Impact of Biogas Purification System on Generated Power in Gas Engine Generator

Fadlilatul Taufany[1], Bobby Rama Jaya R[1], and Ardhiya[1]

Abstract* - One of alternative renewable energy is biogas, which is the end product of anaerobic degradation by methanogens bacteria. In general, biogas contains CH_4, CO_2, H_2S and H_2O. Biogas is potential in a power generation but must be purified to meet the desired specifications by removing its impurities, i.e. CO_2, H_2S and H_2O. This research aims to perform a feasibility study for the biogas purification with respect to CO_2 and H_2S removal by utilizing various alkalines and their respective salts (NaOH, KOH, $Ca(OH)_2$, Na_2CO_3, K_2CO_3, $CaCO_3$) as the absorbent. Additionally, its impacts on generated power are also being studied. The results indicate that NaOH was the optimum absorbent in perspective of technical and economical aspects.

Index Terms – Alkalines and salts, Amine, Biogas, Power generation, Purification

INTRODUCTION

In respect to the shortage of the fossil fuels, there abundant reports on developing various renewable energy sources, such as biofuel, fuel cells, solar cells, biogas, etc. Among these renewable energy sources, biogas is considered as a promising option, as it can be produced from various sources of organic wastes. Biogas itself is the end product of anaerobic degradation of biomass by methanogens bacteria. In general, biogas is composed of majority of hydrocarbon of CH_4, acid gases of CO_2 and H_2S, and minor saturated H_2O, with their respective composition of 55 - 75%, 25 - 45%, 0.1 - 0.5%, and H_2O is the rest. With such a high CH_4 content, biogas is thus potential to be used as energy source for combustion in gas power generation [4]. In the application of biogas in power plant, biogas therefore needs to be purified to meet the desired specification, namely biogas methane content $\geq$ 75% (GPSA Standards for pipeline gas) by removing its impurities, namely CO_2, H_2S and H_2O.

Gas with higher methane content will give a higher heating value than that of gas with lower methane content. This in effect will impact on the amount of the generated power from the gas engine generator [3]. There are several methods on acid gas removal that are generally being used, *i.e*. solvent absorption, solid adsorption, membrane, direct conversion and cryogenic fractionation. Solvent absorption has three methods which are chemical, physics and hybrid method. Chemical solvent absorption is divided into two ways, which are using amine solvent and alkalines with its respective salts solvent [2].

This research aims to evaluate the chemical absorption method that is using alkalines with its respective salts solvent (NaOH, KOH, $Ca(OH)_2$, Na_2CO_3, K_2CO_3, $CaCO_3$)[1], and its impact on generated power from gas generator.

MATERIALS AND METHODS

Biogas was produced from a pilot plant scale of anaerobic digester reactor. Various absorbents being studied here are base compounds (*i.e*. NaOH, KOH, $Ca(OH)_2$) and their respective salts (*i.e*. Na_2CO_3, K_2CO_3, and $CaCO_3$).

I. Biogas and absorbent preparation

Biogas is produced from 5000 L anaerobic digester. The feed is composed of 9 L molasses and 100 gr urea, which is then dissolved in 1200 L water and HRT 14 days. Biogas is then collected in gas holder at a pressure of 55 cm-H_2O (1.055 atm). Meanwhile, the absorbent solution is prepared by diluting a specific amount of absorbent powder in an aquadest to form a 0.1 N concentration.

II. Absorption Process

Raw (untreated) biogas is subjected through a packed tower of using Raschig ring packing, from the bottom of the tower, while for that of absorbent solvent is subjected through the column from top of the tower, with a gas:liquid (G:L) ratio of 25:1.

III. Power Generation

The purified biogas is then compressed into a biogas tank with pressure approximately 8 barg. Compressed biogas tank is then fed to gas engine generator with suction pressure of 5 barg. Gas generator generates of approximately 400 watt electricity.[5]

RESULT AND DISCUSSION

I. % Recovery of CO_2

It is evident from Fig. 1 that the NaOH absorbent has the highest % recovery of CO_2, which indicating that this

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absorbent is the most reactive one towards the reaction with CO_2 gas.

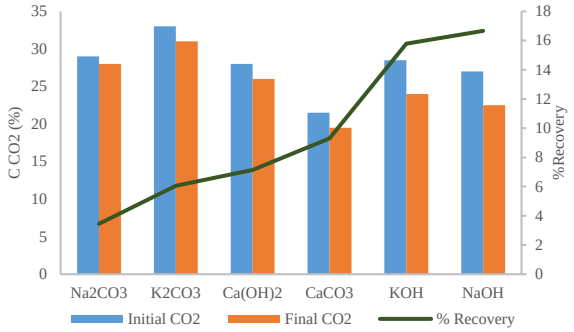

Figure 1. % Recovery of CO_2 from various absorbents.

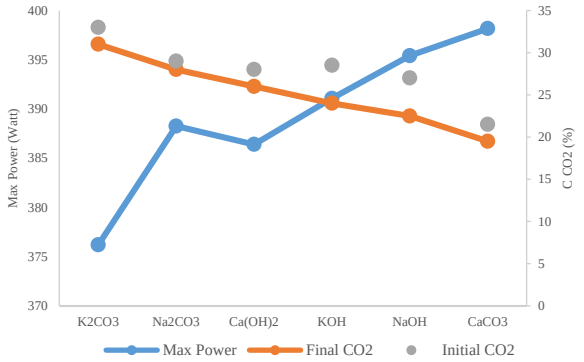

Figure 2. Max Power vs CO_2 Content.

II. Power Generated

It is evident from Fig. 2 that the decrease of CO_2 content inversely proportional with increase of maximum power generated. This means when the impurities of CO_2 acid gas is being removed from the biogas, the burnable CH_4 gas fuel is increased, thus give an improvement in generated electricity power. This can be easily explained from the perspective of the biogas heating value. To be precise, once the unburnt CO_2 gas was removed from the biogas, we will definitely experience the increase in its heating value, which in return gives an increase in generated power. In a detailed inspection in Fig. 2, NaOH and $CaCO_3$ gave a higher generated power.

III. Unit Production Cost

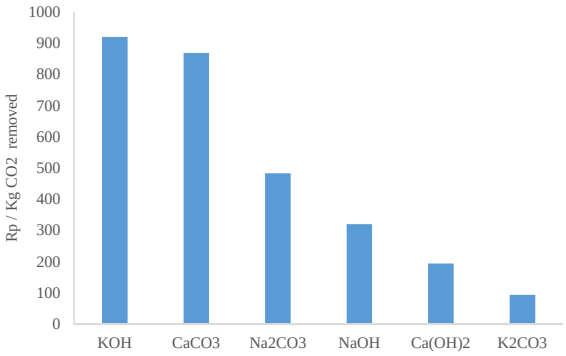

Figure 3. Unit Processing Cost

From the Fig. 3, it is clearly found that the decrease in unit processing cost of CO_2 removal is following a series of K_2CO_3, $Ca(OH)_2$, NaOH, Na_2CO_3, $CaCo_3$, and KOH. In combination from both technical and economical perspectives, we found NaOH is the optimum option

CONCLUSION

From the feasibility studies that have been conducted, the NaOH solvent was found to be an optimum absorbent in perspective of technical (% recovery and maximum power generated) and economic (unit production cost).

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