Biogas Purification and Methane-Enrichment for Efficient Combustion

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Applications of Biogas

- **Domestic:**
  - Cooking and/or lighting

- **Industrial:**
  - Power Generation
  - Fuel in other industrial applications

- **Vehicular:**
  - CNG is cheaper alternative to petrol and diesel
  - Purified biogas can be used as a CNG substitute
The Biogas Ecosystem

- Suitable raw material fed to digesters
- Digesters produce raw biogas containing the following:
  - CH$_4$ : 55-65%
  - CO$_2$ : 35-45%
  - Water vapour : Fully Saturated
  - H$_2$S : Up to 3%
- Bio Fertilizer separately produced
- Raw biogas obtained can be bottled in cylinders or supplied for desired application through pipelines, after purification
**Need for purification**

- Not suitable for use in Gensets or as Automobile Fuel as a CNG substitute, without enrichment
  - The unwanted compounds in raw biogas can lead to engine problems

- Required to increase its Calorific Value and to remove traces of harmful gases
  - In many cases, compliance with environmental regulations to be achieved

- Transporting large quantities of unusable portions of raw biogas an unnecessary cost burden
Removal of impurities

- $\text{H}_2\text{S}$, $\text{H}_2\text{O}$ and $\text{CO}_2$ need to be removed
  - $\text{H}_2\text{S}$ mainly removed by catalytic / chemical process, absorption on Activated carbon/physical process or micro-organisms/biological process

- $\text{H}_2\text{O}$ mainly removed by condensation by cooling to low temperatures or drying over Activated Alumina/Molecular Sieves, or absorption in glycol or hygroscopic salts

- $\text{CO}_2$ mainly removed by MEA system or adsorption over molecular sieves
Technologies Used

- Purification (Enrichment) methods
  - Absorption (scrubbing)
  - Pressure Swing Adsorption (PSA)
  - Cryogenic
  - Gas membranes
Absorption (Scrubbing)

- Removal of H$_2$S and CO$_2$
- Most common solvent used is water
- Efficiency of scrubbing depends on the solubility which depends on
  - Pressure
  - Temperature
  - pH of water.
Pressure swing adsorption

- Adsorbents such as activated carbon and molecular sieves are used
- Selectivity of adsorption is based on different molecular weight and molecular size
- Adsorption is carried out at high pressure
  Desorption is carried out at lower pressure

Advantages of PSA process
- Simple & seamless operation
- Consistent purity of gas is achieved
- Clean process requiring very less floor area
- Dry product gas is produced
Cryogenic separation

- Boiling point:
  - CH\textsubscript{4} : (-)160°C
  - CO\textsubscript{2} : (-)79°C

- Separation of CO\textsubscript{2} by converting to liquid form by way of cooling the biogas to Critical Temperature at Critical Pressure

- Expensive, and hence not practical
Membranes

- Permeability of components through membrane depends on partial pressure.
- High pressure is required.
- Some CH$_4$ losses occur.
Principle of PSA Biogas Purification

- Specially designed adsorbent
- This adsorbent (or molecular sieves) having a micro pore on its surface adsorbs CO2, N2, H2S and H2O molecules selectively under a certain pressure
- After the adsorption process, adsorbent is regenerated by depressurizing
- The PSA systems produce the Purified Methane enriched gas continuously by repeating the above adsorption and regeneration processes
Molecular Sieves (MS)

CH4

CH4

CH4

CH4

3.23Å

CO2

5Å

H2S

CO2

H2O

CO2

H2O

CO2

Magnified View of Molecular Sieves
Flow Diagram of PSA System

Adsorption Columns

Biogas → Coarse H2S Removal → Exhauster Gas

Methane

Silencer
Our Involvement

- We design and manufacture **Scrubbing** and **PSA** technology based Biogas Purification Systems
  - Invented and introduced adsorption based purification systems in India
  - Pioneers and leading supplier in this field
  - Scaled up operations over the years and in addition to the smaller capacity plants, we’re now into much bigger sized industrial purification units – of the order of 25-30,000 Nm3/day – which are very economical and cost-effective when compared to alternatives

- We provide **analyzers** for measuring percentage composition of various constituents of biogas
Our Involvement (contd.)

- Distribution networks
  - Member of committee formed by the Ministry of NonConventional Energy (Govt. of India) to evolve norms for proper framework of biogas generation, purification & compression, and distribution
  - Biogas bottled in LPG or CNG cylinders using compressors (at ~10-15 bar and 200-250 bar respectively) - we deal in such compressors and other fittings and filling systems
  - Or stored and transported in high pressure tanks – we provide these pressure vessels

- Also design and manufacture biogas and biomass fired boilers, which can take this fuel intake for generation of heat – commonly used in sugar factories who have natural access to the raw material required
Summary

- Biogas, if purified, can be used for various applications replacing traditional sources of energy such as fossil fuels

- Purification is definitely required for transportation and storage of gas & for vehicular use

- PSA system has the unique advantage of
  - simultaneous removal of various impurities
  - being economical for large scale industrial applications compared to other technologies
Thank You!

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