THE IMPACT OF TOTAL MOISTURE AND ASH ON CALORIFIC VALUE: COAL RESEARCH IN BERAU SUB-BASIN. EAST KALIMANTAN

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Abstract *— Coal quality is one of the key factors in determining the effectiveness of processing and utilization. Coal quality assessment involves analyzing physical and chemical aspects to determine its characteristics. Coal quality is also influenced by geological conditions at the mining site, which affect the quality and amount of carbon in the coal. To ensure consistency. it is necessary to implement coal quality control based on physical and chemical parameters from the mining process in the pit to storage in the stockpile. Analysis of the effect of total moisture and ash on the calorific value of coal is the purpose of this study. The method used is a ROM (Run of Mine) coal sample located at the stockpile location. The relationship between Total Moisture and Ash to the calorific value of coal shows a negative linear correlation. This means that every 1% increase in Total Moisture results in a decrease in calorific value of 71.343 kcal/kg and likewise every 1% increase in Ash value results in a decrease in calorific value of 82.588 kcal/kg. Total Moisture increases by 1%. reducing the calorific value of coal by 71 kcal/kg, and increasing Ash content by 1% reduces the calorific value of coal by 83 kcal/kg.*

Keywords*: Ash, Berau Sub-basin, Coal, Total Moisture*

I. INTRODUCTION

Proximate analysis is an analysis in determining the quality of coal which is determined by the factors of moisture, ash, volatile matter, and fixed carbon [1]. The problem that arises from coal quality is the difference in the calorific value of coal every time a test is carried out, either samples in the same location or in different locations. This proves that in the same location, it does not necessarily have the same coal quality value. Differences follow the difference in calorific value in the values of other parameters such as total moisture, ash, inherent moisture, volatile matter, fixed carbon, and total sulfur. The main elements that makeup coal consist of Carbon (C), Hydrogen (H), Oxygen (O), and Nitrogen (N) [2]. Coal also has complex physical and chemical properties and can be found in various forms. The types of coal are distinguished based on the number of calories contained in it, the higher the quality value of the coal, the higher the carbon content and heat content, while the hydrogen and oxygen content will decrease [3]. Low-quality coal such as lignite and sub-bituminous have high total water content and low carbon content. Thus, coal also has low energy characteristics. Generally, the higher the carbon content, the harder and denser the coal will be, and the blacker and shinier it will be. Some coal quality parameters that must be considered in determining its content or quality are as follows:
(a). Calorific Value; the energy content contained in a coal that represents a combination of combustion of Carbon, Nitrogen, Hydrogen and Sulfur [4].
(b). Moisture; the water content of coal affects the use of primary air. Coal with high water content requires more primary air to dry the coal so that the temperature of the coal coming out of the mill is constant to ensure the quality of industrial production results [5].

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(c). Ash; when coal is burned, the inorganic compounds present are converted into fine oxide compounds in the form of ash. The ash produced during coal combustion is referred to as ash content. This ash is a collection of carbon-forming materials that cannot be burned (non-combustible material) or oxidized by oxygen [6]. The ash content in coal is one of the important parameters to analyze because it affects the environment [7].
(d). Sulfur Content; the presence of sulfur in carbon affects the level of cold corrosion (external) that occurs in air heating elements (especially when the working temperature is lower than the sulfur dew point) and also affects the efficiency of the electrostatic precipitator. The presence of sulfur in the atmosphere, either inorganic or organic, triggers rainwater [8], causing the formation of acid water (known in the coal mining world as acid mine drainage, pH <7).
(e). Volatile Matter; due to excessive pressure, the water content of the coal decreases, conversely, the lower the water content, the higher the calorific value. At the same time, the carbon evaporation process takes place. All remaining Oxygen, Hydrogen, Sulfur, and Nitrogen are reduced so that the concentration of volatile substances decreases. The higher the fuel ratio, the more unburned carbon.
(f). Fixed Carbon; defined as the material remaining after moisture, volatiles and ash have been reduced. If the moisture content and ash content values are equated with the volatile matter value, it can be concluded that the lower the water content, the smaller the moisture content and the higher the fixed carbon value.
(g). Hardgrove Grindability Index; is how easy or difficult it is to grind the coal into powdered fuel. In practice, before using coal as fuel, the grain size is equalized from fine to coarse. The finest grains measure <3 mm, while the coarsest grains measure up to 50 mm. The lower the HGI value, the harder the coal condition [9].

The grindability is related to its physical properties, chemical composition, and petrography of coal [10]. Factors that affect changes in coal quality include:
(a). Dilution and Contamination [11]; this factor is the mixing of other materials in the coal pile. Handling of contaminants or contamination can be done with strict supervision when loading materials at the front and periodic cleaning of equipment.
(b). Coal transportation activities; in coal transportation activities, wet or dusty road conditions also affect the quality of coal [12]. Handling of ash from the coal transportation process must receive serious attention because an increase in ash content will directly affect the decrease in calorific value.
(c). Fine coal due to the handling process; coal handling is one of the activities that greatly affects the quality of coal because it has the potential to produce fine coal [13]. Mining and handling coal activities in stockpiles using large equipment such as loaders, excavators and dump trucks result in the formation of fine coal. Fine coal formed from these activities results in an increase in the ash content of coal which directly results in a decrease in the calorific value of coal.
(d). The size of the coal grains is not uniform; the smaller the size of the coal grains, the higher the surface water content and the higher the total water content, causing a decrease in the calorific value of coal [14].
(e). Weather and climate; the influence of weather and climate is an unavoidable influence in carrying out mining industry activities. Frequent rainy weather causes the water vapor content in coal to increase [15]. especially in coal that has a small grain size and has been stored for a long time. Conversely, when the weather is hot, it will cause spontaneous combustion which has the potential to increase the ash value which directly reduces the calorific value of coal.

Administratively, the research location is located in Berau Regency, East Kalimantan (Figure 1). This regency has coal-bearing formations with bitumen-subbitumen types, namely the Latih Formation, Labanan Formation, Domaring Formation, Sajau Formation, and Sembakung Formation [16]. Geologically, the Labanan Formation consists of alternating sandstone, siltstone, claystone intercalated with limestone and coal. The coal thickness is about 0.2-1.5 meters. The unit thickness is approximately 450 meters. This formation was deposited in a fluviatile environment, and is of Late Miocene-Pleistocene age [17].

The purpose of this study was to analyze the effect of total water content and ash content on the calorific value of one of the coal-producing formations in the Berau Sub Basin, East Kalimantan, namely the Labanan Formation.

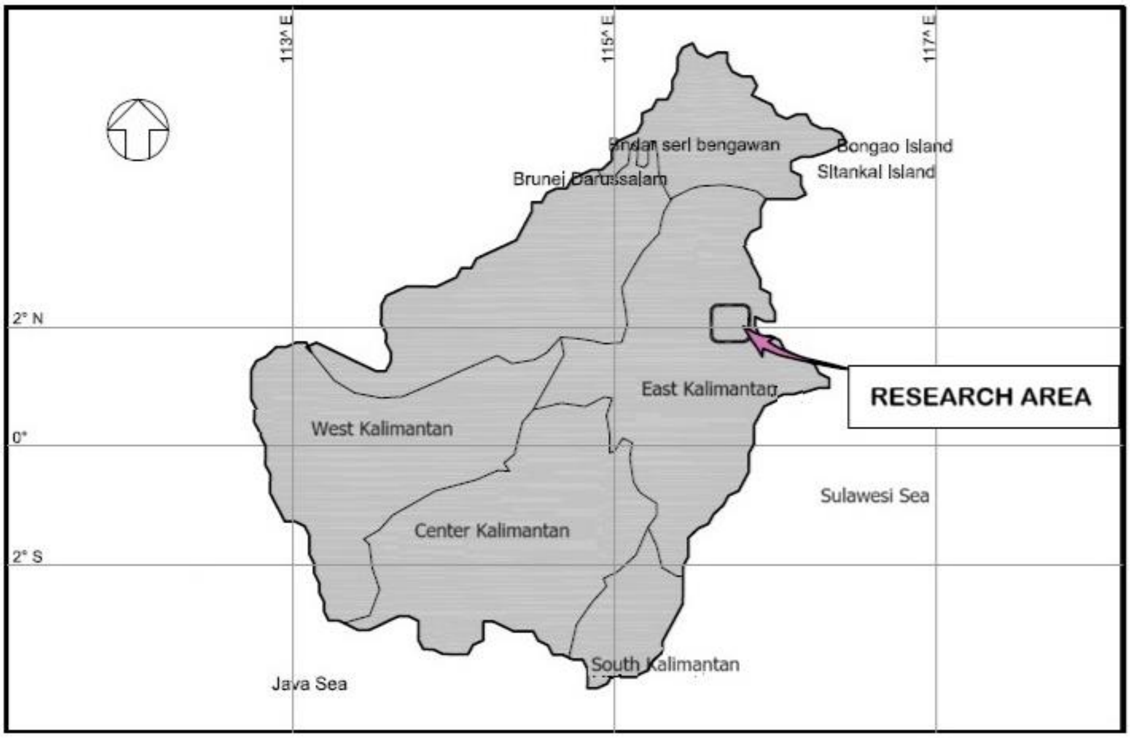

Figure 1. Research location in Berau Regency, East Kalimantan [16]

II. METHODS

The research method used in the research area is coal samples located at the ROM coal pile location (Figure 2). The analysis standards used in this research use the American Society for Testing and Materials (ASTM), namely the method for Total Moisture in Coal (ASTM D 3302). Ash in the Analysis Sample of Coal and Coke from Coal (ASTM D 3174), and Gross Calorific Value of Coal and Coke (ASTM D 5865) [18]. The basis used in the analysis of coal samples in this investigation is As Received (AR), which is coal from mining that still contains moisture content, ash content and pure coal, and Air Dried Basis (ADB), which is coal where the surface moisture content is assumed to be lost because the sample has been dried in the open air. Coal analysis was carried out in the laboratory of PT. Ithaca Resources Sambarata site, Berau Regency, East Kalimantan.

Figure 3 shows the flowchart of research methods and implemented in the research area, Coal samples found in the stockpile were subjected to regression analysis tests. Regression analysis tests are carried out to determine the direction of the relationship between the independent variables and the dependent variables, whether each independent variable is positively or negatively related and to predict the value of the dependent variable if the value of the independent variable increases or decreases [19]. The analysis used is a simple linear regression equation as follows (1):

$$Y=a+bX \tag{1}$$

where:
Y = Dependent variable (predicted value)
X = Independent variable
a = Constant
b = Regression coefficient (increase or decrease value)

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Figure 2. *Location of ROM coal at the research area*

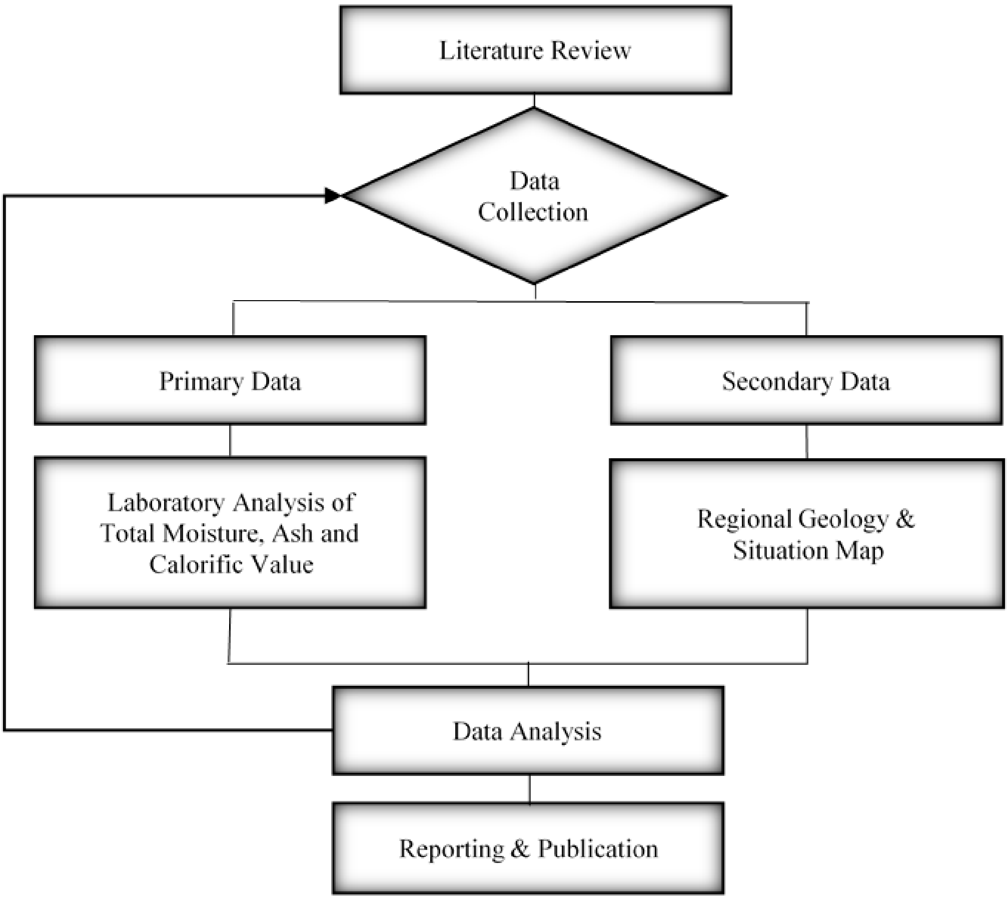

Figure 3. Flowchart of research methods in the research area

III. Results and Discussion

The Raw of Mine (ROM) coal comes from Labanan Formation. From the 20 samples of coal, the average of Total Moisture 37.54%, Ash 5.32%, and Gross Calorific Value 3795 kcal/kg. The minimum value of Total Moisture 34.64%, Ash 3.51%, and Gross Calorific Value 3573 kcal/kg. The maximum value of Total Moisture 39.63%, Ash 8.61%, and Gross Calorific Value 4003 kcal/kg. The results of laboratory tests on the quality of Raw of Mine (ROM) coal in stockpile area on 20 coal samples are as in Table 1 below.

Table 1. ROM coal quality parameters in the research area

No	Sample ID	TM (% ar)	Ash (% adb)	GCV kcal/kg (ar)
1	ROM 01	39.13	4.21	3788
2	ROM 02	38.12	5.51	3752
3	ROM 03	36.76	5.01	3818
4	ROM 04	39.46	5.31	3724
5	ROM 05	38.78	5.32	3754
6	ROM 06	37.61	5.16	3784
7	ROM 07	38.46	5.02	3805
8	ROM 08	35.37	3.71	3986
9	ROM 09	35.57	3.54	3970
10	ROM 10	35.12	3.51	3992
11	ROM 11	37.55	4.96	3817
12	ROM 12	34.64	3.89	4003
13	ROM 13	34.72	4.16	3982
14	ROM 14	39.20	7.87	3584
15	ROM 15	39.63	7.76	3573
16	ROM 17	38.26	4.71	3785
17	ROM 18	38.18	5.17	3726
18	ROM 19	37.54	8.61	3621
19	ROM 21	38.56	5.76	3793
20	ROM 22	38.16	7.15	3651
AVERAGE		37.54	5.32	3795
MIN		34.64	3.51	3573
MAX		39.63	8.61	4003

On Figure 4 below, the liner correction is directed Northwest - Southeast. In the distribution of 20 coal samples on TM vs GCV, there is an impression of a gap, namely the distribution in the Northwest and Southeast. There are not coal samples were found that had a TM value of around 36% at GCV around 3900 Kcal/kg. In GCV low-grade coal as characterized by changes in water content, fixed carbon, volatile matter, and ash content (proximate analysis) is influenced by environmental factors, such as temperature, humidity, and air flow affecting [20].

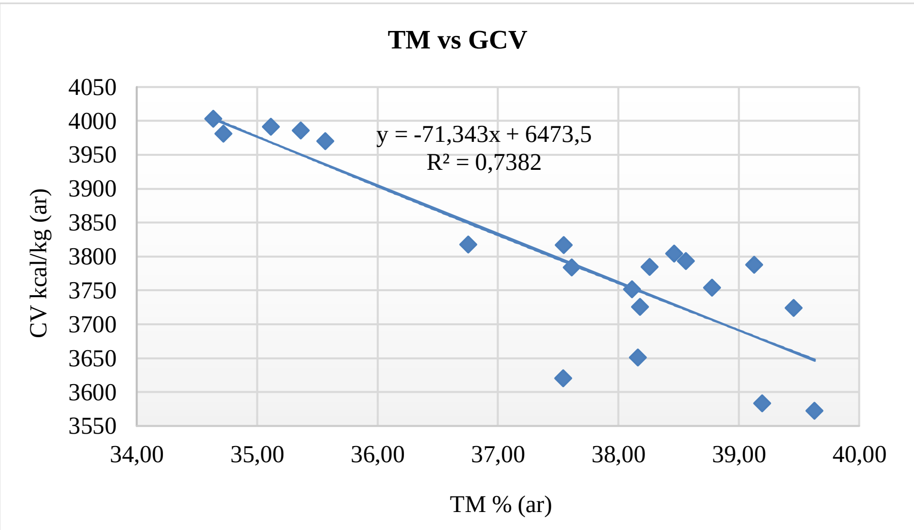

Figure 4. Linear correlation between Total Moisture and Caloric Value of coal

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On Figure 4 shows a negative linear correlation where the influence value for a 1% increase in Total Moisture is -71.343 kcal/kg of its calorific value (decrease) so that the regression equation is obtained (2):

$$Y = -71.343X + 6473.5 \quad (2)$$

where:
Y = Dependent variable (GCV)
X = Independent variable (TM)

The linear line in Figure 4 shows a negative relationship with a correlation value of 0.7382, meaning that the addition of X (TM) causes a reduction in Y (GCV) which can be interpreted that if the Total Moisture value is high causes the coal calorific value (GCV) decreases.

On Figure 5 below, the liner correction is directed Northwest - Southeast. There are two gaps on Ash vs GCV coal distribution, located on the top, middle and bottom. There are not coal samples were found that had a Ash value of around 4% at GCV around 3900 Kcal/kg, and Ash on 7% at GCV 3700 Kcal/kg. On Figure 5 shows a negative linear correlation where the influence value for a 1% increase in Ash is -82.588 kcal/kg of its calorific value (decrease) so that the regression equation is obtained (3):

$$Y = -82.588X + 4234.4 \quad (3)$$

where:
Y = Dependent variable (GGCV)
X = Independent variable (Ash)

The linear line in Figure 5 shows a negative relationship with a correlation value of 0.8183, meaning that the addition of X (Ash) causes a reduction in Y (GCV) which can be interpreted that if the Ash value is high. the coal calorific value (GCV) decreases.

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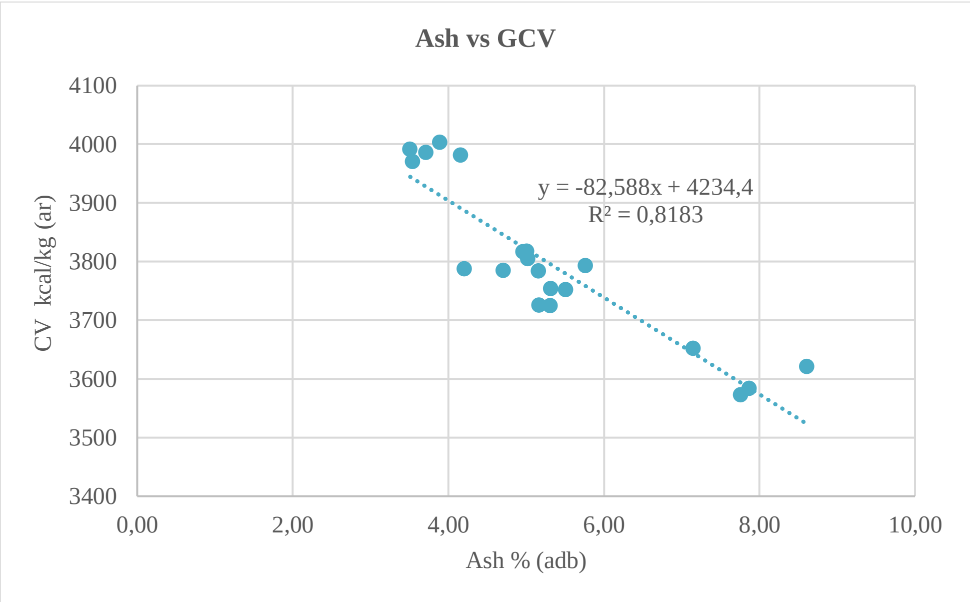

Figure 5. Linear correlation between Ash and Caloric Value of coal

Minerals reduce the economic value of coal [21]. The ash produced from coal combustion is the minerals contained in the coal [22]. Low ash content has a high calorific value, and high ash content has a low calorific value. This correlation is caused by the presence of unburned mineral matter in the coal seam sample, thus disrupting the combustion process and causing the calorific value to be small [23]. The high and low calorific value of coal does not only depend on the ash content, and there are still other parameters as determinants of the calorific value of coal.

IV. Conclusion

Total Moisture and Ash have a significant effect on the calorific value of coal. The higher the Total Moisture and Ash content, the lower the calorific value of coal. In ROW coal, it is known that increasing the Total Moisture content by 1% will reduce the calorific value of coal by 71 kcal/kg and increasing the Ash content by 1% will reduce the calorific value of coal by 83 kcal/kg.

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