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DESIGN FOR BOTTLING OF BIO GAS

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ABSTRACT: In the present scenario of dwindling petroleum resources and global warming, exploring other avenues for eco-friendly fuels became essential. Biogas which is a clean and environmental friendly fuel emerged as one of the potential alternative fuels.Raw biogas contains about 50-70% methane (CH4), 30-40% carbon dioxide (CO2), traces of Hydrogen sulphide(H2S) and fractions of water vapours. But its wide spread use is hampered by the associated problems like low energy density due to the presence of impurities, generation at low pressures and the absence of means for storing and transporting.
In this context this work intends to design and establish a facility at the site of biogas production in the campus for purifying, compressing, bottling and making it transportable.
Keywords: biogas, purification, compression, bottling.

I. INTRODUCTION

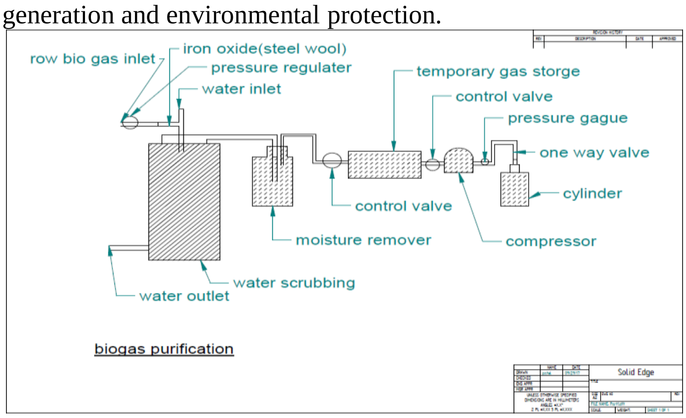
Biogas is generated when bacteria degrade biological material in the absence of oxygen; in a process known as anaerobic digestion. Since biogas is a mixture of methane (CH4), carbon dioxide (CO2), hydrogen sulphide and traces of water vapour. It is a renewable fuel produced from waste treatment. Anaerobic digestion is basically a simple process carried out in a number of steps by many different bacteria that can use almost any organic material as a substrate – it occurs in digestive systems, marshes, rubbish dumps, septic tanks and the Arctic Tundra. Biogas is a gas produced from organic materials such as animal manure, human excreta, kitchen remains, crops straws and leaves after decomposition and fermentation under air tight (no oxygen) condition. Main products of the anaerobic digestion are biogas and slurry. it conserves the natural resources from cutting trees to get firewood, as shown in table 1.

Substances	Symbol	Percentage
Methane	CH_4	50-70 %
Carbon dioxide	CO_2	30-40 %
Hydrogen	H_2	5-10 %
Nitrogen	N_2	1-2 %
Water Vapour	H_2O	0.3 %
Hydrogen Sulphide	H_2S	Traces

Table 1:- Composition of biogas.

1.1 PROPERTIES OF BIOGAS:
1. Change in volume as a function of temperature and pressure.
2. Change in calorific value as function of temperature ,pressure and water vapour content.
3. Change in water vapour as a function of temperature and pressure.

1.2 BENEFITS OF BIOGAS TECHNOLOGY:
1. Production of energy.
2. Trnsformation of organic wastes to very high quality fertilizer.
3. Improvement of hygienic conditions through reduction of pathogens.
4. Environmental advantages through protection of soil, water, air etc.
5. Micro-economical benefits by energy and fertilizer substitutes.
6. Macro-economical benefits through decentralizes energy generation and environmental protection.



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1.3 USER DEFINE PROBLEM

Problem
It is suggested that limitations also exists based upon maximum requirements of biogas in the user community. Most digesters will have limited capacity to store the product of their fermentation and, should demand not exceed supply, biogas production will be slowed. This is inefficient and occurs due to the lack of safe methods of transportation and storage.
Purpose
If biogas is stored, it will be at the digestion site in large impermeable bags. In regions where piping systems are unachievable, biogas systems prove to be unsustainable and such systems may fail. So it is necessary to compress the biogas & store it in bottles/Cylinders so that it can be used in place of LPG and can be transported as per requirements. Even it can be used in place of CNG cylinders as a clean &

green fuel to the vehicles.

Scope

Enriched biogas is made moisture free by passing it through filters after that it is compressed up to 200 bar pressure using a three stage gas compressor. Compressed gas is stored in high pressure steel cylinders as used for CNG. There is large potential of this technology in buses, tractors, cars, auto rickshaws, irrigation pump sets and in rural industries. This will help to meet our energy demand for rural masses thus reduces burden of petroleum demand, moves towards energy security and will improve economic status by creating employment +generation in rural area.

Present Scenario in India

Biogas has mostly been used as fuel for cooking and running stationary engines. However, its potential has not fully utilized, yet. There is a great enhancement in its utilization potential particularly where bigger plants are in operation e.g. institutional biogas plants in Gaushalas, dairy farms or community biogas plants in villages. Gaushalas are running generally on charity basis and most of Gaushalas are not in sound financial position. Enrichment and bottling of biogas will help to improve it.

II. TERMINOLOGY

2.1 MATERIAL AND METHOD USED COMPRESSOR

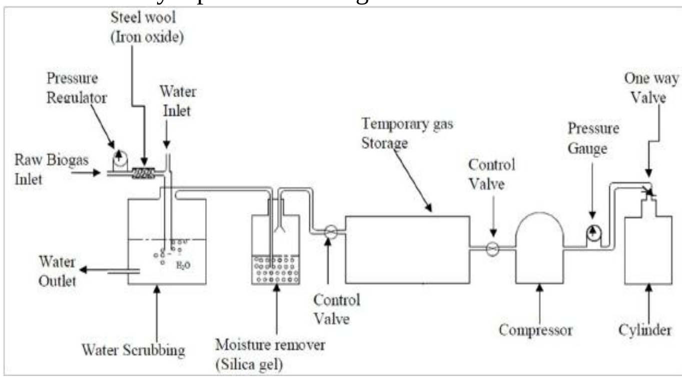
Biogas compressors are readily available in the local market in the range of 2.5 bar up to 200 bars. Depending on the application a suitable compressor can be chosen. This paper proposes a suitable hand compressor with a compressibility of 4-5 bars. The hand compressor works on the principle of suction and compression similar to that of a bicycle pump. The hand compressor consists of one inlet for biogas to enter in and one outlet for compressed biogas. The hand compressor consists of specific valve at its base which consists of two ports, one port for suction and other for compression.

PARAMETERS	ACTUAL VALUE
Diameter of cylinder	290mm
Stroke length	200mm
Thickness of cylinder	5.2mm
Compressibility	5-6 bars

The procedures followed in this experiment involves: Designing and establishing of biogas purification, compression and bottling unit and Executing different tests, namely amount of carbon dioxide in the biogas test, water acidity test and water boiling test. Due to unavailability of standard measuring instruments (Gas Analyser) required to verifying the results, experiments were limited and improvements were made through trial and error, i.e. only by the evaluation of amount of CO2 available in the gas.

2.2 DESIGN AND ESTABLISHMENT OF BIOGAS AND STORAGE FACILITY

The designed biogas scrubbing and storage facility is composed of two units, namely the scrubbing unit and the storage unit. The entire biogas scrubbing and storage facility is schematically represented in Figure.



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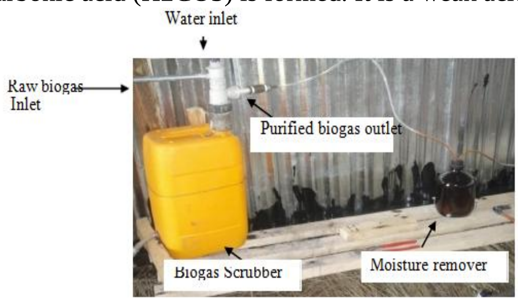
2.3 BIOGAS SCRUBBLING

The biogas scrubbing system consists of three units, the hydrogen sulphide (H2S) removing unit, Carbon dioxide (CO2) removing unit, and moisture trapping unit. The three units are interconnected with plastic hoses. In the purification process of biogas which was conducted; steel wool, pure water and an adsorbent material (silica gel) were used. The steel wool is to react with the hydrogen sulphide, the water is to reduce the percentage of carbon dioxide and the silica gel is to reduce the presence of water vapour in the purified biogas. The experiment was done by taking the raw biogas with pressurebuilds up in the digester head and forced through the steel wool on its way to the biogas scrubber unit to remove hydrogen sulphide.

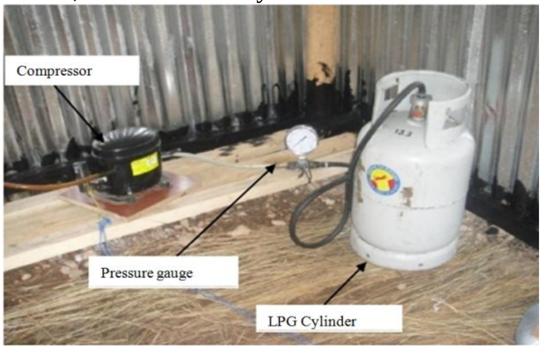
After the hydrogen sulphide was removed by the steel wool, the raw biogas passes into the water scrubbing unit for further purification. When carbon dioxide dissolved in water carbonic acid (H2CO3) is formed. It is a weak acid.



The liquid leaving the scrubbing unit will thus contain increased concentration of carbon dioxide, 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. To reach water contents as low as in the purified biogas, silica gel was used in this experimental set up. Silica gel is a material that has a capability of absorbing moisture.

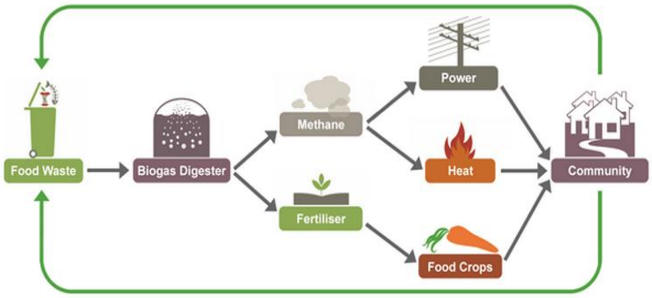
2.4 BIOGAS COMPRESSION AND STORAGE

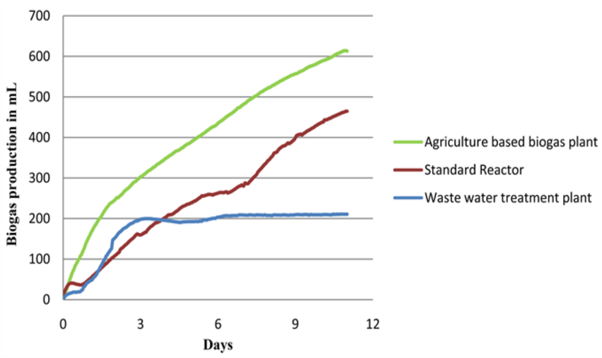
The biogas storage system consists of three units; a compressor, a pressure gauge and an LPG cylinder. The compressor used in the experiment is a hermetic reciprocating type compressor used in the manufacture of commercial refrigerators with a hydrocarbon refrigerant. The pressure of the gas at various points of compression can be noted using pressure gauge. For storing the gas after compression, a normal LPG cylinder was used.

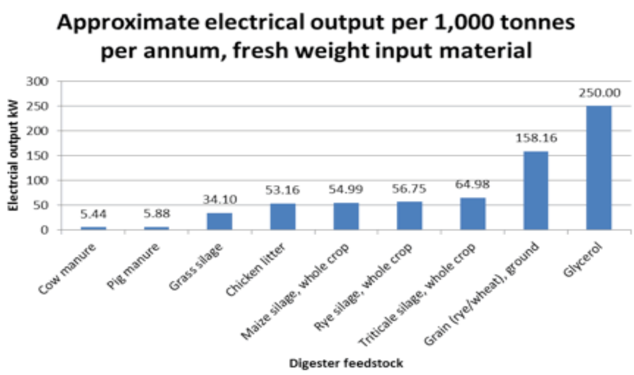


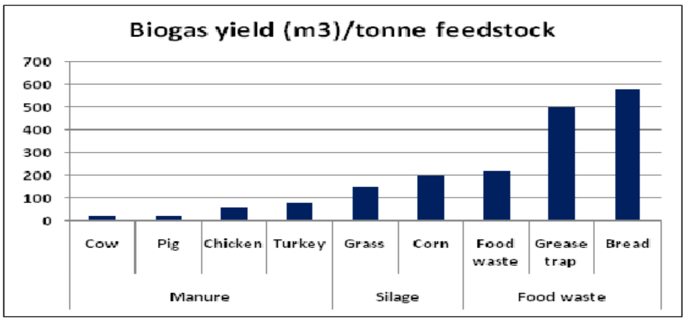
FLOW DIAGRAM OF BIOGAS PLANT

Images are taken from the google patent and research papers.









III. DESIGN& CALCULATION

3.1 Cost of Bottling:-

50 percent less than LPG cylinder.

Capacity of tan: - most economic size is 300 meter cube for commercial purpose

Cost of project: - depends upon capacity of pant, varies from 2.5 laces to 5 laces (for large scale).

For our project minimum cost up to RS 30000.

According to an estimate, it can give fuel efficiency of 12 to 15 km/kg.

Whereas in comparison CNG cost is around 24rs per KG and LPG cost is 90rs per KG.

3.2 Calculation:-

Calorific value of LPG = 50 MJ/KG

Calorific value of methane = 55 MJ/KG

Percent of methane in biogas = 60%

Calorific value of biogas = 33 MJ/KG and 24 MJ/meter cube

1 meter cube capacity reactor produces = 0.7 meter cub/day

Feed capacity for 50 meter cube reactor = 35 meter cube/day

Gas produced by50 meter cube reactor = 35 meter cube/day

Density of biogas = 1.15 KG/meter cube

Height of the digester cylinder body = 3 meter

Radius of the digester cylinder boy = 10 meter

Height of the digester top dome body = 0.2500 meter

Radius of the digester top dome = 1 meter

Calorific value of one cylinder of LPG = 950 MJ/KG

Meter cube of biogas equivalent to 1 cylinder = 45.52 meter cube

Gas production – G=W*0.012 (for 1 meter cube biogas, W=83.3KG biomass)

Active slurry volume, Vs. = HRT*2W/1000

The size of the digester - the digester volume (VD) - is determined by the length of the retention

Time (RT) and by the amount of fermentation slurry supplied daily (SD). The amount of fermentation

Slurry consists of the feed material (e.g., cattle dung) and the mixing water.

Example:-

30 l dung + 30 l water = 60 l fermentation slurry

The digester volume is calculated by the formula

VD (l) = SD (l/day) x RT (days)

Example:-

Daily supply (SD): 60 l

Retention time (RT): 80 days

Digester volume (VD):

60 l/day x 80 days = 4800 1 (4.8 m^3)

For a specific digester volume and a known amount of

fermentation slurry, the actual retention time is given by the formula
RT (days) = VD (l) -:-SD (l/day)

Example:-
Digester volume (VD): 4800 l
Daily supply (SD): 60 l/day
Retention time (RT):
4800-:- 60 l/day = 80 day

IV. RESULTS AND CONCLUSION

4.1 Purification

Purification of the gas was done using different methods and relative purity of the gas was tested by water boiling test. From this experimental result the amount of methane available in the raw and purified biogas was approximately 68± 2.52 % and 90 ± 1.53 % respectively. Scrubbing is an operation that removes H_2S from raw biogas; as a result the hydrogen sulphide is converted into black iron sulphide by the steel wool. The steel wool used before and after scrubbing is shown in figure.

Steel wool before scrubbing

Steel wool after scrubbing

Silica gel before scrubbing

Silica gel turns pink once it has soaked up moisture

4.2 Effect of purification on heating valve

In order to clarify the impact of purification on the heating value and cooking time of the purified biogas, purified and raw biogas were used to heat 500 ml of water as shown in table 2. Due to unavailability of gas analyser, calorific value of raw biogas and purified biogas were compared by heating 500 ml of water.

Table 2: Time for boiling 500 ml of water

Energy Source	Time (minutes) for boiling 500 ml of water
Raw biogas	5.62 ± 0.02
Purified biogas	4.54 ± 0.03

The reduced heating time required by the purified biogas means the calorific heating value of the purified biogas was more than that of raw biogas. This is because only methane contributes to the combustion property where as the other mixture is useless, toxic or harmful. Therefore it is very necessary to remove CO_2 from raw biogas in order to increase its calorific value.

4.3 Water acidity test

This experimental test was done to know whether carbon dioxide dissolves with water or not. During biogas scrubbing, carbon dioxide dissolves with water and gives carbonic acid. Carbonic acid is a weak acid. Measuring its pHvalue is helpful in determining the acidity of water outgoing from the scrubbing unit. The pH value of pure water and water outgoing from the scrubbing unit was 6.6 ± 0.21 and 4.9 ± 0.15 respectively. From the test result we conclude that carbon dioxide was dissolved in water and removed from raw biogas.

4.4 Compression and storage

The storage of biogas may also be a problem, as it is always with gaseous products. Biogas could not be stored easily, as it does not liquefy under pressure at ambient temperature. Its critical temperature and pressure are -82.5°C and47.5bar. Compressing the biogas reduces the storage requirements, offers concentrated energy content and gives pressure to overcome the resistance to gas flow. Most commonly used biogas storage options are in propane or butane tanks and commercial gas cylinders up to 200bar. Depending on the application of biogas (e.g. vehicle fuel, domestic cooking) the storage facilities vary (Demirbas,M.F et al, 2006).

Biogas is not typically produced at the time it is needed or in the quantity needed to satisfy the conversion system load that it serves. Therefore, compression and storage of biogas is important in order to smooth out variations in gas production, gas quality and gas consumption. The storage component also acts as a reservoir, allowing downstream equipment to operate at a constant pressure. Finally, the purified and dried biogas was compressed into an LPG cylinder by using a refrigerant reciprocating compressor up to an absolute pressure of 5 bars in total of 12-14 minutes.

4.5 WORKING OF PROJECT

By an approximate formula, 100 cows will give/day 1000/Kg of cow dung; this in a bio digester will yield about 40 m^3 of Gobar gas. After removing impurities such as CO_2, Sulphur, Moisture etc. will yield about 20M^3 or 17Kg of pure methane gas. It is only now that, a Technology has been developed by us, enabling the use of this gas from Bio digester. Gobar gas is purified of all impurities and moisture. Pure Methane gas is than Compressed. This Compressed Bio - Gas is capable of running Power plants & Vehicles.

Brief description & operation of the plant is as under:
This Project is designed for Bottling Biogas Generating power using non-conventional energy. Driving conventional vehicles using non-conventional energy.

The Project has two parts:
1st part: Biogas is an economical, renewable and an eco-friendly fuel. Biogas is produced in an anaerobic digester i.e. a Gobar gas plant. Biogas generated from the digester is allowed to flow through moisture traps. This process drains out the Moisture present in the gas. The gas is than allowed to counter flow in a specially designed Sulphide extractor. This filter drains out Balance Moisture along with the present sulphides. Treated gas is pressurized with the help of a primary compressor. The filters mounted drain out any present moisture and Oil present post compression. The pressurized clean gas is than passed through a Physical Separation Device. The Physical Separation Device is a specially designed modern high pressure combined directional flow device for cleaning Biogas of it high impurities. A measuring device is fitted after the filters to gauge the quantum of clean Methane gas collected in the collecting tank.

2nd part: This part of our system now deals in bottling this clean Methane gas into a standard CNG bottle. Gaseous Fuel generates maximum efficiency when it is injected into any CNG converted Internal combustion Engine with the desired constant pressure. The cleaned Methane gas is than taken into a 3-Stage high-pressure compressor. The compressor compresses the gas from
a) Atmospheric to 10Kg/cm2 in stage I.
b) 10Kg/cm2 to 60Kg/ cm2 in stage II.
c) 60Kg/cm2 to 250Kg/ cm2 in stage III.
This pressure is considered suitable to fill up a CNG bottle rack. This CNG Bottle Rack can then be connected to a standard CNG Dispenser unit. Now this purified Gobar gas is ready to be used as Fuel in a motor car, or run a Gas Turbine or any CNG converted internal combustion engine connected to an alternator to produce electricity.

4.6 Biogas Composition and Properties
Biogas comprises of 50-70% methane, 30-40% carbon dioxide, 0.5-1.0% hydrogen sulphide, rests of watervapour etc. Biogas is non-toxic, color less and flammable gas. It has an ignition temperature of 650 - 7500C. Its density is 1.214kg/ m3 (assuming about 60% Methane and 40% CO2). Its calorific value is 20 MJ/m3 (or 4700 kcal.). It is almost 20% lighter than air. Biogas, like Liquefied Petroleum Gas (LPG) cannot be converted into liquid state under normal temperature and pressure. It liquefies at a pressure of about 47.4 Kg/cm2 at a critical temperature of -82.10c. Removing carbon dioxide, Hydrogen Sulfide, moisture and compressing it into cylinders makes it easily usable for transport applications & also for stationary applications. 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. Purified biogas (bio-methane) has a high calorific value in comparison to raw biogas.

4.7 COMPONENTS USED

CYLINDER PRESSURE GAUGE

BALL VAVLE

SAFTY VALVE

V. CONCLUSION

As a matter of fact, the biogas-bottling plants are one of the most potent tools for mitigating 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 and wherever CNG is currently used, compressed biogas (CBG) can be used as an alternative.
Biogas is a potential renewable energy and carbon neutral source for rural as well as for urban India. There is a need for tax incentives, support, and regulations in this direction from the government to enable our country to be self-reliant in the energy sector.
Taking biogas generation as a base activity and compressing it for decentralized power production, cooking needs at highway motels, industrial complex, dairy, food processing units can be taken up, which will not only help us to-wards reducing unemployment and alleviating economy, it will also help us mitigate climate change by the use of bio-energy in an efficient way.
In this paper efforts are made to exploit biomass resources in the region and suggest some of the cost effective and environment friendly ways to meet the demand.
The cost analysis predict in spite of having huge capital and installation cost renewable energy sources prove to be more reliable and environmental friendly source to provide electricity in remote or off grid areas.

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