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The characteristics of combustion of non-catalyst Rubber Seed Oil (*Hevea Brasilliensis*) combustion with variations of Methanol mixture

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Abstract. This study aims to analyze the characteristics of the combustion of a mixture of rubber seed oil with methanol using droplets. The observed characteristics are flame temperature, ignition delay time, combustion rate, and visualization (high heat and flame colour). The variation of the mixture used in this study was a mixture of rubber seed oil and methanol with mixed percentages of 0%, 10%, 20%, 30%, 40%, and 50%. The droplet tool used for research is a tool designed by the researcher. The results showed that the highest flame temperature value was found in the 0% mixture, 114oC, and the lowest was in the 50% mixture, namely 79.67ºC. The highest Ignition delay time value is in the 0% mixture, which is 3.33 s, and the lowest is at 50%, which is 2.21 s. The highest combustion rate value at 50% mixture is 0.517 mm^2/s and the lowest at 0% is 0.317 mm^2/s. The highest flame height in the 0% mixture was 42.6 mm, and the lowest at 50% was 23 mm.

Keywords: *Droplets, Rubber Seed Oil, Ignition Delay Time, Characteristics of Combustion*.

1. Introduction

The supply of petroleum in the world is getting depleted in Indonesia due to the increasing human need for petroleum energy. This condition is also triggered by the increasing demand for oil energy in the transportation sector or the industrial sector in Indonesia. Therefore, there is a need for new renewable energy sources as a substitute for petroleum fuel [1].

Alcoholic fuels such as ethanol, methanol, butanol, and propanol can also be used as alternative vehicle fuels. One is processing rubber seeds into diesel engine fuel through an extraction process. Due to several factors, the oil obtained from the rubber seed extraction process is further processed to obtain suitable diesel fuel [2].

Based on the explanation above, research on rubber seed oil with a mixture of methanol will be conducted to determine its combustion characteristics and its use on a larger scale. The combustion characteristics to be carried out include ignition delay time, flame visualization, flame temperature, and burning rate.

Rubber seeds, if used, will be quite profitable because they are very abundant. South Kalimantan is one of the rubber-producing provinces (Hevea brasilliensis), with an area of ± 239,442 ha in 2012.

Rubber seeds contain 40-50% oil, where the composition of palmitic acid is 13.11%, stearic acid is 12.66%, arachidic acid is 0.54 %, oleic acid 39.45%, linoleic acid 33.12%, and the rest is Lemark Lane acid. Oleic, linoleic, and linolenic acids are very beneficial for health, as a source of omega 3, 6, and 9 fatty acids. In contrast, palmitic and stearic acids have the potential to be used as fuel of good quality [3].

Methanol has the chemical formula (CH_3OH) and is the simplest form of alcohol. In atmospheric conditions, it is a light, volatile, colorless, flammable, and toxic liquid with a characteristic odor (smells lighter than ethanol). Methanol has one carbon bond, so it is easier to obtain glycerol separation.

Combustion is a rapid oxidation process in fuel with the production of heat and light. The release of light and heat from a fire. Complete combustion occurs when there is sufficient oxygen supply, and usually, combustion requires air to take place completely [4].

Droplet combustion is also called non-premixed combustion. It occurs because the fuel contained in the droplets mixes with the air. The droplets will evaporate to spread the fuel vapor with the air and produce a flame when heated.

Flame temperature is the maximum temperature of the fuel flame that occurs when there is no heat leakage around it. The adiabatic flame temperature is needed to determine how much heat occurs when other fuels with lower calorific values will cause a decrease in flame temperature and vice versa. The flame temperature value is directly proportional to the heat possessed by the fuel [4].

Ignition Delay Time is the time it takes for fuel to ignite when it receives heat. The value of the combustion delay is very important for fuel because the higher the combustion lag time, the longer it will take for fuel to ignite; this will cause a reaction delay. Combustion causes symptoms of decreased performance of an engine [4].

The average combustion rate is the speed at which the fuel burns when it starts burning until it runs out. The formula for the average combustion rate is the quotient of the average droplet diameter and the time of flame evolution. It is measured from the temperature signal in seconds and has the equation mm^2/second [5].

2. Material and Methods

The research was carried out from April 15 to May 31, 2021. The manufacture of biodiesel from rubber seeds and the testing process were conducted at the Laboratory Mechanical Engineering, Faculty of Engineering, University of Lambung Mangkurat Banjarbaru. Tools and materials used: Injection with a volume of 1.0 ml, the Heating element with a coil diameter of 1.30 mm, Datalogger, Thermocouple type-k, T-transformer model: OSKA-60-12, Combustion chamber and ruler, Camera specification camera 50MP, f/1.8 with autofocus, Tripot, sample bottle, water heater, measuring cup and digital balance type Dj6001a. Ingredients used: 90 ml rubber seed oil and 30 ml methanol (Figure 1).

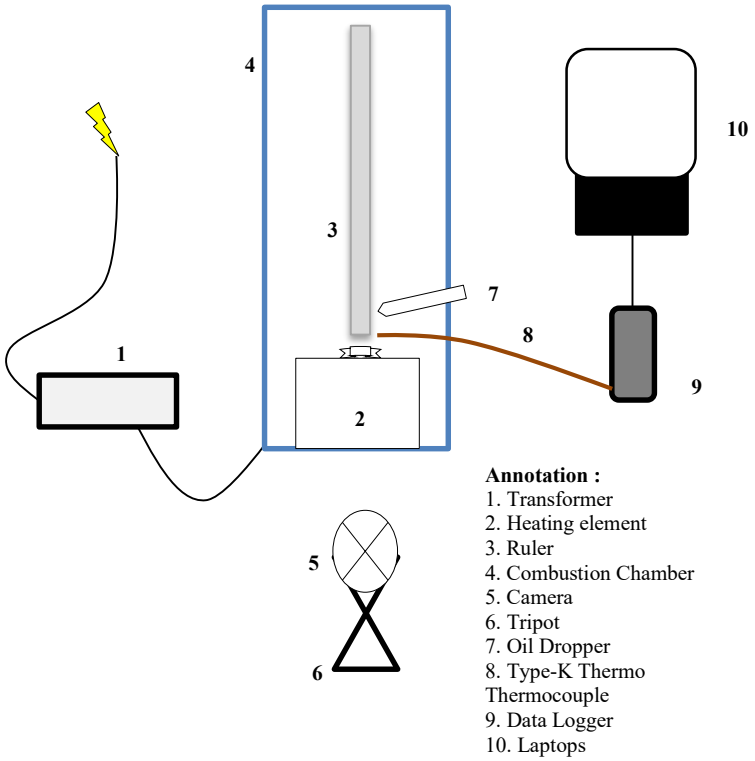

Figure 1. Research Installation

2.1. Manufacturing of Raw Material

Collecting rubber seeds found in community plantations in Sidomulyo village, Wanaraya sub-district, Barito Kuala Regency. Then do the separation of the rubber seed shell and take the contents. After that, the rubber seeds are mashed with a blender machine; the crushed rubber seeds are then dried. The dried rubber seeds are collected for further extraction to obtain pure rubber seed oil. The method used is reflux extraction; this extraction is carried out at the FMIPA Lambung Mangkurat University Lab with a mixture of 300 ml of solvent and 150 grams of crushed rubber seeds; when reflux extraction is complete, distillate for 1 hour to separate the solvent content from the oil (Figure 2).

2.2. Test Sample Preparation

Preparation of rubber seed oil obtained by using the reflux extraction method [6,7]. Methanol can be found in chemical shops in the area near the study.

2.3. Test Sample Making

Preparing rubber seed oil and methanol, Prepare variations of the methanol mixture with a ratio of 0%, 10%, 20%, 30%, 40%, and 50% of 5 ml of rubber seed oil for each sample. Prepare 50 ml of pure rubber seed oil and heat to a temperature between 50 degrees Celsius; measure with a thermocouple. Mixing rubber seed oil that has been heated with methanol in each variation. Rubber seed oil that has been heated and mixed with methanol is deposited for 24 hours.

2.4. Testing Procedure

Place the camera (figure 1.5) at a predetermined distance of 50 cm. Dropping rubber seed oil with the same drops, all samples that have been completed are varied using a droplet dropper at the point provided. Turn on the heating element within 5 seconds then the heating element is shifted to near a predetermined point. Observing the visualization of the flame, which includes the height and color of the fire, using the camera that has been provided with a predetermined distance of 50 cm. Observe the

temperature on the data logger generated from each sample. Observe the ignition delay time of each sample. Observe the burning rate of each sample. Observe and record the results of each test.

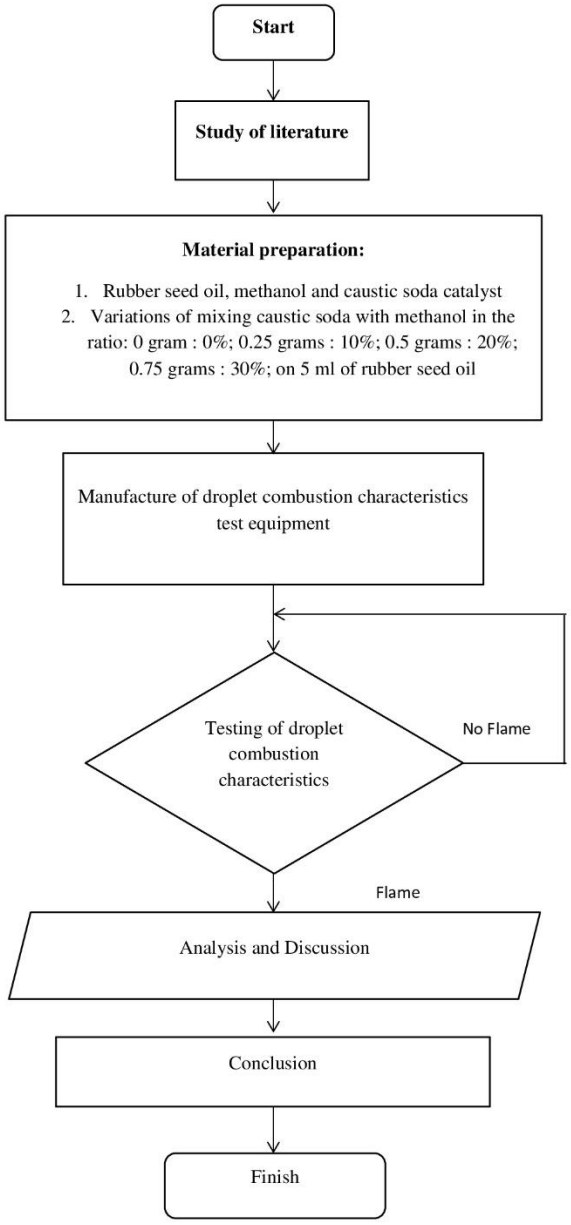

Figure 2. Flowchart

3. Result and Discussion

The effect of the percentage of the mixture of rubber seed oil with methanol on the Flashpoint can be seen in Figure 3.

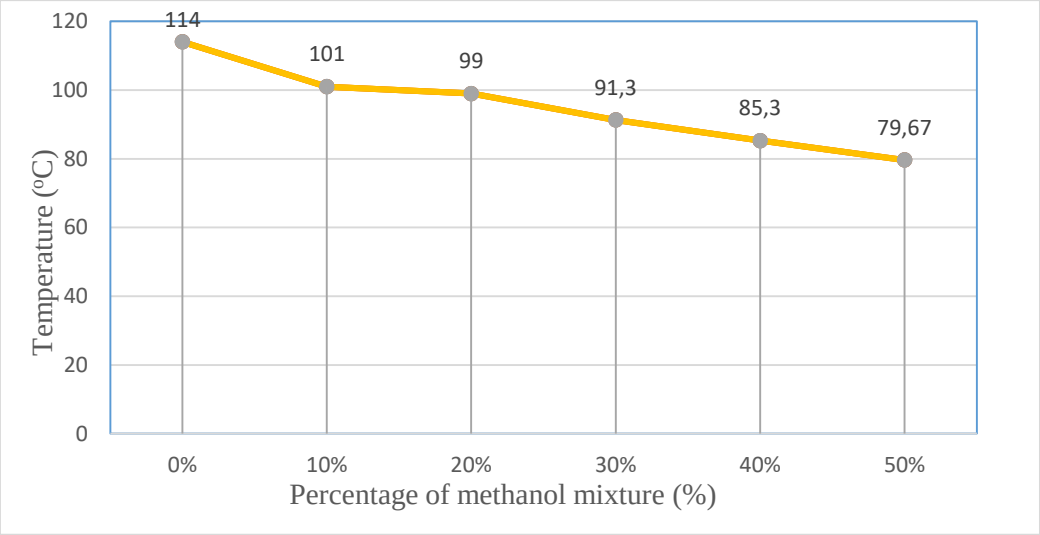

Figure 3. The effect of the amount of rubber seed oil mixed with methanol on the Flashpoint

Figure 3 describes the effect of the percentage of rubber seed oil with methanol on the flashpoint temperature. The lowest flash point value is shown at the percentage of 50% methanol mixture with a temperature value of 79.67ºC, while the highest flash point value is shown at the percentage of 0% methanol mixture with a temperature value of 114ºC. The graph above shows that the higher the percentage of rubber seed oil and methanol mixture, the temperature will decrease. The flashpoint value of methanol is smaller than that of rubber seed oil, where methanol itself has a flashpoint value of 11oC. The addition of methanol can also cause the calorific value of the fuel mixture to decrease. Flashpoint is influenced by the rate of evaporation (volatility) influenced by the nature of the fuel. The effect of the amount of rubber seed oil mixed with methanol on the ignition delay time can be seen in Figure 4.

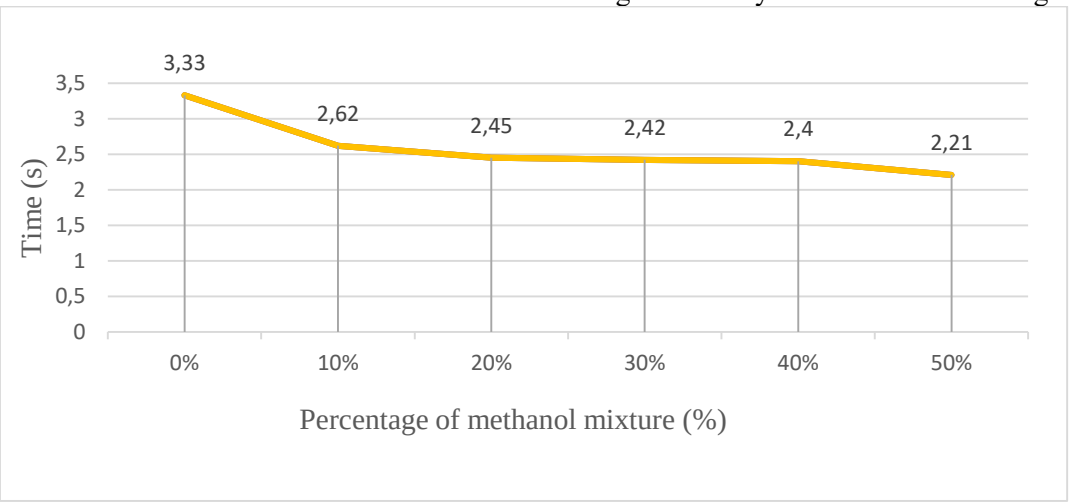

Figure 4. The influence of the percentage of the mixture of rubber seed oil with methanol on ignition delay time

Figure 4 describes the percentage of the mixture of rubber seed oil with methanol at the ignition delay time. The graph above shows that the lowest ignition delay time is shown at 50% mixture percentage with a duration of 2.21 s, while the highest ignition delay time is shown at 0% mixture percentage with a duration of 3.33 s. The graph above shows that the higher the percentage of rubber seed oil + methanol mixture, the lower the ignition delay time value. The flashpoint value of methanol is lower than rubber seed oil, where the flashpoint value of methanol itself is 11ºC. The Flashpoint is the fuel's Flashpoint at the lowest temperature; the lower the flash point value, the faster the ignition time. The evaporation rate affects ignition delay time; the faster the evaporation and burns also lower the ignition delay time value. The effect of the percentage of the mixture of rubber seed oil with methanol on the burning rate can be seen in Figure 5.

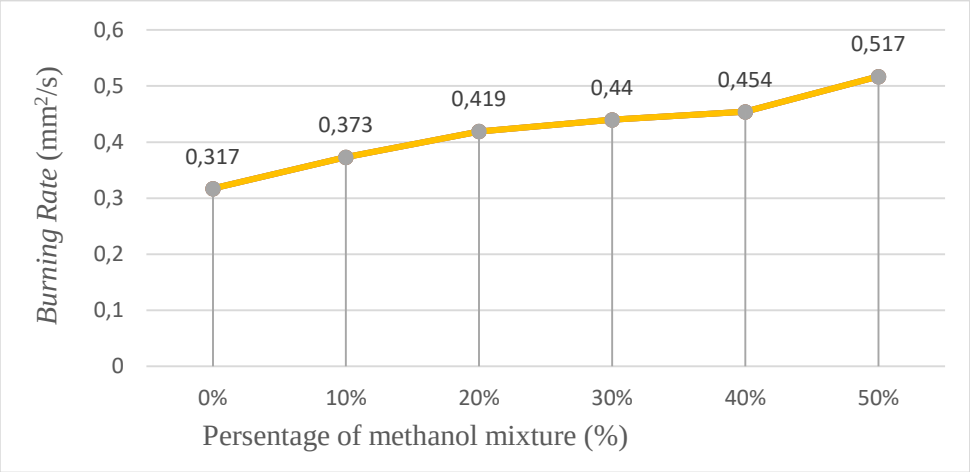

Figure 5. The effect of a mixture of methanol and rubber seed oil on the burning rate

Figure 5 describes the effect of the percentage of mixing rubber seed oil with methanol on the burning rate. The lowest average burning rate value is indicated at the percentage of the mixture of 0% with a duration of 0.317 s. In comparison, the highest burning rate appears at the percentage of 50% mixture with a duration of 0.517 s. Figure 5 shows that the higher the percentage of rubber seed oil + mixture of methanol, the higher the buring rate will be. The oxygen content in methanol can accelerate the combustion reaction, with the addition of methanol will increase the oxygen concentration in the fuel. With each addition of volume-based methanol, the oxygen concentration in the fuel will increase. The increase in oxygen in the fuel can lead to better combustion quality and faster combustion reactions so that the value of the combustion rate is higher.

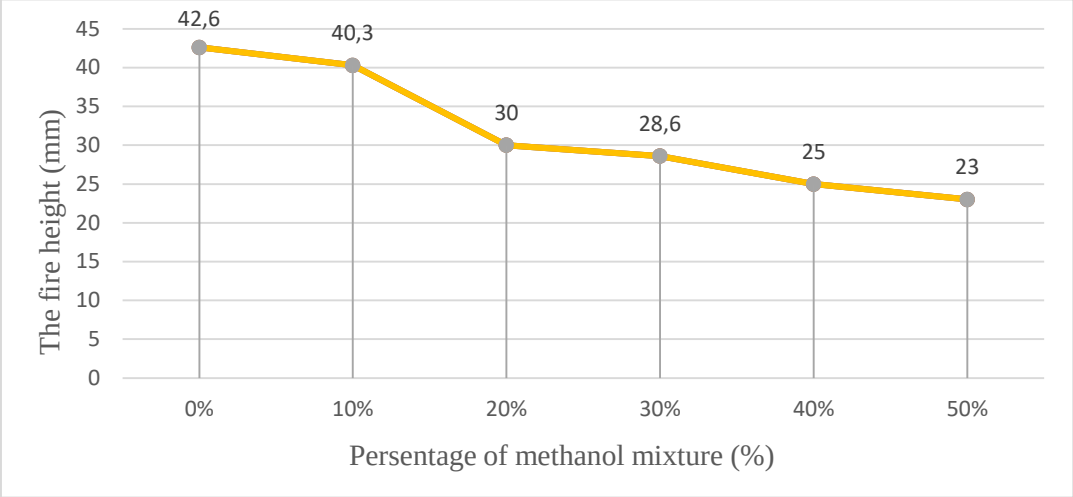

Figure 6. The effect of a mixture of rubber seed oil and methanol on fire height

Figure 6 explains the effect of the percentage of mixing rubber seed oil with methanol on high heat. The lowest fire height is shown at the 50% mixture percentage, which is 23 mm, while the highest fire height is shown at the 0% mixture percentage, which is 42.6 mm. Figure 6 reveals that the higher the percentage of rubber seed oil + methanol mixture, the lower the flame height. The rate of evaporation and diffusion of fuel affects the flame height. Pure rubber seed oil is slower at evaporation and diffusion of fuel but burns faster. If the percentage of the methanol mixture added is higher, the combustion reaction rate will increase [8-10]. The reaction rate affects the flame time and flame height; the higher the combustion reaction rate, the relatively shorter flame time produced, and the lower the resulting flame height. The image below shows the visualization of the fire of a mixture of rubber seed oil and methanol with mixed percentages of 0%, 10%, 20%, 30%, 40%, and 50%.

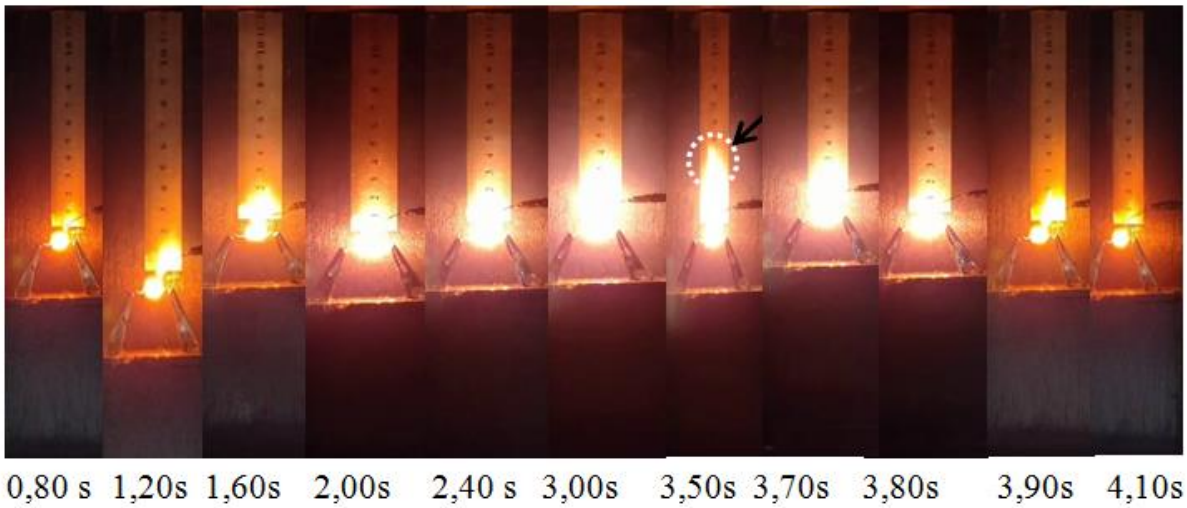

Figure 7. Visualization of Fire Percentage Mix 0%

Figure 7. shows that the mixture of rubber seed oil + and methanol with a percentage of 0% takes 3.50 s to reach the maximum height with a fire height of 42.6 mm. The dominant flame colour is yellow. Extinguished at 4.10 s.

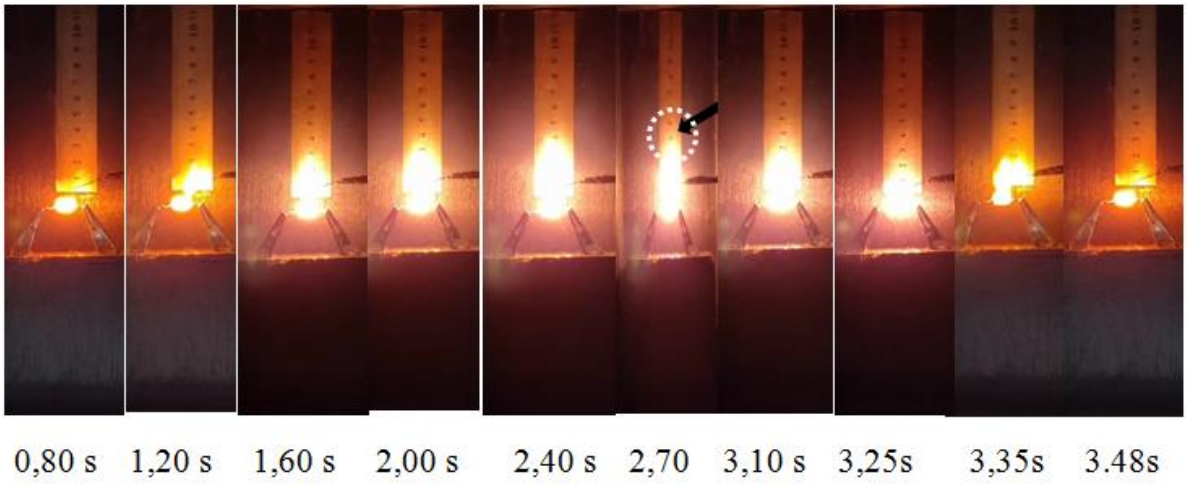

Figure 8. Visualization of Fire Mixed percentage 10%

Figure 8 shows that a mixture of rubber seed oil + methanol with a 10% percentage takes 2.75 s to reach the maximum height with a fire height of 40.3 mm, and the dominant color of the fire is yellow; after reaching the maximum height, the fire gradually decreases until it is extinguished at 3.48 s.

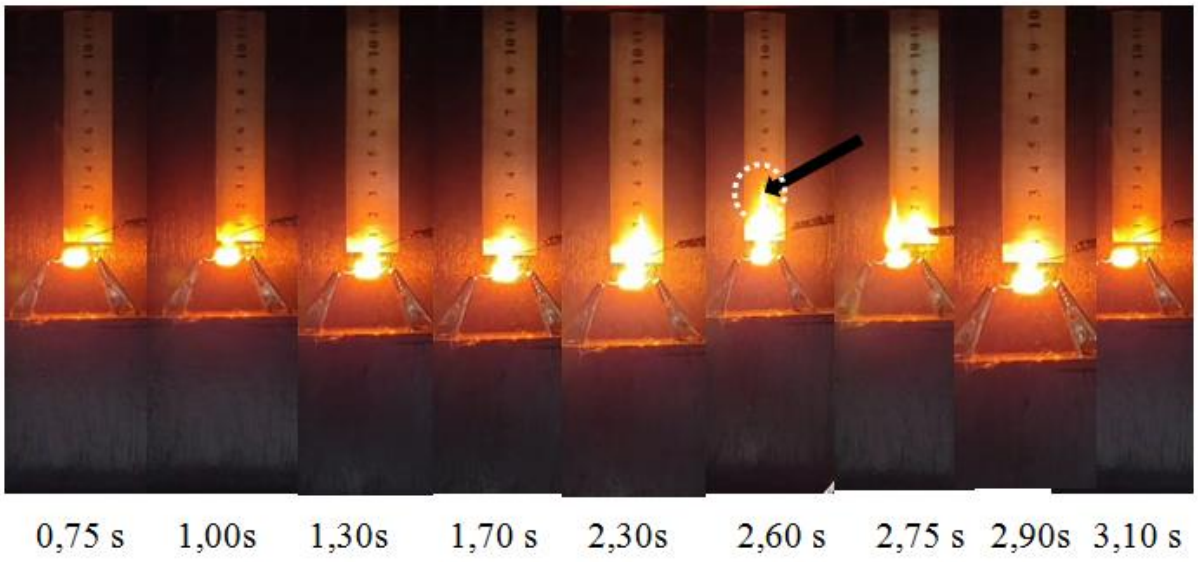

Figure 9. Visualization of Flame Percentage of Methanol Mixture 20%

Figure 9 shows that a mixture of rubber seed oil + methanol with a percentage of 20% takes 2.60 s to reach the maximum height with a flame height of 30 mm, and the dominant colour of the fire is yellow after reaching the maximum height, the fire gradually decreases until it is extinguished over time 3.10s.

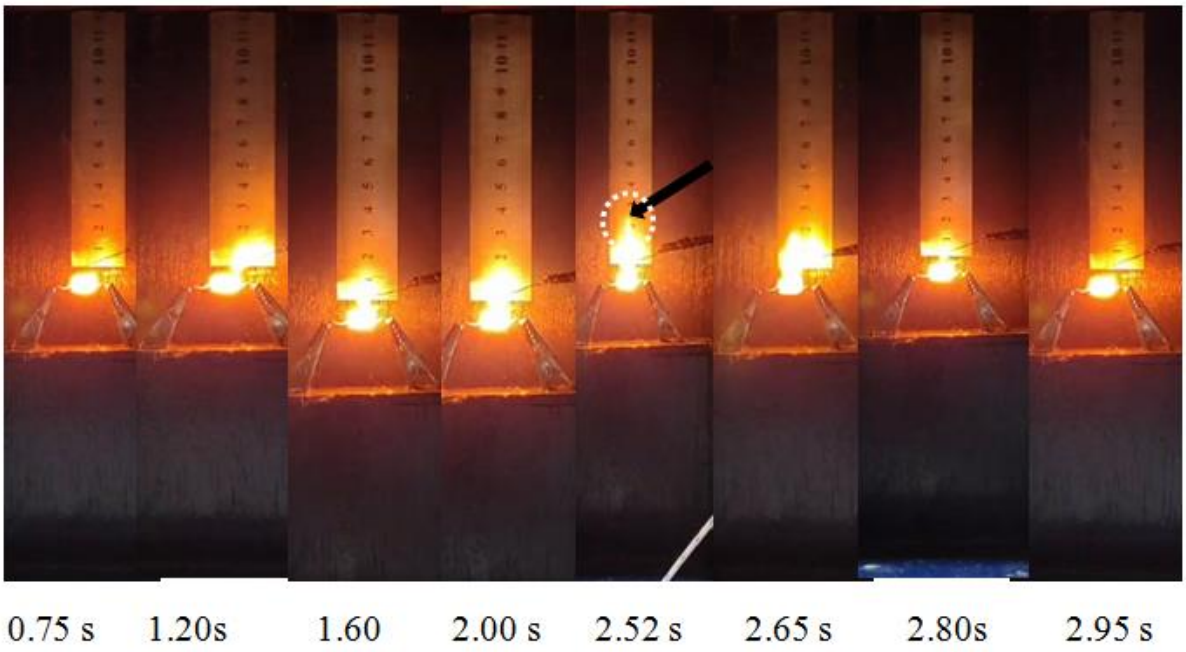

Figure 10. Visualization of Flame Percentage of 30% Methanol Mixture

Figure 10 shows that a mixture of rubber seed oil + methanol with a percentage of 30% takes 2.52 s to reach the maximum height with a fire height of 28.6 mm, and the dominant colour of the fire is yellow; after reaching the maximum height, the fire gradually decreases until it is extinguished at 2.95 s.

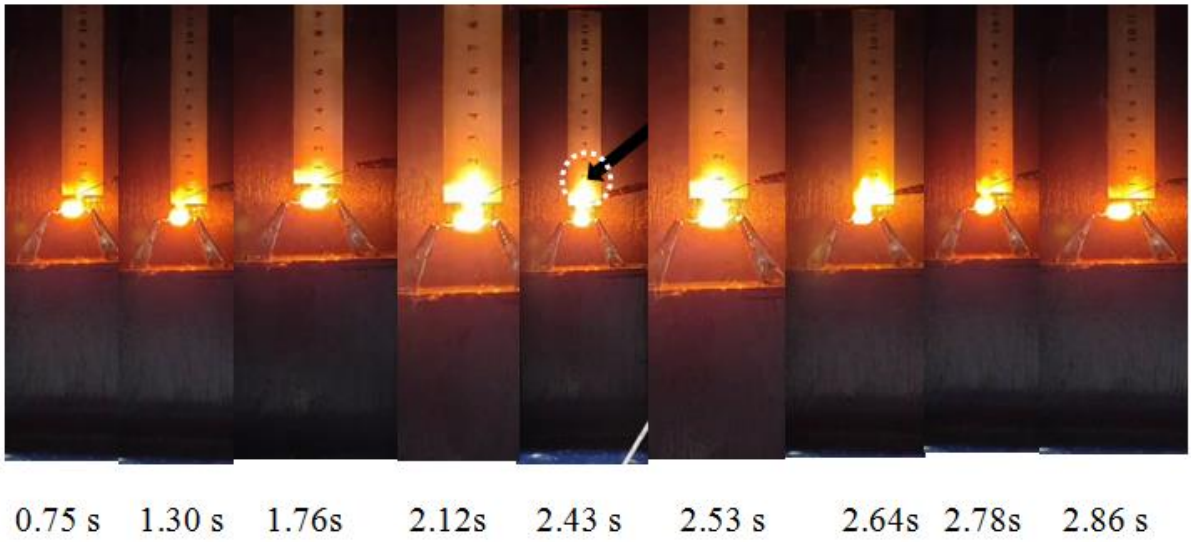

Figure 11 Visualization of Flame Percentage of 40% Methanol Mixture

Figure 11 shows that a mixture of rubber seed oil + methanol with a percentage of 40% takes 2.43 s to reach the maximum height with a fire height of 25 mm, and the dominant colour of the fire is yellow after reaching the maximum height, the fire gradually decreases until it is extinguished over time 2.86s.

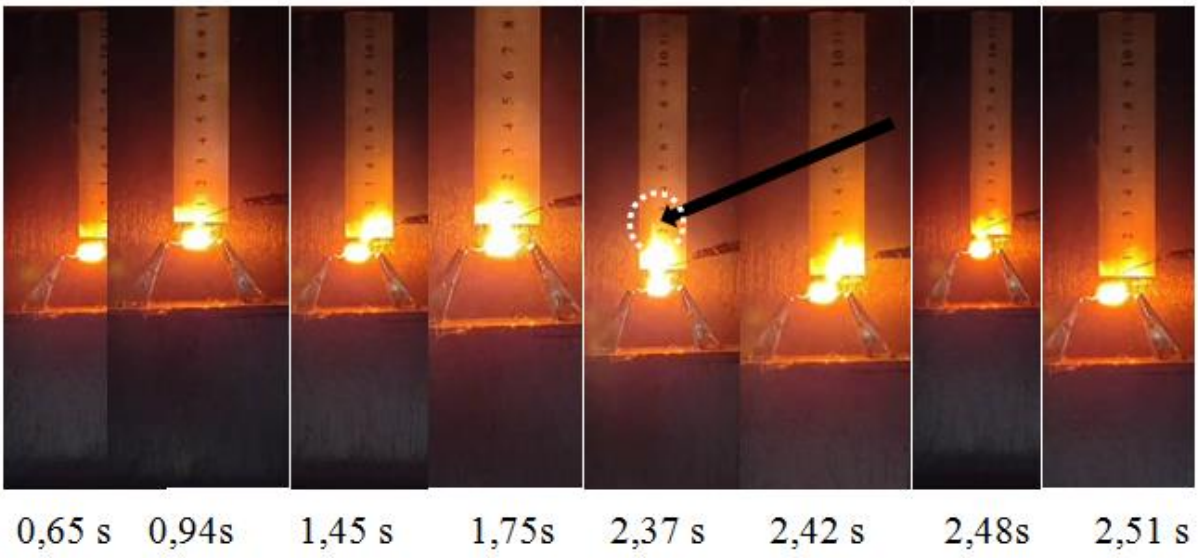

Figure 12 Visualization of Flame Percentage of Methanol Mixture 50%

Figure 12 shows that a mixture of rubber seed oil + methanol with a percentage of 50% takes 2.37 s to reach the maximum height with a flame height of 23 mm, and the dominant colour of the fire is yellow after reaching the maximum height, the fire gradually decreases until it goes out in time 2.51 s.

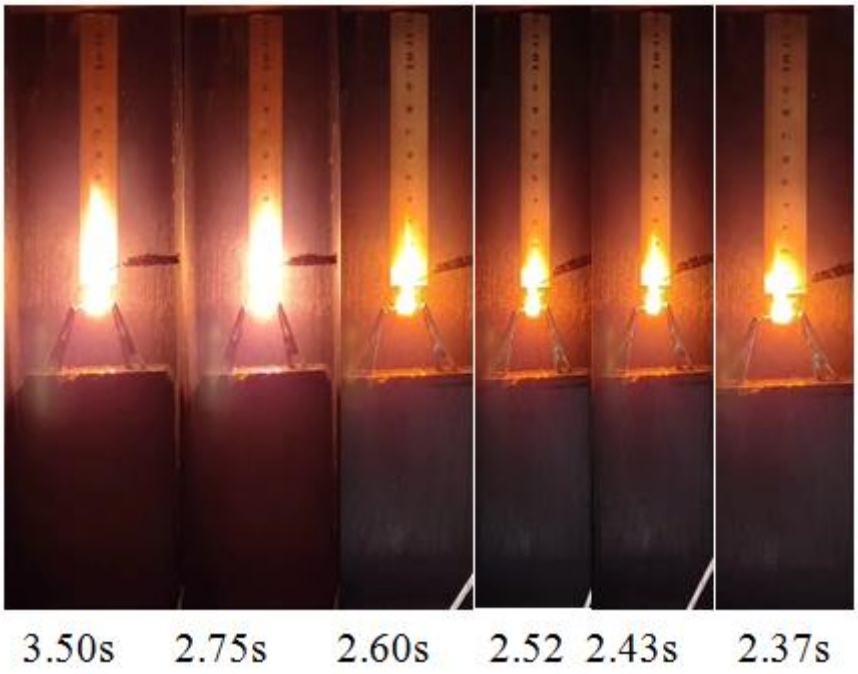

Figure 13. Comparison of Maximum Fire Height in Each Mixture With Percentages of 0%, 10%, 20%, 30%, 40%, and 50%

From figure 13, it can be seen that the mixture of rubber seed oil + methanol has a different flame duration and time to reach the maximum height. The value of the longest flame time is indicated by a mixture of 0% methanol with a value of 4.10 s, and the fastest is indicated by a mixture of 50%, which is 2.51 s. For fuel with a percentage of 50% to reach the maximum fire height, it takes a faster time than fuel with other percentages; this is due to the burning rate with a percentage of 0% lower than the

percentage of other mixtures. In the condition of the fire colour of the fuel with a percentage of 0% to 50%, the colour of the fire resulting from burning is predominantly yellow.

4. Conclusions

The more methanol mixture in rubber seed oil, the more flashpoint value decreased; this was due to the flammable nature of methanol because it had a low flash point value where the flashpoint value of methanol itself was 11ºC. With the increasing percentage of the methanol mixture, the Ignition delay time value decreased because the flashpoint value of methanol was smaller than rubber seed oil; the lower the flash point value, the faster the combustion. The higher the percentage of the mixture of methanol to rubber seed oil, the higher the resulting burning rate; this is because the oxygen content in methanol can accelerate the combustion reaction; the addition of methanol will increase the oxygen concentration in the fuel. The results of the high flame test increase the percentage of the rubber seed oil + methanol mixture; the lower the flame is because the methanol mixture increases the rate of the combustion reaction, the reaction rate affects the flame time and flame height.

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