ANLAGEN- UND APPARATEBAU
Lüthe GmbH
Biogasanlagen

... what you always wanted to now about biogas !

Creation of biogas

Biogas is a product of the metabolism of methane bacteria and is created when the bacteria degrade a mass of organic material. The methane bacteria can only work and reproduce if the substrate is sufficiently bloated with water (at least 50 %). In contrast to aerobic bacteria, yeasts and fungi they cannot exist in a solid phase.

Exclusion of air
These micro-organisms are strongly anaerobic. If the substrate still contains oxygen, as for example is the case with liquid manure, then aerobic bacteria must use this up first. This happens during the first phase of the biogas process. Low quantities of oxygen, such as occur through the deliberate aeration of air in order to desulphurise the material, do not cause any harm.

Temperature
The working range of the methane bacteria lies between 0 and 70℃. At higher temperatures they are killed off, with the exception of a few strains which can survive in temperatures up to 90℃.
The speed of the decomposition process is heavily dependent on temperature. The following applies: the higher the temperature, decomposition occurs more quickly, the production of gas is higher, the decomposition time is shorter and the content of methane in the biogas is lower. Practical experience has shown that there are typical temperature ranges in which particular strains of bacteria feel quite comfortable:

mesophile strains at temperatures of 25-35℃
thermophile strains at temperatures above 45℃

The higher the temperature, the more sensitive the bacteria are to temperature variations, especially when these occur for a short time and the temperature drops. Whilst in the mesophile range daily variations of from 2 to 3℃ about the medium can still be supported, for the thermophile range these variations should not be more than 1℃. Over longer periods of time (around 1 month) the bacteria become accustomed to new temperature ranges.
The pH value
The pH value should be in the weakly alkaline range of about 7.5. For liquid manure and dung this range usually occurs naturally during the second phase of the decomposition process, as a result of the creation of ammonium. For more acidic substrates such as slop, whey and silage it may be necessary to add lime in order to increase the pH value.

Supply of nutrients
Methane bacteria cannot break down fats, protein, carbohydrate (starch, sugar) and cellulose in pure form. In fact they need soluble nitrogen compounds, minerals and trace elements to break down the cellular mass of these materials. Sufficient quantities of these substances are present in dung and liquid manure. But grass too (in fresh and preserved form) as also marc, slop and whey contain sufficient total nutrients and can in principle be broken down alone. In practice however it is recommended that dung and liquid manure are used as a stable basic substrate and additional amounts of the materials referred to are added, so as to avoid segregation and to achieve a good buffering of acids and lyes.

Large material surfaces
The organic materials which have not dissolved in water must either be finely dispersed (e.g. through the addition of fat) or have a structure (e.g. cellulose) such that a large working surface is created. Materials such as straw, long grass or organic waste must be shredded and as far as possible split into fibres, since otherwise the decomposition times needed would be too long and problems would occur through the formation of a layer of scum.

Retarders
Organic acids, antibiotics, chemical therapeutic agents and disinfectants can retard the decomposition process and can even stop it completely. This can happen when whole herds of animals have to be dealt with at the same time, or when stalls have to be disinfected. The treatment of single animals does not have any negative impact.

Loading rate
This is a value which indicates the maximum rate at which quantities of dry organic material can be added to the fermenter without the bacteria being "overfed" and the process collapsing. The loading rate is primarily dependent on the temperature level, the amount of dry organic material and the retention time. Normal loading rates at 35°C lie between 2 and 3 kg oTS/M^3xd (oTS = organic dry matter), i.e. some 2 to 3 kg oTS per day is added and processed per m^3 of fermenter content.

Steady rate of addition of the substrate
In order to avoid too large a loading in the filling zone of the fermenter, it is best to provide a constant loading at as short intervals as possible. This applies both to the basic substrate (liquid manure or dung) but also to a special degree to highly concentrated coferments such as fat. This also avoids too great a drop in temperature in the filling area.

Degassing the substrate
High rates of decomposition can only be achieved by the methane bacteria if the biogas is able to continuously escape from the substrate. For thin liquid substrates it is even possible for small bubbles of gas to rise up in the substrate by themselves. Agricultural substrates with higher dry substrate contents above 5% should however be additionally degassed. Stirring several times a day is one method of doing this which has proven itself in practice.

The 4 phases of the decomposition process
The decomposition process runs through 4 main phases:
In the first phase the different types of anaerobic bacteria (not any methane bacteria yet) work with the aid of enzymes to convert the high molecular organic substances (protein, carbohydrate, fat, cellulose) into low molecular combinations such as simple sugar, amino-acids, fatty acids and water. This process is called hydrolysis.
Acid-forming bacteria can then further breakdown the matter into organic acids, carbon dioxide, hydrogen sulphide and ammonia.
Next, acetic acid bacteria work on this to produce acetates, carbon dioxide and hydrogen.
Methane bacteria create methane, carbon dioxide and water in the alkaline range.
With the constant addition of organic material, such as is usually the case with most biogas plants, these processes take place at the same time and are not separated either physically or by time. Separate decomposition only takes place during the start-up phase of a biogas plant. For this reason it can be several weeks following the commissioning of a plant before the 4th phase, the creation of methane, is reached, and before the gas created can be exploited.

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The throughput process
Most of the biogas plants around the world work on the throughput process. This process is distinguished by the fact that the digestion tank is always kept full and is only occasionally emptied, either for repair or to remove grit layers. The fresh substrate is moved from a smaller advance container – usually once or twice a day although several times a day would be better - into the digestion tank, whereby at the same time a corresponding amount of decomposed substrate automatically leaves the tank via its overflow. This flows down through natural slopes into the container. If the container is too high then a catchpit is excavated between tank and container from where the overflow material can be pumped out later. The advantages of the throughflow process are the even production of gas, the good loading rate and the resulting cost-effective, compact design with its low losses of heat energy. The process also allows the filling stage to be automated.

The end product
A difference is made between two designs of plant:
- agricultural biogas plant, operated with liquid manure, solid dung, corn silage, grass silage, grain
- non-agricultural biogas plant, operated with waste from food production, fats, slaughterhouse waste etc.

In agricultural biogas plants, only the organic dry material is removed from the substrates during fermentation. This is converted by the methane bacteria into methane gas. The resulting “fermented“ substrates, the end product, can then be considered as a normal commercial fertiliser with a very good quality. It can be spread onto agricultural crop land in a thin phase and reduces the purchase costs of artificial fertilizer products.

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