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Chemical composition study of coal ash content as potential material

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ABSTRACT

Coal in Indonesia is used as fuel for power plants to support the availability of electricity. Besides that several industries such as the cement, paper, textile, and fertilizer also use coal as fuel for production process. Due to that the coal waste such as ash was generating as increasing coal usage. Therefore, research was carried out to investigate ash content and chemical composition of coal with various types of calories in the South Kalimantan and Central Kalimantan. In addition, this study provides information about management and potential processing of coal ash so that environmental pollution able to minimized. As a result, coal with low to high value has a percentage of ash content, respectively 2.5%; 2.3% and 9.7% and mineral content, respectively 77.40%; 0,96% and 95.06%. As well as the chemical composition of coal for SiO_2, respectively 26.56%; 30;50% and 58.76%, Al_2O_3 respectively 11.14%, 12.41% and 28.86%, Fe_2O_3 respectively 16.12%, 16.40% and 4.24%. CaO and TiO_2 respectively 0.50%, 0.64% and 1.53%. The results obtain, the calorific value can increase value of ash content. The value of ash content and the amount of minerals show an increase in each variation of the type of coal calories. This research provides information regarding the potential for managing and processing ash coal and minimize the environmental pollution.

1. Introduction

Indonesia has coal alternative reached 24.24 billion tons and production rate of coal reached 461 million tons. If coal production continues and no exploration, it is estimated that coal reserves in Indonesia will be exhausted within the next 53 years [1]. The coal is used as fuel for power plants to support the availability of electricity in Indonesia. Besides power plants which requires coal as fuel, industry such as the cement, paper, textile, and fertilizer industries also use coal as fuel. This is because the extraction process from coal is relatively easy and lower infrastructure cost comparated to fossil fuels [2].

Generally, there are three types of coal in Indonesia which can be divided based on their calorific value (CV), namely coals with low, medium and high. Coal with low to medium CV has properties are soft, and high water content of around 20% to 50% while coal with high CV has properties are hard, low water content, invisible wooden structure and resistant to physical damage in the production process [1].

Coal with this type of calories is one of them found in the South Kalimantan and Central Kalimantan. However, the most dominant is coal with low to medium CV, coal with high CV is also available but the availability is less than 30% [1]. Coal that is used as fuel can produce ash as a residual combustion material. The ash produced can be in the from of fly ash and bottom ash, both of types are hazardous waste. Ash content in coal seams is caused by organic and inorganic compounds produced from a mixture of modified materials during the coal formation process. Ash content in coal is caused by organic and inorganic compound produced from a mixture of modified materials during the coal forming process. Oxides, metals, and minerals are the most important chemical components of ash. Thus, in the combustion process of coal produces combustion residue, such as SiO_2, Al_2O_3, Fe_2O_3, CaO, MgO, Na_2O, K_2O, MnO_2, TiO_2, P_2O_5 dan SO_3 [3].

From an environmental perspective, the use of coal when compared to fossil fuels look more “unclean” both in term of combustion and transportation. Moreover, can produce greenhouse gases and ash as by-product of combustion which can damage environment. In fact, environmental problems caused by coal start from the mining process, because damage in the around mining area is caused by mining process does not applying the rules of “good mining practices” for examples aquatic ecosystems will be disrupted as becoming a transportations route for coal-carrying ships. However, from an economic perspective, the use of coal fuel is cheaper when compared to fossil fuels and natural gas [1].

2. Materials and Methods

2.1. Materials

The coal sample was taken from PT ABC at Tanjung, South Kalimantan for low and medium ash category, while for high ash category was taken from PT XYZ at Central Kalimantan. This research was conducted in PT Sucofindo Banjarmasin Km 18,2 No. 238, Landasan Ulin, Liang Anggang, Kota Banjarbaru, Kalimantan Selatan (70722) which consisted of several stages, namely determination of calorific value, ash content, and ash analysis.

Equipment used in this work are analytical balance, vessel. Calorimeter, furnace, refactory tray, hot plate and Erlenmeyer. Materials used in this study are ash samples, oxygen, indicator methyl orange, Na2CO3, aquadest, Li2B4O7, HCl as solvent.

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2.2. Preliminary Observation for Ash Samples

Preliminary observation activities are carried out to observe things that are needed as a support in the research process, these steps are divided into several stages namely, (1) observing the physical characteristics of samples, (2) collecting data and information by looking at composition of each parameter, (3) determining variables, (4) carried out tests for each parameter, and (5) collected data. Data analysis was performed using univariate analysis and bivariate analysis. Univariate analysis is statistical method and has only one variable. Univariate data requires to analyze each variable separately. Data is gathered for the purpose of answering a question or more specifically, a research question and bivariate analysis is to involves the analysis of two variables, for the purpose of determining the empirical relationship between them.

3. Results and Discussion

3.1. Effect of calorific value of various types of coal on ash content and chemical composition of ash

Coal is divided into three types according to calorific value (CV) i.e., low, medium and high calories of coal. CV of coal is affected by moisture and ash content, so the ash content increases causing the CV to decrease [4]. Samples for this research was taken from PT. ABC which is located at Tanjung, South Kalimantan for low and medium samples, whereas for high samples was taken from PT XYZ which is located at Central Kalimantan. The calorific value for various types calorie types of coal can be seen in Figure 1.

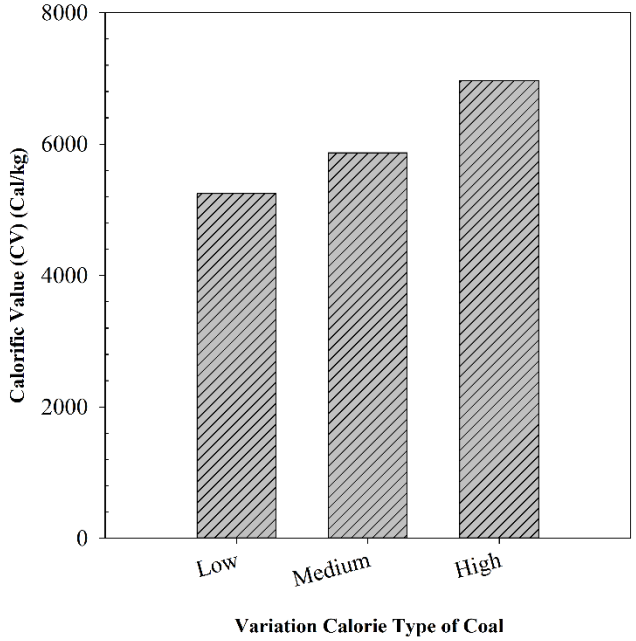

Fig. 1. Correlation between calorific value and calorie types of coal

Based on Figure 1, the calorific value of coal was increases in direct proportion to the quality of coal calorie type. This is accordance woth research that has been conducted by Toding, Triantoro and Riswan [4] calorific value of coal is strongly influenced by moisture and ash content. In addition, calorific value is also influenced by geological and geographical condition of coal formation process [5]. One of these geological conditions is type of soil that contains inorganic minerals [6]. Inorganic mineral content in the soil layers taken will effected reduce calorific value of coal [7]. Inorganic minerals contained in coal can affect combustion process [8].

Coal mining process also affects the calorific value, where contamination can occur in the coal bed produced. Contamination that often occurs is overburden which is also collected so that it mixed with the coal bed. In addition, coal impurities which are very difficult to separate are known as clay bands or parting, the visually similar to coal. Clay band can also reduce the calorific value of coal [4].

According to Nursanto and Ilcham [9], South Kalimantan has a layer of soil with a moisture content of 21.5%, this is due to peat soil content attached to the coal bed, thereby reducing the quality of coal combustion. Whereas in the Central Kalimantan, the moisture content is 0.99% which is causes minimal soil inorganic minerals to attach on coal. The difference inorganic mineral content causes Central Kalimantan have a higher calorific value than South Kalimantan. Furthermore, calorific value is also influenced by the main components of coal, namely carbon, hydrogen, nitrogen and sulfur. High component values can produce 20% of the calorific value of coal [10].

According to Nursanto and Ilcham [9], in his research stated that the carbon, hydrogen, nitrogen and sulfur content of coal in South Kalimantan respectively amounted to 64.16%; 6.26%; 1.25%, and 0.32% while for Central Kalimantan respectively 85.1%; 5.22%; 1.87%; and 0.70%. The mineral inorganic content has an influence on ash content in coal combustion. By Malaidji, Anshariah and Budiman [11] in his research that the lower inorganic content of minerals in coal, it can improve combustion process so as to reduce the ash content. The calorific value and ash content (% ad) for various type of coal based on calorific value level can be seen in Figure 2.

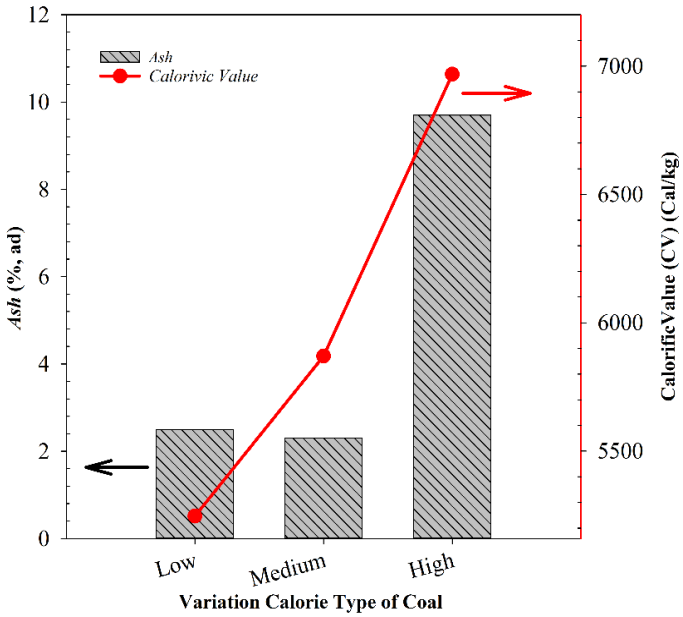

Fig. 2. Correlation Between Calorie Value and Percentage of Ash Content on Calorie Type of Coal

Figure 2, shown that the greater calorific value that can increase the ash content of the chemical composition of coal. This is in line with research conducted by Kijo-Kleczkowska, Szumera, Gnatowski and Sadkowski [12] which is explains that the ash content can indicate the calorific value of coal content. Ash content and calorific value were increased for each variation of type coal calorie. However, percentage of ash content for the medium type is lower than the low type with difference of 0.2%. The difference is caused by presence of complex content in ash coal that is not uniform and bonds between complex content in ash coal causing the ash content to be smaller [13]. Inorganic mineral content of coal can be grouped into major component consisting of SiO_2, Al_2O_3, Fe_2O_3 and minor component consisting of CaO dan TiO_2, each of elements has different characteristics [14].

Correlation between component complex on ash content and ash analysis on the type of coal based on variations in the type of calories can be seen in Figure 3.

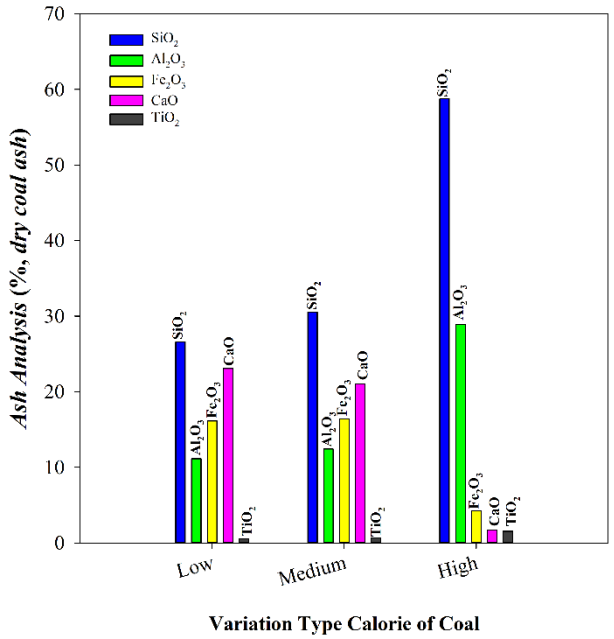

Fig. 3. Correlation between component complex on ash content and ash analysis (AA) on the type of coal based on various variation type calories of coal

Figure 3 shown about silica compound (SiO_2) has increased with variations in type of coal calorie. SiO_2 value increases with increasing various variation type calories of coal. This is due to the influence of silica alkalinity which can increase conductivity during the coal combustion. Besides being able to increase conductivity, the alkalinity of silica also increase pH of minerals in coal and decreased the acidity component [15]. Silica also affects for combustion of coal and causing crystal deposition in instrumentation of coal burning tools [13]. It can be seen on Figure 3, that silica is directly proportional to the aluminum in variations type of coal calorie. At temperature >1000^{0}C for combustion, silica will be easily bind to alumina and it can be increased the pH and form crust on the walls of instrumentation of coal burning. The bond between silica and calcium can decrease the pH at ash content [15]. This is evidenced from graph which increases the variation in type of coal calorie. Ash content which is acidic can caused low conductivity therby reducing the coal combustion. Titaium (Ti) represents the level of viscosity in ash content, the lower of Ti indicates level of viscosity ash are greater so that the formation of precipitates can be minimized [16].

Figure 3 also shows that the ratio between Ca and Fe can be used as benchmarks in determining for stability of chemical component in coal-fired equipment with the aim of preventing scale formation [17]. As for percentage of fusibility ratio of variations in the type of coal calorie, respectively 1.43; 1.28; dan 0.40 it can be concluded that using the high type of calorie can minimize scale formation and extend service life for coal-fired equipment.

4. Conclusion

Coal with low to high value has a percentage of ash content, respectively 2.5%; 2.3% and 9.7% and mineral content, respectively 77.40%; 0,96% and 95.06%. As well as the chemical composition of coal for SiO_2, respectively 26.56%; 30;50% and 58.76%, Al_2O_3 respectively 11.14%, 12.41% and 28.86%, Fe_2O_3 respectively 16.12%, 16.40% and 4.24%. CaO and TiO_2 respectively 0.50%, 0.64% and 1.53%. The results obtain, calorific value can increase the value of ash content. The value of ash content and the amount of minerals show an increase in each variation of the type of coal calories as well as the economic value shows a graph that always increases.

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