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Biogas: Cleaning and Uses

Biogas consists of methane (CH_4) and carbon-dioxide (CO_2) along with some trace gases such as water vapour, hydrogen sulphide (H_2S), nitrogen, hydrogen and oxygen.

Carbon dioxide and trace gases such as water vapour and H_2S must be removed before the biogas can be used because:

- the hydrogen sulphide gas is corrosive
- water vapour may cause corrosion when combined with H_2S on metal surfaces and reduce the heating value

Uses

Biogas is mostly used as a fuel in power generators and boilers. For these uses, the H_2S content in biogas should be less than 200 parts per million (ppm) to ensure a long life for the power and heat generators.

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Biogas can also be upgraded to pipeline natural gas quality for use as a renewable natural gas. This upgraded gas may be used for residential heating and as vehicle fuel.

When distributing the biogas using pipelines, Canadian oil and gas pipeline standards may become applicable. According to Canadian oil and gas pipeline standards, the H_2S content shall not exceed 4.6 ppm at 0 C. The CO_2 level should be lower than two per cent (CH_4> 95 %).

Removing water vapour is easier than removing CO_2 and H_2S from biogas. A condensate trap at a proper location on the gas pipeline can remove water vapour as warm biogas cools by itself after leaving the digester.

Producing pipeline gas quality requires the use of advanced and expensive technologies. The cost of cleaning and producing pipeline quality gas (renewable natural gas) is $3 to 6/GJ and $6 to 12/GJ, respectively.

The following sections include brief information about these technologies as well as about using biogas as a transportation fuel.

CO_2 removal

Water scrubbing

Carbon dioxide is soluble in water. Water scrubbing uses the higher solubility of CO_2 in water to separate the CO_2 from biogas. This process is done under high pressure and removes H_2S as well as CO_2. The main disadvantage of this process is that it requires a large volume of water that must be purified and recycled.

Polyethylene glycol scrubbing

This process is similar to water scrubbing; however, it is more efficient. It also requires the regeneration of a large volume of polyethylene glycol.

Carbon molecular sieves

The carbon molecular sieve method uses differential adsorption characteristics to separate CH_4 and CO_2. This adsorption is carried out at high pressure and is also known as pressure swing adsorption. For this process to be successful, H_2S should be removed before the adsorption process.

Membrane separation

There are two membrane separation techniques:

- high pressure gas separation
- gas-liquid adsorption

The high pressure separation process selectively separates H_2S and CO_2 from CH_4. Usually, this separation is performed in three stages and produces 96 per cent pure CH_4.

Gas liquid adsorption is a new development and uses microporous hydrophobic membranes as an interface between gas and liquids. The CO_2 and H_2S dissolve while the methane (in the gas) is collected for use.

H_2S removal

Biological desulphurization

Natural bacteria can convert H_2S into elemental sulphur in the presence of oxygen and iron. This can be done by introducing a small amount (two to five per cent) of air into the head space of the digester. As a result, deposits of elemental sulphur will be formed in the digester. Even though this situation will reduce the H_2S level, it will not lower it below that recommended for pipeline-quality gas.

This process may be optimized by a more sophisticated design where air is bubbled through the digester feed material.

It is critical that the introduction of the air be carefully controlled to avoid reducing the amount of biogas that is produced.

Iron/iron oxide reaction

Hydrogen sulphide reacts readily with either iron oxide or iron chloride to form insoluble iron sulphide.

The reaction can be exploited by adding the iron chloride to the digester feed material or passing the biogas through a bed of iron oxide-containing material. The iron oxide comes in different forms such as rusty steel wool, iron oxide pellets or wood pellets coated with iron oxide.

The iron oxide media needs to be replaced periodically. The regeneration process is highly exothermic and must be controlled to avoid problems.

Activated carbon

Activated carbon impregnated with potassium iodide can catalytically react with oxygen and H_2S to form water and sulphur. The reaction is best achieved at 7 to 8 bar (unit of pressure) and 50 to 70 C. Activated carbon beds also need regeneration or replacement when saturated.

Scrubbing and membrane separation

As discussed in the section on CO_2 removal, the CO_2 and H_2S can be scrubbed by water, polyethylene glycol solutions or separated using the membrane technique.

Biogas as transportation fuel

Using the upgraded biogas for automotives is similar to using natural gas. In Canada, there are about 20,000 natural gas vehicles in use. This transportation fuel can either be in the form of compressed natural gas (CNG) or liquefied natural gas (LNG).

When CNG is used as a transportation fuel it is generally referred to as natural gas for vehicles (NGV). Typical vehicles require modification to run on natural gas. The cost of modification is about $6,000 and depends on the size of the vehicle.

Certified natural gas compressors for refueling the vehicles (known as vehicle refueling appliances or VRAs) are commercially available. These allow refueling at home or work. Your local natural gas company may provide information on different brands of refueling equipment and equipment providers.

Advantages

- CNG burns cleanly
- CNG engines make less noise than do diesel engines
- nitrogen oxide emission is very low
- natural gas users can take advantage of on-site refuelling units located at their home or business
- CNG is less likely to cause contamination than is gasoline in the event of leak or spill

Disadvantages

- high cost ($3-6/GJ) to clean the biogas
- reduced driving range
- less cargo space

Summary

Traces of impurities are present in biogas. Removal of these impurities (such as water vapor, CO_2 and H_2S) is essential prior to using as fuel for various applications.

It is possible to upgrade biogas to pipeline-gas quality using the above discussed techniques. The upgraded biogas may be termed as renewable natural gas and has similar applications as natural gas.

References

NRCAN 2007. Natural Gas Applications. http://www.nrcan.gc.ca/energy/alternative-fuels/fuel-facts/natural-gas/3527

IEA Bionenergy 2005. Biogas Production and Utilization. https://www.iea.org/topics/renewables/subtopics/bioenergy/

For additional information, check the following web pages:

Anaerobic Digesters Agdex 768-1
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex10945

Anaerobic Digesters: Frequently Asked Questions, Agdex 768-2
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11290

Biogas Energy Potential in Alberta, Agdex 768-3
http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/agdex11397

Integrating Biogas, Confined Feedlot Operations and Ethanol Production, Agdex768-4
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex11839

Biogas Distribution – Rural Utilities Division of Alberta Agriculture and Rural Development
http://www1.agric.gov.ab.ca/general/progserv.nsf/all/pgmsrv13?opendocument.

Incentives for Biogas Production – Alberta Bioenergy Producer Credit Program
http://www.energy.gov.ab.ca/BioEnergy/bioenergy.asp

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