Development of a Biomass Anila Furnace with a casing for preheating

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Abstract—This study aims to determine the effect of using a shroud mounted on an anila biomass gasification furnace. The casing is a guide and heats the air entering the combustion chamber. The method used in this study is experimental. The type of furnace used in the experiment is a biomass anila furnace. This furnace is made of metal. The casing is attached to the outside and envelops the furnace. Measurements were made between long flame, starting time, and flame stability. The test results show that the average startup time is 10 minutes. Long flame flame with cover is 87.79 minutes, while without cover is 72.28 minutes. The stability of the flame using the casing is more stable than without the casing.

Keywords— Biomass, gasification, long flame, anila biomass.

I. INTRODUCTION

One concern for finding environmentally friendly alternative fuels is getting much attention [1]. This is related to concerns that it will continue to occur as fossil fuel prices increase and fossil fuel reserves decrease [2]. Biomass is an alternative energy generator that can be studied because it can be applied in every region and without other energy sources. One example is wind and geothermal energy, which are only available in certain areas [3].

In areas with quite large waste production, this waste can be utilized as biomass fuel; in this case, [4] have carried out a mapping of biomass potential aimed at utilizing waste that can be concentrated into a source of biomass fuel in large waste-producing areas that can support the required energy needs. Biomass can be used in all regions due to the availability of waste that can be converted into other fuels or burned directly into heat energy. The development of research on biomass is proliferating in the context of energy use. Often, the raw materials used are vegetable materials, but to date, studies have been carried out on animal raw materials; this condition is being reviewed in the academic and industrial fields with the aim that biomass can become a source of renewable energy in the future [5].

In the biomass working system, thermochemical conversion is a way to achieve high efficiency (gasification) [6,7,8]. Gasification is a work process that converts raw materials into liquid form or into gaseous fuel. The passivation-pyrolysis stove that has been researched by [9] states that the stove design that uses gasification-pyrolysis can be used to meet energy needs such as being used for cooking. One example is an ICS and biochar stove, which can be used with various types of biomass input. Gasification in a very complex biomass working system starts from a physical process followed by a chemical process. In physical processes, phenomena are often encountered, such as drying and heating, while in chemical processes, the phenomenon of oxidation of materials into gas, solid, and liquid pyrolysis processes.

Pyrolysis is a thermal decompression process that occurs when biomass material is converted into gas, solid, and liquid. The pyrolysis process also results in hydrocarbon molecules being broken down into smaller molecules, where the speed of pyrolysis affects the fuel yield produced. Pyrolysis at high speed generally produces liquid fuel, but pyrolysis that is slow enough will produce solid charcoal [10]. In everyday life, biomass is very useful in helping to meet the energy needs used in the cooking process. Optimization of stoves with a biomass heat source needs to be done to increase efficiency and control emissions from the stove. This research aims to adapt detailed information from the combustion process using a biomass stove with micro-gravitation biomass stove annealing, which develops a pre-heating and airflow control system..

II. METHODS

The method used in this research uses an experimental method [11,12,13]. This research refers to the Anila Biomass Gasifier Stove research [14] in Figure 1. Then, the biomass stove used in this research was developed from the anila biomass stove shown in Figure 2, which is a biomass stove designed with two fuels in one combustion process with the addition of a pre-heating system. The results of the component design development were adjusted with the addition of a pre-heating system but did not change the gasification process that occurred in the biomass stove anila.

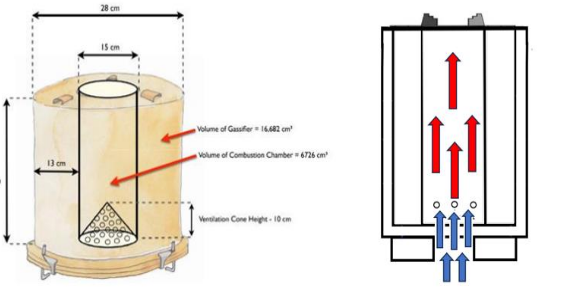

Fig. 1. Biomass Anila Furnace

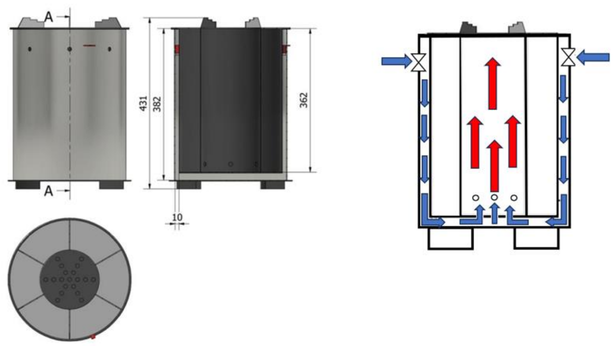

Fig. 2. Biomass Anila Furnace development

In this research, testing was carried out using Long Flame testing and starting time. The Long Flame test is intended to obtain data relating to the flame's length in the biomass stove's working process until the stove is turned off. According to research conducted by [15], the flame that occurs in the working process of a biomass stove is influenced by the dimensions of the stove. The working process of a biomass stove can be seen in Figure 3. Wood biomass or palm shells are put into the internal combustion tube, and rice husk biomass or

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wood dust is put into the outer combustion tube. Combine the combustion tube filled with biomass fuel with the pre-heating tube. Then, install the stove coaster to cover the outer combustion tube where the pyrolysis occurs tightly. Ensure the airflow control valve is open to start the start-up stage of the biomass stove flame. Prepare a piece of paper to light as an initial trigger in start-up until the rice husks burn. After the start-up process, the wood biomass or palm shell will start to burn from top to bottom.

When the combustion temperature has reached 360 0C, the pyrolysis that occurs in the outer combustion tube (rice husk biomass or sawdust) will begin to release gas and become biochar. The gas resulting from pyrolysis will enter the combustion tube and burn with wood biomass or palm kernel shells. At the end of the process, the biomass in the internal combustion tube produces biochar and ash, while the external combustion tube, where pyrolysis occurs, will produce biochar.

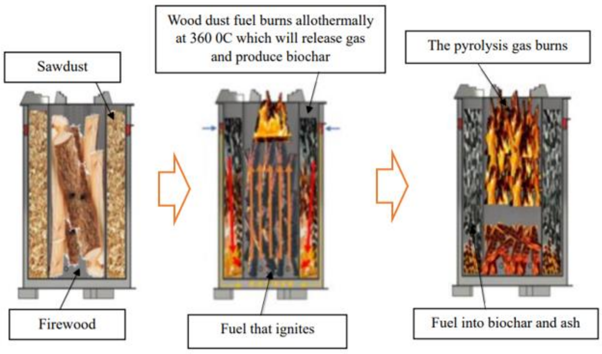

Fig. 3. Scheme of How the Developed Biomass Stove Works

Long Flame (F) Is the flame time per combustion process (start up, prolysis flame, and ember flame) until the flame dies.

F= F_x+F_n+F_y

Where

F : Long Flame (s)

Fx : Start up Flame (s)

Fn : Fame Pirolisis (s)

Fy : Burning embers (s)

III. RESULTS AND DISCUSSION

Development design of the Anila Biomass Stove are shown in Figure 4. The combustion tube consists of two cylindrical tubes with a height of 360 mm, a diameter of 150 mm (inner tube), and a diameter of 270 mm (outer tube). The inner tube burns medium-sized biomass such as wood twigs or palm shells. The inner tube burns biomass such as rice husks and wood dust. In the inner tube the biomass is burned directly with fire, and in the outer tube the biomass is burned allothermally (indirect combustion) or using heat generated by the inner tube's walls. At the bottom of the combustion tube it is closed with a 2 mm plate which contains nineteen air vents with a diameter of 10 mm to supply oxygen to the internal combustion tube.

Fig. 4. Biomass stove

Meanwhile, on the outer combustion tube, there are six air ventilation holes at the top of the tube wall with a diameter of 10 mm as an air supply for indirect combustion. On the bottom side of the internal combustion wall, there are also six ventilation holes intended as a place for the biomass gasification results to exit in the external combustion tube. Table 1 shows the specifications of the biomass stove.

TABLE 1. BIOMASS STOVE SPECIFICATIONS

No	Component	Parameters	Dimensions
1	Pre-Heating Tube	(Ø X T)	300 mm X 260 mm
		material	Iron plate 1 mm
		(Ø)	305 mm
2	Internal Combustion Tube	(Ø X T)	152,4 mm X 260 mm
		material	Iron plate 2 Mm
		Air Inlet (Ø)	8 mm X 38 Hole
3	Outer Combustion Tube	(Ø X T)	280 mm X 260 mm
		material	Iron plate 1 mm
		Gas Oulet (Ø)	8 mm X 21 Hole
		(Ø)	285 mm
4	Stove Coasters	(Ø X T)	210 mm X 40 mm
		(Ø)	153 mm

A. *Startup Flame on Biomass Stove*

From the tests carried out, the fastest startup time was the first experiment, which had a time of 10 minutes and 17 seconds. The second experiment had a time of 10 minutes and 39 seconds, and the longest time required was the third experiment, with 11 minutes and 8 seconds. The fourth experiment resulted in 10 minutes 49 seconds, presented in Table 2. The biomass fuel used in this test is wood material from tree branches with a mass of 1 kg, which is used to trigger the pyrolysis process, and biomass fuel, as a result of the gas obtained, comes from wood dust with a mass of 1.8 kg.

TABLE 2. FLAME STARTUP TEST RESULTS

No	Testing	Time (minutes)
1	Experiment 1	10.17
2	Experiment 2	10.39
3	Experiment 3	11.08
4	Experiment 4	10.49

From the data obtained in Figure 5, a graph shows the effect of experimental trials on time carried out, where the first trial of flame startup occurred for 10.17. In the second to third trials, there was a significant increase in startup time, but in the fourth trial, the flame startup Biomass stove fires have decreased..

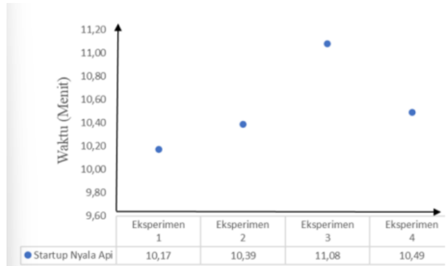

Fig. 5. Flame Starup

B. *Long Flame on a biomass stove*

The Long Flame system preheating and airflow control testing took longer in the experiment compared to testing the non-system preheating and airflow control. Tests with the preheating system and airflow control recorded a maximum of 89 minutes 49 seconds and 86 minutes 8 seconds with an average long flame of 87.79 minutes. Meanwhile,

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non-system preheating and airflow control testing recorded a maximum of 75 minutes 39 seconds and 69 minutes 17 seconds with an average long flame of 72.28 minutes. The average time difference recorded was almost 12 minutes between experiments using a preheating system and airflow control and experiments without a preheating system and airflow control. A comparison of the Long Flame Test averages can be seen in Figure 6. In the Long Flame test with a non-preheating system and airflow control, the trigger fuel produced light ash, while the pyrolysis fuel produced biochar and wood dust. Meanwhile, in the Long Flame test with a preheating system and airflow control, the trigger fuel produced light ash and a little biochar, while the pyrolysis fuel produced biochar and wood dust.

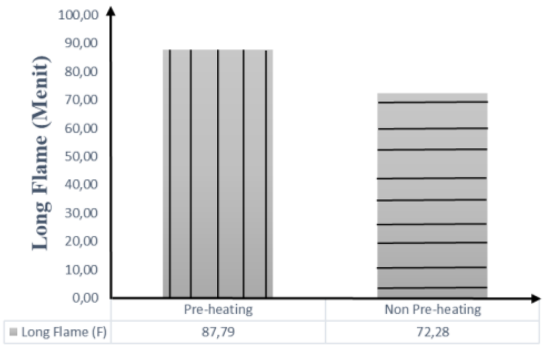

Fig. 6. Average Long Flame Test

IV. CONCLUSION

From the test data and experimental results that have been carried out, the average time used for startup is 10 minutes. The results of the extended flame test using a sheath showed that the longer flame time achieved using a sheath was 87.79 minutes, while without the sheath, the long flame time was 72.28 minutes. Flame stability using a sheath shows better stability than without a sheath.

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DECLARATION OF COMPETING INTEREST

The author declares no conflicts of interest

REFERENCE

[1] S. Allifah, Y. Syaukat, and P. Wijayanti, "Dampak Tenaga Air dan Bahan Bakar Fosil terhadap Implementasi Ekonomi Hijau di Indonesia," *Jurnal Sumberdaya Alam dan Lingkungan*, vol. 9, no. 3, pp. 102–112, Dec. 2022, doi: 10.21776/ub.jsal.2022.009.03.3.

[2] R. Pratama and L. Parinduri, "Penaggulangan Pemanasan Global," *Cetak) Buletin Utama Teknik*, vol. 15, no. 1, pp. 1410–4520, 2019.

[3] I. Kholiq, "Pemanfaatan Energi Alternatif Sebagai Energi Terbarukan Untuk Mendukung Subtitusi Bbm," *Jurnal IPTEK*, vol. 19, no. 2, pp. 75–91, 2015.

[4] B. Pranoto, "Peta Potensi Limbah Biomassa Pertanian Dan Kehutanan Sebagai Basis Data Pengembangan Energi Terbarukan Biomass Potential Map As A Database Of National Scale Biomass Energy Development," *Ketenagalistrikan Dan Energi Terbarukan*, vol. 12, no. 2, pp. 123–130, 2013.

[5] L. Parinduri and T. Parinduri, "Konversi Biomassa Sebagai Sumber Energi Terbarukan," *Journal of Electrical Technology*, vol. 5, no. 2, 2020.

[6] V. Novandri, T. Setioputro, and M. Kosim, "Kaji Eksperimental Gasifikasi Biomassa Reaktor Tekanan Vakum," *Mesa Jurnal Fakultas Teknik Universitas Subang*, vol. ISSN: 23-55-9241, pp. 1–10, 2023.

[7] P. C. Murugan, S. J. Sekhar, G. Glivin, P. S. Raveendran, T. H. T. Le, and T. Mathimani, "Investigation on thermochemical co-gasification of rice husk and groundnut shell in open core gasifier for the generation of producer gas : An optimization by central composite design," Environ. Res., vol. 242, no. August 2023, p. 117741, 2024, doi: 10.1016/j.envres.2023.117741.

[8] Z. Wang, S. Liu, W. Weng, Y. He, M. Ald, and Z. Li, "Alkali metal release in thermochemical conversion of biomass and coal : Optical measurements and modeling," vol. 100, no. August 2023, 2024, doi: 10.1016/j.pecs.2023.101131.

[9] J. R. Pangala, A. H. Tambunan, H. Kartodihardjo, and G. Pari, "Design and Performance Testing of Gasification – Pyrolysis Stove," Journal of Natural Resources and Environmental Management, vol. 6, no. 1, pp. 61–70, Jul. 2016, doi: 10.19081/jpsl.6.1.61.

[10] S. A. Novita, S. Santosa, N. Nofialdi, A. Andasuryani, and A. Fudholi, "Artikel Review: Parameter Operasional Pirolisis Biomassa," Agroteknika, vol. 4, no. 1, pp. 53–67, Jun. 2021, doi: 10.32530/agroteknika.v4i1.105.

[11] P. Pradhan, S. P. Deore, P. Gadkari, A. Arora, and M. Mahajani, "Field evaluation of biomass gasifier for bioenergy application : Case studies on institutional cooking in India," Sustain. Energy Technol. Assessments, vol. 59, no. September 2022, p. 103409, 2023, doi: 10.1016/j.seta.2023.103409.

[12] A. Hailu, "Heliyon Development and performance analysis of top lit updraft : natural draft gasi fi er stoves with various feed stocks," Heliyon, vol. 8, no. November 2021, p. e10163, 2022, doi: 10.1016/j.heliyon.2022.e10163.

[13] M. Deng, P. Li, M. Shan, and X. Yang, "Characterizing dynamic relationships between burning rate and pollutant emission rates in a forced-draft gasifier stove consuming biomass pellet fuels *," Environ. Pollut., vol. 255, p. 113338, 2019, doi: 10.1016/j.envpol.2019.113338.

[14] S. Carter and S. Shackley, Biochar Stoves: an innovation studies perspective. 2011. 9-35 [Online]. Available: http://biocharinnovation.wordpress.com/

[15] M. Iwan Fermi Laboratorium Pengendalian dan Perancangan Proses, "Pengaruh Dimensi Kompor Dan Kadar Air Biomassa Terhadap Kinerja Kompor Gasifikasi Forced Draft," Jurnal Teknik Kimia Indonesia, vol. 11, no. 4, pp. 222–228, 2013.

https://jurnal.polines.ac.id/index.php/eksergi

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