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Analysis of the Effect of Air Flow Rate and Waste Cooking Oil on Furnace Efficiency

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ABSTRACT: Using waste cooking oil (WCO) as an alternative fuel can reduce dependence on fossil fuels and address the problem of waste oil. This study aims to analyze the effect of variations in air flow rate and WCO on the combustion characteristics and efficiency furnace. The combustion process was carried out by varying the fuel and airflow rates of the furnace. The experiments included measuring the flame temperature, boiling water tests, and measuring the efficiency of heat absorption by water in the pan. The results showed that the highest combustion temperature of 925.55℃ was achieved at an airflow rate of 10.5 m^3/hour with a fuel flow rate of 10.5 x 10^{-4} m^3/hour. This comparison also produced the fastest water boiling time of 2 minutes with a heat absorption efficiency by water in the pan of 33.37%. The highest heat absorption efficiency by water in the pan was obtained at a fuel flow rate of 6 x 10^{-4} m^3/hour with an airflow rate of 6 m^3/hour of 42.14%. These results demonstrate the potential of WCO as an alternative fuel for efficient household combustion appliances, with the right air supply to achieve optimal combustion.

Keywords: waste cooking oil; fuel flow rate; airflow rate; combustion temperature; efficiency

1. Introduction

The rapid advancement of economic globalization, population growth, and industrialization has led to a surge in fossil fuel consumption, resulting in increased energy demand (Goh et al., 2020). This has prompted governments and researchers worldwide to seek alternative energy sources that consider sustainable and environmentally friendly principles (Mahfouz et al., 2020). A promising solution currently to replace fossil fuels is biofuel; however, the mass production of bioenergy crops driven by rising energy needs often sacrifices food crops, leading to threats to food security and skyrocketing harvest prices (Jaya et al., 2021; Zhao et al., 2020). Waste cooking oil (WCO) can reduce this risk due to its high potential yield and low-cost supply (Alabi et al., 2024). WCO is oil that has been used two times or more and is no longer suitable for reuse because it can impact health (Jaya et al., 2022; Setyawan et al., 2021). WCO is produced in large quantities by households, restaurants, and industries daily (Permadi et al., 2022; Susilawati et al., 2020). WCO production in Indonesia reaches 416.36 million kiloliters per year (Al Qory et al., 2021). WCO has an energy content of 41.8 MJ/kg, comparable to that of fuel oil at 43 MJ/kg (Capuano et al., 2017). With such a large quantity, WCO has the potential to be used as an alternative fuel due to its high energy content and its ability to address waste management issues (Zhao et al., 2020).

The current methods of utilizing WCO are biodiesel conversion through transesterification, distillation, pyrolysis, and micro-emulsification (Rajak et al., 2019). Many studies have been conducted on biodiesel production and combustion over the past two decades. However, it should be noted that the high costs of complex physical-chemical treatments are also a major barrier to the commercialization of biodiesel in households, especially in rural households with low incomes. In addition, the biodiesel conversion process is often influenced by reaction temperature, time, and catalysts (Jaya et al., 2020; Zhao et al., 2020). Therefore, from an economic, energetic, and environmental perspective, the direct burning of WCO in rural households will be a better option, which only requires simple and inexpensive mechanical processing (Capuano et al., 2017). Directly using WCO as fuel will reduce harmful gas emissions such as SOx because it contains no sulfur (Arita et al., 2022; Jaya & Soegondo, 2016). Table 1 compares the content of fresh cooking oil and WCO.

The combustion process occurs when the following conditions are met: (1) Fuel, (2) Activation energy or heat, and (3) Air or oxygen (Kurniawan et al., 2021). Thus, the use of WCO as fuel requires a supply of air. This must be considered in the combustion process because air reacts with the fuel as an oxidizer, leading to complete combustion

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(Idris et al., 2024; Junaidi et al., 2021). In complete combustion, the compounds in the fuel react with air and produce fuel elements such as CO_2 and H_2O (Kurniawan et al., 2021; Prasetyo et al., 2024). To achieve perfect combustion, air flow rate control is carried out to ensure the total air supply is at a level that allows fuel combustion to take place optimally and thoroughly. (Panggabean et al., 2023). If there is a lack of air supply during combustion, it will result in the formation of emissions that are harmful to health when inhaled by humans, such as CO. This process is called incomplete combustion (Idris et al., 2024; Jasmine & Hermana, 2020).

Table 1. Comparison of the content of fresh cooking oil and WCO (Hutasoit & Hartutik, 2022).

No	Compound	Chemical Formula	Molecular Weight (g/mol)	Fresh Cooking Oil (wt%)	WCO (%wt)
1.	*Cis-9-Octadecanoate*	$C_{18}H_{34}O_2$	282.5	45.16	43.2
2.	*Methyl Palmitate*	$C_{16}H_{32}O_2$	256.4	-	25.45
3.	*Methyl Palmitoleate*	$C_{17}H_{32}O_2$	268.4	37.79	13.28
4.	*Linolelaidic Acid*	$C_{18}H_{32}O_2$	280.4	10.82	11
5.	*Methyl Stearate*	$C_{19}H_{38}O_2$	298.5	-	2.44
6.	*Elaidic Acid*	$C_{18}H_{34}O_2$	282.5	3.13	-
7.	*Methyl Myristate*	$C_{15}H_{30}O_2$	242.4	1.45	1.25
8.	*Cis-13,16-Docosadienoic Acid Methyl ester*	$C_{23}H_{42}O_2$	350.6	0.53	-
9.	*Methyl Linolenate*	$C_{19}H_{32}O_2$	292.5	0.37	0.35
10.	*Methyl Laurate*	$C_{13}H_{26}O_2$	214.3	0.2	0.35
11.	*Gamma-Linolenic Acid*	$C_{18}H_{30}O_2$	278.4	0.2	0.33
12.	*Methyl Erucate*	$C_{23}H_{44}O_2$	352.6	-	0.3
13.	*Methyl Arachidate*	$C_{21}H_{42}O_2$	326.6	0.19	0.2
14.	*Methyl Linoleate*	$C_{19}H_{34}O_2$	294.5	0.15	0.15

Several studies have been conducted to understand the mechanisms and characteristics of combustion. In the study by Mahardhika et al., (2020), which used the spray method for burning WCO under maximum operating conditions with a fuel flow rate of 4.8×10^{-7} m³/s and an airflow rate of 2 m/s, a temperature of 784.6°C was achieved. This research indicates that an increase in air velocity affects the temperature rise, and the length of the flame, and accelerates the combustion time. Additionally, a higher fuel flow rate influences the increase in temperature and flame length but does not affect the combustion time. Similarly, the study conducted by Mahfouz et al., (2020), using WCO fuel, states that air pressure affects combustion temperature. At a pressure of 2 bar, the combustion temperature rises to 700°C. In contrast, with the air pressure at 1 bar, the combustion temperature drops to 500°C. Meanwhile, in the study by Sukri et al., (2021), which analyzes the flame height of combustion using WCO biodiesel, it is noted that the fuel pressure affects the fuel flow rate, leading to a wider contact with air, thus resulting in a higher flame produced. The results of this study at a pressure of 5 bar produced a temperature of 664.2 °C.

Based on previous research that has been conducted, the combustion of WCO by varying the airflow rate and the fuel flow rate has rarely discussed the efficiency of household domestic stoves. Therefore, this study was conducted to analyze the effect of variations in air and fuel flow rates on combustion characteristics in household stoves, which are reviewed from the combustion flame temperature, exhaust gas emission temperature, and heat absorption efficiency by water in a pan using the water boiling test (WBT) method. This method is useful for determining how long it takes to boil a certain amount of water and how much heat can be absorbed by the water per unit of time. The furnace used in this research is specially designed, where the fuel directly enters the combustion chamber. It is hoped that the research on the direct burning of WCO in households will provide useful theoretical guidelines for promoting the utilization of WCO in the future for household combustion devices to reduce the use of fossil fuels.

2. Materials and Methods

2.1. Research materials and tools

The raw materials used in this research are waste cooking oil obtained from residents around Kotagede, Yogyakarta, and water obtained from Mrs Diah's water well in Kotagede, Yogyakarta. This research uses a series of tools as shown in Figure 1. Including a furnace, fuel tank, faucet, blower, blower speed controller, fuel pipe, air pipe, thermocouple type K, anemometer, pan, pycnometer, Oswald viscometer, digital scales, and bomb calorimeter.

2.2. Procedures

Before the combustion process is carried out, the material characteristics are first assessed, which include density testing using a pycnometer, viscosity testing using an Ostwald viscometer, flash point testing, and calorific value testing using a bomb calorimeter. As shown in Figure 1, the combustion process begins with 500 ml of WCO being placed into the fuel storage tank. Next, the fuel is channeled through pipes to the combustion furnace. After that, air is supplied to the combustion furnace using a blower. Before carrying out the combustion process in the furnace, initial data collection is carried out, namely the air flow rate (m^3/hour) and the fuel flow rate (m^3/hour). Next, the pan is filled with 1 kg of water to measure the heat that can be extracted during the combustion process. Then, the combustion process begins by lighting tissue as a starter for the fuel in the furnace. The heat generated will be used to warm water in a boiling water test conducted for 8 minutes, with measurements taken every minute and recording the flame temperature every 10 seconds for 2 minutes. After the combustion process is complete, the water will be weighed again to determine the remaining amount. The experiment was repeated with variations in airflow rates starting from 2.9 m^3/hour, 4.4 m^3/hour, 6 m^3/hour, 7.5 m^3/hour, 8.9 m^3/hour, 10.5 m^3/hour, to 12.2 m^3/hour, and fuel flow rates starting from 6 x 10^{-4} m^3/hour, 7.5 x 10^{-4} m^3/hour, 9 x 10^{-4} m^3/hour and 10.5 x 10^{-4} m^3/hour.

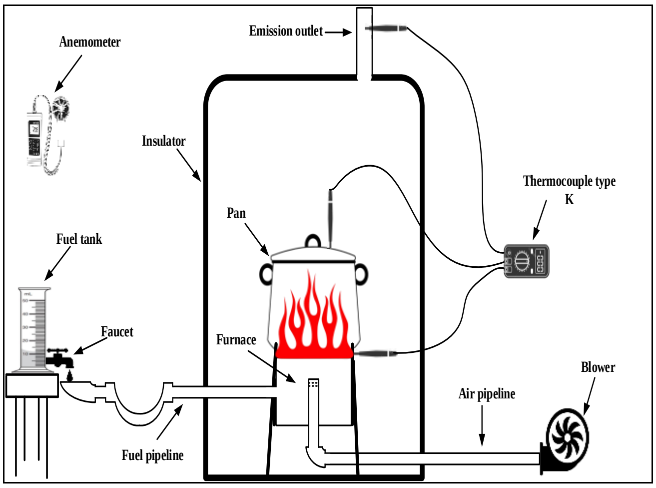

Figure 1. Schematic diagram of the equipment used in the experiment of combustion WCO.

3. Results and Discussion

3.1. Characteristics of WCO

The results from Table 2 show the characteristics of WCO. The density of this WCO is 864.5 kg/m³, which is slightly lower than that of fresh cooking oil, which is 900 kg/m³ (Rohim et al., 2023). The decrease in density is caused by thermal degradation that occurs when oil is repeatedly heated during cooking. Heating at high temperatures causes oxidation, hydrolysis, and polymerization reactions in fats, resulting in changes in chemical composition (Hutasoit & Hartutik, 2022). As seen in Table 1, the compounds in the new cooking oil experienced a decrease after use; for example, methyl palmitoleate dropped from 37.79% to 13.28%.

Table 2. Main characteristics of WCO.

Parameters	Value
Density (kg/m^3)	864.5
Flashpoint (°C)	307
Water content (%)	0.2
Calorific value (MJ/kg)	39.7

The flash point of WCO is 307°C, which is the temperature at which the oil begins to release vapors that can ignite when exposed to a heat source. This value is significantly lower compared to the flash point from the study conducted by Suhartono et al., (2018), which is 460°C. WCO has experienced degradation due to repeated exposure to heat and contact with air during the frying process. This thermal degradation causes chemical changes, such as oxidation and the formation of polymer compounds, free fatty acids, and other more volatile decomposition products. These volatile compounds evaporate at lower temperatures compared to fresh cooking oil, thereby lowering the overall flash point.

The water content in WCO is 0.2%, which is relatively low but important to note. Water can enter the WCO through the water vapor released by fried food or from the environment. The presence of water in WCO can accelerate the hydrolysis reaction, leading to the formation of free fatty acids and speeding up the degradation process of oil (Mardiah et al., 2019).

The calorific value of WCO in this study is 39.7 MJ/kg, which is slightly lower than that of fresh cooking oil at 40.5 MJ/kg (Alabi et al., 2024). The decrease in calorific value in WCO occurs due to the degradation of the compounds that make up the oil, particularly triglycerides, which form oxidation products and free fatty acids. However, the calorific value of WCO is still quite high, making it suitable as an alternative energy source (Febriani et al., 2024).

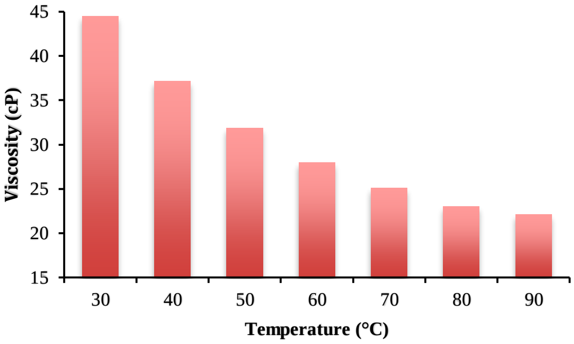

Figure 2. The effect of temperature (°C) on the viscosity (cP) of WCO.

The change in viscosity as a function of temperature is shown in Figure 2. It can be seen that the viscosity of WCO decreases with an increase in temperature. In this study, the temperatures used ranged from 30°C to 90°C to observe their effect on viscosity. The highest viscosity of 44.497 cP occurs at a temperature of 30°C, while at 90°C, the lowest viscosity of 22.1233 cP is recorded. This decrease in viscosity is due to the general properties of liquids, where an increase in temperature leads to a decrease in viscosity. As the temperature rises, the molecules in the oil move faster, causing the intermolecular forces to weaken, making the oil flow more easily (Alabi et al., 2024). According to a study conducted by Sutiah et al., (2014), fresh cooking oil has a viscosity of 39.8 cP at a temperature of 40°C, while WCO at the same temperature in this research has a viscosity of approximately 37.1836 cP. The decrease in viscosity is caused by various chemical processes that occur during the use of the oil. WCO undergoes thermal degradation, where large oil molecules break down into smaller and more fluid components, resulting in a viscosity that may be slightly lower than that of new cooking oil that has not been exposed to heat and oxidation (Rohim et al., 2023).

3.2. Effect of Flow Rate of Air (m^3/hour) with WCO (m^3/hour) on Flame Temperature (°C).

Flow rate of air and WCO can affect the resulting flame temperature as seen in Figure 3. At a fuel flow rate of 6 x 10^{-4} m^3/hour and an airflow rate of 6 m^3/hour, or a mol/mol ratio of fuel to air of 0.0079, the maximum combustion temperature reaches 728.5°C. Then, at a fuel flow rate of 7.5 x 10^{-4} m^3/hour, the highest combustion temperature occurs at an airflow rate of 7.5 m^3/hour with 803.35°C and a mol/mol ratio of 0.0078. At a fuel flow rate of 9 x 10^{-4} m^3/hour and an airflow rate of 8.9 m^3/hour with a mol/mol ratio of 0.0079, the highest combustion temperature reaches 866.4°C. Furthermore, at a fuel flow rate of 10.5 x 10^{-4} m^3/hour, the maximum combustion temperature at an airflow rate of 10.5 m^3/hour is 925.55°C with a mol/mol ratio of 0.0078. So the average mol/mol ratio between fuel and air to achieve the maximum combustion temperature is 0.0079. When the ratio of fuel to air reaches the correct ratio, complete combustion will occur, resulting in the most optimal combustion temperature. After exceeding that ratio, the combustion temperature tends to decrease as the airflow rate increases. This happens because the heat from combustion is used to warm excess air.

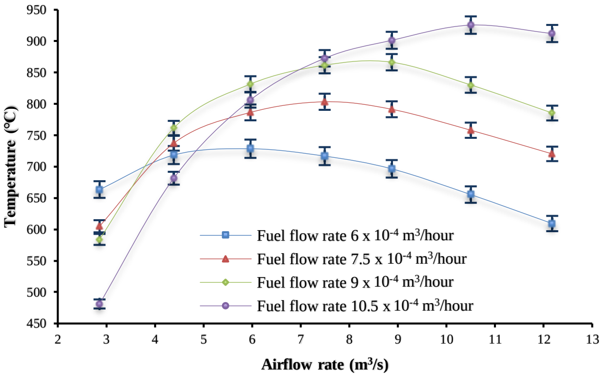

Figure 3. Effect of flow rate of air (m^3/hour) vs WCO (m^3/hour) on flame temperature (°C).

The maximum temperature based on Figure 3 occurs at an airflow rate of 10.5 m^3/hour with a fuel flow rate of 10.5 x 10^{-4} m^3/hour, resulting in a combustion temperature of 925.55°C. This temperature is significantly higher compared to the research conducted by Mahardhika et al., (2020), which produced a temperature of 784.6°C using the same fuel. The maximum temperature was achieved because this ratio allows for more fuel to burn with a sufficient supply of oxygen for complete combustion. The minimum combustion temperature is 418.15°C, occurring at a fuel flow rate of 10.5 x 10^{-4} m^3/hour with an airflow rate of 2.9 m^3/hour. The cause of this occurrence is due to the oxygen supply being too low for the fuel flow, resulting in insufficient oxygen to achieve complete and optimal combustion.

3.3 Effect of Flow Rate of Air (m^3/hour) with WCO (m^3/hour) on Exhaust Gas Emission Temperature (°C).

Based on Figure 4, it can be seen that as the fuel flow rate and airflow rate increase, the temperature of the exhaust gas emissions will also rise; this is a direct correlation that experiences an increase. A higher fuel debit means more fuel is burned, which generates greater thermal energy. As a result, the exhaust gas temperature increases because more heat is released during combustion. For example, at an airflow rate of 10.5 m^3/hour with a fuel flow rate of 10.5 x 10^{-4} m^3/hour, the emission temperature reaches 308.8°C, indicating that this combination produces very hot combustion. However, if the fuel flow rate increases too high without sufficient oxygen addition, incomplete combustion may occur, leading to inefficient emissions and relatively lower exhaust gas emission temperatures. For instance, at a fuel flow rate of 10.5 x 10^{-4} m^3/hour with an airflow rate of 2.9 m^3/hour, the resulting emission temperature is 158°C. Meanwhile, if the airflow rate is very high, such as 12.2 m^3/hour, the exhaust gas emission temperature begins to decrease compared to the peak emission temperature (for example, at an airflow rate of 10.5 m^3/hour), especially at lower fuel flow rates. This happens because the exhaust gases disperse more quickly, resulting in reduced heating time.

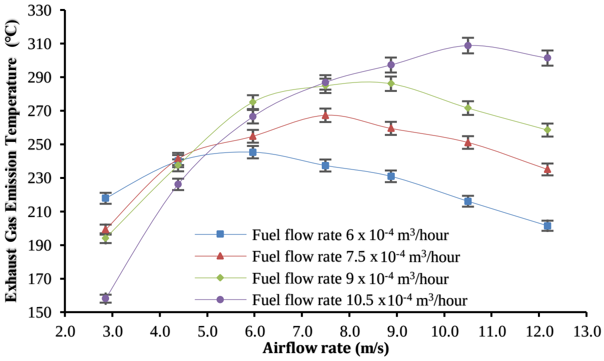

Figure 4. Effect of flow rate of air (m^3/hour) vs WCO (m^3/hour) on exhaust gas emission temperature (°C).

3.4 Effect of Flow Rate of Air (m^3/hour) with WCO (m^3/hour) on Water Temperature (°C) and Cooking Time (minute)

Figure 5, shows that the increase in WCO flow rate accelerates the average time to reach the boiling point of water. At a fuel flow rate of 6 x 10^{-4} m^3/hour, the average time to reach the boiling point of 1 kg of water is around 4-5 minutes. Meanwhile, the fastest time to reach the boiling point of 1 kg of water at the same flow rate, with an additional airflow rate of 6 m^3/hour, is about 4 minutes. The longest time to reach the boiling point of water is 6 minutes with an airflow rate of 12.2 m^3/hour. The reason for the boiling time of water is due to the excess supply of oxygen, which lowers the combustion temperature.

The average time to boil 1 kg of water at fuel flow rates of 7.5 x 10^{-4} m^3/hour, 9 x 10^{-4} m^3/hour, and 10.5 x 10^{-4} m^3/hour is around 3-4 minutes. The fastest time to reach the boiling point of water with a mass of 1 kg at fuel flow rates of 7.5 x 10^{-4} m^3/hour and 9 x 10^{-4} m^3/hour is 3 minutes, with an additional air supply of 7.5 m^3/hour and 8.9 m^3/hour, respectively. For a fuel flow rate of 10.5 x 10^{-4} m^3/hour, the fastest time to boil 1 kg of water is approximately 2 minutes with an additional air supply of 10.5 m^3/hour. Higher fuel debit tends to accelerate the boiling time of water because more heat is generated from combustion. However, after the flow reaches a certain point, the increase in airflow rate also plays a role in accelerating the heating process by providing a sufficient oxygen supply for complete combustion. Meanwhile, at an airflow rate of 2.9 m^3/hour with fuel flow rates of 7.5 x 10^{-4} m^3/hour, 9 x 10^{-4} m^3/hour, and 10.5 x 10^{-4} m^3/hour, the longest time to boil 1 kg of water is approximately 6 minutes, 6 minutes, and 7 minutes, respectively. The reason for this is the high fuel supply rate while the added air is minimal, resulting in incomplete combustion that leads to less effective heat generation.

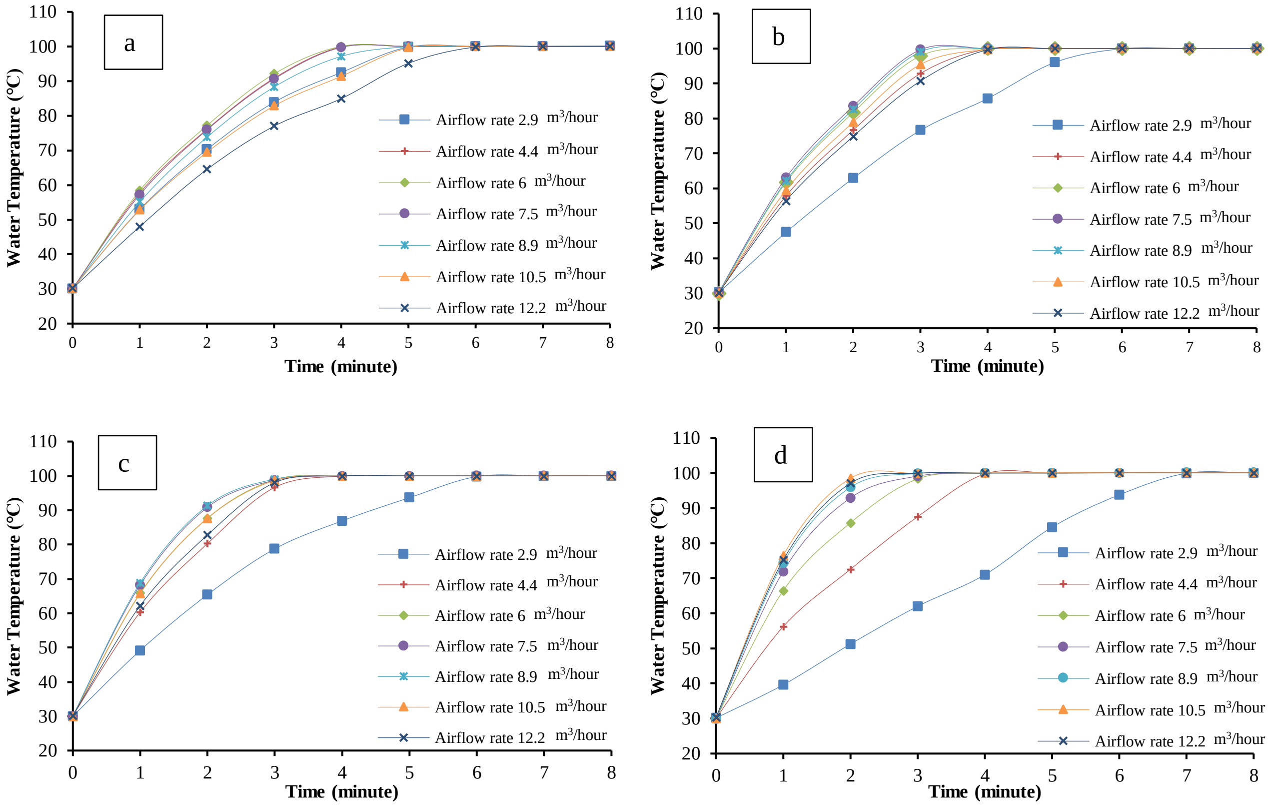

Figure 5. Effect of flow rate of air (m^3/hour) vs WCO (m^3/hour) on water temperature (℃) and cooking time (minute). a) WCO Flow Rate 6 x 10^{-4} m^3/hour, b) WCO Flow Rate 7.5 x 10^{-4} m^3/hour, c) WCO Flow Rate 9 x 10^{-4} m^3/hour, d) WCO Flow Rate 10.5 x 10^{-4} m^3/hour

Based on Figure 5, it shows several points exceeding the normal boiling point of water. For example, at a WCO flow rate of 10.5 x 10^{-4} m^3/hour with an airflow rate of 10.5 m^3/hour, the final water temperature is 100.2℃ with the same cooking time of 8 minutes. The increase in the boiling point of water above 100℃ is due to the well water used. According to Singkam et al., (2021), well water contains dissolved minerals such as calcium, magnesium, and other salts that affect the molecular structure of water. These minerals disrupt the hydrogen bonds between water molecules, requiring higher heat energy to reach the vapor phase. The higher the concentration of dissolved minerals, the higher the temperature required to boil water, depending on the composition and chemical characteristics of the well water used.

3.5 Effect of Flow Rate of Air (m^3/hour) with WCO (m^3/hour) on the Efficiency of Heat Absorption by Water in a Pan (%)

The efficiency of heat absorption by water in a pan using WCO as fuel on a furnace can be determined using WBT by transferring thermal energy from combustion to boiling water. Here is the equation to calculate the efficiency of combustion WCO in a furnace:

$$\eta = \frac{((M_{w1} \times C_{pw} (T_{w2} - T_{w1})) + (M_{w2} \times \lambda))}{(M_f \times C_{vf})} \tag{1}$$

Remarks:

- η is efficiency (%)
- M_{w1} is initial mass of water (kg/hour)
- C_{pw} is heat capacity of water (kJ/kg.K)
- Tw_1 is the initial temperature of water (K)
- Tw_2 is the final temperature of water (K)
- M_{w2} is mass of water that evaporates (kg/hour)
- λ is latent heat of water (kJ/kmol)
- M_f is mass flow rate of fuel (kg/hour)
- C_{vf} is the calorific value of fuel (kJ/kg)

Figure 6 shows the efficiency values measured for the tested fuel at various airflow rates and fuel flow rates. The graph for a fuel flow rate of 6 x 10^{-4} m^3/hour shows the highest efficiency among the flow rates of 7.5 x 10^{-4} m^3/hour, 9 x 10^{-4} m^3/hour and 10.5 x 10^{-4} m^3/hour, achieving an efficiency of 42.14% at an airflow rate of 6 m^3/hour. At a flow rate of 7.5 x 10^{-4} m^3/hour, the maximum efficiency is reached with an airflow rate of 7.5 m^3/hour, resulting in a heat absorption efficiency of 36.74% by the water in the pan. Next, at a flow rate of 9 x 10^{-4} m^3/hour with an airflow rate of 8.9 m^3/hour, the heat absorption efficiency by the water in the pan is 34.54%. Meanwhile, the maximum efficiency of WCO combustion at a flow rate of 10.5 x 10^{-4} m^3/hour is 33.37% at an airflow rate of 10.5 m^3/hour. From the data, it is evident that the efficiency of heat absorption by water in the pan decreases as the fuel flow rate increases. As the fuel flow rate increases, more potential energy is contained in the fuel. However, with a higher air rate, some heat is lost due to the increased volume of combustion gases. A greater airflow rate does indeed provide more oxygen, but at a certain point, efficiency begins to decline due to the system's inability to optimize the combustion of the increased fuel.

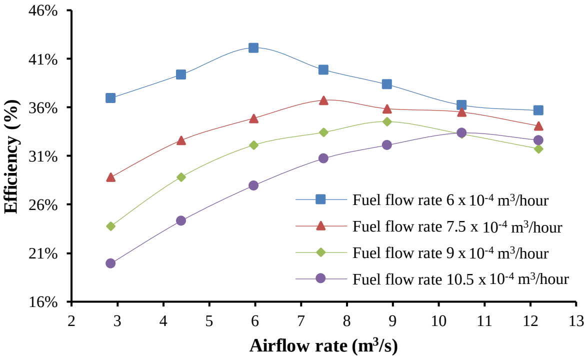

Figure 6. Effect of flow rate of air (m^3/hour) vs WCO (m^3/hour) on the efficiency of heat absorption by water in a pan (%)

In this study, the efficiency of heat absorption by water in the pan is a maximum of 42.14%. This efficiency is significantly higher than the efficiency obtained in the research by Suhartono et al., (2018), which was 23.65%. Various factors cause a decrease in efficiency when using WCO, including the amount of air added to the fuel, the water and dirt content in the WCO, the surface area of combustion heat contact, the physical and chemical properties of the fuel, and operational conditions. To maximize the efficiency of heat absorption by water in the pan using used cooking oil as fuel, it is crucial to optimize the airflow rate, maintain adequate combustion temperature, ensure good fuel atomization for complete combustion, and provide maximum combustion heat contact area. The presence of impurities and water in WCO also needs to be controlled to avoid reducing the quality of combustion.

4. Conclusions

WCO has the potential to serve as an alternative fuel with viable characteristics, although there are some differences compared to fossil fuels. WCO shows a decrease in density, an increase in flash point and viscosity, as well as a decrease in calorific value due to chemical degradation during repeated heating. The density and viscosity of WCO at a temperature of 30°C are 864.5 kg/m³ and 44.497 cP, respectively. The flash point of WCO is 307°C, while its calorific value is 39.7 MJ/kg. The combustion results indicate that the fuel flow rate and airflow rate significantly affect the combustion temperature and exhaust gas emission temperature. The highest combustion temperature was achieved at a WCO flow rate of 10.5 x 10^{-4} m^3/hour and an airflow rate of 10.5 m^3/hour, with a combustion temperature of 925.55°C, while the exhaust gas emission temperature reached 308.8°C at the same fuel and airflow rate. Then, in terms of the fastest time needed to boil 1 kg of water, it takes about 2 minutes with a fuel flow rate of 10.5 x 10^{-4} m^3/hour and an airflow rate of 10.5 m^3/hour. Meanwhile, the longest time to boil the same amount of water is around 7 minutes with a fuel flow rate of 10.5 x 10^{-4} m^3/hour and an airflow rate of 2.9 m^3/hour. In terms of the efficiency of heat absorption by the water in the pan, a lower fuel flow rate with an optimal airflow rate provides higher efficiency, with a maximum efficiency of 42.14% at a WCO flow rate of 6 x 10^{-4} m^3/hour and an airflow rate of 6 m^3/hour.

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Statement

At the time of writing this work, the author used Google Translate to improve their English. After using the service, the writer reviews and edits the content and takes full responsibility for the published material.

Credit authorship contribution statement

M. Idris: Writing – original draft, Resources, Visualization, Investigation, Conceptualization. **Martomo Setyawan:** Writing – review & editing, Visualization, Validation. **Totok Eka Suharto**: Conceptualization, Formal analysis.

Declaration of competing interest

In this article, the authors state that there are no personal relationships or financial interests that influence their work.

Data availability

The raw/processed data required to reproduce the above findings cannot be shared at this time due to legal/ ethical reasons.

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