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Experimental Gasification of Coffee Husk Using Air In Updraft Gasifier

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ABSTRACT : *Coffee husk is a by-product of coffee processing that is abundant in Indonesia, specifically in South Sumatra. In this study, gasification test was conducted using a conventional updraft gasifier and fuel at a 3.5 kg bed. The results showed that the gas fuel produced for 3.5 kg of coffee husk was stable for approximately 70 minutes and was obtained approximately 23 minutes after the reactor was turned on.Movable grate was rotated 20 minutes before the gasification process ends.*

KEYWORDS : *Gasification, Coffee husk, Updraft Gasifier, Combustible Gas, South Sumatera*

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I. INTRODUCTION

Coffee husk is capable of being processed into fuel and this by-product is observed to be significantly abundant in Indonesia, specifically the South Sumatra province, without optimal use. In 2020, the province had the most coffee production with a total of 198.94 thousand tons [1]. The by-product after the processing is known as coffee husk which can be converted to gas fuel in the form of producer gas such as CO, CH_4, H_2, N_2, CO_2, and O2 through different methods, including gasification. Several studies have applied gasification process to coffee husk such as the focus of Fona [2] on gasification of parchme coffee from Central Aceh using a throatless downdraft gasifier. The the results show the stability of the combustible gas produced for approximately 29 minutes. Another study by Tung [3] conducted gasification through a downdraft gasifier using coffee husk from Vietnam, and the results showed the gas produced was 29.7% CO, 11.97% H_2, and 2.16% CH_4. Moreover, Bonilla [4] adopted gasification to coffee powder using an updraft gasifier with air and steam media, and the calorific value was found to be 5052 kJ/m3. Bonilla [5] also applied an updraft gasifier to coffee husk with a pure gasification media of a mixture of oxygen and steam to produce a calorific value of 8681 kJ/m3. Another study by Nam [6] focused on Vietnam coffee husk using a char gasification process on TGA with H_2O and CO_2 as the media, and the results showed that the application of H_2O was faster than CO_2. Furthermore, Wilson [7] implemented gasification on coffee husk using a mixture of air and steam, and the results showed that the high temperatures used had a positive effect on the process. The review showed that previous studies have analyzed the use of coffee husk in different countries. The material is also capable of producing electrical energy as observed from the analysis conducted in previous studies [8-10]. Therefore, coffee husk from the Empat Lawang of South Sumatra, Indonesia was experimentally used in this study to produce gas fuel through gasification technology. The aim was to determine the operational characteristics, specifically the amount of fuel used against the time of stability for one bed.

II. METHODOLOGY

The experiment was conducted using a conventional updraft gasifier [11-12] with a 22 cm diameter and 65 cm height as shown in Figure 1. The gas produced through gasification process exited from the top of the gasifier while air was supplied using a blower from the bottom. The amount of coffee husk in the gasifier during the full condition was approximately 3.5 kg. The air velocity was also measured using an anemometer [13] and subsequently applied in calculating the mass flow rate. Moreover, coffee husk used was obtained from South Sumatra, specifically Empat Lawang, as presented in Figure 2. The results from the proximate and ultimate analyses of the material are presented in Table 1 and found not to be quite different from the method applied in the previous study by [14].

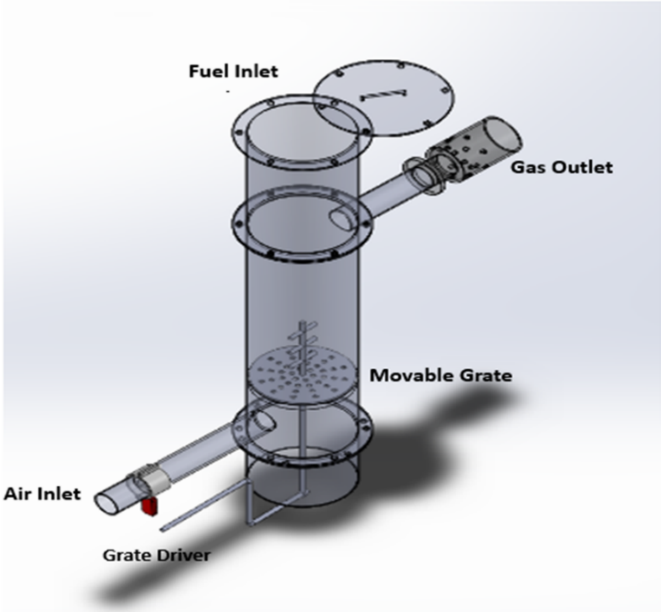

Figure 1. Updraft gasfier

Figure 2. Coffee Husk

Table1. Proximate and Ultimate

Parameter	
Proksimate	**(%) by weight (adb)**
Moisture	13.61
Ash	6.48

Volatile Matter	59.74
Fixed Carbon	20.17
Ultimate	**(%) by weight (adb)**
Carbon (C)	41.42
Hydrogen (H)	6.34
Nitrogen (N)	1.73
Sulfur (S)	0.16
Oxygen	43.87
Calorific Value	**Cal/g**
Gross Calorific Value	3792

III. RESULT AND DISCUSSION

The operation of the gasifier system started from the initial ignition time with 0.5 kg of fuel used as input burned as an ember at air velocity of 2.1 m/s through gasification process. The average ember-making time was approximated at 5 minutes. The next step was the re-insertion of the fuel, determined as 3 kg, for each test with gasification reactor tightly closed. The average time required to form gas fuel was estimated at 23 minutes. The amount of coffee husk used and the length of time of producer gas existed are compared in Figure 3 while the shape of the resulting flame is presented in Figure 4. It was observed that the flame existed for approximately 60 minutes and was reduced 10 minutes before the fuel was exhausted. The continuation of the operation on the next bed would have led to faster production of the gas fuel at approximately 10 minutes because the temperature in the reactor was already high, causing an easier reaction. Moreover, the gas fuel produced was stable as observed from the continuous production of flame with the length identified to be sometimes shortened due to the uneven application of fuel in the reactor. The stability of the flame can be restored by moving the grate to avoid fluctuation.

The grade rotation is usually done 20 minutes before the gasification process ends because the amount of fuel in the reactor has been significantly reduced. Furthermore, the process of lowering the fuel in the reactor is no longer even so that the gasification reaction does not take place perfectly. The comparison between the time of gas fuel existed without rotating the grade and gas fuel existed with rotating the grade is shown in Figure 5. The rate of air consumption in this test is greater than the rate of fuel consumption as shown in Figure 6.From the test results covering the stability of the gas fuel material produced, the gas fuel resulting from coffee husk gasification can be used for application in internal combustion engines through a series of gas cleaning stages first [15-17]

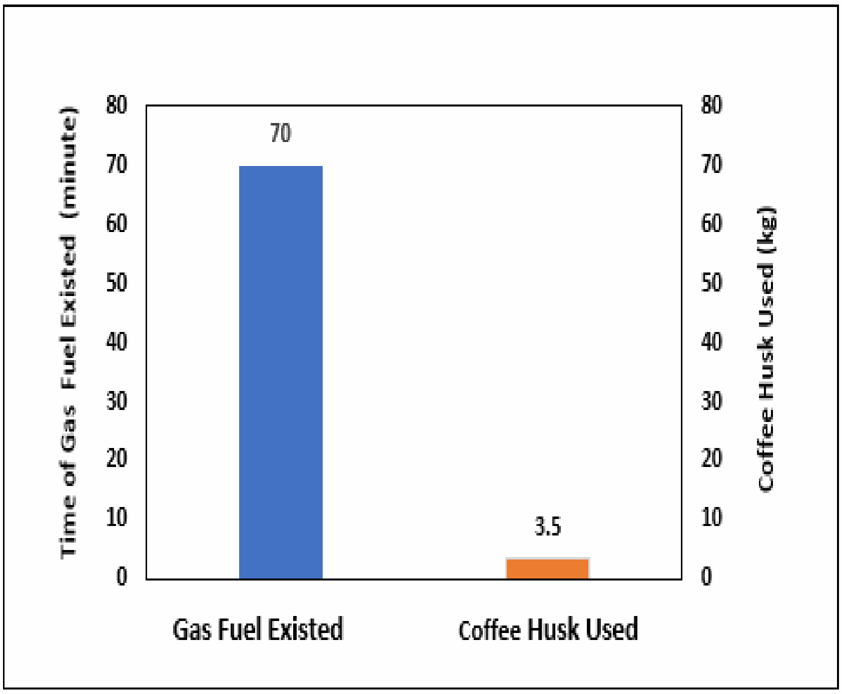

Figure 3. Gas Fuel Existed and Coffee Husk Used

Figure 4. The shape of flare

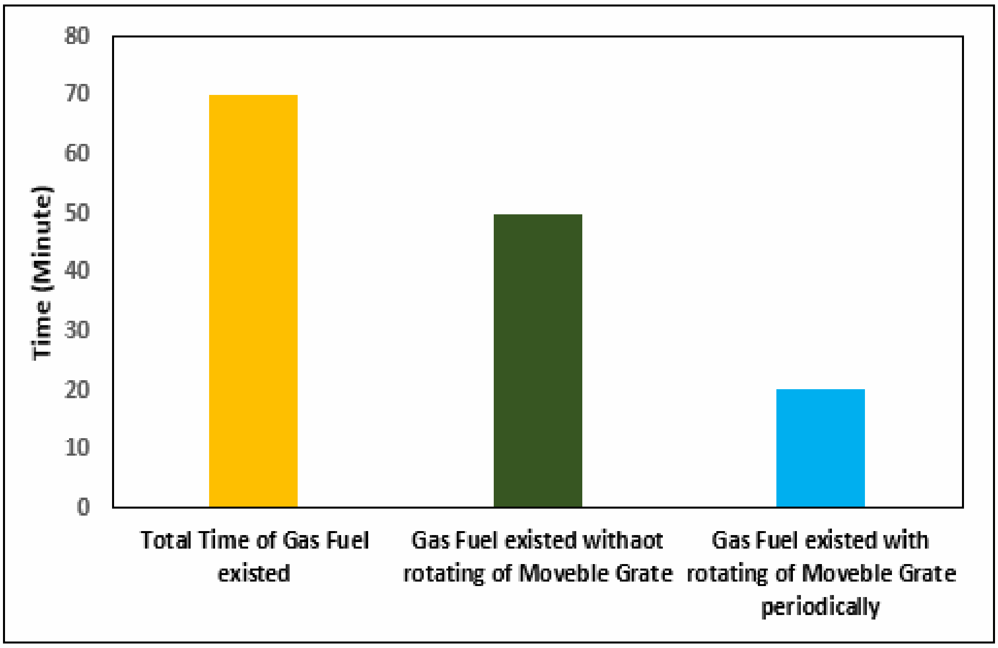

Figure 5. The Time of Gas Fuel Existed without and with Rotating Movable Grate

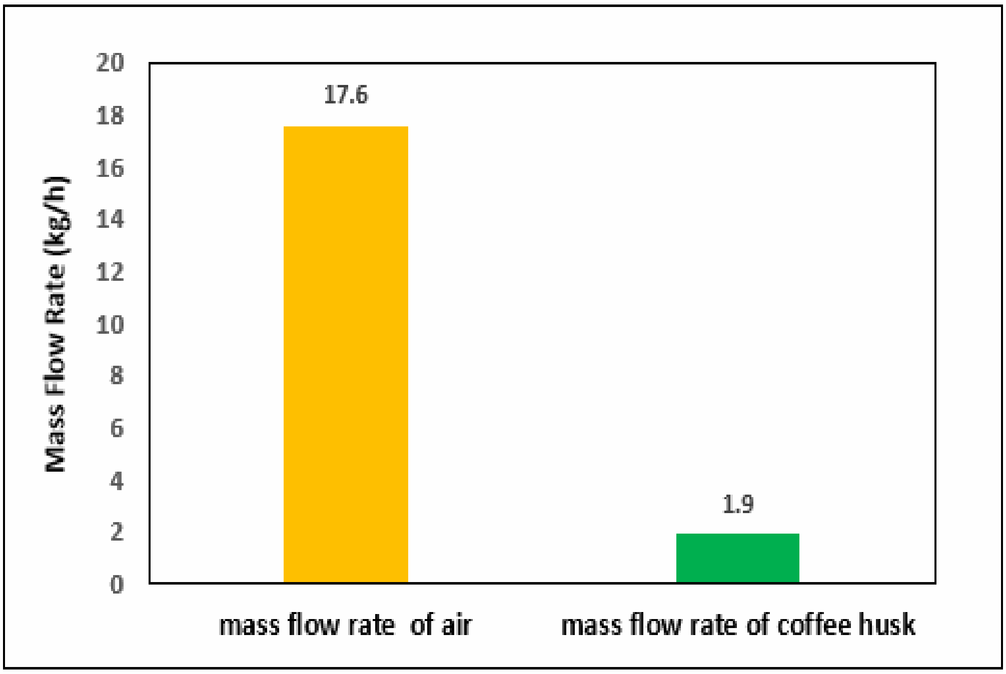

Figure 6. Mass Flow Rate of Air and Coffee Husk

IV. CONCLUSION

In conclusion, coffee husk waste from Pagar Alam, South Sumatra, was successfully used in gasification process to produce gas fuel. The amount of fuel used was 3.5 kg of bed and the gas fuel produced existed for 70 minutes. Moreover, the time required to obtain fuel after the reactor was turned on was 23 minutes. There was generally no problem in coffee husk gasification process with the updraft gasifier model used.

REFERENCES

[1] Direktorat Statistik Tanaman Pangan, Hortikultura, dan Perkebunan, "Statistik Kopi Indonesia" Badan Pusat Statistik Indonesia, (2020)

[2] Zahra, Fona, Z., Irvan, Tambun, R., Fatimah, Setiawan, A., Hadiansyah, M., Ramadani, Z., Gasification of Coffee Parchment as Potential Method for Coffee Agro-Industry Waste Utilization, Journal of Chemical Engineering and Environment 18 (2),162-171 (2023.

[3] Tung, N.D., Assoc. Prof., Dr.-Ing, Study of Possibility of Producing Syngas from Industrial Scale Continuous Downdraft Coffee Husk Gasifier, Applied Mechanics and Materials 889, 254-265,(2019)

[4] Bonilla, J., Gordillo, G, Adiabatic Fixed-Bed Gasification of Colombian Coffee Husk Using Air-Steam Blends for Partial Oxidation, Hindawi Journal of Combustion 2017 (3576509), 1-10, (2017)

[5] Bonilla, J., Gordillo, G., Cantor, C., Experimental Gasification of Coffee Husk Using Pure Oxygen-Steam Blends, Front. Energy Res, 7 (127), 1-11, (2019)

[6] Nam, NH., Ngoc, CTA., Bay, TV., Investigation on gasification of coffee husk in CO_2, H_2O, and mixed atmospheres, Vietnam J. Chem., 59(6), 775-780, (2021)

[7] Wilson, L., John, GR., Mhilu, CF., Yang, W., Blasiak, W., Coffee husks gasification using high temperature air/steam agent. Fuel Processing Technology 91, 1330–1337, (2010)

[8] Freitas, LCF., Renó, MLG, Environmental and economic evaluation of coffee residues, Eng Sanit Ambient, 27(4), 715-721, (2022).

[9] Rivera J.A., Ortega-Jimenez, CH, Power Generation with Biomass from Coffee: A Literature Review, Current Trend and Scope for Future Research, MATEC Web of Conferences, 293(05002), 1-5, (2019)

[10] Miito, GJ., Banadda, Noble., A short review on the potential of coffee husk gasification for sustainable energy in Uganda, F1000Research, 6(1809), 1-1, (2017)

[11] Zhanga, W., Huanga, S., Wua, S., Wua, Y., Gaoa, J., Study on the structure characteristics and gasification activity of residual carbon in biomass ashes obtained from different gasification technologies, Fuel 254 (115699), 1-9, (2019)

[12] Quintero-Coronel, DA., Lenis-Rodas, YA., Corredor, L., Perreault, P., Bula, A., Gonzalez-Quiroga, A., Co-gasification of biomass and coal in a top-lit updraft fixed bed gasifier: Syngas composition and its interchangeability with natural gas for combustion applications, Fuel 316 (123394), 1-11, (2022)

[13] Kumar, A., Experimental analysis of dual-stage ignition biomass downdraft gasifier based on various gasification media for the generation of high-quality producer gas, Fuel, 361(13070), 1-15

[14] Mutuku, K., Characterization of Physical Properties of Biomass Waste Materials in Kenya for Gasification: Rice Husks and Coffee Husks, International Journal of Engineering Research and General Science, 7(2),20-25, (2019)

[15] Vidian. F, Kholis. A, Performance Small Spark Ignition Engine Using Producer Gas from Coal Gasification : Dual Fuel Operation, Journal of Southwest Jiaotong University,2021, 56(3), 242-247

[16] Vidian, F., Safrialto., Basri, H., Alian, H., Application of Producer Gas from South Sumatera, Indonesia, Low Rank Coal Gasification on Spark Ignition Engine or Gasoline Engine, International Journal of Mechanical and Production Engineering Research and Development (IJMPERD), 2019, 9(5), 611–620.

[17] Vidian, F., Aritonang, A.H., Pinem, S.J.S., Hadi, Q, Experimental Operation of Diesel and Gasoline In Dual Fuel Mode Using Producer Gas From charcoal Gasification, International Journal of Mechanical Engineering and Technology, 2019, 10(2), 80-86.