QUANTITATIVE AND QUALITATIVE ANALYSIS OF BIOGAS PRODUCED FROM COW MANURE DIGESTION

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Abstract

In today's era, due to the depletion of fossil fuels such as oil, gasoline, etc., their expensiveness and the harm caused by their use, such as environmental pollution, have made people to use renewable energy of biofuel. Biogas, like solar and wind energy, is a renewable and environmentally friendly energy source that can be produced from raw materials and waste recycling. Biogas is produced by anaerobic digestion or fermentation of biodegradable materials such as manure, sewage, municipal waste, green waste, plant material, and agricultural products. Extraction of biogas from anaerobic processes of sewage, in addition to energy production, can also be effective in odor control. One of the ways in which a lot of gas can be obtained is wastewater treatment using the UASB method. This method is used to treat industrial wastewater with a high organic load, which has a high removal efficiency, and in this method, a lot of methane, hydrogen sulfide, and carbon dioxide are produced, which, if not properly collected and disposed of, cause odor production. And an explosion occurs.

Keywords: biogas, cow manure, environment, renewable energy sources, fossil fuel, biofuel

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Introduction

Today, the greatest problem of human civilization is the energy crisis [1]. Conventional energy sources are being replaced by renewable energy sources due to limited reserves and high emission of pollutants [2]. Issues related to the energy crisis, depletion of fossil fuels and global warming are increasing, so renewable energies play a very important role to deal with this situation in front of global energy demands. Biogas is a suitable renewable energy source that can solve the problem of energy crisis to a great extent [3].

Biogas energy is actually the energy obtained from the fermentation of animal excreta and plant residues, and in general, in a word, organic wastes, which release methane gases (up to 70%) and carbon dioxide as a result of this process [4]. In this process, the released methane gas can be used to supply electricity or fuel. Utilization of biogas technology in micro and macro scale has been considered as a promising approach in development plans, management and organization of organic wastes in urban and rural areas [5]. Biogas as a renewable source of energy has significant economic and social benefits and plays a significant role in solving environmental problems caused by pollutants and organic wastes produced in human societies [6]. Obtained from the wastes of the forests and agricultural products of the world can make 70 billion tons of crude oil energy available to mankind every year, which is 10 times the annual energy consumption in the world. Also, these fuels can be used more in heat production because they can cause significant economic savings [8].

Biomass has the ability to produce electricity, heat, liquid fuels, gaseous fuels and various useful chemical applications. Biomass has a large share among other types of new energy sources, so that after coal, oil and natural gas, it is the fourth largest source of energy in the world. This source provides about 14% of the world's primary energy, while in the United States, 3-4% of the primary energy needed is provided only from biomass sources. Biomass capabilities are not only used in heat production, but also in cold production, fuels needed for transportation and electric energy production [9-12].

Biogas obtained from sludge digester tanks usually contain between 55 to 65% methane, 35 to 45% carbon dioxide and less than 1% nitrogen, biogas obtained from organic waste usually contains 60 to 70% methane, 30 to 40% carbon dioxide. And they are less than 1% nitrogen. While in the gases obtained from landfill, the percentage of methane is usually between 45 and 55, and the percentage of carbon dioxide is between 30 and 40, and for nitrogen it is between 5 and 15 [13]. Of course, there are other secondary compounds in biogas, compounds such as hydrogen sulfide and other sulfur-containing compounds, siloxanes, aromatics, and halogen compounds; Although these compounds are very small compared to methane, but due to the existence of environmental problems such as the destruction of the ozone layer, the effect of greenhouse gases, or the increase in air pollution, as well as the presence of some of these compounds, it causes engine damage [14]. Compounds such as ammonium, moisture and oxygen are also found in biogas compounds, which decrease the calorific value of biogas [15].

According to what was said in the introduction about the importance of developing biomass energy sources. It is possible to mention the production and use of biogas, which mainly consists of methane and carbon dioxide, biogas produced in raw form has different impurities, the percentage of which can be different according to the type of production source. The presence of impurities in these gases, in addition to reducing its energy content, may even cause environmental problems due to the release of some pollutants. Therefore, it is necessary to purify these pollutants and impurities before using these gases. Therefore, it is necessary to design a set of measures and processes to purify these gases so that biogas can be used as a fuel for heat production or transportation.

This research focuses on the reduction of biogas impurity and actually the Reduction of hydrogen sulfide, which affects the efficiency of the engine and the energy production process. However, the compounds in biogas depend on the sources of its production, and we must act in such a way that different sources are purified simultaneously.

For this purpose, in this project, a one-piece process set has been designed as a biogas refinery to produce high quality biogas and side products such as solid sulfur, etc. produce a gas with the calorific value of natural gas. The process of physical absorption and amine absorption is carried out in Aspen HYSYS software, and also the optimization of the operational parameters of the process is done based on the RMS method. Finally, the results are analyzed and reviewed.

-Basics of biogas treatment and purification

Removal of hydrogen sulfide from biogas

Water vapor target from biogas

Removal of ammonia from biogas

Removal of siloxanes from biogas

Removal of halogenated hydrocarbons from biogas

Removal of oxygen from biogas

Nitrogen removal from biogas

Biogas upgrading methods and processes

Methods that increase the purity of methane in biogas and also increase the calorific value of biogas are called upgrading process. In general, upgrading processes can be categorized as follows: - Chemical removal method, surface adsorption pressure fluctuation, cryogenic separation, washing with high pressure water. Washing with water is a technique based on physical effects on gases dissolved in liquids. Washing with water can be used to simultaneously remove CO_2 and H_2S in biogas. This absorption process is completely physical and to absorb these gases in water, their contact should be maximized. Therefore, in washing with high-pressure water, gas enters from the bottom with high pressure. Then the water is sprayed from above in a counter-flow downwards. To increase the contact surface, the column can be filled with special packings. After the drying stage, it has been observed that the purity of methane has reached 98%. There are two types of washing with water; Washing with one pass and absorption recovered. In washing with one pass, water is used for washing only once, and this causes it to absorb a large amount of H_2S and CO_2 and have a higher separation efficiency than the recovered absorption mode. But it needs a lot of water. In recovered absorption, water is used again after washing the biogas. Which consumes significantly less water than the washing process with one pass, but since the recovered water contains small amounts of pollutants. Therefore, the separation efficiency is lower than the washing mode with one pass 30.

Pacing

In order to be able to decide which process is more suitable for promoting biogas. First of all, upgrading processes should be compared and their performance should be investigated, and since the construction of these processes is very expensive and time-consuming even on a semi-industrial and laboratory scale, process simulation software must be used to further study these processes. Did the simulation software used for these processes are: ASPEN, ASPEN PLUS and HYSIS.

In the first step, criteria should be defined so that these comparisons can be made based on them. Criteria such as;

***The percentage of final methane in the gas has been improved**

***Methane recovery percentage**

***The amount of heat used**

***Electricity consumption**

***Amount of H_2S in the final product**

***Amount of CO_2 in the final product**

***Process temperature**

***Process pressure**

The final goal in the simulation of these processes is to achieve a higher purity percentage for methane gas and all the process conditions have been determined in such a way that the percentage of methane eventually reaches the highest possible level and then according to the value of the aforementioned criteria. Processes are compared 44-39.

-Specify an input feed

Because the input feed parameter has a very decisive role on other process simulation conditions. Therefore, an input feed has been considered as the basis for all processes, and the operating conditions (temperature, pressure, etc.) of the processes have been determined in such a way that the final product has the highest purity of methane.

Optimizing the process of washing with water

In order to optimize the process, Expert Design software has been used. In this software, the RSM-CCD method has been used to reduce the calculations. At first, by specifying the number of parameters in this process, we have three parameters: temperature, pressure and flow. Water was examined. The objective function is that the amount of CO_2 impurity is considered to be as low as possible, which means that the output gas will have a high calorific value. According to the existence of 3 parameters, the tests must be repeated 20 times, of which six tests are related to Repetition is the central point.

Simulation conditions

Hysys software has been used to simulate this process.

The aim of this simulated process is to reach a rich flow of methane gas. Therefore, the discharge, pressure and temperature of the process streams were determined so that the final output stream has high purity. Figure 2 and 3 shows the effect of changes in water flow rate on the amount of main biogas compounds (H_2S, CO_2 and CH_4). It can be seen that the amount of H_2S becomes almost zero after coming in contact with Kgmole/hr 2000 water, but this amount for CO_2 also becomes almost zero, it is about Kgmole/hr 2000 water.

As can be seen, with increasing temperature, the amount of methane decreases and the molar fraction of CO_2 increases. Also, Figure 5 shows the changes in the pressure of the separation tower. According to the figure, at pressures higher than 500 Kpa, no noticeable change in the percentage of compounds has been observed. Therefore, the operating pressure for the tower is 5 atmospheres.

Simulation conditions

Hysys software has been used to simulate this process. Due to the presence of acid gases in the process, ACID GAS equation of state has been used to predict the physical behavior of process fluids. The aim of this simulated process is to reach a rich stream of methane gas. Therefore, the discharge, pressure and temperature of the process streams were determined so that the final output stream has high purity. The parameters that have been investigated to determine the separation efficiency, their changes are: flow rate, tower pressure and amine temperature. Figures 6 to 10 show the effect of changes in these parameters on the amount of compounds in refined biogas.

Introduction

In the previous chapter, the simulation conditions were determined so that the percentage of methane in the output gas reached its maximum level. That is, the aim of the simulation was to reach a higher methane percentage.

Optimizing the process with the above parameters determines the possibility of better investigation and understanding of the process and gives researchers and industrialists the possibility of choosing and prioritizing one or more criteria for further study and investment. Of course, one of the most important criteria for the comparison of these processes is economic considerations, which should be the total cost of a cubic meter of biogas, but since the costs of process equipment and energy carriers are not available, this indicator cannot be compared, so it should be He used other indicators such as energy consumption, separation efficiency, etch.

-Optimizing the process of washing with water

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In order to optimize the process, the Expert Design software has been used. In this software, the RSM-CCD method has been used to reduce the calculations. At first, by specifying the number of parameters, the three parameters of temperature, pressure and amine flow are used in this process. It was investigated. The objective function is that the amount of CO_2 impurity is considered to be as low as possible, which means that the output gas will have a high calorific value. According to the existence of 3 parameters, the tests must be repeated 20 times, of which six tests are related to Repetition is the central point.

After forming the test table, in the Analysis section, the Model section of the data fitting equation was selected from the 2FI function. After that, in the ANOVA table, the correlation relationship between the functions is obtained, the report of which is expanded in Figure (5-9). According to the ANOVA table, the P-Value parameter is reported, which is described in its analysis as follows. If the P-value for a parameter is less than 0.05, it indicates that the relevant parameter is effective, and if it is greater than 0.1, it indicates that the mentioned parameter does not have such an effect on the result of the process.

According to Figure 18, the parameters of temperature (T), flow (m), square of flow (m2) and square of temperature (T2) have great effects on the process.

After forming the ANOVA table, now it is time to check the relationship created by the software. In the first step, he checked the amount of Pared R-Squared and Ad R-Squared in Table 11, which shows that it has a reasonable amount. In the second step, the final relationship is reported by actual values.

After forming the ANOVA table, the effects of temperature-flow parameters at constant pressure are shown in Figure 19. According to the shape, the more the selected values of temperature and flow are in the blue area, the less CO_2 is in the purified biogas.

In the Optimizing part of the software, by specifying the goal of optimization, i.e. minimizing the amount of CO_2 in the final biogas stream, calculations have been performed according to figures 20 and 21 by the software, which considering that the percentage of compounds cannot be negative, the smallest percentage The amount of 0.0100486 is considered, which is obtained at a temperature of 33.2 degrees and a pressure of 6.38 bar, as well as with a flow rate of 264.48 Kgmole/hr bar.

Conclusion

Biomass has the ability to produce electricity, heat, liquid fuels, gaseous fuels and various useful chemical applications. Biomass has a large share among other types of new energy sources, so that after coal, oil and natural gas, it is the fourth largest source of energy in the world. This source provides about 14% of the world's primary energy, while in the United States of America, 3-4% of the primary energy needed is provided only from biomass sources. The capabilities of biomass are not only in the production of heat, but also in the production of cold, fuels needed for transportation and electric energy production. In 2005, about 44,000 megawatts of power generation plants (with various technologies) and 225,000 megawatts of modern thermal power plants with biomass sources have been built, of which about 10,000 megawatts were in the United States alone. This shows the importance of biomass resources and its high potential for energy production. According to what was said in the introduction about the importance of developing biomass energy sources, we can mention the production and use of biogas, which is mainly composed of methane and carbon dioxide, the raw biogas has different impurities. Its percentage can be different according to the type of production source. The presence of impurities in these gases, in addition to reducing its energy content, may even cause environmental problems due to the release of some pollutants. Therefore, it is necessary to purify these pollutants and impurities before using these gases. Therefore, it is necessary to design a set of measures and processes to purify these gases so that biogas can be used as a fuel for heat production or transportation.

Among the principles of biogas purification and purification are biological stabilization, injection of iron chloride, washing with water, use of activated carbon, use of iron hydroxide, use of sodium hydroxide, removal of water vapor, passive gas cooling, refrigeration. And ... pointed out.

For this purpose, this research focuses on the reduction of biogas impurity and actually the reduction of hydrogen sulfide, which affects the efficiency of the engine and the energy production process. However, the compounds in biogas depend on the sources of its production, and we must act in such a way that different sources are purified simultaneously.

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