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Coal quality characterization in East Kalimantan Province, Indonesia: review from proximate, ultimate and calorific value analyses

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Abstract. This study discussed the characterization of the different qualities of coal in Kalimantan. The chemical and physical characterization of Kalimantan coal aimed to find the level of coal quality through proximate, ultimate and calorific value analysis. Based on the results of the study, the coal obtained from PT. Kideco Jaya Agung (KJA) had a moisture content of 17.86%, a fixed carbon of 36.56%, ash of 2.94%, volatile matter of42.64%, carbon of 44.86%, sulfur of 0.079% and calorific value of 4468.65 cal/gram. PT. Indemix Coalindo (IC) had coals with the moisture content of 25.94%, fixed carbon of32.48%, ash of 3.78%, volatile matter of 38.26%, carbon of 45.03%, sulfur of 0.436% and calorific value of 4462.67 cal/gram. Based on the results of the study, the efforts were needed to improve the quality of coal so that the coal collected could become an alternative energy-source with its highest quality and calorific value. Thus, it could compete in the international market.

1. Introduction

Indonesia is an archipelago and has more than 17,000 islands from Sabang to Merauke. Besides, Indonesia is also around 5,200 km from the equator, has many active volcanoes, and is located in a tropical climate [1,2]. Therefore, Indonesia is rich in mineral and coal resources. Coal in Indonesia is potential. From the total reserve of around 28 billion tons, Indonesia has 7 billion tons; so far, it has been proven there are around 10 billion tons. Total coal reserves in Indonesia reached 49.44%, spread in South Sumatra (38.01%), South Kalimantan (7.68%), and East Kalimantan (3.75%) [3].

One of the second-largest coal-producing regions in Indonesia is Kalimantan island with a total of around 37.5 billion tons; after Sumatra with 42.6 billion tons in total [4-7]. Some of the biggest coal producers in Indonesia are Bumi Resouce, Adaro, Kideco, Berau Coal, Banpu, and PTBA, which have 75% of production. Bituminous and Sub-bituminous is the type of coal mostly produced in Indonesia [8]. Coal is an alternative energy source that substitutes oil and gas which is economically valuable.

Coal is beneficial to meet daily fuel needs, especially in industry. The highest quality of coal is more efficient and effective. Coal quality is strongly influenced by several factors namely moisture content, ash, volatile matter, fixed carbon, which can reduce the quality for fuel, calorific value, sulfur, and carbon content [9]. To find out the best coal quality, the characteristics of the content in coal must be checked through the analysis of physical and chemical characterization [10]. This study aimed to determine the quality and identify the physical and chemical characteristics of coal so that the feasibility of its use could be determined as alternative energy. The analysis of coal characterization included proximate, ultimate, and calorific value analysis.

2. Samples and method

The following (figure 1) the the coal sampling locations in East Kalimantan Province:

Figure 1. Location Map of Coal Sampling of PT. Kideco Jaya agung and PT. Indemix Coalindo in East Kalimantan Province, Indonesia.

Coal samples were collected from PT. Indexim Coalindo (IC). This company, administratively, is located in Kaliorang Village, Sangkulirang District, East Kutai Regency, East Kalimantan Province. Moreover, the samples were also obtained from PT. Kideco Jaya Agung (KJA) in Paser Regency, East Kalimantan Province, precisely located in Batu Kajang Village, Batu Sopang District. Kideco's location is about 130 km from Balikpapan city to the south of East Kalimantan Province. The location can be reached by speedboat for ± 20 minutes to cross the Balikpapan bay and then use a 2-wheeled or 4-wheeled vehicle with a travel time of ± 3 hours [11].

Before conducting a physical and chemical characterization analysis, the researcher first applied a crushing process to reduce the size of coal grains to facilitate the grinding process. Milling and sifting aimed to obtain finer grain sizes; a coal mesh size of 200 was required for each sample analysis [12]. After that, physical and chemical analysis was applied to determine the quality of coal. The Proximate Analysis Process (direct analysis) included four stages, namely: Moisture Testing (Moisture Content) (%) (ASTM D. 3173-03) [13] [14], Ash Content Testing (%) (ASTM D 3174-12) [13] [15], Volatile Material Testing (%) (ASTM D. 3175-07) [13] [16], and Fixed Carbon Levels (%) (ASTM D. 5142) [13] [17].

The Ultimate Analysis Phase in the form of carbon and sulfur analysis was determined through elemental analysis; Sulfur Level (S) (ASTM D. 3177) [13, 18]. The sulfur analysis used the High Combustion Method, which utilized the SC-144DR Dual Range Sulfur Analyzer. In the carbon content analysis (C) (ASTM D. 3178-89) [19], the researcher determined it using the same method as the sulfur content determination process. Calorie Value Measurement (ASTM D-2015-96) [20] to analyze the calorific value was using the Hilton C200 PA digital bomb calorimeter.

3. Results and discussion

3.1. Proximate Analysis

The result of the proximate analysis in both coal samples is shown in **Table 1.**

Table 1. The Following Are The Results Of The Proximate Analysis of Coal Samples.

Samples ID	Moisture Content (%)	Ash Content (%)	Volatile Matter (%)	Fixed Carbon (%)
KJA	17.86	2.94	42.64	36.56
IC	25.94	3.78	38.26	32.48

Information:
KJA : PT. Kideco Jaya Agung
IC : PT. Indemix Coalindo

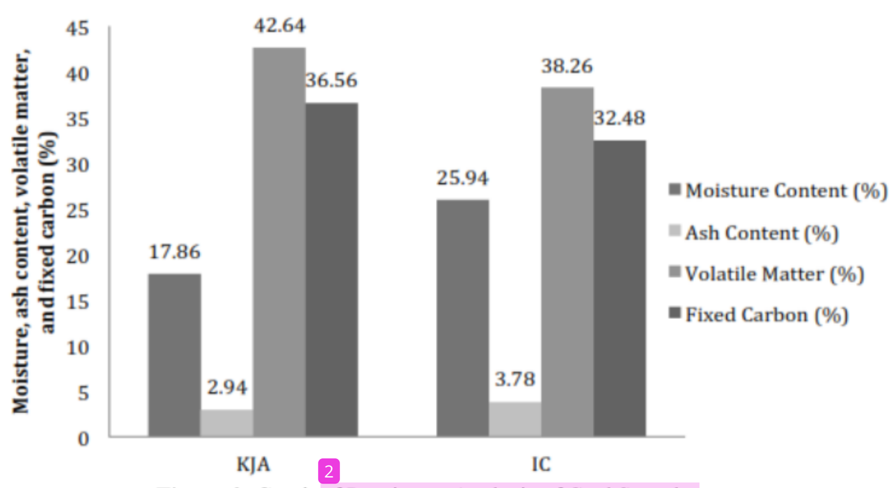

Figure 2. Graph of Proximate Analysis of Coal Samples

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Based on the proximate physics test in the graph of Fig. 2, PT. Kideco Jaya Agung and PT. Indemix Coalindo had a significant difference. Kideco held the lowest moisture content (KJA = 17.86%), while the IC produced a high moisture content of about 25.94%. The lowest ash value was generated by KJA (2.94%) and the highest was from IC (3.78%). The lowest volatile matter was shown by IC (38.26%), while KJA was 42.64%. IC obtained the lowest fixed carbon (32.48%), while KJA was 36.56%. Based on Fig. 2, KJA was shown low moisture and ash content, while IC indicated the lowest volatile matter as well as fixed carbon.

3.2. Ultimate Analysis

The result of ultimate analysis in both coal samples are shown in **Table 2.**

Table 2. Results of Ultimate Analysis in both of Coal Samples.

Samples ID	Carbon (C) (%)	Sulfur (S) (%)
KJA	43.52	0.079
IC	45.03	0.436

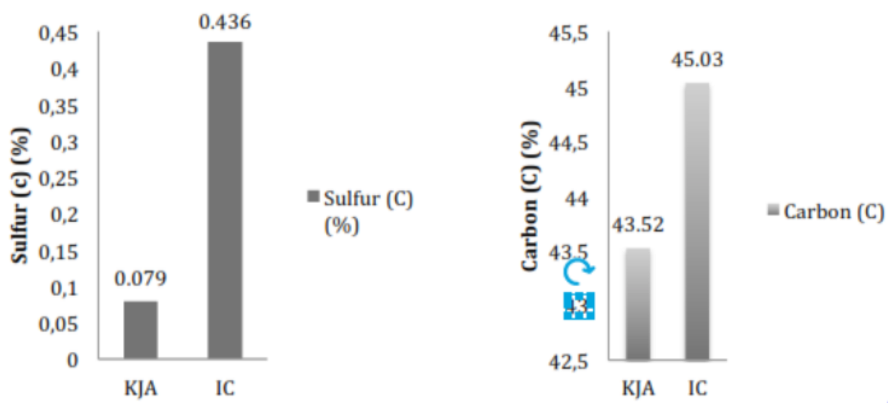

Figure 3. Graph Of The Result Of Ultimate Analysis In Both Of Coal Samples.

The ultimate analysis is a method to find out the elements contained in coal, as shown in Fig. 3. In the sulfur analysis, the lowest sulfur content found in the IC was very much different from the KJA (0.079%) and IC (0.436%). Even so, the two coals were still considered safe or include into the low sulfur category of < 1 % [21] [22]. IC carbon analysis provided high carbon at 45.03% while for KJA indicated 43.52%, and the difference between the two coal samples was not too significant.

3. Ultimate Analysis

The result of ultimate analysis in both coal samples are shown in **Figure 4.**

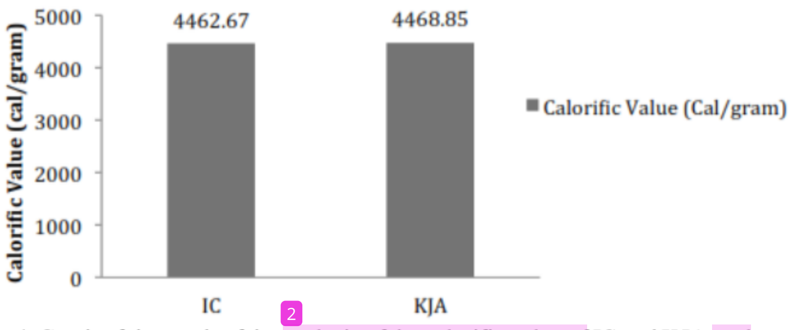

Figure 4. Graph of the result of the analysis of the calorific value of IC and KJA coal samples.

The graph in **Figure 4** shows the calorific value obtained from the two sites of coal. The analysis found the calorific value was not so much different from the details of KJA (4468.65 cal/gram) and IC of

4462.67 cal/gram. Based on the domestic market, the calorific value of the two coals was still sufficient to meet the standards, which generally ranged from 4.000 to 6.500 cal/gram; including the medium quality of coal. Both of these coals were sub-bituminous coals with a calorific value of 3.700 - 4.200 cal/gram [23].

4. Conclusion

Based on the results of the proximate analysis of the two coal samples at PT. Kideco Jaya Agung, it showed inversely proportional results for moisture content (17.86%) and ash (2.94%), while PT. Indemix Coalindo on volatile matter and fixed carbon produced low volatile matter of 38.26% and fixed carbon of 32.48%. In the ultimate analysis, the lowest sulfur content was shown at PT. Kideco Jaya Agung by 0.079% while at PT. Indemix Coalindo had 0.436%.

The sulfur content in both coals was still included in the safe category or low sulfur of <1 %. The lowest carbon content was in PT. Kideco Jaya Agung of 43.52% and PT. Indemix Coalindo of 45.03%. The calorific values produced by these two samples were not so much different; at PT. Kideco Jaya Agung was 4462.67 cal/gram and PT. Indemix Coalindo was 4468.85 cal/gram. The calorific value generated is met the domestic market standard and included in medium-rank lignite (sub-bituminous) because the calorific value was 4.000-6.500 cal/gram. Based on the analysis of coal characterization in this study, the efforts were needed to improve the quality of coal so that the coal obtained could be an alternative of energy source with the best quality and high calorific value. Thus, Indonesian coal can compete in the international market.

Acknowledgment

The use of a reduced beam section on the beam flange could suppress the effect of cyclic loading; thus, the damage did not occur on the connection of beam and column flange. The damage only occurred on the column face. The experiment results show that shear failure occurred on the column face of the RBS area. This means that the castellated beam had a buckling on the beam web due to the cyclic loading, which caused damage to the RBS area.

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