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The Influence of Rice Husks, Coconut Shells, and Sugarcane Bagasse on the Quality of Bio Briquettes

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Abstract:- Coal is a limited natural resource and is found in certain geological locations. Indonesia has abundant mineral and coal resources, with fairly good quality and quantity. The use of coal as fuel has an impact on the environment because CO2 emissions resulting from burning coal can cause a greenhouse effect. One solution to the problem of using coal is the production of alternative energy in the form of briquettes from biomass. This research aims to study the effect of adding a mixture of bagasse, rice husks and coconut shells on the calorific value. The carbon and hydrogen content in biomass greatly influences the water content of the briquettes produced. The increase in carbon content is generally inversely proportional to water content. Briquettes from coconut shell biomass have a higher carbon content than those from rice husks and sugar cane bagasse. The highest calorific value was obtained from coconut shell biomass briquettes, namely 5280.85 cal/g, because briquettes from coconut shells had the highest carbon content, namely 57.18% compared to the carbon content of rice husks and sugar cane bagasse, namely 37 respectively. 24 and 50.04%. Carbon is one of the main components that influences the energy value of briquettes. Although the hydrogen content also contributes to the heating value, its impact is not as big as the carbon content in biomass. The elemental composition of CHNS can affect the water content and calorific value produced. Briquettes from this biomass are only suitable for use as fuel for household purposes.

***Keywords**:- Alternative Energy, Biobriquettes, Biomass, Briquette Quality*

I. INTRODUCTION

Coal is a finite natural resource that is only found in specific geological locations. Indonesia has substantial coal reserves with varying qualities, ranging from high to low quality coal [1]. In Indonesia, the primary consumption of coal is concentrated in the medium and low-quality sectors, particularly within the conventional power plant sector. As environmental concerns and the necessity for climate-friendly technology continue to gain traction, the utilization of coal as an energy source is witnessing a gradual decline [2].

One of the alternatives currently under development with the objective of reducing environmental impact is the concept of co-firing, which involves the combustion of coal in conjunction with biomass. The combustion of biomass, including biogas, bioethanol, and briquettes, has the potential to reduce carbon emissions while simultaneously reducing fuel costs in certain circumstances [3]. Indonesia stands to gain considerably from integrating biomass into its coal-fired power plants, given the country's abundant biomass potential.

A variety of biomass types may be employed in co-firing, including agricultural, forestry, and plantation residues [4]. Rice husks represent a significant and readily available biomass source, particularly given that Indonesia's rice production reached 31.33 million tons in 2021. Approximately 20-30% of this quantity is comprised of rice husks, amounting to 179 million GJ per annum. This has the potential to enhance combustion stability. In addition to rice husks, other potential biomass sources include coconut shells and sugarcane bagasse. Coconut shell waste has the potential to generate up to 18.7 million GJ of energy per year, while sugarcane bagasse has an estimated energy potential of 78 million GJ per year [5].

Despite its considerable potential, the direct utilisation of biomass as a fuel source is confronted with a number of significant challenges. Biomass exhibits a range of heterogeneous characteristics, including hygroscopic properties, low energy density, and complex fiber structures that present processing challenges [3]. These characteristics impact the quality of the energy conversion produced. One potential solution to enhance efficiency is the utilisation of biomass briquetting. The production of briquettes results in a higher energy density, which in turn facilitates storage and transportation, while also reducing operational costs [6]. Previous studies have shown that coconut shell briquettes have a high carbon content, but require blending with other materials to reduce pollution [7]. Conversely, bagasse and rice husk briquettes exhibit a relatively low fixed carbon content; however, they are subject to limitations due to their high moisture and ash content.

This research project is concerned with the combination of three types of biomass rice husk, coconut shell, and sugarcane bagasse to create briquettes of optimal quality. The selection of these materials is based on their abundant availability and potential for waste reduction. Further studies are needed to determine the ideal mixing composition, with the objective of producing briquettes with the best performance while minimizing emissions during combustion.

II. MATERIALS AND METHOD

A. Materials

The materials utilized in this study are bagasse charcoal, coconut shell charcoal, and rice husk charcoal, which serve as the primary raw materials for the fabrication of briquettes. Tapioca is employed as a binder in this process. The principal raw material is subjected to sifting with a mesh size of 50. The equipment utilized in this study includes briquette molding tools, beaker glass, a stirrer, scales, an oven, a furnace, and a variety of instrumentation tools for testing the briquettes.

B. Methods

➤ *Raw Material Preparation*

The biomass, comprising rice husk, coconut shell, and bagasse, was subjected to a cleansing process involving the use of running water and the removal of impurities. Following washing and drying, the biomass was subjected to pyrolysis in a furnace at 500°C for a period of two hours. It was then sieved and ground before being incorporated into the briquette mixture.

➤ *Biomass Analysis*

Biomass analysis is conducted with a CHNS Analyzer instrument. The briquette sample is subjected to high temperatures to facilitate the release of CHNS element gases. Subsequently, the gases are separated and quantified by means of detectors that are specific to each element. Subsequently, the analysis software processes the analyzed data in order to calculate the percentage of each element present in the sample. The organic constituent composition of biomass briquettes is analyzed using a CHNS Analyzer (CHNS Elementar, Germany). The application of CHNS analysis allows for the monitoring of the quality of briquette production and the subsequent evaluation of the environmental impact.

➤ *Preparation of Adhesive*

In order to create the adhesive, 200 grams of tapioca are combined with one litre of water at a temperature of 60°C Celsius for a period of 30 minutes, resulting in the formation of an adhesive. Subsequently, the adhesive is incorporated into the briquette mixture at a ratio of 10% by weight.

➤ *Manufacture of Biobriquettes*

The formulated raw materials are compressed using a hydraulic press fitting, with a maximum capacity of 200 grams. Subsequently, the compressed material is subjected to a drying process in an oven maintained at 110°C for a period of three hours. Subsequently, the briquettes were stored in a PET ziplock container at room temperature until further utilization.

C. Analysis Method

➤ *Analysis of Physical Parameters, Including:*

- *Moisture Content Test*

Biobriquette samples are weighed and put into the oven to heat at 110°C for 4 hours until constant weight, then the water content can be calculated by the equation:

$$\text{Moisture Content (\%)} = \frac{M_0 - M_1}{M_0} \times 100\% \quad (1)$$

where:
M_0 = sample weight before drying (g)
M_1 = sample weight after drying (g)

- *Ash Content Test*

The biobriquette sample is weighed in a porcelain cup and then placed in a furnace at 800°C for 2 hours. The operating temperature is set in the furnace. Ash content can be calculated by the equation:

$$\text{Ash Content (\%)} = \frac{\text{Ash weight (g)}}{\text{Weight of sample (g)}} \times 100\ \% \quad (2)$$

where:
Ash weight = weight of cup and sample after drying - weight of empty cup
Weight of sample= weight of cup and sample before drying - weight of empty cup

- *Compressive Strength Test*

Briquette samples are loaded until they are destroyed, then the data obtained during the test is analyzed to determine the maximum compressive strength.

➤ *Analysis using instruments, including:*

- *Calorific Value*

Prepare the briquette sample to be tested, the sample to be tested is dry. Introduce oxygen into the bomb calorimeter to create optimal oxidation conditions, then place the briquette sample inside the bomb calorimeter. Initiate the combustion reaction and allow the sample to burn completely inside the bomb calorimeter The bomb calorimeter will record the amount of heat generated during the combustion process. This heat will be used to calculate the calorific value of the sample. The briquette combustion value/calorific value is determined using a bomb calorimeter (6400 Automatic Isoperibol Calorimeter, Parr Instrument Company, United States). The calorific value of the sample is calculated based on the temperature change that occurs, i.e. the initial temperature during the test minus the final temperature of the test and divided by the mass of the briquette. The calorific value is measured in energy units, namely calories per gram (cal/g).

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III. RESULT AND DISCUSSIONS

The moisture content and calorific value of briquettes are among the parameters that determine the quality of briquettes. In this study, CHNS testing was conducted to ascertain the impact of moisture content and heating value. The results of the CHNS analysis on rice husk, bagasse, and coconut shells are presented in Table 1.

Table 1. CHNS Analysis of Rice Husk, Bagasse, and Coconut Shells

Content Analysis	Rice Husks	Bagasses	Coconut Shell
Carbon	37.24%	50.04%	57.18%
Hydrogen	6.062%	5.137%	4.192%
Nitrogen	0.74%	0.37%	0.21%
Sulfur	0.218%	0.085%	0.096%

A. The Effect of Rice Husk, Sugarcane Bagasse, and Coconut Shell Content on Briquette Water Content

The effect of rice husk, bagasse, and coconut shell content as biomass raw materials used in the briquette making process on water content as shown in Table 2.

Table 2. Effect of Rice Husk, Bagasse, and Coconut Shell Content on Water Content

Content Analysis	Rice Husks	Bagasses	Coconut shell
Water content (%)	16.18	6.65	6.39

As evidenced by Tables 1 and 2, the results of the CHNS (Carbon, Hydrogen, Nitrogen, Sulfur) analysis of the biomass utilized can influence the water content of the briquettes produced from each biomass type. As illustrated in Table 2, there is a direct correlation between the water content of biomass and the CHNS content, particularly that of carbon and hydrogen [8]. The water content of rice husks is 16.18%. Consequently, briquettes produced exclusively from rice husks fail to meet the Indonesian National Standard, which stipulates a maximum water content of 8% for biobriquettes.

As evidenced in Table 1, the carbon content of rice husk is 37.24%. The elevated carbon content is a contributing factor to the higher water content observed in rice husk relative to other biomass sources, such as bagasse briquettes and coconut shells. The high water content of biomass can affect the carbon content, as some of the carbon is not completely burned [9]. In addition to the carbon content, the water present in biomass can also interfere with the measurement of hydrogen. This is because the hydrogen detected originates from the water present, rather than from the organic matter in the biomass [10]. The hydrogen content produced in rice husk biomass was found to be 6.062%, while in bagasse and coconut shell biomass, the hydrogen content was observed to be lower, at 5.137% and 4.192%, respectively. The presence of a high hydrogen content will result in an increase in the accuracy of water content measurements. This phenomenon occurs because hydrogen is a constituent of the H_2O molecule, which consequently leads to an increase in the results of water content measurements [11].

The carbon and hydrogen content of the biomass has a significant impact on the water content of the briquettes produced. An increase in carbon content is typically inversely proportional to water content. Consequently, briquettes manufactured from coconut shell biomass tend to have a lower water content than those produced from rice husks and sugarcane bagasse, given that they possess a higher carbon content than other materials.

B. The Effect of Rice Husk, Sugarcane Bagasse, and Coconut Shell Content on the Calorific Value of Briquettes

The impact of varying proportions of rice husk, bagasse, and coconut shell as biomass raw materials on the calorific value of the resulting briquettes is illustrated in Table 3.

Table 3. Effect of Rice Husk, Bagasse, and Coconut Shell Content on Calorific Value

Content Analysis	Rice Husks	Dregs Sugarcane	Coconut shell Coconut
Calorific Value (cal/g)	4647.535	5198.495	5280.85

Tables 1 and 3 illustrate the correlation between the calorific value of the briquettes produced and the CHNS composition of the three biomasses utilized, specifically coconut shells, bagasse, and rice husks. As evidenced in Table 3, the highest calorific value was observed in coconut shell biomass briquettes, reaching 5280.85 cal/g. A review of Table 1 reveals that coconut shell briquettes also exhibit the highest carbon content, at 57.18%. This is based on the principle that an increase in the carbon content of the biomass results in an increase in the energy produced during combustion, which directly increases the calorific value of the briquettes [12]. In contrast, briquettes produced with rice husk biomass exhibit the lowest calorific value, at 4647.535 cal/g. As illustrated in Table 1, rice husk also demonstrates the lowest carbon content among the biomass materials, at 37.24%. It can thus be concluded that carbon is a principal factor influencing the energy value of briquettes. While hydrogen content also affects the calorific value, its influence is less pronounced than that of carbon content in the biomass itself [11].

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The composition of CHNS elements can affect the water and heat content values which can be proven by *Net Heating. Value* (NHV) is obtained through the following formula:

$$NHV = GHV - \Delta Hf\theta \times (H + 9 \times \textit{Moisture Content}) \quad (3)$$

$\Delta Hf\theta$ = Enthalpy of vaporization of water, KJ/mol
H = Hydrogen content, %wt

Accordingly, the net heating value (NHV) of briquettes produced with 90% rice husk, sugarcane bagasse, and coconut shell content, respectively is 462,918 cal/g; 5184,49 cal/g; and 5269,21 cal/g. Furthermore, the low sulfur and nitrogen content in all samples indicates that the emissions generated from the combustion of these briquettes have low emissions, thus making them a more environmentally friendly choice. By calculating the higher heating value (NHV), it is possible to ascertain the impact of the carbon, hydrogen, nitrogen, and sulfur (CHNS) content on the quality and energy value of the briquettes. This can be employed to ascertain the most efficacious biomass mixture for energy production.

IV. CONCLUSION

The carbon and hydrogen content of the biomass has a significant impact on the water content of the briquettes produced. An increase in carbon content is typically inversely proportional to water content. Consequently, briquettes product from coconut shell biomass tend to have a lower water content than those produced from rice husks and sugarcane bagasse, given that they possess a higher carbon content than other materials.

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