Portable Biogas Purification System using NAOH Water Scrubber, Iron Wool and Silica Gel

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***Abstract*- — Energy is an essential prerequisite for accelerated economic development and improved quality of life for citizens of any country. Due to advancements in industrial and commercial sectors in the last few years, there is an increase in demand for non-conventional resources such as crude oil, coal, and fossil fuels. This spurred for replacing the current energy resources with renewable resources. About 70% population of India lives in rural areas and the majority of them are engaged in agriculture, animal husbandry and small-scale rural industries. Biogas is generated by anaerobic digestion of biomass such as cattle dung, vegetable waste, poultry droppings, industrial wastewater, municipal solid waste, and landfill, etc. In rural areas cattle dung and vegetable waste whereas in cities and urban area municipal solid waste are available in abundant quantity, from which biogas can be generated. Biogas is constituted of different component gases, the majority of them being methane (CH4), Carbon Dioxide (CO2) with traces of Hydrogen Sulfide, and moisture. It is possible to improve the quality of biogas by removal of CO2, H2S and enriching its methane content up to the natural gas level. After methane enrichment and compression, it can be used as vehicle fuel like compressed natural gas (CNG). Any cheaper and portable method to extract carbon dioxide and hydrogen sulfide from biogas can make biogas a userfriendly viable fuel. In this paper low-cost biogas purification system is proposed and is shown that using this system we can covert raw biogas into bio CNG which can be used as a vehicular fuel.**

Keywords— Purification, water scrubber, silica gel, iron wool, vacuum pump

I. INTRODUCTION

Biogas is generated by anaerobic digestion of biomass and organic waste. Micro-organisms are the main living organisms that contribute towards the production of biogas. The organic waste consists of cattle dung, vegetables, sheep and poultry droppings, municipal solid waste and industrial waste water. The biogas is used as a fuel since hundreds of years. Many researches have been done already for effective generation of biogas and its usage. Similarly, immense development had been done for purification of biogas.

Biogas applications are increasing day by day due to overload consumptions of existing conventional resources.
The different constituents in biogas are-

Constituents	Percentage
Methane	50-60
Carbon dioxide	30
Hydrogen Sulphide	10
Nitrogen	7
Other gas	3

The different types of biogas purification techniques are: -

A. Bio-scrubber-

In a bio-scrubber, a liquid is allowed to flow into a adsorption column in a counter current manner. In this column the pollutants are absorbed, similar to a water scrubber. Later, the water is sent to a bioreactor for microbes to cease the pollutants. Contaminants in the biogas contact absorb and adsorb and interact with the microorganisms. Bio-filtration are effective for treating high- and low-level hydrogen sulphide up to 50-120 ppm to 20004500 ppm. This results in a 89.99 % removal of H_2S.

1. Adsorption-

It is method of adhesion of pollutants to solid surface. When biogas is led to flow on the adsorbent bed the impurities tend to adhere to the surface and hence separating the contaminants from the main stream. Effective adsorbents have high surface area and great adhesive properties.
Pressure swing adsorption (PSA) is a technique foe removing carbon dioxide from methane by adsorbents. The adsorbents used mainly are activated carbon or carbon zeolites. These adsorbents are designed to be selectively permeable for specific pollutants.

2. Refrigeration and Chilling-

Chilling provides a quite easy means to remove moisture from biogas. Moisture can be reduced the effectiveness of biogas to a considerable amount. Therefore, removing moisture content

is a primary priority. In this technique the biogas is freezed to a temperature of -18 to -2 degrees. In such low temperatures the moisture content in the biogas condenses and can be accumulated and collected in separate traps. The main problem in this method is removal of hydrogen sulphide before refrigeration. This is because hydrogen sulphide is responsible for corrosion of the inner wall if the refrigeration unit and thereby damage the entire refrigeration process.

In this article, we emphasize on purification of biogas by avoiding the flaws in the existing techniques. The main objective to make the entire unit portable for all types of application, whether small or big or industrial or household applications. This system consists of namely three filters viz,

1) Water scrubber (8% NaOH).
2) Iron wool filter.
3) Silica breather.
4) vacuum suction pump.

II. METHODOLOGY

The main impurities which we had to remove were Carbon dioxide, sulphur and moisture; therefore we incorporated three different filters for the same. Biogas was passed through water scrubber(filter 1), iron wool filter(filter2), silica breather(filter) respectively. A suction pump was placed between the raw biogas source and the water scrubber which creates the necessary pressure difference to push the gas through all three filters. CO2 is filtered out in the water scrubber, H2S is treated in iron wool filter where the gas reacts with the iron pellets to form iron sulphide. The moisture absorbed by the gas affects the actual gas combustion and reduces its net heat output, thus the moisture present in the biogas is removed in silica breather.

A. Filter 1:

A thermoplastic polymer container is used for accommodating mixture of water and 8-10% NaOH which reacts with CO2 present in the biogas. A pvc pipe is connected to the filter via a suction pump and the gas inlet is air sealed. The pipe runs till bottom of the filter and biogas is bubbled upwards. An outlet is provided at the top which is at low pressure and serves a way for the biogas to move to the next filter.

B. Filter 2:

A pvc pipe connects the first filter to the iron wool filter. This is an air tight filter of thermoplastic material where we have interchanged the inlet and outlet port as it serves our requirement. A hollow perforated pipe is press fitted at the inlet port and stackings are provided to support the iron pellets. The stackings on the pipe are then wrapped around by iron wool which completes the 2nd filter. The pressured gas then leaves the filter through the outlet. C. Filter 3:

Biogas has a lot of moisture as it leaves the 2nd filter. This problem is addressed with the introduction of silica breather. Here, packets of silica beads are placed in the iron net cups held one above the other where the gas passes through the setup from bottom to up then to the to exit.

B. Reactions

Biogas is a mixture of gases that is composed chiefly of:

— Methane (CH4): 40-70 vol.%
— Carbon dioxide (CO2): 30-60 vol.%
— Other gases: 1-5 vol.% including
— Hydrogen (H2): 0-1 vol.%
— Hydrogen sulfide (H2S): 0-3 vol.%

III. RESULT

Sr No.	Tests	Results		Unit
		Before	After	
1	Oxygen	21.0	21.3	%
2	Carbon Dioxide	3000	2259	ppm
3	Carbon Monoxide	1000	160	ppm
4	Total Volatile Organic Compound	>1000	>1000	ppm
5	Ammonia	220	196	ppm
6	Formaldehyde	9.99	8.20	ppm
7	Hydrogen Sulphide	191	159	ppm

IV. CONCLUSION

The biogas compressing and purification plants are one of the most potent tools for climatic change by preventing black carbon emission from biomass chulha since biogas is used as a cooking fuel and methane emissions from untreated cattle dung and biomass wastes are also avoided. The purified biogas can be bottled in CNG cylinders or double membrane rubber balloons and wherever CNG is currently used, compressed biogas (CBG) or Bio-CNG can be used as an alternative. There is an immense potential for the generation of biogas in the country. In extra to the energy generation, biogas plants also provide bio-manure and are helpful in tackling with the issues of waste management, providing pure environment and mitigating pollution in urban, industrial and rural areas. Biogas is also a promising alternative to petroleum fuel like LPG, CNG, petrol and diesel.

Storage options for Biogas: -

Sr No.	PRESSURE	STORAGE DEVICE	MATERIAL
1	Low (up to 0.414 bar)	Water sealed gas holder	Steel
2	Low	Gas bag	Rubber, Plastic, Vinyl
3	Medium (up to 1.97 bar)	Propane or Butane tanks	Steel
4	High (200 bar)	Commercial gas cylinders	Alloy

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