Parameter Variation of Microwave Torrefaction Time of Blotong and Bagasse Briquettes

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Abstract. Briquettes are one way to increase the economic value of biomass. Blotong and bagasse are two biomass wastes that can pollute the environment if stored for an extended period of time. This study aimed to determine the effect of torrefaction time on the heating value of briquettes, moisture content, and the number of organic carbons. Blotong and bagasse microwave torrefaction uses 1000 watts of power and time intervals of 20, 30, 40, 50, and 60 minutes. When the best take for torrefaction between blotong and bagasse with molasses is compared, the result is 1:1:4. Based on the analysis results, the best briquettes produced have a water content of 2.1 percent, a calorific value of 5475.8 cal/gram, and an organic carbon content of 64.75 percent at a time variable of 60 minutes. These results indicate that variations in the torrefaction process time can affect the characteristics of the resulting briquettes. Based on the results obtained, the longer the torrefaction time, the lower the water content in the briquettes. Likewise, the calorific value and carbon content are also getting higher.

1. Introduction
Dependence and availability of fossil fuels are not balanced, where fossil fuel spare parts are running low while dependence increases. Fossil fuel users are in the industrial sector and the transportation, agriculture, and household sectors. Therefore, it is necessary to find an alternative solution to help energy reserves that are renewable and have a lot of availability [1,2]. One alternative is to utilize biomass energy. Biomass energy is optimistic about being used as an energy source because its availability is very abundant, while biomass sources come from an agricultural, plantation, and domestic waste. Thus, it can reduce waste and can increase the economic value of biomass[3,4].

The process of converting biomass into pellets or briquettes has many advantages, including a higher calorific value, easy storage, easy transportation process, and specifications close to coal [3,5,6]. Blotong is a source of biomass that has the potential to be converted into biomass energy. In addition, the availability of blotong is relatively abundant because it is a waste product from the sugar industry and bagasse. In general, the utilization of blotong is not optimal, so that blotong can develop as an alternative energy source [7]. The utilization of blotong as an alternative energy source can reduce the negative environmental impact and benefit the industry [8,9]. The conversion of biomass from the blotong is in the form of solid fuel with the term briquettes. The household sector and rural communities can apply these briquettes [10]. Several factors can affect the characteristics of briquettes, including particle fineness [11], carbonation temperature [12], adhesive composition [13], and compaction pressure [14]. According to the Indonesian National Standard (SNI), one can pay attention to these factors [15,16].

Torrefaction is a method for converting biomass in the absence of oxygen with high efficiency. This process uses a temperature of 200 – 300°C at atmospheric pressure to produce solid fuel at a specific time [17]. This process has the advantage of improving the quality of briquettes in terms of physical,
chemical, and calorific value [18] and producing solid fuels approaching the characteristics of coal [19]. The content of hemicellulose and volatile matter will decrease when the torrefaction process takes place. This decrease can increase the calorific value of the biomass. The development of the torrefaction method is to use a microwave [20,21]. A microwave can speed up the evaporation process by utilizing microwaves in the microwave [22]. Microwaves can significantly increase the calorific value compared to conventional torrefaction [23,24]. Microwaves in the microwave turn into heat energy to reduce the water content of the biomass. This research will study the characteristics of briquettes from blotong and bagasse with molasses adhesive using the microwave torrefaction method. Based on previous research, the factors that affect the characteristics of briquettes are microwaves in the microwave and the length of the torrefaction process. This study focuses on knowing the effect of time variation of torrefaction based on the water, organic carbon, and calorific contents.

2. Experimental methods
2.1 Pre-treatment of raw materials
The first step, blotong and bagasse is dried in the sun until the blotong has a moisture content of at least 10%. Furthermore, the size of the blotong and bagasse was reducing in size to 40 mesh. The size reduction makes the torrefaction process perfect. The uniformity of water content can reduce emissions in the resulting briquettes [25].

2.2 Torrefaction Microwave Process
The torrefaction microwave equipment circuit is shown in Figure 1. Figure 1 shows that the microwave is connected to electricity and a nitrogen hose. Pressure control on nitrogen regulator. Position the nitrogen cylinder valve at 25% of the valve opening. The sample was put into a 500 ml measuring cup, which had the top closed. Then the measuring cup is connected to the nitrogen gas hose in the microwave. The microwave is closed, and the power is on. The torrefaction process was carried out at 1000 W microwave power with time variations of 20, 30, 40, 50, and 60 minutes. The combustion process in the microwave takes place without oxygen so that complete combustion occurs.

![Microwave Torrefaction Apparatus Schematic](image)

2.3 Adhesive Preparation
Blotong charcoal powder and bagasse resulting from the torrefaction process were adhesive together with molasses. The ratio of blotong: bagasse: molasses is 1:1:4 (w/w). The addition of molasses as an adhesive can increase the density, compressive resistance, volatile matter content, and ash content [26].

2.4 Briquetting Process
The process of making briquettes using press machine equipment. The press machine serves to compact the briquettes to which molasses has been added as an adhesive. The composition of the mold is 50 grams. Furthermore, the briquettes are printed with a length of 4 cm and a width of 2 cm. Then the briquettes were dried in an oven at 100°C for three hours [27]. The resulting briquettes were then...
analysed based on the parameters of water content (ASTM D-3173), organic carbon value (gravimetric), and calorific value (ASTM-2015).

3. Results and discussion
This research is a conversion of biomass into biomass briquettes by the torrefaction method and using a microwave. The torrefaction method can produce exhaust gases that are environmentally friendly and require less energy [28]. The conversion of biomass into briquettes utilizes blotong and bagasse to obtain the characteristics of briquettes according to SNI. The carbonization method used is torrefaction, where this process is a carbonization method with a low temperature of between 200 – 400°C. After the carbonization process, it is mixed with an adhesive, namely molasses. The addition of adhesive can affect the strength and density of the resulting briquettes, and the mass ratio of blotong, bagasse, and molasses is 1:1:4. The next step is the molding process and analysis of the characteristics of the briquettes, namely water content, carbon content, and calorific value. Figure 2 show the samples of briquettes Bio-charcoal mixture of blotong and bagasse that has been produced.

![Figure 2. Sugarcane Dregs Blotong Briquette](image)

3.1 Water Content (%)
The water content has an important role in the quality of the briquettes. The presence of water in the briquettes affects the calorific value [29]. Moisture content in briquettes based on SNI 01-6235-2000 8% [30,31]. The amount of residual water is to bind between particles [32]. The effect of torrefaction time on water content is presented in Figure 3.

![Figure 3. The Relationship Between Torrefaction Time and Moisture Content](image)

Figure 3 shows that it can be concluded that the longer the torrefaction process, the lower the water content. Low water content is obtained at 1000 watt microwave power with a time of 60 minutes. The water content value was 2.19%. In all time variables of 20, 30, 40, 50, and 60 minutes, the water content showed that it had met the quality standard of SNI 01-6235-2000 briquettes with water content below
8%. The water content of the torrefaction process can reduce water content very significantly. The use of high power is directly proportional to the temperature of the microwave [33]. The generated microwaves are converted into heat energy absorbed by the biomass of blotting and bagasse [34,35]. So, with a long torrefaction process, the heat energy absorbed is significant and causes the water content in the biomass to evaporate [18]. The torrefaction process decreased water content showed that the reduction reached 80% of the initial content [18,21].

### 3.2 Carbon Content (%)

High cellulose indicates a carbon content that will affect the energy content of the biomass [36]. The carbon value is influenced by the raw materials used as briquettes. Bagasse is used as a raw material because it contains a high enough carbon value [37]. The presence of a high carbon value in the raw material of briquettes can improve the quality of combustion [38]. Based on the results of the analysis of the carbon value after going through the torrefaction process, it is directly proportional to the torrefaction time [33]. The greater the carbon value obtained. This is because the constituent components in the briquette raw material used are cellulose [31].

Figure 4 shows the higher the organic carbon content with the more extended the torrefaction process. The carbon value produced in bagasse and blotong briquettes was 60.4% at 20 minutes for the lowest carbon value, and the highest carbon value was 64.75% at 60 minutes. Based on Figure 4, it is concluded that the torrefaction process time affects the value of organic carbon in briquettes.

![Figure 4. Graph of time to carbon % organic value](image)

### 3.3 Caloric Value

According to SNI standards, the calorific value is one of the parameters to assess fuel characteristics to be used as a consideration for fuel quality. Factors that can increase the calorific value and the raw materials used are also the conversion process used[39]. The torrefaction process is an alternative effort to increase biomass's added value at a low cost because it can increase the heating value by 36% [24,28,33]. The calorific value of blotong and bagasse briquettes with molasses adhesive can be seen in Figure 5.

Figure 4 shows that it can be concluded that the longer the torrefaction process, the greater the calorific value (Cal/gram). The minimum value was obtained at 20 minutes of the Calorific (cal/gram) of 3800 cal/gram, while the optimum value at 60 minutes of the Calorific value (cal/gram) was 5475.8 Cal/gram. Based on the analysis data, only in 60 minutes did the calorific value meet the SNI quality standard of 5000 (Kal/gram). The increase in calorific value is influenced by the calorific value of the raw materials in bagasse and molasses, which are used as an adhesive [7,13]. In addition, the long torrefaction process time can reduce the water content, which increases the calorific value by lowering the water content [11,40].
4. Conclusion
Based on the results and previous discussions, it can be concluded to get the characteristics of good briquettes as follows:
1. Torrefaction process using a microwave can be used as a briquette manufacturing process.
2. Torrefaction time influences briquette heating value, moisture content, and organic carbon content.
3. The calorific value obtained exceeds the SNI limit of 5475.8 Cal/gram at 1000 watts of power, and the time required is 60 minutes.
4. In the 60-minute torrefaction process, the lowest water content reached 2.19%, and the C content was 64.75%.

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Figure 5. The Relationship Between Time and Calorific Value
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