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| RESEARCH ARTICLE

Analysis of Coal Combustion Characteristics of PT. Prolindo cipta Nusantara Sungai Loban District, Land Bumbu Regency, South Kalimantan Province

Deddy NSP Tangga[1] ✉ Widi Novianti[2] and Yossa Yonathan Hutajulu[3]
[123]Mining Engineering Department, Palangka Raya University, Indonesia
Corresponding Author: Deddy NSP Tangga, **E-mail**: deddy.nspt @gmail.com

| ABSTRACT
Indonesia is one of the countries with the most significant coal mining resources globally. Its reserves are estimated at 36,3 billion tonnes. It is just that 50-85% low quality. So in this study, researchers can determine the characteristics of coal combustion and coal rank for its utilization by using a Thermogravimetry Analyzer (TGA). The method used in this study is quantitative. Wherein this quantitative method, the researcher will analyze the TGA/DTA graph, which results from laboratory testing. This quantitative method is used to obtain coal combustion characteristics by observing changes in temperature and time in the coal mass. The research results on the characteristics of coal combustion are that the calculation of the activation energy of PCN 1 coal is 9932,9 Btu/lb, and PCN 2 coal is 10270,2 Btu/lb. Based on the results of this study, it is known that PCN 1 and PCN 2 coal are included in sub-bituminous coal B, so their use is for power generation, cement production, and industrial use.

| KEYWORDS

Characteristics, Combustion, Coal, TGA, Activation Energy

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1. Introduction

The potential of coal resources in Indonesia is very abundant, especially on the islands of Kalimantan and Sumatra. Coal is currently widely used in large-scale industries, including power plants, cement factories, and industries requiring heating processes, such as foundries and steel processing plants.

Indonesia is one of the countries with the most significant coal mining resources globally. Its reserves are estimated at 36.3 billion tonnes. It is just that 50-85% low quality. This is seen from the low calorific combustion value and the high sulfur and water content. The calorific value of coal dramatically affects its quality in its utilization as fuel. So in this study, researchers can determine the characteristics of coal combustion and coal rank for its utilization by using a Thermogravimetry Analyzer (TGA). So with that, the utilization or use of coal energy sources will be as efficient as possible in dealing with the energy crisis, and the use of coal in the future can be done more wisely so that this energy source does not run out quickly.

2. Methodology

The coal used in this research comes from PT. Prolindo Cipta Nusantara , Sungai Loban District, Tanah Bumbu Regency, South Kalimantan Province (Figure 1). In this study, two samples of the same coal were used; then, the coal samples were sent to the TekMIRA Research and Development Center Bandung for TGA testing.

The method used in this research is library research, quantitative method, and descriptive method. Literature research is looking for literature related to the research topic. The quantitative method is to obtain the characteristics of coal combustion by analyzing the TGA/DTA graph, which results from laboratory testing. The descriptive method is used to determine the characteristics of coal combustion.

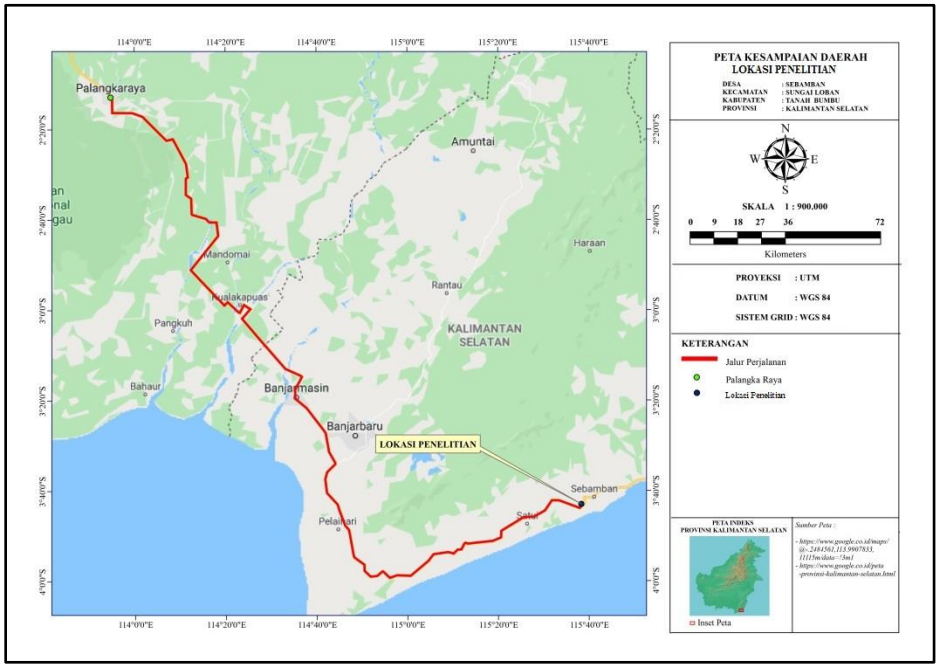

Figure 1. Location of Research Area

3. Results and Discussion

3.1 PCN 1 . Coal Combustion Characteristics

Based on the combustion characteristics using TGA/DTA analysis (Figure 2), the combustion characteristics are divided into several zones, namely zone 1, zone 2, and zone 3. Zone 1 is the adsorption process of releasing water (H 2 O), carbon dioxide (CO 2), and methane (CH 4), resulting in a decrease in mass of -12.6254% with a temperature of 46.1ºC-240.5ºC for 18 minutes of combustion time.

Zone 2 thermal decomposition occurs, namely compounds of water (H 2 O), carbon monoxide (CO), and carbon dioxide (CO 2) with a decrease in mass of -71.4488% with a temperature of 240.5ºC–376.6ºC for 32 minutes of combustion time. Zone 2 has a peak point for the first reaction with an enthalpy of 1922.83 V s/mg. The starting point of heating occurs at a temperature of 110.0ºC (9 minutes), begins to react with an enthalpy of 71.854 V at a temperature of 153.2ºC (12 minutes), and the peak maximum with an enthalpy of 87.906 V at a temperature of 172.6ºC (13 minutes) and the endpoint of heating at a temperature of 348.4ºC (19 minutes t).

In Zone 3, gas and oil formation occurs with a mass increase of 10.0417% with a temperature of 376.6ºC-1000ºC for 76 minutes of combustion time, and in zone 3, there is a second peak point of reaction with an enthalpy of 3432.78 V s/mg, the starting point heating occurs at a temperature of 320.9ºC (27 minutes), begins to react with an enthalpy of 125.305 V at a temperature of 337.9ºC (29 minutes) and a maximum peak with an enthalpy of 204.414 V at a temperature of 364.7ºC (31 minutes) and the endpoint of heating is at a temperature of 387,5ºC (38 minutes).

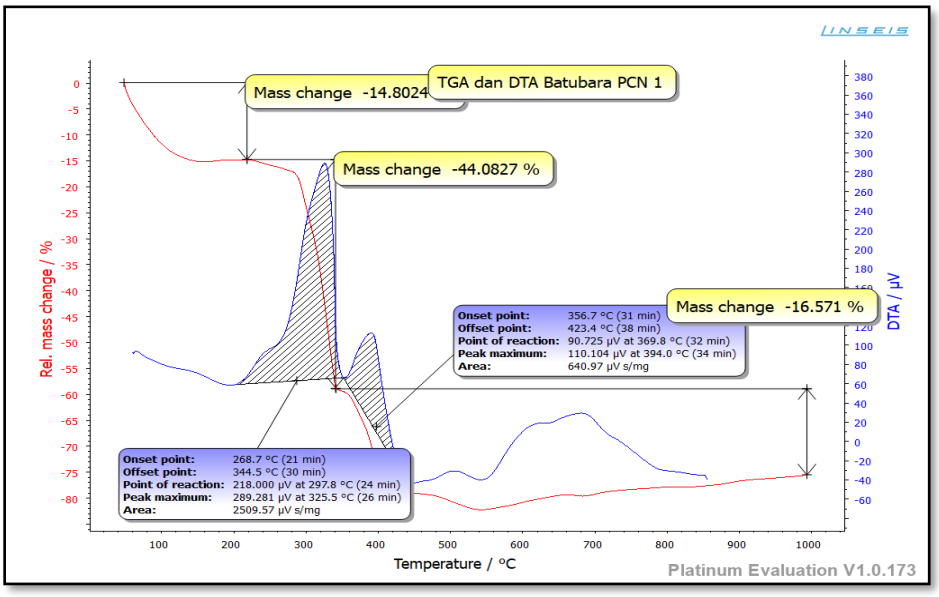

Figure 2. Graph of PCN 1 . Coal TGA/DTA

From the TGA/DTA combustion characteristics, it can be seen from zone 2 that PCN 1 coal combustion activation energy is obtained, which is at a temperature of 221ºC–326.9ºC. The activation energy calculation is carried out in this zone because this zone has the most changes in coal mass. Then, the calculation results of activation energy are obtained from the temperature and time data (Table 1).

Table 1. Activation Energy Calculation Results

No	T1 _ (K)	T2 _ (K)	T average (K)	1/T average (K)	time(s)	$\frac{1}{t}$	ln $\frac{1}{t}$= ln K
1	482.45	494,15	488,3	0,002048	996	0,001004	-6,90375
2	494,15	505,25	499,7	0,002001	1056	0,000947	-6,96224
3	505,25	515,95	510,6	0,001958	1116	0,000896	-7,01751
4	515,95	526,25	521,1	0,001919	1176	0,00085	-7,06987
5	526,25	536,25	531,25	0,001882	1236	0,000809	-7,11964
6	536,25	546,15	541,2	0,001848	1296	0,000772	-7,16704
7	546,15	556,15	551,15	0,001814	1356	0,000737	-7,21229
8	556,15	566,45	561,3	0,001782	1416	0,000706	-7,25559
9	566,45	580,85	573,65	0,001743	1476	0,000678	-7,29709
10	580,85	595,45	588,15	0,0017	1536	0,000651	-7,33694
11	595,45	603,75	599,6	0,001668	1596	0,000627	-7,37526

Note: T_1 (Initial temperature (Kelvin)); T_2 (Final temperature (Kelvin)); $T_{average}$ (Average temperature (Kelvin)); t (Time (*Second*))

Furthermore, from Table 1 above, there is a relationship between ln K vs. 1/T (Figure 3). From the graph, it can be seen that the activation energy of PCN 1 coal combustion is 10479.8 kJ/mol. Moreover, from the activation energy, the degree or grade of coal can be determined by converting it to Btu/lb, 9932.9 Btu/lb. So from the coal activation energy, PCN 1 coal is included in the sub-bituminous coal grade B.

From the graph also obtained R 2 = 0.9975, namely the level of confidence with a scale of 0 to 1, which is used to get the best curve limit, and because the value is 0.9975 close to 1, it can be categorized as the best curve limit, and the calculation of the activation energy is correct.

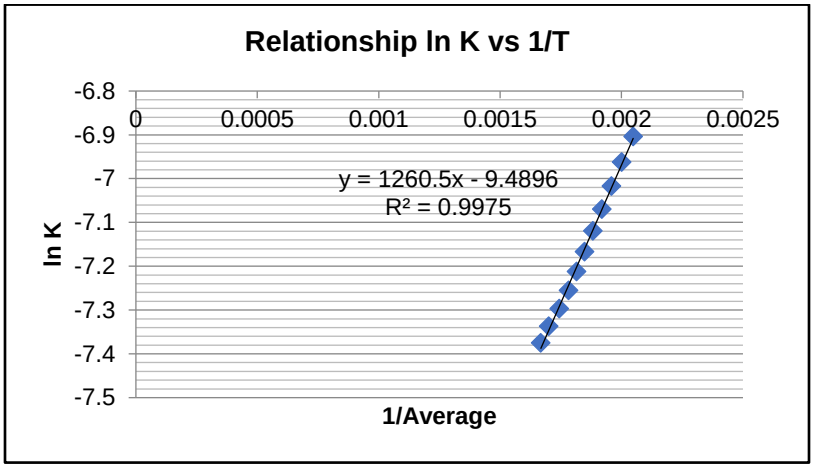

Figure 3. Relationship in K vs 1/T

3.2 PCN 2. Coal Combustion Characteristics

Based on the combustion characteristics using TGA/DTA analysis, the combustion characteristics are divided into several zones, namely zone 1, zone 2, and zone 3 (Figure 4). Zone 1 is an adsorption process that releases water (H2O), carbon dioxide (CO2), and methane (CH4), resulting in a decrease in mass of -12.6254% with a temperature of 46.1ºC-240.5ºC for 18 minutes of combustion time.

Zone 2 thermal decomposition occurs, namely compounds of water (H 2 O), carbon monoxide (CO), and carbon dioxide (CO 2) with a decrease in mass of -71.4488% with a temperature of 240.5ºC–376.6ºC for 32 minutes of combustion time. Furthermore, in zone 2, there is a peak point for the first reaction with an enthalpy of 1922.83 V s/mg. The starting point of heating occurs at a temperature of 110.0ºC (9 minutes), begins to react with an enthalpy of 71.854 V at a temperature of 153.2ºC (12 minutes), and the peak maximum with an enthalpy of 87.906 V at a temperature of 172.6ºC (13 minutes) and the endpoint of heating at a temperature of 348.4ºC (19 minutes t).

In Zone 3, gas and oil formation occurs with a mass increase of 10.0417% with a temperature of 376.6ºC-1000ºC for 76 minutes of combustion time. In zone 3, there is a second peak point of reaction with an enthalpy of 3432.78 V s/mg. The starting point heating occurs at a temperature of 320.9ºC (27 minutes), begins to react with an enthalpy of 125.305 V at a temperature of 337.9ºC (29 minutes), and a maximum peak with an enthalpy of 204.414 V at a temperature of 364.7ºC (31 minutes) and the endpoint of heating is at a temperature of 387,5ºC (38 minutes).

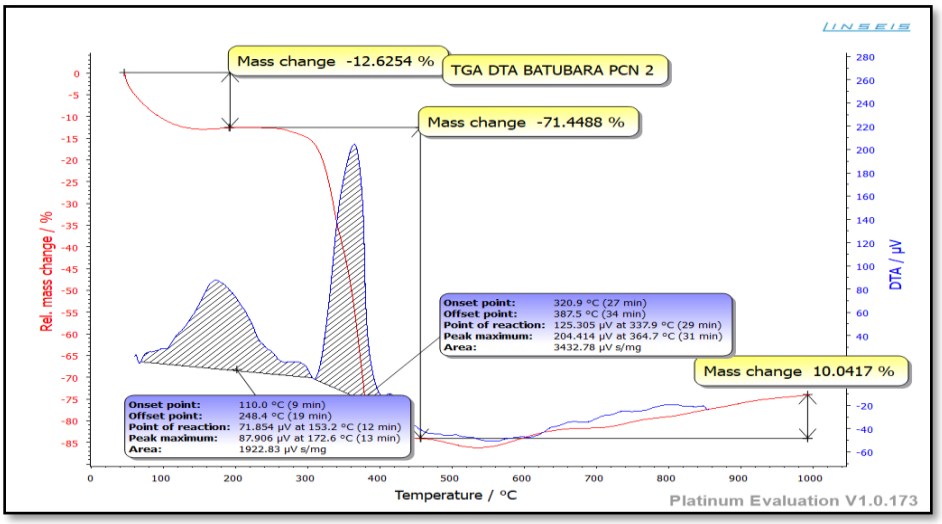

Figure 4. Graph of PCN 2 . Coal TGA/DTA

From the TGA/DTA combustion characteristics, it can be seen from zone 2 that PCN 2 coal combustion activation energy is obtained, which is at a temperature of 240.5ºC–376.6ºC. The activation energy calculation is carried out in this zone because this zone has the most changes in coal mass. Then from the temperature and time data obtained, the activation energy calculation (Table 2).

Table 2. Calculation of Activation Energy

No.	T1 (K)	T2 (K)	T average (K)	1/T average (K)	time(s)	$\frac{1}{t}$	ln $\frac{1}{t}$= ln K
1	502.95	513,65	508,3	0,001967	1120	0,000893	-7,02108
2	513,65	523,85	518,75	0,001928	1180	0,000847	-7,07327
3	523,85	533,75	528,8	0,001891	1240	0,000806	-7,12287
4	533,75	543,45	538,6	0,001857	1300	0,000769	-7,17012
5	543,45	553,15	548,3	0,001824	1360	0,000735	-7,21524
6	553,15	562,75	557,95	0,001792	1420	0,000704	-7,25841
7	562,75	572,25	567,5	0,001762	1480	0,000676	-7,2998
8	572,25	581,95	577,1	0,001733	1540	0,000649	-7,33954
9	581,95	591,55	586,75	0,001704	1600	0,000625	-7,37776
10	591,55	601,25	596,4	0,001677	1660	0,000602	-7,41457
11	601,25	611,35	606,3	0,001649	1720	0,000581	-7,45008
12	611,35	626,65	619	0,001616	1780	0,000562	-7,48437
13	626,65	638,25	632,45	0,001581	1840	0,000543	-7,51752
14	638,25	645,75	642	0,001558	1900	0,000526	-7,54961
15	645,75	651,05	648,4	0,001542	1960	0,00051	-7,5807

Furthermore, from Table 2, we get the relationship between ln K vs. 1/T (Figure 4). From the graph, it can be seen that the activation energy of PCN 2 coal combustion is 10835.63 kJ/mol. Moreover, from the activation energy, the degree or grade of coal can be determined by converting it to Btu/lb, 10270.2 Btu/lb. So from the coal activation energy, PCN 2 coal is included in the sub-bituminous coal grade B.

From the graph also obtained R 2 = 0.9985, namely the level of confidence with a scale of 0 to 1, which is used to get the best curve limit, and because the value is 0.9985 close to 1, it can be categorized as the best curve limit, and the calculation of the activation energy is correct.

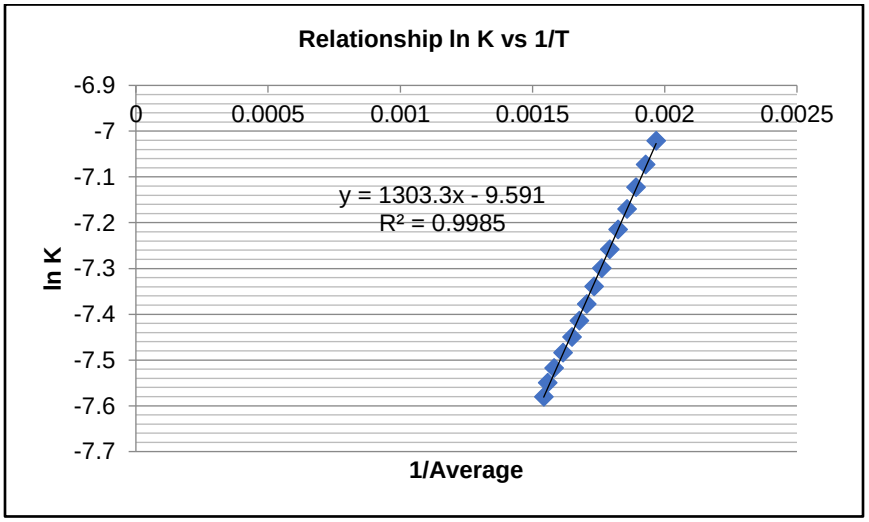

Figure 4. Relationship ln K vs 1/T

5. Conclusion

The characteristics of PCN 1 and PCN 2 coal combustion-based on TGA/DTA analysis, there are three combustion zones and two peak points of combustion reactions in zones two and three.

The activation energy is obtained from the combustion characteristics of PCN 1 and PCN 2 coal. From the activation energy, it can be seen that PCN 1 and PCN 2 coal are included in sub-bituminous coal B.

PCN 1 and PCN 2 coal are included in sub-bituminous coal, so their use is for power generation, cement production, and industrial use.

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Conflicts of Interest: "The authors declare no conflict of interest."

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