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The analysis of ignition and combustion properties of the burning briquettes made from mixed biomass of rice husk and corn cob

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Abstract. This research aims to determine the characteristics of briquettes made from charcoal mixed with rice husk and corn cobs. The test that has been done is to determine the ignition and combustion properties of the burning briquettes that have been produced. The test of the time duration of briquette ignition is divided into two, the first is the time duration of burning briquette to boil one liter of water and the second is the time needed for the burning briquettes which is started when the briquette is burned until it has come into the ash. Correlation between the time duration of the boiling water in the furnace and the briquettes combustion temperature was also observed. The next step is the analysis of carbon monoxide (CO) emissions from its combustion and the quality of the carbonization furnace, and also calculates the thermal efficiency value of the carbonization furnace. The resulting briquettes can be implemented and can be used as an alternative fuel for economic and environmentally friendly in the community.

1. Introduction

Biomass is a renewable source of fuel derived from biological materials and modified anthropogenic material such as agricultural and industrial waste and municipal waste [1]. Burning using biomass does not damage the atmosphere. Many authors emphasize carbon neutrality, where the emissions of carbon from the combustion of these materials are balanced by capturing carbon in the next planting period [2].

Biomass energy from agricultural waste, especially rice husks have long been known to the public, but its limited to the household and small-scale industries. The use for various sectors in the modern application is still quite a bit compared to the existing potential source such the coal, due the rice husks are considered to have a low value in efficiency.

Rice husk is the outer part of the rice grain which is a byproduct of the milling process. About 20-30% of the weight of the rice grain is the rice husk, according to the Ministry of Agriculture 1 kg of rice husk has a heating value of 3300 Cal/g [3]. There are several ways to increase the heating value



such as mixing the rice husk with corn cobs which have higher heating value, the densification process, and the torrefaction process. The biomass densification process generally consists of drying and reducing particle size. Whereas to increase the heat value, the torrefaction process is one of the right choices. The torrefaction of the rice husk can hold more than 70% carbon in rice husks, even though oxygen in rice husks is delowficient [4]. The combination of the densification and torrefaction processes will produce high-quality biomass solid fuels in the form of briquettes.

This study aims to find out the best alternative of solid fuel in the form of charcoal briquettes, such as bio-briquettes that can be made from mixed agricultural wastes. By using the appropriate percentage of the composition ratio and chosen the right particle size will produce better quality briquettes, and also expected to have the low in CO emissions.

2. Materials and methods

2.1. The process of making charcoal material

The material used in this study is dried rice husk as the base material for making briquettes which are added with teak sawdust and coffee bark powder. Water and tapioca flour are used as adhesive materials for making briquettes. The first step is the carbonization process, the dry test materials are placed in an electric furnace equipped with a temperature controller and carbonized at a certain temperature. The speed of the furnace temperature rise is 10 °C/min from room temperature (29 °C) until the desired temperature is reached in the range of 100 °C - 250 °C. The duration of carbonization is varied, 1, 2, and 3 hours depending on the moisture content of each material. The second stage is drying the charcoal using a temperature of 50 °C in an oven for 1 hour. The third stage is refining charcoal particle size using the sieve of 40 and 100 mesh.

2.2. The bio-briquette making process

The stages of making biobriquette consist of making adhesive material from a mixture of water and tapioca flour. A comparison of the concentration of rice husk base material with mixing material (100:0, 70:25, 50:50). The sample name of the many briquettes composition selected in this experiment is shown in table 1 below.

Table 1. The composition of the rice husk and corn cob.

Name of sample	Rice Husk (%)	Corn Cob (%)	Sieve Size (Mesh)
A1	100	0	40
A2	75	25	40
A3	50	50	40
B1	100	0	100
B2	75	25	100
B3	50	50	100

The cylindrical briquette printing with a height of 7 cm and a diameter of 4 cm in the middle hollow cylinder. Finally, pressing briquette using a 45 kg weight, and drying the briquette in an oven for 4.5 hours at 50 °C.

2.3. Characterization of bio-briquettes

Characterization of bio-briquette materials carried out using thermal test, water heating value using briquette stove, and carbon monoxide (CO) gas emission test:

2.3.1. Thermal test. The thermal test is an essential part of qualification and characterization programs for virtually all heat-sensitive products and materials. In this case, the thermal test is done by determining the combustion rate of each briquette. The weight of the initial mass of the briquette has

to be measured first. After the bottom of the briquette is burned, then insert the briquette into the combustion container and let the briquette burn out. During the combustion of the briquettes, the temperature of the combustion was observed using an infrared thermometer. The change was observed for every 2 minutes until the briquettes tested were burned out. The calculation of the combustion rate of briquettes done by using these equations (1) and equation (2).

$$\text{Combustion rate} = \text{Burning briquette mass (g)} / \text{Burning time (minutes)} \quad (1)$$

$$\text{Burning briquette mass (g)} = \text{Initial briquettes mass} - \text{Remaining briquette mass} \quad (2)$$

2.3.2. *Briquette test for boiling 1 liter of water.* The procedure for determining the calorific value (Q) can be known by boiling 1 liter of water using briquette fuel as follows:

- weighing the mass of briquettes,
- prepare 1 liter of water,
- put the burnt briquettes on the briquette stove,
- d.put a pan containing 1 liter of water on the briquette stove,
- e.record the temperature of water and coals every 2 minutes until the water boiled and the maximum temperature is reached,
- f.continue to record until the briquette burns out,
- g.measure the ash mass and the water mass after the water boiled process.

Each substance has a different heat quantity to increase the temperature of a certain mass. The calculation of heat given to substances as shown in equation (3).

$$Q = m.c.(t_2 - t_1) \quad (3)$$

where: Q is calories needed (J), m is mass (kg), c is specific heat capacity (J/kg•C) and (t₂-t₁) is temperature difference (°C).

2.3.3. *Carbon monoxide (CO) emission test.* Testing of carbon monoxide gas emissions from briquettes that have been made is done by burning them. First, weighing the initial mass of briquettes to be tested is ± 80 grams. The bottom briquette is burned first, then put the briquette into the combustion container and let the briquette burn out. During the combustion of carbon monoxide gas emissions, it was observed with the carbon monoxide gas sensor for every 2 minutes change.

3. Results and discussion

3.1. Thermal test results of the briquettes

In this test, the initial mass of briquettes and the mass after being ash is measured, the difference between these two is the material that has been burned and the burning time can be observed as seen in table 2.

Table 2. The mass of briquettes tested versus burning time.

Parameter	Samples					
	A1	A2	A3	B1	B2	B3
Initial briquette Mass (g)	80	79	78	82	82	76
Remaining briquette Mass (g)	46	34	27	37	26	18
Burning briquette mass (g)	34	45	51	45	56	58
Burning Time (s)	3960	5760	6600	5040	6240	6000

From the results, the combustion of briquettes obtained the data of temperature and combustion time. The results of the measurement of the combustion temperature of briquettes are taken for every 2

minutes until the briquette changes to ash. The observations of the burning duration are shown in figures 1 and 2.

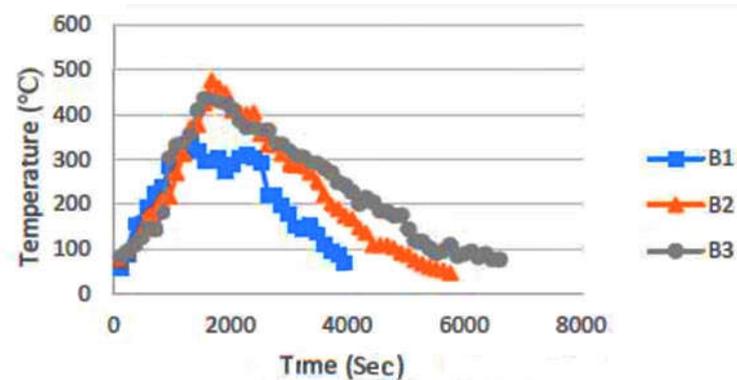


Figure 1. Graph of temperature versus briquettes burning time at 40 mesh particle.

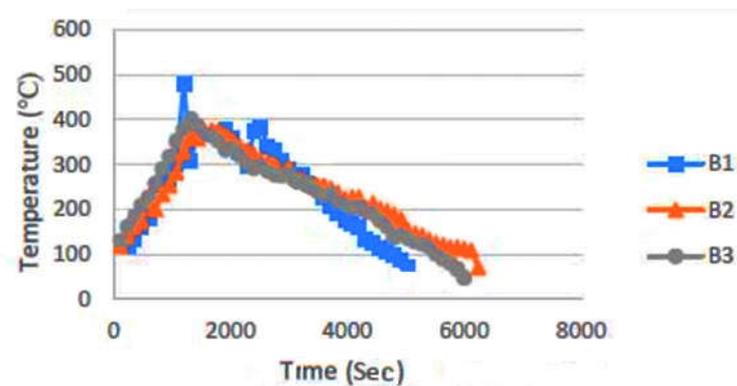


Figure 2. Graph of temperature versus briquettes burning time at 100 mesh particle.

Based on figures 1 and figure 2 it can be seen that the combustion produces temperatures that are getting higher and higher, each briquette has a maximum temperature. After reaching the maximum temperature, the combustion temperature will decrease, which indicates that the combustion starts to stop. The briquette with a sample name A2 reaches a maximum temperature of 475.17 °C. The briquette with sample name B3 reaching the maximum temperature at 401.07 °C. These data show that the particles size can affect the combustion temperature, as seen in the sample A3 & B3, whereas the temperature of A3 is higher than B3 but need more time to achieve.

3.2. Water boiling test

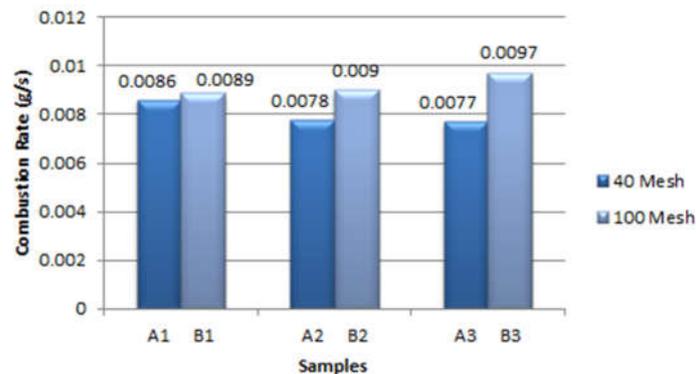


Figure 3. Combustion rate against particles size.

From the six samples in figure 3, the briquettes that have large particles at 40 mesh (B1, B2, B3) have a higher average combustion rate. The highest combustion rate is obtained on sample B3 with a composition of 50:50 and particles of 100 mesh equal to 0.0097g /s.

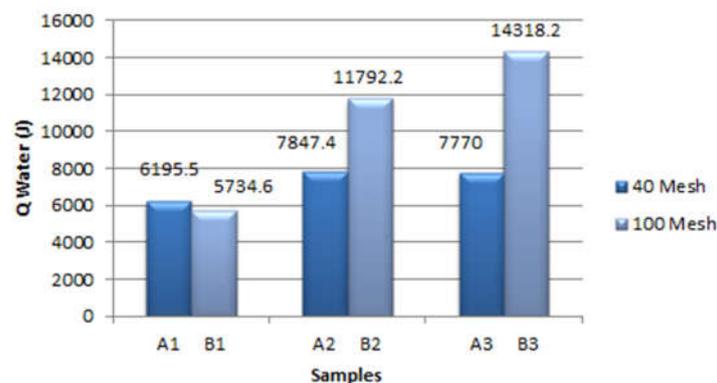


Figure 4. Heat received by water against briquettes particles size.

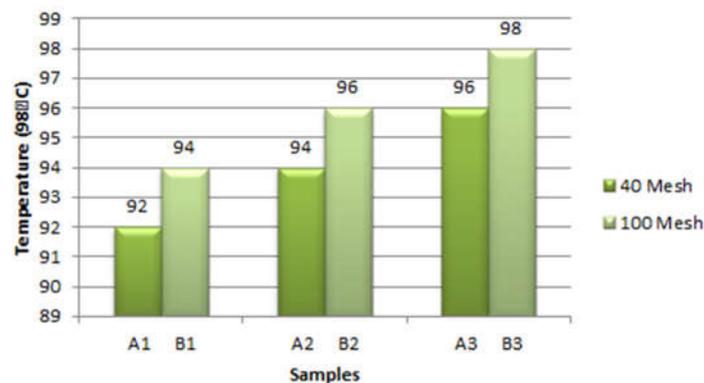


Figure 5. Temperature received by water against briquette particles size.

In figure 4 and 5, the maximum temperature (98°C) and the maximum amount of heat received by water (14,318.18 J) are at composition B3. From both of these figures, the differences in composition ratio are no significant effect on maximum temperature & the amount of heat (Q) received by water.

3.3. Carbon monoxide emission

In table 3 shown, the carbon monoxide was 783 ppm at particles size of 100 mesh but slightly reduced to 632 ppm at particle size 40 mesh. The reduction of ppm value is because smaller particles (100 mesh) have more porosity to hold more oxygen efficiently; hence the combustion perfectly happen. Even though there are differences in composition ratios, the effect was insignificant.

Table 3. CO emission and particles size in correlation with the composition ratio.

Compositions	Sample	Particle Size (Mesh)	CO Emission (ppm)
Rice husk: Corn cob (75:25)	A2	40	632
	B2	100	783
Rice husk: Corn cob (50:50)	A3	40	621
	B3	100	765

4. Conclusions

The advantages of using smaller particles size (in this case: 100 mesh), will increase the combustion rate, increase the temperature achievement in Water Boiling Test & increase the amount of heat (Q) received by water, but also increased the CO emission.

The CO emission could be attributed to the fact that the amount of carbon monoxide is a function of the availability of oxygen during briquettes burning process. Therefore, it cannot be reduced by densification and torrefaction. Even though there are differences in composition ratios, the increasing or decreasing of CO emission that affected by the differences were insignificant.

The briquettes sample B3 that has a composition of 50:50 of rice husk & corn cob, and by using particles of 100 mesh is the best sample in results and ready to apply in a household community and the industrial sector.

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Acknowledgments

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