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Dryness Level Measurement of Coconut Shell Charcoal Briquettes using Plate-shaped Electrodes

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Conference Paper

Dryness Level Measurement of Coconut Shell Charcoal Briquettes using Plate-shaped Electrodes

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ABSTRACT

Briquette dryness level is a benchmark for coconut shell charcoal briquette quality. In this study, the measurement of briquette dryness was studied by measuring the resistance of the briquette using plates attached to the sides of the briquette. Performance of copper plate electrodes was compared with the performance of electrodes made of PCB pieces. Briquette dryness is divided into 3 groups. They are wet, half-dry, and dry. From the measurement results, it was found that the measurement of briquette resistance with PCB plate electrodes was more stable than with copper plate electrodes. Briquettes are declared dry if they have a high resistance or low conductivity.

Keywords: Charcoal, briquette, dryness, plate, electrode

Introduction

Currently, the world is facing an energy crisis due to the decreasing reserves of energy from fossil. One of the green energies that can be used is biomass briquettes from coconut shell charcoal. There are several biological waste materials used to make briquettes. Among them are husks (Nikiforov et al., 2023), sawdust (Gwenzi et al., 2020), and stray (Adam et al., 2021).

In producing briquettes, drying the briquettes is significant. Traditional drying of briquettes is done using solar energy. The time needed to dry briquettes in this conventional method reaches 5 days (Sanchez et al., 2022). In addition to using the sun, drying can also be done using fuel, but this method consumes a lot of energy (Conyette & Ajayi, 2023). The dryness of the briquettes determines the quality of the briquettes. The water content affects the calorific value of the briquettes (Marreiro et al., 2021). Dry briquettes can burn quickly and able to burn for more than 150 minutes. In addition, good briquettes do not emit smoke and leave white ash without cracking. To certify the quality, a burning test is usually conducted. However, the burning test to make sure the quality of the briquette is time-consuming (Prasetyadi et al., 2024b).

One method to determine the dryness of briquettes is to use a scale. Drier briquettes have a lighter mass than wetter briquettes (Prasetyadi et al., 2024b). This is because the water content in dry briquettes is less than that of wet briquettes. Unfortunately, the method is not reliable for differentiating between the almost dry and the dry briquettes. Another way to test dryness is to measure the resistance of the briquettes. Research conducted by Prasetyadi, et al. (20204b) has succeeded in distinguishing 3 levels of dryness of briquettes, namely wet, half-dry, and dry, by measuring resistance using an ohmmeter probe for 2 types of briquettes, namely Rainbow-type (Prasetyadi et al., 2024b) and cube (Prasetyadi et al., 2024a). The weakness of this method is that in measuring one side, measurements are needed for several points. This is because there is a possibility that the water content in the briquettes is not homogeneous. Therefore, in this study, resistance measurements were carried out using a plate mounted on the surface of the briquette. The plate size used is the size of the briquette surface in general. With the plate connected to the

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DC power supply, resistance can be obtained by measuring the current and voltage between the two plates mounted on the two sides of the briquette.

Material and Methods

The diagram block of the dryness level measurement of coconut shell charcoal briquettes using plate-shaped electrodes can be seen in Figure 1.

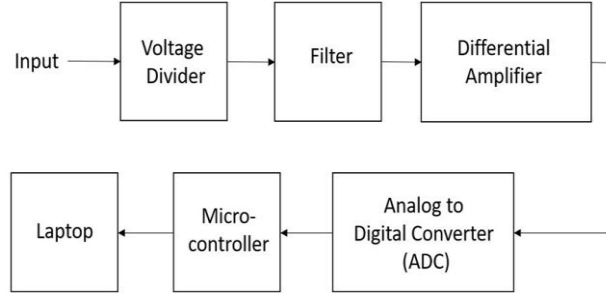


Figure 1. The diagram block of the dryness level measurement of coconut shell charcoal briquettes using plate-shaped electrodes

The dryness level measurement system of coconut shell charcoal briquettes using plate-shaped electrodes consists of a voltage divider, filter, differential amplifier, an Analog to Digital Converter (ADC), a microcontroller, and a laptop. The voltage divider contains the briquette resistance (R_1) measured with a plate electrode in series with R_2 . The circuit is given a voltage input of 5V. Because the measured voltage is still too small, the measured voltage is amplified 10 times with a Differential Amplifier using AD620. The amplified voltage will be filtered to eliminate noise. The voltage divider, differential amplifier, and filter circuits are shown in Figure 2.

The ADC converts the analog voltage to digital codes. In this study, an external ADC was used. This ADC has a greater number than the ADC of the microcontroller. The microcontroller is used to calculate the resistance of the briquettes. For the measurements obtained to be resistant to noise, the voltage measurement results are not directly used to find the current of R_2 and resistance of the briquette, but 30 voltage data points are averaged using the moving average algorithm (Harini et al., 2022)

The V_{avg} is the average voltage of 30 voltage data obtained from the measurement, then the voltage at R_2 can be calculated using equation (1).

$$V_2 = \frac{V_{avg}}{gain} \quad (1)$$

with $R = 10k\Omega$. Then the current value of R_2 is calculated by equation (2).

$$I_2 = \frac{V_2}{R_2} = \frac{V_2}{10000} \quad (2)$$

Using a voltage divider circuit as shown in Figure 2 and a source voltage of 5V, the value of I is calculated using equation (3).

$$I_2 = \frac{5}{R_1 + R_2} = \frac{5}{R_1 + 10} \quad (2)$$

From equations (2) and (3), it can be obtained the value of the briquette resistance (R_1) as shown in equation (4).

$$\begin{aligned}
 I_2 &= \frac{5}{R_1 + R_2} = \frac{V_2}{R_1 + 10} \\
 \frac{V_2}{10000} &= \frac{V_2}{R_1 + 10000} \\
 R_1 + 10000 &= \frac{5 \cdot 10000}{V_2} \\
 R_1 &= \frac{5 \cdot 10000}{V_2} - 10000 = \frac{50000 - 10000V_2}{V_2}
 \end{aligned} \tag{4}$$

The flowchart of the voltage measurement process and briquette resistance calculation is shown in Figure 3.

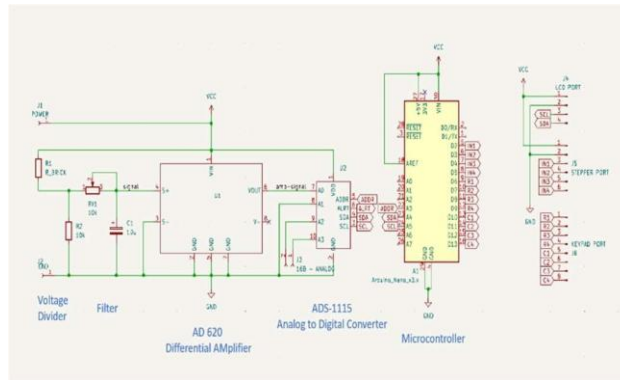


Figure 1. The measurement circuit of the dryness level measurement of coconut shell charcoal briquettes using plate-shaped electrodes

The cube briquettes of 2.6 cm sides are measured for their resistance. The resistances of the briquettes are measured from 3 sides, namely Front-tail, Base-top, and Left-right side, as shown in Figure 4. The resistance value of the briquettes is obtained from the average resistance of the three sides of the briquettes. With R_1 as the total average resistance of the sides, the following values are obtained from equation (5).

$$R_{briquette} = \frac{R_1}{3} \tag{5}$$

As stated in (Prasetyadi et al., 2024a), the dryness of the briquette is expressed by the resistivity with the equation (6).

$$R_e = \frac{RA}{l} \tag{6}$$

Where the R is the material resistance (Ω), R_e is the material resistivity (Ωm), l is the material's length (m), and A is the cross-section of the measured material in the direction of the electric field (m^2). Because the briquettes are cube-shaped, the resistivity value of the briquettes becomes as mentioned in equation (7).

$$R_e = \frac{RA}{l} = \frac{R \cdot L \cdot L}{l} = R \cdot l \tag{7}$$

The conductivity of the briquettes (σ) can then be calculated using equation (8).

$$\sigma = \frac{1}{R_e} \quad (8)$$

The unit of conductivity is S/m.

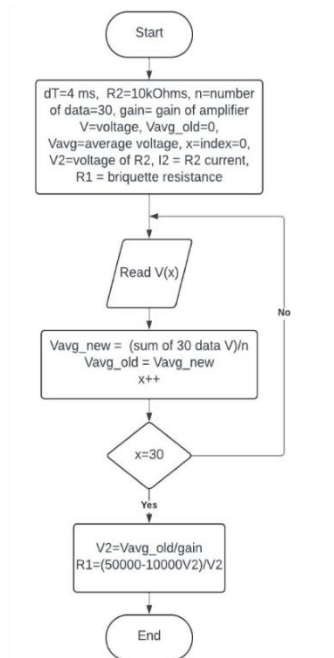


Figure 2. The flowchart of the voltage measurement process and briquette

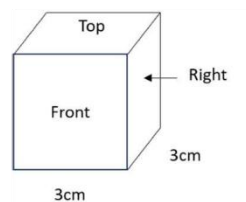


Figure 3. The cube briquette

There are 2 types of plate electrodes used in this study. They are copper plates and PCB pieces, as shown in Figure 5. Both plates are cut to the size of the briquette. The plates are then mounted on the sides of the briquette, as shown in Figure 6.

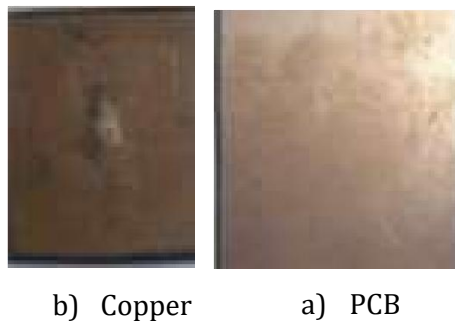


Figure 4. The plate electrodes



Figure 6. Installation of plates on a brigquette

The three conditions for testing the briquette based on the level of dryness are as follows: wet, half-dry, and dry. The briquette that has just finished its molding process is known as the wet briquette. It is regarded as having saturated water content at all parts. The second state is half-dry. It is after the briquettes a day in the oven. The oven room's final temperature is 50°C. The third type is the dry briquette, which is prepared for packaging and cooling to room temperature when it finishes the drying. The process ends with a temperature of 100°C. In the dry conditions, the briquette has 2% water content on average. In addition, the dryness of the briquettes was also measured for rough and smooth surfaces, as shown in Figure 7.

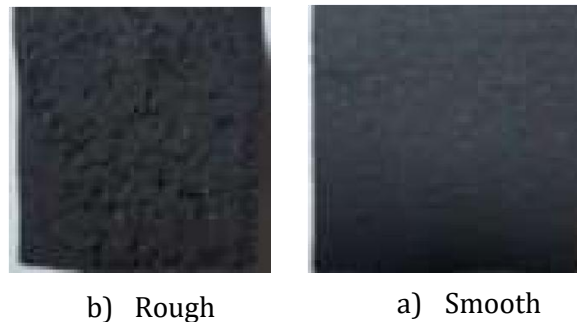


Figure 7. The briquette surface

Results and Discussion

As explained in the method section, based on the level of dryness, the tested briquettes were divided into 3 conditions, namely wet, half-dry, and dry. Each condition has different water content. Therefore, each condition of briquettes has a different mass, as shown in Table 1.

Table 1. Mass of briquette in each condition

Condition	Mass (gram)
Wet	16 - 20
Half-dry	15 - 16
Dry	14 - 15

The results of the implementation of the briquette dryness measurement system are shown in Figure 8. The system consists of plate electrodes mounted on the briquettes, a PCB consisting of a voltage divider circuit, differential amplifier, and filter, a microcontroller, and a laptop used

to display data via a serial monitor. The data displayed on the serial monitor are shown in Figure 9. The dryness level of the briquettes is indicated by the resistance value.

The variables shown in Figure 9 start from the left are V_{avg} , V_2 (V_{sh}), I_2 (I_{sh}), and R_1 (R_{brick}). From the data given in the red box, $V_{avg} = 0.122\text{ V}$ is obtained. Applying gain = 10, so the V_2 , I_2 , and R_1 are obtained using equation (1) – (4) as below.

$$V_2 = \frac{V_{avg}}{10} = \frac{0.122}{10} = 0.0122\text{ V} \quad (9)$$

$$I_2 = \frac{V_2}{10000} = \frac{0.0122}{10000} = 0.00000122\text{ V} \quad (10)$$

$$R_1 = \frac{50000 - 10000}{V_2} = \frac{50000 - 1000 \cdot 0.0122}{0.0122} = 3.99\text{ M}\Omega \quad (11)$$

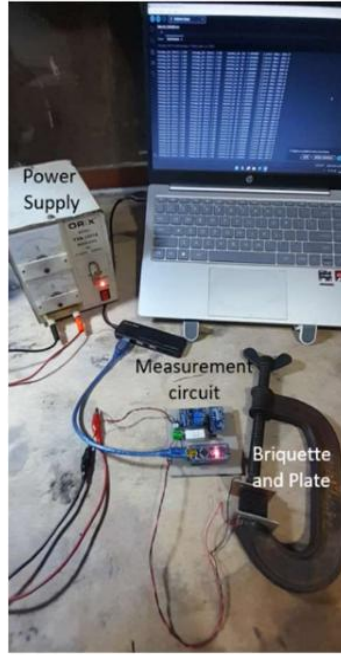


Figure 5. The implementation of the briquette dryness measurement system

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0.122, V_sh: 0.012, I_sh: 0.00000122, R_brick (M): 3.99
0.122, V_sh: 0.012, I_sh: 0.00000122, R_brick (M): 3.99
0.156, V_sh: 0.016, I_sh: 0.00000156, R_brick (M): 3.10
0.176, V_sh: 0.018, I_sh: 0.00000176, R_brick (M): 2.74
0.127, V_sh: 0.013, I_sh: 0.00000127, R_brick (M): 3.83
0.108, V_sh: 0.011, I_sh: 0.00000108, R_brick (M): 4.55
0.127, V_sh: 0.013, I_sh: 0.00000127, R_brick (M): 3.83
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Figure 6. The briquette dryness measurement system that is shown in the monitor

In this study, 2 types of plate electrodes were used, namely copper plates and plates from PCB pieces. The measurement results of both plates are shown in Figure 10.

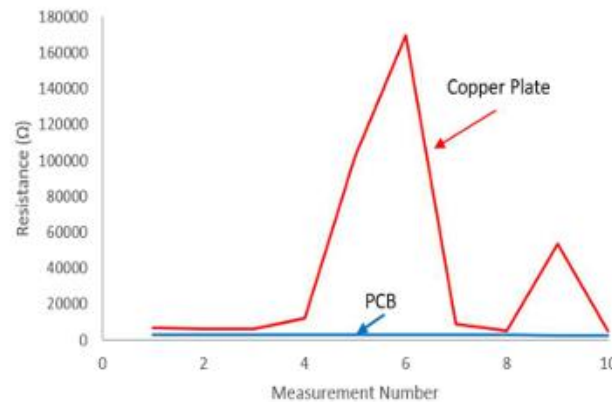


Figure 7 Comparison of the results of measuring the dryness of briquettes using copper plates and PCB pieces.

From the graph in Figure 10, it can be seen that the measurement of briquette resistance using PCB pieces produces more stable results than the measurement of resistance using copper plates. The measurement results using copper plates are very volatile, making it difficult to obtain the correct resistance value. Therefore, the next measurement of briquette resistance uses PCB pieces.

Briquette dryness measurement was conducted to determine the wet, half-dry, and dry categories. Each category was tested for 2 samples. Each sample was measured for 3 different sides. They are front-tail, base-top, and left-right side as shown in Figure 4. Each side of the briquette was measured 30 times and then averaged (V_{avg}). Ten data of V_{avg} were then averaged, and the data obtained were as shown in Table 2. Furthermore, the results of the three sides of the measurement will be averaged to obtain the briquette resistance value. The results of the briquette dryness measurement are shown in Table 2.

Table 2. The resistance value of the briquette

Condition	Sample Number	Resistance Value (KOhm)			
		Smooth Side		Rough Side	Average
		Front-tail	Base-top	Left-right	
Wet	1	2.86	2.87	2.86	2.87
	2	3.58	2.86	2.86	3.10
Half-dry	1	23.58	47.46	47.25	39.43
	2	88.42	88.42	88.42	88.42
Dry	1	384.78	1,834.16	384.78	867.91
	2	592.60	1,543.66	1,561.53	1,232.60

From the table, it appears that the briquettes in the wet category have the lowest resistance, which is below 5kΩ. The briquettes in the half-dry category have a resistance of tens of kΩ, while the briquettes are declared dry if they have high resistance. In this measurement, the resistance obtained was hundreds of kΩ, even reaching Mega Ω. From the table, it appears that the roughness of the briquette surface does not affect the measurement. As long as the water content on the surface is the same, the resistance value obtained is also the same. If the briquette surface is equally smooth, but the water content contained in it is different, then the measured resistance

value is also different. Therefore, to determine the resistance of the briquette, an average of the resistance values from the three sides is taken, namely Front-tail, Base-top, and Left-right side.

This category division is shown in Figure 11. It can be seen in the figure that the dry category briquettes have high resistance, far from the resistance in the other two categories. This shows that by measuring the resistance of the briquettes, the quality of the briquettes can be determined. In this case, dry briquettes are the desired product.

Table 3 shows the resistivity and conductivity values of the briquettes. The resistivity of the briquettes follows equation (7), while the conductivity of the briquettes follows equation (8). Wet briquettes have the highest conductivity, which is above $1.2 \cdot 10^{-2}$ S/m, while dry briquettes have the lowest conductivity. This confirms the assumption that the water content in the briquettes that have pores affects their conductivity. This confirms that the dryness level measurement of coconut shell charcoal briquettes can be carried out by measuring the resistance of the briquettes using Plate-shaped Electrodes.

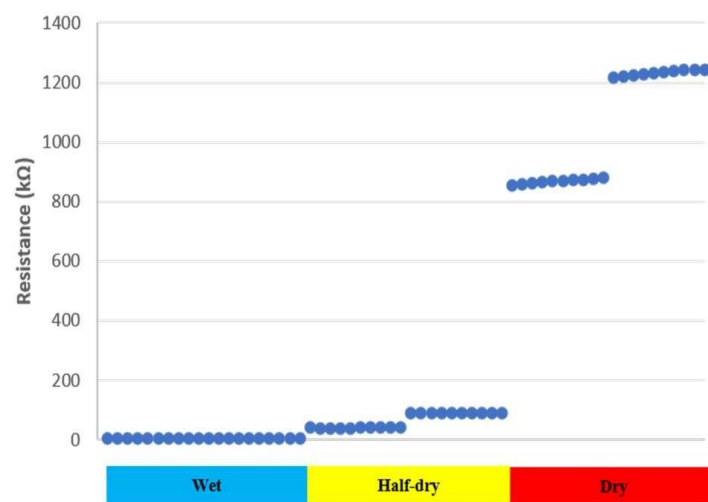


Figure 8. Comparison of the results of measuring the dryness of briquette categories

Table 3. The resistivity and conductivity of the briquette

Condition	Sample Number	Resistance Value (kΩ)	Resistivity (kΩ.m)	Conductivity (S/m)
Wet	1	2.87	0.07	$1.34 \cdot 10^{-2}$
	2	3.10	0.08	$1.24 \cdot 10^{-2}$
Half-dry	1	39.43	1.03	$9.75 \cdot 10^{-4}$
	2	88.42	2.30	$4.35 \cdot 10^{-4}$
Dry	1	867.91	22.57	$4.43 \cdot 10^{-5}$
	2	1,232.60	32.05	$3.12 \cdot 10^{-5}$

Conclusion

The quality of coconut shell charcoal briquette production can be determined by the level of dryness of the briquette. Measurement of the level of dryness of coconut shell charcoal briquettes can be done by measuring the resistance of the briquette using a plate-shaped electrode. Plates made of PCB cut material have more stable measurement results compared to measurement results using copper plates. Dry briquettes have the highest resistance, which is in the order of hundreds of kilo Ohms, even Mega Ohms. The conductivity level of dry briquette is the smallest compared to wet or half-dry briquette.

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The Alana Hotel & Convention Center – Solo, Surakarta, Jawa Tengah

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