Effect of mixed additions in residual oil to improve the quality of sub-bituminous coal from Sangatta, East Kalimantan

Flaviana Yohanala Prista Tyassena and Widya Ashari Amin

Department of Mineral Chemical Engineering, Politeknik ATI Makassar, Sulawesi Selatan, Indonesia

Email: flaviana.yohanala@atim.ac.id

Abstract. Indonesia is well-known for its abundant coal reserves but is included in low-rank coal with a total moisture content of 40%. In the combustion process, this water content will reduce the calorific value so that the use of coal becomes inefficient and not environmentally friendly. The purpose of this study was to determine the effect of added additives to residual oil to improve the quality of sub-bituminous coal originating from Sangatta, East Kalimantan. Variations of additives used include NaOH, HCl, and Pertalite, mixed with residual oil. The results in this study indicate an increase in calorific value in each composition of mixed additives. The best results were obtained for residual oil mixtures with Pertalite, which obtained coal with a calorific value of 7204 cal/g, moisture content 16.9%, ash content 3.5%, carbon content 40.7%, sulfur content 0.41%, and flying substance content 38.9%.

1. Introduction

The amount of volcanic activity makes Indonesia rich in mineral content, one of which is coal. In 2009 coal production in East Kalimantan was 123,256,163 tons, in 2010 it rose to 140,753,374 tons and in 2011 production had reached 204,989,756 tons [1]. However, coal reserves in Indonesia are generally low-rank coal. Based on BP Statistical Review of World Energy data, June 2012, Indonesia has 5,529 billion tons of coal resource reserves, with the percentage of high-quality coal and low-quality coal, respectively 27.49%.

The type of coal is influenced by the process of its formation. One type of coal that is commonly found in Sangatta, East Kalimantan, is the Sub Bituminus type. Sub Bituminous contains little carbon and a lot of water content. In the combustion process, water content will reduce the calorific value and the amount of coal used is much greater. It makes a negative environmental impact. Therefore sub-bituminous coal is a less efficient source of heat compared to bituminous, which has higher calorific value. Sub-bituminous coal has calorific value for about 4500 – 5000 cal/g, while bituminous coal has a calorific value of more than 7000 cal/g [2].

Used oil is a class of B3 waste because used oil can cause the soil to become barren and lose its nutrients. While its nature, which is not soluble in water, can cause water pollution, besides that oil is also flammable [3]. The nature of flammable used oil can be utilized to improve the quality of coal.

Improving the quality of coal can be done by upgrading. Several studies that have been done previously show that with the upgrading process, the calorific value of coal will increase so that it will be more efficient to be used as an energy source, for example, in steam power plants. Several studies have been carried out, among others, by Arisandy et al. (2017), the process of improving the quality of sub-bituminous coal using a process by adding residual oil and premium that is heated at a temperature of 150-200°C results in water content, and sulfur content decreases, while ash content, fly levels increased [2]. The disadvantages of this research are that the levels of ash and flying matter have increased, and this will reduce the heating value and environmental pollution. Therefore in this study, additional NaOH, HCl, and pertalite are used in combination with used oil and are expected to increase the calorific value of coal without increasing sulfur and ash content.
2. Experimental Methods

2.1. Size Reduction
Sub-bituminous coal from Sangatta, East Borneo was first crushed using jaw crusher then sieved to get particle below 3 mm.

2.2. Desulphurisation
Coal that has been crushed before then dried in dry sheet for about 18 hours at 40°C. After obtaining a constant weight, coal then mixed by each solvent. For the desulphurisation method, coal was mixed with used oil and hydrochloride acid in a ratio of 2: 1: 1. The mixture was put into a beaker glass then heated in hotplate at temperature 200°C for 75 minutes. The mixture was filtered at room temperature to get the coal particle. And then the coal was put back into the dry sheet for further drying.

2.3. Demineralisation
For demineralization, coal, which has been crushed before, was mixed by used oil and sodium chloride in a ratio of 2: 1: 1. As in desulphurization method, the mixture was put into a beaker glass then heated in hotplate at temperature 200°C for 75 minutes. The mixture was filtered at room temperature to get the coal particle. And then the coal was put back into the dry sheet for further drying.

2.4. Pertalite Addition
The third method is addition method. In this method, some solvent that has high calorific value was added into the coal. For addition method, pertalite was chosen as additives. As the other methods, coal, which has been crushed before, was mixed by used oil and pertalite in a ratio of 2: 1: 1. As in desulphurization method, the mixture was put into a beaker glass then heated in hotplate at temperature 200°C for 75 minutes. The mixture was filtered at room temperature to get the coal particle. And then the coal was put back into the dry sheet for further drying.

2.5. Analysis
The filtered coal sample was dried in dry sheet for several days. After it was really dry, the coal was analyzed. Analysis conducted includes inherent moisture, ash content, volatile matter, fixed carbon, total sulfur, and calorific value. Inherent moisture, ash content, volatile matter, and fixed carbon analysis using laboratory instrument and chemical apparatus. Total sulfur was analyzed using a sulfur analyzer. Furthermore, the calorific value was analyzed using a bomb calorimeter.

3. Results and Discussion
In improving the quality of coal three methods can be used, namely: desulphurization, demineralization, and the addition of a solution (Pertalite), all three methods are used in this study to improve the quality of coal. The principle of the desulfurization method is to improve the quality of coal by reducing the sulfur content of coal. The principle of the demineralization method is to improve the quality of coal by reducing ash content, while the last method is to add a solution containing high calorific value.

In this research, several compositions of mixed materials were used, namely used oil as an adsorbate, HCl as a solvent in the desulphurization method, NaOH as a solvent in the demineralization method, and pertalite as a solvent in the method of adding solutions.
Based on the results of the study as shown in Figure 4.1, for a combination of used oil and NaOH (demineralization method) has a calorific value of 6,610 cal / g, for a combination of used oil and HCl (desulfurization method) of 6,807 cal / g, and combination used oil and pertalite (method of adding solution) is 7,204 cal / g.

The combination of used oil and pertalite can increase the calorific value of coal from 4,379 cal / g to 7,204 cal / g and provides the highest value compared to the other two solvents. This increase in calorific value is due to the high calorific value of pertalite, which is 44,260 kJ / kg [4]. while used, oil will facilitate the absorption of pertalite into coal. This combination of used oil and pertalite can make this sub-bituminous coal has the same calorific value as bituminous coal (more than 7000 cal/g), the highest rank of coal.

**Figure 1.** Effect of method variation in improving calorific value of coal.

**Figure 2.** Effect of method variation in reducing sulphur content of coal.
Besides calorific values, sulfur content and ash content are also important parameters in determining coal quality. Low levels of coal ash and sulfur content are desirable, so coals will not cause adverse effects on the environment. The combination of used oil solvents and pertalite can increase the calorific value without increasing the sulfur content and ash content of coal. Figure 2 shows the sulfur content before and after treatment. Sulfur content from untreated sub-bituminous coal was 0.44%. While the sulfur content after being treated was 0.43%. Meanwhile, Hydrochloric Acid can reduce the sulfur content from 0.44% to 0.37%.

![Figure 2](image)

**Figure 2.** The sulfur content before and after treatment.

Figure 3 shows the ash content of sub-bituminous coal before and after treatment. The combination of used oil solvents and pertalite can also reduce the ash content of coal from 7.4% to 5.6%. However, Sodium Hydroxide is the best additive to reduce ash content. Sodium hydroxide can dissolve some minerals content in coal, such as Si, Al, Fe, Cr, Ti, Mn, Mg, Na, and K [5].

4. Conclusion

The combination of used oil and pertalite can increase the calorific value of sub-bituminous coal from Sangatta, East Kalimantan, without increasing sulfur and ash content. The calorific value obtained was 7,204 cal / g with sulfur content of 0.43% and an ash content of 5.6%. This result gives the highest calorific value compared to the combination of used oil + NaOH and used oil + HCl.

References

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