Desulfurization of Low Rank Coal through Flotation Method Using Crude Palm Oil Surfactant

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Abstract. The need for fossil fuels in the world from year to year is increasing. However, its availability does not increase and even tends to be constant. This causes a fuel crisis that has a comprehensive impact on other fields. Coal originating from the Lembantongoa area, Palolo District in Central Sulawesi is in the sub-bituminous and lignite classes. This study aimed to analyze the characteristics of Lembantongoa coal as the first stage in determining the method of handling coal. The stages of the research were coal sampling and preparation. At the preparation stage, it included reducing water content, impurities, reducing the size and uniformizing the size. The next step was a proximate analysis consisting of the moisture content determination tested with a minimum free space oven, ash with muffle furnace ash, volatile matterwith volatile matter furnace; the carbon value remained in the difference of 100% with the results of the previous proximate analysis and the caloric value using the bomb calorimeter. The final stage of analysis was the ultimate analysis. This process tested sulfur content such as total, organic, and inorganic sulfur carried out by the combustion method at high temperatures. The results of the coal characteristics of the Lembantongoa region showed a proximate form of the water content of 8.12%; ash 42.17%; volatile matter27.05%; carbon remained 22.66%; calorie value of 4,030 calories/gram. In addition, there was also an ultimate analysis in the form of total sulfur content of 3.4%, inorganic sulfur including 1.7% pyrite sulfur; sulfur sulfate 0.6% and organic sulfur 1.1%. This ultimate characteristic analysis of coal showed that the quality was not much different from the results of coal analysis conducted by PT. Sucofindo.

Keywords: Sub-Bituminous Coal, Proximate Analysis Lignite, Ultimat Analysis

1. Introduction

Coal is an organic sedimentary rock with the main components of combustible carbon, hydrogen, and oxygen. Also, there are inorganic compounds, especially mineral elements derived from clay, quartz sand, limestone and so on [1,2]. The chemical content of coal consists of organic compounds as the main component and inorganic compounds and sulfur compounds [3]. According to [4] and [5], inorganic compounds as minor components of coal have the form of mineral compounds such as carbonates, oxides, sulfides, sulfates, and phosphates. The need for fossil fuels in the world from year to year is increasing, while its availability has not increased and even tends to be constant. This causes a fuel crisis that has a comprehensive impact on other fields. Hence, it is essential to explore the potential of fossil fuels that can increase the number of fuel reserves. Coal is a fossil fuel that has a large reserve potential compared to petroleum and natural gas. In general, the criteria for coal utilization in the power plant and cement industry are the lowest at 6,000-7,000 cal/g, the highest being 0.4-0.8% sulfur and 6-7.8% ash content [6]. Combustion of high sulfur coal can form SOx gas pollutants [5,7,8]. Inorganic sulfur has the form of sulfur iron (major), pyrite or marcasite (FeS2). Sulfur sulfate (minor) has a variant of gypsum and jarosite [Fe3 (SO4) 3 (OH) 6], [9,10,11].

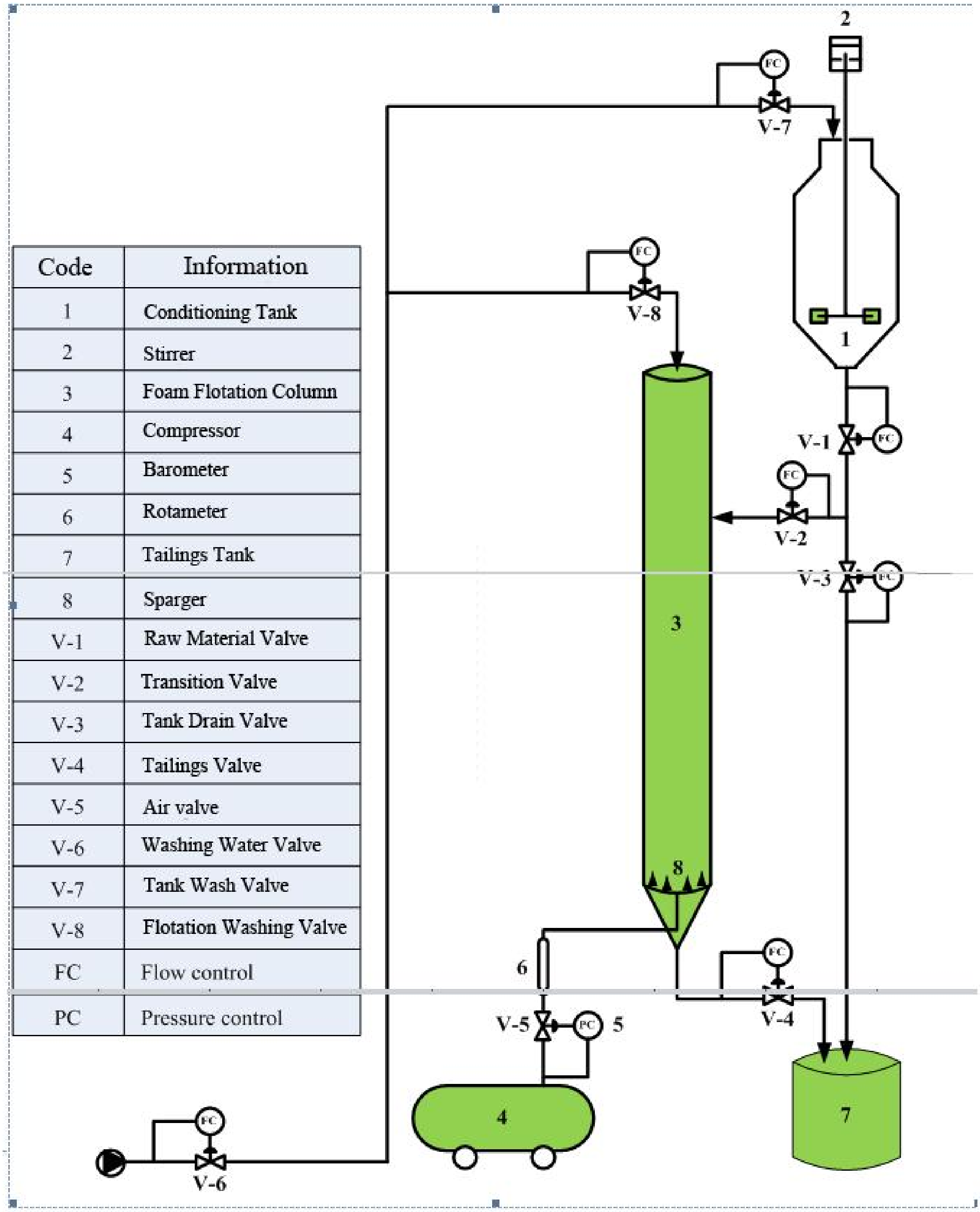
The existing coal reserves are dominated by low-quality variants such as sub-bituminous and lignite classes. The condition of coal like this is the same as the potential of coal originating from the Lembantongoa area, Palolo district, which is estimated to have sub-bituminous and lignite classes. The method for improving the quality of low-rank coal is very dependent on the characteristics of both proximate and ultimate coal. This is because the quality of coal in the Lembantongoa region is quite high in lignite, which contains sulfur and ash. And to maximize the separation by flotation, a CPO surfactant is needed. With the knowledge of methods to improve coal quality in the Lembantongoa region, it is hoped that the fuel crisis in the world, especially in Central Sulawesi can be overcome. It is relevant to the accumulation of coal potential both low rank and high rank is quite high around 90% of the existing fossil fuel reserves.

2. Materials and Methods

This research study was carried out in the Geological Structure and Environmental Laboratory of the Geological Engineering Study Program, Faculty of Engineering, Tadulako University, and the Analytical Laboratory of PT. Sucofindo Makassar in 2018. To achieve the research objectives, low-rank coal was chosen from the Lembantongoa area of Palolo District. Crude Palm Oil was from Morowali Regency and coconut water from ParigiMoutong Regency, Central Sulawesi Province.

Sample preparation was conducted at the Geological Structure and Environmental Laboratory of the Faculty of Engineering, Geological Engineering Study Program, Tadulako University. This process involved crushing chunks and sifting coal to 100 mesh so that it was ready to undergo the process of proximate analysis, ultimate analysis, sulfur content and heat value. The analysis was performed at the Analytical Laboratory of PT. Sucofindo Makassar. The analytical tools used, for example, Drinking Free Space Oven, Muffle Furnace Ash, Volatile Matter Furnace, CHN LECO 2000, LECO S-144 DR, and Bomb Calorimeter brand LECO AC-350.

Coal samples were first crushed and mashed up through crushing, grinding and sieving methods to obtain 100-mesh coal size. Some of these coal samples were characterized and analyzed following the ASTM Standard used as the main set of tools for further research. The research study was in the form of improving the quality of low-rank coal from Central Sulawesi Province by flotation using CPO surfactant; as shown in Figure 2. The tools shown in Figure 2 were made based on materials available on the market. In addition to the tools mentioned in Figure 2, research support tools were available at the Geological Structure and Environment Laboratory.



Code	Information
1	Conditioning Tank
2	Stirrer
3	Foam Flotation Column
4	Compressor
5	Barometer
6	Rotameter
7	Tailings Tank
8	Sparger
V-1	Raw Material Valve
V-2	Transition Valve
V-3	Tank Drain Valve
V-4	Tailings Valve
V-5	Air valve
V-6	Washing Water Valve
V-7	Tank Wash Valve
V-8	Flotation Washing Valve
FC	Flow control
PC	Pressure control

Figure 2. Series of flotation devices

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3. Result and Discussion

3.1 Coal Characteristics in the Lembantongoa Region

The results of the coal characterization of the Lembantongoa region can be seen in Table 2 as follows:

Table 2. Characterization of coal

Type of Analysis (Measurement)	Content
Proximate	
➢ Moisture (water content)	8.12%
➢ Ash (ash content)	42.17%
➢ Volatile matter	27.14%
➢ Fixed carbon*	22.57%
Ultimate	
➢ Total sulfur	3.40%
Sulfur :	
➢ Inorganic	
Pyrite sulfur	1.70%
Sulfur sulfate	0.60%
➢ Organic**	1.10%
Calorific Value	4,030 cal/gr

*) Counted **) Counted (=total sulfur – sulfur inorganic)

The results of the analysis of the characteristics of the coal in the Lembantongoa area evaluated using coal classification based on [5] can be seen in Table 3.

Table 3. Classification of coal **Invalid source specified.**

Criteria (dry base)	Coal Classes			
	I. Anthracite	II. Bituminous	III. Sub-Bituminous	IV. Lignite
Proximate and heat				
Fixed carbon (%)	≥ 86	86 – 54	53 – 56	≤ 52
Volatile matter (%)	≤ 14	14 – 54	53 – 56	≥ 52
Moisture (%)	≤ 6	5 – 16	18 – 30	≥ 38
Calorific value (kcal/kg)	7,740 – 8,300	7,410 – 8,741	5,990 – 7,540	≤ 5,250
Ultimate and Density				
Carbon (%)	75 – 85	65 – 80	55 – 70	35 – 45
Hydrogen (%)	1.5 – 3.5	4.5 – 6	5.5 – 6.5	6 – 7.5
Oxygen (%)	5.5 – 9	4.5 – 10	15 – 30	38 – 48
Nitrogen (%)	0.5 – 1	0.5 – 2.5	0.8 – 1.5	0.6 – 1
Sulfur (%)	0.5 – 2.5	0,5 – 6	0.3 – 1.5	0.3 – 2.5
Density (kg/liter)	1.35 – 1.70	1.28 – 1.35	1.35 – 1.40	1.40–1.45

The results of the characterization of coal from the Lembantongoa area evaluated using coal classification showed that the coal was included in the lignite class. This could be evaluated from its calorific value, which presented 4,030 calories/gram, the total sulfur content of 3.40% and ash 42.17%. The results of the characterization of coal from the Lembantongoa area were not much different from the characteristics of coal from Malawa and Pattuku, which were also included in the lignite class [7]. This was because the coal of the regions of Lembantongoa, Malawa, and Pattuku was still in one Sulawesi Island and could not be separated from the island's geological processes.

4.2 Selection of Coal Quality Improvement Method

The results of the characterization of coal from the Lembantongoa area showed a proximate form of the water content of 8.12%, ash 42.17%, volatile matter 27.05%, fixed carbon 22.66%, the calorific value of 4,030 calories/gram. The ultimate analysis showed total sulfur content of 3.4% with inorganic sulfur including 1.7% pyrite sulfur; sulfur sulfate 0.6% and organic sulfur 1.1%. If the characterization results from the Lembantongoa area were evaluated by the criteria of coal as a fuel made based on industry reviews [7], then it could be determined as in Table 4 below.

Table 4. Criteria for coal as fuel

Parameter	Content (%) / Calorific value (kcal / kg)	
	Cement Factory	PLTU
1. Total sulfur (*max*)	0.8	0.4
2. Volatile matter (*max*)	36	30.3
3. Ash (*max*)	6	7.8
4. *Moisture* (*max*)	12	13.6
5. *Fixed carbon* (*min*)	46	48.3
6. Calorie (*min*)	6,000	7,000

The results of the evaluation of the characterization of coal from the Lembantongoa area against the criteria of coal as fuel in cement plants and steam power plants indicated that the coal does not meet the criteria as fuel. This was because the coal had a very low calorific value of 4,030 calories/gram, a high ash value of 42.17% and a high sulfur of 3.4%. From the characteristics of the coal in the Lembantongoa area, it was hoped that the method of improving the quality of low-rank coals could simultaneously increase the calorific value and reduce the value of sulfur and ash. Of all the approaches to improving the quality of low-rank coal, which had been considered to handle these problems were desulfurization and deashing through flotation methods with crude palm oil surfactant. This method required a low cost and the Sulawesi region is rich in crude palm oil surfactants.

4. Conclusion

Based on the results of the analysis and discussion of the characteristics of coal from the Lembantongoa area, the coal is included in the lignite class. The results indicate that the proximate analysis includes a moisture content of 8.12%; ash 42.17%; volatile matter27.05%; carbon remains 22.66%; caloric value of 4,030 calories/gram and ultimate analysis in the form of total sulfur content of 3.4% with inorganic sulfur including 1.7% pyrite sulfur; sulfur sulfate 0.6% and organic sulfur 1.1%. From the characteristics of the coal in the area of Lembantongoa, it is hoped that the method of improving the quality of low-rank coal, which working simultaneously, can increase the calorific value and also reduce the value of sulfur and ash. The systems are desulfurization and deashing through the flotation method with surfactant crude palm oil.

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