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THE EFFECT OF CHIMNEY HEIGHT ON STOVE ON THE PERFORMANCE OF TOP LIT UP DRAFT GASIFICATION STOVE [TLUD]

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ABSTRACT

Top Lit-Up Draft (TLUD) gasification stove has a flame output at the top of the stove, the flame produced by this stove is held above the biomass at the point of mixing with secondary air. The stove design has an important role in improving its performance, there are also other components that are considered quite important, namely the addition of a chimney located at the top of the stove as a path for fire to escape. Although the design of the chimney plays an important role in the combustion that occurs in the TLUD gasification stove, there is still no systematic scientific study of the stove chimney design and its effect on the combustion of the TLUD stove. This study aims to determine the effect of chimney height on the performance of the Top-Lit Up Draft (TLUD) gasification stove. The chimney model with varying heights were 5 cm, 10 cm, and 15 cm, with an air flow velocity of 1.5 m/s. and biomass fuel: bagasse, as much as 600 grams. The dependent variables are fire height, flame temperature, flame duration, and stove thermal efficiency. This study concludes a.) the height of the chimney has an effect on the performance parameters of the resulting TLUD gasification stove, namely the flame height, flame temperature and flame duration [flame stability]. TLUD gasification stove performance parameters. b.) the height of the chimney has less effect on the value of the thermal efficiency of the TLUD gasification stove.

1. INTRODUCTION

Gasification is a chemical and thermal decomposition process through combustion techniques or material conversion into gas fuel with limited air [1]. In this process, gasification utilizes heat from the combustion reaction, the reactions that occur include reduction, pyrolysis, drying and combustion reactions [2]. TLUD (Top-Lit Up Draft) is a semi-gasification innovation technique. The gasification process utilizing the TLUD method can create fewer emissions. Until now there are many uses of the TLUD method on gas cooking stoves with different models. This is done to get the best gasification cooking stove. Sugarcane is one of the most widely grown plants in Jember Regency and produces a lot of bagasse. Bagasse is one of the energy sources that can be used as industrial raw materials and as an energy source for human needs.

Previous research was conducted by [3] regarding burner design with variations in the number of secondary airflow holes 11,13,15,17 and hole diameters of 5 mm, 1 mm, 15 mm in the gasification furnace. This study concludes that the greater the secondary air flow in the burner, the greater the temperature of the combustion flame. However, if the secondary air flow in the burner is too large, the combustion flame temperature will decrease and the water boiling time will be longer. [4], conducted research on the effect of variations in the number of air holes on the efficiency of biomass stoves. This study uses a biomass stove with variations of air holes in the combustion tube, namely 6 holes, 12 holes and 18 holes using pulai wood briquettes as fuel. Research conducted by [5], on the effect of the number of air holes in the combustion furnace and variations in air flow velocity on the performance of gasification stove with teak wood pellet fuel. This study resulted in the best efficiency stove performance of 13.55% with a speed of 3.50 m/s and 40 holes, the best char percentage of 11.55% with a speed of 2 m/s and 40 holes, and the best fuel consumption rate of 1 0.05 kg/hour with a speed of 3.50 m/s and a hole of 20. Research conducted by [6] on the PP-Plus gasification stove fueled by processed wood waste. Where the fuel used is processed wood waste such as wood twigs, leftover wood plants and pieces of wood that have been dried. From this research, it can be concluded that fuel variations affect the thermal efficiency of the PP-Plus gasification stove. Research on PP-Plus gasification stoves fueled by processed wood waste resulted in thermal efficiency between 9-31%. The size of the biomass affects the start-up time and operating time of the stove. The smaller the size of the biomass material, the faster the start-up time of the stove and the longer the operation time of the stove. Research conducted by [7], on a gasified biomass stove with variations in fuel wood pellets of rice husks, wood pellets of teak wood, and wood pellets of sengon wood. The conclusion obtained from this study is that of the three types of biomass that are good for use as fuel in terms of the highest efficiency value and fast operating time, namely rice husk wood pellets. In wood pellets, rice husks have drawbacks in terms of a lot of fuel consumption, which is more than 1 kg/hour, and the percentage of char produced is high at 4%. [8], has conducted research on biomass stoves with the fuels used are coconut shells, corn cobs and jackfruit wood. Testing of biomass stoves with coconut shell fuel used to boil water with a volume of 1 liter is 0.67 kg, corn cobs fuel uses 0.28 kg and jackfruit wood fuel uses 0.57 kg. So from the three fuel variations, the effectiveness value obtained is from corncob fuel with an average use of 0.28 kg.

Top Lit-Up Draft (TLUD) gasification stove has a flame output at the top of the stove, the flame produced by this stove is held above the biomass at the point of mixing with secondary air. The stove design has an important role in improving its performance, there are also other components that are considered sufficient, namely the addition of a stove chimney (chimney) located at the top of the stove as a fire escape route [9]. The pressure drop generated by the chimney will draw air into the stove through the primary and secondary air holes [9]. The amount of incoming air flow caused by the addition of the chimney is related to the chimney geometry of the TLUD stove itself. However, according to [9] although the design of the chimney plays an important role in the combustion that occurs in the TLUD gasification stove, there is still no systematic scientific study of the stove chimney design and its effect on the combustion and emissions of the TLUD stove. This research focuses on the effect of chimney height on the Top-Lit Up Draft (TLUD) gasification stove. This research is expected to be a solution to the problem of non-renewable fuels that are increasingly depleting and can be a development of the use of agricultural waste as biomass which is a renewable energy.

2. Methods

The gasification process occurs in a gasification stove with the type of Top-Lit Up Draft and the type of forced draft air flow. Biomass in the form of bagasse will be used as the main fuel in the gasification

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process. The schematic of the research tool can be seen in Figure 1.

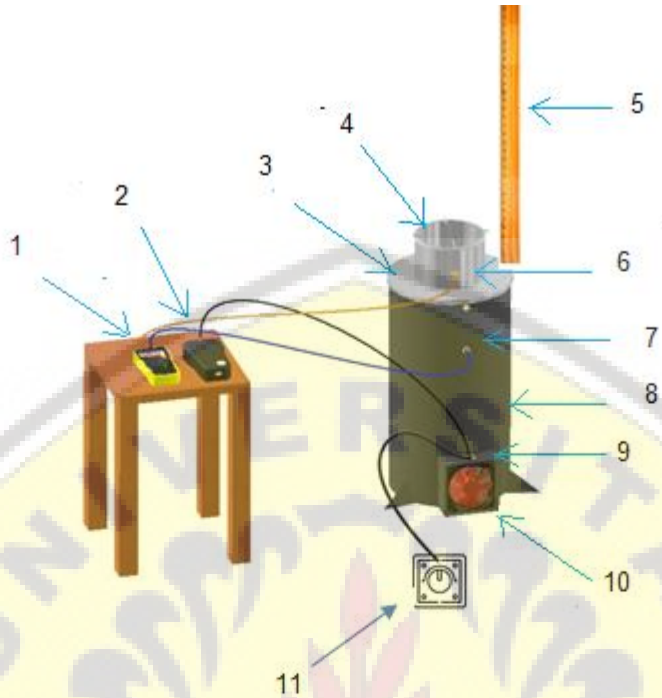

Figure 1. TLUD Gasification Stove Test Scheme

Caption:
1. Thermocouple reader
2. Anemometer reader
3. Concentrator disk
4. Chimney (Chimney)
5. Ruler
6. Thermocouple (T1)
7. Thermocouple (T2)
8. Gasification stove
9. Anemometer
10. Fan
11. Dimmer

This TLUD gasification stove has a height of 60 cm with a diameter of 26 cm. The reactor (gasifier) in the form of a cylinder has a diameter of 20 cm and a height of 35 cm. This gasification stove is added with a chimney with a diameter of 15 cm and with 3 variations in height, each of which is 5 cm, 10 cm, and 15 cm. At the bottom front of the stove there is a hole with dimensions of 12 cm x 12 cm as a place to put the fan where this line is the primary air inlet with forced draft air flow type with a speed of 1.5 m/s. In the inner gasifier, there are 36 holes in the bottom of the gasifier, 30 holes on the bottom side of the gasifier, and 50 holes on the top side of the gasifier as secondary air holes, where each hole has a diameter of 0.3 cm.

Free Variables: Chimney model, the chimney model with varying heights is 5 cm, 10 cm, and 15 cm. Bound Variable: flame height, flame temperature, flame duration, and stove thermal efficiency Control Variable: a). Air flow speed; 1.5 m/s. b). Biomass fuel; bagasse, as much as 600 grams.

The gasification stove testing process is as follows:

a) Weighing 600 grams of biomass [bagasse with 10.6% moisture content] as fuel for the gasification stove.

b) Putting weighed biomass fuel into the gasification stove.

c) Install the stove chimney and adjust the air flow speed of 1.5 m/s using a dimmer.

d) Processing biomass fuel in a gasification furnace by starting a fire using a gas torcher.

e) Maintain the flame until all the materials are burned.

f) Record the data needed to analyze the performance of the gasification stove such as the height of the fire every 2 minutes, the length of the flame, and the temperature of the fire.

g) Repeat Steps 4-9 with 3 variations of the chimney and without the chimney.

h) The experiment was repeated 10 times.

i) Analyze the data that has been obtained.

3. Results And Discussion

The performance test of the Top Lit-Up Draft (TLUD) gasification stove with variations in the chimney height (Chimney) this time has 3 parameters, namely high flame, flame temperature, flame length, and flame duration.

3.1 The Flame Height

Figure 2. The flame height of the stove without chimney

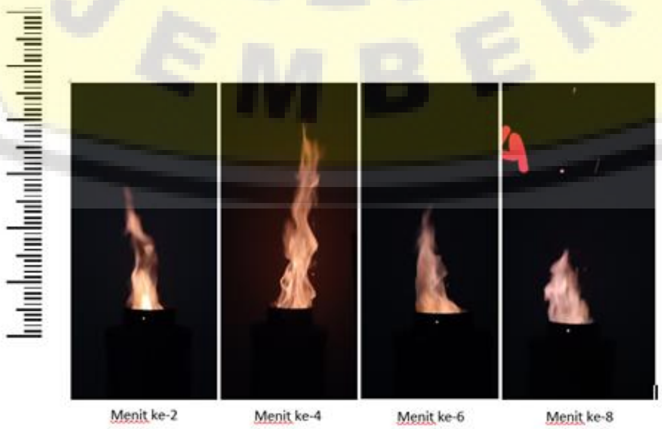

Figure 3. The height of the flame with the chimney stove 5 cm

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Figure 4. The height of the flame with the chimney stove 10 cm

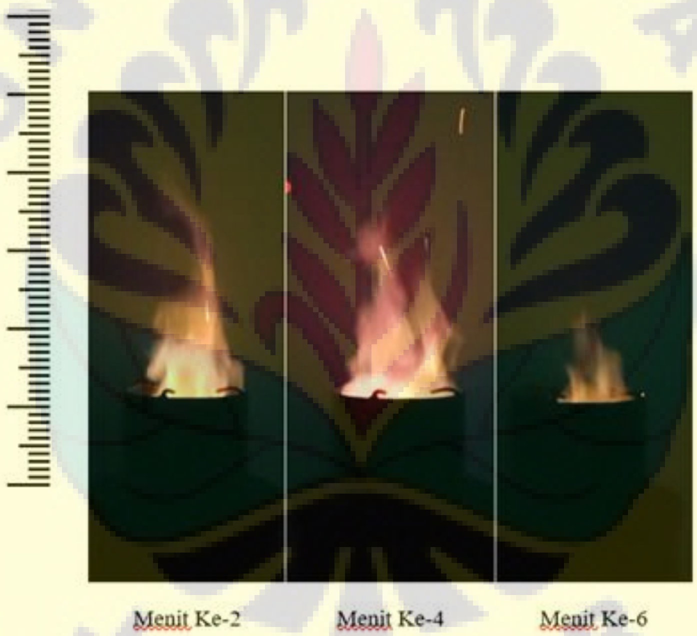

Figure 5. The height of the flame with the chimney stove 15 cm

Figure 2 shows a visualization of the height of the stove fire without chimmey which decreases every 2 minutes, and the fire starts not being visible from the outside at 8 minutes 2 seconds. The fire appears to be blue on average at the 6th minute. Figures 3 to 5 show a visualization of the height of the stove fire with chimmey 5 cm, 10 cm and 15 cm. In the picture, it can be seen that the highest fire reached 33.91 cm in the 4th minute for the 5 cm chimney variation. The lowest fire height was at 4.46 cm in the 8th minute for the chimney variation of 10 cm. The flame temperature on the gasification stove [TLUD] can range from 700 °C – 1100 oC. Flame temperature can be used as an indicator of fuel calorific value and combustion quality [10]. The flame temperature is influenced by the type of fuel, the mass of the fuel and the supply of air from the environment. The calorific value and composition of the fuel gas have an effect on the resulting fire [11]. The greater the calorific value and the volatile matter of the fuel will determine the amount of heat released by the fire and increase the temperature of the fire. The higher the temperature of the fire, the greater the heat released by the fire. The difference in flame color is influenced by some gas content in the biomass fuel. When more CO gas is produced, the color of the fire produced will be more orange and even closer to red [12]. The orange flame color is caused by a lot of CO gas that is formed and there are still a lot of carbon particles being burned. While the blue color of the flame indicates the burning CH4 and H2 gases [13]. The height and shape of the resulting fire tends to be unstable due to the visually turbulent secondary air flow [14].

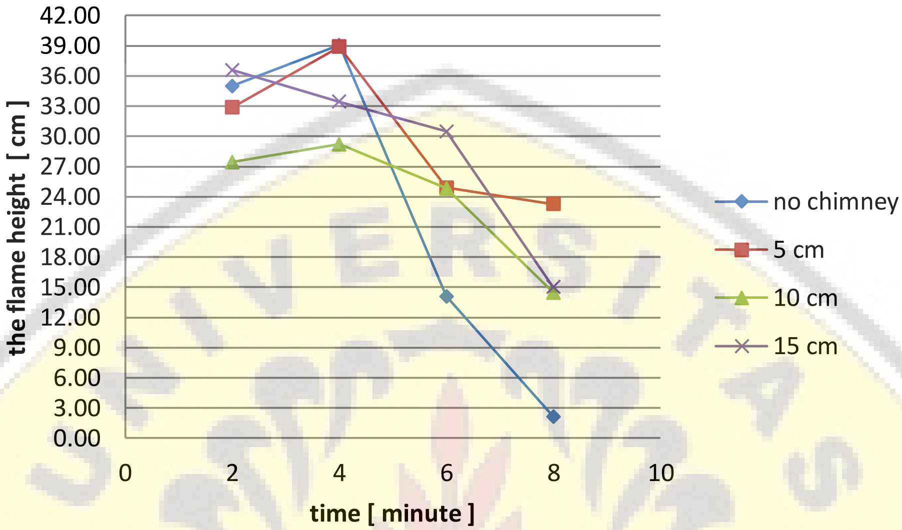

Figure 6. Graph of flame height

Based on the graph of fire height in Figure 6, it can be seen that the highest fire was reached in the 4th minute by stove without chimmey and stove with chimmey 5 cm. The lowest heat is at 2.15 cm in the 8th minute for the stove without chimney. Figure 4.5 shows that each variation of chimney has a different flame stability. Based on the four graphs, the fire that has a more stable and safe height is the 15 cm chimney variation. The 15 cm chimney variation reached its maximum height in the 2nd minute, namely the first minute of data recording, which was 36.59 cm and gradually decreased with an average decrease of 3.0 cm in the 4th and 6th minutes until the fire did not occur. appears in the 8th minute. The fire height is closely related to the sentence proposed by [9] that the burning fire will remain above the biomass where there is also a mixing process with secondary air and then the fire will rise through the chimney. Based on this sentence, the 15 cm chimney variation has a more stable graph because the graph decreases along with the burning fuel and the fire that comes out of the stove for only 8.47 minutes, therefore a chimney with a height of 15 cm is considered to have a higher fire height. stable and safe to use.

3.2 The Flame temperature

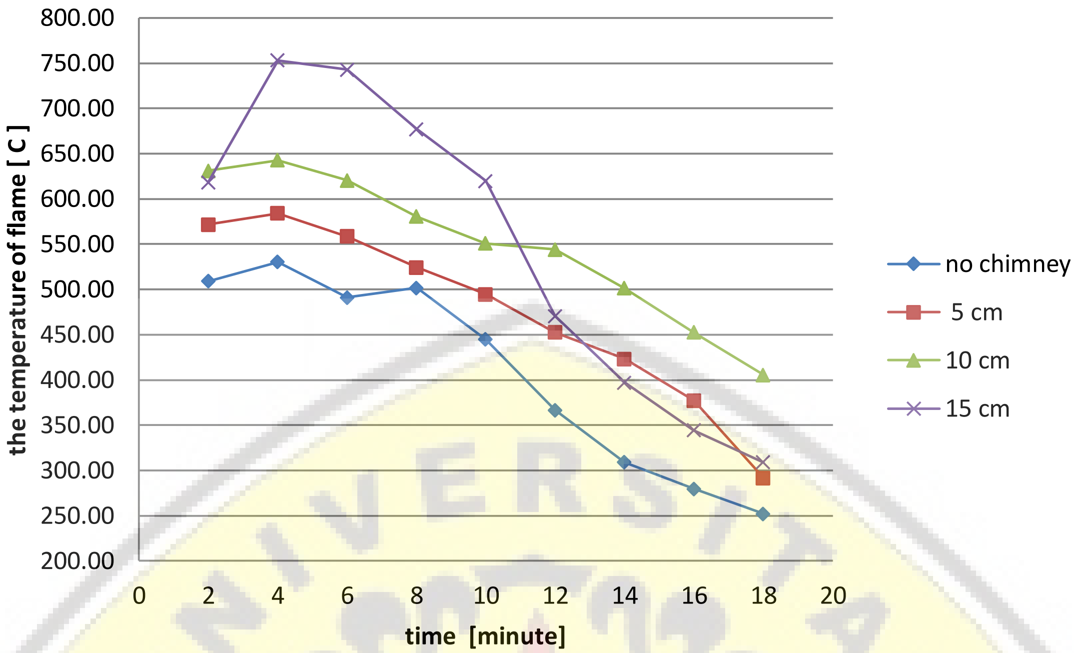

Figure 7. Graph of flame temperature

Based on Figure 7, the highest temperature is found on the stove with 15 cm chimney, then the lowest temperature is on the stove without chimney. This is related to the influence of the chimney geometry, in this study the height of the chimney. The stove chimney (chimney) will lower the pressure, so that air will be drawn into the stove through the primary air duct hole and the secondary air duct hole [9]. The chimney with a higher height can cause a higher pressure difference, so it is expected that the air flow rate will be higher. However, the higher the chimney, the lower the viscosity [9]. Viscosity has a relationship with temperature, namely if the viscosity decreases, the temperature will increase [15].

3.3 The length of time the fire burns

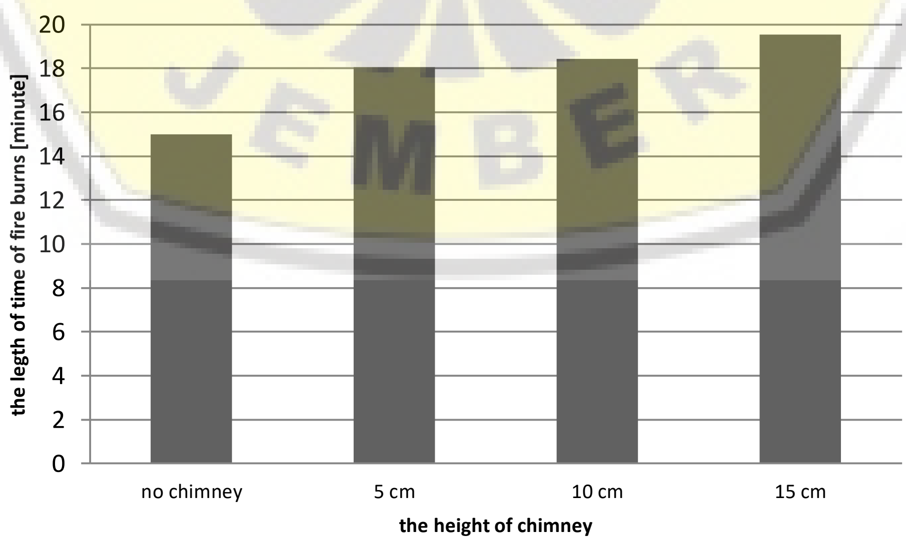

Figure 8. The length of time the fire burns

Based on the graph of the length of the flame in Figure 8, it can be seen that the length of time the fire burned in this study was at the 15 cm chimney variation, namely the fire was burning for 19.54 minutes, while the shortest fire time was without chimney for 14.99 minutes. This shows that the higher the chimney, the longer the time the fire burns. The increase in combustion temperature affects the length of the combustion time, the greater the temperature increase, the shorter the combustion time [16]. Stoves with chimney variations of 15 cm have an average increase in fire temperature, which is low so that the burning time is longer. The number of air holes also affects the length of time the fire burns, namely the more air flows through the fuel, the faster the fuel burns out [4]. The duration of the flame is also influenced by the flow of air that enters the gasifier, where the more air that enters, the more air reacts with biomass in the combustion process [17].

3.4 The Thermal efficiency

Figure 9. The thermal efficiency

The thermal efficiency of the stove is the ratio between the energy used in heating water and the heat energy contained in the fuel. Thermal efficiency (ηth) is calculated using the equation [18], [19], $\eta_{th} = [\ m_a\ Cp\ \Delta T + \Delta m_a\ \lambda]\ /\ [\ \Delta m_k\ LHV]$, where ma is the mass of water (kg), Cp is the heat capacity of water (4.186 J/kg oC), ma is the mass of evaporated water (kg), T is the difference in temperature of the final water to the initial milk water, is the heat of vaporization of water (2260 kJ/kg) and LHV is the value fuel heat. From Figure 4.8, it can be seen that the efficiency of the stove basically has the same value, which ranges from 42.7% to 42.95%. This shows that the variation in chimney height does not have much effect on the efficiency value, but the variation in chimney height has more effect on the characteristics of the fire produced by kompro TLUD, namely the length of the flame, the temperature of the flame and the height of the flame.

4. Conclusion

Based on the data analysis and analysis that has been done, the following conclusions are obtained:

1. The height of the chimney has an effect on the performance parameters of the resulting TLUD gasification stove, namely flame height, flame temperature and flame duration [flame stability], the higher the chimney, the higher the value of the gasification stove performance parameters. TLUD.
2. The height of the chimney has less effect on the value of the thermal efficiency of the TLUD gasification stove.

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