Analysis of the Influence of Chevcon Stacking Patterns on the Occurrence of Self-combustions in Stockpiles 1 & 2 of the UBP PLTUPangkalan Susu, Desa Tanjung Raja Kecamatan Pangkalan Susu, Kabupaten Langkat, Provinsi Sumatera Utara

Lamhot Gloria Sitanggang[1], Analiser Halawa[2], Bonar SM Naibaho[3], dan Marvin F.S. Hutabarat[4)]

[1,2,3)]Department of Mining Engineering, Faculty of Mineral Technology,
[4)]Department of Electonic, Faculty of Industrial Technology
TD. Pardede Institute of Science and Technology Medan
Jl. Dr. TD Pardede No. 8 Medan 20153 North Sumatra
Indonesia

LamhotGloriaSitanggang@gmail.com, halawaftm@gmail.com,
Naibaho.Bonar@gmail.com, marvinhutabarat@gmail.com

ABSTRACT

PT PLN Indonesia Power UBP Pangkalan Susu is located in Tanjung Pasir Village, Pangkalan Susu District, Langkat Regency, North Sumatra Province. PT PLN UBP Pangkalan Susu is a company engaged in the coal-fired power plant industry, which uses coal as its main fuel. The coal used at PT PLN UBP Pangkalan Susu comes from South Sumatra. Due to the large demand for coal-fired power plants, there is a need for large-volume storage facilities. PT PLN UBP Pangkalan Susu has a stockpile with a capacity of 295,000 MT. It uses the FIFO (first in first out) stacking method with a Chevcon (truncated pyramid) stacking pattern. The Chevcon stacking area covers 10,496.9 m2 with a top length of 165 m, a width of 15 m, a bottom length of 198 m, a width of 40 m, a stack height of 10 m, and a stack volume of 34,989.6 m3. The coal pile is checked for temperature regularly every day, at heights of 3 meters, 6 meters, and 9 meters. The average temperature of the Chevcon pile at a height of 3 meters is 41.6˚C, at a height of 6 meters is 44.7˚C, and at a height of 9 meters is 46.9˚C. The average daily temperature is 29.8˚C. The coal pile is routinely checked for temperature, and a significant increase in temperature has been observed from the first day of stacking, with an initial temperature of 34˚C and a maximum temperature of 61˚C. 5. At temperatures ≥ 55˚C, the coal pile shows signs of spontaneous combustion. In the Chevcon stacking pattern, the stack temperature reached 61˚C on the 4th and 8th days. Spontaneous combustion is triggered by the fire triangle, namely heat, air, and fuel. However, it is not only these three elements that can trigger spontaneous combustion, but also the quality of the coal.

Keywords:PLTU, Temperature, Accumulation Patterns and Spontaneous Combustion

1. INTRODUCTION

Coal stockpiling is an integral part of the coal handling process. When the stockpiling system is inadequate, it can not only disrupt unloading activities but also increase the risk of fire.This is especially true for naturally combustible coal. Therefore, improving stockpile management is crucial to reduce the potential for fire. One way to reduce the risk of fire is to improve stockpile management. This includes strict monitoring of stockpile conditions, proper ventilation, the use of flame retardants when necessary, and other fire prevention measures (Sarmidi, 2024). It is important to limit the duration of coal storage. Storing coal for too long can degrade its quality and increase the risk of spontaneous combustion. Therefore, it is recommended to ensure rapid stock turnover to prevent coal from being stored longer than necessary. This step will improve operational safety and maintain coal quality. Spontaneous coal combustion often occurs in stockpiles, especially in large piles (Henny Magdalena, 2022).

The research conducted has several aims and objectives, namely:

The purpose of this study is to analyze the effect of coal stacking patterns on the temperature in coal stacks.

The objectives of this research are as follows:

1. Knowing the quantity/tonnage capacity of the stockpile.
2. Knowing the shape of the coal pile regarding the potential for spontaneous combustion.
3. Knowing the temperature of the coal pile.
4. SOP for handling when spontaneous combustion is detected.

Problems that occurred in this research:

1. Has FIFO (First in first out) management been implemented?
2. The problem that occurs in this research is what is the influence of the form of coal piles applied in the company, then does the temperature in the stockpile area also affect the occurrence of spontaneous combustion, how to minimize spontaneous combustion so that spontaneous combustion does not occur.

The problem limitations in this research are:

1. Does not discuss the size of coal in the stockpile.
2. Does not discuss the blending and stockpiling systems applied.
3. Just discussing the Chevcon stack on the Stockpile.

2. METHODOLOGY

This type of research falls into the quantitative category. Quantitative research is research that works with numbers, where the data is in the form of scores or values, rankings, or frequencies.

A literature review is the initial step in research, where researchers seek and collect various sources, such as books, scientific journals, articles, previous reports, and other relevant information related to the research topic. The goal is to gain a thorough understanding of the material being discussed and to ensure that the research conducted is substantially supported by existing literature.

Primary data is data collected through direct observation or measurement in the field. The primary data in this study are:

- Stockpile Stacking Pattern

This data was obtained by observing the stacking and unloading patterns of coal piles implemented at the company. The stacking pattern used in the stockpile is the chevcon stacking method.

- Stack Dimensions

Stack dimensions include length, width, and height. Dimensional measurements are taken using a tape measure to determine the length, width, and height of the stack in the stockpile.

Table 2.1 Measurement Data Stockpile

No.	Dimensions	Value
1	length	53 m
2	wide	33 m
3	height	10 m
total		17490 m³

The process of forming a coal pile in

the stockpile goes through several stages, namely: First, unloading is carried out from the barge, then the coal will be moved from the barge to the stockpile using a belt conveyor with a distance of ± 1000 meters. The second stage of coal that has arrived at the stockpile will be stacked using an excavator and dozer to the other side of the stockpile, the stacking pattern used by the company is the chevcon stacking pattern and the cone ply stacking pattern, with a stack height of ± 10 meters.

- Stack Temperature

Direct temperature measurement in the field using a thermogun as many as13 Sample.

Table 2.2 Chevcon Stack Temperature Data

Tanggal	Hari	Ketinggian		
		3 meter	6 meter	9 meter
05/06/2025	1	34	37	37
10/06/2025	2	39	40	43
11/06/2025	3	40	41	42
13/06/2025	4	46	57	61
16/06/2025	5	42	43	44
17/06/2025	6	41	40	45
18/06/2025	7	41	44	45
19/06/2025	8	47	59	60
20/06/2025	9	45	47	52
23/06/2025	10	45	44	48
24/06/2025	11	39	43	42
25/06/2025	12	40	41	43
26/06/2025	13	42	46	48
TOTAL		541	582	610
Rata - Rata		41,61538	44,76923	46,92308

Based on the temperature measurement data of the pile in the field, we can see that the temperature data was measured using a thermogun.

Secondary data is data obtained from existing data, books or previous documents and several literature that supports this research.

Secondary data in this study are:

- Stockpile Capacity

PT PLN UPB Pangkalan Susu has a stockpile capacity of 295,000 MT.

- Coal Quality Data

The coal used by the company comes from South Sumatra Province. This coal is classified as sub-bituminous coal with a calorific value of 4,611 kcal/kg – 5,833 kcal/kg (ASTM 1980). Coal specifications are based on the Certificate of Analysis (COA) issued by PT Sucofindo.

Parameters	Units	Results (Basic)				Metods
		ARB	ADB	DB	DAFB	
Proximate Analysis :						
Total moisture	%	28.21	-	-	-	ASTM D 3302/3302M-19
Moisture in analysis	%	-	14.82	-	-	ASTM D 3173 - 17a
Ash Content	%	4.44	5.27	6.19	-	ASTM D 3174 - 18
Volatile Matter	%	33.90	40.22	47.22	50.33	ASTM D 3175 - 20
Fixed Carbon	%	33.45	39.69	46.60	49.67	ASTM D 3172 - 21e1
Total sulfur	%	0.35	0.42	0.49	0.53	ASTM D 4239 - 18e1
Gross Calorific Value	Kcal/kg	4859	5765	6768	7214	ASTM D 5865 - 19
Ultimate Analysis :						
Total Moisture	%	28.21	-	-	-	ASTM D 3302/3302M-19
Moisture in Analysis	%	-	14.82	-	-	ASTM D 3173 - 17a
Ash Content	%	4.44	14.82	6.19	-	ASTM D 3174 - 18
Sulfur	%	0.35	0.42	0.49	0.53	ASTM D 3175 - 20
Hydrogen	%	6.91	6.11	5.23	5.57	ASTM D 3172 - 21e1
Carbon	%	50.03	59.36	69.69	74.28	ASTM D 4239 - 18e1
Nitrogen	%	0.79	0.94	1.10	1.18	ASTM D 5865 - 19
Oxygen	%	37.47	27.90	17.30	18.44	ASTM D 5373 - 21
HGI	Point Indeks	-	59	-	-	ASTM D 409M - 16

Source: Sucofindo, May 6, 2025

The data collected from both literature studies and data collection in the field are grouped based on their type and use.

The stack dimensions are taken using a rolling meter, then calculating the stack volume using the pyramid formula for the chevcon stacking pattern.

Table 2.3 Chevcon Pile Area Measurement Results

	Dimensions	Stack Pattern
1.	Stack Form	*Chevcon*/ Truncated Pyramid
2.	Width of the upper floor	15 Meter
3.	Width of the ground floor	40 Meter
4.	Length of the upper floor	165 Meter
5.	Length of the lower floor	198 Meter
6.	Tall	10 Meter
7.	Ground floor area	2,475 m2
8.	Upper floor	7,920 m2

	area	
9.	Stack volume	34,898.6 m3

Based on temperature data in the field, the occurrence of spontaneous combustion can be estimated using equation (3.3). The purpose of calculating the rate of temperature increase is to help predict the daily temperature increase so that the company can anticipate spontaneous combustion in coal piles.

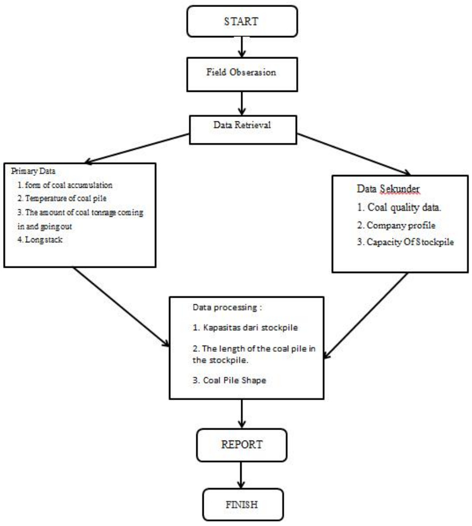

Figure 2.1 Research Flowchart

3. RESULTS AND DISCUSSION

The area of the coal stockpile was measured using a tape measure. The ground floor area of the coal stockpile, obtained from field measurements, is as follows:

The following is the calculation of the volume of coal piles with a chevcon stacking pattern:

- Bottom Area
  L = Length × Width
  L = 198 meters × 40 meters
  L = 7,920 m2
- Top area
  L = Length × Width
  L = 165 meters × 15 meters
  L = 2,475 m2
- Volume

Volume =1/3 × t (La + Lb + √La+Lb)
= 1/3 × 10(2,475 + 7,920 + 101.9)
= 1/3 × 10(10,395 + 101.9)
= 1/3 × 10 (10,496.9)
= 1/3 ×104,969
= 34,989.6 m3

Measuring the temperature of a coal pile using a thermogun by shooting and directing a laser at the coal pile, then the results will appear on the thermogun monitor screen and then will be processed using Microsoft Excel.

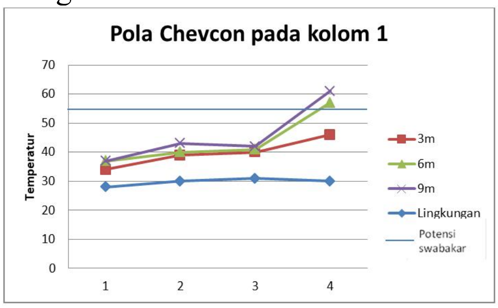

Figure 3.1 Chevcon 3m, 6m and 9m

It can be seen in the graphic above that there is an indication that a spontaneous combustion will occur on the 4th day, since the temperature measurements began, where at a height of 3 meters a very significant increase in temperature has begun to be seen and continued with a height of 6 meters which has passed the indication that a spontaneous combustion will occur and at a height of 9 meters a spontaneous combustion has occurred.

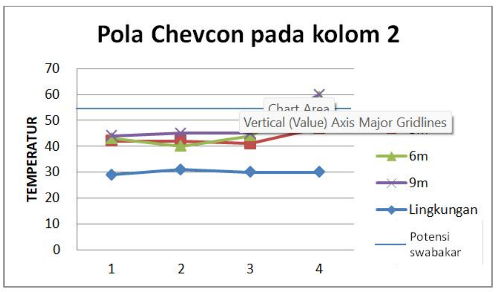

Figure 3.3 Chevcon 3m, 6m and 9m

It can be seen that the graph above shows an indication that a spontaneous combustion will occur on the 5th day, since the temperature measurements began, where at a height of 3 meters a very significant increase in temperature has begun to be seen and continued with a height of 6 meters a spontaneous combustion has occurred and at a height of 9 meters a spontaneous combustion has occurred.

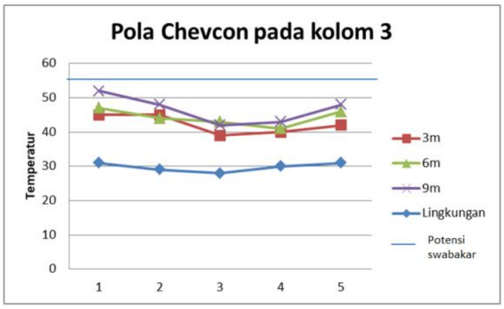

Figure 3.2 Chevcon 3m, 6m and 9m

In the graph above, it can also be seen that on the 9th day there was an increase in temperature, but there was no spontaneous combustion in the coal pile and the coal was immediately unloaded to prevent spontaneous combustion.

The time of spontaneous combustion can be estimated, To find the estimated time for spontaneous combustion in the chevcon stacking pattern, the following is done:

- Estimated calculation of spontaneous combustion at an elevation of 3 meters:
  Initial temperature of the pile = 34˚C
  Average temperature = 41.6˚C
  Temperature increase rate = 0.9˚C/Day
  Estimated temperature increase
  $= \frac{41{,}6^\circ C - 34^\circ C}{0{,}9^\circ C/Hari}$ = 8.4˚C/Day
- Estimated calculation of spontaneous combustion at an elevation of 6 meters:
  Initial temperature of the pile
  = 37˚C
  Average temperature
  = 44,7˚C
  Rate of temperature increase
  = 0,9˚C/Day
  Estimated temperature increase
  $= \frac{44{,}7^\circ C - 37^\circ C}{0{,}9^\circ C/Hari}$ = 8.5 ˚C/Day
- Estimated calculation of spontaneous combustion at an elevation of 9 meters:
  Initial temperature of the pile
  = 37˚C
  Average temperature
  = 46,9˚C
  Rate of temperature increase
  = 0,9˚C/Day
  Estimated temperature increase
  $= \frac{46{,}9^\circ C - 37^\circ C}{0{,}9^\circ C/Hari}$ = 11 ˚C/Day.

Based on the graph you provided, the effect of wind speed on temperature increases does not show a consistent or direct relationship. Instead, the graph shows complex fluctuations between the two variables.

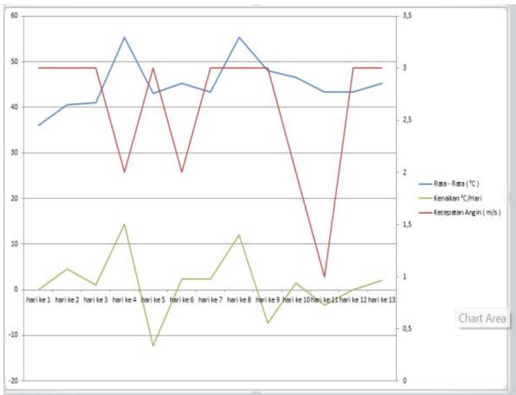

Figure Graph of the Effect of Wind Speed on Temperature Increase

In the context of spontaneous combustion, the effects of increased oxidation are usually more dominant, especially in dense piles of material where heat is difficult to escape. Let's look at some specific patterns on the graph:

1. Day 4: There is a significant increase in average temperature (the blue line rises). At the same time, wind speed (the red line) drops sharply. This suggests that

the temperature increase on this day is likely not caused by wind, but by internal factors, such as increased oxidation rates within the pile of material isolated from the cooling effects of the wind.

2. Day 8: A sharp increase in average temperature occurred and reached a peak. At the same time, wind speeds were also high (around 3 m/s). This may indicate that the wind provided a sufficient oxygen supply to accelerate oxidation reactions, ultimately triggering a significant temperature increase.
3. Day 10: A sharp drop in average temperature occurs. Wind speeds also drop drastically to their lowest point. Under these conditions, the reduced oxygen supply and possibly the cooling effect of the surrounding air can cause the oxidation rate to slow, resulting in a decrease in internal temperature.

The stockpile stacking method uses a chevcon stacking pattern in the form of a truncated pyramid and coneply. The coal on the barge will be unloaded using a Grab Bucket Cran then filtered first with a hopper with a filtering size of 15cm × 15cm before being transported to the stockpile using a belt conveyor, after being poured into the stockpile, the excavator and dozer will make a stacking pattern, making a maximum stacking pattern with a height of 10 meters, this is done to make it easier for the stacker reclaimer when filling the banker boiler.

Spontaneous combustion is the process by which coal ignites naturally, caused by an oxidation reaction that continuously increases its temperature. All types of coal have the potential for spontaneous combustion, but the time and temperature required vary.

Spontaneous combustion in coal piles is caused by coal containing methane gas (CH4), which comes into direct contact with air, triggering spontaneous combustion. The Chevcon stacking pattern minimizes air entry into the cavities of the coal pile and facilitates stacker recailmer filling. The Chevcon stacking pattern is typically used for large-scale coal storage and storage. Parameters that can cause spontaneous combustion in stockpiles include:

1. Stack Form
   A stack with a chevron pattern will inevitably form a truncated pyramid. This truncated pyramid shape will cause the sides of the coal pile to be exposed to more air. The reaction between the outside air and the coal will trigger spontaneous combustion.
2. Accumulation Time
   The stockpile typically holds for 10 days after unloading from the barge, but this can vary depending on the boiler's usage. The later the unloading from the port, the shorter the coal will remain in the stockpile.
3. Area of the Side of the Pile Exposed to Wind
   Wind also influences spontaneous combustion. Broadly speaking, wind affects the rate and speed of coal oxidation in the stockpile, ultimately triggering spontaneous combustion.
4. Effect of Wind on Self-Ignition
   - Wind acts as a heat transfer medium in coal piles. The flowing air carries the oxygen necessary for the coal's oxidation reaction, which generates heat.
   - Wind speed significantly affects the rate of coal oxidation in stockpiles. The higher the wind speed hitting the coal pile, the more air and oxygen are trapped within the coal's pores. As a result, the heat generated by the oxidation reaction increases more rapidly, potentially accelerating spontaneous combustion.

4. CONCLUSION

1. The capacity of stockpiles 1 and 2 at PT PLN UBP Pangkalan Susu is 295,000 MT.
2. By knowing the capacity of the stockpile, coal stacking in the stockpile can be arranged using a chevcon stacking pattern.
3. The length of time of accumulation has a significant influence, so that in this study it was found that at a height of 6 meters it showed indications of spontaneous combustion at a temperature of 57˚C, then at a height of 9 meters with a pile temperature reaching 60˚C on the 4th day and on the 8th day it showed spontaneous combustion.

5. ACKNOWLEDGMENT

1. PLTU UBP Pangkalan Susu, Desa Tanjung Pasir, Kecamatan Pangkalan Susu, Kabupaten Langkat

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