Coal Upgrading: Desulfurization and Dehydration of Low-Rank Coal and High-Rank Coal through Blending Method

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ABSTRACT

Introduction : Sulawesi coals contain significantly high of sulfur. This makes it not suitable to be used as fuel, unless it went through an engineering process so that the use of low-rank coals can be optimized by preserving the environmental impacts that may be caused. The process is in the form of upgrading the coals through physical desulfurization and dehydration with blending method. The purpose is to make coal meet the fuel use standard in industry. **Method:** This study used low-rank coal from Pattuku (BP),while the high-rank coal studied was from PT Semen Tonasa (BT) on a dry base with a size of 100 mesh. The variables observed were the smallest total sulfur content, the largest calorific value, and the smallest (optimal) water content. **Results and Disscussion**: The results showed that the total sulfur content in all variations of BT:BP ratios are 1:0, 3:1, 1:1, 1:3 and 0:1. Thus, based on the ratios, the coal fulfilled the standard to be used as fuel for cement industry while the variation of BB that fulfilled the standard to be used as coal-fired power plants had ratios of 1:0, 3:1 and 1:1. The smallest (optimal) total sulfur level was 0.1046% at the BB ratio of 1:0. BB water content in all variations of BT: BP ratiosmetthe standard to make it as fuel for cement industry and coal-fired power plant (PLTU). **Conclusion**: The smallest (optimal) water content was 2.48% on the blending coal ratio of 0:1. The calorific values of BB on all variations of BT:BP met the standard to be used as fuel for cement industry had ratios of 3:1, 1:1 and 1:3,yet there was no single BB that metthe standard to be used as coal-fired power plant (PLTU). The largest (optimal) calorific value was 6.506.39 kcal/kg at the BB ratio of 0:1.

1. Introduction

Coal is organic sedimentary rock with combustible carbon, hydrogen and oxygen as well as inorganic compounds as the main composition, especially mineral elements derived from clay, quartz sand, lime stone and others [1,2]. Furthermore, coal also has chemical contents, such as organic compounds as the main component, inorganic compounds and sulfur compounds [3]. According to [4] and [5], the in organic compounds in coal are minor components in the form of mineral compounds such as carbonates, oxides, sulfides, sulfates and phosphates. Moreover, coal has the potential to be an alternative fuel beside oil and gasfor its abundant reserves. In Indonesia,the coal reserves reach 38.8 billion tons [6]. However, the quality of coal in Indonesia is still low with not maximumcalorific value and high sulfur and ash content. Thus, coal cannot be fully utilized as fuel in industry. Low-rank coal which has low calorific value, high sulfur and water content can result in combustion equipment in the form of corrosion and cause pollution to environment.

Engineering process toward low-rank coal such as coal from Pattuku region, Bone Regency is needed to carry out to maintain possible environmental impacts. The engineering process is in the form of upgrading, namely desulfurization and dehydration of coal physically, chemically and biologically. Physical upgrading is very suitable for low-rank coal with low calorific value, high sulfur and water content. The process occurs at low temperatures and can be done quickly. The process is done through coal blending method. The purpose is to make coal fulfill fuel use standards in cement industry with a maximum of 0.8% total sulfur and 12% water content, while for power plant the maximum total sulfur and water content are 0.4% and 13.6%, respectively [7]. Blending is a process of mixing low-rank coal with high-rank coal in certain compositions and made them as homogeneous as possible. Therefore, low-rank coal such as the coal from Pattuku, Bone Regency, can be utilized through blending method with high-rank coal such as the coal from PT Semen Tonasa, Pangkep Regency. In general, coal should be as low as 6,000-7,000 cal/g or maximum contains 0.4-0.8% sulfur and 6-7.8% ash to be used for power plant and cement industry [8]. However, combustion of high sulfur coal can form SOx gas pollutant [5,2,9].

Some previous studies had been done to analyze blending method for high-rank coal and low-rank coal. [10] have conducted a research on the blending of semi-anthracite coal with sub-bituminous coal, while [11] and [12] have conducted research on mixing coal between flotation coal and bituminous coal from East Kutai region. The characteristics of blending coal depend on the quality of the coal. According to the previous studies, lignite and sub-bituminous coal had never been mixed. The sulfur content of coal ranges from 0.5-4% even according to [13] Turkish coal has 13%sulfur. Sulfur compounds in coal is in the form of organic sulfur, in general, a smaller composition of about 1.5% consists of 0.144% non-aromatic organic sulfur and the remaining aromatic ring is less than 1.5%. In addition, inorganic sulfur is mainly found in the form of sulfur iron (mayor): pyrite or marcasite (FeS2). On the other hand, the sulfur sulfate (minor) is in the form of gypsum and jarosite [Fe3(SO4)3(OH)6] [14-16].

According to [5], based on the quality, coal consists of four main classes based on ASTM standards: anthracite, bituminous, sub-bituminous and lignite. The coals used in this study were obtained from Pattuku and PT Semen Tonasa. The variables to be observed were total sulfur, calorific value and water content of blending coal in various mixed low-rank coal compositions.

2. Method

This In order to obtain the research objectives, the researchers looked for low-rank coal Pattuku, Bone Regency, and high-rank coal from PT Semen Tonasa, Pangkep Regency. The main tools used in this research is upgrading in the form of desulfurization and dehydration of low-rank coal and high-rank coal through blending method as shown in Fig 1. The research also done by utilizing materials available in the market. In addition to the tools mentioned in the figure, the support tools were get from the Research Laboratory of the Faculty of Engineering, Tadulako University.

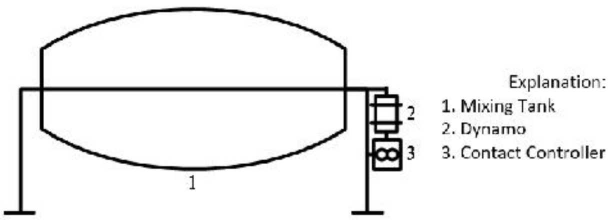

Fig 1. Coal Blending Tool

2.1 Coal Preparation

Firstly, the coal sample went through crushing and grinding process by crushing, grinding and sieving until the size was 100 mesh on wet basis. The result were then dried at 105 ^{o}C for 3 hours until the water content is constant and the coal produced is on dry basis. The sulfur level, water content and calorific values in the dry coal were then analyzed according to the ASTM standard.

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2.2 Coal Blending Procedure

The coals used as sample were get from two locations: Pattuku, Bone Regency and PT Semen Tonasa, Pangkep Regency. The samples went through some process namely crushing, grinding and sieving to obtain 100 mesh coal size on a wet basis. After that, the coal is dried at 103oC for 3 hours so that the coal is on dry basis. The blending was done between 100 mesh coal size from Tonasa and 100 mesh coal size from Pattuku based on dry basis by varying the ratios of the mixture composition namely1:0, 3:1, 1:1, 1:3 and 0:1 for 1 hour.

2.3 Analysis of Coal Blending Result

The result of coal blending was analyzed based on its sulfur content, water content and calorific value. The analysis was carried out at the Makassar Branch of PT Sucofindo Laboratory using the analysis of the Minimum Free Space Oven, LECO S-144 DR and Bomb Calorimeter under LECO AC-350 brand.

2.4 Data Processing

Based on the results of the study, the ratios used for coal blending was observed. It is expected that an upgrading empirical equation in the form of desulfurization and dehydration of low-rank coal and high-rank coal through blending method will be obtained based on the variables observed. The empirical equation obtained will be used as the basis for designing a coal blending tool.

3. Results and Discussion

3.1 The Sulfur Content of Blending Coal

From this study, the value analysis of total sulfur content of blending coal was obtained as presented in Figure 2. The results showed that the total sulfur content in all variations of the Tonasa: Pattuku coal ratios of 1:0, 3:1, 1:1, 1:3 and 0:1 met the criteria required to be used as fuel for cement industry, while the variations of blending coal that can be used as fuel for coal-fired power plant (PLTU) has the ratios of 1:0, 3:1 and 1:1. The smallest total sulfur content (optimal) was 0.1046% in blending coal ratio of 1:0.

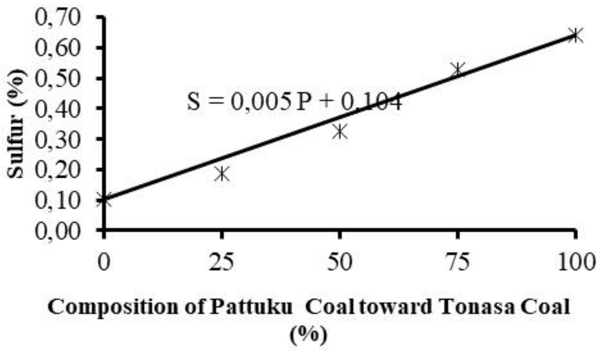

Fig 2. Changes in Total Sulfur Content of Blending Coal

The result of the analysis of total sulfur content of blending coal from Pattuku and Tonasa followed the rule of the mass balance without any indication of a chemical reaction. The total sulfur content as a function of coal blending based on simulation count is a linear function with the following equation:

$$S\ (\%) = 0.104 + 0.005\ P \qquad (1)$$

S symbolizesthe total sulfur content (%),while P symbolizesthe composition of Pattuku coal against Tonasa coal blending (%). This equation means that if the composition of Pattuku coal is 0%,the Tonasa coal has a total sulfur content of 0.104%. If it is compared with the total sulfur content in blending coal,the laboratory measurementamounted to 0.3256% only give a Sum Squer Error (SSE) of 0.0054 or 9.27 % which means that the differences can be neglected.

3.2 The Water Content of Blending Coal

From the result of the study, it is showed that the water content of blending coal in all ratios variations of Tonasa:Pattuku coal metthe standard to be used as fuel for cement industry and coal-fired power plant (PLTU). The smallest (optimal) water content was 2.48% in the blending coal ratio of 0:1. The water content of blending coal in each ratio can be seen in Fig. 3.

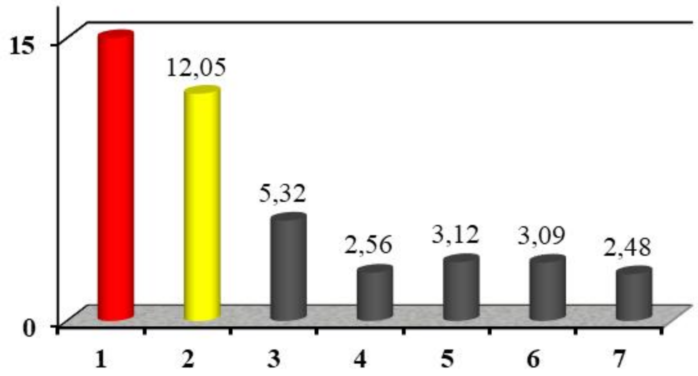

Fig 3. Changes in Water Content of Blending Coal

3.3 The Calorific Value of Blending Coal

From the result of the study, it is showed that the calorific value of blending coal in all ratios variations of Tonasa:Pattuku coal met the standard to be used as fuel for cement industry with the ratios of 3:1, 1:1 and 1:3, but there is no single coal blending ratio that met the standard to be used as coal-fired power plant (PLTU). The largest (optimal) calorific value was 6.506.39 kcal/kg at the blending coal ratio of 0:1.

The calorific value measurement of blending coal from Tonasa:Pattuku. The calorific value as a function of coal blending based on simulation count is a linear function with the following equation:

$$Q\ (kcal / kg) = 5{,}933{,}103 + 0.005\ P \qquad (2)$$

Q symbolizes the calorific value of blending coal (kcal/kg),while P symbolizes the composition of the blending coal of Tonasa:Pattuku (%). This equation means that in 0% Pattuku coal, all of them are in the form of Tonasa coal which has a calorific value of 5,933,103 kcal/kg. From the total sulfur content of blending coal as described above, when compared with the calorific value of blending coal according to simulation calculation, the calorific value of blending coal between Pattuku:Tonasa did not have a significant difference with quite small SSE value of 0.023 or the small error is 0.77% (Fig. 4).

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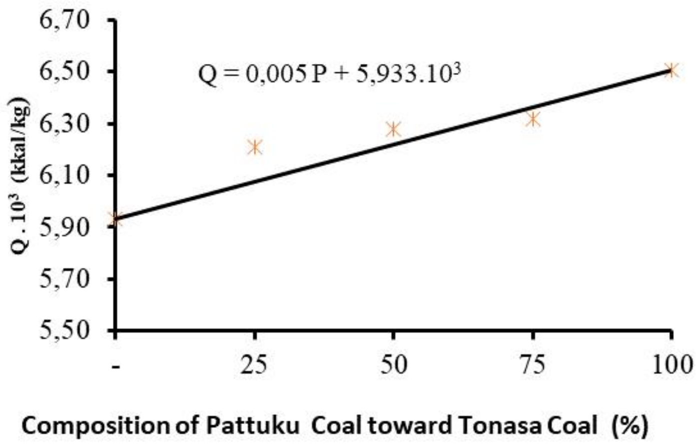

Fig 4. Changes in Calorific Value in Blending Coal

The equation (2) can be used quite accurately to predict the calorific value in blending coal. For instance, if the coal from Tonasa:Pattuku will be blended with the composition of Pattuku coal is 70%, according to equation (2), the calorific value of blending coal is 6,334,103 kcal/kg

4. Conclusion

Total sulfur content in all variations of the Tonasa: Pattuku coal ratios of 1:0, 3:1, 1:1, 1:3 and 0:1 met the criteria required to be used as fuel for cement industry, while the variations of blending coal that can be used as fuel for coal-fired power plant (PLTU) has the ratios of 1:0, 3:1 and 1:1.The smallest total sulfur content (optimal) was 0.1046% in blending coal ratio of 1:0. Furthermore, the water content of blending coal in all ratios variations of Tonasa:Pattuku coal met the standard to be used as fuel for cement industry and coal-fired power plant (PLTU). The smallest (optimal) water content was 2.48% in the blending coal ratio of 0:1. Moreover, the calorific value of blending coal in all ratios variations of Tonasa:Pattuku coal met the standard to be used as fuel for cement industry with the ratios of 3:1, 1:1 and 1:3, but there is no single coal blending ratio that met the standard to be used as coal-fired power plant (PLTU). The largest (optimal) calorific value was 6.506.39 kcal/kg at the blending coal ratio of 0:1.

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