuel magnetism on engine performance and emissions,” *Aust. J. Basic Appl. Sci.*, vol. 4, no. 12, pp. 6354–6358, 2010.

[13] A. S. Faris *et al.*, “Effects of magnetic field on fuel consumption and exhaust emissions in two-stroke engine,” *Energy Procedia*, vol. 18, pp. 327–338, 2012, doi: 10.1016/j.egypro.2012.05.044.

[14] M. Chandrasekaran, K. B. Prakash, S. Prakash, and M. Ravikumar, “Influence on performance and emission characteristics of diesel engine by introducing medium strength magnetic field in fuel and air lines,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 764, no. 1, 2020, doi: 10.1088/1757-899X/764/1/012006.

[15] M.S.Gad, “Influence of magnetized waste cooking oil biodiesel on performance and exhaust emissions of a diesel engine,” *Int. J. ChemTech Res.*, vol. 11, no. 11, pp. 255–267, 2018, doi: 10.20902/ijctr.2018.111126.