JOURNAL OF INFORMATION, KNOWLEDGE AND RESEARCH IN MECHANICAL ENGINEERING
ISSN 0975 – 668X| NOV 16 TO OCT 17 , VOLUME –04, ISSUE – 02

Production of pure methane gas in Biogas Plant

[1]GirameOmkar, [2]KhopadeMayur, [3]KhopadeHrushikesh, [4]DorgeNitin,[5]JagtapRushiraj

[1, 2, 3, 4, 5]Department of Mechanical Engineering,

RDs SCSCOE, SavitribaiPhule, pune University,

Dhangawadi, Bhor,Pune–412206, Maharashtra, India.

[1]omkarg22@gmail.com [2]mayurkhopade188@gmail.com

[3]hrushikeshkhopade@gmail.com [4]jagtaprushiraj9322@gmail.com

Abstract: *Anaerobic Digestion is a biological process that takes place naturally when microorganisms break down organic matter in the absence of oxygen. In an enclosed chamber, controlled anaerobic digestion of organic matter produces biogas which is predominantly methane. The produced methane then can be directly used for rural cooking; or after certain conditioning, can be used in onsite power generation, heating homes or as vehicle fuel. When methane gas (biogas) and oxygen (air) combine in the fuel cell, it produces electricity along with water and carbon dioxide. Even though the SOFC produces carbon dioxide, studies shows that the level of carbon dioxide produced using a fuel cellis much less than the typical method of producing electricity by burning biomass.*
This method is very simple, economical and pollution free.

Keywords: Methane gas, Biogas Plant,Biogas Production

1. Introduction:

The production of Methane from biomass is an attractive method to replace declining fossil natural gas reserves. Methane produced from biomass is referred to as Bio-Methane, Green Gas, Bio-Substitute Natural Gas (Bio-SNG) or Bio-CNG when it is used as a transport fuel. The composition of Bio-Methane is similar to conventional Natural Gas, making replacement of Natural Gas by Bio-Methane straightforward. Biomass energy is expected to make a major contribution to the replacement of fossil fuels. The future world-wide available amount of biomass for energy is estimated to be 200 to 500 EJ per year, based on an evaluation of availability studies [1]. Word wide natural gas consumption was approximately 100 EJ or2750 billion cubic meters (bcm) in 2005 [2].

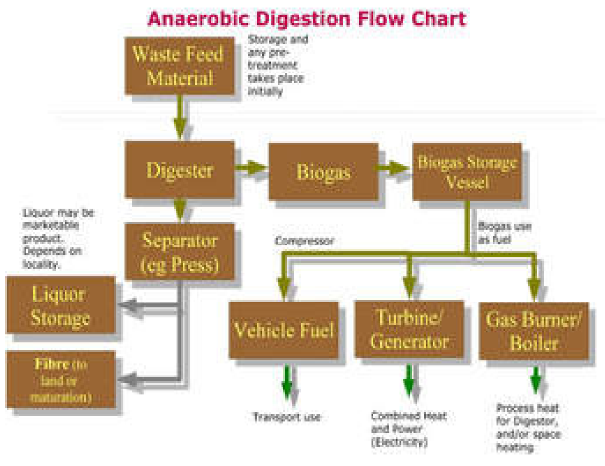

Fig. 1 Anaerobic Digestion Flow Chart

2. Waste Material:

Biogas from Food Waste:
Disposal and treatment of biological waste represent a major challenge for the waste industry. For a wide range of organic substances from agriculture, foodstuff of feed industries, anaerobic digestion is a

superior alternative to composting. Biogas – a mixture of both methane and carbon dioxide – is created during anaerobic digestion and serves as a high-energy renewable fuel that can be used as a substitute for fossil fuels. Biogas-fuelled gas engines improve waste management while maximizing the use of an economical energy supply.

3. Production:

Biogas is produced as landfill gas (LFG), which is produced by the breakdown of Biodegradable waste inside a landfill due to chemical reactions and microbes, or as digested gas, produced inside an anaerobic digester. A biogas plant is the name often given to an anaerobic digester that treats farm wastes or energy crops. It can be produced using anaerobic digesters (air-tight tanks with different configurations). These plants can be fed with energy crops such as maize silage or biodegradable wastes including sewage sludge and food waste. During the process, the microorganisms transform biomass waste into biogas (mainly methane and carbon dioxide) and digestate.
The biogas is a renewable energy that can be used for heating, electricity, and many other operations that use a reciprocating internal combustion engine, such as GE Jenbacher or Caterpillar gas engines.[4] Other internal combustion engines such as gas turbines are suitable for the conversion of biogas into both electricity and heat. The digestate is the remaining inorganic matter that was not transformed into biogas. It can be used as an agricultural fertilizer.There are two key processes: Mesophilic and Thermophilic digestion which is dependent on temperature.
Biogas is a flammable mixture of 50-80% methane, 15-45% CO_2, 5% water and some other trace gases.Biogas is produced by biomethenation and is self-regulating symbiotic microbial process operating under anaerobic conditions and functions at temperature around 30^{o}C.
Organisms involved are all found naturally in ruminant manures. In such system the animal dung is mixed with water and allowed to ferment in near anaerobic conditions, under ideal condition 10Kg of dry organic matter can produce 3m^3 of biogas, which will provide 3hrs of cooking, 3hrs of lighting and 24hrs of refrigeration with suitable equipment.

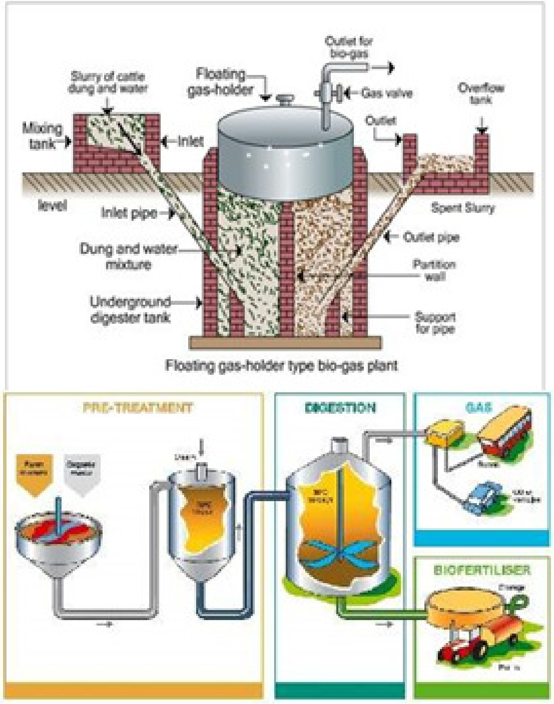

Fig. 2Production Process for Methane Gas

4.Design of Biogas Plant:

The fixed dome biogas plant buried underground. There are three main connecting parts:

Mixing Chamber: Where the animal excrement is mixed with water before it is poured into digesterchamber.

Digester Chamber: Where excrement and water are fermented. Methane and other gases will be produced in the chamber and these gases will push manure and slurry at bottom of the floor into expansion chamber.

Expansion Chamber: Collects excess manure and slurry. When gas is being used, manure and slurry will flow back into digester chamber to push gas up for usage.

When the excess manure exceeds the volume of the chamber, the manure will be drained out. This system is called dynamic system, when gas is produced inside the pit, the gas pressure will push manure and slurry at the bottom of the pit to flow up into expansion chamber. When this gas is used the slurry in the expansion chamber will flow back into the digester chamber to push the gas up for usage. This happens consistently. The plant will be operated efficiently for a long period of time if the gas pit does not cracked and the system runs regularly. In each case the strength of plant depends on fine construction, specifications of materials according to the criteria suggested by biogas programme, and strict adherence to the instruction manual on maintenance of the biogas Formula used = Fresh manure day x amount of animal x 2 (for cow/buffalo) or x 3 (for pig) x Retention time (60 days) **Fresh Excrement of Animal per Day**.

1 meat or buffalo produces 8 kg of fresh excrement per day 1 milk cow produces 15 kg of fresh excrement per day 1 pig (over > 60 kg) produces 2 kg of fresh excrement per day 1 pig (< 60 kg) produces 1.2 kg of fresh excrement per day 200 chickens or 200 birds, Bio-gas plant should be built at the size of 1 M3 Modified **RCC KVIC biogas plants for Goshalas of M.P. has** been designed for different capacities viz. 25 cum, 35 cum, 45cum, 60 cum, 85 cum. It is found that RCC KVIC Biogas plants are better than conventional Biogas plants. There is a minor increase in cost i.e.18% to 30% while the space required for RCC KVIC Biogas digesters is less for designed capacity and life of Biogas digester is increased many times as compared to the old conventional old methods of constructing Biogas Digesters

5.Literature Review:

5.1ARTI: The city of Pune in the Indian state of Maharashtra may be relatively prosperous, but on its roadsides you will often find waste food, discarded and left on road and creating a potentially serious health hazard. However, for the Appropriate Rural Technology Institute (ARTI) this problem is also an opportunity.Founded by scientists and social workers, ARTI looks to technology for solutions to rural issues. In the case of the waste in Pune, their solution is a domestic biogas plant. The plant breaks down the kitchen waste. The broken-down waste in turn produces biogas that can replace more polluting and expensive fuels. The whole process is neat and efficient.

5.2 Low Pressure Separation Technique of Biogas into CH_4 and CO_2Employing PDMS Membrane: Membrane gas separation technique is very advantageous as it doesn't require huge infrastructure for plant set up due to low pressure requirement for the process and availability of membrane at a reasonable cost. This technique has generated immense commercial interest. This paper deals with an advanced separation technique employing Poly-DimethylSiloxane (PDMS) hollow fiber membrane module. The results clearly show that, PDMS double membrane module in series gave the upgraded methane with 93 % purity and carbon dioxide with 96% purity.

6.Experimental Details:

6.1 Materials: Biogas is obtained from the biogas plant running on kitchen waste, the membrane material used for this project was hydrophobic, dense, polymeric hollow fiber membrane made up of silicon cured with platinum. The membrane was purchased from Med Array Inc. USA (Perm select). The size of the membrane is 10 cm^3 i.e. PDMSXA-10[6]. Foranalysis purpose CH_4 gas analyzer and CO_2 gas analyzer are used. Apart from this Gas flow meter,Compressor, Moisture separator, Heater, pipe connectors and pressure gauge is used for the experiment.

6.2 Experimental Set-up: A small biogas plant running on kitchen waste installed by the Appropriate Rural Technology Institute (ARTI) Pune is used in this set up. The system for separation was developed on the plywood board by fixing all necessary accessories. Compressor, pressure gauge with ball valve, gas flow meter, moisture separator, Pre-heater and membrane module was attached in a series. Two way & three way connectors for pipe connections; plastic pipe was used for connecting the all the accessories. Gas storing bags (bladder and tube) were used for collecting samples for analysis. Gas leakages were checked with the help of soap solution

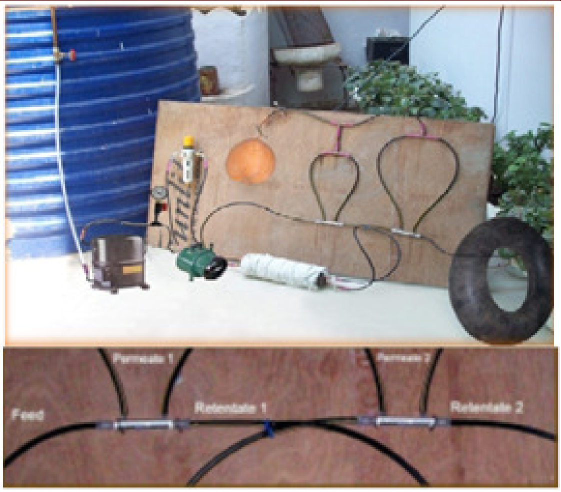

Fig. 3Setup of Separation of CO_2 from Methane

6.3Process flow diagram for biogas separation through membrane module:

1. Bio-gas outlet was attached to compressor.
2. In compressor, the gas was stored and released at 1.6 bar pressure through pressure valve which was attached immediate next to compressor.
3. Gas flow meter for flow rate measurement was attached next to pressure valve.
4. Constant flow rate was maintained at 7.8 lit/hr as seen on gas flow meter.
5. Moisture separator was placed next to gas flow meter to remove the moisture content of Bio-gas
6. It was then passed through gas pre heater to maintain the temperature between 33-40 o C.
7. The heated Bio-gas was then passed through first membrane module.
8.The retentate of first module (R-1) was passed tosecond module and retentate of second module (R-2) was collected separately for analysis.
9.The permeate of first membrane module (P-1)and second membrane module (P-2) were separately collected for analysis.

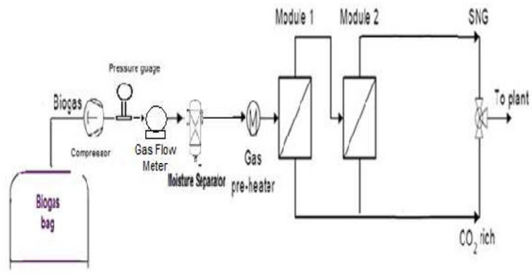

Fig. 4Block Diagram of Separation of CO_2 gas from Methane Gas

6.4 Separation of H_2S (Biological Desulphurization):

Natural bacteria can convert H_2S into elemental sulphur in the presence of oxygen and iron. This can be done by introducing a small amount (two to five per cent) of air into the head space of the digester. As a result, deposits of elemental sulphur will be formed in the digester. Even though this situation will reduce the H_2S level, it will not lower it below that recommended for pipeline-quality gas. This process may be optimized by a more sophisticated design where air is bubbled through the digester feed material. It is critical that the introduction of the air be carefully controlled to avoid reducing the amount of biogas that is produced.

6.4.1 Iron/iron Oxide Reaction:

Hydrogen sulphide reacts readily with either iron oxide or iron chloride to form insoluble iron sulphide. The reaction can be exploited by adding the iron chloride to the digester feed material or passing the biogas through a bed of iron oxide-containing material. The iron oxide comes in different forms such as rusty steel wool, iron oxide pellets or wood pellets coated with iron oxide. The iron oxide media needs to be replaced periodically. The regeneration process is highly exothermic and must be controlled to avoid problems.

6.4.2 Activated Carbon:

Activated carbon impregnated with potassium iodide can catalytically react with oxygen and H_2S to form water and sulphur. The reaction is best achieved at 7 to 8 bar (unit of pressure) and 50 to 70 C. Activated carbon beds also need regeneration or replacement when saturated.

6.4.3 Scrubbing and Membrane Separation:

As discussed in the section on CO_2 removal, the CO_2 and H_2S can be scrubbed by water, polyethylene glycol solutions or separated using the membrane technique.

7.Conclusion:

We found that there is number of method are available in production pure methane from separation of different gases. e.g. CO_2 and H_2S can be removed with the help of above methods. Also it is possible separate moisture from methane gas.

8.References:

[1] Abass A. Olajire , "CO_2 capture and separation technologies for end-of-pipe applications" , Department of Pure and Applied Chemistry, LadokeAkintola University of Technology, Energy 35 page no 2610-2628 (2010)

[2] BirgirNorddahl, Jan du Preez, "A membrane based process for the upgrading of biogas to substituted natural gas(SNG) and recovery of carbon dioxide for industrial use" a Institute of Chemical-, Bio, and Environmental Technology, University of Southern Denmark, DK-5230 Odense M, Denmark Veolia Water SA, Percy St., Four ways 2055, South Africa ; 16-20 (September 2007)

[3] Richard W Baker "Membranes for Vapour/Gas Separation" Membrane technology and Research inc, 1-25; 2006.

[4]Er.TriRatnaBajracharya, Ph.D, PURIFICATION AND COMPRESSION OF BIOGAS: A RESEARCH EXPERIENCE, Journal of the Institute of Engineering, Vol. 7, No. 1, pp. 1-9

[5] Mohamed NajibSannaa, Prof. Ole Jess Olsen, "The Development of Biogas Technology in Denmark: Achievements & Obstacles", Department of Environment, Technology and Social Studies Roskilde University RUC, Denmark, Group nr: S04 Master-2217

[6] J. Patrick Montoya "Membrane Gas Exchange Using Hollow Fiber Membranes to Separate Gases from Liquid and Gaseous Streams" MedArray, Inc 1-7; (2010).

[7] http://www.molecularsoft.com/help/Gas_Laws-Ideal_Gas_with_Density.htm

[8] Renate M. de Vos*,a, Wilhelm F. Maierb,1, HenkVerweija "Hydrophobic silica membranes for gas separation" University of Twente, Faculty of Chemical Technology, Laboratory of Inorganic Materials Science, P.O. Box 217, 7500 AE, Enschede, The Netherlands b Max Planck InstitutfuÈrKohlenforschung, Kaiser-Wilhelm-Platz 1, D-45470, MuÈlheiman der Ruhr, Germany Received 14 October 1998; received in revised form 14 January 1999; accepted (14 January 1999)

[9] Richard D. Noble and John L. Falconer "CO2 Separations Using Zeolite Membranes" Joseph Poshusta, Vu Tuan, Christopher Gump, HalilKalipcilar University of Colorado Chemical Engineering Dept. UCB 424 Boulder, (June 30, 2001)

[10] Sayed A.M. Marzouka, Mohamed H. Al-Marzouqib, Muftah H "Removal of carbon dioxide from pressurized CO2–CH4 gas mixture using hollow fiber membrane contactors". Journal of Membrane Science 351 page no 21–27 (2010)

[11] SubhankarBasu, Angels Cano-Odena, Ivo F.J. Vankelecom "Asymmetric membrane based on Matrimid and polysulphone blends for enhanced permeance and stability in binary gas (CO_2/CH_4) mixture separations" 2-7-2010