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Flame Characteristics of Biogas From Coffee Waste Materials

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Abstract. This study aims to hide data or information on pixel image using EOF method and to improve the security of hidden data than combine with cryptography algorithm Modular Multiplication Block Cipher algorithm for the encryption process. The image file used as the test sample consists of 3 types of image types (JPG, BMP, PNG), this file type is the most widely used by users with different width and height as well as various file sizes. The results of this study prove that the data could embed in pixel image using EOF method and the file size of carrier will increase its capacity as byte of embedded text.

1. Introduction

The need for fossil energy such as petroleum continues to increase, on the contrary, its reserves on the earth are running low. Renewable alternative energy is a source of energy produced from energy resources that are naturally endless and sustainable if managed well, for example geothermal, hydropower, wind power, biomass and biogas 1. Indonesia with extensive agricultural area has the potential of various plants that have a large enough waste, namely coffee. In addition, livestock waste is one source of materials that can be utilized to produce biogas. One of the livestock waste that can be utilized as a source of biogas producer is cow dung 2. Biogas is a mixture of several gases, classified as fuel gas which is the result of fermentation of organic material under anaerobic conditions. Biogas contains a number of dominant gases are methane (CH4 50-70%) and carbon dioxide (CO2 30-40%), hydrogen sulfide (H2S 0% - 3%), water (H2O 0.3%), oxygen (O2 0.1% - 0.5%), hydrogen (H2 1% - 5%) and other gases in small quantities3,4. According to Lastella5, concentrations other than CH4 and CO2 are relatively small. In the combustion process, gases other than methane (CH4) will decrease the biogas heat

value and combustion efficiency. So to get a greater calorific value of biogas must be optimized percentage of methane gas (CH4) by reducing other gas main CO2 because its content is greatest after CH4. CO2 gas will be detrimental to the combustion process because in combustion reaction CO2 is a combustion gas product that could not burn again6. Therefore it is necessary to purify biogas process to reduce CO2 content Several studies on purification of biogas have been done. Asadi7 purified biogas with NaOH solution with flame velocity parameter on biogas flame. Purification of biogas by absorption method using KOH solution is done by Hamidi8. In this study the solution of Potassium Hydroxide (KOH) was activated with zeolite stone. The duration of the test and the KOH composition on the zeolite absorber have an effect on the biogas heat value, in which the higher the KOH compound used, the zeolite adsorption capacity is increasing and the longer the testing time of the CH4 and O2 gas content is increased due to the increasing of CO2 and gas H2S is absorbed in biogas.

Parameters to test the fire quality of fuel gas are still widely used relatively expensive equipment, such as compositional tests using Gas Chromatography and gas analysers, or testing calorific values

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with calorimeter bombs. Hadi9 conducted gasification research with variation of AFR to know fire quality of syngas in the form of fire temperature and composition and flammable gas calorific value using calorimeter bomb. Hosseini4 tested the composition of biogas with an ankle gas. The color had used as a quality parameter of biogas flame10, 11. This research was conducted to determine the quality of gas fuel with the thermal characteristics of biogas flame which include fire color and combustion ion compared with biogas composition and calorific value calculation.

2. Research Methods

Biogas as research material obtained from digestor output with main ingredient of coffee skin mixed with cow dung with ratio 1: 1. The biogas reactor as shown in figure. 1 is made up of drums connected with a continuous system, in which materials can be inserted at any time and on other parts, materials that have not produced biogas out. The resulting biogas is accommodated on a drum that is fitted into one with a floating system reactor, where if the biogas starts to form then the drum will be lifted. This system allows biogas to be used for applications directly without having to apply pressure. The biogas from the reservoir was incorporated into several storage plastics of equal volume and then purified by using 1 M and 4 M potassium hydroxide (KOH) solutions. The carbon dioxide (CO2) compositions of biogas before and after purification were measured in composition with gas analyzers and tested its flame with color and ion observation parameters on fire.

The research equipment consists of one unit of biogas purifier circuit which is connected directly to biogas storage plastics. Biogas refining is carried out for 10 minutes for a single test (Fig.1). After the biogas testing process is re-measured volume to know the CO2 that has been absorbed.

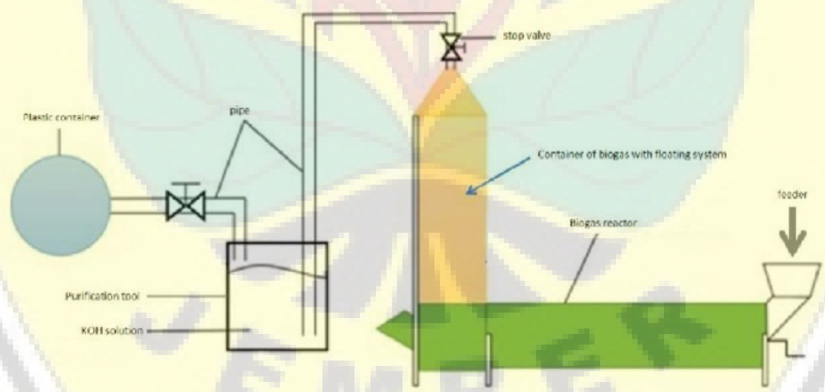

Figure 1. Continuous Biogas Reactor with Floating System Container

From the measurement of the composition, the calorific value of biogas was calculated. The resulting biogas contains H2O in the form of gas/ vapor, so the calculated heat value is Lower Heating Value (LHV). The calculation of LHV is determined by equation according12, namely:

LHV = Hc = H reactants - H products

In biogas used dominant components, namely methane (CH4) and Carbon dioxide (CO2). By using the chemical equation of biogas combustion reaction with air, where x and y are the composition of CH4 and CO2, we use the following equation to calculate the biogas heat value:

$$xCH_4 + y\,CO_2 + (O_2 + N_2) \rightarrow CO_2 + H_2O + N_2$$

Flame testing can be used to determine fuel quality11. In this study, flame testing was used as a bunsen burner as shown in Figure 2 (a). The fire burned on the bunsen burner is recorded with a Fujifilm camera with a resolution of 1280 x 720. The obtained fire is then cut into several images and each image is taken sample data at some point to analyze the percentage of fire color as shown in Figure 2 (b) by using application software13, so that the resulting fire color distribution that can be compared between the fire color red and blue.

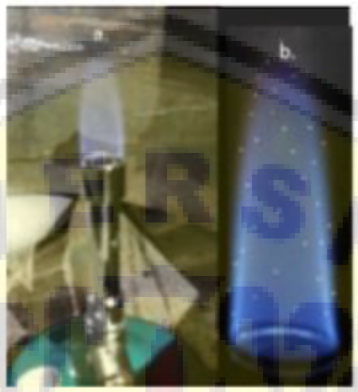

Figure 2. There was a fire on the Bunsen burner: a).bunsen burner; b).measuring the color of fire

The magnitude of the resulting voltage of fire indicating the presence of ions on fire is measured with an sensor ion made of 2 pieces of aluminum foil with a width of 1 cm and a length of 30 cm, which is placed opposite the Hele Shaw Cell at a distance of 1 cm to capture the signal of the ion occurring during The combustion reaction process takes place. The ion sensor scheme is shown in Figure 3.

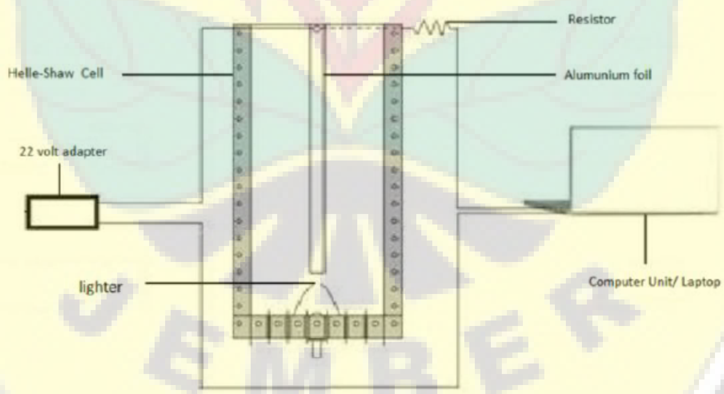

Figure 3. Schematic of ionic sensors in HSC

In Figure 3 it is shown that an aluminum foil ion sensor is connected to an adpator as a current source, a resistor and a cable connected to a laptop that will read and record the voltage generated by fire at biogas combustion in HSC. To know the amount of voltage generated by the fire, used multi-instrument instrument sound virtin. In the application disetting 50x magnification calibration on probe 2 to know the voltage generated by burning ionization. After generating the graph, the voltage is taken the highest value for the data of the ionization voltage of the burning.

3. Experimental Results

A study of the biogas thermal characteristics of coffee leather has been done by purification using KOH 1 M and 4 M with thermal parameters including carbon dioxide, heating, flame, and ionization on biogas flame. The results of the research are biogas composition data, heating value, flame, fire color, and ionic sensors are shown in Table 1-4. Biogas from coffee skin waste produced in this study contains 37.23% CO2, so the content of methane and other impurities around 62.77%. CO2 content decreased, after biogas was purified with KOH 1 M to about 23.01% and decreased again to 18.66% after being purified with KOH 4 M. These results are shown in Table 1.

Table 1. The composition of CO2 and CH4+impurities

Biogas Condition	Average (%)	
	CO_2	CH_4 + Impurities
Not yet purified	37,22	62,77
Purification 1 M	23,01	76,99
Purification 4 M	18,66	81,34

Table 2. Biogas Calorific Value Calculation Result

Biogas Condition	Low Heating Value – LH (kJ/kg)			
	data 1	data 2	data 3	Average
Not yet purified	21775	22358	20876	21670
Purification 1 M	25431	28798	28526	27585
Purification 4 M	29547	30330	29418	29765

Table 3. Percentage of Biogas Fire Color Percentage

Testing number	Biogas Condition	Percentage of Fire Color (%)	
		Blue Fire	Red Fire
1	Not yet purified	57,67	42,33
	Purification 1 M	71,79	28,21
	Purification 4 M	68,81	39,19
2	Not yet purified	63,50	36,50
	Purification 1 M	70,47	29,53
	Purification 4 M	70,39	29,61
3	Not yet purified	60,40	39,60
	Purification 1 M	71,12	28,88
	Purification 4 M	75,86	24,14
4	Not yet purified	74,28	35,72
	Purification 1 M	70,20	29,80
	Purification 4 M	71,12	28,88
5	Not yet purified	54,96	45,04
	Purification 1 M	68,93	31,07
	Purification 4 M	70,20	29,80
Average	Not yet purified	60,16	39,84
	Purification 1 M	70,50	29,50
	Purification 4 M	71,28	30,32

Table 4. Ion Sensor Test Results on Biogas Fire

Biogas Condition	Ion Sensors (Volt) (Average)
Not yet purified	14,69
Purification 1 M	29,18
Purification 4 M	33,08

The content of carbon dioxide in biogas affects the calorific value14, as shown in Table 2, where the table shows the biogas heat values before purification and after purification. Biogas before purification that still contains high carbon dioxide, average calorific value is low enough that only reach 21.670,47 kJ / kg. The decrease of carbon dioxide after purification caused increased heating value, named at 1M KOH purification, the calorific value to 27,585.30 kJ / kg and on KOH purification of 4M calorific value to 29,765,56 kJ / kg. This calorific value will increase with the decrease of carbon dioxide content, to close to 50,144,375 kJ / kg which is the heat value of pure Methane (CH4)15.

Flame is a combustion chemical reaction. Burning is influenced by fuel quality. Carbon dioxide in gas fuel acts as an inhibitor6, 16. One of the parameters that determine the quality of combustion is the fire color11. Carbon dioxide content can be analyzed from flame characteristics including fire color and ionization of biogas fire combustion.

The result of the research has been done that the fire color in three conditions is before purification, after purification KOH 1M and after purification KOH 4 M as shown in Figure 4

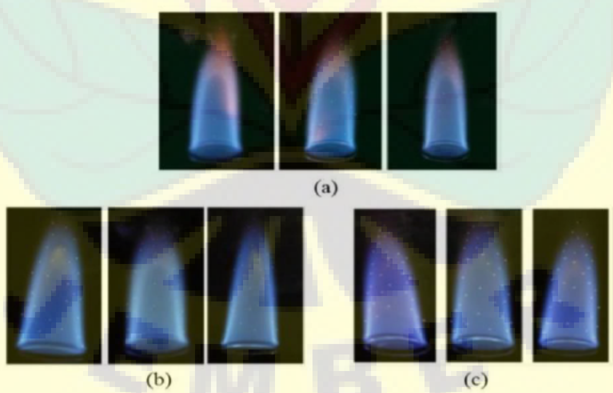

Figure 4. Examples of Biogas Fire: Before purification (a) Purification 1 M (b) and 4M (c)

The picture shows the fire color biogas with three repetitions. In Figure 4.a seen fire biogas before purification, where the fire color is dominated by blue, but the top looks reddish color. From the calculation of the percentage of fire color on the three colors, the average fire blue color on fire before purification is reached 60.16% and the red color is high enough that is 39.84% as shown in Table 2. After purification on biogas, color The flame is shown in Figures 4.b and 4.c. Figure 4.b shows the biogas flame with 1M KOH purification, from which the red flame color looks very little on the inside of the flame and decreases in fire with KOH 4M purification indicated by the percentage of fire color with the percentage Red is 29.5% lower (at 1M KOH purification) and 28.75% (on KOH 4M purification). From this result shows the decrease of CO2 content in the fire causes the combustion reaction to be better indicated by increasingly dominant blue color and decreasing the percentage of red color.

This result is reinforced by the result of the combustion ion, where in the biogas fire before purification where, when the red color is close to 50% (Table 2), the combustion ion shown with the average resulting voltage is about 14.79 volts (Table 3). In biogas fire after KOH 1 M purification, the voltage increased from 14.69 volts to 29.18 volts and in KOH 4 M purification increasing again to 33.08 volts. This shows that fire with high CO2 content causes the combustion reaction to decrease due to collisions of fuel molecules inhibited by CO216 causes the number of ions to decrease as indicated by the decrease of the voltage on the flame. When CO2 decreases, collisions occur more frequently so that more and more ions are formed due to the larger combustion reaction as indicated by the higher voltage on the ion sensor17.

4. Conclusion

Research on thermal characteristics of biogas flame with coffee leather waste with KOH 1M and 4M purification, with the result:

1. Purification KOH quite effectively reduce the carbon dioxide content in biogas, from 37% decreased to 18%.
2. The content of carbon dioxide determines the calorific value of biogas, where the higher the carbon dioxide content the lower the biogas heat value, and vice versa.
3. The quality of biogas fuel can be seen from the testing of flame, where on fire with high calorific value of low carbon dioxide content, the percentage of blue fire color is more dominant. This percentage increases with increasing calorific value.
4. Flame is a chemical reaction, resulting in an ion in a flame capable of conducting electrical current. The greater the combustion reaction, the more ions are formed, so the flow that flows is also higher which is indicated by the voltage captured by the ion sensor is greater.
5. The flame color and voltage of the ion sensor can be used as a parameter to determine the quality of the flame.

References

[1] Immanue, U. 2012. Biomass Potential as Renewable Energy Sources In Indonesia. Http://www.scribd.com [March 11, 2015]

[2] Eliantika. & Efriza, F. 2009. Biogas Cattle Livestock Waste Alternative Green Source Alternative Energy. Bengkulu: University of Bengkulu.

[3] Sugiarto, Oerbandono T., Widhiyanuriyawan D., and Son. 2013. Biogas Purification Continuous System Using Zeolite. Malang: Universitas Brawijaya.

[4] Hosseini S. E., Bagheri G, Khaleghi M., and Wahid M.A. 2015. Combustion of Biogas Released from Palm Oil Mill Effluent and the Effects of Hydrogen Enrichment on the Characteristics of the Biogas Flame. Journal of Combustion, Vol. (2015) 1-13.

[5] Lastella, Testa, Cornacchia, Notornicole, Voltasio and Sharma..Anaerobic Digestion of Semi-Solid Organic Waste: biogas production and its purification Energy Conversion ang management, 43 (2002) 63-75.

[6] Hamidi N., Nasrul Ilminnafik, 2014. Inert Effects of Flammability Limits and Flame Propagation of LPG by CO2, Applied Mechatronics and Materials, 664 (2014) 226-230.

[7] Asadi G. F., N. Ilminnafik, A. Syuhri. Decrease in CO2 in Biogas with NaOH Absorption to Fire Propagation Speed, Journal of Rotor Mechanical Engineering, 7 (2014) 30-34.

[8] Hamidi, N., Wardana, I. N. G., and Widhiya-nuriyawan, D. 2011. Improvement of Biogas Fuel Quality through Purification Process with Natural Zeolite. Malang: Universitas Brawijaya.

[9] Hadi S., dan S. Dasopuspito. 2013. Effect of Air-Fuel Comparison Variations on Fire Quality at Downdraft Reactor Gasification with Continuous Supply of Coconut Biomass Supply. Jurnal Teknik Pomits, 3.2 (2013) 384-387

[10] Ilminnafik N., Frenico A.O. Characteristics of SynGas Fire on Downdraft Gasification with Rice Husk Biomass Material, Journal of Rotor Mechanical Engineering, 9.1 (2016) 15-19.

[11] Ilminnafik N., Setiyawan D.L., Sutjahjono H., 2017. Thermal Characteristic of Flame as Quality Parameter of Biogas of Market Waste, International Journal of Applied Environmental

Sciences, 12.7 (2017) 1379-1385.
[12] Strehlow R. A., 1968. Combustion of Fundamentals, Published by International Textbook Company.
[13] Handoyo, E. D. 2006. Design of Mini Image Editor Version 1.0 as a Supporting Application of Digital Image Processing Lecture. Maranata Christian University.
[14] Harasimowicz, M., P. Orluk, G. Zakrzewska-Trznadel and A.G. Chmielewski. Application of Polyimide Membranes for Biogas Purification and Enrichment. Journal of Hazardous Materials, 144 (2007) 698 - 702.
[15] Wardana, I.N.G. 2008. Fuel and Combustion Technology. First print. Brawijaya University Pres
[16] Ilminnafik N., Nurkholis Hamidi, ING Wardana. 2011. Behavior of Flame Propagation in LPG Premixed with Carbon Dioxide Inhibitors, International Journal of Academic Research.
[17] Akbar, A., Wardana, I., and Yuliati, L. 2014. Influence of HHO Addition on Performance and Ionization of Gasoline Engine Burning. Malang: Universitas Brawijaya.