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Trends in biogas technology

Energy production from biogas offers opportunities in agriculture through growing the raw materials and participation in investment in new added value chains. The good conditions within the EEG regulations do not completely guarantee a high return from such plants. Decisive for economic success is a clear plant concept and planning to match local conditions. Subsequently it is important to identify suitable technology with which a high annual plant capacity utilisation is possible.

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Keywords

Biogas plants, dosing, process monitoring

By the end of this year there will be over 3000 biogas plants producing electrical power for the public network in Germany. In the last year more than 700 new plants were built and many others extended. This boom was started by the January 2004 amendment to the German Renewable Energy Act which had the aim of definitely improving the governing conditions for supply of electrical power produced from biogas. According to estimates of the Biogas Association maize is now one of the regenerative raw materials fermented in around 80% of existing plants. In Germany 2005 around 70000 ha was used for producing biogas maize, around 4% of total maize area. In 2006 so-called energy maize area has more than doubled to an estimated 144000 ha.

Biogas plant technology

The increased use of regenerative raw materials in biogas plants means high demands on required technology for feeding regenerative raw material with other fermenting products into the fermentation process independently of liquid livestock manure. With this biomass dry matter content in the fermenter can be increased and thus gas productivity. The stackable raw material is usually fed into the fermenter from holding hoppers via auger. Feed mixer wagons or hoppers based on such are increasing used as preliminary bunkers. Especially where material is fibre-rich, intensive preparation is required in the preliminary bunker so that bridging and subsequent breakdowns during dosing of the fermenter cab be avoided.

The diameter and constructional strength of the feed augers have increased substantially and higher quality material is now used for these. But even when they are of stainless steel, wear and corrosion cannot be avoided. Shaftless spiral augers can also transport foreign bodies such as larger stones without damage. When, however, such augers are built-in at an angle the continual chafing of the inner spiral leads to increased wear.

A few firms now offer systems for metering biomass into the fermenter featuring chopped material in an almost liquid flow. Augers and choppers achieve the desired small length to achieve this which also gives a material more easily degraded by microorganisms in the fermenter. Macerators from liquid manure processing are also used for more intensive milling of the input biomass.

Through stirring of the fermenter substrate floating and sinking layers are avoided or broken up. Additionally the agitation helps the mixing of fresh material with fermented substrate, the expelling of gas and promotes uniform temperature. Fermenter conditions are more difficult than liquid manure storage. Temperature is mostly around 38°C. Additionally the fermenting substrate is much more aggressive than liquid manure with sulphur presence quickly causing corrosion. This has to be watched out for when installing equipment in the fermenter.

High performance submersible motor mixers are said to have a high energy requirement. Certainly wear is greater because of the more rapid propeller action although they are usually fitted to be height adjustable

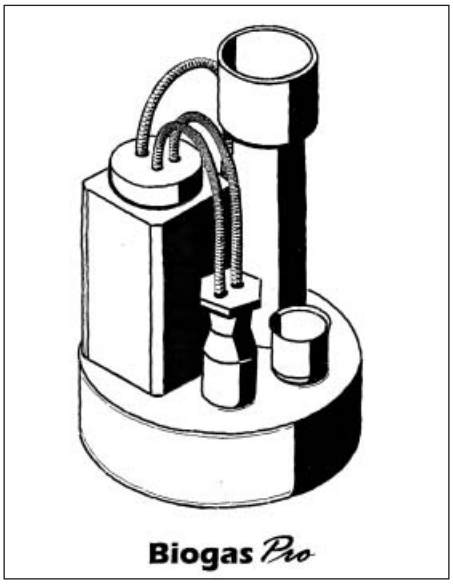

Fig. 1: BiogasPro is designed for process monitoring of biogas plants. Offered jointly by Bonn University (H 23 St F1) and Rimu-Lüftungstechnik (H 26 St D35) the equipment has been awarded a silver medal.

and thus universally applicable. They are also able to break-up floating layers. Increasingly slow-revolving paddle, angled-axle or central mixers are being fitted as agitators. They have the advantage of low specific energy consumption and their motors are situated outside the fermenter which makes servicing easier. However these mixers have problems breaking-up existing floating layers.

The pumps used are built according to principles known from liquid manure handling technology. Centrifugal pumps are known for their simple design, flexible working mode and high performance. However, those can neither apply suction nor meter their throughput. Because of this, the transporters most often used in biogas plants are eccentric auger pumps and rotary piston pumps. The latter have an advantage over the former in that they are less susceptible to damage from foreign bodies and don't run dry so easily.

Fig. 2: Decisive for economic success is a clear plant concept and high annual utilisation of capacity (Photo: KTBL Archive/SK)

Process monitoring

Feeding the fermenter is made more difficult when there's a variety of substrates involved. Increasingly important is exact documentation of the substrates applied as well as monitoring and recording the process. The following should be recorded daily:

- The mass of the materials fed into the fermenter,
- Gas quality (CH_4, CO_2, H_2S contents);
- Fermenter temperature and
- Biological parameters such as pH value and buffer capacity.
- Short chain fatty acid presence (when problems occur in fermentation).

To calculate process efficiency the exact mass of all materials fed into the fermenter has to be known. Then the plant operator can control whether the daily gas production matches that expected from the inputs. A possibility for recording weights is installation of a weighbridge at the plant. Manufacturers of solid aggregate dosage equipment also offer weighing facilities on their systems. The recording of liquid material fed into the fermenter can be through electronic flowmeters. Measuring the amount of gas produced daily and its quality is necessary so that the expected amount can be matched to actual production. Changes in gas composition indicate problems in the fermentation process and for control of the process biology the pH value or the buffer capacity can be manipulated. Fatty acid content has to be determined via a laboratory in general and thus the values are only available after a few days. Important for permanent process control are investigation methods that allow measurements on the spot. One step in this direction is the volumetric determination of the carbonate buffer. This system works completely without the application of electrochemical equipment and enables the plant operator to control and monitor process stability. It should be self-evident that process temperature should be regularly checked.

Also important for process control is monitoring continuity so that variations from normal values can be identified quickly. For support here, there are several computer programmes now available enabling continuous process and cost control.

Production of regenerative raw material

Biomass production capacities under local conditions identify crop plants particularly suitable for biogas production. In Germany the conventional grain crops and especially maize have proved suitable. Farm economic observations indicate that biomass production costs for regenerative material can represent over 50% of total annual running costs of a plant. This is why it is important to, on the one hand, ensure high yields in raw material production and on the other to avoid wastage in the silage clamp and during preparation for the biogas plant. Silage clamps must be covered with plastic film immediately after compression of the silage. When taking out biomass for the fermenter there should be a sufficient forward feed of at least 1.5 m per week in winter and 2.5 m per week on summer to avoid losses at the cutting face.

So that the ensiling takes places rapidly ensiling additives have been developed especially for biogas maize. This sinks pH value rapidly and encourages formic acid production at the end of the process to improve conservation in the clamp and at withdrawal.

Increasingly enzymes are offered to encourage and speed-up biogas production during fermentation but whether these give definite performance increases in the biogas plant needs more research.