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# Evaluation of diaper waste combustion efficiency in a steam-pressed oil waste stove-based incinerator with two air intakes

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**Abstract**
Waste such as used diapers remains a persistent environmental challenge that requires effective waste management solutions. This study aims to evaluate the performance and efficiency of an incinerator using diapers as the primary waste material. An incinerator can reduce waste volume and mass by converting it into ash. This experimental study using used oil and cooking oil as fuels for a steam-pressurized burner system. Variations in two-tiered air intakes are also used as a measure of evaluation of air velocity, which are 6 m/s, 8 m/s, and 10 m/s. The results demonstrates that for used oil fuel, average combustion temperatures of 376°C, 405°C, and 452°C were obtained at 6, 8, and 10 m/s, with combustion times of 97, 75, and 56 min, respectively. Residual ash masses were 1.01, 0.80, and 0.60 kg. For used cooking oil fuel, average temperatures reached 325°C, 354°C, and 387°C, with combustion times of 120, 107, and 86 min, respectively. Residual ash masses were 1.20, 1.08, and 0.85 kg. The results show that increasing air velocity significantly improved combustion temperature and reduced burning time for both fuels, while its effect on ash residue was less pronounced. Used oil produced higher combustion temperatures and faster waste reduction, whereas the highest thermal efficiency of 70% was achieved using used cooking oil at an air velocity of 10 m/s.

**Keywords:**
Incinerator, water steam stove, diaper, oil waste, two air intakes.

## 1 Introduction

Waste is a problem that humanity will continue to face. Garbage is waste from human activities that is worthless or useless and will pollute the environment [1]. The impact of environmental pollution from waste extends beyond the land; it can impact all aspects of life, from air and water pollution to waste, which can worsen and negatively impact human health [2-4].

Waste is inherently present at all times. This is because not all waste can decompose naturally quickly. It can sometimes take tens to thousands of years for waste to decompose naturally. Meanwhile, the amount of waste continues to increase daily due to the waste from the population's activities, which continues to increase annually [5-7]. This increase in population is directly proportional to the increase in waste volume, resulting in an imbalance between the amount of waste collected and the amount of waste that is successfully decomposed. This results in waste always being present at all times [8-9].

Waste is anything that is unused, unused, unloved, or discarded, resulting from human activities and does not occur naturally[10]. According to data from the National Waste Management Information System (SIPSN) in 2023, the amount of waste generated in East Java reached 10,000 tons/day, equivalent to 3.7 million tons/year [11]. Based on this data, the largest source of waste in East Java comes from household waste, at 60%. Therefore, household waste is one of the causes of the large amount of waste. There are several types of waste generated from household waste, including food waste and disposable waste such as Styrofoam, diapers, sanitary napkins, and others [12-13].

Diapers are a type of waste with a composition of more than one type of waste. The composition of diapers contains materials such as plastic, synthetic fibers, and absorbent substances. This is supported by research stating that 55% of the content in diapers is plastic, also stating that the absorbent properties of diapers are generally made from absorbent materials such as tissue, fluff, and pulp. Diapers have quite good characteristics, such as being waterproof or able to store water, having a fairly high absorbency, to their ability to isolate moisture from the skin. These materials support the diaper's ability to absorb and retain fluids from the body. In addition, diapers also contain chemicals such as polyacrylate granules, fiber, cellulose, and chemical fragrances such as polychlorine dibenzodioxins [14-16].

With so many different types of waste, the question is how to use the right method for waste management to reduce environmental pollution. One method that can be used for waste management is landfilling, which is carried out in a specific location. Generally, waste will go through a process of confinement and landfilling. This method is widely used by district/city governments because it is considered cheap and easy [17-19]. If waste is left to accumulate for 2 to 3 days, it will disturb the surrounding community due to the odor produced by the waste, so a solution is needed to handle waste accumulation using the incineration process. The incineration process has a shorter degradation period than open dumping, landfills, and composting. Waste management using the incineration process can reduce waste volume by up to 90%, while composting methods in landfills and open dumping can only reduce waste volume by 40% [20].

The process of burning waste in open spaces can result in uncontrolled combustion. Furthermore, the air produced by open burning of waste can endanger the health of people in the surrounding area, thus causing health and environmental problems. Analyzing open and uncontrolled waste burning, it is hoped that waste management can control the combustion process so that it does not cause health and environmental problems. Therefore, the use of incinerators in waste burning is necessary because incinerators can control the waste combustion process so that it does not cause health and environmental problems [21].

An incinerator is a device used to burn waste, whether in solid, liquid, or gaseous form. Incinerators can reduce the negative impacts of the combustion process, such as odor, smoke, radiation, and heat, by utilizing advanced combustion technology. Technological assistance in the incineration process can reduce the amount of waste dumped in large quantities and produce ash that is more easily decomposed by the soil.

An incinerator is a waste disposal device that has the least negative impact on the environment and is relatively inexpensive to maintain. Incinerators require significant energy consumption because the burners used in the combustion process are constantly running, requiring a large amount of fuel. Using large incinerators and burning large volumes of waste also requires significant energy resources, resulting in significant smoke accumulation. Therefore, small, household-scale incinerators are needed to reduce the amount of resources needed and the amount of smoke produced [22].

Based on the existing shortcomings of the incinerator, namely the need for additional oxygen in the zone that has not been fully burned, the gas resulting from the decomposition of waste with oxygen so that it accelerates oxidation, the importance of increasing turbulence, which accelerates gas mixing and increases contact between fuel gas and oxygen. Therefore, with compressed air, the combustion rate can be accelerated so that the time needed for the fuel to reach the ignition temperature, devolatization, and oxidation is shorter. This makes the incinerator combustion product be higher or more efficient.

This research is very innovative to develop because the combustion in the incinerator is closed, and the oxygen supply can be controlled, so it is not affected by the weather, reducing the formation of thick smoke, soot (particulate), and the pungent odor that generally occurs in open combustion. In addition, the incinerator allows the implementation of staged combustion (primary-secondary chamber) to break down the pyrolysis gas more thoroughly, thereby reducing harmful pollutant emissions and producing less and more controlled ash residue than conventional methods.

## 2 Research methods/ materials and methods

### 2.1 Materials

The waste oils used in this study were used motor oil and used cooking oil. The used oil was derived from motorcycles and cars, while the used cooking oil was obtained from fried foods. The characteristics of both wastes are shown in Table 1.

Table 1. Characteristics of waste oil and used cooking oil [29]

| Waste oil | Parameter | Value |
|---|---|---|
| Used oil | Density | 866 kg/m$^3$ |
| | Viscosity | 15.921 mm$^2$/s |
| | Calor value | 10038.24 kcal/kg |
| Used cooking oil | Density | 850 kg/m$^3$ |
| | Viscosity | 68.5 mm$^2$/s |
| | Calor value | 9799.24 kcal/kg |

Diapers are a type of waste with a composition of more than one type of waste. The composition of diapers contains materials such as plastic, synthetic fibers and absorbent substances. This is supported by research [24] which states that 55% of the content in diapers is plastic. Diapers consist of four layers: the top layer that comes into contact with the baby's skin is made of polypropylene; an acquisition layer made of cellulose and polyester; a diaper core containing a superabsorbent polymer gel that can store urine; and an outer layer made of polypropylene fabric that prevents leakage of fluids [25]. Table 2 is a table of diaper waste content.

Table 2. Diaper waste content [26-28]

| No | Composition | Waste | |
|---|---|---|---|
| | | Mass (kg) | % |
| 1 | Cellulose Fibre | 0.014 | 6.86 |
| 2 | Super Absorbent Polymer | 0.01 | 5.01 |
| 3 | Low-Density Polyethylene | 0.001 | 0.72 |
| 4 | Polypropylene | 0.006 | 3.14 |
| 5 | Adhesive | 0.001 | 0.48 |
| 6 | Faeces | 0.01 | 4.9 |
| 7 | Urine | 0.161 | 78.9 |
| | Total | 0.204 | 100 |

### 2.2 Method

Experimental research was conducted to assess the performance of a running incinerator. Diaper waste was fed into the incinerator using varying forced convection with two levels of air flow. The goal was to determine the incinerator's efficiency in reducing diaper waste. Experimental testing was also useful for assessing the incinerator's performance, with outputs including combustion temperature, combustion duration, and ash residue. This incinerator test used oil and cooking oil as fuel for the stove.

The fuel variations used were used oil and used cooking oil, while the air flow variations used air flow rates of 6 m/s, 8 m/s, and 10 m/s. The air flow was determined according to the calculation of the air flow required in the stoichiometric AFR, which resulted in 7.6 m/s. The equation used to obtain the ideal speed value for burning diapers is:

$$AFR_{stoic} = \frac{\dot{m}_{air}}{\dot{m}_{fuel}} \tag{1}$$

Stoichiometric AFR data on diapers were chemically tested to determine their content values, so that carbon and hydrogen values became the reference for calculating stoichiometric AFR. Meanwhile, the fuel mass rate (diapers) was calculated using the following equation:

$$\dot{m}_{fuel} = \frac{m_{fuel}}{t} \left[\frac{kg}{s}\right] \tag{2}$$

After that, find the ideal air speed value using the following equation:

$$V_{air} = \frac{\dot{m}_{air}}{\rho_{air}.A} \left[\frac{m}{s}\right] \tag{3}$$

The addition of varying air flow rates in this study was carried out using two blowers. The addition of two blowers aims to provide sufficient air supply for the combustion process, because the characteristics of the solid fuels used in incinerators each require the same air supply in different placements. The first blower serves to supply air to the left side of the incinerator, while the second blower supplies air to the right side of the incinerator. Thus, increasing the air flow rate through these two blowers is expected to accelerate the combustion process in the incinerator.

The application of the research implementation flow is depicted in Fig. 1.

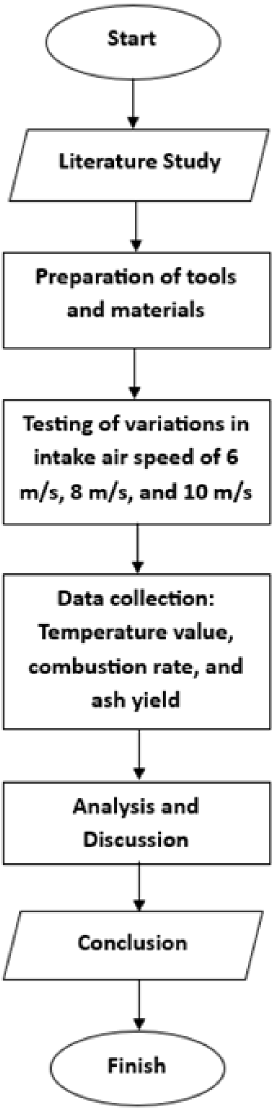


**Fig. 1**. Research flowchart

Table 3. Desain of experiment

| Parameter | Used Oil | | | Used Cooking Oil | | |
|---|---|---|---|---|---|---|
| Air velocity | 6 m/s | 8 m/s | 10 m/s | 6 m/s | 8 m/s | 10 m/s |
| Diapers mass | 30 kg | | | | | |
| Fuel volume | 300 ml | | | | | |

The following are the stages in the research process.

1. Weighed diaper waste and placed it in the incinerator.
2. Insert the measured fuel into the stove.
3. Ignite and adjust the air flow according to the specified parameters.
4. Use a stopwatch to measure the duration of the combustion process.
5. Record the ambient temperature.
6. Read the combustion chamber temperature and record the temperature data periodically.
7. After combustion is complete, turn off the stopwatch and record the duration of the combustion process.
8. Weigh the mass of ash from the combustion process, then measure the remaining fuel volume (used oil and cooking oil).

### 2.2.1 Incinerator

An incinerator is a furnace or special device designed to process and reduce the volume of waste (solid, liquid, or gas) through high-temperature combustion. The incinerator used has the following specifications.

**a. Combustion reactor, Chimney, and Grate**

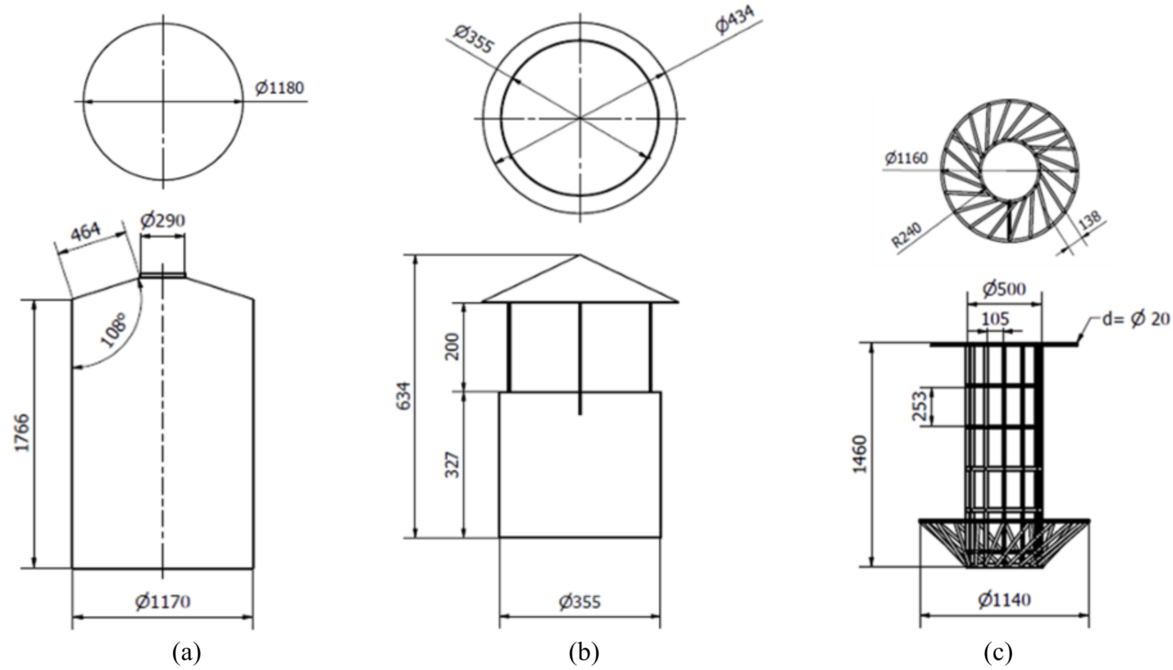


**Fig. 2**. (a) Combustion reactor, (b) Chimney, (c) Grate

**b. Incinerator design with two air inlets**

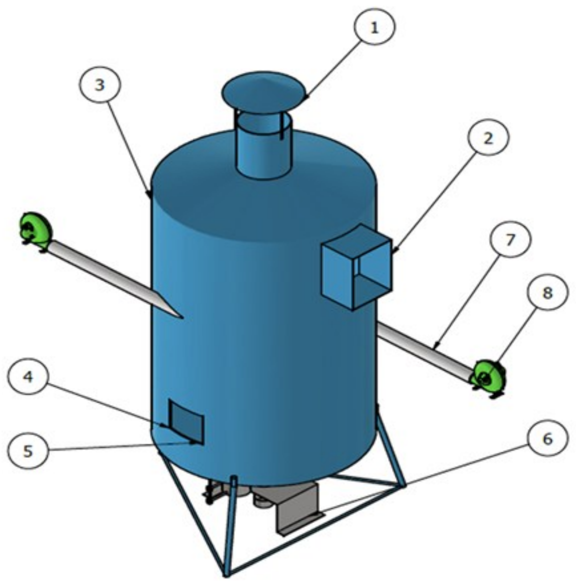


**Fig. 3**. Incinerator design with two air inlets

Table 4. Water steam stove specifications

| No. | Part Name | Material |
|---|---|---|
| 1 | Chimney | Iron |
| 2 | Garbage feeder | Iron |
| 3 | Incinerator | Iron |
| 4 | Ash extractor | Iron |
| 5 | Grate | Concrete Iron |
| 6 | Steam oil stove | Iron |
| 7 | Air inlet pipe | Galvanis |
| 8 | blower | Iron |

An incinerator works by burning in a closed cylindrical chamber, with forced air added using a blower in the oxidation and drying zones. The combustion process inside the incinerator allows for even combustion due to the vertical structure of the fuel furnace. The use of a steam-pressurized stove fueled by used oil and cooking oil can increase the incinerator's thermal efficiency.

The incinerator performance was tested to determine the combustion characteristics of diaper waste until it turns to ash. The temperature inside the incinerator can reach upwards of 450°C. This temperature can be further increased by increasing the air intake and adding thermal insulation to the cylinder walls to retain heat, thereby significantly increasing the diaper waste combustion rate. In the waste feeder section, flames can be seen rising up toward the chimney, demonstrating that combustion is evenly distributed throughout the combustion chamber [23].

**Fig. 4.** Diaper waste incinerator

### 2.2.2 Water Steam Stove

A steam-pressurized oil stove is an innovative stove often designed to utilize waste oil (such as used cooking oil or cooking oil) as fuel more efficiently and environmentally. Its working principle involves heating water to produce pressurized saturated steam, which is then circulated to aid the oil's combustion process. The resulting steam pressure serves to increase the intensity and quality of the flame, reduce thick smoke, and produce more complete combustion than waste-fueled stoves without a steam system, making it an effective alternative solution for energy savings and waste management. Information on the specifications of the steam stove can be explained in Table 5.

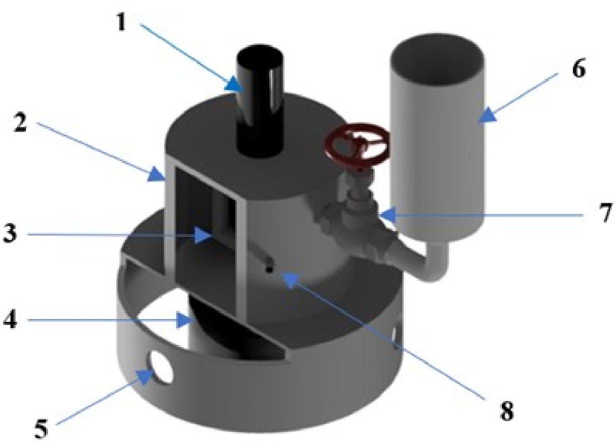


**Fig. 5**. Water steam stove parts

Table 5. Water steam stove specifications

| No. | Part Name | Material |
|---|---|---|
| 1 | Fire Funnel | Stainless Steel |
| 2 | Boiler | Iron |
| 3 | Nozzle | Stainless Steel |
| 4 | Fuel Tank | Iron |
| 5 | Air Intake Hole | Iron |
| 6 | Water Funnel | Iron |
| 7 | Stop Valve | Iron |
| 8 | Drainage Screw | Iron |

**Fig 6.** Water steam stove testing

### 2.2.3 Measurement of temperature values, combustion residue ash, and thermal efficiency

Temperature is the reaction produced by the heat during the combustion process, which involves the interaction of fuel and oxygen. Temperature is also a crucial parameter in determining combustion efficiency and performance. Temperature can be determined using a thermocouple, measured in Celsius (C).

The ash from the combustion process is used to determine the effectiveness of the incinerator's combustion process, or to determine how much waste the incinerator can reduce. The unit used to calculate and analyze ash from the combustion process is the kilogram (kg). The ash from the combustion process is weighed to determine the ash yield, which is then used to calculate the percentage ratio between the mass of the ash and the mass of the waste.

Thermal efficiency is a crucial parameter in determining the efficiency of a device. Thermal efficiency is used to determine the ratio of the output produced by a device (incinerator) to the input provided. Thermal efficiency is typically used to calculate heat. The equation used to calculate thermal efficiency in research is as follows [30-31].

$$\eta_{thermal} = \frac{Q_{out}}{Q_{in}} = \frac{m.Cp.\triangle T}{Vfuel.HVfuel.tm}.100\% \quad (4)$$

## 3 Result and discussion

### 3.1 Temperature value testing

Combustion temperature data collection in this study was conducted during the combustion process. The data collection process was carried out using variations in fuel and air velocity, with three repetitions for each variation. Combustion temperature was obtained by measuring the flame in the incinerator using a digital thermocouple, with the data collection process carried out using a test sensor placed into the burning incinerator. The data collection process was carried out every 5 minutes after the test began until the test was completed, then the highest results from each type of variation were identified. The following are the highest data results and the average value of the combustion temperature.

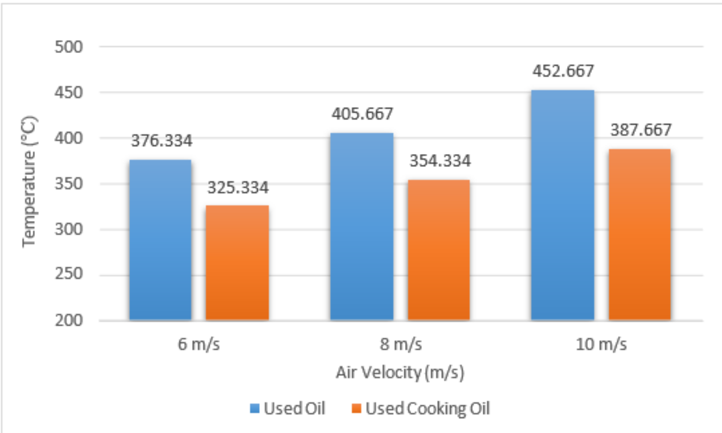


**Fig. 7.** Graph of temperature value against air inlet speed in the incinerator

In general, an increase in air speed (from 6 m/s to 10 m/s) causes an increase in combustion temperature in both types of fuel. This shows that a greater supply of air (oxygen) improves the combustion process, resulting in higher temperatures. At any air speed, the combustion temperature of used oil is always higher than that of used cooking oil.

- Air velocity at 6 m/s: 376.33°C vs 325.33°C
- Air velocity at 8 m/s: 405.67°C vs 354.33°C
- Air velocity at 10 m/s: 452.67°C vs 387.67°C

This difference can be caused by the energy (calorie) content of used oil being higher than used cooking oil, the carbon content in used oil is greater, so it can produce hotter combustion. Used cooking oil usually contains residual water, free fatty acids, and other impurities that can inhibit the complete combustion process.

At 6 m/s, combustion is still not optimal because the air (oxygen) supply is limited. At 8 m/s, there is a significant increase in temperature because the air is sufficient for a complete combustion reaction. At 10 m/s, the highest temperature is reached. This shows that the higher the air speed, the better the air-fuel mixing process, resulting in a more stable flame and a higher temperature. However, if the air speed is too high (exceeds the optimum limit), there is a possibility that the temperature will decrease again due to cooling due to excess air flow. But in this graph, this limit has not been reached.

### 3.2 Combustion time testing

The data collection process is carried out using variations in fuel and air speed. The burning time data was collected using a stopwatch. The data collection process is carried out from the initial stage of testing until testing is complete. Data results on the length of burning time are obtained by measuring how quickly the incinerator takes to reduce waste (minutes). The following are the data results and the average burning time.

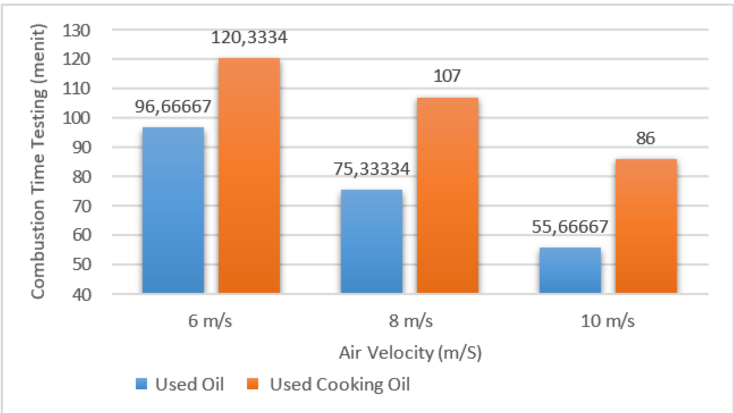


**Fig. 8.** Graph of combustion time test values against air velocity in the incinerator

Variations in air speed have a direct effect on reducing combustion time for both types of fuel. At higher air speeds, the oxygen supply becomes greater so that the oxidation process occurs more completely and the combustion time is faster. Based on test results, used oil has a lower burning time than used cooking oil at all variations in air speed. This shows that used oil has the characteristics of burning more easily and producing heat energy more quickly, while used cooking oil takes longer because it still contains residual fat, water and other contaminants. Thus, increasing air speed is proven to increase combustion efficiency, especially when using used oil as an alternative fuel.

### 3.3 Combustion ash testing

Data collection on residual combustion ash in this research was carried out when the testing (combustion) process was complete. The process of collecting data on the remaining ash from the combustion is carried out by collecting the remaining ash from the combustion area under the incinerator and then weighing it. This process was repeated three times for each variation test. These results will be added up to then take the average of each type of variation. The following are the data results and averages from combustion ash.

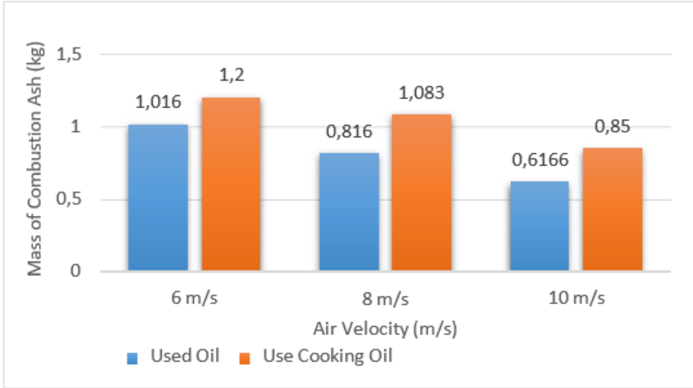


**Fig. 9.** Graph of combustion ash values against the air velocity in the incinerator

The test results show that the mass of combustion ash at each air speed tends to be higher for used cooking oil fuel than for used oil. At a speed of 6 m/s, used cooking oil produces 1.2 kg of ash while used oil produces 1.016 kg of ash. When the air speed increased to 8 m/s, both materials experienced a decrease in ash mass, but used cooking oil remained higher at 1.083 kg compared to used oil at 0.816 kg. At the highest air speed, namely 10 m/s, the mass of ash again decreases with a value of 0.85 kg for used cooking oil and 0.6166 kg for used oil. In general, increasing air speed causes a decrease in the amount of ash formed, which shows that the combustion process takes place more completely at higher air speeds, especially for used fuel oil.

### 3.4 Fuel consumption value for each test

Table 6. Data on consumption values for used fuel oil and used cooking oil in various variations of inlet air speed tests

| Parameter (Fuel: Air Velocity) | Burning Time (Minute) | Fuel Consumption (Liter) |
|---|---|---|
| Used oil: 6m/s | 96.66 | 1.6 |
| Used oil: 8m/s | 75.33 | 1.3 |
| Used oil: 10m/s | 55.66 | 0.9 |
| Used cook oil: 6m/s | 120.33 | 2.0 |
| Used cook oil: 8m/s | 107 | 1.2 |
| Used cook oil: 10m/s | 86 | 1.4 |

### 3.5 Data analysis and statistics

Data processing and analysis are steps used in research to process and analyze data obtained from tests carried out. The following is the data processing and analysis used.

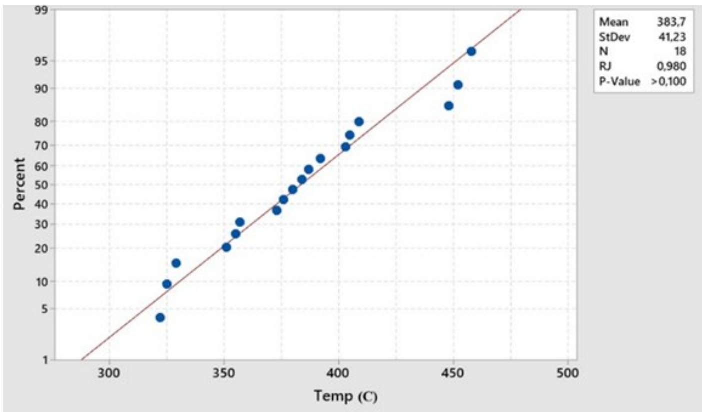


**Fig. 10**. Test the normality of combustion temperature data

Table 7. Hasil *two-way* ANOVA temperatur pembakaran

| Source | DF | Seq SS | Contribution | Adj SS | Adj MS | F-value | P-value |
|---|---|---|---|---|---|---|---|
| Fuel | 1 | 14000.2 | 48.44% | 14000.2 | 14000.2 | 988.25 | <0.001 |
| Air velocity | 2 | 14542.3 | 50.31% | 14542.3 | 7271.2 | 513.26 | <0.001 |
| Fuel*Air velocity | 2 | 191.4 | 0.66% | 191.4 | 95.7 | 6.76 | 0.011 |
| Error | 12 | 170.0 | 0.59% | 70.67 | 5.89 | | |
| Total | 17 | 28904.0 | 100.00% | | | | |

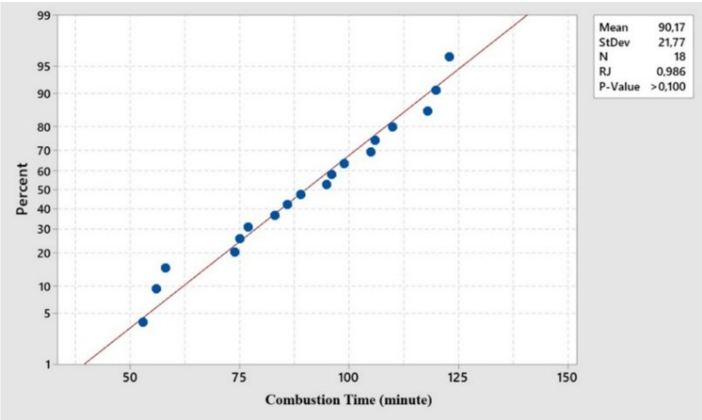


**Fig. 11**. Test the normality of the burning time data

Table 8. Hasil *two-way* ANOVA lama waktu pembakaran

| Source | DF | Seq SS | Contribution | Adj SS | Adj MS | F-value | P-value |
|---|---|---|---|---|---|---|---|
| Fuel | 1 | 3669.39 | 45.52% | 3669.39 | 3669.39 | 623.10 | < 0.001 |
| Air velocity | 2 | 4265.33 | 52.92% | 4265.33 | 2132.67 | 362.15 | < 0.001 |
| Fuel*Air velocity | 2 | 55.11 | 0.68% | 55.11 | 27.56 | 4.68 | 0.031 |
| Error | 12 | 70.67 | 0.88% | 70.67 | 5.89 | | |
| Total | 17 | 8060.50 | 100.00% | | | | |

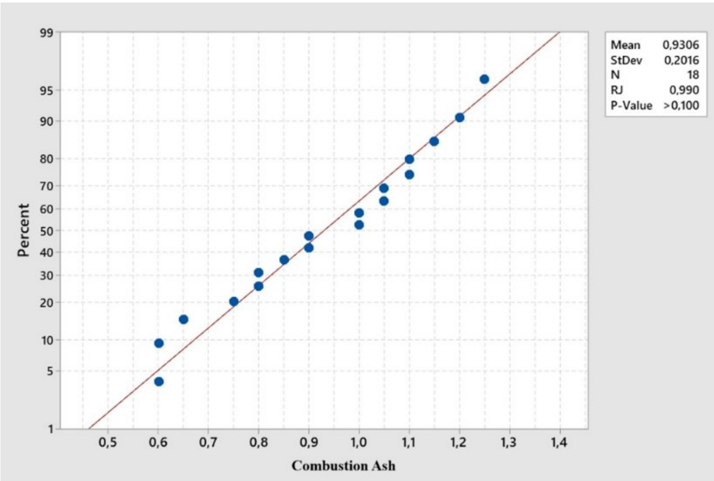


**Fig. 12**. Normality test of combustion ash data

Table 9. Hasil *two-way* ANOVA abu sisa pembakaran

| Source | DF | Seq SS | Contribution | Adj SS | Adj MS | F-value | P-value |
|---|---|---|---|---|---|---|---|
| Fuel | 1 | 0.233472 | 33.80% | 0.233472 | 0.233472 | 105.06 | < 0.001 |
| Air velocity | 2 | 0.425278 | 61.57% | 0.425278 | 0.212639 | 95.69 | < 0.001 |
| Fuel*Air velocity | 2 | 0.005278 | 0.76% | 0.005278 | 0.002639 | 1.19 | 0.338 |
| Error | 12 | 0.026667 | 3.86% | 0.026667 | 0.002222 | | |
| Total | 17 | 0.690694 | 100.00% | | | | |

The results of the ANOVA indicate that there is a significant influence between the type of fuel on the response of temperature, duration, and combustion residue ash, so it can be assumed that the type of fuel significantly influences the response results in this study. The results of the two-way ANOVA test then obtained a P-value <0.001 for variations in air speed, which means that the value is smaller than the α value of 0.05 (P-value <0.05). These results indicate that there is a significant influence between variations in air speed on combustion temperature, combustion duration, and combustion residue ash, so it can be assumed that air speed has a significant effect on the response (temperature, duration, and combustion residue ash) in this study.

### 3.6 Thermal Efficiency

Thermal efficiency is calculated based on the ratio of heat energy produced to the total energy used during the combustion process. This aspect provides an overview of the incinerator's ability to achieve efficient test results that meet standards. Fig. 9 is a graph of thermal efficiency results.

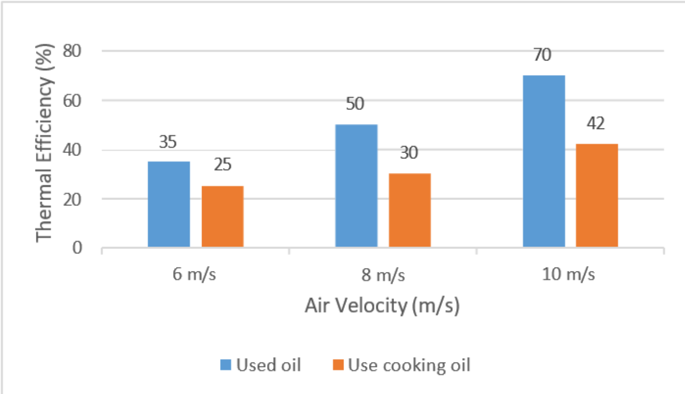


**Fig. 13**. Graph of thermal efficiency values against the air velocity in the incinerator

Based on Graph 9, the thermal efficiency obtained shows that there has been a significant increase in the test results for each variation. Fig. 9 shows that the use of used oil as fuel produces a higher average value compared to used cooking oil. This increase in efficiency occurs due to the higher calorific value or chemical energy contained in used oil. Variations in air flow of 6 m/s get a thermal efficiency of 35%, then variations in speed of 8 m/s get a thermal efficiency of 50%, and thermal efficiency with variations in air flow of 10 m/s reaches 70%.

This happens because the air flow variation of 6 m/s is a rich combustion category, so the combustion reaction cannot take place optimally. Rich combustion in this variation is characterized by low thermal efficiency calculation results. The decrease in thermal efficiency is caused by an imbalance between the amount of energy provided by the stove and the energy produced by the incinerator. This phenomenon is reflected in the low combustion temperature and high combustion time achieved in the combustion process using this variation.

Variations in air flow of 8 m/s show more ideal calculation results. Calculations between the air requirements and the fuel provided show good balanced results, so that efficient combustion can occur within a variation of 8 m/s in this study. Increasing the air flow rate to 8 m/s makes the air supply sufficient for the needs of the combustion process, resulting in more complete combustion and being able to increase the thermal efficiency value in this research.

Thermal efficiency with variations in air flow of 10 m/s shows results that continue to increase compared to using variations of 6 m/s and 8 m/s. This phenomenon results from acceleration in the combustion reaction, but accelerating the combustion reaction does not affect ideal combustion. The fast combustion process will affect the combustion temperature in the incinerator, so that, at an air flow speed of 10 m/s the calculated thermal efficiency can increase up to 70%. Please note that increasing air flow can also cause an imbalance between air and fuel supply. When the air supply provided is too large and the fuel supply is inadequate, poor combustion will occur. Tests using an air flow speed of 10 m/s produce higher predicted efficiency values, meaning that the fuel's capabilities are still adequate for the given air flow speed. The efficiency results obtained have an efficiency value that is almost the same as research conducted by Fitriyadi & Purwanto (2021) with an efficiency value of 40.72%.

## 4 Conclusion

The addition of variations to the air system with forced convection of two stages of air and variations in fuel can improve the performance of the incinerator, with the results of combustion temperature, duration of combustion and residual combustion ash. The combination of used oil parameters with an air flow rate of 10 m/s in this study resulted in an average combustion temperature of 452.667°C, a burning time of 55 minutes, and residual ash of 0.6 kg, which is closer to ideal conditions. However, this combination has not reached the optimal point in testing this tool. This occurs because the increase in combustion temperature continuously occurs along with the addition of air flow, thus potentially affecting the duration of combustion and the amount of residual ash from combustion.

The effect of forced convection of two stages of air in the incinerator has been proven to increase the thermal efficiency value with an average thermal efficiency value of 35%, 50% and 70% for variations of used oil fuel with an air flow rate of 6 m/s, 8 m/s and 10 m/s. Meanwhile, variations in used cooking oil fuel get thermal efficiency values of 25%, 30% and 42%. This increase in thermal efficiency is influenced by the increase in combustion temperature which occurs along with increasing air speed, which contributes to higher efficiency values. The variation of used oil with an air flow rate of 10 m/s is the highest combustion temperature recorded in this research, reaching 452°C, resulting in a thermal efficiency of 70%. Apart from that, the duration of combustion also affects the thermal efficiency value, where in the variation of used cooking oil with an air flow rate of 6 m/s, which has an average burning time of 120 minutes, the thermal efficiency reaches 25%.

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