Manfred Hoffmann, Triesdorf

Fermenting of stackable materials

The legally established increased payment for energy supply into the public electricity network is a positive sign for the biogas producer. The nearly-800 biogas producers in Germany work almost exclusively with the 'liquid fermentation' process by which the substrate, mainly liquid manure, with or without added co-fermentation materials, is methanised in a pumpable form. Stackable materials such as grass, silage or farmyard manure (fym) can only be used in pumpable form as co-fermentation materials. Here, a process is presented which also allows the methanisation of materials in a stackable condition through 'dry fermentation'.

Prof. Dr. Manfred Hoffmann represents the specialist division Agricultural Engineering with Regenerative Raw Materials/Regenerative Energy; FH Weihenstephan/Triesdorf, D-91746 Weidenbach, Steingruberstr.2; e-mail: manfred.hoffmann@fh-weihenstephan.de

Keywords

Biomass, fermentation, energy production, processes

When one speaks about "dry fermentation" this means that the dry matter (dm) of the substrate to be fermented is 25%. With the importance of liquid manure systems in today's farming, the emphasis on "liquid fermentation" is understandable, to the extent that slurry fermentation has established itself as the standard process, although its financial viability without co-fermentation products has repeatedly attracted individual critical observations.

But nowadays, under altered energy and environment-political, as well as economical, conditions, it is fair to ask whether or not "dry fermentation" offers a promising alternative - especially with the large amounts of fermentable biomass materials which have not, up until now, been utilised.

The fermentation of solid material such as clippings from roadside greenery, lawn cuttings, household rubbish or the waste from landscape-tending operations, wins ever more importance. It is also attractive as an environmentally-friendly way of removing waste in the sense of the recycling economy. It creates supplementary income for farmers and offers them partial or complete transformation from farm producer to an energy producer.

First beginnings

Apart from individual large communal plants, it was really in Switzerland that the first research initiative toward the development of farm plants for dry fermentation was developed which led to the development of continuously or semi-continuously working research plants in the form of a container (Anacom process) or the fermentation canal variation [1, 2].

Both prototypes are conceived for straw-rich fym and have proved themselves in a practicality study. The silo plant especially won recognition, from the aspect of plant dependability, process stability and energy production when considered against a comparable liquid plant, whilst the investment and running costs lay at around the same level. Through the additional fermentation of the straw, the biogas production is around 50 to 70% higher so that a better cost-utilisation relationship is produced.

Own trials

For around two years now, solid material fermentation trials have been carried out at the FH Weihenstephan/Triesdorf (batch system). The batch system features the filling and emptying of the fermenter in single charges. This features a process that has proved itself in laboratory work but which, however, did not in the past fit-in well with on-farm routines and also proved problematical with regard to handling. Modern filling and emptying technologies with powerful front loaders or four-wheel loaders, hydraulic tipping systems and mobility technology in the form of removable containers for tractor trailers or trucks offer completely new handling possibilities nowadays. To this can be added new microbiological knowledge and procedural-technical solutions for the inoculation of methane-producing bacteria. Alongside the many possible process variants for methanisation of loose material and silage in clamp-form fermenters, and from round and rectangular bales in pit-form containers, two demonstration forms are currently in first practical trials:

- The free-standing fermenter in the form of a loadable container, and
- the housed container (*fig. 1*).

The free-standing fermenter is a fully-insulated container such as, e.g., used in intensive rotting in composting. Because of practical requirements this type is conceived in the form of a mobile loadable container in order to serve a special segment of the market optimally. The housed fermenter consists of two construction units, as it were: a garage-type insulated and gas-tight envelop within which is fitted a mobile fermenter. Stationary technology is also possible here with powerful servicing equipment (front loader, four wheel loader) to allow a charge-system of filling and emptying.

The fermentable material decomposes during a substrate-dependant rotting time from two to four weeks in all process variants whereas the biogas production, measured in m^3 biogas /kg dm, equals at least that produced through wet fermentation. Still being in-

Criterium	Liquid fermentation	Dry fermentation
Substrate	pumpable (max. 13% dm)	stackable (max. 50% dm)
Technical input	homogenisation	perculate-recirculation
Foam building/sinking layers	possible	not applicable
Plant construction	complex stationary only	modular mobile or stationary
Breakdown	affecting the entire fermenter	only applicable to individual modules
Process-energy	higher (homogenisation)	lower (perkulate-re-circulation)
Transportability of decom posed material	worse	better
Odour production	unavoidable	avoidable to a great extent
Associated technology	special liquid manure technology	fym or compost technology
Hygiene/ weeds	more problematical	unproblematic through microbial pre-heating possibility
Investment costs	as a rule higher	mostly lower

Table 1: Comparison of liquid and dry fermentation

vestigated at the moment is a series of microbiological and procedural optimisation possibilities. After an economically defined decomposition time, the fermenter is emptied and the residue is then either directly spread on the fields as solid manure or temporarily stored as a clamp on the edge of a field. It is, however, also possible to produce compost fertiliser through subsequent composting. As gas production and gas collection is not constant in a batch system, at least three fermenters are managed at the same time and worked in a phase system.

Manifold advantages

Basis for the new technological application in the methanisation of agricultural biomass was a large number of microbiological laboratory trials at the Institute for Agricultural Engineering in Potsdam-Bornim in which [3] it was able to be shown that up to a dm content of 50 % it is still possible to achieve economically viable production of methane. On this basis, it appeared that there was no longer any sense in diluting fermentable biomass until it was pumpable and, through this action, create technological and energy problems which apply repeatedly to "wet fermentation".

According to knowledge so far, the new techniques offer the following itemised advantages and opportunities:

- A larger energy density in relation to utilised volume of fermenter allows the transition to smaller units which can stretch to modular and mobile loadable containers of up to 30t and thus within the limits for public road tranportation. Through the minimised liquid proportion, the decomposed material offers substantially better transportability. The mobility and flexibility thus achieved opens completely new market opportunities for competent energy farmers.
- The different types of fermenter modules available allow monitoring and precise controlling of the decomposition materials in batch systems. In concrete terms, this means that the farmer need no longer in every case be the final customer for the decomposed material. After energy has been produced from the material, he has the choice of delivering charges of waste containing toxic materials to composting depots outside the farm. Also substantially simplified through the system is the cooperation with other farmers in the avoidance of over-manuring under the terms of the manure application legislation. The farmer can load-up with biomass where it is offered at economical prices and deliver the resultant where the best return is offered.
- The running of a dry fermentation plant mostly requires no specialist technology because suitably-powerful filling, emptying and mixing machinery for substrate and decomposed material is already on-hand on most farms nowadays. Where there's a special requirement, there's also the opportunity nowadays of between-farm sharing of four wheel loaders, fym spreaders and tractor-pulled container-trailers.
- In the fermenting itself, there are other energy and technology advantages:
  - A substantially smaller process energy requirement because, through possible aerobic microbiological pre-warming, only transmission losses have to be made-up for and a continuous homogenisation is not required. A single percolate pump ensures tempered percolate is filtered into the substrate around three to four times daily.
  - There are no longer problems with foam creation and sinking layers. In the case of the fermentation stopping, the individual module can be "re-started" without problems.
  - Fermentation-restricting material such as in wet fermentation play no role in the dry fermentation process.
- The problems of odour emission and hygiene which are increasingly critical nowadays for many of those interested in the building of biogas plants are easier to solve because the typical slurry smell does not occur and, with regard to hygiene, a recordable and controllable tempering of the fermenter contents can be ensured.
- In that all imaginable variants can be created as individual fermenter units, many risks can be limited, financial difficulties avoided, and utilisation of technical advances secured.
- In that the fermenter can be worked in such a way that no, or hardly any, seepage water occurs, there are no decisive water pollution protection statutes to be expected. The same applies to building permissions, in so far as mobile fermenters are concerned.
- Finally, "dry fermentation" makes possible for the first time a consequent biogas production for many farms that use straw bedding and also organic farms. On the one hand, these can retain their farm concepts and, on the other, receive, after energy exploitation, a decomposed material which still retains the soil structural and biological effects of fym or compost.

As with wet fermentation, no general statements are possible with regard to investment costs and the labour economy because dry fermentation plants must also be planned and run according to the individual farm concerned and this means that, at the moment, only the communicated comparison has general applicability (*table 1*).

Summary

As a whole, it is thus possible to determine that dry fermentation offers completely new possibilities and opportunities for farmers which not only enable the creation of new "biogas crop rotations" but also lead to new service-industry opportunities such as, e.g., the fermentation of biomass from outside the farm (by-products from landscape-care operations, grass cuttings), and additional income sources within new organisation forms such as energy agencies or energy centres.

Literature

[1] *Basarga, U., K. Egger* und *A. Wellinger*: Entwicklung einer Pilotanlage (Anacom) zur Vergärung von Festmist. Bundesamt für Energiewirtschaft, Forschungsprogramm Biomasse, Juli 1994, 42 S.

[2] *Basarga, U. und K. Egger*: Entwicklung der Gärkanalpilotanlage zum Vergären von strohhaltigem Mist. Bundesamt für Energiewirtschaft, Forschungsprogramm Biomasse, September 1995, 30 S.

[3] *Linke, B., und H. Schelle*: Stabilisierung halbfeuchter Reststoffe. Forschungsbericht des Institut für Agrartechnik Bornim e.V.