

Research Article

Study of The Effect of Coal Quality Parameters on Gas Methane (CH₄) Emission in Coal Fire for Sustainable Environment

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ABSTRACT

Coal is formation media of Methane Gas which retains the ability to store gas in large quantities. Methane gas (CH₄) one of the greenhouse gases that its existence can be troubling, because the gas can increase the impact of global warming, the can damage the ozone layer and increase the temperature of the earth. Methane gas (CH₄) emissions occurred in the coal combustion process were strongly influenced by the physical and chemical of coal. This research was intended to know how the influence of quality parameters and calorific value of coal methane gas (CH₄) emission, and temperature in combustion process. This research is quantitative research with method of quantitative descriptive and descriptive associative approach. Average methane gas emissions (CH₄) occurring for each calorific value of coal calories: 3.98 ppm from 5900 kcal/kg, 1.30 ppm from 6300 kcal/kg, 0.26 ppm from 6700 kcal/kg, and 0.08 ppm from 7600 kcal/kg. The relationship of temperature, calorific value and methane gas emission (CH₄) is the higher the calorific value, the required temperature will be higher and the gas emission smaller: for the calories of 5900 kcal/kg, the average temperature was 63.75°C; 6300 kcal/kg, 60.92°C; 6700 kcal/kg, 52.59°C, and 7600 kcal/kg, 113.98°C, respectively. Indonesian coal mostly consists of low rank coal which can cause high methane (CH₄) emissions that would also cause problems to the environment.

Keywords: Coal, Methane, Methane emissions, Global warming

1. INTRODUCTION

Coal is a formation medium of Coal Methane Gas (CMG) has the ability to store gas in large quantities. This is because the surface of the coal has many pores smaller in size than the micron scale, causing the coal surface to absorb large amounts of gas. Gas trapped in coal consists mostly of methane gas [1]. Coal Methane Gas (CMG) is a methane gas (CH₄) produced from natural processes that occur during the coal formation process. The gas will be formed biogenically due to decomposition by microorganisms producing methane and CO₂ gas [2].

Methane gas (CH₄) is one of the greenhouse gases that its existence can increase the temperature of the earth, because the gas can increase the impact of global warming (global warming) which will lead to a decrease in environmental quality. Methane gas is the greenhouse gas emitting second place after CO₂ [3].

Coal in Indonesia lies in the boundary between sub bituminous and bituminous coal, but almost 59% is lignite [4]. PT. Bukit Asam (Persero) Tbk as one of the coal producer in 2016 total production is 19.69 million tons increased by 3% from 2015 by 19.29 million tons, while the production target PT. Bukit Asam (Persero) Tbk in 2017 increased again by 22% from 2016 that is 24.07 million tons, where most of the coal is low rank coal [5].

Low rank coal has in the combustion process will result in higher gas methane (CH₄) emissions compared to high calorie coal [6]. This can lead to an increase in the impact of global warming which will cause a decline in environmental quality.

The scope of the problems in this study includes coal quality parameters, calorific value, gas methane (CH₄) emissions, and the effect of temperature on the combustion process. This study aims to (1) analyze the effect of calorific value of coal on methane emissions (CH₄), (2) calculate how much methane gas emission (CH₄) occurs during coal combustion, (3) analyze the effect of

temperature of methane gas emissions (CH₄) during the combustion process.

2. EXPERIMENTAL SECTION

2.1. Coal Burning Process

Coal is one type of fuel for energy generation. Coal may also be used not as fuel, but is used as a reducing agent for tin smelting, ferro-nickel industry, iron and steel industry, as a purification agent in the chemical industry (in the form of activated carbon), as a calcium carbide (in the form of coke, or semi coke) [7].

The coal combustion process is a very quick reaction between coal and oxygen to produce the product. The requirements for perfect combustion according to are: (1) all carbon (C) contained in coal to CO₂ in the product; (2) all hydrogen (H) present in coal to H₂O in the product; (3) all the sulfur (S) inside the coal is SO₂ in the product [8]. The coal-forming element consists mainly of carbon and hydrogen, so the carbon and hydrogen content will greatly determine the combustion process of coal. Based on the calculation of the amount of air needed to burn various types of coal can be seen in Table 1.

2.2. Methane Gas in Coal

Methane gas is the simplest hydrocarbon compound in the form of a colorless gas and also odorless with CH₄ chemical formula.

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Table 1. Air Needs of Combustion of Different Types of Coal [8]

(% mass)	PROXIMATE ANALYSIS				
	Variation of Coal				
	Anthracite	Bituminous	Sub bituminous	Lignite	
Fixed Carbon (FC)	83.3	70	45.9	30.8	
Volatile Matter (VM)	5.7	20.5	30.5	28.2	
Moisture (M)	2.5	3.3	19.6	34.8	
Ash (A)	8	6.2	4	6.2	
	ULTIMATE ANALYSIS				
	Carbon (C)	89.3	80.7	58.8	42.4
	Hydrogen (H)	2.9	4.5	3.8	2.8
	Sulfur (S)	0.7	1.8	0.3	0.7
	Oxygen (O)	0.7	2.4	12.2	12.4
	Nitrogen (N)	1.3	1.1	1.3	0.7
	Water (H ₂ O)	2.5	3.3	19.6	34.8
	HHV Heat Value (Btu/lb)	13,710	14,310	10,130	7,210
	Air combustion requirements (lb air/lb coal)	10,423	12,819	9,098	6,423

Other properties of methane gas (CH₄), among others, can burn at 5-15%, have a boiling point of -161°C, and have a water solubility of about 35mg/ L at atmospheric pressure. The methane gas was first invented by Alessandro Volta from 1776-1778 who conducted research on Manggiore Lake and observed gas bubbles and found that the gas could burn [9]. Methane gas can be stored in coal in 4 ways: 1) gas in micro pores and cleats, (2) water-soluble gases, (3) gas absorbed by molecular pull on micro pore coal particles and cleat surfaces, (4) gas absorbed in coal structure [10].

Gas in coal is generally formed in two ways, Biogenic Gas and Thermogenic Gas [11]. For the Biogenic gas, it occurred in the 2 stages of the initial stage and the final stage. In the early stages, the gas formation was caused by the activity of early microfication of coalification, from peat-lignite to sub bituminous. The formation of gas in the final stage is also caused by the activity of the organism, but the process of occurrence after the coal seam is formed. Coal is generally a quifer, where the activity of microorganisms in the aquifer can produce gas. This process can occur in any rank (rank) of coal. For the Thermogenic gas, the gas produced in the coalification process due to increased pressure and temperature on the coal having a higher rank, was in sub bituminous A to high volatile bituminous upwards [12]. The gas content formed is closely related to the temperature and rank of coal as shown in Figure 1 [13].

Characteristics of coal methane gas is influenced by some parameters, such as sedimentary environment, coal distribution, coal rank, gas content, permeability, porosity, geological structure, and hydro geological conditions. Coal as sedimentary rock is composed of elements of carbon, hydrogen, oxygen, nitrogen, and sulfur. The carbon content was contained in coal causes coal to become combustible. For coal, especially low calorie has a large porosity so that oxygen will be able to easily enter into coal,

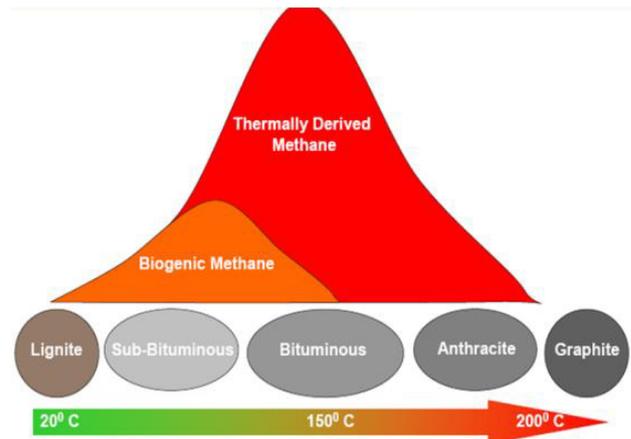


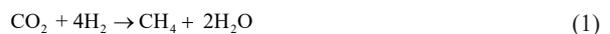
Figure 1. Gas formation in relation to Temperature [13]

causing the oxidation reaction in coal. This oxidation reaction can cause heat happening to coal so that make emissions of gas CO₂, CH₄, and H₂S when coal is burned [6].

The formation of CH₄ gas emissions occurs by the following reactions:



Another possibility is the formation of CH₄ gas by the following Methanezation reaction:



The formation of CH₄ gas emissions depends on the length time of combustion and combustion temperature

Methane gas (CH₄) is formed in the initial process of coalification, where coal is still in peat condition, so methane gas (CH₄) is mostly found in low rank coal. The low rank coal will have a low calorific value between from 4,830-6,360 kcal/kg (Classification according to ASTM). Thus the emission of methane gas (CH₄) will be smaller if the rank and calorific value of coal will be higher, but it is also influenced by the combustion temperature.

2.3. Materials and Methods

2.3.1. Material

This type of research is a quantitative research. This research activity will be carried out in the Materials Processing Laboratory of Mining Department of Engineering Faculty of Sriwijaya University for coal combustion process and Laboratory of PT. Sucofindo Palembang for examination of proximate and ultimate analysis. While the sampling location for coal quality analysis of methane gas emission (CH₄) was done at PT. Bukit Asam (Persero), Tbk. Kertapati Palembang docks Unit with calorific value level of 5,900 kcal/kg (BA-59), 6,300 kcal/kg (BA-63), 6,700 kcal/kg (BA-67) and 7,600 kcal/kg (BA-76).

Instruments used in this study include coal oven burner equipment complete with gas cylinders and regulator hose, calibrated multigas detector, anemometer, thermocouple, and stopwatch.

2.3.2. Method

Stages performed in this study to achieve the purpose of this study include:

Table 2. Classification of Market Brand Coal (BA) Based on Proximate Analysis Result (Exhibition Unit and PJP)

Mine brand	CV (Kcal/Kg,abd)	TM (%ar)	IM (%adb)	Ash (%adb)	VM (%adb)	FC (%adb)	TS (%adb)
TE 59	5900	28	13.1	6	40.4	40.5	0.6
TE 63	6300	21	11.3	5	41.2	42.5	0.6
TE 67	6700	18	7.8	5	41.5	45.7	0.6
TE 76	7600	14	6.1	5	41.9	47	0.6

Literature Study

Gather all the information associated with the study. Stage of Preparation; Set up the variable format measurement, equipment modification burning, and preparation equipment. Sampling and Data Collection; Coal samples from PT. Bukit Asam Unit Kertapati Pier Palembang with a calorific value of 5,900 kcal/kg (BA-59), 6,700 kcal/kg (BA-67), and 7,600 kcal/kg (BA-76). The collection data can be divided into two class, i.e.

Primary data: Combustion temperature, combustion time, methane gas emissions generated, and air discharge in the combustion process.

Secondary Data: Coal quality data (proximate test, ultimate, and calorific value of coal), environmental condition of coal deposition, Coal transport process from Tanjung Enim Mining Unit to Kertapati Pier Unit, sample location map.

Coal and Combustion Testing

Measurements of natural gas emissions include CH₄, CO₂, H₂S, O₂, (multigas detectors), measurement of combustion time (stopwatch), temperature measurement (thermocouple).

Processing and Data Analysis

Data processing using SPSS with quantitative was descriptive approach method and statistical method. Data analysis by using descriptive associative, among others, analysis of the effect of quality and value of coal calorific to methane gas emission (CH₄) in coal combustion process, temperature analysis to methane gas emission formation during burning process,

Conclusion

3. RESULTS AND DISCUSSION

3.1. Coal Quality Analysis

Many ways that can be done to know the quality of coal. In principle coal quality test can be known through two analyzes, namely proximate analysis and ultimate analysis. Proximate analysis is an analysis whose purpose is to know: (1) moisture, consisting of free moisture, inherent moisture, and total moisture; (2) ash content; (3) volatile matter; (4) carbon blocked (fixed carbon). While the ultimate analysis is an analysis conducted on coal to know the elements of coal formers, among others, carbon, hydrogen, oxygen, nitrogen, and sulfur that exist in coal [7].

Coal calorific value which is an indicator of coal quality is divided into two types, namely High Heating Value (HHV) and Low Heating Value (LHV). High Heating Value (HHV) is obtained by burning coal as much as one kilogram and measuring the calories obtained using a calorimeter at 150 °C so that the moisture generated from this combustion condenses and releases its condensing calories. While Low Heating Value (LHV) or low calorific value obtained by reducing the value of upper calories with water-condensing calories it contains [14].

Coal quality classification aims to determine the variation of coal quality. There are two classifications that are used based on the proximate analysis and the calorific value of coal, namely Tanjung Enim Mine Brand (TE) for unprocessed coal mining and Market Brand Bukit Asam (BA) for processed coal processing,

such as blending. Market Brand Classification (BA) is used for coal sales.

Calorific value of coal used in the study in accordance with the classification of the brand market (BA), among others, the calorific value of 5900 kcal/kg (BA-59), 6300 kcal/kg (BA-63) calories, 6700 kcal/kg (BA-67) calories, and 7600 kcal/kg (BA-76) calories. The classification of brand market coal (BA) for each calorific value used in this study can be seen in Table 2.

3.2. Methane Gas Emission (CH₄) in Coal

Methane gas emission (CH₄) in this study can be seen from the measurement results, where for coal with a calorific value of 5900 kcal/kg (BA-59) the measurement is done until 72 minutes with average methane gas emission (CH₄) of 3.98 ppm, and methane gas start out to emerge 7 minutes after the burning process of 0.3 ppm and continue to increase until time 72 minutes of 9.8 ppm. Coal with a calorific value of 6300 kcal/kg (BA-63) has an average emission of 1.30 ppm with a measurement time of 53 minutes of 2.8 ppm and methane gas the first arises 10 minutes after the combustion process of 0.3 ppm. Coal with a calorific value of 6700 kcal/kg (BA-67) has an average methane gas emission (CH₄) of 0.26 ppm with a measurement time of 50 minutes, the gas emissions after of 50 minutes of 0.7 ppm and methane gas arising first after 19 minutes of burning with emissions of 0.2 ppm. While for coal with calorific value of 7600 kcal/kg (BA-76) the average methane emissions that occurred at 0.08 ppm with a burning time of 46 minutes, the largest methane gas emissions generated at the combustion process of 0.3 ppm and gas methane arises first after 34 minutes of burning process of 0.2 ppm.

Based on the above measurements can be seen the higher the calorific value of coal will be the smaller the gas emissions that occur and the longer time required for the combustion process that can cause the emission of methane gas (CH₄), while the process of methane gas emissions will be smaller.

3.3. The Effect of Temperature on Methane Gas Emission (CH₄)

Combustion temperature will greatly affect the combustion process for each coal calorific value, where the higher the calorific value of coal, the temperature required for combustion process is also higher. In the coal combustion process the relationship between calorific value and combustion temperature with methane gas emission (CH₄) that will arise can be seen from the research results the higher the quality of coal the required temperature for the combustion process will be greater and the methane gas (CH₄) that occurs will be smaller.

The results of this study indicate that coal with a calorific value of 5900 kcal/kg (BA-59) of methane gas (CH₄) will arise at 31 °C with methane gas of 0.3 ppm, for coal with a caloric value of 6300 kcal/kg of methane gas emissions CH₄) occurs at 40°C of 0.2 ppm, and coal with a calorific value of 6700 kcal/kg (BA-67) of methane gas (CH₄) occurs first at 48°C of 0.2 ppm, whereas coal with caloric value 7600 kcal/kg (BA-76) new methane gas arises at 138°C temperature of 0.2 ppm (Table 3).

4. CONCLUSION

Table 3. Temperature and Emission of Methane gas (CH₄) for each Calorific

Calorific Value (kcal/kg)	T (°C)	CH ₄ (ppm)
5900 (BA-59)	63.75	3.98
6300 (BA-63)	60.92	1.3
6700 (BA-67)	52.5	0.26
7600 (BA-76)	113.98	0.08

The result of methane gas (CH₄) emission analysis to the calorific value of coal, the higher the coal calorific value, the methane emissions that will arise will be smaller. The average value of methane gas emissions (CH₄) occurring in the coal combustion process for each calorific value, for an average calorific value of 5900 kcal/kg (BA-59) the average emission is 3.98 ppm occurs 7 minutes after the combustion process with the initial emission of 0.3 ppm, the average calorific value of 6300 kcal/kg (BA-63) the average emissions of 1.30 ppm arises 10 minutes after the burning of 0.3 ppm, the calorific value of 6700 kcal/kg (BA-67) has average methane emissions. (CH₄) of 0.26 ppm and emissions arising after 19 minutes of burning with emissions of 0.2 ppm, while for caloric values of 7600 kcal/kg (BA-76) the average methane emissions of 0.08 ppm and arising after 34 minutes burning of 0.2 ppm.

The results of the analysis show that the higher the coal calorific value of the required combustion temperature will be greater, where coal with the calorific value of 5900 kcal/kg (BA-59) emissions arise at 31°C, coal with calorific value of 6300 kcal/kg of methane gas emissions (CH₄) occurs at a temperature of 40°C, and coal with calorific value of 6700 kcal/kg (BA-67) occurs first at 48°C, whereas coal with calorific value of 7600 kcal/kg (BA-76) of new methane occurs at temperature 138°C.

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