EFFECT OF CARBONIZATION PROCESS ON TIBARAU SUGARCANE BRIQUETTE TO INCREASE CALORIFIC VALUE

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ABSTRACT: Tibarau sugar cane is a renewable energy plant that has the potential to be processed into solid fuel in the form of briquettes. The development of tibarau briquettes is an effort to find alternative fuels to overcome the lack of fuel energy. By diversification the potential sources of energy derived from biomass can improve and national capacity in an effort to implement government programs. The development of biomass energy into briquette fuel is needed in order to produce it. The ability to obtain tibarau sugarcane briquette fuel which has a heat value quality can be done by carbonization process. The method of making briquettes is done by mixing tibarau bagasse raw material with adhesive. The percentage composition content is 80%: 20%. Through the tibarau briquette product development process after being treated with carbonization technology in the furnace at a certain temperature so that an increase in heating value occurs. The produced briquettes are declared as tibarau sugarcane charcoal briquettes. From this study showed the effect of carbonization treatment on increasing the calorific value of tibarau briquettes into charcoal briquettes. The characteristics of the heat value of charcoal briquettes are influenced by the carbonization temperature given. This study has an impact on the development of tibarau briquettes which are recommended as alternative fuels. The use of tibarau sugar cane into charcoal briquettes is an effort in developing renewable energy to achieve national energy security.

Keywords: Tibarau, Briquette, Carbonization, Calorific Value

1. INTRODUCTION

In everyday life, people need energy sourced from various activities. One of these energy needs is fuel oil. In line with the increasing human population and increasing energy needs, the scarcity of fuel oil supplies. The impact felt by the community is increasingly fuel oil price. Increasing fuel prices, encouraging the development of looking for other energy alternatives. Biomass is an alternative energy that can be converted as fuel oil. Along with that, the effort taken to reduce energy consumption with oil is to use renewable energy. The APERC overview has become the platform to monitor APERC goals energy intensity reduction by 45% by 2035 [1]. The Asia Pacific Energy Research Center (APERC) estimates that Indonesia will depend on imports to meet domestic energy needs by 2030 **[2]**. Republic of Indonesia Presidential Regulation Number 79 of 2014 concerning National Energy Policy, which states that the government invites all parties and the Indonesian community to succeed in developing alternative energy sources to replace oil fuels [3]. Alternative renewable energy sources in the form of waste and residues from agriculture and industry can be used to produce energy. Utilization of agricultural waste and livestock waste and food industry waste to produce alternative energy, is known as Biomass. Biomass is organic material derived from plants which includes leaves, grasses, twigs, weeds, agricultural wastes, livestock waste, forestry and peat wastes produced through photosynthetic processes, both in the form of products and waste [4]. Biomass energy sources have several advantages such as renewable energy so that they can provide a sustainable source of energy. The policy on renewable energy development and energy conversion of the Department of Energy and Mineral Resources [5] mentioned that the potential of biomass energy in Indonesia is quite large reaches 49.8 GWe.

The development and utilization of this biomass has not been carried out maximally. This is because the community does not yet understand how to use biomass or waste to be something more useful. Sugar cane as an untapped plant is used as a candidate for raw material for briquettes in the development of renewable energy to achieve national energy security **[**6]. Sugar cane plants (*Saccharum Spontaneum Linn*) are plants whose lives are often found around the banks of the river, and also are swamped or swamped. Utilization of tibarau sugar cane as a forgotten energy plant can be used as a solid fuel (briquette) which is processed with a combination of other potential biomass energy sources **[7]**. This plant grows in shrubs on the banks of rivers and inland. The community does not use it, and is only left as shrubs. Sugar cane which is recommended as a substitute for alternative fuel that is environmentally friendly and economical can be developed into solid fuel in the form of briquettes. Tibarau sugarcane briquette is a form of innovation of solid fuel products as a potential source of energy which is the forerunner of alternative energy [6]. In addition, the utilization of sugarcane bagasse and durian skins waste into a solid fuel candidate consists of a hybrid briquette as a renewable energy development [8].

The research on fresh tibarau sugarcane briquettes has been carried out and the amount of calorific value is 11221.72 kJ/kg with a density of 0.565 gr / cm3 in the corresponding component 80: 20 [6]. Lalit K Singh, et al [9] from Pelgia Research Library-Indian Institute of Technology reported that tibarau cane plant has chemical content. The potential of this tibarau cane plant can be recommended for raw materials for the development of biofuels. The sugar cane briquettes that have been developed and have characteristics are still possible to improve their quality. Of course, this is done by giving treatment of sugarcane briquettes with a chemical process technology. The possible treatment is carbonization technology.

Carbonization is a process by which solid residues with increasing content of the element carbon are formed from organic material usually by pyrolysis in an inert atmosphere [10]. Carbonization technology is a process of combustion with limited air without the presence of oxygen to organic materials that produce charcoal and change the level of low fixed carbon to high by increasing the heating value [11]. Carbonization of biomass or better known as pengarangan is a process to increase the heating value of biomass and produce clean combustion with a little smoke. The result of carbonization is in the form of charcoal composed of carbon and black. The principle of the carbonization process is the combustion of biomass without the presence of oxygen. So that only the volatile matter is released, while the carbon remains in it. Carbonization temperature will greatly affect the charcoal produced so that the right temperature determination will determine the quality of charcoal.

Development of tibarau sugarcane briquettes as an alternative fuel to improve the quality of its characteristics on an ongoing basis. The development carried out in this study led to an increase in the characteristics of tibarau sugarcane briquettes. The treatment given to briquettes by carbonizing at various temperatures has an effect on increasing the calorific value. Experiments and evaluations of quality obtained become innovations that can be applied as contributions to achieving sustainable national energy security.

2. RESEARCH METHODS

In this study, experiments were carried out on the tibarau sugarcane briquette test sample. The focus of the research is by observing the characteristics of tibarau sugarcane briquettes after carbonization. The orientation of the development of briquettes made from tibarau sugarcane particle which is mixed with various adhesives such as tapioca and damar. Tibarau sugarcane bagasse (Figure 1) as a raw material for briquettes after processing by extracting starch.

Fig. 1 Tibarau Sugarcane Bagasse

The next process, bagasse is dried to remove the remaining water content. After drying, bagasse is chopped and smoothed into particles or granules. The method of making briquettes is carried out at a percentage of the mixture ratio of 80%: 20% between tibarau sugarcane bagasse and adhesive tapioca (Figure 2) and damar (Figure 3).

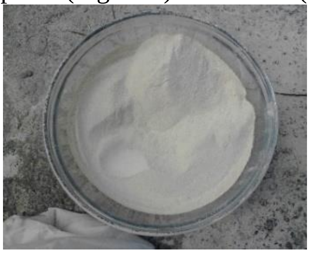

Figure 2. Tapioca

Figure 3. Damar

The mixing of bagasse bagasse with glue is prepared as needed and then made with compaction pressure of 100 kgf/cm^2. Drying of briquettes is done by drying in the sun in a few days. Briquettes that have dried, and then given a carbonization process using a heater so that the product produced is charcoal briquettes (bio-briquettes). The heating method is applied to briquettes to maintain temperature during carbonization. The process carried out in the form of an increase in the rate of burning briquettes is carbonization treatment. It should be noted, in the carbonization process on a heating furnace, the briquettes should be isolated with aluminum foil. The carbonization process on heating stoves was carried out at temperatures of 200 ^{o}C, 250 ^{o}C, 300 ^{o}C, 400 ^{o}C, and 500 ^{o}C with a holding time of 1 hour (Figure 4).

Fig 4. Carbonization Process of Tibarau Sugarcane Briquettes in Furnaces

After the carbonization process is complete, proceed with testing the calorific value for each test sample. In obtaining test data the calorific value using is a "Bomb Calorimeter" apparatus (Figure 5). Testing is done by conditioning the temperature of the laboratory room. Tests carried out related to the measurement of the calorific value of tibarau sugarcane briquettes after the process of carbonization (tibarau bio-briquettes).

Fig. 5 Bomb Calorimeter Apparatus

In analyzing the tibarau sugarcane briquettes calorific values, the treatment parameters will be recorded and tabulated in the data collection table designed according to needs. Analysis and calculation of calorific value data using existing equations. Experimental tests conducted to obtain calorific value (N_{bb}) of tibarau sugarcane briquettes is calculated by the equation:

$$N_{bb} = \frac{(H \cdot \Delta t)}{m_{bb}} \qquad (kJ/kg) \qquad (1)$$

Where, N_{bb} is the actual calorific value of the briquette (in kJ/kg). Δt is changes in temperature at the time of combustion (increase in temperature) ^{o}C obtained from the calorimeter bomb test equipment. m_{bb} mass of fuel (kg).

3. RESULTS AND DISCUSSION

The manufacture and produced of tibarau bio-briquettes using tapioca adhesive is carried out with appropriate procedures based on the flow of thought in producing a form of physical prototype resulting from the development. Figure 6 shows the tibarau sugarcane briquette before the carbonization process. Tibarau bio-briquettes after the carbonization process (Figure 7) produce physical changes is blackening (change in color from brown to black).

Fig. 6 Tibarau Sugarcane Briquettes Before the Carbonization Process

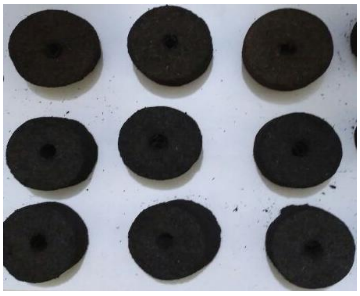

Fig. 7 Tibarau Bio-Briquettes After the Carbonization Process

From testing the calorific value of tibarau sugarcane briquettes using tapioca adhesive with a percentage variation of 80%: 20% obtained the average results tabulated shown in Table 1. From this results it shows that the briquette calorific value which is carbonized at temperature 300^{o}C obtained the optimum calorific value of 32270.26 kJ/kg. Compared with the carbonization process at other temperatures the minimum calorific value is obtained.

Table 1. Tibarau Bio-Briquettes Calorific Value with Tapioca Adhesive (Mixed 80%: 20%)

Carbonization Temperature (⁰C)	Mass of Briquettes Before Carbonization (gr)	Mass of Briquettes After Carbonization (gr)	Calorific Value kJ/kg
200	21	20	22623,88
250	20	19	25608,01
300	22	10	32270,26
400	21	6	22369,42
500	21	4	21212,78

In the graph in Figure 8, it can be seen that at the carbonization temperature of 200°C to 250°C the tibarau bio-briquette calorific value has increased to the temperature of 300°C. This is caused by the higher carbonization temperature above 300°C and higher ash content. At the carbonization temperature below 300°C the briquette calorific value is still in a low condition. While at temperatures of 400°C and 500°C a decrease in calorific value. At temperatures of 400°C - 500°C the tibarau sugarcane briquettes are perfectly carbonized but along with the increase in temperature in the carbonization process will result in increased ash levels which will reduce the calorific value.

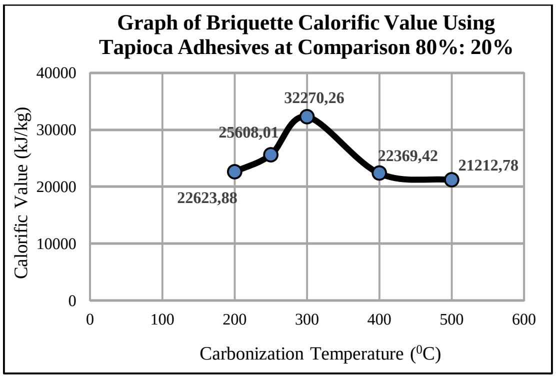

Fig. 8 Graph of Tibarau Bio-Briquette Tapioca Adhesive Calorific Value After The Carbonization Process

While the results of testing the calorific value of tibarau bio-briquettes with a composition of 80%: 20% with damar adhesive, the maximum value of 36943.08 kJ/kg. Other test results are shown in Table 2. In figure 9 shows that at carbonization temperature 300°C the maximum calorific value of tibarau bio-briquettes can be achieved. So, this results show that the differences in the adhesive can affect the calorific value of the briquettes.

Table 2. Tibarau Bio-Briquettes Calorific Value with Damar Adhesive (Mixed 80%: 20%)

Carbonization Temperature (⁰C)	Mass of Briquettes Before Carbonization (gr)	Mass of Briquettes After Carbonization (gr)	Calorific Value kJ/kg
200	21	20	17060,44
250	20	18,67	28383,95
300	20	10	36943,08
400	22	6,33	24220,04
500	23	4,67	21004,58

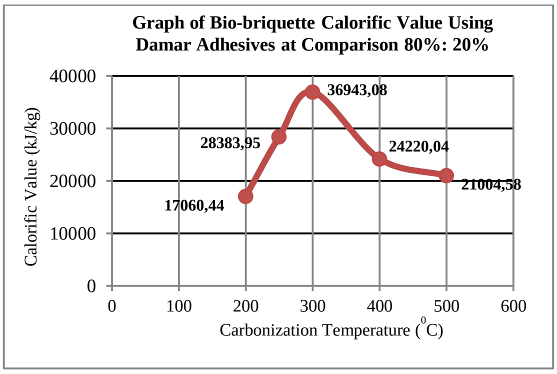

Fig. 9 Graph of Tibarau Bio-Briquette Damar Adhesive Calorific Value After The Carbonization Process

With the carbonization process treatment on tibarau bio-briquettes, it can affect the calorific value. Effect of temperature on the carbonization process shows that the higher the temperature, the smaller the amount of carbon produced and the tar produced will be greater at a certain threshold (temperature 300°C).

Table 3 shows the results of the chemical composition of the Carbon Content and Ash Tibarau Briquette and Tibarau Bio-briquette. The carbon content of the tibarau bio-briquettes that used tapioca adhesive was obtained 54.39% with 14.19% ash content. Whereas in tibarau bio-briquettes that use damar adhesive obtained 65.93% carbon content with 15.1% ash content. This compared to the carbon content in tibarau briquettes (non carbonized) obtained only 52.33% (Table 3). This proves that the carbonization process can increase the carbon content in briquettes which is estimated to reach 25.98% which also has an impact on increasing the calorific value. From this study, it can be stated that the effect of the carbonization process can increase the tibarau sugarcane briquette (tibarau bio-briquette) value which is optimal at 300ºC. Calorific values were calculated using the fixed carbon content of the charcoal briquettes according to the method presented in [12]. However, for the binder concentration levels investigated in this work, all the briquette grades exhibit values for the fixed carbon content that fall short of the requirement for industrial applications of fixed carbon of 86.7% [13]. With the higher carbonization temperature, it tends to decrease the calorific value, water content, air content and solid carbon content so that it affects the briquette ash content, tends to increase [14].

Table 3. Carbon Content and Ash Tibarau Briquette and Tibarau Bio-briquette

Test sample	Temperature (ºC)	Carbon (C) %	Ash %
Tibarau Briquette with Tapioca Adhesive	30	52,33	14,19
Tibarau Briquette with Damar Adhesive	30	53,58	12,09
Tibarau Bio-Briquette with Tapioca Adhesive	300	54,39	20,71
Tibarau Bio-Briquette with Damar Adhesive	300	65,92	15,11

The higher the calorific value contained in a fuel, the better the fuel is used for combustion. The calorific value is usually said to be the heat released in complete combustion which starts at a standard temperature and the product is cooled to the same temperature in the flow system for adiabatic without work. Generally, the calorific value was observed to increase with increasing binder concentration [15].

The temperature and time of carbonization have a significant effect on increasing the calorific value and improving proximate analysis. Both of these factors also have a significant effect on decreasing water content and volatile charcoal charcoal. The higher of temperature and time of carbonization, the higher of calorific value, carbon content and ash content. While the water content and volatile matter decreases [16].

The percentage of water content shows that the mass loss of raw material is quite large during the process. This shows that the bagasse has very high volatile material, which during the process occurs the release of volatile substances. If viewed from the variation of activation temperature given, there is a tendency that the higher the activation temperature, the more the higher percentage content of the water content will be.

In the process of combustion can not be separated from the initial stage of ignition where the transition state from non-reactive to reactive. The existence of an external push that triggers a thermochemical reaction is followed by a fast transition so that combustion can take place. Ignition occurs when the heat produced by combustion is greater than the heat lost to the environment. Combustion is an exothermic chemical reaction of the elements present in the fuel with oxygen and produces heat.

Perfect combustion will produce the maximum amount of heat. Combustion is expressed qualitatively or quantitatively by chemical reactions. The amount of heat produced by the fuel is expressed as the calorific value of the combustion. Chemical reactions occur through an oxidation process of carbon, hydrogen and sulfur compounds present in fuels. This reaction generally produces a flame.

While hydrogen is easily combined with oxygen, releasing large amounts of energy in the form of heat. Hydrogen does not produce dangerous byproducts when burning. Only energy and clean water are produced when hydrogen reacts with oxygen in fuel cells.

The carbonization process in briquettes makes the conversion of organic matter into charcoal intensively to produce gas and less water. The carbonization process makes an important step in making charcoal briquettes in increasing the calorific value.

4. CONCLUSION

This research can be summarized as follows:

a. Successfully developing alternative fuels to achieve national energy security in the form of tibarau sugarcane briquettes (tibarau bio-briquettes) as a manifestation of diversification renewable energy
b. Characteristic of tibarau sugarcane briquettes using tapioca adhesive with a mixing ratio of 80% : 20% obtained a calorific value of 32270.26 kJ/kg. While briquettes that use damar adhesive produce a maximum heating value of 36943.08 kJ / kg. From this condition shows the influence of the calorific value on the use of adhesives.
c. The carbonization process at a temperature of 300ºC can affect and increase the tibarau sugarcane briquette calorific value to the maximum. In the carbonization process an increase in carbon and ash content in the briquettes has an impact on the heating value of the briquettes.

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