BIOGAS AND ITS ENERGY USE

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ABSTRACT

This work deals with the use of energy from the biogas. Energy from biogas can be used to produce electricity, heat or the combined production of electricity and heat. In this work we describe some of the technologies which are used to produce electricity and heat. Such as cogeneration units, gas Otto motors, diesel engines with flammable jet, Stirling motors, microgas turbines and fuel cells.

1. INTRODUCTION

Biogas can be used in the same technologies, in which is used fuel gas. Generally it is used for combustion in boilers, cogeneration, to drive means of transport and can be used as a source of hydrogen.
If the biogas is burned in the boilers, is necessary its permanent quality, composition and energy parameters. If the biogas contains large amount undesirable components, it is necessary to clean it before incineration, because these ingredients can clog boilers and chimneys. For this reason it is important more frequent inspection and maintenance.
Between some components of raw biogas and ceramic coating inside the boiler can lead to chemical reactions. These chemical reactions can damage ceramic layer. This problem can be eliminated cleaning biogas, but this technology is expensive and difficult to operation and maintenance. Moreover, it is disadvantageous to burn the biogas in boilers for heat generation. Better solution is burn it in the cogeneration units.
Biogas can be used as a source of hydrogen H2 too. A method called "reformiring" separates the majority component of biogas and hydrogen, which can be used in fuel cells.
This process is only suitable for biogas, which has high hydrogen content. It can be increase by changing conditions during fermentation. [1]

2. TREATMENT OF THE BIOGAS

Biogas is saturated with water vapor and contains besides methane and carbon dioxide and other traces of hydrogen sulfide gas.
Hydrogen sulfide is toxic and foul-smelling gas. In conjunction with steam contained in the biogas arises sulfuric acid which causes corrosion engines gas lines, waste gas lines, etc.
For these reasons, it is normal for agricultural biogas plants made desulfurisation and drying the obtained biogas. Depending on the composition biogas and the use technology large-scale gas treatment may not be necessary.
Manufacturer cogeneration unit requires minimal requirements for properties used biogas.

2.1. Desulfurisation

During desulfurisation can be used biological, chemical and physical procedures.
To ensure reliable desulfurization, it is necessary to use oversized desulfurization equipment.

2.2. Biological desulfurization

Biological desulfurization is carried out in gas holder in the presence of oxygen and bacteria Sulfobacter oxidants, which converts hydrogen sulfide to elemental sulfur. Bacteria are normally present, but may not be active. The oxygen is brought into the gas holder by blowing air, for example through a small compressor.

- Suitability: For all fermenters which have a space for collecting biogas or if they have their own gas holder.
- Advantages: Very competitive cost and maintenance
- Disadvantages: Inaccuracy in determining the (estimated) amount arising hydrogen sulfide
  Unable to determine the optimal values for desulfurization
  Strong corrosion of structural components of the gas holder
  The necessary explosion protection as a result of an explosive gas and air mixture

To avoid these disadvantages can be desulfuristion carried out gas hold. Desulfurization tower can be used. Because of it, it possible to observe boundary conditions for desulfurization, as air supply and oxygen supply.

2.3. Chemical desulfurization

During Chemical desulfurization is fed to the fermentation substrate agent that chemically binds sulfur and thereby prevents the release of hydrogen sulfide, usually is used $FeCl_3$ or $FeCl_2$.

- Suitability: All systems with "wet" fermentation
- Advantages: There is no need to perform any special maintenance
  The preparation can be applied to the substrate already before the fermenter
  No harmful ingress of O2 into the fermenter
  No internal corrosion of structures in contrast from biological desulfurisation
  Additional equipment is not necessary
- Disadvantages: Difficult to find the dose due to the sulfur content substrate
  Increased production costs for the purchase of chemicals [1]

3. ENERGY USE OF BIOGAS

The best solution how to get the energy from the biogas, is its combustion in cogeneration units.
Cogeneration means the production of mechanical power, which is transferred to electrical and heat energy. In the cogeneration units are mostly used combustion piston motors connected with electric power generator. These motors rotates at constant speed (1500 rotates per minute). The alternative source of mechanical power for electric generator can be used combustion gas turbine, Stirling engines or fuel cells. But using this ways is minimal.

3.1. Cogeneration units with combustion piston engines

Cogeneration unit consist: combustion motor, electric power generator, heat exchanger system (to recover heat energy from waste gates) and closed circulation of cold water and lubricating oil.
As a combustion motors are used the gas Otto engines, modified diesel motors or diesel motors with flammable jet (dual fuel engines). Gas diesel motors (modification of basic commercial diesel engine) and gas Otto engines are run without additional diesel fuel, but there is one difference in amount of compression of gas.

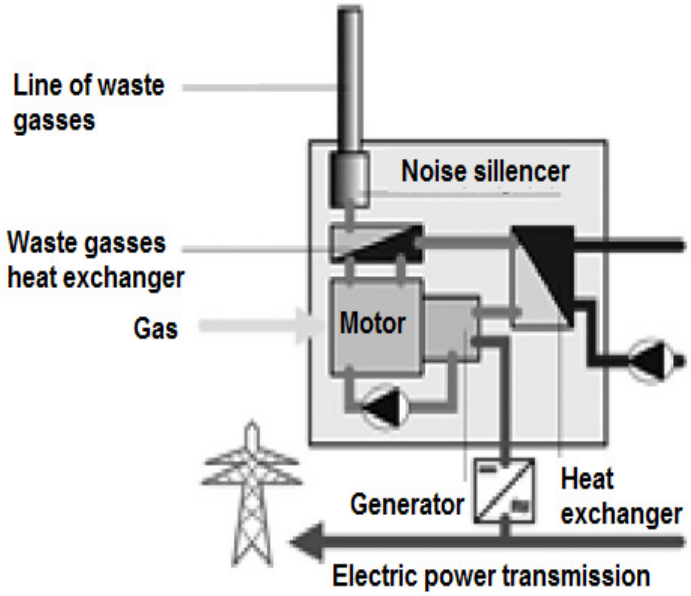

Figure 1 – Cogeneration unit diagram [1].

Gas Otto motors

Gas Otto motors are developed for the gas-power and working on the Otto principle. The motors are operated to a minimize emissions of nitrogen oxides as engines with low fuel and excess air. The motors are equipped with a turbocharger to increase the boost air pressure. These motors need minimum methane content in biogas about 45%. The less methane content can cause problems with the correct motor run.
Alternative fuel or fuel for first start of motors can be natural gas. These motors are made by largest manufacturers, for example: Jenbacher, Deutz etc.

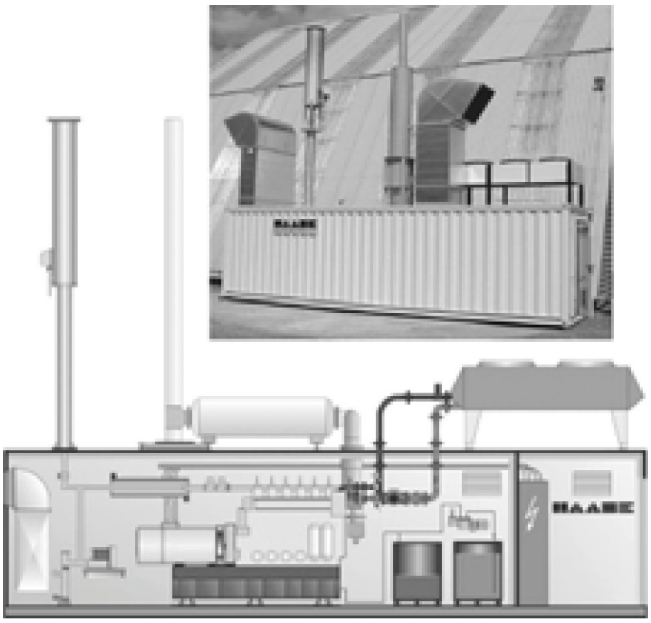

Figure 2 – Biogas cogeneration unit, complete module in container with emergency turner (Haase Energietechnik AG) [1].

- The characteristics: Electric power >1MW (<100kW less frequently)
  Electrical efficiency 34 – 40 % (nominal power >300kW)
  Lifetime 60.000 hours
  Regulation according to biogas quality
  Used fuel: Biogas with minimum content of 45% CH_4
- Positives: Designed especially for biogas, compliance with the emission limits, Total efficiency is higher than combustion motors
- Negatives: Higher price, in low power motors is bad efficiency

Diesel engines with flammable jet – dual fuel engines

Diesel dual fuel engines work on diesel principle. Biogas is mixed with the gas and then with diesel fuel, which is pumped to the combustion space. Motors are again operated with high excess of air.
Load regulation is realized by regulating the input of ignition oil or gas quantity. This type of motors can be alternatively powered by pure oil or diesel fuel.
As an ignition fuel is usually used diesel fuel, black oil (mazut) and renewable sources: biodiesel or pure vegetable oil. Here it can be calculated with higher wear of filters, nozzles become resin and lower viscosity of vegetable oil.
These motors are supplied e.g. Schnell et al Engine.

- The characteristics: Minimum of liquid fuel to burn 10 %
  Electrical output max. 350 kW
  Electrical efficiency 30-40%
  Lifetime 35.000 hours
  Suitable for all biogas applications
  Regulation according to biogas quality

- Positives: Cost-effective use of standard motors

In the lower power range increased electrical effectiveness in comparison with gas Otto engine

- Negatives: Clogging of injection nozzles (carbonization)
  Need to use an additional fuel (diesel fuel, rape oil)
  Worse emission in some parameters

3.2. Stirling motors

The Stirling motor is a type of heat engine. The piston gets movement by expansion of heat gases (heat supply from the external power source).
The main advantage is that the engine can work with different sources of thermal energy. Energy efficiency of motors 1-50 kW is 18-22%. Other advantages are quiet run, long service life and minimal chance to failure.
The basic principle of the Stirling engine is that the gas change temperature performs some work associated with changing volume. The disadvantages are poor controllability and long starting. To get a higher efficiency motor has to work with high pressures of gas and has got a large powerful fan.
Power of Stirling motors is usually under 50 kWe.
The biogas is not burned in an indoor environment engine (in a cylinders) so the biogas can have a poor quality and also may be used gases with small amounts of methane. Stirling motors are now available in very small power classes and for competitive production and using needs further development. [1]

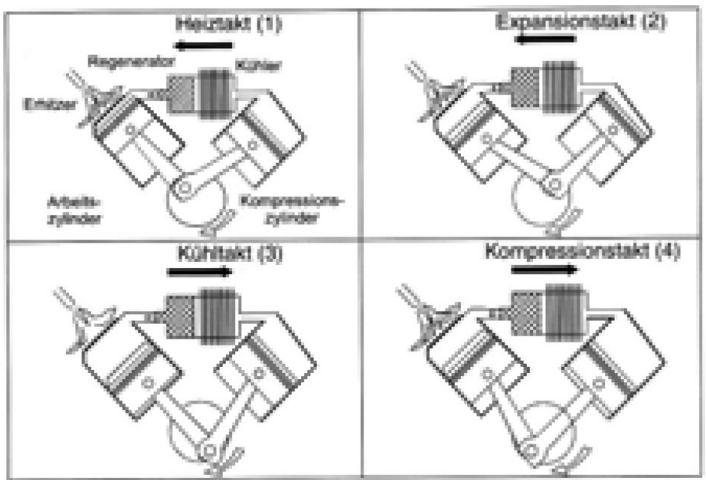

Figure 3 - Principal of Stirling motor [1]

3.3. Microgas turbines

Microgas turbines are called small, fast-running gas turbines with low combustion chamber temperature and low pressure.
Performance is usually up to 200kW.
These turbines are very vulnerable to quality of biogas, especially to undesirable added substances, which can damage all turbines. So gas must be cleaned and dried. Microgas turbines need biogas with methane content from 35 to 100%.
The disadvantage of microgas turbines is low efficiency about 28% and the total efficiency about 82% is often lower than the previous motors. Investment costs are about 15-20% higher, but in the future we can expect a decrease of costs connected with the potential increase of use this technology.

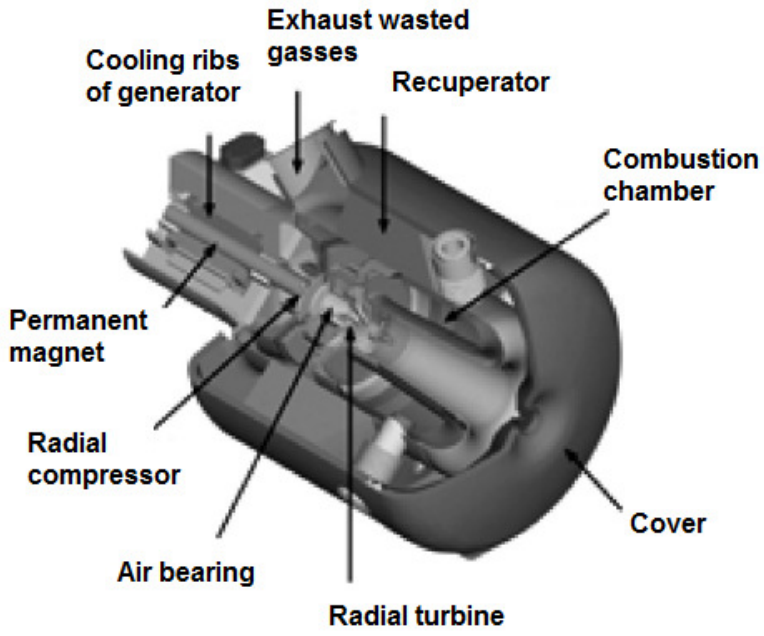

Figure 4 - Structure of microgass turbine (G.A.S. Energietechnologie GmbH)[1]

3.4. Biogas in fuel cells

This method is fundamentally different against usual methods energy conversion. The conversion of chemical energy of biogas to electricity happens directly. Fuel cell guarantees a high electrical efficiency up to 50%. Another important advantage is minimized emissions. Operating principle of the fuel cell is comparable to the return of electrolysis water. Biogas must be modified for use in fuel cells. Hydrogen sulfide (H_2S) is removed by the biological desulfurization, by catalytic cleavage or by active carbon.
The name of fuel cell types are connected with the type of used electrolytes and dividend to this groups: low-temperature fuel cells, intermediate-temperature fuel cells and high-temperature fuel cells. Using of different type of fuel cells depends on the type of heat evaluation and evaluation and predisposed power classes. [1]

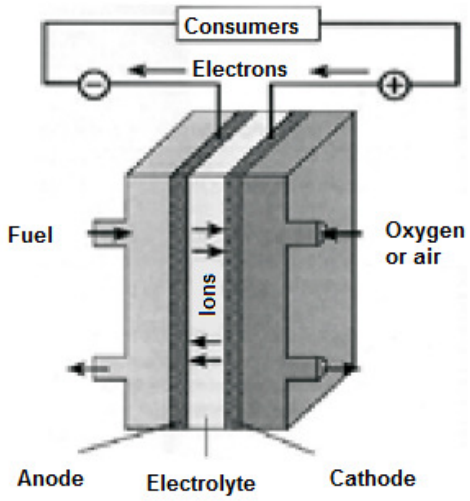

Figure 5 – Operating principle of the fuel cell [1]

4. CONCLUSIONS

Biogas is most often used for production electric energy and heat energy. It is a renewable source of energy. In our work we wrote about some types of engines which are used to transform energy from biogas to electric energy and heat energy. In these types of engines can be used biogas of different quality.
Finally, we would like to say that biogas may be used only to generate electricity and heat. In Scandinavian countries such as Sweden, biogas is used as fuel for buses and trucks. Also it is supplied to the natural gas pipeline networks or sold to heating plants. These ways of using biogas are much more economical than its use in the production of electricity. We hope that these ways will be used also in the Czech Republic one day. [2]

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