Biogas Plant with Cheap and Effective Method of Purification and Revamping of Biogas

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ABSTRACT

Biogas is one of the potential alternative fuel to conventional fossil fuel and compressed natural gas (CNG). However biogas scrubbing cost is one of the major barrier to use of biogas in commercial application. To enable the efficient use of biogas in these applications the gas must be upgraded, i.e. the CO_2, which constitutes a large part of the raw biogas from the digester, must be separated from the methane.Apart from CO_2 there are other poisonous impurities like H_2S and NH_3. At present biogas scrubbing cost is very high so it makes bio-CNG uneconomical. Again the amount of biogas getting from waste material is very small and huge amount of dung and slurry handling cost hinter the use of biogas in many applications. To solve above problem, we designed novel economical biogas scrubber which upgrade biogas with low cost make it commercially viable as compared to CNG and LPG, and novel concept of biogas dairy is presented. Number of biogas dairy plant can be opened along village in India and which provides number entrepreneurial opportunities to villagers and helps to cut the oil import and dependency for fuel on foreign countries. Again this research project will helps to reduce CH_4 and CO_2 emission worldwide.

Keywords:*Biogas dairy, Bio-CNG, Biogas scrubber, Bio-diesel.*

I. INTRODUCTION

One of techniques of biogas purification is absorption technique using water and $Ca(OH)_2$ absorbent . The absorption process is used to reduce CO_2 and H_2S gases. Other is the use of different scrubbers for the separation of CO_2, H_2S and moisture. One of the most important driving forces behind the development of biodiesel is to hope for a reduction in dependence on fossil fuels, almost all of the stages involved in the production of its feedstock and synthesis are tied up with application of fossil fuels.[1]

The presence of high concentration of CO_2 in biogas lowers the energy content per unit mass/volume and limits its utility to only low quality energy applications. Again presence of H_2S, NH_3 and SO_2 gives bad odour to biogas and H_2S is very harmful for engine component. Therefore, removal of carbon dioxide and hydrogen sulphide is necessary as it will help to enhance the utility of biogas for wider range of applications. [2]

Numerous biogas upgrading technology are available. However present technological development is commercially not viable. If the cost of scrubbing can be reduced by technological development then biogas can be successfully used as a substitute of natural gas, transportation fuel, combined heat, power and electricity generation applications.Upgraded biogas is a renewable energy source which can help both in waste management and in building a clean and sustainable environment.

Already CNG technology has become easily available and therefore, bio-methane (purified biogas) which is nearly same as CNG, can be used for all applications for which CNG are used. After removing carbon dioxide, hydrogen sulphide, moisture and compressing it into cylinders makes it easily usable for transport applications and also for stationary applications.A total of about 3.4 million family size biogas plants had been installed all over India by December 2002. This is only 28.3% of the total potential (12 million) of the family size biogas plants that can be put up in India.

1. Inference
   - 1.1 There is a definite scope to do research in Biogas enrichment and bottling.
   - 1.2 Economical biogas scrubber need to be developed.
   - 1.3 Feed material and slurry transportation cost make large biogas plant project and community biogas plant uneconomical.
   - 1.4 H_2S, NH_3, SO_2, CH_4, moisture need to eliminated.
2. Problem Statement
   - 2.1 Feed material and slurry transportation cost is very high and limits the popularity of large biogas plant and community biogas.
   - 2.2 Biogas which contains impurities such as CO_2, H_2S, NH_3, SO_2 and water vapour limits biogas commercial applications.
   - 2.3 Very less percentage of CH_4 limits it application in petrol and diesel engine.
   - 2.4 CH_4 and CO_2 emission increasing day by day due to agriculture and commercial waste.
3. Problem Solution
   - 3.1 Removing of SO_2, NH_3, and H_2S by using waste of lathe machine.
   - 3.2 Removing of CO_2 by using Coconut coir and water scrubber.
   - 3.3 Removing of moisture by coconut coir scrubber.
   - 3.4 Bottling of upgraded biogas in cylinder at high pressure.

II. BIOGAS PLANT SETUP

The actual plant setup is shown. Firstly, raw biogas is prepared by using anaerobic fermentation of waste materials(cowdung) and water.mixed in the mass ratio of 1:1 in a cylindrical storage reactor. The reactor was kept in sunlight and biogas was prepared. The produced biogas is compressed and stored in the cylinder. The compressed biogas is then passed through the scrubbing system unit for upgradation and purification process.

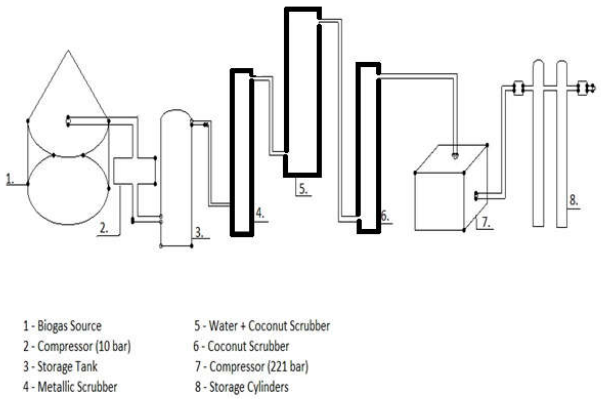

Fig.1 Actual Plant Setup (Highlighted part is the purification setup consisting of 3 scrubbbers)

After the purification, the upgraded biogas is compressed and bottled in cylinders for application purposes.All the units of the biogas plant setup are connected using pipes/hoses such that there is no leakage of biogas at any stage of plant process.

III. SCRUBBING/PURIFICATION UNIT

The scrubbing unit consists of 3 pipes made up of pvc material. The pipes are 20 feet long and 1 foot diameter. The scrubbing materials are packed in a steel cage like structure to hold and keep the scrubbing material in place. These cage fits perfectly into the pipes. The 3 pipes are 3 scrubbing units namely: carbon dioxide (CO_2) removing unit, hydrogen sulphide (H_2S) removing unit and moisture trapping unit. The three units are interconnected with plastic hoses. In the purification process of biogas which was conducted; pure water, steel wool, and an adsorbent material (silica gel) or dry coconut choir were used. The water is to reduce the percentage of carbon dioxide, steel wool is to react with the hydrogen sulphide and the coconut choir is to reduce the presence of water vapour in the purified biogas. The detailed working of the scrubbing (purification) unit is explained.

1. CO_2 Separation Unit

   Pressurised biogas is passed through the first separating unit/pipe consisting of packed bed of coconut choir from the bottom and water is sprayed from the top. The choir is used to increase the area of contact and time for which the biogas and water are in contact.

   When carbondioxide is dissolved in water, carbonic acid (H_2CO_3) is formed. It is a weak acid. The liquid leaving the scrubbing unit will thus contain increased concentration of carbonic acid, while the gas leaving the scrubbing unit will have an increased concentration of methane. The purified biogas that was collected at the top of the scrubber unit has some water vapours. Water vapour is the leading corrosion risk factor. [3,4,5]

   $H_2O + CO_2 = H_2CO_3$(1)

Fig.2 CO_2 Seperation Unit

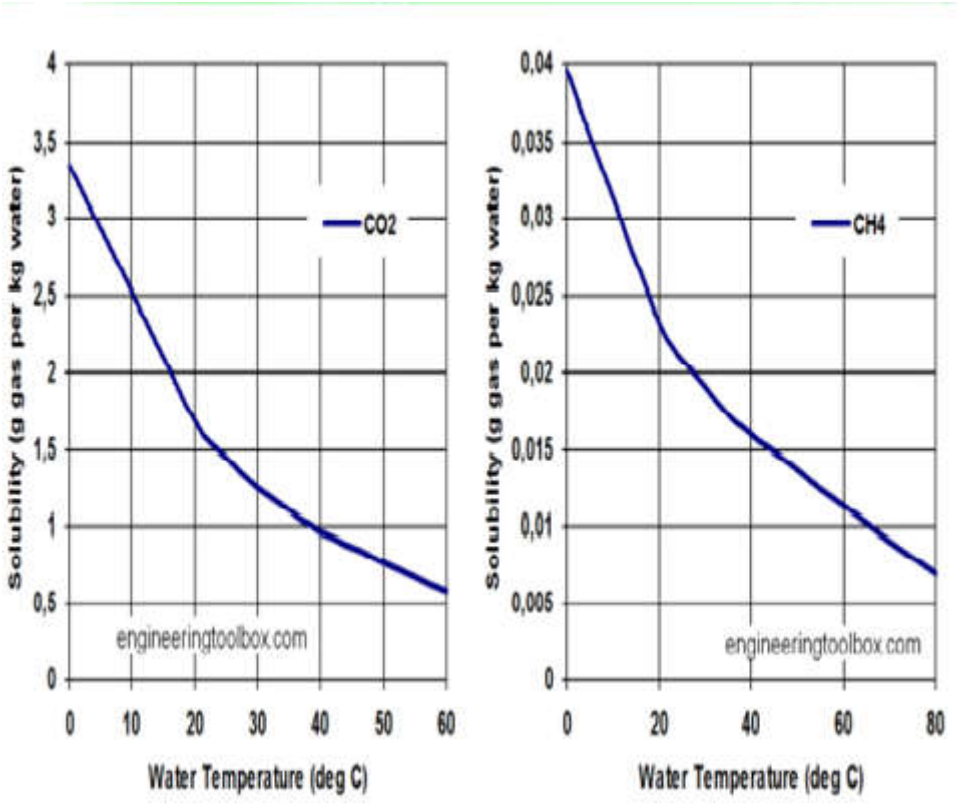

Fig.3 Comparison of solubility of CH4 and CO2 in water at certain pressure [6]

2. H_2S Separation Unit

The biogas free from CO_2 is then passed through the next pipe containing iron wool. Hydrogen sulphide is removed by using catalyst iron oxide in the form of oxidized steel wool or iron turnings. We used waste iron oxide available in any machine workshop.

Once biogas comes in contact with this wool, iron oxide is converted into elemental sulphur. The pungent smell of biogas is because of the presence of H_2S present in it. The smell was removed after passing it through this separating unit. [7]

$$2Fe_2O_3 + 6H_2S = 2Fe_2S_3 + 6H_2O_2 \quad (2)$$

$$Fe_2S_3 + 3O_2 = 2Fe_2O_3 + 6S \quad (3)$$

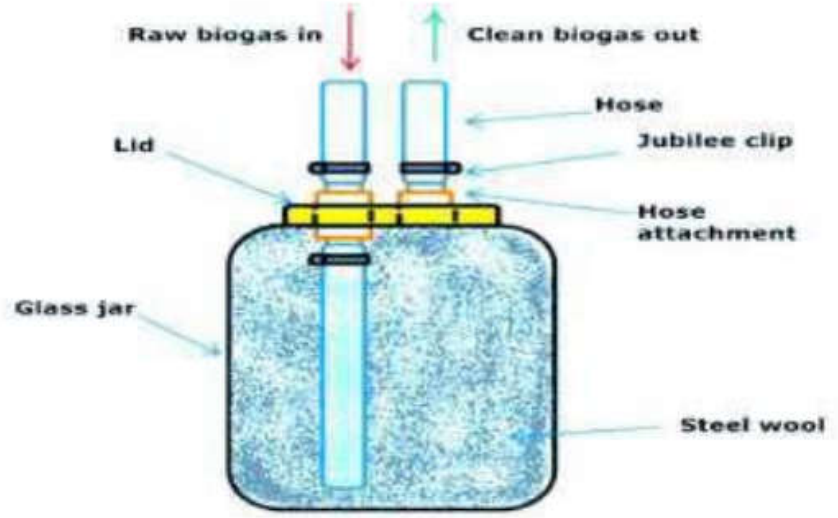

Fig.4 H_2S Separating Unit

3. Moisture Separating Unit

The biogas is then passed through a moisture separation unit containing coconut choir to separate moisture. As the the gas is passed through the water for the dissolution of CO2, the biogas has some moisture content which needs to be removed.The coconut bed should be replaced after a specific time according to the rate of purification. The capacity of the unit is decided according to the size of the biogas plant.

IV. UPGRADED BIOGAS ANALYSIS INSTRUMENT

Upgraded biogas tests are carried out to find out the amount of carbon dioxide which constitutes the major amount of composition of biogas. Also, nitrogen oxide and oxygen content are measured with the help of this gas analyser (Digas 444).

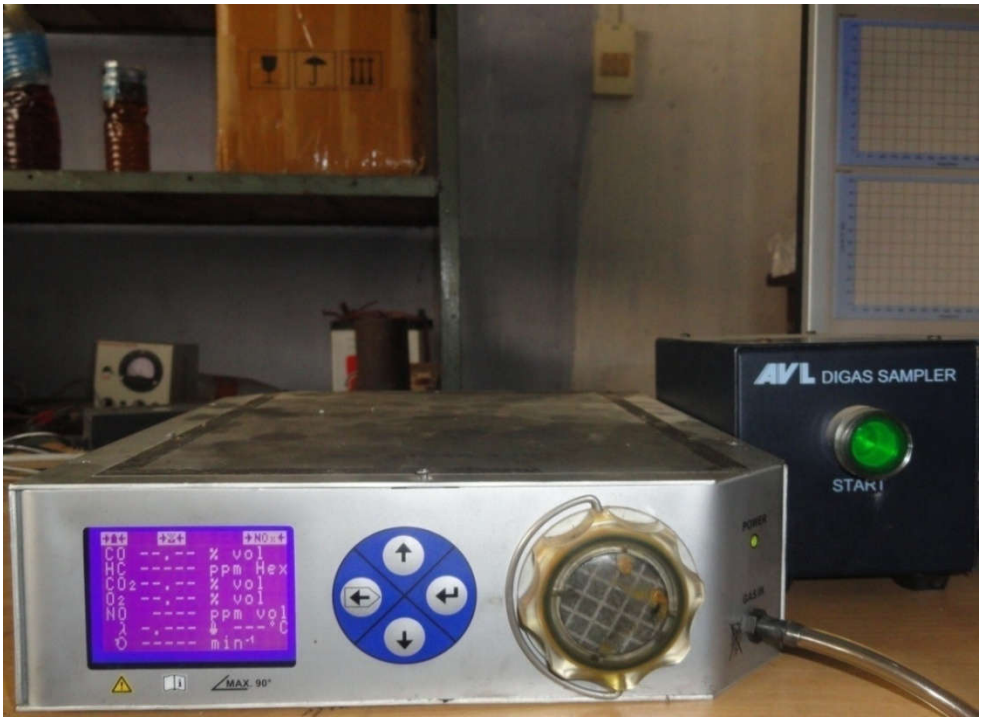

Fig.5 AVL Gas analyzer(Digas 444)

Table.1 Measuring range of Gas Analyzer

Measuring Quality	Measuring range
CO	0- 10%
CO_2	0-20%
HC	0-20000 ppm
O_2	0-22%
NO_x	0-5000 ppm

V. RESULTS

Table.2 Result Table

Composition	CNG	Raw Biogas	Biogas Composition India for Vehicle application	Upgraded biogas
Methene (Vol-%)	95	50-65	90	85
CO_2(Vol-%))	4	35-55	4	13
H_2S (ppm)	20	2000-3000	16	250
NH_3	Less	Traces	Less	Less
Moisture (mg/m^3)	Less	Traces	5	-
$S0_2$	Less	Traces	-	-
O_2	Less	Traces	0.5	-
$CO_2+N_2+O_2$	Less	-	10 (max)	-

VI. ADVANTAGES/APPLICATIONS

1. Only profit and no loss condition of farmers.
2. Use as a transportation fuel in vehicles, trains etc.

3. In engines for electricity production.
4. Injection into natural gas grid.
5. Environment friendly.
6. Reduce CH_4 and CO_2 emission worldwide.

VII. DISADVANTAGES

1. Frequent change of the scrubbing materials.
2. Feed material and slurry transportation cost is very high and limits the popularity of large biogas plant and community biogas.
3. Very less percentage of CH_4 compared to input raw material limits its application in petrol and diesel engine.
4. Unawareness of people about the potential of biogas after upgradation.
5. Bottling is another major issue restricting the use of biogas.

VIII. CONCLUSION

The aim of this study is to explore the potential of biogas production in India from animal waste and its prospects in wider perspective. Presently, biogas is mainly used for cooking purpose in India. To tap full potential of biogas, need emerges for its commercialization by making it transportable. Therefore biogas scrubbing and compression at high pressure for storage in cylinders are essential. Different methods of scrubbing are reviewed and found that water scrubbing is simple, continuous and less expensive method for CO_2 removal from biogas for Indian conditions.

It simultaneously also removes H_2S. After removal of CO_2, biogas is enriched in methane and becomes equivalent to natural gas. It can be used for all such applications for which natural gas is being used viz. as a fuel for vehicles, CHP, electricity generation, etc.

1. Raw CO_2 % is decreased from 43% to 13%.
2. H_2S is reduced from 2500 ppm to 250 ppm.
3. Upgraded Biogas is successfully compressed and bottled in cylinder.
4. CH_4 and CO_2 emission is successfully reduced.

IX. FUTURE SCOPE

1. Establishment of ideal village and installation of Biogas bottling & enrichment plant in village for farmers.
2. CH_4 recovery needs to be controlled and maximized.
3. Commercialization by making it transportable.
4. Making a mobile biogas upgrading unit.
5. Making upgraded biogas as a successful transportation fuel as an alternative to CNG.

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