

Characteristics of Charcoal Briquettes from Rice Husk Waste with Compaction Pressure Variations as an Alternative Fuel

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ABSTRACT

The availability of increasingly scarce fossil fuels causes high fuel prices, so alternative fuels are needed to reduce the use of fossil energy. Briquettes are an alternative energy that can be made from biomass, one of which is rice husk. The quality of the briquettes was determined by the material, the type of adhesive, and the strength of the briquette pressure. The briquette pressure will affect the mechanical properties of the briquettes such as density, stability and durability of the briquettes. This study aimed to determine the features of rice husk charcoal briquettes with variations in compacting pressure as an alternative fuel. The compaction pressure used in this study was 3 tons, 5 tons, and 7 tons. In general, the briquettes produced from this study can be used as an alternative energy source in terms of the resulting combustion temperature which ranges from more than 300–500 °C. The combustion rate obtained shows that the briquettes with a compaction pressure of 3 tons have a high combustion rate value of 0.553 g/minute, while the briquettes with a compaction pressure of 5 tons and 7 tons have a low combustion rate value of 4.20 g/min and 0.418 g/minute respectively. Therefore, the best quality briquettes from this study were the briquettes with a compaction pressure of 5 tons and 7 tons, so that they could be considered as alternative energy for wood and fossil fuels for energy needs in the domestic industry.

Keywords: alternative fuel, briquettes, compacting pressure, rice husk, quality of briquettes.

INTRODUCTION

The problem of energy for human survival is a complex issue in many countries in the world today. The need for energy which has so far been supplied by fossil energy continues to decrease, forcing people to innovate in responding to it. The increasingly scarce availability of fossil fuels leads to high fuel prices; Therefore, alternative fuels are needed to reduce the use of fossil energy (Sunardi, et al. 2019).

There are quite a lot of renewable alternative energy sources available, including organic waste and biomass. Some of the biomass that has considerable potential are rice husks, wood waste, coconut shells, and other agricultural wastes (Werther et al. 2000). Biomass and energy crops are important energy sources that can meet future energy demands by utilizing their residues for the production of solid fuels (Sotanne, et al. 2010).

Biomass can be processed and used as an alternative fuel, such as briquettes. Briquettes are charcoal made of soft and hardened materials (Ramadhini et al. 2021). They are solid fuels that contain carbon and have a high calorific value and can burn for a long time (Onukak et al. 2017). Briquettes can replace the use of firewood the consumption of which is starting to increase. In addition, the price of briquettes is relatively affordable by the community (Sunardi, et al. 2019).

Rice is the largest agricultural commodity in Indonesia; this industry produces rice husks as biomass waste. About 20% -30% of the results of rice milling is rice husk waste (Patabang 2012). Rice husk is a waste of agricultural biomass derived from the rice milling process which has not been utilized optimally (Qistina et al. 2016; Ramadhini et al. 2021). Converting rice husks as a waste material into fuel such as briquettes can further increase the economic value of rice husks (Suryaningsih et al. 2019).

The quality of the briquettes is determined by the material, the type of adhesive, and the compressive strength of the briquettes (Aljarwi et al. 2020). The briquetting process is carried out by applying a certain pressing pressure so that it can be formed into briquettes. The amount of pressure in the briquetting process greatly affects the quality of the resulting briquettes. The briquette pressure will affect the mechanical properties of the briquettes, such as density, stability and durability of the briquettes (Suryaningsih and Nurussyifa 2020). Several characteristics of biomass need to be studied to make plans and treatments for its use as a bioenergy feedstock (Suryaningsih and Nurhilal 2018).

This study aimed to determine the effect of variations in the pressure of molding rice husk briquettes on the quality of the resulting briquettes so that they can be considered as alternative fuels. Variations of compaction pressure used in this study were 3 tons, 5 tons and 7 tons.

EXPERIMENT

Tools

The tools used in this study were rice husk charcoal grinding machines, biomass stoves, dough containers, briquette dough mixing machines, pneumatic briquette press with a capacity of 30 tons, Memmert electric ovens, digital scales, weighing cup, 12 channel thermocouple, perforated iron plate, and caliper.

Materials

The materials used in this study included rice husk charcoal powder obtained from agricultural

areas around Merauke Regency, South Papua, Indonesia; tapioca flour; water; and a lighter for a test burn.

Preparation of materials and tools

The materials used in this study were rice husk charcoal powder as a basic ingredient, tapioca flour and water as an adhesive for briquette dough. Tapioca flour used was 20% and water used was \pm 80% of the mass of rice husk flour. Rice husk flour was obtained from the coagulation and grinding process of rice husk charcoal obtained in the area around Merauke Regency, South Papua Province, Indonesia. The ingredients for the briquette dough, namely rice husk charcoal powder and adhesives, are shown in Figure 1.

The equipment used in this study was a biomass furnace and equipment for making adhesive mixtures, a mixer with a screw to homogenize the briquette mixture, and a hydraulic briquette press to print briquettes.

Briquette making

The briquette dough that has been made was then printed using a hydraulic press machine. The briquette mixture was placed in a cylindrical mold and then flattened until the mold was completely filled. The dough was then pressed with a compaction pressure of 3 tons, 5 tons and 7 tons. After compaction, the dough was pressed out until briquettes are obtained which are ready to be dried. The next stage was drying the briquettes which are exposed to the sun for 7 days to dry (Suryaningsih and Nurhilal 2018). The process of pressing the dough and printed briquettes is shown in Figure 2.



Figure 1. Briquette dough ingredients: (a) rice husk powder and (b) adhesive mixtures



Figure 2. One of the stages of making briquettes: (a) dough pressing; and (b) printed briquettes

Briquette quality testing

The dried rice husk charcoal briquettes were then measured for their physical properties a combustion test was carried out to determine the duration of combustion, the maximum temperature that can be achieved, and the speed of combustion to determine the potential of rice husk briquettes as alternative energy.

Physical properties of briquettes

The physical properties of rice husk charcoal briquettes observed in this study were the mass of the briquettes, briquette diameter, briquette height, density/density, and water content. The mass of the briquettes was obtained by weighing the briquettes before and after drying. The diameter and height of the briquettes are obtained by measuring using a caliper. Density (ρ) and water content are calculated by Equation 1 and Equation 2, respectively.

$$\rho = \frac{m}{V} \quad (1)$$

where: ρ – density (g/cm^3);

m – mass (g);

V – volume (cm^3).

$$\text{Moisture content} = \frac{x_1 - x_2}{x_2} \times 100\% \quad (2)$$

where: x_1 – initial mass (g);

x_2 – mass after drying (g).

Burning time and temperature

The length of time was calculated using a stopwatch every 5 minutes and the combustion temperature was measured using a thermocouple

until the briquettes burn to ashes, the temperature recorded on the thermocouple display was recorded as the combustion temperature.

Burning rate

The briquette burning rate is calculated using Equation 3.

$$\text{Burning rate} = \frac{\text{burnt mass of briquettes (g)}}{\text{burning time (min)}} \quad (3)$$

RESULTS AND DISCUSSION

Physical properties of briquettes

The briquettes produced from variations in compacting pressure of 3 tons, 5 tons and 7 tons have a cylindrical shape as shown in Figure 3. The physical characteristics of the printed husk charcoal briquettes are shown in Table 1.

The data in Table 1 shows that the mass of wet briquettes, namely immediately after being printed, shows a decreasing trend as the compacting-pressure was increased. The average mass values of wet briquettes were 110.78 g, 94.22 g, 91.33 g, respectively, and decreased to 73.78 g, 62.67 g and 62.22 g after being dried in the sun for 7 days. The highest mass value in this study was obtained at a pressure of 3 tons, namely 73.78 g, while the lowest mass was obtained from a compacting pressure of 7 tons. This was thought to be related to the input mass of the dough before compacting which was less uniform, so that it has an impact on the mass of the briquettes. The reference for determining the input of the briquette dough to be



Figure 3. Physical appearance of the rice husk charcoal briquettes with a compacting pressure of 3 tons, 5 tons and 7 tons

Table 1. Average physical properties of rice husk charcoal briquettes

Compacting pressure (ton)	Mass before drying (g)	Mass after drying (g)	Diameter (cm)	Height (cm)	Density (g/cm ³)	Moisture content (%)
3	110.78	73.78	5	5.09	0.74	7.62
5	94.22	62.67	5	4.48	0.71	7.37
7	91.33	62.22	5	4.40	0.72	6.72

printed was only seen when the dough has filled the mold, so it was suspected that there are parts that have low density which can reduce the mass of the printed briquettes. According to Pambudi et al. (2018), the greater the pressure applied, the more particles will be forced to fill the empty cavities, thereby reducing the porosity of the briquettes.

The average value of the height of the briquettes produced with variations in compacting-pressure of 3 tons, 5 tons and 7 tons was 5.09 cm, 4.48 cm and 4.40 cm, respectively, with a diameter of 5 cm for all variations of compacting pressure. The average density value of briquettes in this study tends to be the same in the range of 0.71–0.74 g/cm³. Although, in general there was a downward trend in the briquette density value as the compacting pressure increases. The density values in this study met the standards for briquette density values set by America and Japan with density values of 1 g/cm³ and 1–2 g/cm³ respectively. (Rahmat and Suharjadinata 2022; Rahmawati et al. 2020; Suprapti and Ramlah 2013).

The results of the water content test in Table 1 show that the water content has a decreasing trend as the compacting pressure increases. The highest water content was obtained in the briquettes with a compaction pressure of 3 tons, namely 7.62%. In turn, the lowest water content

was obtained in the briquettes with a loading pressure of 7 tons, namely 6.72%. In general, the average moisture content in the briquettes obtained in this study met the briquette requirements specified by the Indonesian standard (SNI) of 8% and the Japanese standard which required a moisture content of 6–8% (Rahmat and Suharjadinata 2022). The water content in the briquettes was expected to be as low as possible to produce high calorific values and will produce combustible briquettes. The lower the water content, the higher the calorific value and combustion power (Sunardi, et al. 2019).

Burning time and temperature

The process of testing combustion power which includes the length of time and combustion temperature was carried out on 3 groups of rice husk briquettes with a total of 27 briquettes, as shown in Figure 4.

The graph of the results of the rice husk briquettes flammability test with variations in compacting pressure of 3 tons, 5 tons, and 7 tons can be seen in Figure 5. On the basis of the results obtained, it can be seen that the time required for all the briquettes to burn to ashes was 295 minutes for the three pressure variations. The burning time of the briquettes in this study was longer

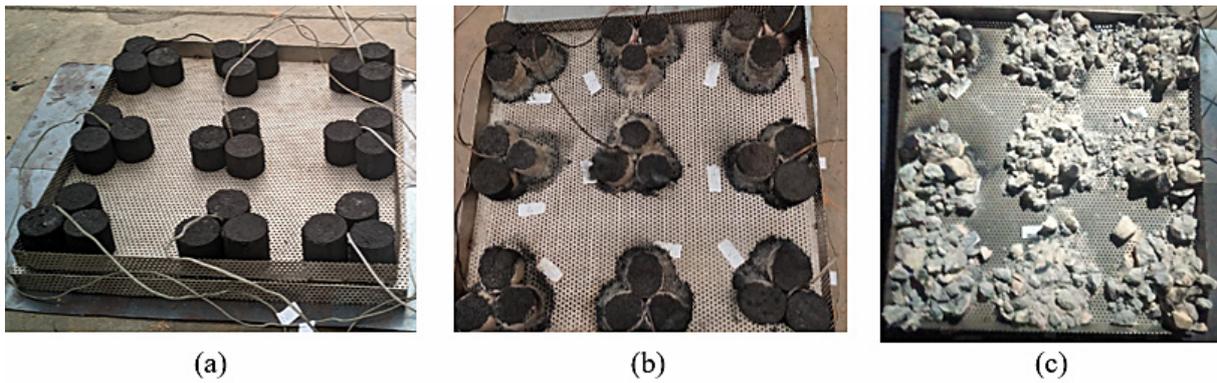


Figure 4. Changes in conditions of rice husk charcoal briquettes at different compacting pressures during combustion testing: (a) initial conditions; (b) briquettes start to smolder; (c) briquette burning ash

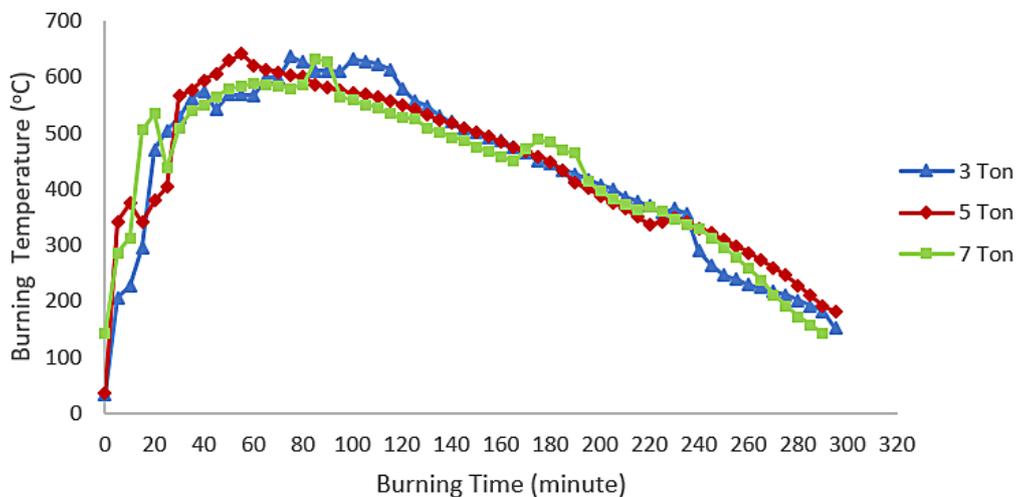


Figure 5. Burning time to ashes from rice husk charcoal briquettes of different compacting pressures

when compared to some previous studies, for briquettes made from rice husks (Suryaningsih et al. 2019; Ramadhini et al. 2021), woods (Syarif et al. 2021), as well as coconut shells (Jamilatun 2008; Patandung and Silaban 2017).

The briquette burning test process was limited to a recorded temperature of 300 °C as the optimum temperature for burning briquettes. Combustion of briquettes has a maximum temperature requirement that ranges from 300–500 °C (Nurochman in Ismayana and Afriyanto 2011). When the measured combustion temperature was below 300 °C, the combustion temperature does not meet the maximum temperature requirements. The temperature under the maximum combustion temperature requirements recorded during the test for each compacting pressure of 3 tons, 5 tons, 7 tons was 289.93 °C (240th min), 298.3 °C (255th min), 296.17 °C (255th min), respectively. On the basis of the data obtained, it can be seen that the briquettes with a compacting pressure of

5 tons and 7 tons have a longer burning resistance than the briquettes with a compacting pressure of 3 tons at a maximum combustion temperature of 300–500 °C, which was ± 15 minutes apart.

The data in Figure 5 also shows that the highest combustion temperature that can be achieved when burning briquettes with a compacting pressure of 3 tons was 636.03 °C, namely in the 75th min, while the lowest temperature was 151.67 °C in the 295th min, the average maximum temperature that can be achieved during combustion was 641.8 °C in 55 min and the lowest temperature was obtained at the end of burning 180.9 °C. In turn, the maximum temperature that can be achieved by the briquettes with a compacting pressure of 7 tons was 630.97 °C in the 90th min while at the end of the combustion, a temperature of 142.6 °C was obtained. The temperature value affects the quality of the briquettes. The higher the temperature, the better the burning time of the briquettes (Ramadhini et al. 2021). On the

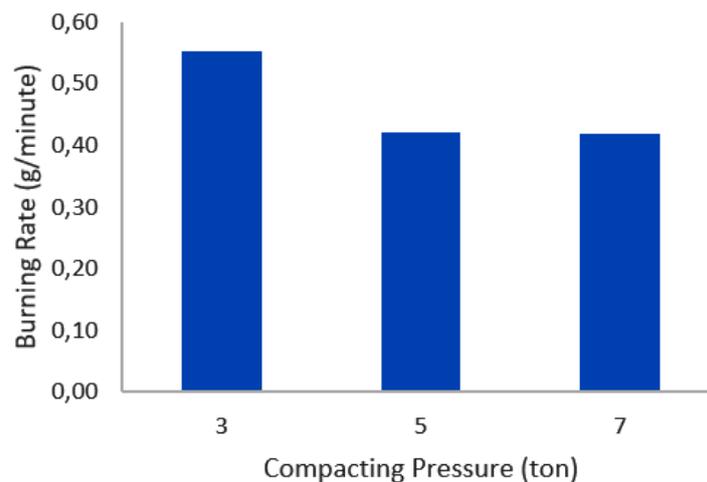


Figure 6. Burning rate of rice husk charcoal briquettes at different compacting pressures

basis of the results obtained, it can be seen that the highest combustion temperature occurs in the briquettes with a loading pressure of 5 tons and the lowest temperature was obtained in the 7 ton briquettes. In general, the combustion temperature achieved in this study met the optimum briquette burning temperature of 300–500 °C.

Burning rate

The briquette burning rate was the mass of the briquettes that are burned for a certain time. This test was conducted to determine the effectiveness of a fuel (Siki 2019). The burning rate of rice husk briquettes with variations in compacting pressure of 3 tons, 5 tons and 7 tons was carried out in the open air. The results obtained from calculating the burning rate of rice husk briquettes in this study can be seen in Figure 6.

The combustion rate obtained ranged of 0.418–0.553 g/min, and showed a decreasing trend with increasing compacting pressure. The briquettes with a compacting pressure of 3 tons had the highest burning rate (0.553 g/min). Meanwhile, the lowest burning rate was obtained from the briquettes with a compacting pressure of 7 tons (0.418 g/min), which was similar to a pressure compacting of 5 tons (0.420 g/min). Slow combustion rates are considered as fuels because the small amount of fuel required (Davies and Abolude 2013). The burning rate of briquettes was determined by the heating value and moisture content, material structure, bonded carbon content, and the hardness level of the briquettes (Jamilatun 2008; Putri and Andasuryani 2017; Rahmadani, Hamzah, and Hamzah 2017). The rate

of combustion will tend to decrease as compaction pressure increases (Amrullah, et al. 2020).

CONCLUSIONS

On the basis of the conducted research, it can be concluded that in general the resulting briquettes can be used as an alternative energy source in terms of the resulting combustion temperature which ranges from more than 300–500 °C. Meanwhile, the longest burning duration was obtained from the briquettes with a compacting pressure of 5 and 7 tons. The combustion rate obtained shows that the briquettes with a compacting pressure of 3 tons have a high combustion rate value of 0.553 g/min, while the briquettes with a compacting pressure of 5 tons and 7 tons have a low combustion rate value of 0.420 g/min and 0.418 g/min, respectively. Therefore, the best quality briquettes from this study were briquettes with a compacting pressure of 5 tons and 7 tons so that they could be considered as alternative energy for wood and fossil fuels for energy needs in the domestic industry. However, it was necessary to carry out further tests directly on the domestic industry, for example in the rice drying industry, which is widely available in Indonesia.

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