Calcium Hydroxide and Amine Solution based Biogas Purification System Development

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***Abstract*- This study presents a development of biogas purification system using Calcium Hydroxide and Amine solution. The liquid spray absorption tower was used to purify the biogas fromlayer chicken manure. The solution used in the experiment were 5 types which were 1) pure water 2) Calcium hydroxide 0.1 mol, 3) Calcium hydroxide 0.2 mol, 4) Mono Ethanol Amine (MEA) 0.1 mol and 5) Mono Ethanol Amine (MEA) 0.2 mol. The flow rate of the biogas was set at 5, 10 and 15 l/min and the flow rate of solution was varied by 10, 20 and 30 l/min .The time for experiment was set at 30 minutes for each solution and flow rate. The biogas composition was measured before and after biogas purification in order to test the efficiency of this purification system. From the experiment, it was found that the average ratio of methane and carbon dioxide in biogas was 51.00% and 39.36%, respectively. The most effective solution for biogas purification was Calcium Hydroxide 0.2 mol which can give a maximum ratio of methane at 89.30% at solution flow rate of 30 l/min and biogas flow rate of 5 l/min. The results revealed that the biogas flow rates, types of solution, the solution flow rates and concentration of the solutions were affected to biogas purification.**

Index Terms- Calcium Hydroxide, Bio gas, Mono Ethanol Amine (MEA).

I. INTRODUCTION

Biogas is produced from oxygen deprived organic degradation and can be used as a renewable thermal energy source for the engines of vehicles [1]. At present, ranch operators use animal manure to produce organic fertilizers and biogas while facing problems with the process flow efficiency biogas treatments [2]. Biogas is composed of important elements including CH_4(%65-55),CO_2(%45-30) ,H_2S (< 4 000,ppm), and vapour (< 1%). Improving the quality of the biogas by obliterating CO_2 will increase the ratio of methane gas to a level similar to that of natural gas so that it can be used as a fuel for vehicles [4]. With respect to the elimination of CO_2 from biogas, the results of studies conducted in both the steady state and isothermal (through NaOH absorption in the compression column) were shown to eliminate up to 80% of CO_2 [5]. Carbon dioxide was treated in the compressioncolumn by an ammonia solution and a mass transfer process for absorption was controlled by the resistance of the liquid and with the ammonia concentration [6]. A study was also made on CO_2 absorption and exudation in the wet wall column by using Mono Ethanolamine (MEA) and Piperazine (PZ) [7]. Another study removed carbon dioxide and hydrogen sulfide with a suspension from rice husks [8]. In a laboratory experiment, Sodium hydroxide (NaOH), Ethylene glycol (EG), Ethanoloamine (EA), Diethanoloamine (DEA), barbotage distilled water (H_2O), bog iron ore (BIO), and activated carbon (AC) were used in the absorption column [9]. The processes stated above are all high efficient biogas treatments which can accomplish the following: 1) increase the ratio of methane gas, 2) reduce the corrosion and damage on metal & parts and 3) change the attributes of the biogas to make it more similar to natural gas. However, further research should also be concerned with cost efficiency and the effects of biogas treatments [10] since it was found that these topics had rarely been included in pilot scale studies. The aim of this study was, therefore, to develop a treatment system for biogas from chicken manure by spraying a solution in the compression column. This is to be followed by a study on how the system worked by changing the following: 1) the biogas flow rates, 2) the types of solutions, 3) the solution flow rates, 4) the solution concentrations, and 5) the amounts of material for absorbing the biogas. The study was conducted to compare the differences and each solution type in order to find the system's maximum value that could reduce carbon dioxide and hydrogen sulphide during biogas treatments.

II. THE BIOGAS PURIFICATION SYSTEM

If the untreated biogas is used as fuel, it will result in incomplete combustion in the combustion chamber. Therefore,before using biogas, it is necessary to treat the carbon dioxide and hydrogen sulfide with the following: 1) waterscrubber technology, 2) pressure swing adsorption (PSA) technology, 3) chemical adsorption technology, and 4)membrane separation technology. For efficient combustion in the combustion chamber, quality biogas is a necessity[11].

Biogas treatments with distilled water, Calcium hydroxide, and Mono Ethanol Amine (MEA) can be expressed bythe chemical reactions (1), (2), and (3), respectively [12].

$H_2O + CO_2 \leftrightarrow H_2CO_3$ (1)

$Ca(OH)_2 + CO_2 \leftrightarrow CaCO_3 + H_2O$ (2)

$2(R\text{-}NH_2) + CO_2 \leftrightarrow RNHCOONH_3R$ (3)

III.EXPERIMENTS & METHODS

3.1 The Experimental Equipment

The aim of this research was to develop and improve the quality of biogas in chicken farms by using spray tower scrubbers. The scrubbers are a systemdesigned to improve the quality of biogas by using chemical absorption including the following: 1) FeS chemical scrubber tank, 2) Calcium Hydroxide or Mono Ethanol Amine scrubber tank, and 3) a silica gel tank to remove vapour by as shown in Figure 1. This treatment system is effective in eliminating carbon dioxide. However, the aims of the study did not include the removal of hydrogen sulfide.

3.2 The Experimental Methods

The biogas treatment system that was used for the experiment is shown in Figure 2. Five different solutions were used in the experiment: 1) pure water, 2) Calcium hydroxide (0.1mol), 3) Calcium hydroxide (0.2 mol), 4) Mono Ethanol Amine (MEA) (0.1 mol), and 5) Mono Ethanol Amine (MEA) (0.2 mol). The solution flow rate was fixed at three levels: 10, 20, and 30 l/min and the biogas flow rate were fixed at 5, 10, and 15 l/min. The time used to test the carbon dioxide absorption for each of the solutions was 30 minutes per solution per flow rate. The component values of the biogas were measured both before and after the treatment to analyse the system's ability to treat biogas.

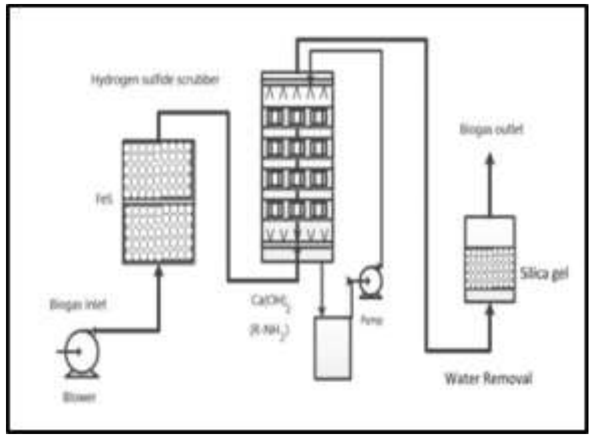

Figure 1. The Schematic Diagram

Figure 2: The Purification Biogas System

IV. RESULT

4.1. The Biogas Component

The biogas, used in the experiment, had been derived from the chicken manure biogas system. The amount ofbiogas generated differed from day to day depending on the time. The average component values in the biogas beforetreatment are shown in Table 1. Also, the amount of biogas, generated each day, depended upon the COD of the wastewater from chicken manure that had been in the biogas generating system. The component values of the biogas foreach day were found to be similar.

Table 1: The Average Values of Biogas Composition

Bio – Gas Components	Average Value
(%) CH_4	51.00

(%) CO_2	39.36
(%) O_2	0.21
(ppm) H_2S	2940.61

4.2. The Removal of CO2 from Biogas by Pure Water

Carbon dioxide can be dissolved in water thus changing it to carbonic acid and transmuting it into bicarbonate and carbonate. From the experiment, it was found that when the biogas and solution flow rates were changed, the amount of methane changed only minimally because the carbon dioxide was unable to be dissolved by the water in the spray tower water scrubber column. As a result, carbon dioxide could not be treated.

4.3. The Removal of CO2 from the Biogas by Calcium Hydroxide

After treating the biogas with a solution of calcium hydroxide at concentrations of 0.1 and 0.2 mol. And at different biogas and solution flow rates, the amounts of CH4 remained are shown in Table 2. The highest level of methane (89.3%) was achieved by using a calcium hydroxide solution of 0.2 mol. with a gas flow rate of 5 l/min. and a solution flow rate of 30 l/min. Therefore, it was found that this treatment could increase the amount of methane when the solution flow rate was high, but when the biogas flow rate was low. In other words, the biogas and solution flow rate can affect the biogas treatment efficiency.

Table2: The Removal of CO2 from Biogas by Mono Ethanol Amine (MEA)

Biogas Flow (l/min)	Max CH_4 composition (%)					
	Calcium Hydroxide 0.1 mol Solution flow (l/min)			Calcium Hydroxide 0.2 mol Solution flow (l/min)		
	10	20	30	10	20	30
5	59.9	75.4	81.1	58.8	78.3	89.3
10	58.5	74.0	77.7	57.6	75.5	87.4
15	55.2	70.3	71.7	56.7	70.7	84.3

4.4. The Removal of CO2 from Biogas by Mono Ethanol Amine (MEA)

Biogas treatments with a mono ethanolamine solution at a concentration of 0.1 mol., with a biogas flow rate of 15 litres/min., and solution flow rate of 10, 20, and 30 litres/min, were found to yield methane at the highest levels of 72.0%, 81.5%, and 72.3%, respectively. Biogas treatments with an Amine solution at a concentration of 0.2 mol, with a biogas flow rate of 15 l/min, and with solution flow rates of 10, 20, and 30 l/min were found to contain methane at the highest level of 73.5%, 75.3%, and 77.2%, respectively. This is shown in Figure 3.

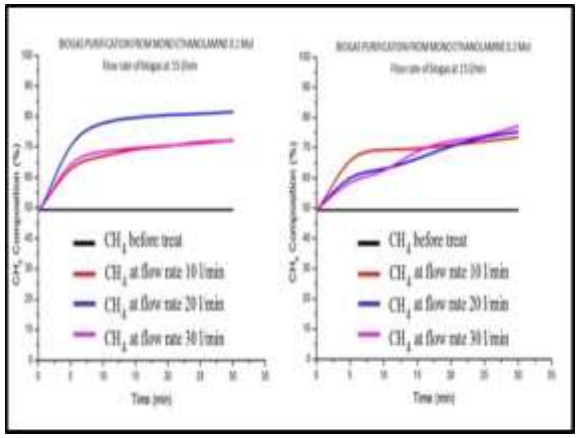

Figure 3: Biogas Purification from Mono Ethanolamine at a Biogas Flow Rate of 15 l/min

V.CONCLUSION

This research was conducted to develop a system that can be used to improve the quality of biogas in chicken farms by using spray tower scrubbers. Before and after treatments, the component values of the biogas were measured by a biogas analyser. The biogas flow rate used in the treatment included 3 levels: 5, 10, and 15 l/min, while the solution flow rates, used for treating the biogas, were 10, 20, and 30 l/min. The time used for the experiment was 30 minutes per solution per flow rate. Test results showed that before treatment, biogas average component values included methane 51.00% and carbon dioxide 39.36%. Tests with a solution of distilled water resulted in no changes or in very minor ones. Tests with a calcium hydroxide solution with a concentration of 0.1 and 0.2 mol, resulted in the highest methane value of 81.1% and 89.3% when the biogas flow rate was 5 l/min and the solution flow rate was 30 l/min. Tests on biogas treatments with an mono ethanolamine solution with concentrations of 0.1 and 0.2 mol. resulted in the highest methane levels of 81.5% and 77.2%, respectively. The highest level of methane (89.3%), produced from this experiment, occurred when the biogas flow rate was 5 l/min. and solution flow rate was 30 l/min. With a

0.2 mol calcium hydroxide solution, a low biogas flow rate, and a high solution flow rate; the biogas treatment was very efficient because the low biogas flow rate had resulted in a high efficiency reaction with large amounts of solution. Solutions with high concentrations were also more efficient in treating biogas. From the study, it was found that the factors that had affected the change in the amount of carbon dioxide by liquid absorption had consisted of the following: 1) the type of solution, 2) the concentration of the solution, 3) the flow rate of the biogas, and 4) the flow rate of the solution used in the chemical treatment. These factors can increase the efficiency of carbon dioxide absorption. The amounts of chemicals, dissolved in the water, can have an effect on carbon dioxide absorption. The more contact that the liquid has with the gas, there is a greater degree of absorption that can occur. Therefore, if this method is to be used in biogas treatments to provide the highest benefit, the previously discussed factors affecting treatment must be taken into account. In addition, the cost and economics factors of this treatment solution must be further examined.

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