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The influence of drying temperature variation on the quality of bagasse bio-pellet

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Abstract

Demand for bio-pellet as alternative energy has widely increased. It occurs as people are aware of energy-saving for today and future living. Therefore, the increment in bio-pellet quality has also been a concern. The bio-pellet quality can be influenced by the materials (biomass) and its treatments. One of the treatments for the bagasse bio-pellet is drying. It is conducted to lessen its moisture before it is produced by the ring die pellet mill. The influence of drying temperature on bagasse bio-pellet quality is the focus of this experiment. The result shows that the different drying temperature for bagasse bio-pellet gives a different quality. However, those qualities comply with the requirement of the Indonesian National Standard for biomass energy.

Keywords*: bagasse, bio-pellet, drying temperature*

1. INTRODUCTION

The production of sugar made of sugarcane increases every year in Indonesia, which it results in increasing waste. The solid waste of bagasse is one of the sugar production by-products. The utilization of bagasse for bio-pellet as bio-energy (1) has been widely researched to respond to an energy crisis. The fermentation of bagasse is the process to result in bioethanol (2) as an alternative fuel, bio-fuel. Bio-conversion of bagasse to be bioethanol using various methods is not an inexpensive process. The machine with the several steps of the procedure and the supplementary instruments are the reason. Moreover, the degradation method of bagasse with microorganisms requires high costs, especially for the experiments and tests (3). Bagasse processing for electricity is the waste utilization to be bio-energy and more researches have been conducted for gaining the optimum energy (4), (5). Electricity is being a necessity in every field of activity. Zimbabwe encountered an increment in electricity needs to 50%. This situation leads this country to processed bagasse into electric energy (6).

The bio-pellet made of bagasse is mostly utilized for households or the boiler in the sugar factory. The direct application of bagasse for boiler fuel leads to the efficiency loss due to the high value of bagasse water content, 17 to 18 % (7), (8). The processing bagasse for fuel by pelletizing and briquetting (9) is to decrease the water content (moisture) and to increase the density of bagasse intended to be fuel.

The quality of bio-pellet is influenced by the feedstock, the size of the pellet particle, or the processing (10–12). The drying process has a prominent role in increasing the quality of pellets (9), (13). Drying, in pre-processing of bagasse intended for decreasing water in the fiber and the surface pores of bagasse. The drying process of 125 g of bagasse using a microwave with 450 to 900 Watt of power shows the different drying rates (14). Akomo compared two drying methods to increase the calorific value. The drying process was conducted by drying the bagasse in the sun for 6 to 8 hours a day for five days and drying it by using an oven. The decrement of bagasse moisture in 8 to 9% by drying it in the sun results in a decent calorific value while drying bagasse with oven results in less moisture and higher calorific value but the process needs more power (15).

The examination had been conducted to previous work and this study proposes a different temperature variation drying bagasse by using the bagasse dryer. The temperature is set to 500°, 600°, and 700°C with a 0.5 cm diameter of pellet milled in ring die pellet mill. A specimen with a specific drying temperature will be weighed by moisture analyzer, exicator, and analytical scales. The standard for determining moisture, density, and calorific value of bio-pellet is the Indonesia standard, SNI 8021:2014.

2. Methods

The experimental method was conducted by determining the temperature of the rotary dryer for drying the bagasse. The variation was applied to observe the influence of the different temperature toward the moisture, density, and the calorific value of bagasse pellet.

The procedure had been arranged to implement the experiment. The bagasse weighed 3 kg for a specimen. It is dried for 5 minutes in the rotary dryer at the temperature of 500°, 600°, and 700° C before it is milled. The dried bagasse was chopped by using the crusher machine and is milled in the ring die pellet mill with a particle size of 0.5 cm. The measurement of the pellet was carried out to rate the moisture, density, and calorific value.

Proximate analysis was the method to analyze the bagasse pellet. The parameter of this analysis is moisture, density, and calorific value. The analysis method and the variation of temperature for the dryer are aimed to obtain the effective bio-pellet made of sugarcane bagasse.

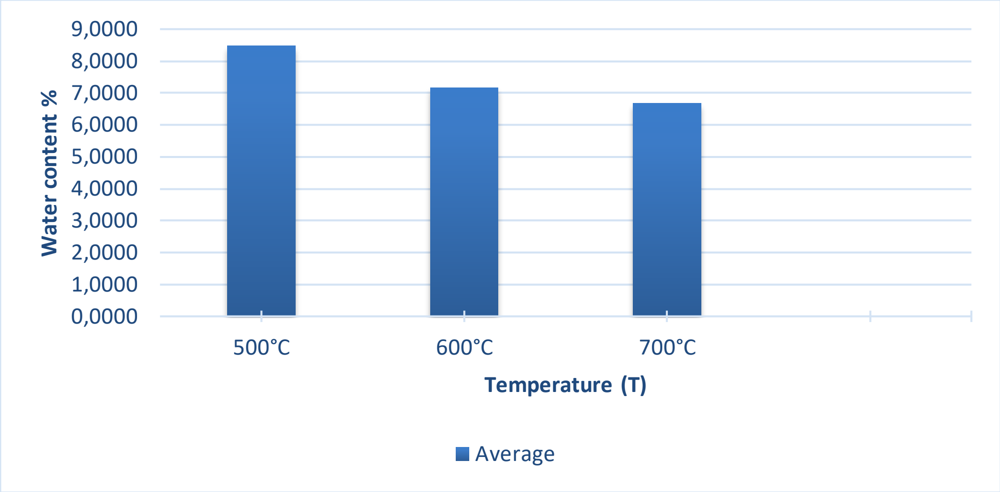
3. Result and Discussion

Research of bio-pellet bagasse with three variations of temperature was conducted to obtain the appropriate quality of bio-pellet for the combustion fuel of the boiler furnace. This study was conducted to meet the standard of bio-pellet in Indonesia. The Indonesian National Standard determined six characteristics of bio-pellet.

Table 1. The characteristics of bio-pellet

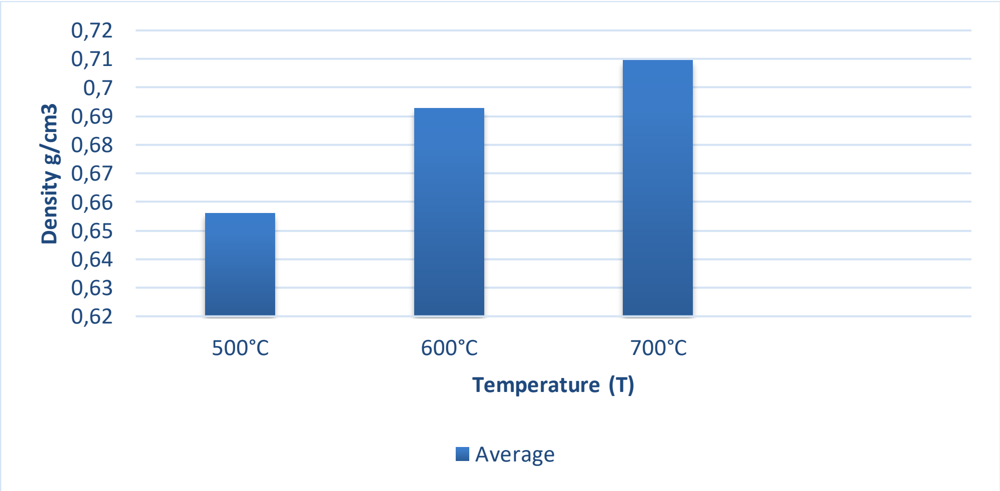
Parameter	Unit of measurement	Standard
Density	g/cm³	Min 0,8
Moisture	%	Max. 12
Ash	%	Max. 1,5
Volatile matter	%	Max. 80
Carbon	%	Min. 14
Calorific value	Cal/g	Min. 4000

Bio-pellet specimens with variation temperature of drying, 500°, 600°, and 700° C show the different moisture and density. It is depicted in Figure 1. The SNI 8021:2014 shows the maximum moisture of bagasse is 12%. The testing of the specimen with 500°C drying temperature reaches 8.4727% of moisture and 7.1628% for the temperature variation of 600° C. The average value of moisture decreases to 6.6803% on the drying temperature of 700° C. The increment of drying temperature shows a significant influence on the decrement of bagasse bio-pellet moisture. This result is particularly different from the bagasse dried in the pneumatic dryer machine, where the moisture reaches 5% (16). The drying process by using a horizontal dryer showed the different value of bagasse moisture, 10-15% (17).



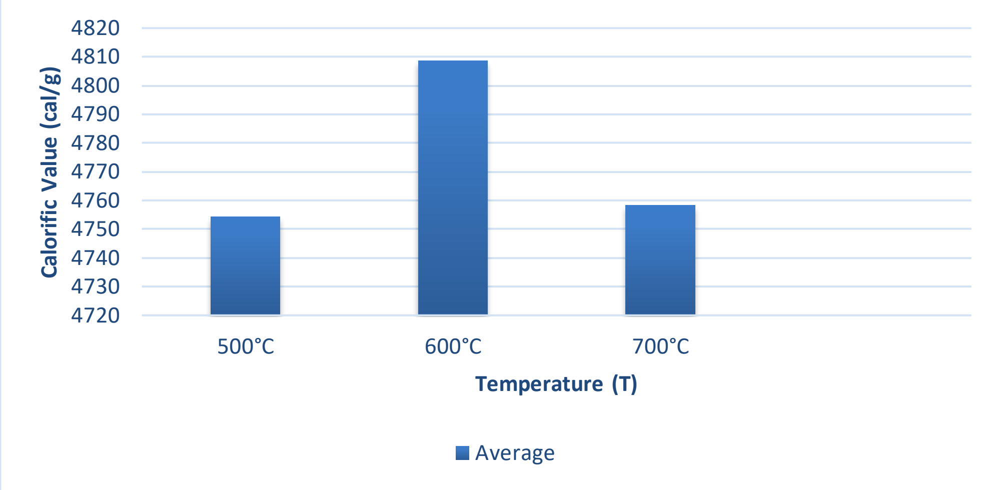
Graph 1. The average value of moisture

Density is one of the mechanical characteristics determining the quality of bio-pellet (18). Bagasse as the feedstock of bio-pellet has a low density, 80-120 kg/m^3 (19). Experiments were conducted to obtain the optimum density value. It was conducted by pressing, giving adhesive substance (20), (21), or drying process. Drying bagasse by using a heater in 60^o C for 16 hours resulted in 0.57 g/m^3 of density (20). The Standard applied in this study shown that the minimum density of bio-pellet bagasse is 0.8 g/cm^3. Figure 2 shows the average density value obtained by testing bio-pellet reaches 0.6560 g/cm^3 on the drying temperature of 500^{o}C, while in the drying temperature of 600^{o}C, it reaches 0.6928 g/cm3. In 700^{o}C drying temperature of bagasse, the average density value reaches 0.7096 g/cm^3. The testing shows the significant influence of increasing temperature on the density of the bagasse pellet.



Graph 2. The average value of density

The calorific value was measured in the bagasse pellet specimen dried with the three variations of temperature. Those variations contribute to different calorific values. Figure 3 shows the calorific value on the drying temperature of 500^o C, 600^o C, and 700^o C. At the temperature 500^o C, the calorific value obtained is 4.754,3 Cal/g and it increases to 4.808,7 Cal/g on 600^o C drying temperature. The average calorific value is slightly decreased to 50 Cal/g on 700^o C of drying temperature that it reaches 4.758,3 Cal/g. This value is close to the average calorific value dried in 500^o C.



Graph 3. The average calorific value

Temperature and time for the carbonization process also influence the calorific value of bio-carbon. The different time of carbonization process with the same temperature, 500º C, resulted in the difference of calorific value significantly (22). The optimum temperature of carbonization for water hyacinth (Eichhornia crassipes) by adding 45% of coal resulted in high calorific value, 5666 Cal/g (23). In addition to the blending coal with organic briquettes, the diameter size also influences the calorific value of bio-pellet. The higher calorific value is gained on the bagasse pellet with a 0.5 cm ring diameter [10]. In this study, the variation of drying temperature 500º C, 600º C, and 700º C resulted in the required calorific value, 4000 Cal/g, based on the standard. The effective calorific value has resulted in the drying temperature of 600º C, 4808.7 Cal/g. In the drying temperature of 500º C and 700º C, it has resulted in a slight difference. At the 500º C temperature of the drying process, the average calorific value is 4754.3 Cal/g, while in 700º C, it reaches 4758.3 Cal/g.

4. Conclusion

The temperature variation for drying bagasse bio-pellet on 500º, 600º, and 700º C shows the different average values of moisture, density, and calorific value. Drying bagasse bio-pellet in 700ºC shows the lowest moisture, but it resulted in the highest average density value. The highest calorific value is obtained from the drying temperature of 600ºC. The experiment was conducted to the object of bagasse bio-pellet with the variation of drying temperature, 500º, 600º, and 700º C results in the required bio-pellet based on the standard, SNI 8021:2014.

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