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Experimental Study of Low-rank Coal from South Sumatra used in Humidifier and Flash Dryer

Irwin Bizzy^{1,a}, Riman Sipahutar^{1,b}, Eddy Ibrahim^{2,c}, Muhammad Faizal^{3,c}

¹Mechanical Engineering Department, Sriwijaya University

²Mining Engineering Department, Sriwijaya University

³Chemical Engineering Department, Sriwijaya University

^airwin@unsri.ac.id, ^brimansipahutar@ft.unsri.ac.id, ^ceddyibrahim838@yahoo.com,

^dmfaizal1405@gmail.com

Abstract. Low-rank coal is one of the potential natural resources owned by the South Sumatra Province of Indonesia. Research to reduce water content has greatly increased its calorific value. Coal water content can be reduced with low-temperature dry air using dehumidifier and flash dryer equipment with a capacity of 0.30 g per second has been carried out on low-rank coal in South Sumatra, especially for samples of Muara Enim Coal (MEC) coal with 20 mesh and dry air temperature at 70 °C. The results showed an increase in the calorific value of 0.32% and a decrease in water content of 15.92%. The results of the proximate and ultimate analysis have also been carried out at each of the testing stages.

1. Introduction

Indonesia's energy scenario until 2050 shows a significant increase, especially to support the industrial sector. In particular, the need for coal to supply energy to industries, such as cement plants, textiles, and others [1]. The largest coal producers in Indonesia are the islands of Kalimantan and Sumatra. South Sumatra Province is the largest coal producer on the island of Sumatra. Also, the Province of South Sumatra is also one of the provinces in Indonesia that has large low-rank coal reserves. Most of this low-rank coal is exported and is used for domestic use for fueling steam power plants. The policy of building a low-rank coal-fired steam power plant at the mouth of the mine is one solution to overcome the expensive transportation costs.

Low-rank coal has advantages and disadvantages. One of the advantages of low-rank coal in South Sumatra is the low levels of ash and sulfur [2], but the calorific value is low because the water content is quite high. Efforts to increase the calorific value of coal have been carried out by researchers. The researcher [3] has made bio briquette with the use of palm shell as an ingredient for mixing it with low-rank coal in South Sumatra using a mini screw conveyor machine. Test results show an increase in calorific value from the mixing of this bio briquette manufacture. Even researchers [4] and [5] mix palm oil with low-rank coal, and the result is an increase in calorific value and is resistant to moisture absorption by low-rank coal caused by the coating of palm oil.

Besides, studies and reviews of low-rank coal have been carried out by researchers with various technologies applied. This research was carried out in the hope of finding new technologies to increase the calorific value of low-rank coal and research other followings, such as ash and sulfur which have an impact on the environment [6] [7], [8], [9], [10]. While researchers [11] stated that there were three



variables of low-rank coal drying rates to increase the high drying rate, namely high temperatures, low relative humidity, and high fluidization velocity.

Field surveys are reducing water vapour in low-rank coal by reducing water at the mine site (such as when coal is transported by conveyor) or in factories that use coal as a fuel for electricity generation (such as utilizing residual heat for coal drying). The purpose is to reduce operational costs and increase the efficiency of using low-rank coal. Meanwhile, most researchers are interested in using high temperatures to release moisture in low-rank coal. High temperature requirements can be made when utilizing the residual heat from a process, but on the contrary, it will increase the cost when heat is supplied with an energy source rather than from the residual heat of the process. Meanwhile, the reduction of water vapour in coal at temperatures, low relative humidity, and high air velocity has not been widely studied.

Based on the description above, this study uses a combination of dehumidifier equipment and flash dryer to increase calorific value and check low-rank coal elements through laboratory scale cyclone separation. The dehumidifier is used to reduce moisture in the atmospheric air [12], and the flash dryer for quick drying in the drying column. The dehumidifier used here is specifically designed to get a ratio of moisture and dry air under certain conditions by adjusting the valve openings in the Split Air Conditioning system. This research was carried out with low temperature, relative humidity, and air as the drying medium.

2. Methodology

The use of research methodology was experimental by taking low-rank coal samples at the mine site and tested in the thermal research laboratory of the Department of Mechanical Engineering, Faculty of Engineering, Sriwijaya University. The research equipment used is a dehumidifier and a flash dryer.

2.1. Material

Low-rank coal samples selected from the Province of South Sumatra which consists of one mining location, namely Muara Enim District (MEC). Based on the test data from Table 1 and Table 2, it can be seen that the sample chosen is low-rank coal. The moisture content in coal is still quite high, and the calorific value is still below 7000 Cal / g. Furthermore, low-rank coal samples are made into mesh 20. Next, put it into the drying column in the flash dryer system (Figure 1). The equipment used to analyze the proximate and ultimate are the minimum free space of oven-carbolite type mfs1, Carbolite furnace type oaf, carbolite furnace type vmf, and CHN Analyzer-Leco type CHN 628.

Table 1. Proximate Analyses of the Samples

Test	Value
TM (%adb)	24.8
IM (%adb)	17.22
Ash (%adb)	3.88
VM (%adb)	40.49
FC (%adb)	38.41
TS (%adb)	0.65
GCV (Cal/gr)	5721

Table 2. Ultimate Analyses of the Samples

Test	Value
C (%adb)	58.56
H (%adb)	6.34
N (%adb)	0.97
S (%adb)	0.65
O (%adb)	29.61

2.2. Experimental Section

Test equipment designed as shown in Figure 1. This test equipment is a combination of two main equipment, namely the Humidifier and Flash Dryer. Humidifier has been made using split AC with 2 PK power and a flash dryer which has a pipe length of 4 m, the pipe diameter is 0.05 m, and the pipe thickness is 0.0018 m. Some supporting equipment is added, such as blowers, heaters and electric motors. The evaporator component is modified by installing several baffles in an isolated box for producing dry air. Figure 2 below describes the steps of the low-rank coal drying process in the test device.

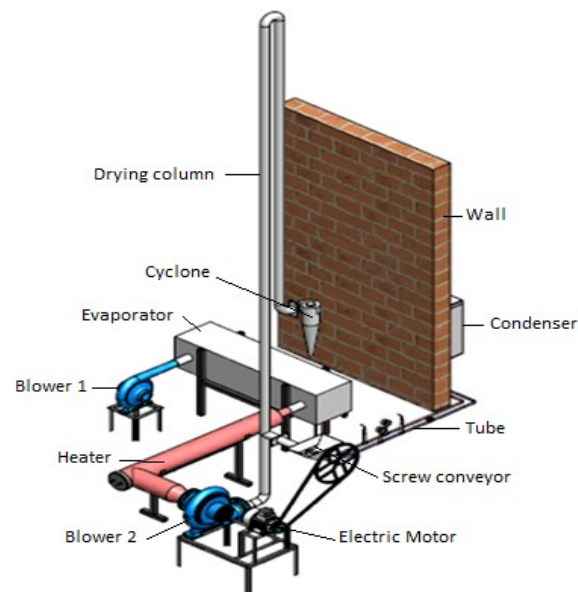


Figure 1. Dehumidifier and flash dryer test equipment

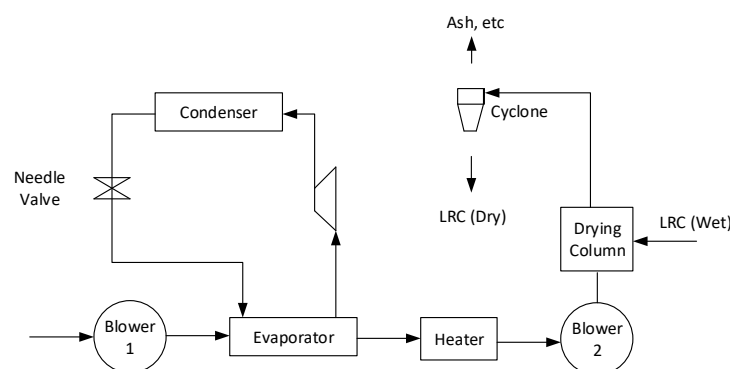


Figure 2. Low-rank coal drying process diagram

Ambient air is sucked and blown by the blower 1 (550 Watt) to the modified evaporator to produce air at a certain temperature and humidity conditions. This air is heated by a heater and sucked and blown back by the blower 2 (900 Watt) to the drying column to reduce the moisture content of low-rank coal. Finally, low-rank coal is through to a mini cyclone (Figure 3) which produces low-rank coal dry and some of the volatile matter are wasted including moisture content too.

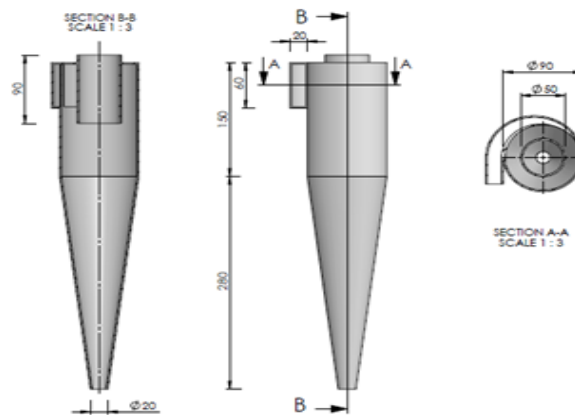


Figure 3. Cyclone

The cyclone function here is to separate between low-rank coal particles that have greater and smaller densities (dust, gas, and water vapour). The process that occurs in the cyclone is air, and coal particles enter the cyclone from the side channel, then induced into the cone-shaped cyclone and rotate it because there is a centrifugal force based on vortex flow. Therefore, the presence of gravitational forces causes coal particles to fall towards the side of the cyclone wall towards the downside of the cyclone. Meanwhile, particles that have a smaller density outward through the upper channel of the cyclone. The larger the particle size, the more efficient but tends to be constant at certain particle sizes.

3. Result and Discussion

3.1. Set up Test Equipment

The air entering and exiting the evaporator at an average temperature and humidity is 29°C, 66%, and 8°C, 87% respectively. This condition set uses the Needle Valve in the Split Air Conditioning system (Figure 1 and Figure 2). Furthermore, it is heated at a temperature of 70°C using a heater before entering the blower 2. The heater temperature setting uses temperature control equipment. Low-rank coal with mesh 20 goes into a small container and is pushed using a screw conveyor with a capacity of 0.3 gr/s. The hot air coming out of the heater is sucked and blown by the blower two towards the drying column and pushes the low-rank coal out of the reservoir. At the end of the process, coal ranks low through a mini cyclone that will separate dry coal and volatile substances, such as ash and moisture.

3.2. Proximate and Ultimate Analysis

The results of this test were carried out for conditions when making and after mesh 20 testing (Table 3 and Figure 4).

Table 3. Proximate and Ultimate Analyses of the Samples

Test	Mesh 20	
	Before	After (70°C)
Proximate Analysis		
TM (%adb)	-	-
IM (%adb)	24.34	20.54
Ash (%adb)	2.19	2.40
VM (%adb)	38.58	40.16
FC (%adb)	34.90	36.90
TS (%adb)	0.53	0.58
GCV (Cal/gr)	5395	5571

Test	Mesh 20	
	Before	After (70°C)
Ultimate Analysis		
C (%adb)	57.15	59.20
H (%adb)	6.81	6.95
N (%adb)	0.90	0.81
S (%adb)	0.58	0.33
O (%adb)	32.16	34.52

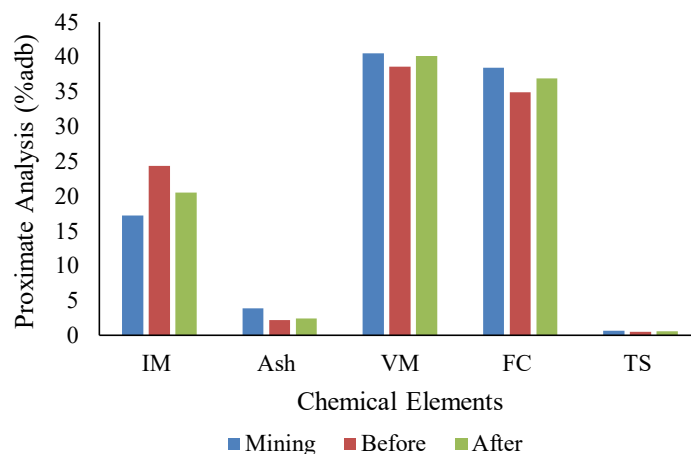


Figure 4. The proximate analysis of MEC with 20 mesh

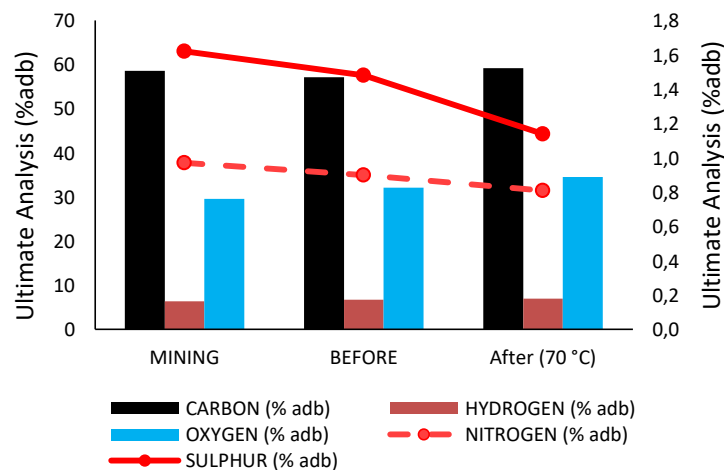


Figure 5. The ultimate analysis of MEC with 20 mesh

Coal is very reactive to oxygen at ambient temperatures, especially in dry conditions so that spontaneous combustion is easy. In this study, there was no spontaneous combustion due to the drying process using dry air exceeding the ambient air temperature and carried out in the high-speed air.

This thermal drying process of an average air temperature of 70°C has increased the value of the elements, such as carbon 57.15% adb to 59.20% adb, oxygen from 32.16% adb to 34.52% adb, hydrogen from 6.81% adb to 6.95% adb. Conversely, there was a decrease in nitrogen and sulfur elements from 0.90% adb to 0.81% adb and 0.58% adb to 0.33% adb.

In addition, based on the examination of the proximate analysis in table 3 it is known that there is an increase in the low GVC of coal by 0.32%, the decrease in IM by 15.92% and FC by 36.9% but the percentage of Ash, VM, TS increases respectively was 2.19%, 3.93% and 8.62%.

4. Conclusion

The use of dehumidifier and flash dryer test equipment has increased in calorific value and a reduction in water content from low-rank coal in South Sumatra, especially low-rank coal from the Muara Enim location. Based on the proximate and ultimate analysis at each stage of the test resulted in a reduction in the presentation of carbon content, there was a decrease in the percentage of carbon when it was made into a mesh of 20 from samples taken from mining. Conversely, there was an increase in carbon before and after entering the test equipment with a temperature of 70°C. Similarly, there is a decrease in sulfur and nitrogen percentages at each stage of the test. While the percentage of oxygen tends to rise and the percentage of hydrogen tends to remain at each stage of the test.

Through preliminary studies using dehumidifier and flash dryer equipment, it is possible to increase the calorific value and reduce the water content of low-rank coal with a low air temperature or below 100°C. For that, further testing is needed to obtain better results.

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