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The Effect of Grinding on Biogas Production from Rice Husk Waste During Solid State Anaerobic Digestion (SS-AD)

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Abstract. Biogas technology solves the problem of energy crisis. Biogas is a renewable and environment friendly fuel (Franthena, 2015). This study aims to determine the optimum value of grinding size variations in biogas production with the solid state anaerobic digestion (SS-AD) method of biogas production from rice husk waste. We divide the method used into four stages, namely, the testing phase of total rice content, solids, preparation phase, operation phase, and results analysis. The rice husk waste used for this study came from the Rowosari area. We accept rice for preliminary treatment with chemical pretreatment (NaOH). We soaked rice husk with a concentration of 6% NaOH for 24 hours as a control variable. Milling variations used as physical pretreatment are 10 mesh, 18 mesh, 35 mesh, 60 mesh. We used bioreactors with a volume of 200 ml. We observed all biogas reactors produced every two days for ± 60 days of research. The results showed that the reactors with 10 mesh, 18 mesh, 35 mesh, 60 mesh milling variations obtained a total biogas yield of 11.688484; 9,479955; 12.50772; 19,03718 ml / grTS until the 60th day. The control reactor (without grinding variations) produced 9,084606 ml / grTS. The highest biogas production level is 60 mesh with a value, (A) 19.03718 (ml / grTS); the rate of biogas production (U) 0.2416979 (ml / gr TS.day); and the minimum time for biogas formation (λ) is 3.83908 days.

1 Introduction

The population continues to increase, resulting in increased energy consumption, while the source of energy produced is limited, thus requiring efforts to obtain renewable energy. The energy crisis like fuel is one of the global issues that occur. It does not balance RFO (Refined Fuel Oil) and production with population consumption. Petroleum as a raw material for producing RFO is limited [1]. According to [2], in aggregate, fuel sales data for

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2016 amounted to 66,939,112 Kiloliters, down 0.84% from the previous year which was 67,509,826 Kiloliters. Biogas technology is an alternative solution to the problem of the energy crisis. Biogas is a flammable gas with CH4 as the major component resulting from the decomposition process of organic materials by microorganisms under anaerobic conditions. Biogas is a renewable and environment friendly fuel, making it suitable for use as one solution to energy scarcity that is happening right now [3].

One of the factors that can influence biogas is physics. Therefore, it is necessary to conduct research related to the effect of physical size. The variation in the enumeration's size used, was chosen based on previous research by [4], which states that the most optimal size of rice straw counting is 35 mesh (0.5 mm). The additional size variations approaching the size of the enumeration pass 35 mesh is chosen to find out whether there is an optimal value of the other sizes above or below 35 mesh. In this study variations in enumeration size of 10 mesh (2 mm), 18 mesh (1 mm), 35 mesh (0.5 mm) and 60 mesh (0.25 mm) were passed. Therefore, from the above explanation, the author background to conduct research with the title Effect of Physics (Grinding) in 4 Kinds of Measures Against Biogas Production From Rice Husk Waste in Solid State Anaerobic Digestion (SS-AD) Conditions.

As the consequences of past research, it is important to lead an examination identified with the streamlining of biogas creation through physical pre-treatment (pounding) of rice husks within 60 days.

2 Methodology

This research use the rice husks from Rowosari, Central Java. The rice husks need to be measures the TS (total Solid) using the standard APHA method. To remove the lignin, the rice husks need to be pre-treatment by the 6% of NaOH for 24 hours. After that, washed and dried the rice husks so that the resulting pH becomes neutral. Utilizes size varieties of rice husk with 10 work (2 mm), 18 work (1 mm), 35 work (0.5 mm), and 60 work (0.25 mm), which has been sieved utilizing a shiver.

This research was carried out in 2019-2020 at the Environmental Laboratory, Department of Environmental Engineering, Diponegoro University, Indonesia. It was conducted with a duplicated sample to obtain the reliability and validity of the data taken from each variable accurately. This study uses size variations of rice husk with 10 mesh (2 mm), 18 mesh (1 mm), 35 mesh (0.5 mm), and 60 mesh (0.25 mm), which has been sieved using a shiver. The size variations toward to 35 mesh was picked to see if there is an ideal estimation of the size that has been concentrated in past examinations by [4].

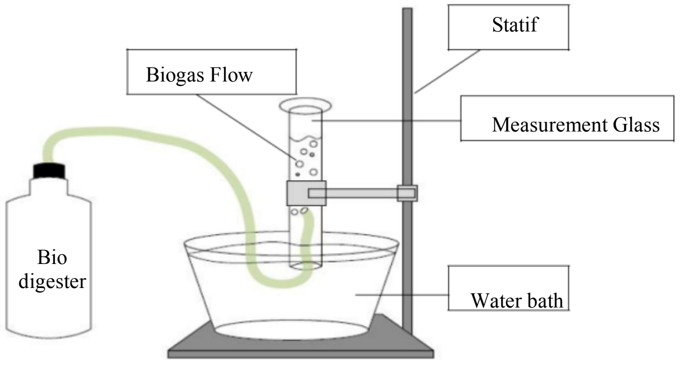

Fig 1. Schematic diagram of bioreactor in laboratory scale

The biodigester was 600 ml to placed the rice husks. For pH and temperature perception are required utilizing widespread litmus paper and a thermometer where it settled for all time in the reactor. At this stage, the rice husk structure was likewise examined utilizing the Scanning Electron Microscope (SEM) to decide the microstructure of rice husk after the biogas arrangement process.

Biogas volume information were investigated as biogas volume diagrams relationship with time utilizing Polymath 6.1 and Microsoft Office Excel programming.

3 Results and Discussions

3.1 Preliminary Treatment and Solid Anaerobic Digestion

The preliminary treatment in this research with rice husk raw material aims to improve the optimization of rice husks up to 30% [5]. The result of analysis TS content is 93,4% of total solid. Then, Rice husk was soaked with 6% NaOH concentration for 24 hours as a control variable. 1.5 kg of rice husk is soaked in 45 liter of water. NaOH needed:

$$NaOH\ 6\% = 6\% \times 45 \text{ liter of water} = 2{,}7 \text{ gr}$$

After the treatment done, the rice husks need to sifting with enumeration sizes passing 10 mesh (2 mm), 18 mesh (1 mm), 35 mesh (0.5 mm), and 60 mesh (0.25 mm). The size variations toward to 35 mesh was picked to see if there is an ideal estimation of the size that has been concentrated in past examinations by [4].

According to [6], the preliminary treatment on biogas production for each of the TS concentration ratios, 7% (L-AD) and 21% (SS-AD) using the addition of NaOH as a preliminary treatment. All reactors were observed biogas volume produced every two days for ± 60 days of research.

3.2 Effect of Grinding Size Variations

In the following research, variations of grinding used as physical pre-treatment are 10 mesh, 18 mesh, 35 mesh, 60 mesh. This study aims to analyze the effect on rice husk in biogas production by the SS-AD method.

According to [7], smaller substrate pieces can open cellular structures and increase the specific surface area of biomass. It also increases the rate of enzymatic degradation, which is very important for lignocellulosic substrates. In addition, it can reduce the viscosity in the digester (thus making mixing easier) and can reduce the problem of floating layers. According to [4], which states that the most optimal size of rice straw counting is 35 mesh (0.5 mm). The addition of size variations approaching the size of the enumeration pass 35 mesh is chosen to find out whether there is an optimal value of the other sizes above or below 35 mesh. In this study, variations in enumeration size of 10 mesh (2 mm), 18 mesh (1 mm), 35 mesh (0.5 mm), and 60 mesh (0.25 mm)). Based on Figure 2, it is known that the highest biogas yield is found in the 60 mesh reactor, which producing a biogas yield of 143.5 ml on the 40th day. Then on the 60th day, the four reactors still produce biogas. However, the smallest biogas production is in the 18 mesh reactor, which produces a total biogas yield of 960.5 ml.

This study aims to analyze the effect on rice husk in biogas production by the SS-AD method. The results of observations of daily biogas volume in preliminary studies using research variations can be seen in fig. 2.

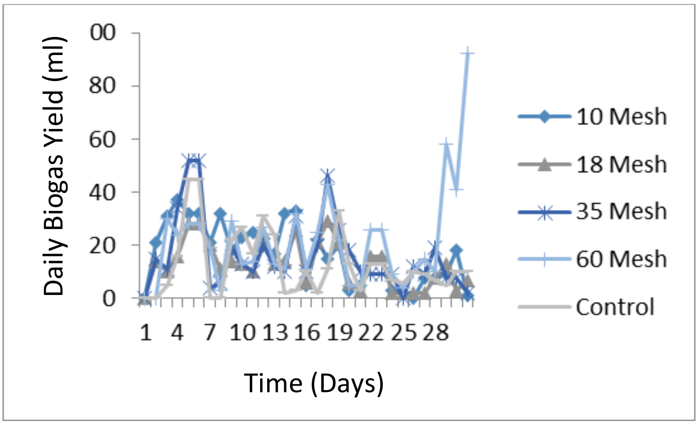

Fig. 2. Daily biogas yield presented in ml

On the graph, days 4 and 5 gas volume increased significantly. However, on the 14th day all grinding sizes were not at their peak. It can be seen that the highest graph result is the 60 mesh reactor variation with the highest number at 92 ml. On the 34th day suddenly the 60 mesh reactor gets the highest yield, then after that the results obtained gradually drop. In fact, initially 60 mesh produced gas below 10 mesh and 35 mesh. It can be seen in the graph that 60 mesh is not always stable and volatile. Then the measurement is needed continuously.

As stated in the literature review, there are several factors that influence the formation of biogas, including; anaerobic conditions, raw material stuffing, c / n ratio, acidity, and total solid content (ts). According to [8], methane gas was produced on the 10th day. Day 1 to 8 gas formed its CO_2. The composition of 54% CH_4 and 27% CO2 produces biogas on the 14th day.

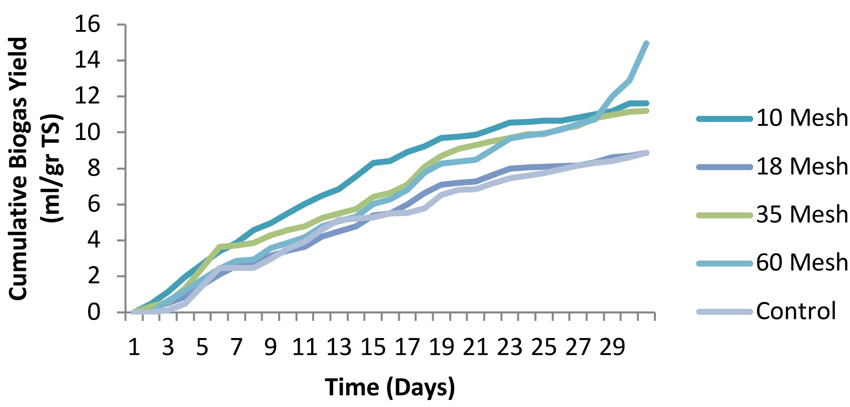

Fig. 3. Cumulative daily bogas yield presented in ml/grTS

By using a concentration of 45 grams of solids obtained from the division of solids in the husk value of 93.4% which results from laboratory testing, with the volume of the solution in the digester as much as 200 ml, and multiplied by the weight of the solids obtained from the multiplication of the volume of the digester solution with a variable total solids. Then the [9] result of accumulative biogas volume divided by the concentration of solid yields in Figure 4.3. It was shown that the highest yield on 60 mesh grinding size variations was 14.95555556 ml / gr TS. 60 mesh becomes the highest size because of the highest accumulative yield compared to other reactor results.

As stated in the literature review, there are several factors that influence the formation of biogas, including; anaerobic conditions, raw material stuffing, c / n ratio, acidity, and total solid content (ts)[9]. In addition, the factors that can influence the graph fluctuate by the activity of microorganisms in the digester where small-scale anaerobic digesters that are used operate at room temperature (25°C - 37°C) or in the environment where *mesophilic* bacteria live[10]. As a result of adjusting the temperature and supporting conditions of microorganisms in the digester can reduce the rate of activity of *mesophilic* bacteria in the digester, causing fluctuating conditions.

3.3 Biogas Production Rate

In this study aims to analyze the rate of biogas production from rice husk waste by the SS-AD method. The data has been obtained, then solved numerically with non-linear regression using Polymath 6.0. In Polymath, we will get a constant rate of biogas production (U), maximum biogas production (A), and minimum time of biogas formation (λ).

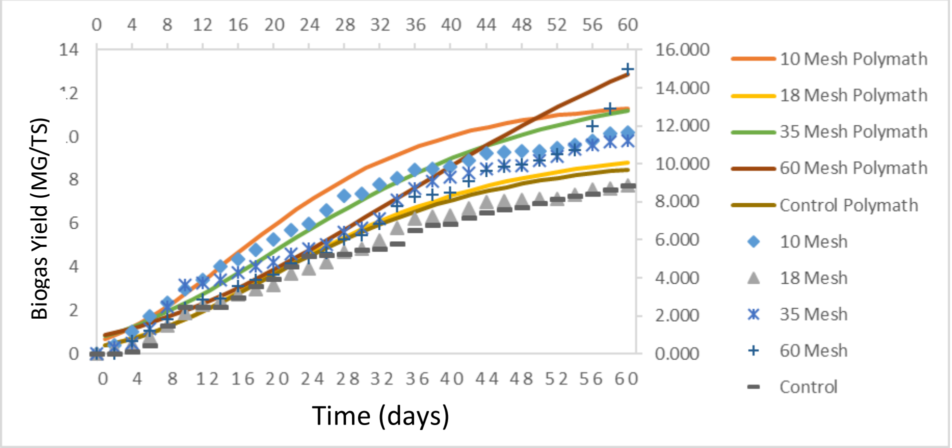

Fig. 4. The correlation between experimental data and calculation results on the effects of grind size

Figure 4 and Table 4.2 show that grinding variations have a real influence on the kinetic constant of biogas production. From the results of Polymath 6.0, 60 mesh has the highest biogas production rate compared to 10 mesh, 18 mesh, 35 mesh, and control. The kinetic constant of 60 mesh is expressed as a constant rate of production of biogas rate (U), maximum biogas production (A), and minimum time of biogas formation (λ), each of which is worth 19.03718 ml / (gr TS days), 0.2416979 ml / gr TS; and 3.83908 days. This means that rice husk is done with 60 mesh grinding variations, has a constant production rate of 19.03718 ml / (gr TS days), produces biogas production of 0.2416979 ml / gr TS, and produces biogas for the first time on 3.83908.

Table 1. Kinetic constant on the effect of variation in grinding size

Konstanta	10 mesh	18 mesh	35 mesh	60 mesh	Kontrol
A, ml/grTS	11,68584	9,479955	12,50772	19,03718	9,084606
U, ml/(grTS.days)	0,3158069	0,2174608	0,2452516	0,2416979	0,2126544
λ, days	0,5584436	2,37128	0,1350256	3,83908	2,223805

The results of biogas yield with 60 mesh produce the highest biogas yield compared to 10 mesh, 18 mesh, 35 mesh, and control. The 35 mesh reactor has biogas yield and second order biogas production rate, each of 12.50772 ml / (gr TS days), produces biogas production of 0.2452516 ml / gr TS, and produces biogas for the first time on day 0.1350256. Furthermore, for 10 mesh, it has a biogas yield of 11,68584 ml / (gr TS day), produces biogas production of 0.3158069 ml / gr TS, and produces biogas for the first time on day 0.5584436. Then for 18 mesh with the lowest grinding variation yield is 9.479955 ml / (gr TS days), produce biogas production of 0.2174608 ml / gr TS, and produce biogas for the first time on day 2,37128. Whereas the reactor without pretreatment (control), has a biogas yield of 9,084606 ml / (gr TS day), produces biogas production of 0.2126544 ml / gr TS, and produces biogas for the first time on 2.222805 days. This shows that the variation of 60 Mesh grinding in rice husk results in the highest biogas yield and 18 Mesh in rice husk results in the lowest biogas yield compared to rice husk without preliminary treatment. It means that it is known the highest biogas production using grinding variations has a constant production rate of 19.03718 ml / (gr TS days), produces biogas production of 0.2416979 ml / gr TS, and produces biogas for the first time on day 3.83908 .

After calculating using Polymath 6.0, it is known that the maximum biogas yield that can be produced and can be known on what day the biogas stops to produce biogas production. The 60 mesh grinding variation has the highest rate of 19.03718 ml / (gr TS days). In Figure 4.5, shows the calculation of biogas results from 60 mesh grinding variations using Polymath 6.0 so that the maximum biogas yield that can be produced and the time to stop producing biogas can be known.

According to [11], the smaller the size of the substrate, the more gas volume results. Because the digestion process of microorganisms decomposes becomes faster. Therefore, 60 mesh is the highest yield of biogas producer because 60 mesh is the smallest substrate. However, the substrate cannot be fast because the highest point is on the 60th day.

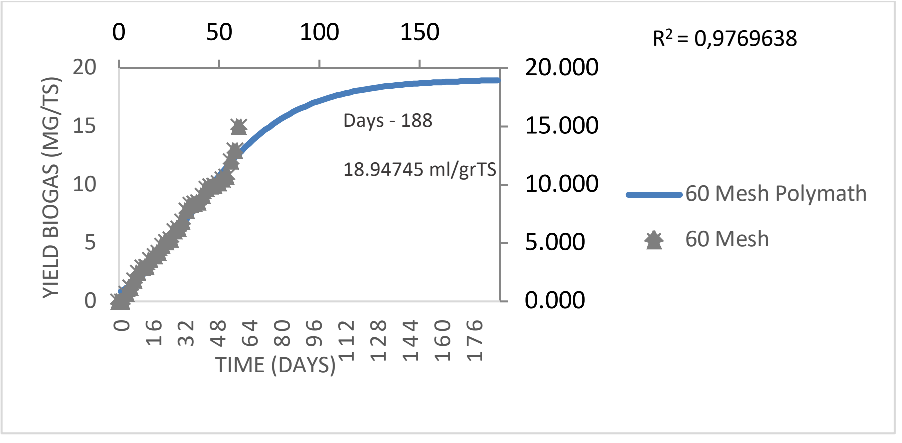

Fig. 5. Calculation Results using Polymath 6.1 on Variation in Grinding Size

From Figure above, the maximum biogas yield at 60 mesh is 18,94745 ml / (grTS) with the correlation obtained is 0.9769638. and is achieved on the 188th day. However, on the 18th day, daily biogas production has gradually declined but has increased on the 60th day. From these data it can be concluded that on the 60th day basically biogas production is still ongoing so that further research is needed.

Gas volume of 60 mesh showed fluctuating results for ± 60 days. The 60th day is the highest peak of 60 mesh with 92 ml. As in the different variations of the others, that 60 mesh initially produces a smaller amount of gas compared to 10 mesh and 35 mesh on the 34th day and the volume has gone up to 43 ml but on the 60th day suddenly the volume rose dramatically. According to polymath calculations, variations of 60 mesh grinding still produce 18.94745 ml / (gr TS days) on the 188th day. The occurrence of fluctuations can be because of bacterial growth factors.

According to [12], growth is an increase in the number, volume, and size of cells. Bacterial growth curves are divided into four main phases: lag phase (slow phase or lag phase), exponential growth phase (fast growth phase or log phase), stationary phase (static phase or stationary phase) and the phase of population decline (decline). These phases reflect the state of bacteria in culture at a particular time.

3.4 Morphological Structure of Treated Rice Husk

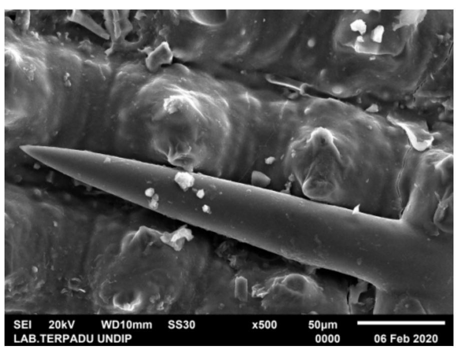

Fig. 1 SEM of rice husk before pre-treatment with 500x magnification

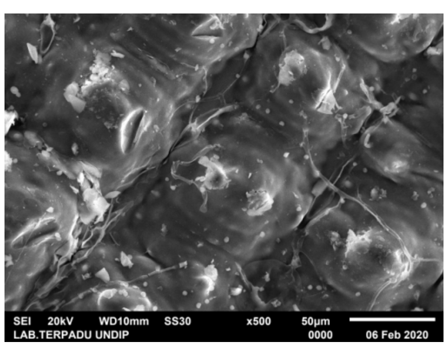

Fig. 7. SEM of rice husk after pre-treatment with 500x magnification

From the figure above, The result of the Scanning Electron Microscope (SEM) test were utilized to decide the morphological structure of rice husks both when treatment in the arrangement of biogas. The after effects of the picture got demonstrate that there is an impact of decomposition during biogas development on the morphological structure of rice husk appeared in Figure 6 and Figure 7.

According [13], This happened because of pre-treatment did wipe out the structure of lignin in rice husks with the goal that cellulose and hemicellulose encompassed by lignin can rapidly be decayed. The substance of hemicellulose will bolster anaerobic microorganisms to corrupt cellulose into biogas. The expansion of NaOH during the pre-treatment procedure additionally makes harm the biomass structure with the goal that it very well may be effectively changed over into glucose mixes.

4 Conclusions

Preliminary treatment with the addition of NaOH and grinding variations causes a significant increase in biogas yield. The reactor without doing variations produces less biogas yield. It was shown that the highest yield on the variation of 60 mesh grinding sizes was 14.955 ml / gr TS. For 10 mesh, 11.622 ml / gr TS, 18 mesh, 8.866 ml / gr TS, 35 mesh, 11.2 ml / gr TS, and for comparison, control produced 8.866 ml / gr TS until the 60th day..

Variation in size (grinding) affects the production of biogas from rice husk waste by the SS-AD method (21% TS). The highest biogas yield of 14,955 ml / grTS was obtained in 60 mesh with the acquisition of polymath $R^2 = 0.9769638$.

The largest biogas production rate in 60 mesh which has a constant production rate of 19.03718 ml / (gr TS days), produces biogas production of 0.2416979 ml / gr TS, and produces biogas for the first time on day 3.83908 . Control or without variation grinding (control) has a biogas yield of 9,084606 ml / (gr TS days), produces biogas production of 0.2126544 ml / gr TS, and produces biogas for the first time on 2,223805 days.

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