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International Conference on Science, Infrasrtucture Technology and Regional Development (ICoSITeR) 2017
Lampung, 25-26 August 2017

“Energy Security for Enhancing National Competitiveness”

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WELCOME SPEECH FROM CONVENER OF ICOSITER 2017

Dear ladies and gentlemen,

Tabik Pun,

On behalf of organizing committee of ICoSITeR 2017, I am pleased to welcome you to the 2nd International Conference on Regional Science, Infrastructure Technology and Regional Development hosted by Institut Teknologi Sumatera. This valuable international conference will be held on 25 to 27 August 2017 which will closed by a field trip program.

This Conference is an event series of Dies Natalis of ITERA. The Conference is presenting five invited speakers for two days. They are 1) Arcandra Tahar, Ph.D., our Vice Minister of Energy and Mineral Resources who represented to Prahoro Yulijanto Nurtjahyo, Ph.D.; 2) Prof. Doyoung Byun from Sungkyunkwan University, South Korea; 3) Prof. Fujii, from Gunma University, Japan; 4) Prof. Toto Winata from Institut Teknologi Bandung, and 5) Dr. Rahayu Sulistyorini, from Institut Teknologi Sumatera.

This year, ICoSITeR 2017 has a big theme: "**Energy Security for Enhancing National Competitiveness**". Growing interest in industrial era, energy security has been becoming the most-spoken discussion topic both in Indonesia and other countries around the world. In Indonesia, the energy crisis caused insecurity to reliability of fuel supply in meeting the needs.

Through this conference, we would like to engage all stakeholders consist of academia, business sectors, government and community in an open and scientific discussion about the problems and potentials of our future energy so that our national competitiveness can be enhanced in the future.

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The first day of ICoSITeR starts with an opening ceremony followed by a plenary session presenting two invited speakers Prahoro Yulijanto Nurtjahyo, Ph.D from Ministry of Energy and Mineral Resources and Prof. Fujii, from Gunma University, Japan. After the plenary session, the discussion will be divided into several parallel classes which has a various open and constructive dialogues and presentations from our valuable presenters. We also have a Gala Dinner presenting special performances.

The second day of ICoSITeR, starts with a plenary session presenting Prof. Doyoung Byun from Sungkyunkwan University, South Korea. For the next session, we have parallel session which is divided into four parallel classes as in Conference day-1. As the parallel session finished, the Conference presents Prof. Toto Winata from Institut Teknologi Bandung, and Dr. Rahayu Sulistyorini from Institut Teknologi Sumatera in the last plenary session.

The interest of ICoSITeR is clear. The Conference has attracted 142 participants. We will hear 87 oral presentations. The subjects range from 1) New trends and technology for energy security, 2) Policies and strategies for energy security, 3) Energy conversion studies, 4) Decision support system for energy security, 5) Artificial intelligence and machine learning studies for energy security 6) Computational methods for energy security, 7) Energy savings for urban livelihood, 8) Public awareness and education for energy security, 9) Renewable energy systems in smart cities, 10) Future challenges of energy security. For publication purposes, we offer to our presenter to submit their paper to IOP Proceeding, indexed by Scopus. As the closing of the Conference series, we also offer a field trip program that will trip to Pahawang Island on 27 August 2017.

Finally, I would like to deliver my appreciation for all parties for having a good cooperation, strong effort and coordination for making successfully ICoSITeR 2017. My special thanks to our rector, Prof. Ofyar Z. Tamin who fully supports ICoSITeR 2017, also Prof. Mitra Djamal and Prof. Sukrasno, I thank you for your supports. I should express my gratitude to all sponsors who support the success of ICoSITeR 2017.

Concluding, I wish you in the name of ICoSITeR 2017 an enjoyable and enlightening conference.

Thank you!

Convener of ICoSITeR 2017

Prof. Leo H. Wiryanto

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Preface

Papers

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The digester modification for biogas production from palm oil mill effluent by Fed-batch

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Abstract. The purpose of this research is to biogas production in the digester modification equipment by Fed-batch of the palm oil mill effluent (POME) to determine the quality of POME after a treatment and the concentration of biogas that is formed every 24 hours within 10 days. The raw materials used are POME from PT Mitra Ogan, Tbk. In the initial stage is sedimentation process in the first digester tank at a flow rate 6 liters/minute and then observing the retention time of 24 hours. POME flowed into the second digester tank for fermentation process with the addition of active microbes seed every 24 hours to produce biogas. After the fermentation process is complete, POME flowed to third digester tank for water treatment stage before being released into the environment. COD content test values obtained after processing are 766, 362 and 350 mg/L, approximately. While the BOD value is 212.75; 125 and 110.9 mg/L, approximately. Biogas production for 10 days fermentation are 10.88% methane, 19.2% oxygen and 75.83% nitrogen, approximately.

Keywords: Digester Modification, POME, Biogas, Fed-Batch

1. Introduction

According to data from the Statistics Book of Palm Oil Commodities published by Directorate General of Plantation (2015) [1], oil palm plantation spread in 32 provinces in Indonesia. Riau Province in the year 2014 with an area of 2.3 million ha and crude palm oil (CPO) production reached 7 million tons is the province that has the largest oil palm plantations and South Sumatra in the 4th largest with an area of 1.11 million ha and production reached 2,85 million tons [1].

CPO production in the palm oil industry produces solid waste and liquid waste. Solid waste consists of empty fruit bunches of palm oil and its waste that has not been utilized properly, as well as shells and fibers that have largely been used as a source of energy by burning it directly. Based on the analysis, 100% production of fresh fruit bunches (FFB) in the palm oil industry will produce 21.5% empty fruit bunches, 22.5% crude palm oil (CPO), and 56% of liquid waste. Liquid waste or palm oil mill effluent (POME) production in Indonesia is estimated around 63 million ton/year [2]. To be able to control the consequences caused by the liquid waste of the palm oil industry, it is necessary to do the processing stages using a biological process involving aerobic bacteria and anaerobes that can be utilized into new products such as biogas that have economic value.

Methane (CH_4) gas is a gas that can cause greenhouse effect causing global warming phenomenon because methane gas has an impact 21 times higher than carbon dioxide (CO_2) gas. Continued reduction of methane gas can play a positive role in addressing global (greenhouse effect) problems that result in global climate change. Wastewater treatment of the palm oil industry is generally done by an open pond system, which consists of several treatment ponds. However, technically these pools are not maintained properly and increasing of methane in the atsmosphere.

For biogas production, POME generated from the three-stage process, namely sedimentation, fermentation, and collection stages. Our research were build of three stages in two shaped such as beam and truncated-pyramid-shaped. According to a final report written by Sari [3], the efficiency comparison between the beam sedimentation tank design and the tank sedimentation tank design for the 6 L/min flow rate is very different. In the design of the beam, the efficiency of the sedimentation process reached 13.9%. While truncated pyramid-shaped efficiency higher reaches 15.6%. So the design of the truncated pyramid-shaped tool has proven that the settling process is faster compared to the beam design tool, so as to minimize the failure in wastewater treatment.

Fermentation system in treatment batch and fed-the batch system. The batch system is fermented by incorporating media and inoculum simultaneously into the bioreactor and the product taking is done at the end of fermentation. Fed-the batch system has been widely applied in various fermentation industries and is relatively easier to use for batch process improvement compared to the batch system.

According to a final report written by Fahlevi [4], the results of the study on a beam and truncated pyramid shape for fermentation tank obtained percent mole of CH_4 for a starter volume of 30% within 4 days. A beam and truncated pyramid-shape had 7.3564% and 6,439%. So the design of the beam-shaped tool has been proven that the fermentation process is better than the design with truncated pyramid-shaped.

Based on this, the authors conducted a study on the process of wastewater treatment of POME by modifying the tool digester with truncated pyramid-shaped for sedimentation and beam-shaped for fermentation. So it is expected with truncated pyramid-shaped sedimentation tank has a faster deposition process while by using the tank fermentation beam-shaped. This design tool is one way more effective and efficient in terms of place, time, and processing costs.

2. Methodology

2.1. Raw material and digester

The raw material in the form of palm oil industry wastewater or Palm Oil Mill Effluent (POME) is done waste treatment by modification of digester through sedimentation and fermentation process. In the design of digester, tools consist of several tools that are important components to support the POME for wastewater treatment. The digester serves to replace an anaerobic pool in conventional systems assisted such as the open pond. The modified digester has truncated pyramid and beam-shape, and there are supporting components such as the centrifugal pump, flowmeter, Tedlar bag, swan neck and vacuum pump. The following is a drawing of the design of the digester tool shown in Figure 1.

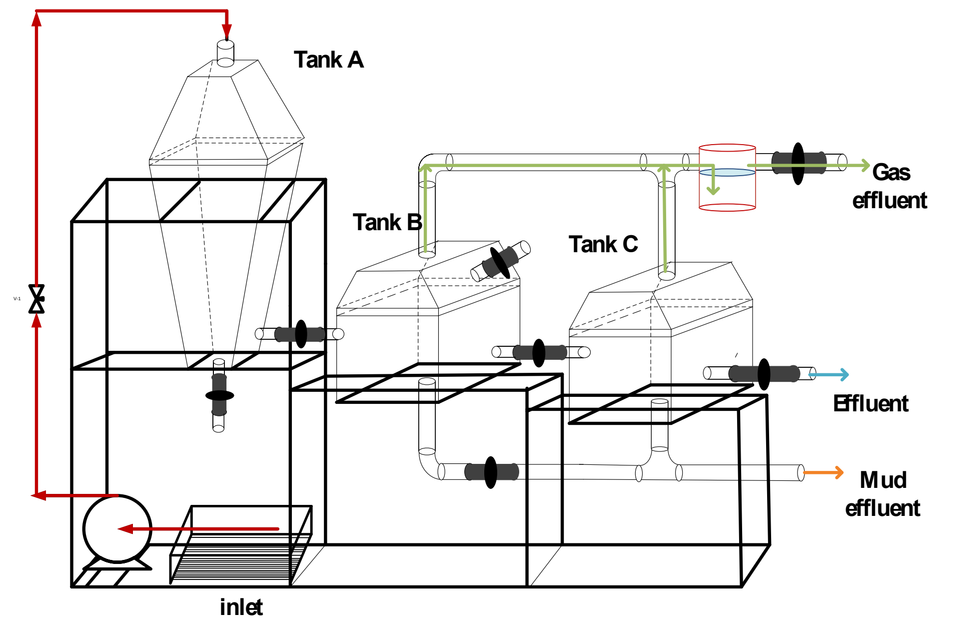

Figure 1. Design of a truncated pyramid-beam Digester

The truncated pyramid digester (tank A) is a container for the initial process of POME. A tank serves as a site for the sedimentation process of the feed. Feed in the form POME which still contains many solid particles or dirt. POME flows from the feed to the tank A. The feed in tank A is carried out by the precipitate to separate the solid particles from the feeder. The collected deposit is separated into a pipeline at the bottom of tank A. This is done so that the dirt/solid particles do not enter in the next tank which can disrupt the fermentation process.

The fermentation process in the digester occurs in the beam shape (tank B). Tank B is a place of degradation of POME by anaerobic fermentation. POME and activity microorganisms (cow manure and POME with 70:30 by fermented at 1 month) in anaerobic processes have the ability to produce biogas. POME rich in organic compounds and carbon, decomposition of organic compounds can produce biogas. After fermented process effluent from tank B is brought to the tank C.

The second beam tank (tank C) as a feeding container for the final processing process of POME. Tank C also serves as a second fermentation process. The bait still has the bacteria that are entangled from the tank B stream and utilized for the fermentation process to re-form methane gas before it is finally discharged into the environment. The precipitates accumulated in the fermentation process are separated through the pipelines at the base of the B and C. The anaerobic conditions can produce residual nutrient-rich wastes such as nitrogen and phosphorus. And the residual liquid waste in the form of fermentation tank can be used for fertilization.

Sedimentation tank supported with one centrifugal pump. The centrifugal pump serves to drain the feed from the feeding point to the A flowmeter tank to adjust the feed flow rate to be flown from the feeding to the tank A. Tedlar bag serves as a gas catcher from the fermentation process and temporary gas reservoir before the methane gas test. The vacuum pump serves to pull the gas from the tank B and the C tank into the Tedlar bag.

2.2. Analytical analysis

The raw material in the form of POME and fermented POME were analyzed by guidelines of the American Public Health Association [5]. Determined of biogas were using a gas chromatograph (GC-8A, Shimadzu).

3. Result and Discussion

3.1. Modified Digester on Truncated pyramid Tank For Sedimentation Process

The sedimentation process for separating water and sludge from the POME in a modified digester in truncated pyramid tank can be determined based on the residence time and flow rate by looking at the results of research conducted by Sari (2015) [3] with using a flow rate of 6 L/m which can achieve the sedimentation efficiency of 15.6% with the observed deposition period that is at 1, 3, 6, 12, and 24 hours with the same feed volume amount 18 liters.

In this research, it is aimed to optimally process of POME by creating a tool that represents the modeling system in waste treatment ponds in the palm oil industry, so it is expected to provide more benefits in treating waste. This research applies the principle of processing done by sedimentation and fermentation process, in the hope that the absence of result from waste treatment is thrown away.

The process that occurs in POME wastewater treatment by using this digester modification is the process of separation between water and sludge with sedimentation (deposition) step by gravity. Where, with the residence time and using a certain flow rate, the raw material in the form of wastewater of palm oil industry will be separated into two layers, the bottom layer is sludge, while the top layer is the wastewater itself. The mud produced will not be thrown away, because the mud from the wastewater treatment can be applied to liquid organic fertilizer.

The sedimentation tool used is a modeling system in waste treatment ponds in the palm oil industry, but different from the model of waste treatment pond commonly used in the form of the beam. The tool used has a truncated pyramid-shaped design based on the results of Sari research (2015) [3], where the sedimentation efficiency obtained from the pyramid design is 15.6% will be separated into two layers of water and mud at the feed rate of 6 L/m. The relationship between the residence time to the volume of water and mud can be seen in Figure 2.

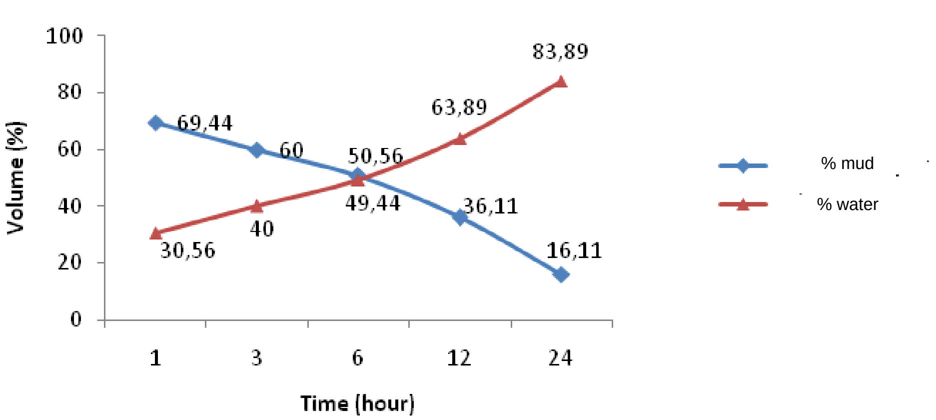

Figure 2. Percentage volume of water and mud at 6 Liter/minute flow rate

Figure 2 showed the percentage of volume water and muddy on truncated pyramid-shaped of the digester (tank A). Percentage mud was 69.44% and 16.11% mud at 1 and 24 hours, approximately. This is because the sedimentation process that occurs in the digester takes place well during the residence time, where the longer the residence time the mud will settle completely and solidify on the base of the digester, causing more water to separate from the mud. According to Fahlevi [4], residence time is directly proportional to the flow rate, so the faster the flow rate it will be faster the time of stay. The longer the residence time, then the volume of water from the truncated pyramid-shaped digester will be constant because the mud has settled completely.

3.2. Analysis Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)

Chemical Oxygen Demand (COD) is used as a measure of the quantity of organic matter in industrial wastewater and has the potential to produce biogas [6]. In the anaerobic renovation process, the decomposed COD is present in the organic material and a final product called methane and new bacterial mass is formed. The measurement of the final COD value in the palm oil industry wastewater after the sedimentation and fermentation process in the digester modification can be seen in Figure 3.

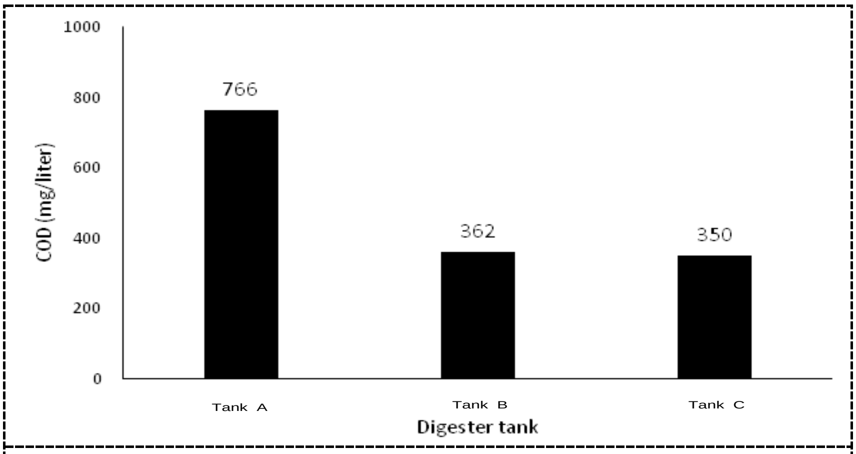

Figure 3. Concentration of COD of POME in Digester Modification

Figure 3 showed the COD values that on the mixture of palm oil and cow dung after the sedimentation process in tank A has decreased the COD value before processing 26352 mg/liter and after processing to 766 mg/liter. The COD value in the fermentation process decreased to 362 mg/liter in the B tank and the final COD value of treatment in the C tank became 350 mg/liter. This indicates that POME waste contains high pollutant load and can be decreased by using anaerobic sedimentation and fermentation processing. The content of organic substances in POME wastes has been degraded by active microbes from cow dung so that the organic material has been shrunk and its COD value has decreased and in the final processing result the COD value has been in accordance with the waste quality standard to be discharged to the environment or the water receiving body. The final result of the processing can also be used as fertilizer in the area of oil palm plantation. The concentration of BOD in POME after fermentation process on digester could be seen in Figure 4.

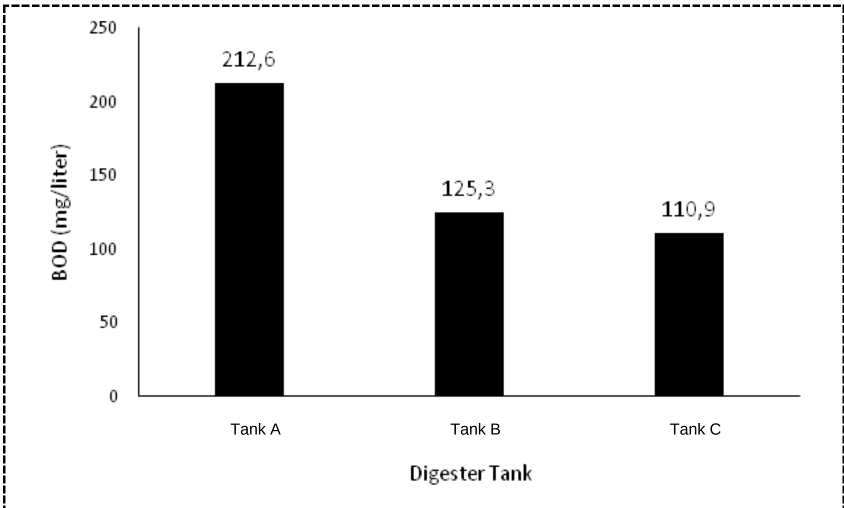

Figure 4. Concentration of BOD of POME in Digester Modification

Figure 4 observed that the decrease in BOD content occurring in POME occurs due to the effect of COD decrease. Where the initial BOD content value before getting the processing on the digester of 1.755 mg/liter. The BOD value after processing has decreased to 110.9 mg/liter in tank C as a result of the final waste treatment product. This is because POME contains a high pollutant load and can go down by using a sedimentation and anaerobic fermentation process. The content of organic substances in POME wastes has been degraded by active microbes that the organic material has been overhauled and the COD and BOD values have declined.

BOD content has decreased, but the BOD content is still high through the standard of waste quality. So waste still needs to be done processing to reduce the BOD content as low as possible based on the regulations made by the Gubernatorial of South Sumatera Number 8 Year 2012 dated February 15, 2012, where the quality standard of waste palm oil industry ready to be released to the receiving river bank or the surrounding environment must have maximum COD 350 mg/liter and BOD maximum 100 mg/liter. The decrease of COD and BOD content occurring after the treatment is due to the fact that some of the organic substances in the waste have been degraded into sludge and some have been degraded into other methane [7].

3.3. Biogas Production Analysis

Wastewater treatment of POME in the modification of digester there are 2 processes consisting of sedimentation and fermentation process. The digester modification on the processing is done by fed-batch system. In the beam-shaped tank (Tank B and C) occurs fermentation stage and addition of substrate. In the fermentation process, the bait decomposed organic compounds by activity microorganisms, the longer the fermentation time the more biogas production increases for 30 days and after that, for 10 days there is a decrease in biogas every day. Therefore, the addition of substrate fed-batch to increase biogas production again. Production of biogas in tank B and tank C is taken using a Tedlar bag to hold gas at the top of the tank beam every 24 hours (1 day) for 10 days.

Biogas is a gas resulting from the final product of digestion or anaerobic degradation of organic materials by anaerobic bacteria in an oxygen-free environment or air [8]. This biogas formation process requires a special installation called a digester, its function is that anaerobic reshuffle can take place well. Therefore, this research treats POME to reduce the harmful chemical compounds. the resulted products from the processing of sludge and biogas (methane) by using digestion modifier. The graph of methane measurement results could be seen in Figure 5.

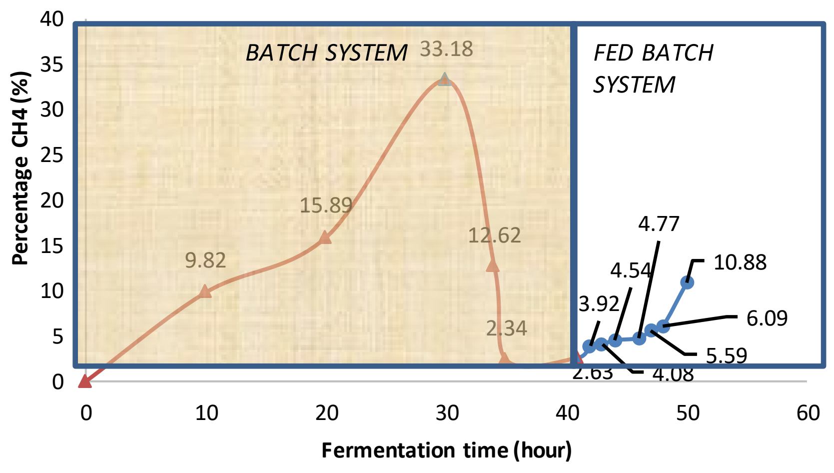

Figure 5. Percentage Methane and fermentation time on fed-batch processing

Figure 5 could be observed the influence of time of fermentation time fed-batch to biogas produced. The fed-batch process there is the addition of new substrate into the tank every day and obtained a single output at the end of incubation for 10 days so that it can be handled in the same way as in batch process. So there is an increase in bacterial growth during fermentation time. On the 1st day it can be seen that the quantity of biogas produced is still low but the longer the fermentation time, the higher the methane gas content in biogas. Fermentation time gives a significant difference to gas production, where fermentation time has a direct effect on biogas production [9].

The content of POME contains high protein and fat and takes several days to experience hydrolysis stage in fermentation to biogas production. At the eco enzymic and anaerobic hydrolysis stage it takes several days to decompose carbohydrates, proteins, and fats into monomers such as amino acids and glucose. Anaerobic bacteria need time to degrade organic substances and certainly can affect the production of biogas.

Fermentation time becomes important in affecting the fermentation process because the process of carbohydrate hydrolysis can be short for several hours. The amount of fat in 39.43 ppm and hydrolysis of protein and fat takes several days until POME does not undergo an effective reshuffle because the methane formation stage has not occurred yet [10]. To form methane needs to experience several stages of hydrolysis, fermentation, acetogenesis, and methanogenesis.

From the graph, it can be concluded that the addition of new substrate in the fed-batch process aims to increase and increase the growth of bacteria so that biogas production that has begun to decline can increase. This is because anaerobic bacteria are added to increase the process of degradation of organic substances and can certainly affect the production of biogas. And the longer the fermentation time the more the content of biogas.

3.4. The Effect of Oxygen Contents on Biogas Production

The concentration of oxygen was high in the digester can disrupt the process of decomposition of organic substances, because organic substances can produce more optimal biogas in oxygen-free [11]. The graph of oxygen and methane gas relations could be seen in Figure 6.

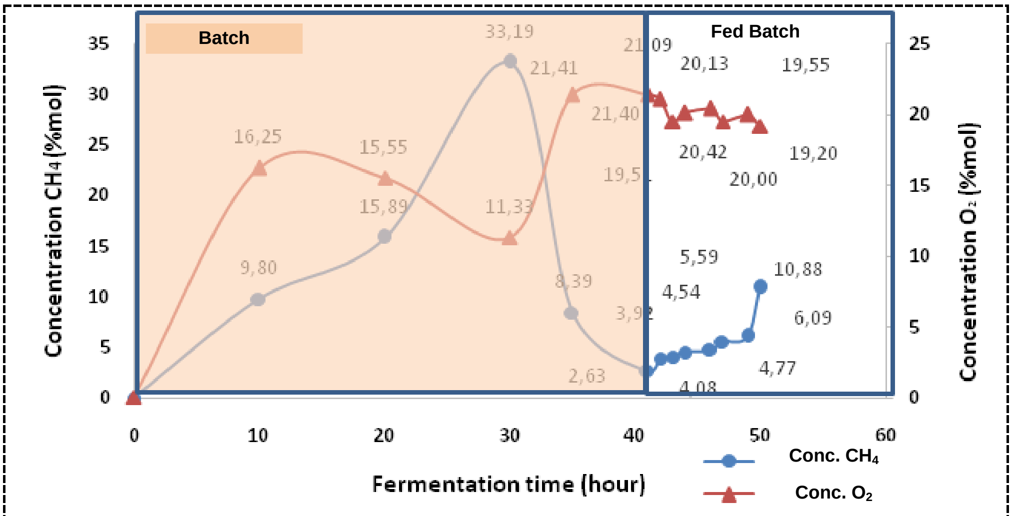

Figure 6. Percentage Methane and oxygen on Fed-batch processing

Figure 6 showed a graph of concentration changes in methane and oxygen gas. That can be observed in biogas production continuously improvement, this is caused by the addition of substrate so that the degradation process is increased to produce biogas. On the contrary, the oxygen content in the digester modification lasts longer then decreases will lead to increased production of biogas. Biogas will form naturally when microorganisms decrease the level of organic matter of POME in the condition of minim oxygen (anaerobic) [12]. From the graph, it can be concluded that increasing the production of biogas associated with oxygen content in the digester. The more oxygen content in the digester decreases, the more the increase in biogas production. Because the process of decomposition or degradation of organic substances carried out by bacteria should be done on conditions of minimal or without oxygen (anaerobic). Biogas is an anaerobic degradation end product gas from organic materials by bacteria in an oxygen-free environment (anaerobic) [8]. The processes that occur in anaerobic treatment are hydrolysis, acidogenic and methanogenesis. Several types of bacteria together gradually degrade organic materials from wastewater [7]. Reaction in the stage of anaerobic is not the influence of oxygen. So the less the oxygen content in the digester the more the increase in biogas production.

3.5. Comparison of biogas production in design of digester

Biogas production is obtained from the fermentation process of POME within the reactor, where the fermentation system used is the fed-batch process. The fed-batch system is a system that adds new media regularly to the closed culture that exists in the reactor so that the volume of culture is increasingly increasing [13]. The fed-batch method of incorporating some sources of nutrients into a bioreactor with a certain volume to be obtained by a product close to the maximum, but the concentration of nutrients source is made constant [11]. Comparison of biogas production results from previous researchers can be seen in Table 1

Table 1. Comparison of Biogas Production Results with Previous Research

Digester shape	% volume starter	System	Fermentation time (day)	% mol CH_4	Reference
Beam	30%	Batch	4	7.356	[14]
Truncated pyramid	30%	Batch	4	6.439	[4]
Beam	30%	Fed-batch	45	25.140	[15]
Modification of Truncated pyramid and beam.	30%	Fed-batch	10	10.882	This research, 2017

From Table 1 compare previous research with this research. Previous research Fahlevi [4] and Saputri [14] produced CH_4 with a maximum of 30% of starter in 4 days fermentation time. The yield of methane was 6.439% mole CH_4 using truncated pyramid digester [4] while according Saputri [14] with beam digester was 7.3564% mole CH_4. So from the data above, the form digester also affect the process of biogas formation. The beam-shaped digester produces more biogas than the truncated pyramid-shaped diets. But the truncated pyramid-shaped digester is more efficient in the sedimentation process than the beam digester.

The biogas production result from Fahlevi [4] and Saputri [14] research is still under biogas production by modification of digester with % mole CH_4 which is 10.8817% mole in fermentation time for 10 days. Production biomethane were increasing in fed-the batch system, was 25.14 mol% at the time the addition of substrate every fifth day for 30 days [15]. The longer the fermentation time the more biogas produced. Biogas production is affected by fermentation time because the time of fermentation is directly related to the amount of time required to pass through the stages of CH_4 formation ie hydrolysis, asedogenogenesis, acetogenesis, and methanogenesis.

4. Conclusion

The modification of digester for biogas production from POME by Fed-batch. The Fed-batch process affects the increase in biogas concentration in the fermentation stage of the digester modification. The determining COD were 26352 mg/L (before treatment) to 766; 362; and 350 mg/L (after treatment). BOD values of water products obtained were 1755 mg/L (before treatment) to 212.7; 125.3 and 110.9 mg/L (after treatment). The results of research in determining the concentration of biogas formed the CH_4 value of the biogas concentration obtained was 2.63% (day 1) to 10.88% (day 10). The value of O_2 from the biogas concentration obtained were: 21.4% (day 1) to 19.2% (day 10). The value of N_2 from biogas concentration obtained is: 78,85% (day 1) to 75,83% (day 10). The less oxygen content (anaerobes) in the modification of the digester the more the increase in biogas production. Future investigations need to focus on scale-up fermentation and feeding strategies with appropriate concentration of POME

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