Coal blending preparation for non-carbonized coal briquettes

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Abstract. Referring to the national energy policy targets for the years 2025, the government has launched the use of coal briquettes as an alternative energy replacement for kerosene and firewood. Non-carbonized briquettes in the form of coal briquettes as well as bio-coal briquettes are used in many small-medium industries and households, and are rarely used by large industries. The standard quality of coal briquettes used as raw material for non-carbonized briquettes is a minimum calorific value of 4,400 kcal/kg (adb); total sulfur at a maximum of 1% (adb), and water content at <12% (adb). The formation of coal deposits depends on the origin of the coal-forming materials (plants), the environment of deposition, and the geological conditions of the surrounding area, so that the coal deposits in each region will be different as well as the amount and also the quality. Therefore, the quantity and the quality of coal in each area are different to be eligible in the making of briquettes to do blending. In addition to the coal blending, it is also necessary to select the right materials in the making of coal briquettes and bio-coal briquettes. The formulation of the right mixture of material in the making of briquettes, can be produced of good quality and environmental friendly.

1. Introduction

Coal is a combustible organic mineral, formed from the remnants of ancient plants deposited which subsequently change shape due to the physical and chemical processes that last for millions of years. According to [1] the formation of coal begins with biochemical processes, followed by geochemical and physics processes. At this stage, geochemistry and physics process is very influential on the rank of coal (coal rank) such as changes in types ranging from peat to lignite, bituminous, to anthracite. Factors that play role in the geochemistry and physics process are temperature, pressure, and time. According to [1-3], coal contain organic materials of more than 80%. Coal is in addition to a sediment deposition rich in organic matter as a maceral, coal also contains inorganic materials called minerals. Coal deposition will form well, if it occurs in the area of the basin which slowly decreases the land. The thick coal deposition generally occurs in areas near the mountain arc, especially in the foredeep position and the back arc basin (back arc). An example is the formation of coal deposits occurring in the foredeep of the Sundanese bow of Sumatra [3].

Indonesia has low rank coal resources (lignite) in large quantities with a calorific value of less than 4,200 kcal/kg [4], spread over the islands of Borneo, Sumatra and Java. Therefore, to use such low rank coal should be blended with higher value coal to meet the existing briquette quality requirements. Coal blending is to mix several types of coal to improve and integrate the properties and qualities of coal with different types, so as to meet the specifications of coal consumers desire [5]. Based on coal blending quality data between low ratings and high ratings it is possible to meet the requirements of calorific values and other additive parameters such as moisture content, ash content and sulfur content.
One of the utilization of coal is in the form of briquettes, this coal briquettes as one of substitute alternative fuel kerosene and firewood, the price is cheaper because the process of making using technology and simple equipment. Coal briquettes are batching products through the process of molding coal-based solid particles at specific pressures, molded either with binders or other additives with certain shapes and sizes. According to [6] the process of making coal briquettes is a mixture preparation of materials (drying, homogenization, addition of binding) and printing under pressure using mechanical devices.

Coal briquettes consist of two types, namely carbonated and non-carbonated briquettes. Carbonated coal briquettes are coal briquettes that have undergone carbonation processes to eliminate/reduce the content of flying substances, so the resulting coal briquettes are odorless and smoky. Non-carbonation coal briquettes are coal briquettes that are not carbonated before they are processed into briquettes, resulting in lower quality and cheaper price than carbonated coal briquettes. In the use of coal briquettes as fuel need to be done carefully and done in a room that is quite ventilated, because coal briquettes contain components that can endanger human health and pollute the environment after the combustion process [7].

There are two types of coal briquettes, namely carbonized coal briquettes and without carbonization. The briquettes have different properties and uses, namely: (1). Carbonized briquettes: coal used for the manufacture of briquettes is first carried out the process of carbonization to reduce the substances of flying with the aim of burning briquettes relatively odorless and smoky, this briquette is suitable for household use. (2). Bricket without carbonization, the coal used for the manufacture of briquettes is not carried out carbonization, but the burning of briquettes must use the furnace to produce perfect combustion because the fly can be burned by flame, the briquettes without carbonization are generally used for small industries (limestone burning, Pottery, and blacksmith).

According to the Regulation of the Minister of Energy and Mineral Resources Number: 047 Year 2006 [8] coal briquettes without carbonization shall have coal briquette quality standard with maximum moisture content of 12%, maximum sulfur 1%, minimum compressive strength of 65 kg / cm² and minimum calorific value 4,400 Kcal/kg.

2. **Review paper on coal blending in the making of non-carbonized coal briquettes**
The review paper result of briquettes making non-carbonization coal in the form of coal briquettes [9-10] and bio-coal briquettes [11] are as follows:

2.1. **Coal briquettes**

2.1.1. **Blending of Garut-West Java and South Kalimantan coals.** The briquettes made by coal blending with South Kalimantan coal samples have a calorific value of 5,900 kcal/kg (adb) and Garut-West Java coal samples have a calorific value of 4,462 kcal/kg (adb) with a mixture ratio of 30 : 70 obtained improved briquette quality to 5,015 Kcal/kg, moisture content 11.70%, 12.45% ash content, 1.85% sulfur content, 36.60% volatile matter content and 39.25% fixed carbon [9].

2.1.2. **Blending of Caringin Garut-West Java and Lebak-Banten coals.** Caringin Garut-West Java coal samples have a calorific value of 2,646 kcal/kg (adb) and ash content 38.33 %, so the quality is less good when used for briquettes. For this purpose, Caringin Garut-West Java coal blending was done with better quality from Bayah Lebak-Banten coal area with ash content of 23.80%, fixed carbon 39.37%, and calorific value of 5,885 kcal/kg (adb). Based on Caringin Garut-West Java coal blending experiment with Bayah Lebak-Banten coal as material for briquettes preparation, it is known that the best blending formulation is 30% : 70%. The result of the briquettes blending formulation is greater bonded carbon, and the content of ash is smaller compared to the initial sample of Caringin Garut-West Java and Bayah Lebak-Banten coals, ie 41.14% and 17.30% [10].
2.2. Biocoal briquettes
Non-carbonized coal briquettes prepared from mixture of coal (4,555 kcal/kg), wood powder (3,500 kcal/kg), lime powder as desulfurization agent and molasses as binder is coal = 90%, wood powder = 5%, lime = 5%, molases = 5% of the total weight of the coal mixture, wood powder and lime outages. The result of briquettes biocoal analysis is ash content 36.76%, volatile matter 31.65%, fixed carbon 27.93%, total sulfur 0.66% and calorific value 4,289 kcal/kg [11].

3. Results and discussion
The coal samples used in the research of briquettes manufacture are taken from area of Garut West Java, Bayah Lebak Banten and PT Adaro Kalimantan Selatan. Petrographically, Cikabunan Garut-West Java coal includes low rank coal with RV = 0.45 including sub-bituminous coal types. Cikabunan Garut-West Java coal samples have a calorific value of 4,462 kcal/kg [9], and Caringin Garut-West Java coal samples have a calorific value of 2,646 kcal/kg [10]. Bayah Lebak coal samples have a calorie value of 5,885 kcal/kg with Rv 0.52 [10], higher than the calorific value of the Caringin Garut-West Java coal samples. According to [12] coal in the Bayah region with Rv 0.51 - 0.88; including sub bituminous coal - high volatile bituminous. The coal sample from PT Adaro Kalimantan Selatan has a calorific value of 4,289 kcal/kg [11] and 5,900 kcal/kg ([9].

3.1. Coal briquettes
3.1.1. Blending of Garut-West Java and South Kalimantan coals. The briquettes are made with a coals mixture from South Kalimantan and Garut West Java each has a calorific value of 5,900 kcal/kg and 4,462 kcal/kg with a mixture ratio of 30 : 70. The results (Table 1) obtained briquettes with quality: 5,015 kcal/kg, water content 11.70%, ash content 12.45%, sulfur total content 1.85%, volatile matter content 36.60% and 39.25% fixed carbon [9].

| No. | Parameter                  | Garut Coal | Kalimantan Selatan Coal | Coal Briquette |
|-----|----------------------------|------------|--------------------------|----------------|
| 1   | Moist water, % adb         | 13.00      | 14.32                    | 11.70          |
| 2   | Ash content, % adb         | 22.63      | 0.70                     | 12.45          |
| 3   | Volatile matter content, % adb | 33.55 | 43.60                   | 36.60          |
| 4   | Fixed carbon content, %    | 30.82      | 41.30                    | 39.25          |
| 5   | Sulphur total content, %   | 3.25       | 0.08                     | 1.85           |
| 6   | Calorific value, kcal/kg, adb | 4,462 | 5,900                 | 5,015          |

Based on Ministerial Regulation No. 047/2006 on Quality Standard of coal briquettes (Table 2) quality of coal briquettes (Table 1; [9]) the value of calorie eligible, while moist and total sulfur water is greater than that populated according to Ministerial Regulation No. 047 year 2006. Excess moisture can be reduced by heating coal until moisture content <12% before briquettes is made, while the impact of total sulfur excess can be done by adding calcium oxide (CaO).

3.1.2. Blending of Caringin-Garut West Java and Lebak-Banten coals. Caringin Garut coal has high ash content (38.33%) and low calorific value (2.646 kcal/kg, Table 3), so the quality is less good when used directly for briquettes. For this purpose, Caringin Garut coal blending was done with better quality of coal from Bayah Lebak area which has ash content of 23.80%, fixed carbon 39.37% and calorific value of 5,885 kcal/kg (Table 3).
Table 2. Coal briquettes quality standard (Ministerial Regulation No. 047 Year 2006).

| No. | Type of Briquettes                     | Moist Water (%) adb | Volatile Matter (%) adb | Calorific Value (kcal/kg) | Sulfur total (%) adb | Load burs (Kg/cm²) |
|-----|---------------------------------------|---------------------|------------------------|---------------------------|---------------------|--------------------|
| 1   | Coal briquettes (Non-Carbonized)      | Maximum 12          | According to the original coal        | Minimum 4.400 | Maximum 1 | Minimum 65 |
| 2   | Bio-coal Briquettes (Non-Carbonized) | Maximum 15          | In accordance with the raw materials | Minimum 4.400 | Maximum 1 | Minimum 65 |

Table 3. Proximate analysis results of Caringin-Garut West Java and Lebak-Banten coals [10].

| No. | Parameter                              | Value          |
|-----|----------------------------------------|----------------|
| 1   | Moist water, % adb                     | 14.38          |
| 2   | Ash content, % adb                     | 39.33          |
| 3   | Volatile matter content, % adb         | 25.35          |
| 4   | Fixed carbon content, %                | 20.94          |
| 5   | Sulfur total content, % adb            | 1.80           |
| 6   | Calorific value, kcal/kg adb           | 2,646          |

Based on Caringin Garut-West Java coal mixing experiment with Bayah Lebak-Banten coal as material for briquettes making, it is known that the best blending formulation is 30% : 70%. The result of briquette blending formulation is greater bonded carbon, and the content of ash is smaller compared to the initial sample of Caringin Garut-West Java and Bayah Lebak-Banten coals, ie 41.14% and 17.30% respectively with a calorific value of 5.767 kcal/kg (Table 4, [10]).

Table 4. Proximate analysis result of raw coal briquettes [10].

| No. | Caringin Garut (%) | Bayah Lebak (%) | Moisture Water (%) | Ash Content (%) | Volatile Matter Content (%) | Fixed Carbon Content (%) | Total sulfur Content (%) | Calorific Value (kcal/kg) |
|-----|-------------------|----------------|-------------------|----------------|-----------------------------|--------------------------|--------------------------|---------------------------|
| 1   | 30                | 70             | 4.51              | 17.30          | 37.05                       | 41.14                    | 1.05                     | 5,767                     |
| 2   | 40                | 60             | 4.72              | 20.33          | 37.18                       | 37.77                    | 1.41                     | 5,511                     |
| 3   | 50                | 50             | 4.92              | 21.29          | 37.12                       | 36.67                    | 1.41                     | 5,351                     |
| 4   | 60                | 40             | 5.48              | 22.24          | 35.09                       | 20.94                    | 1.64                     | 4,167                     |
| 5   | 70                | 30             | 6.20              | 23.03          | 34.67                       | 39.37                    | 1.73                     | 4,787                     |

Information: Units in % adb (air dried basis). except the calorific value in kcal/kg.

Sulfur content is slightly above the requirements specified in Ministerial Regulation No. 047 of year 2006 on Standard Quality of Coal Briquette which is maximum of 1%. To reduce the impact of sulfur content, calcium oxide (CaO) could be added sufficiently, so as not to have much effect on the calorific value content.
3.2. Biocoal briquettes

The researchs of coal briquettes non-carbonization are made from coal mixture (4.555 kcal/kg), wood powder (3.500 kcal/kg) as biomass, lime powder as desulfurization agent and molasses as binder is coal = 90%, wood powder = 5%, lime = 5%, molasses = 5% of the total weight of the coal mixture, wood powder and lime outages. The results of biocoal briquettes analysis were ash content 36.76%, volatile matter 31.65%, fixed carbon 27.93%, total sulfur 0.66% and calorific value 4.289 kcal/kg (Table 5; [11]).

Table 5. Proximate analysis results of coal and biocoal briquettes [11].

| No. | Parameter                         | Value       | Coal  | Bio-Coal Briquettes |
|-----|-----------------------------------|-------------|-------|----------------------|
| 1   | Moist water, % adb                | 2.55        | 3.71  |
| 2   | Ash content, % adb                | 38.39       | 36.71 |
| 3   | Volatile matter content, % adb    | 28.72       | 31.65 |
| 4   | Fixed carbon content, %           | 30.34       | 27.93 |
| 5   | Sulfur total content, % adb       | 0.57        | 0.66  |
| 6   | Calorific value, kcal/kg adb      | 4,555       | 4,289 |

From Table 5 it is known that the sulfur content is low (<1%), and still within the permitted threshold as per the standard specification of coal briquettes. However, the calorific value is also low because it is less than 4,400 kcal/kg (Table 2), ie the lowest limit of standard quality standard of noncarbonized coal briquettes.

The addition of lime leads to a decrease in caloric value and increase ash content, because lime have the quality inert. The addition of wood powder aims to accelerate the initial ignition of briquettes, because the biomass has a greater content of flying substances than coal, while the added chalk serves as an absorbent material and stores the SO2 gas resulting from the combustion of briquettes.

The results of the above experiments indicate that the manufacture of biocoal briquettes from high ash coal with molasses binder produces good physical properties but its chemical properties are slightly below the requirements of coal briquettes quality standard. Thus, for the manufacture of biocoal briquettes on a commercial scale does not need the addition of lime, so that the coal briquettes produced still have calorific value above the standard quality requirements.

4. Conclusions

- Blending of 70% Cikabunan Garut-West Java coal and 30% of PT Adaro South Kalimantan coal as material of coal briquetting, the total sulfur content is still high, ie 1.89%. To reduce the negative effects of coal briquettes with a total sulfur content of 1.89% need to be added calcium oxide (CaO), calcium oxide function to absorb and store sulfur content during burning briquettes, there by reducing SO2 wasted with smoke to free atmosphere (atmosphere).
- Blending of 30% Caringin Garut-West Java coal and 70% Bayah Lebak-Banten coal as material of coal briquettes making with higher bound volatile matter, ash and sulfur content is smaller compared to content of Caringin Garut-West Java and Bayah Lebak-Banten coals. The coal briquettes has a calorific value of 5,367 kcal/kg, and a sulfur total reduction of 0.75%.
- The quality of biocoal briquettes with tapioca starch binder has better chemical properties compared with biocoal briquettes made from molasses binder. The addition of biomass can accelerate the initial ignition of biocoal briquettes, but the supple biomass properties make biocoal briquettes less strong.
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