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Biogas Up Gradation using Water Scrubbing for its use in Vehicular Applications

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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 rapid industrialization and urbanization in last few decades, there is a huge pressure on crude oil, coal and other fossil fuels. This resulted into need for finding some alternative sources of energy. Biogas is produced by anaerobic digestion of biomass such as cattle dung, vegetable waste, poultry droppings, industrial waste water, 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 (CH_4), Carbon Dioxide (CO_2) with traces of Hydrogen Sulfide, and water vapour. It is possible to improve quality of biogas by removal of CO_2, H_2S 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 low cost technique to remove carbon dioxide and hydrogen sulfide from biogas can make biogas a techno-commercially viable fuel and equivalent to natural gas. In this paper low cost biogas purification system using water scrubbing 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. It is the cheapest and easiest method of biogas up gradation in which pressurized water is used as absorbent. Water scrubbing involves physical absorption of CO_2 and H_2S in water at high pressure and regeneration by a release in pressure with very little change in temperature.

Keywords: Raw Biogas, Removal of CO_2 /H_2S from biogas, Water scrubbing of biogas.

I. INTRODUCTION

Biogas may provide a sustainable solution of oil crisis replacing oil use in transport and agriculture sector. It may create pollution free environment by reducing green house gas emissions. India has very high population of livestock. In India use of cattle dung is widespread in rural areas as cooking fuel in the form of dung cake or as compost. If for cattle dung biomethanation is carried out it can provide clean fuel in form of biogas and slurry as good quality compost. This may result into reduced consumption of fossil fuels like crude oil, coal, natural gas etc. as well as fertilizer. One cow approximately generates 10 kg of wet dung per day in India and gas yield observed is 0.04 m^3/kg of cattle dung.

Biogas typically consists of methane 50-70 %, carbon dioxide (30-45%) and traces of water vapour and hydrogen sulphide (H_2S).Depending on feedstock this composition of biogas may vary. Biogas is a cheap and clean fuel for cooking, lighting and running engines for producing power. The biogas produced in 4 m^3/day capacity biogas plant has enough energy to cook meals for 25 persons /day or to light lamp of 100 candle power for 20-25 hours or to generate 5 kw of electricity. [1]

To use biogas as vehicle fuel, it is first enriched in methane content and then compressed in a three or four stage compressor up to a pressure of 20 MPa and stored in high pressure cylinder. Being a gaseous fuel, biogas provides excellent cold starting for vehicle because unlike petrol it is
not needed to be vaporized first. [2]

II. NEED FOR BIOGAS ENRICHMENT AND COMPRESSION

Biogas produced is generally stored in digesters or large impermeable bags at biogas plant site. The gas produced in digester is transported by piping to nearby kitchens on pressure developed in digester. But this pressure is not sufficient to transfer gas to farther distances from the biogas generation site. This is why use of biogas has been restricted to few locations. Most digesters will have limited capacity to store biogas produced. If there is any large capacity biogas plant, sometimes produced biogas is not used in full quantity locally (when demand is less than production) resulting into interrupted operation of biogas plant. This problem can be overcome if biogas is compressed and stored in cylinders like other gases, since liquefication of biogas under normal conditions is not possible (like liquefied petroleum gas).Critical temperature for liquefication for methane is -82.1 ° C at 4.71 MPa pressure.[2]

But biogas contains considerable amount of CO_2, H_2S and water vapour which have practically no use as fuel. Presence of methane renders biogas combustible whereas carbon dioxide being a non combustible restrains its compressibility there by making it difficult to be stored in cylinders.

Presence of CO_2 in biogas poses following problems: i) It takes up space when biogas is compressed and stored in cylinder ii) As it is non combustible, power used in compressing CO_2 can be considered wastage.iii) Its

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presence in biogas may lower power output from engine operation. iv) It can cause freezing problems at valves and metering points where the compressed gas undergoes expansion during engine running.

- Removal of CO_2 from biogas enriches biogas in terms of its methane content. Methane burns faster hence yields a higher specific output and thermal efficiency compared to raw biogas when used as fuel.
- H_2S usually amounts to less than 1 % on volume basis in cattle dung based biogas, which is not much harmful. But its concentration more than this may cause corrosion in pipe lines and engines [3]
- Water vapour present in raw biogas also enhances corrosion and decreases heating values of fuel.

So it is essential to enrich the biogas before compression by removing CO_2, H_2S and water vapour to make it suitable as engine fuel.

Compressing biogas reduces storage space requirements, concentrates energy content and increases pressure to the level needed to overcome resistance to flow. Sometimes biogas generation / storage pressure is not as required by the equipment which will be using it (e.g. engine). Compression can eliminate mismatch of pressures and guarantee the efficient operation of the equipment.

Cost of compression will reduce when enriched biogas is used compared to raw biogas. Compressed purified biogas will have higher heating value making it suitable for vehicular engines.

Enriched and compressed biogas can easily be used in i) transportation e.g. auto rickshaw, pick up vans, cars and buses ii) stationary engines used to run water lifting pump for irrigation at remote and distance places.

Biogas can be used as vehicle fuel also. It has been successfully used by European countries like Germany, Sweden, and Switzerland in vehicular engines. CNG kit used for automobile engines can be used without any modification when purified biogas is used as fuel. [4]

III. WATER SCRUBBING

Water scrubbing involves physical absorption of CO_2 and H_2S in water at high pressure and regeneration by a release in pressure with very little change in temperature. CO_2 present in raw biogas reacts with water and carbonic acid is formed.

$$CO_2 + H_2O \rightarrow H_2CO_3.$$

It is the cheapest and easiest method of biogas up gradation in which pressurized water is used as absorbent. The raw biogas can be fed directly at storage pressure or can be compressed and fed to scrubber column from bottom whereas pressurized water is sprayed though nozzles from top of the column. Absorption process is thus made counter current one. This dissolves CO_2 as well as H_2S in water.

The H_2S and CO_2 can be selectively removed through physical absorption that works because both CO_2 and H_2S are more soluble than methane in water.

Since H_2S is more soluble than carbon dioxide in water, water scrubbing can also be used for selective removal of H_2S by further increasing the pressure of the biogas.

Fig.1 Photo of Water Scrubber

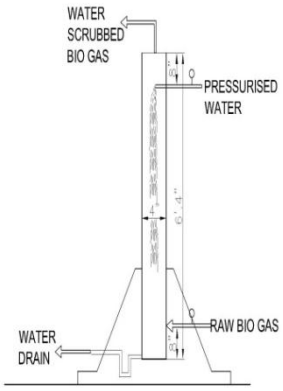

Fig.2 Schematic Arrangement of Water Scrubber

WORKING:

A 6 feet 4 inch pipe made of UPVC having diameter of 4 inch was used to develop a water scrubber for biogas. Water was supplied from upper side (8 inch down from top) of scrubber column and was sprayed through nozzle. Raw biogas was fed from bottom side (8 inch up from bottom) of scrubber column thus providing 5 feet height for scrubbing of raw biogas using water.

Water was pumped using pump of capacity 1100 litre per hour and head of 10 feet and was sprayed through nozzle. Raw biogas entered from biogas plant directly. Here biogas was not compressed. Water after scrubbing was drained from bottom of the scrubber in path of which U bend was provided which was used to store water and prevent biogas going out. Biogas after getting scrubbed comes out from top of the scrubber. Sample of raw and scrubbed biogas were given to a laboratory to know their composition.

IV. RESULTS AND CONCLUSION

Composition of raw biogas and water scrubbed biogas found is as shown in following table:

TABLE-I COMPOSITION OF RAW BIOGAS AND WATER SCRUBBED BIOGAS

Content	Raw Biogas	Water Scrubbed Biogas
Methane %	61.22	89.54
Carbon Dioxide%	32.01	5.02

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HydrogenSulphide, ppm	986	112
Oxygen %	2.76	1.75
Moisture	3.91	3.59

From above table we can say by water scrubbing,

i) Methane % in raw biogas which was 61.22% increased to 89.54%.

ii) Carbon Dioxide % in raw biogas which was 32.01 % reduced to 5.02%.

iii) Hydrogen Sulphide which was 986 ppm in raw biogas was reduced to 112 ppm.

This water scrubbed biogas is identical to natural gas and is also known as Bio CNG. Which can be used for i) cooking purpose and can provide better heating compared to raw biogas ii) to run stationary engine for better engine performance compared to raw biogas.

This Bio CNG was compressed using compressor used in air-conditioner and was stored in tire tube of tractor successfully without any problem. So it can be concluded that this bio CNG is compressible. Using CNG kit available in market, this compressed bio CNG can be used as fuel for vehicular applications.

The water containing absorbed H_2S/CO_2 can be regenerated by de-pressurizing or by stripping the water with air in a similar column.

When water is available in abundant quantity at site, the most cost efficient method is not to re-circulate the water.

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REFERENCES

1. Khandelwal and Mahdi , Biogas Technology : A Practical Handbook , Tata Mc Graw Hill Publishing Co. (1986)
2. Mittal K.M., Biogas Systems: Principles and Applications. New Age International Pvt. Ltd.(1992)
3. V K Vijay (1989) Studies on utilization of biogas for improved performance of duel fuel engine. M E (Ag.) thesis. CTAE Udaipur
4. V.K.Vijay , S.S.Kapdi (2006): Biogas Purification and bottling into CNG cylinders : Producing BioCNG from biomass for Rural Automotive Applications ‘, The second joint international conference on “ Sustainable Energy and Environment “ Bangkok