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State of the Art of Dry Fermentation

Dry or solid (moist matter) fermentation is increasingly establishing itself as an additional alternative to standard wet fermentation. Methane is produced by problematic dry and long fibre substances, such as solid manure, grass silage, or materials from landscape maintenance. All techniques work by the batch system. Odour emissions are lower, and there are no sediment or foam problems. Currently, farmers can choose between several constructional variants. The biogas yields are the same as in standard wet fermentation – based on volatile substances.

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Keywords

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Literatur

Literature references can be called up under LT 07103 via internet: http://www.landwirtschafts-verlag.com/landtech/local/literatur.htm.

Of the estimated number of 3,000 biogas plants at the end of 2006, currently only approximately 20 use the technique of classic dry fermentation. Five companies are currently employing this technology. However, one company built about 95% of all plants. Since the introduction of a technology bonus under the Energy Input Act, this variant is meeting with great interest among farmers.

Under scientific aspects, however, the term is wrong. Correctly speaking, this technique is based on the fermentation of solid or wet matter because it is defined as a methanation technique during which stackable, pourable, i.e. non-pumpable materials remain in this condition during the entire process chain. Thus, this classic form is different from variants where process chain links assume different states of matter of fermentation substrates.

Solid matter fermentation began in pilot plants in Switzerland in the 90s apart from the fact that rumen digestion is the oldest biogas technology in the world and a classic example of bionics. The rumen of cattle, which produce approximately 80 million tonnes of biogas per year, contains a non-pumpable substrate having a dry matter content of 17%. Thus, it is the natural original form of a solid matter digester. Today, one- and two-stage techniques are distinguished (*Fig. 1*).

All these constructional variants have some special characteristics in common:

- They work with stackable biomass, such as solid manure, grass, energy plants, silage, and the mixtures produced from these components.
- Wheeled or front loaders are used to fill the digesters with pourable biomass and to empty them.
- The solid matter and potential additives are fermented using the batch technique, i.e. the batches are changed.
- After individually determined storage periods, this process provides drip-free fermentation products, which can be composted or spread directly on the field.
- For this purpose, technologies from the compost- or stall dung chain are used.
- In order to activate the micro-biological processes, the biomass is either mixed with digested material, and/or liquid bacteria concentrate is added through percolation or submersion.
- Several digesters are always run at delayed intervals such that the block-type thermal power station can be continuously supplied with biogas.

Differences result from the degree of exploitation and the inoculation of the biomass. In principle, two possibilities are available today:

- "showering" with a warm, liquid suspension of methane bacteria (percolate) from above or
- submersion with silage effluents from below.

The single-stage variants in the form of box- or clamp digesters account for the largest number of digesters used in practice and require less sophisticated technology.

Box Digesters

In the currently most widely used variant, garage-shaped boxes with hydraulically closing doors, percolate nozzles at the ceiling and a percolate drain in the bottom are used. The measurements are adapted to the technology used for filling and emptying, i.e. wheeled or front loaders.

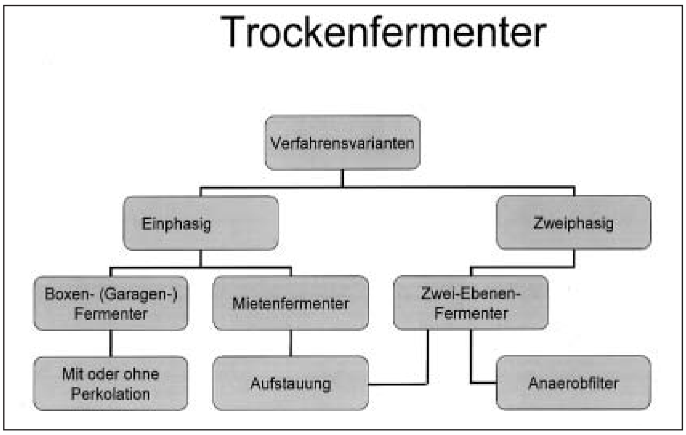

Fig. 1: Process variants

Fig. 2: Clamp digester with unwinding device (source: Hans Wolfertstetter)

Fig. 3: Filling the two-level digester (source: Ratzka consulting engineers)

The times of batch change depend on priorities of farm management and -operation as well as the composition and quality of the substrate. In practice, they vary between 14 days and six weeks. At the individual batch change times, the wheeled loader mixes the different fresh matter portions with additives in the form of fermentation residues from previous batches on a mixing plate according to the recipe. These batches, whose dry matter content varies between 17 and 35% (40%), are fed into a digester at delayed intervals. During fermentation, the substrates are percolated several times for a few minutes in order to promote the spreading of the microbes. Depending on the quality of the biomass, the gas yields provided per tonne of dry matter can be similar to those achieved by wet fermentation after the methane bacteria had enough time to adapt to the individual biomass mixture. This adaptation time requires several (three to four) batch changes. The secret of the success of high yields is also a constant, optimized composition of the biomass and a microbial population adapted to these conditions. While the recipe must provide the proper ratio of "energy-" and "structural" mass, the decisive factor for micro-biology is the patience required until the entire system has adapted to the farm-specific microbial feed. Once established, however, this "micro-biology" is very stable.

The biogas produced is stored in a conventional film store above the digesters or offered to the block-type thermal power stations as compressed gas. It is also possible to run the entire plant fully automatically. Full automatization is also recommended for safety-technological reasons because before the digester can be opened for emptying it is rinsed with clean air until one can drive in without danger. The biogas-air mixture, which can no longer be used, is disposed of using a biofilter. This allows for a virtually odour-free operation of the entire system.

Clamp Digesters

Another concept besides the box digester is the clamp digester. This variant was designed using the farmer´s manure heap and the horizontal silo as models. The clamp digester features an inclined ramp for the storage and removal of the substrate along with an insulating film cover, which also serves as a gas store. Air-tight coverage is provided by a gutter around the digester and sand bag loading. A shifting unwinding device facilitates work with the film during batch change.

Since the clamp digester does not require sophisticated safety technology, only puts a slightly heavier burden on the environment during batch change than stall manure spreading, and features relatively small dimensions, it is recommended in particular for smaller farms. Moreover, a large part of construction work can be carried out by the farmer, which reduces costs even more. In this digester, which is particularly adapted to front-loader operation, the biomass is stacked up to a height of 3 m after pre-mixing or dumping by a stall manure spreader. Under the film cover, the biomass buffer develops, which can be extracted and used almost completely during batch change due to the film weight.

Two-Level Digesters

Three special features set this system apart from the above-described variants:

- The digester is filled and emptied at two different levels.
- Instead of percolation from above, the substrate is submerged from below.
- An anaerobic filter extends the system into a two-stage technique.

This variant has been tested for just two years, and an experience report can be expected during the year 2007.

The biomass is dumped into the digester at the upper level. Layer-wise deposition of the components is intended to provide a mixture.

During the fermentation period, which lasts approximately 30 days, process liquid is pumped into the substrate stack from below. Depending on the pH-value, the process liquid is drained into an anaerobic filter through an overflow, in particular in the initial phase of methanation. In a round container next to the digester, the methane bacteria are grown on grid-shaped carrier material in order to degrade the acids as quickly as possible due to dense bacterial colonization. When the pH-value in the fermenter has reached a stable level of about 6.8 after approximately five days, the recirculation of the process liquid through the anaerobic filter is interrupted, and the silage effluents remain in the boxes until the end of fermentation. Since this two-stage technique allows initial acidification to be reduced, digester capacity can be used more efficiently, which increases the gas yield.

The following comparative overview (*Table 1*) provides decision aids for future energy farmers.

Table 1: Comparing solid and liquid fermentation

Criterion	Solid Fermentation	Liquid Fermentation
Substrate	max. 45% DM	max. 13% DM
Technique	with/without percolate recirculation	homogenizing
Concept	modular	complex
Types of malfunctions	faulty recipe	formation of foam and layers of deposited matter
Malfunction	affects only 1 fermenter	affects the entire facility
Process energy	lower	higher
Verschleiß	lower	higher
Umfeldtechnik	solid manure/compost technique	slurry technique
Removal of fermentation residues	cheaper	more expensive
Extension	easier (modular)	more difficult (complex)
Hygiene	more unproblematic	more problematic
Desulphurization	not necessary	always necessary
Cont. gas supply	at least 3 modules	always guaranteed
Odours	virtually imperceptible	often very unpleasant