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Theme :
The Future of Chemical Engineering for Sustainable Development

1 - 2 November 2016
Surabaya, Indonesia

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Institut Teknologi Sepuluh Nopember

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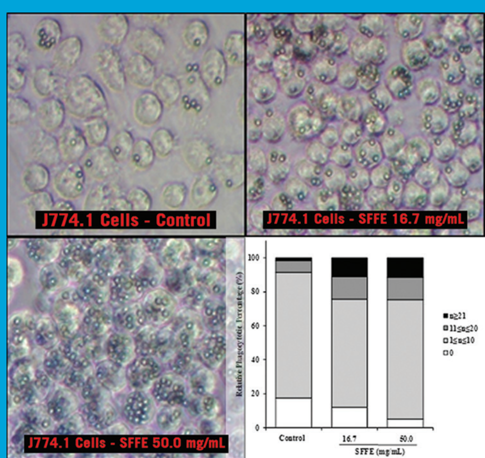
Proceedings of the 3rd International Seminar on Fundamental and Application of Chemical Engineering 2016



East Java, Indonesia
1–2 November 2016

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W. Widiyastuti

Siti Nurkhamidah

Institut Teknologi Sepuluh Nopember
Department of Chemical Engineering
Kampus ITS Sukolilo
Surabaya 60111
East Java
Indonesia

Email: f_taufany@chem-eng.its.ac.id
taufany99@yahoo.com
widi@chem-eng.its.ac.id
dst_eureka@yahoo.co.uk
nurkhamidah@chem-eng.its.ac.id

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Fadlilatul Taufany,* Widiyastuti, and Siti Nurkhamidah
*Editors of ISFAChE 2016
Department of Chemical Engineering, Institut Teknologi Sepuluh Nopember (ITS), Kampus ITS Sukolilo, Surabaya 60111, Indonesia
Address correspondence to f_taufany@chem-eng.its.ac.id

This proceedings volume contains selected articles from the "3rd International Seminar on Fundamental and Application of Chemical Engineering 2016" held in Sheraton Surabaya Hotel & Towers, Indonesia from November 1-2, 2016, that has been peer reviewed. This year marks the third ISFAChE seminar that we have been hosted since 2010, and we are honored to announce that this year we have numerous registered participants from 7 different countries participating in the seminar. The scope of this seminar was quite broad, in which 120 research articles within 10 research topic areas, namely Biochemical Engineering, Catalyst and Reaction Engineering, Waste Water Treatment Technology, Conventional and Renewable Energy, Nano Materials and Nanotechnologies, Modeling and Process System Engineering, Polymer Engineering and Material Processing, Thermodynamics, Separation and Transport Phenomena, and Food Technology, have been extensively discussed.

We must thank all the plenary, keynote, and invited speakers, as well as all the presenters and participants from the researchers, industries, and stakeholders for the excellent sharing knowledge in research experience and scientific information in the field of chemical engineering. There were intense and fruitful discussions after the talks and in the breaks, which created a pleasant and constructive atmosphere. We believe that the seminar has indeed contributed to establish networks for setting guidelines the roles of chemical engineering for progress in the sustainable development.

The incrediblely persistent support from the Department of Chemical Engineering – Institut Teknologi Sepuluh Nopember, in coordination with the Badan Kejuruan Kimia Persatuan Insinyur Indonesia (BKKPII) and the Asosiasi Pendidikan Teknologi dan Kejuruan Indonesia (APTEKINDO), melded with the overwhelming enthusiasm of the seminar speakers, presenters, and participants, as well as all the resolute support of the seminar sponsors, *i.e.* PT. Pertamina, PT. Pupuk Indonesia, PT. Semen Indonesia, PT. Pembangkitan Jawa Bali, PT. IPMOMI, PT. Pertamina Lubricants, PT. Petrokimia Gresik, PT. Pupuk Iskandar Muda, PT. Bank Mandiri, PT. Semen Tonasa, and PT. TJB Power Services, all have brought realization to the production of this proceedings volume.

We would like to thank again the speakers, presenters, participants, and sponsors, who were responsible for the success of the seminar, and look forward to the fourth edition of the ISFAChE seminar.

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Production Of Biomethane From Palm Oil Mill Effluent (POME) With Fed Batch System In Beam-Shaped Digester

Martha Aznury[1,a)], Jaksen M. Amin[1], Abu Hasan[1], Astinesia Himmatuliza[1]

[1]*Department of Chemical Engineering, Politeknik Negeri Sriwijaya, Palembang*
Jl. Srijaya Negara Bukit Besar,Palembang 30139, Indonesia

[a)]Email : martha_aznury@polsri.ac.id

Abstract. Palm oil mill effluent (POME) is the biggest liquid waste which is produced from palm oil production. POME are containing organic matter, high levels of biological oxygen demand (BOD) and chemical oxygen demand (COD) were 28000 mg/L and 48000 mg/L. To reduce the levels of pollution caused by POME, is necessary to do stages of processing using a biological process that involves aerobic and anaerobic bacteria so that it can be utilized as a new product that has economic value, one is biogas. The processing into biogas in anaerobic performed by fed batch system. In the ratio between POME and activated microorganismes are 70:30%. The process of anaerobic fermentation in fed batch is done by time variation of the addition of the substrate. The mixture of POME and activated microorganismes were fermented for a month and then after one month substrates were added gradually as much as 1 liter into the digester with a variety of additional time are 1, 2, and 5 days. The interval of addition of the substrate give effect to the pH and the quantity of biogas produced. The highest increasing of the quantity of biomethane was 25.14 mol% at the time the addition of substrate every fifth day.

1. INTRODUCTION

Palm oil mill effluent (POME) is the biggest waste which is produced from palm oil production. According Zahara (2014), in the palm oil industry, wastewater is produced from the process of sterilization and clarification in large quantities derived from steam and hot water used. Palm oil production requires large amounts of water. One tone of palm oil to produce assumption 3 tones of POME (Aznury, et. al., 2014). POME from palm oil industry generally has a high temperature range of 70-80°C, the color of dark chocolate, which contains dissolved solids such as colloidal and suspended oil residue. POME has a value of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), which tend to be high. According Ibrahim, et al.,(2013), COD from POME 50,000 mg/L POME is discharged directly into the water, it can pollute the environment because it may cause turbidity and will produce a pungent smell that can damage aquatic ecosystems due to the breakdown of the old and tend to consume dissolved oxygen in large quantities. Before the effluent is discharged into the environment must first be given special treatment on the handling of waste that can be processed to conform to the quality standards of waste that has been set by the environmental agency.

POME is a nutrient-rich organic compounds and carbon, the decomposition of organic compounds produced by anaerobic bacteria can produce biogas (Deublein and Steinhauster, 2008). If the gases are not maintained and allowed to escape into the air, it can be one of the causes of global warming due to methane and carbon dioxide released is including greenhouse gases is touted as a source of global warming today. Emissions of methane is 21 times more harmful than CO_2 and methane is one of the largest contributors to greenhouse gases (Sumirat and Solehudin, 2009).

Palm oil industry was using open pond for sedimentation and fermentation for reducing of organic materials in POME. The ponds were only a temporary shelter before finally disposed in bank of the river. Although only a temporary shelter is processing naturally remains the case, but the process is not optimal. To reduce the levels of pollution caused by POME, that it is necessary to stages of processing using a biological process that involves aerobic and anaerobic bacteria so that it can be utilized as a new product that has economic value. POME generated from the three-stage process, namely sedimentation, fermentation, and collection stages.

Anaerobic process is a process of breakdown of organic materials by the activity of methanogenic bacteria and bacterial asidogenic. The bacteria are usually found on organic waste such as animal manure and organic waste. POME waste that has been mixed with activator and then fermented for approximately 1 to 2 months on biogas production.

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Research conducted by Saputri (2015) by using a batch fermentation shows the percentage volume of each variation starter produce biogas quantity varies in every condition, so it can be concluded that giving the number of starter greatly affect the percentage of the quantity of biogas itself. The greater number of starter, the more gas is produced.

Based on this, the authors conducted a study of POME treatment process by fed batch fermentation. Fermentation system is fed batch fermentation by means of new media to add regularly on a closed culture, without removing the existing culture fluid in the fermenter so that increase of culture volume (Widjaja, et. al., 2010). In fed batch fermentation the addition of medium that are expected to generate a higher yield than a batch system.

Research objectives in the purpose of this study include: Analyzing the effect of the turn of the feed to the quantity of biogas generated in the fed batch. To analyze the effect of fermentation time on biogas formation in fed batch system.

2. METHODOLOGY/ EXPERIMENTAL

2.1 Materials

Raw materials is palm oil mill effluent (POME) from PT. Mitra Ogan. Tbk, whereas for activator microorganism from cow manure obtained from slaughter houses in Gandus area, as well as the chemicals used are available in the laboratory of Chemical Engineering Department of the Polytechnic of Sriwijaya.

2.2 Biogas Formation Process

The main research was done by mixing between POME and active microbial. Material was added to the digester for 1 month. After 1 month, feed POME in the effect of time were 1 day, 2 days, and 5 days. Then, accommodate the gas produced in the gas sampling bags for further analyzes biogas, as shown in Figure.1

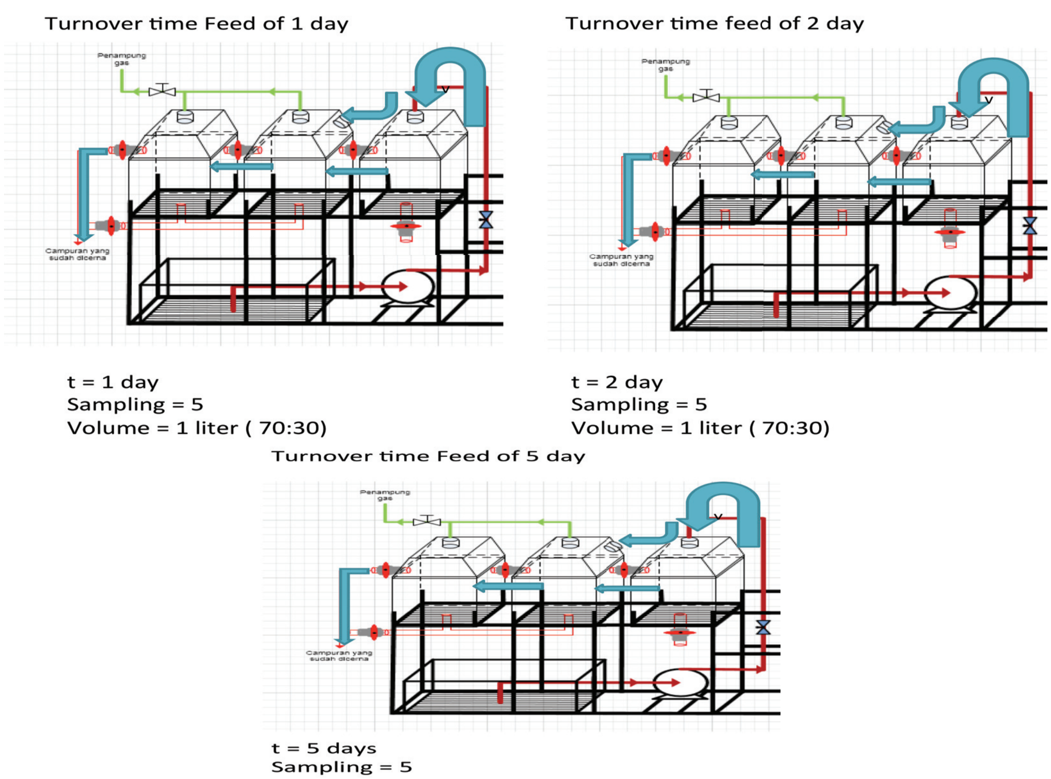

Figure.1. Processing of POME on Biogas Production

2.3 Analytical Analysis

All the tests for the samples were analyzed according to the guidelines of the American Public Health Association (APHA, 1995) for the examination of POME and POME after fermentation. Biogas yield was measured with a wet gas meter (W-NK-O.SA, Shinagawa). Gas samples were obtained through an inverted funnel placed above baffles near the top of the reactor. Biogas composition was determined using a gas chromatograph (GC-8A, Shimadzu, Kyoto)

3. RESULTS

3.1 The Effect of Time on Each Day of Feed POME on CH_4 Production

Study of POME to production of CH_4 was metabolite process by anaerobic microorganisms. Figure 2 shown the effect of time on each day of feed POME on methane (CH_4) production.

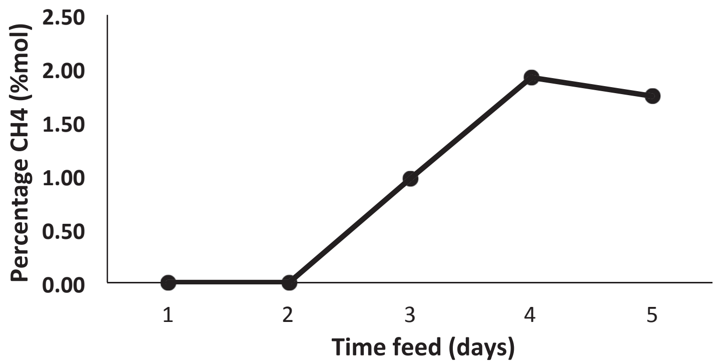

Figure 2. The Effect of Time on Each Day of Feed POME on CH_4 Production.

Figure 2 shown it could be observed the effect of the time change of the percentage of the resulting feed. The percentage of methane gas continued to increase during the 30 days of fermentation. According Mujdalipah, dkk., (2014), fermentation time gives a real difference to gas production, which directly affect the fermentation production of biogas. Effect of fermentation on biogas production was due to the content of POME which contains a lot of protein and fat and takes several days to undergo hydrolysis stage. At this stage ecoenzym hydrolysis and anaerobic bacteria require several days to decipher carbohydrates, proteins and fats into monomers such as amino acids and glucose.

POME was in a batch fermented for 30 days. Then for the next day, the turn of the substrate into the digester is done regularly every day for a feedbatch fermentation. The percentage of methane gas formed decline may be caused by imbalances in the anaerobic process. The imbalance caused by excessive hydraulic load. This condition occured when the residence time in anaerobic to shorter change than the growth rate of bacteria. In this condition occurs excessive accumulation of organic material that causes bacteria can not break down organic compounds, so that the reform process will be disrupted anaerobic feeding of microorganisms in every day into the digester provides less than optimal results in the production of biogas.

Microorganisms were that require time to adjust to the environment with high fat concentration. The imbalance is also caused by toxic materials that already exist in the biomass or compounds produced during anaerobic fermentation process. Fermentation can be slow if the biomass contains high concentrations of fat because fat can be degraded into toxic compounds, namely long-chain fatty acids (Mahajoeno, 2008). The value of pH was 7 went to decreased to 6. The high concentration of acetate may inhibit overhaul (Mahajoeno 2008). At the time of the initial fermentation, acid-forming bacteria produce acids quickly so can cause rapid pH decline anyway. The acid formation will produce acetic acid, H_2, and volatil fatty acid (VFAs), such as butyric acid and propionic acid. When the pH value is low, then the microorganisms will be in a state in-active so that it can affect the rate of formation of biogas, particularly the methanogenic bacteria.

3.2 The Effect of Time on Two Days of Feed POME on CH_4 Production

The percentage of methane generated during the one-day change of bait still little therefore be varied when the turn feeds into two days to determine the effect the time change feed ratio and the percentage of methane produced. Effect of time for POME feed on the percentage of methane (CH_4) is shown in Figure 3.

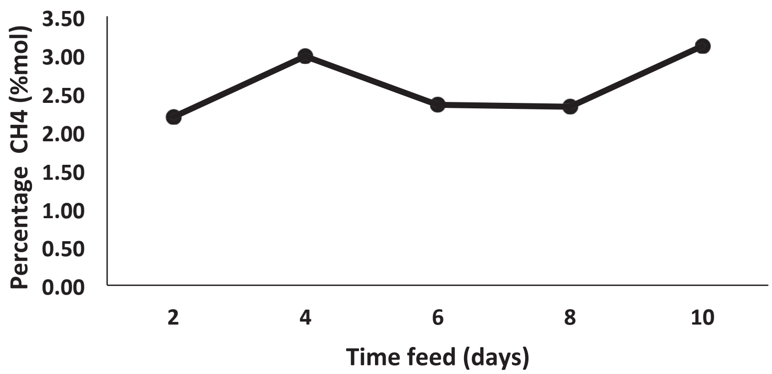

Figure 3. Effect of Time for POME Feed Every Two Days on CH_4 Production.

Figure 3 shown the percentage of methane (CH_4) produced during the two days of feeding. Gas methane formed ranges between 0-1% in feed every two days, while in turn feeds two days increased to 2-3%. It can be observed from the chart above the levels of the element N_2 and O_2 in the product produced is very high. According to Sumirat and Solehudin (2009) many of its elements N_2 and O_2 can influence the process of the formation of compounds of methane in the biogas as an anaerobic bacteria decomposition so that if there is oxygen in the fermentation process, it will cause bacteria decomposition could not work properly thus inhibiting the process of formation of methane. The conditions were within the digester also be taken to ensure there was no contamination of the air entering during an anaerobic process. Anaerobic bacteria can work well to break down organic material into methane.

There was a decrease drastic pH is from 8 to 6. Decrease pH value indicates an interruption of feed of materials in the fermentation process into the digester too much, so the production of acid will be plentiful. This condition causes the microbes are not able to degrade too much acid into methane. A decrease in pH was indicate of the acidification process. According to Aznury et al. (2014), acidification in POME shown hydrolisis to acidic process into volatile fatty acids (VFAs) like as propionate and butyrate. At this stage of methanogenesis, methane forming bacteria will consume VFAs so that alkalinity increases that result in the increase in the pH to achieve a stable pH (Gerardi, 2003).

3.3.The Effect of Time on Five Days of Feed POME on CH_4 Production

The percentage of methane generated during the one-day and two-day addition of the substrate is still little therefore varied of time to 5 days to determine on methane (CH_4) production is shown in Figure 4.

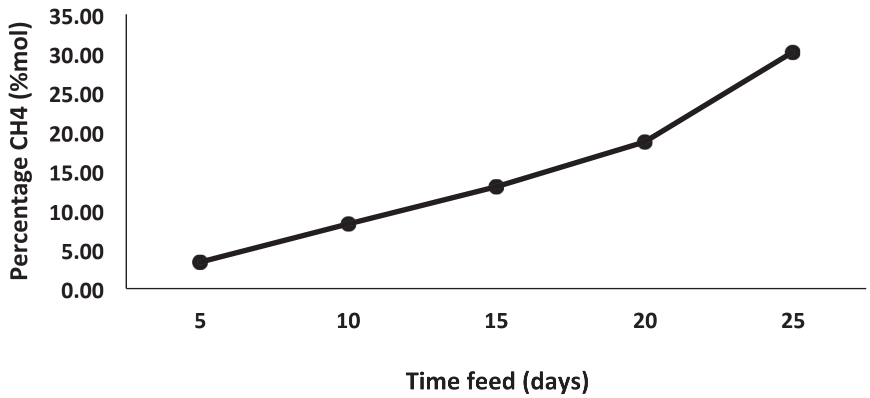

Figure 4. The Effect of Time on Five Days of Feed POME on CH_4 Production

In Figure 4 shown be observed that in five days of POME feed in increased amounts of methane as much as 3-25%, while the levels of oxygen and liquid nitrogen decreased in POME. POME have contains a number of components of high fat and thus take time to hydrolisis of activator that are difficult degraded, such as cellulose and lignin, it takes a long time to be hydrolyzed in the first phase.

If both are used as inputs it takes to stay longer so that these materials can be hydrolyzed. According to research conducted Hasanah (2011), the amount of fat in 39.43 ppm and hydrolysis of the protein and fat needed a few days to POME not been recast effective for methane formation stage has not yet happened. Methane production need to undergo several stages of the hydrolysis, acetogenesis, asedogenesis, and methanogenesis. From the graph it can be concluded that the quantity of biogas produced is influenced by the fermentation time and environmental conditions around the digester. The longer the fermentation time, the more the production of biogas produced. Fermentation time is directly related to the amount of time it takes to pass through the stages of formation of methane is hydrolysis, asetogenesis, asedogenesis, and methanogenesis.

Conditions within the digester also be taken to ensure there was no contamination of the air entering during an anaerobic process. Anaerobic bacteria can work well to break down organic material into methane. The pH value of the five-day addition of the substrate is at a score of 7. The pH value is good in producing biogas between 7. A pH below 6.5 the activity of methanogenic bacteria will decrease and a pH of less than 5, the fermentation activity will stop (Yani and Darwis, 1990)

4. DISCUSSION

POME that has undergone a process of sedimentation in adding with activator microorganisms and passed on to the next II tank fermented for one month and then once a month flowed into the tank III for fed batch process systems. The percentage of gas produced by batch and fed batch system is presented in Figure 5.

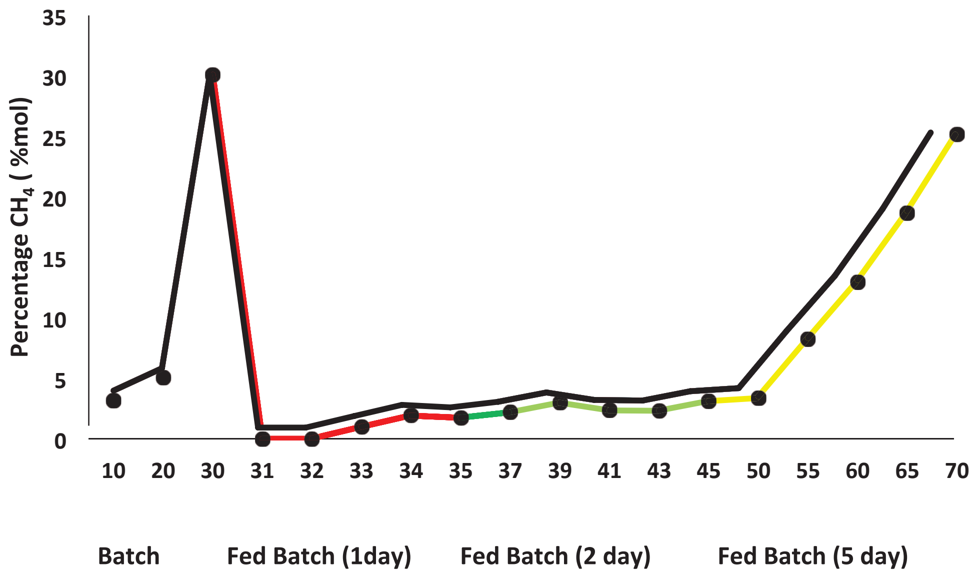

Figure 5. Percentage CH_4 by batch and fed batch fermentation

Time	fermentation
0 -30 days ;	batch
31-34 days;	feed batch (1 day)
35-44 days;	feed batch (2 day for run)
45-70 days;	feed batch (5 day for run)

In Figure 5 shown it can be observed biogas production for one month fermentation increased. In the first 10 days the amount of methane produced is still small, as well as 20 days of fermentation the amount of gas produced is still small. But at 30 days of fermentation the amount of gas produced more. The methane gas generated increased from day to day. In the first 10 days of methane produced is still in small quantities ie 3.1372% mol while on the second day of methane produced is still in small quantities ie 5.0478 mol%. The anaerobic bacteria require a long time to break down organic matter derived from POME. POME has a high fat content so it takes a long time to hydrolyze while activator contains a number of components that are difficult degraded, such as cellulose and lignin, it takes a long time to be hydrolyzed in the first phase.

POME and activator as inputs require a longer residence time so that these materials can be hydrolyzed . At this stage ecoenzym hydrolysis and anaerobic bacteria require several days to decipher carbohydrates, proteins, and fats into monomers such as amino acids and glucose. So the longer the fermentation time, the time it takes the bacteria for longer mendegredasi organic substances and thus affect the production of biogas (Wulansari, 2015). Research conducted by Saputri (2015) using the batch system to produce biogas with a small quantity because the relatively short fermentation time is 4 days. At this time only reached the stage in which the hydrolysis of organic materials such as carbohydrates fats and proteins will be overhauled by bacteria into amino acid and acetic acid. Comparison between batch and fedbatch system is presented in Table 1.

Table 1. Comparison of Batch and Fed Batch System

System	Volume Starter: POME (%)	Fermentation time (day)	CH_4 (%mol)	Reference
Batch	30 : 70	4	7.3546	Saputri, 2015
Fed Batch	30 : 70	40	30.0951	This research, 2016

After 1 month of batch fermentation, methane levels rose, but after the turn of the feed quantity of methane is lowered. Methane forming bacteria re-adjusted to the environment when the addition of the substrate for the bait as a food source to regenerate (turnover). Substitution every single day did not have a significant influence on the percentage of methane produced. Cellulolytic bacteria or hydrolytic will only work remodel polymer complex at the stage of hydrolysis. Substitution every five days were able to increase the quantity of biogas produced. In contrast to the turn of the substrate every day, changing every 5 days will give you a longer time in the stage methane production. Phase of acidogenesis an advanced stage of hydrolysis stage. Pyruvic and butyric acid is the result of an overhaul of volatile fatty acids (VFAs). Propionic acid is oxidised by bacteria *Syntrophobacter wolinii* into products used by methanogenic bacteria in the formation of methane gas (Weismann, 1991).

5.CONCLUSION

From the research that has been the execution of POME into biogas with fed batch system, it can be concluded:

1. Of the three variations of the replacement feed time were 1, 2 and 5 days showed that the replacement time feedback effect on the percentage of methane produced. It can be observed in Percent of methane produced where the amount generated is directly proportional to the length of time the turn feeds.
2. The percentage of methane obtained were 0, 0.9729, 1.9160, 1.7433 mole% CH_4, approximately for the replacement of the feed every time one day. Feeding of POME for every 2 days were 2.1853, 2.9824, 2.3501, 2.3208, 3.1130 mole% CH_4, approximately. Effect of feeding POME for 5 day inside of bioreactor were 3.3651, 8.2054, 12.9596, 18.6627, and 25.1453 mole% CH_4, approximately.

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