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Analysis of The Influence of Wind Speed and Particle Size On Temperature Increase During The Coal Combustion Process of MT-46, BB-50, and Al-55 at PT Bukit Asam Tbk., Tanjung Enim, South Sumatra

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ABSTRACT

Swabakar is an event where coal can burn on its own. The purpose of the PT Bukit Asam Tbk Laboratory is to analyze the influence of wind speed and grain size differences and determine the value of transition temperature and the normality test of time and temperature data of coal samples. The research method used is to measure wind speed using an anemometer and measure the coal temperature before and after the swab. It can be seen from the results of the discussion that coal with a grain size of 13 mm experiences a faster swab process than coal with a grain size of 50 mm. The results showed that coal with a grain size of 13 mm experienced a faster swab than a size of 50 mm. The order of transition temperature values based on the grain size of 13 mm was MT-46 < BB-50 < AL-55, while at 50 mm the same results were found. This shows that MT-46 coal is more susceptible to swabbing than other types. Normality testing of time and temperature data shows that all data are distributed normally, so the validity of the research results can be accounted for. This study concludes that the smaller the size of the coal grains, the faster the oxidation process leads to spontaneous combustion. Wind speed also plays a role in accelerating the spread of oxygen into the coal pile, which increases the risk of swabbing. The implications of this study are important for the coal mining industry to consider the factors of grain size and wind speed in stockpile management to reduce the risk of waste and maintain the quality of coal.

Introduction

Coal remains a crucial energy source globally, especially in developing countries where it is a major driver of industrial and economic growth. (Suryahani et al., 2024). The increasing demand for coal-based energy has raised concerns about environmental hazards, especially related to spontaneous combustion, or known as swabakar (Mochammad Junus, 2024). This phenomenon occurs when coal undergoes self-heating due to oxidation, which can cause fires in piles, during transportation, and in storage facilities.

Coal is a fossil fuel. It is a combustible sedimentary rock formed from organic deposits, mainly plant remains, through decomposition. (Ahmad, 2017; Meliyana et al., 2024; Permadi, 2015)Coal has been widely used for centuries to generate electricity and as the main fuel for industrial activities. It is a non-oil and gas alternative fuel used in the chemical and other industries.

One of the companies engaged in the coal mining industry located in South Sumatra is PT Bukit Asam Tbk. Tanjung Enim Mining Unit. The coal produced serves to meet the needs of the domestic industry and export needs. To meet the needs of consumers, production must be according to their demands and conditions. The quality of coal must be according to the agreed standards.

According to Andrawina & Ernawati, (2019) Coal from the front is generally not directly sent to consumers, so it must be temporarily stacked in a stockpile. The leading problem companies face in accumulating coal in the stockpile is swab root, which can decrease the quality of coal and cause losses for the company because it can affect the market price.

Swacombustion, spontaneous combustion, or self-combustion, is one of the phenomena that occurs in coal when it is stored or in storage/stockpile for a certain period. (Hardianti & Billi, 2018). *Spontaneous combustion* (spontaneous combustion) is the process of burning coal by itself due to an exothermic oxidation reaction that continues to cause an increase in temperature. Coal will oxidize when exposed to the surface during mining, or when coal is stockpiled in large quantities on the stockpile, the oxidation process continues. (Abduh et al., 2023; Purnomo & Rande, 2023).

Swabakar on stockpiles is common and needs attention, especially in large quantities of coal piles. Coal oxidizes when exposed to the surface during mining, so when coal is deposited, this oxidation process continues. The oxidation reaction between oxygen and flammable gases from flying material components generates heat. (Sarana, 2022).

This research discusses the wind speed factor and the difference in grain size. It will examine how much influence it has in increasing the occurrence of swabakar on several existing calorie values. The variations in the caloric value of coal to be tested include coal with calories of 4600 kcal/kg, 5000 kcal/kg, and 5500 kcal/kg.

The research is conducted in a laboratory, where several variations of the ideal tool will be used to bring the variables closer according to the desired needs. It is hoped that the influence of wind speed on temperature increase from the difference in the coal grain size can be known, making the coal burn itself.

Experiment Section

a. The Effect of Wind on Swabakar

According to Genc & Cook, (2015) Swabacas occur in all coal due to direct contact with the atmosphere (air). This coal will show signs of oxidation and weathering, resulting in decreased calorie content, matter volatility, and swelling capacities. The exothermic reaction, which produces heat if not lost, will reach the initiation temperature, which can eventually form a fire point.

There are several causes of the coal swab process on the *stockpile* according to Yolanda et al., (2024) The length of stockpiling, the tools used in the stockpiling method, and the stockpile conditions, such as stockpile height, grain size, stockpile angle, and webroot temperature, are among other things.

Another factor that can also trigger the occurrence of swabakar is the influence of wind speed. (Adiwikarta & Pulungan, 2024). Wind speed determines the speed at which coal undergoes a puncture where air functions as a heat transfer on the *stockpile*, affecting the speed of the coal in the *stockpile* to burn. Exothermic reactions that produce heat, if not lost, will reach hot temperatures that eventually form a fire point, in other words, the wind factor will result in the rapid diffusion of oxygen into the coal, so that the coal will absorb oxygen and trigger an exothermic reaction, so that it will produce heat. The heat that cannot be released will increase and cause the swabakar or baruchara to burn itself.

b. Effect of Grain Size

According to Filah et al., (2016) The coal grain's size also affects the oxidation process's speed. The smaller the size of the coal, the larger the surface area that will be in direct contact with the outside air, and the faster the swab process can take place. On the other hand, the larger the coal block, the slower the swab process.

The size of coal grains differs in the temporary area, ranging from large to tiny blocks. This small size of coal will expose the coal surface area to contact with oxygen carried by the wind, thus increasing the potential for the swab process. (Mirza et al., 2021).

The research conducted at the Laboratory of PT Bukit Asam Tbk, Tanjung Enim Mining Unit also compared the size of coal grains from 13 mm and 50 mm to analyze how fast the swabbing process on coal of different sizes was.

c. Transition Temperature

Transition temperature is a temperature that changes suddenly, causing a slightly different chart pattern. If the transition temperature in the coal sample is smaller, the coal is more reactive for swab root. Meanwhile, if the transition temperature in the coal sample is greater than the comparison of each sample, the coal will take longer to undergo the swab process.

d. Laboratory Scale Coal Pile Design

The coal pile is designed to be as similar as possible to the stockpile in general in the field. The geometry of the stockpile in the field is height, length, width, volume, material size, and angle of repose. Stacking on a laboratory scale can only be done by changing the angle of repose. The size of the coal grain is divided into two sizes, namely 13 mm and 50 mm. This grain size will be tested in the laboratory.

Figure 3.16 shows the coal pile in the laboratory study, designed to be as similar as possible to the conditions in the field. The pile's height ranges from 6-12 cm to facilitate analysis. The minimum pile angle is designed to be close to *the angle of coal repose*, which is 39°-45°.

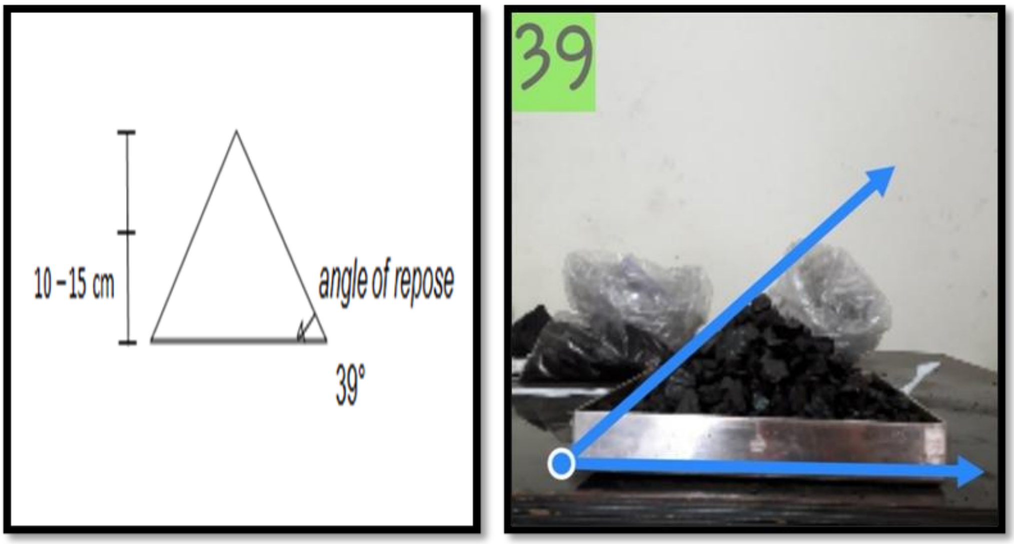

Figure 1. Laboratory Scale Stack Design (1) and Laboratory Research Stack Design (2)
Source: Abdansya, 2016 Source: Author, 2018

This study analyzes the influence of wind speed and particle size on temperature increase during the coal burning process at PT Bukit Asam Tbk., Tanjung Enim, South Sumatra. The novelty of this research lies in the comprehensive evaluation of these variables under controlled laboratory conditions, thus providing empirical insights that can guide industrial practice. Although previous studies have examined the mechanism of spontaneous combustion, this study specifically quantified the effects of variations in wind speed and grain size, thus providing valuable data for risk assessment and coal storage management.

The urgency of this research is further strengthened by the growing reliance on coal as an energy source, despite global calls to switch to greener alternatives. An efficient coal management strategy is needed to minimize economic losses and environmental impacts. By understanding how wind speed and particle size contribute to temperature changes in coal, the industry can implement better storage methods, reduce fire risk, and improve overall safety measures.

This study aims to determine the effect of wind speed on temperature increase in coal samples, analyze the influence of particle size on coal susceptibility to spontaneous combustion and determine the transition temperature of various coal samples based on variations in wind speed and particle size. The results of this research will benefit coal mining companies, the energy industry, and environmental institutions by providing a scientific basis for developing safer coal storage techniques. By reducing the risk of spontaneous combustion, the industry can improve operational efficiency, prevent financial losses, and contribute to environmental sustainability.

Method

This study uses experimental research with a quantitative approach to analyze the influence of wind speed and particle size on temperature increase during the coal combustion process. The data collection technique was carried out through experiments in the laboratory with variations in coal particle size (13 mm and 50 mm) and controlled wind speeds (V0, V1, and V2). Data analysis was carried out using normality tests to ensure data distribution and comparative analysis to see patterns of temperature changes and temperature transitions between coal samples. The experiment results are presented in graphs and tables to illustrate the relationship between wind speed and particle size on the tendency of coal swabs.

This research activity was carried out at the PAB Laboratory for MT-46, BB-50, and AL-55 coal samples from PT Bukit Asam Tbk. Tanjung Enim Mining Unit.
Stages of activities carried out during the research: Literature studies are carried out by searching for theoretical bases related to research. References can be sourced from books, journals, internet sites, related agencies, and other relevant agencies. The MT-46, BB-50 and AL-55 coal samples were from PT Bukit Asam Tbk. Tanjung Enim Mining Unit. The sampling aims to obtain primary and secondary data that will be used to complete this study.

Data that is directly obtained from the first data source at the research location or research object. Primary data include wind speed measurement data using anemometers and coal temperature measurement data before and after the occurrence of swabs, which are complementary data to complete the research. Secondary data includes coal quality proximate and ultimate analysis data, specification data for tools used in the laboratory, and rainfall data.

Results and Discussion

Effect of Wind Speed and Difference in Coal Grain Size on the Self-Burning Process

The results of the research that has been carried out on coal samples show that wind speed and the difference in grain size of 13 mm and 50 mm can trigger the process of rapid or slow detection of coal swabs. During the study, the difference in the size of the coal grain and the wind speed will be analyzed, as well as how much it affects the swab process. Oxygen carried by the wind will enter the coal pile, which results in the coal reacting with oxygen. If the coal undergoes oxidation, it will release heat from the reaction results. The heat generated cannot come out of the pile, increasing temperature in the coal pile and eventually making the coal experience a spatula. The wind speed used to test coal in the swabakar process varies according to the fan's specifications. The wind speed variables used in this study include: V0= No Wind Speed, V1= 1.6 m/s, V2= 2.6 m/s. The coal samples that will be tested are MT-46, BB-50, and AL-55, which are coal from the mine brand PT Bukit Asam, Tbk Tanjung Enim Mining Unit. The grain size used for coal testing in the swabaku process is also different. The researcher used two different sizes of coal grains in various comparisons, namely coal with a size of 13 mm, crushing new coal through a jaw crusher machine, and coal with a size of 50 mm carried out using a wire woven sieve or wiremesh.

Transition Temperature Value and Comparison of Graph Patterns from Each Coal Sample on Wind Speed Influence Conditions

Coal samples with the same wind speed treatment are shown in one graph plot. So it will be easier to describe and interpret how much wind affects the occurrence of swabakar on coal because it will be easier to see the direction of change and the graph pattern generated from each coal sample. The difference in transition temperature between each coal sample is a sign of the beginning of the swabakar stage in the coal. Water and sulfur content are flammable parts of the coal substance. Low-calorie coal generally has a smaller transition temperature value than high-calorie coal, which has a more significant transition temperature, which is what causes low-calorie coal to be more prone to self-absorption because coal is quickly burned at increasing temperatures, while high-calorie coal lasts longer and tends to be challenging to experience self-absorption due to large transition temperatures.

Transition Temperature Value on Coal Sample Grain Size 13 mm

Transition temperature is a temperature that changes suddenly, causing a slightly different chart pattern. If the transition temperature in the coal sample is smaller, the coal is more reactive for swab root. Meanwhile, if the transition temperature in the coal sample is greater than the comparison of each sample, the coal will take longer to undergo the swab process.

Figure 4.19 shows a pattern of temperature change in coal samples treated with the same wind speed. The graph shows different transition temperature patterns in each coal sample with a wind speed of 1.6 m/s and a coal grain size of 13 mm.

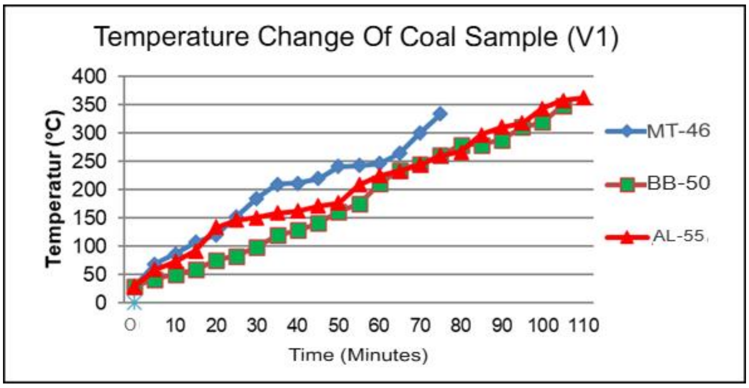

Figure 2. Coal Transition Temperature Size 13 mm at Wind Speed 1.6 m/s (V1)
Source: Author, 2018

Figure 2 shows the graph pattern with wind speed V1 seen in MT-46 coal undergoing oxidation at 153°C at 25 minutes, starting to undergo a swabbing process at 212°C at 40 minutes, and rising quite quickly. So it is known that the transition temperature of MT-46 coal at a wind speed of 1.6 m/s is 212°C at the 40th minute, and the pile of coal ultimately begins to burn at 334°C at the 75th minute.

The BB-50 coal sample shows that the coal graph pattern undergoes an oxidation process in the temperature range of 83°C at minute 25, and the coal begins to emit much smoke at a temperature of 235°C at minute 65. As time increased, the temperature continued to rise until it reached 289°C at the 90th minute, where the coal began to burn at the bottom and began to burn completely at 349°C at the 105th minute.

Meanwhile, the transition temperature in the AL-55 coal sample is greater than that of MT-46 and BB-50. The transition temperature graph explains that the AL-55 only emits smoke at the 70th minute, with a temperature of 245°C, and begins to burn at the bottom of the pile at the 95th minute, with a temperature of 318°C. The coal pile began to burn at 363°C at the 110th minute.

It was concluded that the order of transition temperature from lowest to highest based on V1 wind speed, namely MT-46 and BB-50, was smaller than AL-55, so MT-46 coal was more reactive and more susceptible to sporadic activity. This is due to the high water content in MT-46, which makes the oxidation reaction faster when the coal emits water vapor, making it more reactive and flammable.

Figure 3 shows the graph of the transition temperature in the coal sample with wind speed (V2= 2.6 m/s).

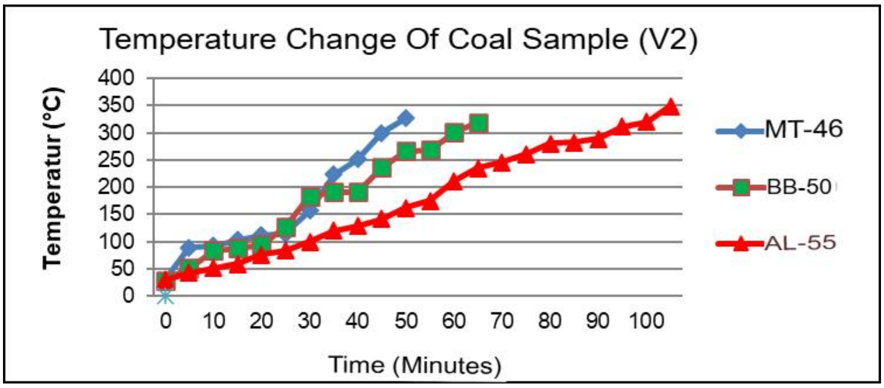

Figure 3. Coal Transition Temperature Size 13 mm at Wind Speed 2.6 m/s (V2)

The MT-46 coal sample was given the influence of wind speed of 2.6 m/s, so that it began to oxidize at a low temperature of around 157°C at 30 minutes and began to burn a small part at 251°C at 40 minutes. Therefore, the transition temperature of MT-46 coal with a wind influence of 2.6 m/s is 251°C. The coal started burning in its entirety at the 50th minute with a temperature of 327°C.

The BB-50 coal sample shows that the coal graph pattern undergoes an oxidation process at a temperature of 94°C at the 20th minute. The coal pile appears at the 50th minute with a temperature of 266°C and begins to burn at 319°C at the 65th minute completely.

The temperature change for the AL-55 sample rose slowly until 83°C at the 25th minute, when the coal began to emit a little smoke. At 235°C at minute 65, the coal began to emit much smoke but did not have any embers. The pile of coal began to burn slightly at the bottom at 289°C at minute 90 and burned as a whole at 349°C at minute 105.

Graph Pattern of Each Sample with the Effect of Wind Speed V1,V2 for 13 mm Grain Size

The graph in Figure 4 looks like the letter J, a satellite dish, and a sloping staircase without being affected by wind (V0) but the temperature rises slowly. This is because the heat produced by coal is not evenly distributed, the heat only comes from iron plates without any air blowing into the rock.

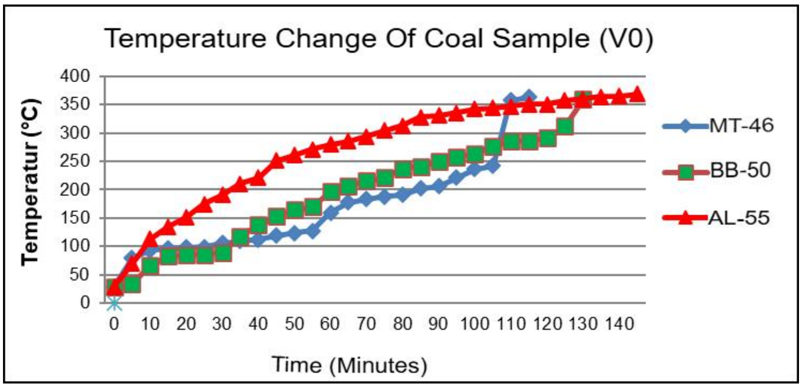

Figure 4. Coal Transition Temperature Size 13 mm Without Wind Speed (V0)

As seen from the figure above, Figure 4.21 shows that the transition temperature from the sample shows that MT-46 and BB-50 coal are smaller than AL-55 coal because MT-46 contains much total moisture, so the hot steam produced accelerates the swab process. MT-46 coal starts burning at 376°C at minute 120, BB-50 coal starts burning at 359°C at minute 130, and AL-55 coal burns at 369°C at minute 145.

Transition Temperature Value on Coal Sample Grain Size 50 mm

Figure 5 shows a pattern of temperature change in coal samples treated with the same wind speed. The graph shows different transition temperature patterns in each coal sample with a wind speed of 1.6 m/s and a coal grain size of 50 mm.

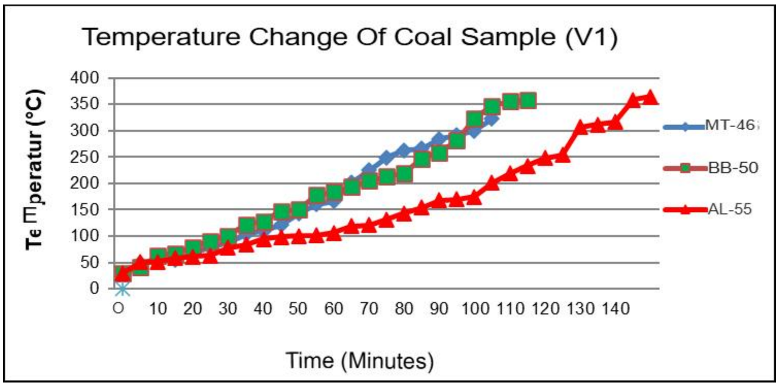

Figure 5. Coal Transition Temperature Size 50 mm at Wind Speed 1.6 m/s (V1)

Figure 5 shows the graph pattern with wind speed V1 seen in MT-46 coal undergoing an oxidation process at 201°C at minute 65 and starting to undergo a swab process at 263°C at minute 80. The temperature rises quickly, and the pile burns at minute 105 paa at 322. So, it is known that the transition temperature of MT-46 coal at a wind speed of 1.6 m/s is 263°C.

The BB-50 coal sample shows that the coal graph pattern undergoes an oxidation process in the temperature range of 205°C at minute 70, and the coal begins to burn at the bottom of the pile at a temperature of 281°C at minute 95. As time increased, the temperature continued to rise until it reached a temperature of 359°C where the coal burned at 115 minutes.

Meanwhile, the transition temperature of the AL-55 coal sample is more significant than that of MT-46 and BB-50. As the graph shows, the transition temperature of AL-55 coal began to burn at the bottom of the pile at 120 minutes with a temperature of 248 °C and completely burned at 150 minutes with a temperature of 364 °C. Figure 6 shows the graph of the transition temperature in the coal sample given the influence of wind speed (V2= 2.6 m/s).

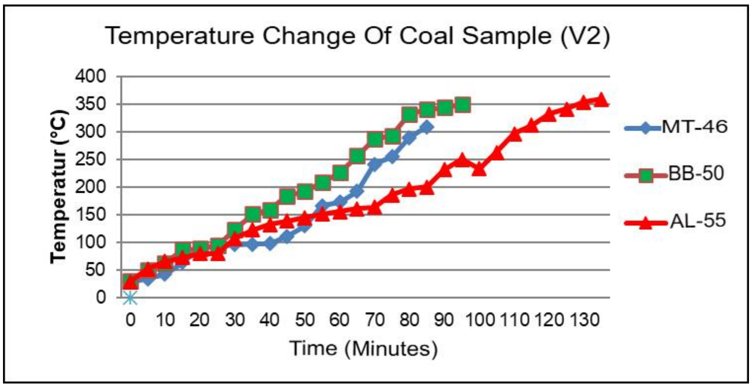

Figure 6. Coal Transition Temperature Size 50 mm at Wind Speed 2.6 m/s (V2)

MT-46 coal is affected by wind at a speed of 2.6 m/s, so the coal oxidizes at a temperature of 166°C at the 55th minute and starts to burn at 241°C at the 70th minute. It is concluded that the transition temperature of MT-46 coal is 241°C. The coal pile began to burn at the 85th minute at 309°C. BB-50 coal with a wind speed of 2.6 m/s undergoes an oxidation process at 159°C at the 40th minute, and the pile starts to burn at the bottom at 208°C at the 55th minute, so the transition temperature value in BB-50 coal is 208°C. The pile started burning at 349°C at the 95th minute. AL-55 coal with the same wind speed began to oxidize at 296°C at the 110th minute, marked by the pile emitting much smoke. At the 135th minute, the coal began to burn at 359°C completely. The value of the transition temperature of AL-61 coal is 296°C.

Graph Pattern of Each Sample with the Effect of Wind Speed V1,V2 for 50 mm Grain Size

The graph in Figure 7 shows the influence of wind (V0) causing the temperature to rise slowly. This is because the heat produced by coal is not evenly distributed, the heat only comes from iron plates without any air blowing into the rock.

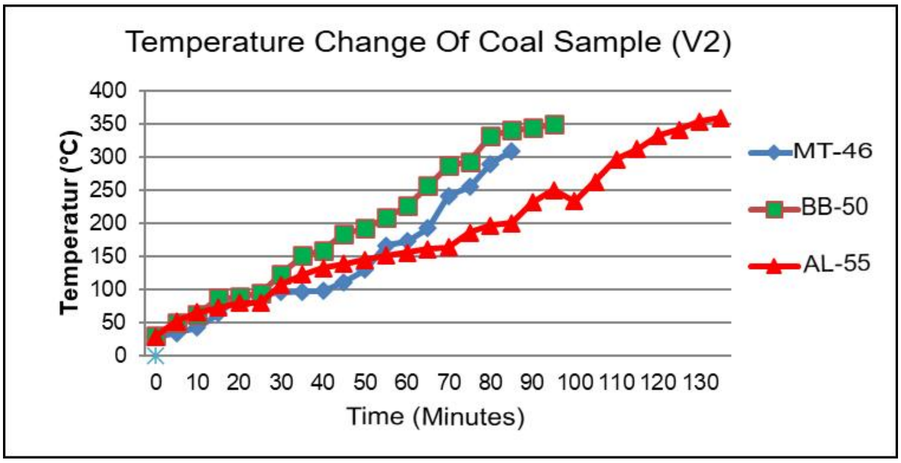

Figure 7. Coal Transition Temperature of 50 mm at No Wind Speed (V0)

Based on Figure 7, the transition temperature from the sample shows that MT-46 and BB-50 coal undergo swabbing faster than AL-55 coal because MT-46 contains much total moisture, so the hot steam produced accelerates the swabbing process.

The MT-46 coal began to smoke at 231°C at minute 105, partially burned at 255°C at minute 120 and completely burned at 323°C at minute 140. For BB-50 coal, it only emits smoke at minute 115 with a temperature of 311°C, it starts to burn partially at minute 135 with a temperature of 338°C and completely burns at minute 175 with a temperature of 366°C. The last one that has experienced the most extended coal burning process is AL-55 where the coal starts to smoke at a temperature of 209°C at the 130th minute, starts to burn at the bottom of the pile at the 160th minute with a temperature of 321°C and completely burns at the 185th minute with a temperature of 369°C.

Statistical Test of Research Data

The normality test aims to test whether a regression model, a free variable, a bound variable, or both have a normal distribution. A good regression model is a standard or near-normal distribution.

Data normality can be detected by looking at the distribution of point data on the diagonal axis of the graph. Policies in decision-making include:

1. If the data is spread around the diagonal line and follows the direction of the diagonal line showing a typical distribution pattern, then the regression model satisfies the normality assumption.
2. If the data spread far from the diagonal line does not show a typical distribution pattern, then the regression does not meet the normality assumption.

The graph shows a separate plot between the x-axis (minutes) and the y-axis (temperature). Each of the normality test results from the existing data can be explained and seen in (Attachments G, H, and I for the grain size of 13 mm) and (Attachments J, K, and L for the grain size of 50 mm). The normality test is used to determine the distribution of the data obtained, whether it is distributed normally, so the data is suitable for use and analysis.

If presented and combined, the normality test results from each research data set will be decomposed as in Tables 1 and 2 to summarize all the normality test results according to the item's size.

Table 1. Normalits Test Coal Testing Data Grain Size 13 mm

No	Data	Hasil Uji Normalitas
1	MT-46 (V_0)	Data Terdistribusi Normal
2	MT-46 (V_1)	Data Terdistribusi Normal
3	MT-46 (V_2)	Data Terdistribusi Normal
4	BB-50 (V_0)	Data Terdistribusi Normal
5	BB-50 (V_1)	Data Terdistribusi Normal
6	BB-50 (V_2)	Data Terdistribusi Normal
7	AL-55 (V_0)	Data Terdistribusi Normal

No	Data	Hasil Uji Normalitas
8	AL-55 (V_1)	Data Terdistribusi Normal
9	AL-55 (V_2)	Data Terdistribusi Normal

Source: Data processed

Table 2. Normalits Test Coal Testing Data Grain Size 50 mm

No	Data	Hasil Uji Normalitas
1	MT-46 (V_0)	Data Terdistribusi Normal
2	MT-46 (V_1)	Data Terdistribusi Normal
3	MT-46 (V_2)	Data Terdistribusi Normal
4	BB-50 (V_0)	Data Terdistribusi Normal
5	BB-50 (V_1)	Data Terdistribusi Normal
6	BB-50 (V_2)	Data Terdistribusi Normal
7	AL-55 (V_0)	Data Terdistribusi Normal
8	AL-55 (V_1)	Data Terdistribusi Normal
9	AL-55 (V_2)	Data Terdistribusi Normal

Source: Data processed

Coal Burning Point

The temperature and time changes for each coal sample for each variable wind speed and grain size difference are regular. This can be seen from the table of coal burning points.

Table 3. P.1. Coal Burning Point

Sample	Grain Size 13 mm			Sample	Grain Size 50 mm		
	V0	**V1**	**V2**		**V0**	**V1**	**V2**
MT-46	376°C 120 minutes	334°C 75 minutes	327°C 50 minutes	**MT-46**	323°C 140 minutes	322°C 105 minutes	309°C 85 minutes
Information	Temperature and time changes for MT-46 coal samples at each wind speed variable were regular.			Information	Temperature and time changes for MT-46 coal samples at each wind speed variable were regular.		
BB-50	**V0**	**V1**	**V2**	**BB-50**	**V0**	**V1**	**V2**
	359°C 130 minutes	349°C 105 minutes	319°C 65 minutes		366°C 175 minutes	359°C 115 minutes	349°C 95 minutes
Information	Temperature and time changes for BB-50 coal samples at each wind speed variable were regular.			Information	Temperature and time changes for BB-50 coal samples at each wind speed variable were regular.		
AL-55	**V0**	**V1**	**V2**	**AL-55**	**V0**	**V1**	**V2**
	369°C	363°C	349°C		369°C	364°C	359°C

Sample	Grain Size 13 mm			Sample	Grain Size 50 mm		
	V0	V1	V2		V0	V1	V2
	145 minutes	110 minutes	105 minutes		185 minutes	150 minutes	135 minutes
Information	Temperature and time changes for AL-55 coal samples at each wind speed variable are regular.			Information	Temperature and time changes for AL-55 coal samples at each wind speed variable are regular.		

Source: Author, 2018

Conclusion

Based on the results of the discussion of the transition temperature of this study, MT-46 coal shows that this coal is more relatively self-absorbed. Where it can be explained for the transition temperature of 13 mm grain size coal, namely MT-46 < BB-50 < AL-55 and for 50 mm grain size coal, namely MT-46 < BB-50 < AL-55 which means that MT-46 coal has a smaller calorific value, and tends to be more flammable than AL-55 which has a more significant transition temperat ure value which indicates that the coal takes more time for swabakar to occur, based on the results of the study on the influence of wind speed and coal particle size on the increase in temperature during the combustion process, it can be concluded that higher wind speed accelerates the oxidation process in coal, thereby increasing the temperature faster and increasing the possibility of swab occurring. The variation in wind speed from 0 m/s (no wind) to 2.6 m/s indicates that the higher the wind speed, the faster the coal transitions to the combustion stage. In addition, the size of coal particles also significantly affects the speed of combustion, where coal with a smaller particle size (13 mm) experiences a faster temperature increase compared to larger particles (50 mm). This is due to the larger surface area in small particles, allowing oxygen to interact more easily with coal and accelerating oxidation reactions. In order, the transition temperature values for the particle size of 13 mm were MT-46 < BB-50 < AL-55, indicating that MT-46 coal is more susceptible to swabbing than other types. The same is true for 50 mm coal, where MT-46 < BB-50 < AL-55 means that MT-46 tends to be more flammable than coal with a higher calorific value. The normality test on the temperature and combustion time measurements data from various coal samples under various wind speed and particle size conditions showed that all data were distributed generally so that the study results could be analyzed with a valid statistical approach. These findings provide important insights into the management of coal storage in stockpiles to reduce the risk of swabbing, taking into account the factors of particle size and wind speed around the storage area. Coal with a smaller size and lower calorific value, such as MT-46, must receive more attention in handling and storage so that it does not experience spontaneous combustion that can be detrimental to the mining industry. Therefore, this research can be the basis for developing more effective prevention strategies to reduce the risk of swabbing in the coal mining industry.

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