EFFECT OF TEMPERATURE ON RUMEN MICROBES ACTIVITY TO PRODUCE METHANE FROM COAL

PENGARUH SUHU TERHADAP AKTIFITAS MICROBA RUMEN UNTUK MEMPRODUKSI GAS METANA DARI BATUBARA

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ABSTRAK

Tulisan ini dimaksudkan untuk menunjukkan pengaruh suhu terhadap pemanfaatan mikroba cairan rumen untuk menghasilkan gas metana dari batubara (lignit, sub-bituminous dan bituminous). Dengan mempertimbangkan pemanfaatannya untuk aplikasi lapangan dimana suhu reservoir GMB lebih tinggi dari kondisi hidup alamiah mikroba di dalam badan sapi, maka percobaan ini dilakukan pada suhu 30ºC dan 50ºC dengan inkubasi selama 105 hari. Penelitian skala laboratorium ini dilakukan dengan mencampurkan antara batubara, air formasi dan cairan rumen (1:1:1) yang dimasukan ke dalam tabung tertutup yang dilengkapi dengan saluran pengukur volume gas terproduksi. Hasil percobaan menunjukkan bahwa mikroba rumen bisa tumbuh pada jenis batubara dan suhu yang berbeda. Untuk semua perlakuan, volume gas terus meningkat selama periode waktu inkubasi. Diperoleh produksi gas metana tertinggi terjadi pada perlakuan suhu 50ºC pada batubara sub-bituminous dengan volume 0,627 liter/kg (22,14cf/ton) dari total volume gas terproduksi sebanyak 7,25 liter/kg (256 cf/ton)..

Kata kunci: gasbio metana, biometana, cairan rumen, pengaruh suhu, bakteri rumen, biostimulasi

ABSTRACT

This paper is intended to show the effect of temperature on utilization microbes of rumen fluid to produce methane from coal (lignite, sub-bituminous and bituminous). By considering to field applications, where the CBM reservoir temperature is higher than the microbes natural living conditions in the cow's body, the experiment is carried out at a temperature of 30ºC and 50ºC with an incubation period time of 105 days. Laboratory scale study was conducted by mixing the coal, formation water and rumen fluid (1: 1: 1). This mixture were inserted into a closed chamber equipped with a hose to measuring the volume of gas produced. The experiment results showed that the microbes of the rumen fluid can grow on different type of coal and temperatures. The volume of gas production increased during the incubation time for all treatments. Obtained the highest methane production occurs at a temperature treatment of 50ºC for the sub-bituminous coal with a volume of 0.627liters/kg (22.14 cf/ton) from the total volume of gas produced as much as 7.25liters/kg (256 cf/ton).

Keyword: *methane biogas, biomethane, rumen fluid, temperature effect, microbe, biostimulation*

I. INTRODUCTION

Currently the government of Indonesia seriously effort to complies the target due to decreasing of oil and gas production, including work on improving of exploration-exploitation the non-conventional resources. One of them is Coal Bed Methane (CBM), which the methane derived from coal layer (seam).

Indonesia has great CBM reserves which is scattered in several islands, and mostly in Sumatra and Kalimantan. The potential methane gas content in

coal is very large. Advances Resources International (ARI) in 2002 reported that the CBM potential in Indonesian reaching of 453 Trillion Cubic Feet (TCF) where located in 11 basins, and the greatest CBM resources was occurred in South Sumatra (183 TCF), Barito basin (101.6 TCF) and East Kalimantan basin (80.4 TCF) (Scott 2003; BP Migas 2011).

Methane usually produced from coal seams at depths of 200 - 1000 meters subsurface because of economical reason especially for drilling cost. To produce the methane is required to reduce water content in cleat system of the coal, which known as dewatering. With pumping technique, dewatering reduces the cleat pressure allowing gas to desorb from the coal matrix to the well bore. At this stage period, along with water production, the gas production will increase until peak production reaches. However, this production would be declined and the production could be terminated. So the CBM is unlike conventional oil and gas production, usually shows highly in amount of production at first, and then steadily declines (Widiyanto 2010). At this condition, the wells need to improve back the production with secondary or enhanced recovery such as water flood, surfactant-polymer and CO_2 injection techniques.

CBM production can be enhanced by biological utilization through biostimulation and bioaugmentation where can be applied either in situ or ex situ (surface). Biostimulation is the methode to stimulate the population of indigenous microorganisms by adding nutrients to the reservoir, while bio-augmentation is the process to inoculation of microorganism consortium into the reservoir. This method is commonly used to reactivate the CBM reservoirs when are not longer in in situ production (Strapoc et al. 2008). Ex situ application is carried out by the mined coal or weathered coal to be converted into methane gas in a bioreactor by utilizing methanogenic microbes. Formation of biogenic methane from coal becomes interesting to study because of its products in the form of clean energy. The bioaugmented microcosm generated methane more rapidly and to a higher concentration than the biostimulated microcosm (Jones et al. 2010).

This paper was made related to the previous study has been succeed to utilize the microbes methanogen to produce gas methane from coal and has potential to use in bioaugmentation (Kosasih et al. 2013). The microbes derived from rumen fluid of cow from slaughter house which can pollute the environment if not utilized. The rumen fluids containing microbial consortium consist of bacteria, protozoa, fungi and as well as methanogenic microbes potential to degrade the coal (Hungate 1996). In addition, the rumen microbes have ability to digest lignin from plants, which the plant itself is the main material of coal formation (Odarza 2000).

This study was purposed to determine the effect of temperature on microbes activity to produce gas from coal. The experiment was performed by combining three types of coal into the medium which is containing of formation water and rumen fluid. The activity of microbes depends on the temperature and their surroundings condition. The rumen microbes has the optimal temperature of 37 – 39ºC, similar with host. Biodecomposition of organic material such as coal will be faster obtained by increasing of the temperature up to 50ºC. The study observe effect temperatures to understand the activity of rumen microbes to produce methane from coal at temperature 30ºC and 50ºC. To support the applications of in situ bioaugmentation, the experiment condition must be similar with CBM wells, so the experiment medium contain water formation. This water contain different types of microbes including methanogens group, expected it can be made a symbiosis interaction with rumen microbes.

II. METHODOLOGY

A. Coal screening

Related for this study, three type of coal sample was collected from south Sumatra coal mining field (bituminous and sub-bituminous) and one sample of lignite was taken from core sample of South Sumatera CBM well. The proximate data presented in Table 1. The coal sample was crushed into small chunks or gravel (size of 2 to 4 centimeter)..

B. Experimental

The medium was made by mixing of 1 L rumen fluid, 1 L formation water, and 1 kg coal (ratio of 1: 1 : 1) and put into anaerobic chamber which have two valves on the bottom and top part. The small hose was mounted on top valve and connected to the volumetric column to measure the volume of

Table 1
The results of proximate analysis

No	ID sampel	Inh. Moisture (% wt, Adb)	Ash Content (% wt, Adb)	Volatile (% wt, Adb)	Fixed carbon (% wt, Adb)	Volatile (DMMF)	Coal Rank
1	CBM#3-S2-3	22.223	6.961	42.244	28.572	59.653	Lignit
2	BA 59 F 3	21.600	1.665	39.330	37.405	51.254	Subbituminus
3	BA 67 HS	16.465	1.325	37.265	44.945	45.329	Bituminus

Table 2
Variations of treatment

Treatment Code	Type of Coal	Ratio of Coal : Rumen : Fm. water	Temp. °C	Remarks
A	Lignite	1 : 1 : 1	30	CBM#3-S2-3
B	Subbituminous	1 : 1 : 1	30	BA-59-F3
C	Bituminous	1 : 1 : 1	30	BA-67
D	Blanko	0 : 1 : 1	30	Control
E	Lignite	1 : 1 : 1	50	CBM#3-S2-3
F	Subbituminous	1 : 1 : 1	50	BA-59-F3
G	Bituminous	1 : 1 : 1	50	BA-67
H	Blanko	0 : 1 : 1	50	Control

gas produced. The blank treatment was conducted to know gas production without a present of coal. Variation of coal types and treatment temperature of 30 ºC and 50 ºC were carried out for 105 days incubated, as shown in Table 2. The incubated chamber was placed on water bath to keep the desired constant temperature. Monitoring and measurement were performed on each sample tested, such as microbial populations with microscope camera, gas volume and gas compositions. The samples of the media liquid were taken by opening the valve at the bottom of the sample chamber (fermentor), and gas sampling was taken at regular intervals by syringe tool to put into the instrument of gas chromatograph for gas composition analysis.

The gas formed was measured by seeing a different of water level in volumetric tube. By using a small hose, this tube is connected to the fermentation chamber and volume of gas can be measured and monitored periodically during the experiment.

III. RESULTS AND DISCUSSION

The experiment shows that all treatments capable to producing gas by different of volume and rates at the temperature of 30ºC and as well as 50ºC. Composition of gas total detected by gas chromatography are consists of methane (CH_4), carbon dioxide (CO_2), Nitrogen (N_2) and other kind of gas. The gas formed as a result of biodegradation of coal in mixture medium of rumen fluid and formation water. Total volume of gas produced indicate increases with incubation time as shown in Figure 1, means that the rumen microbes can utilized the coal to produce gas substrates at temperatures 30ºC and 50ºC according to the temperature applied in this study.

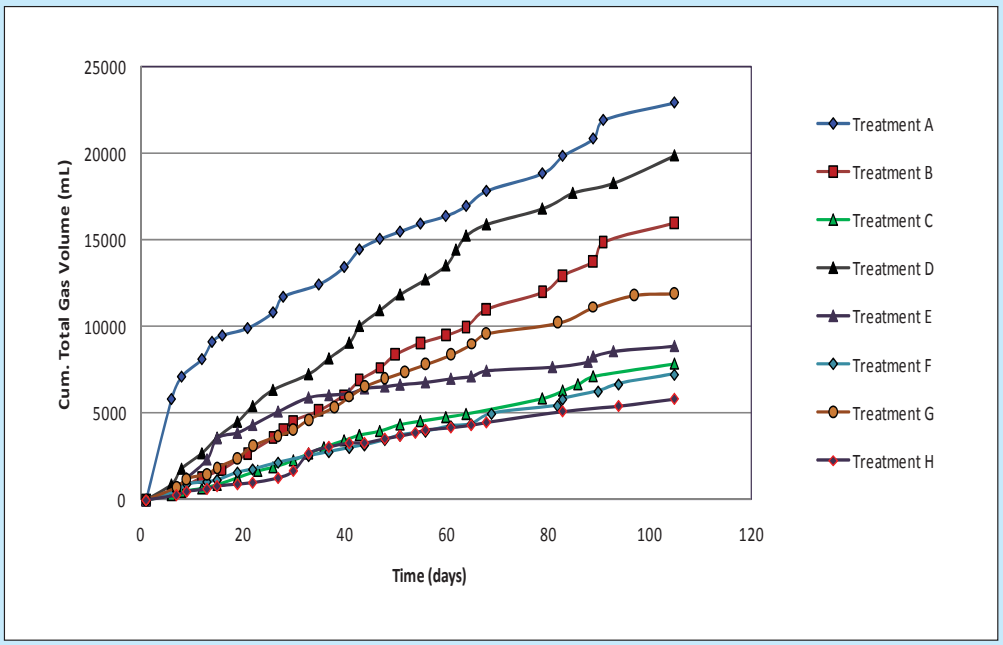

Figure 1
Graphically shows the total gas produced during 105 days incubation of the three types of coal at a temperature of 30°C and 50°C

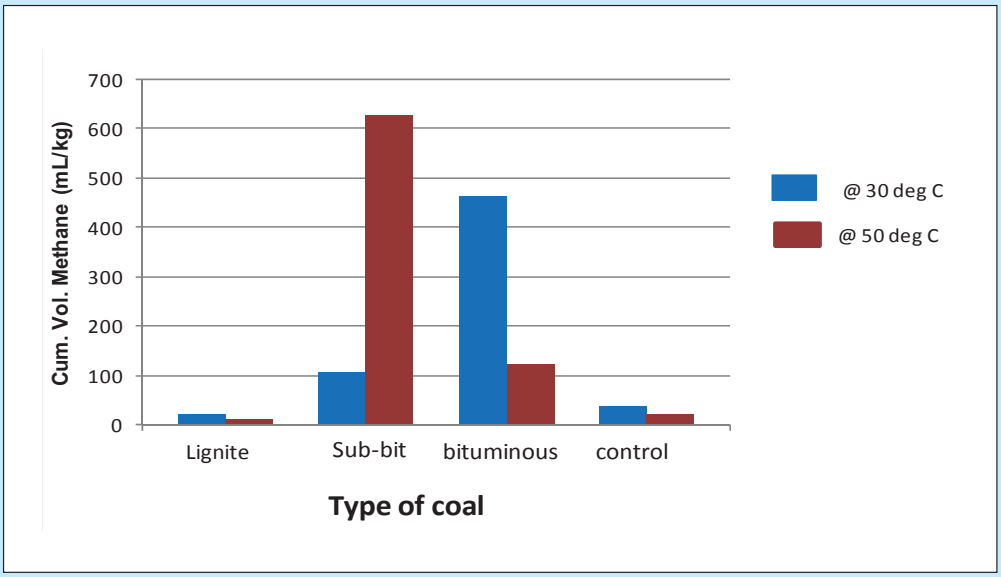

Figure 2
Volume methane produced by the three type of coal at temperature treatment of 30ºC and 50ºC

Figure 1 is a graph of the data plots of average amount total gas produced from two samples (duplo) experiments, which their composition contain of various gas. This graph shows the volume of gas continues to rise with increasing incubation time, which is as a results of degradation coal due to activity of the rumen bacteria. This gas volume was generated by concentration ratio 1:1:1, which is consists mixture of 1 kilogram coal (sized gravel), 1 liter rumen fluid and 1 liter formation water. Results indicate that the highest total gas volume produced by coal type of lignite at a temperature of 30°C. The gas volume is much greater than that produced by medium treatment with absent of coal (control), the differences shows the effectiveness of the performance of the rumen fluid bacteria degrade the coal compared with indigenous or bacteria contained in the medium itself (no present coal). Rumen microbial.

During 105 incubation days on temperature of 30°C (treatment A), the highest amount of total gas volume produced was generated by lignite as much as 22.95 liter/kg of coal (810 cubic feet/ton), this volume was decreased to 8.87 lt/kg (313 cf/ton) while observed at temperature 50°C (treatment E), this was the same experienced by sub-bituminous coal (treatment B & F) which volume gas decreased from 15.99 lt/kg (565 cf/ton) to 7.25 lt/kg (256 cf/ton). It is difference with bituminous coal (treatment C & G), the volume of gas obtain was increased from 7.8 lt/kg to 11.92 lt/kg (421 cf/ton) correspond observed at temperature 30ºC and 50ºC, respectively. Lignite structure has the weak bound than other type of coal, so the rumen and water formation microbe will degrade easily.

With the same incubation times, the highest methane production was obtained from sub-bituminous coal with volume of 0.63 lt/kg (22.14 cf/ton) at temperature 50ºC. This volume is much higher than that obtained at temperatures of 30ºC which was only 0.11 lt/kg (3.8 cf/ton). However, this is not experienced by the two other coal types, which at a temperature of 50ºC the volume of methane is lower than that obtained at temperature 30ºC.

In general, if calculated on percentage, the volume of methane gas obtained at temperatures of 50°C higher than that obtained at 30°C, except for the type of bituminous coal. The methane volume obtained from bituminous coal was decreased from 5.9% to 1% at temperature 30ºC and 50ºC, respectively. The two other coal type of lignite and sub-bituminous, their volume was increased from 0.09% to 0.13% and 0.7% to 8.6%, respectively.

The experiments have shown that the rumen microbes can be interacted with coal and water formation to produce methane at above temperature origin where the microbes ordinary life (survives), and the methane volume may continue to be propagated along with the addition of incubation time as shown by the graph, which (see Figure 2). In other words, methane volume increasing by the time means that the longer the incubation time will be more gas produced.

The activity of microbial metabolism was equal with increasing of environment temperature. The results showed that the temperature of 50^{o}C produced the highest methane, only for subbituminous coal. It could be occurred because the different of coal rank has the different of indigenus microbial and the rumen microbes was made consortium with subbituminous indigenus microbial and water formation. Optimum temperature for microbial of rumen mathanogenic is between 35-40^{o}C (Mc Donald et al. 2001). This research was proved that the microbial of rumen mathanogenic has ability to growth at temperature of 50^{o}C. The research of biostimulation for increasing CBM in Texas showed that the well temperature was more than 90^{o}C, but the methanogenic microbes has ability to produce methane gases (Strapoc et al. 2011).

IV. CONCLUSION

The results showed that all types of coal can be used to produce methane gas by utilizing microbial source of rumen fluid and formation water at temperatures of 30º C and 50ºC.

The highest total gas production was derived from lignite coal with a total volume of 22.95 l/kg (810 cf/ton) at a temperature of 30ºC, but the volume of methane contained is a low which recorded of 0.0206 lt/kg of coal (0.73 cf/ton).

The highest methane gas production was obtained from sub-bituminous coal at a temperature of 50ºC on 105 days incubation time. Total amount of gas generated by this coal type is 7.25 lt/kg (256 cf/ton). This gas volume contain of methane concentration

is 0.63 lt/kg (22.14 cf/ton) or 8.6% of total gas produced. This volume value is highest than two other coal types.

The volume of methane can be continue increased production along with the addition of incubation period, or in other words the longer of incubation time will be more gas volume obtained.

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