A practice-oriented test system for determining suitable additives for biogas plants

# The most effective enzyme preparation to improve flowability?

Stirrer failures, unstable processes, excessive power consumption and the associated loss of performance are often caused by insufficient flowability of the fermenter media. The application of a new test system for the selection and application of optimal enzyme mixtures to reduce viscosity and substantially improve flowability promises a solution.

Frieder Eiskamp operates a 1.1 MW biogas plant in Harpstedt, Germany. He currently uses maize silage and whole plant grain silage (Figure 1). The main fermenter, which holds a volume of 2,800 $m^3$, is fed with 50 tons fresh mass on a daily basis. A post fermenter of the same volume is installed downstream. Recirculation takes place between the main fermenter and the post fermenter, with time limited solids separation with a total volume flow of 250 $m^3/d$. The average retention time is 116 days and the loading rate is 3.2 kg oDM/$m^3$/d.

Since the start of 2018, Eiskamp has been struggling with the formation of floating layers in the fermenter. The entire content of both fermenters was no longer fluid enough to stir. As a result, the substrate supply had to be reduced, and the plant energy output dropped to 70%.

In view of this situation, a biogas consultant recommended the company Biopract with the aim of finding a sustainable solution to the problem. Biopract had developed an inclined channel test, a customer-specific analysis tool to assess the flow behaviour of fermenter content. Consequently, a sample of undiluted fermenter media was sent to the Biopract lab.

A few days later, Frieder Eiskamp was provided with the report showing the results and the recommendation for the use of ViscoPract® CP.

Over a period of eight days, the target enzyme concentration level was established in the main fermenter. The dosage was then lowered to the calculated daily dosage

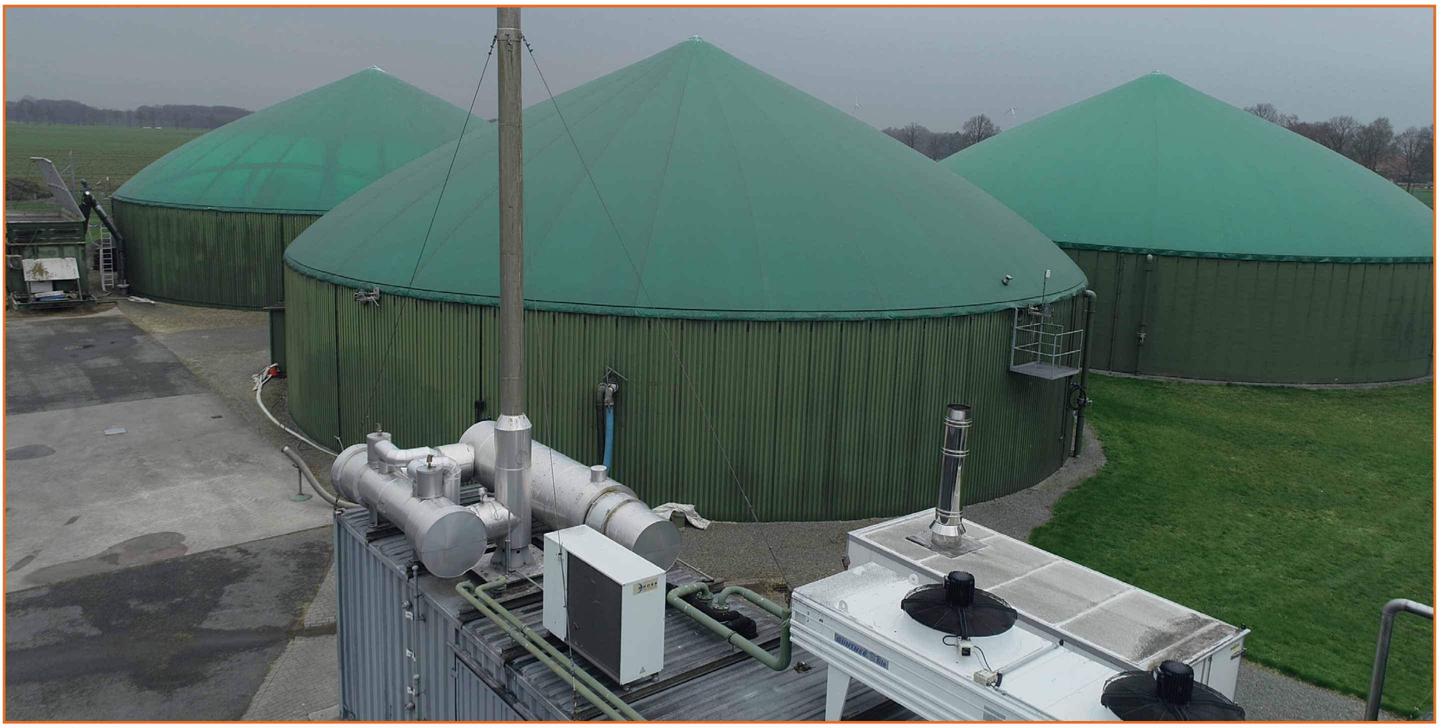

Figure 1: Digester of Bioenergie Eiskamp GmbH & Co. KG

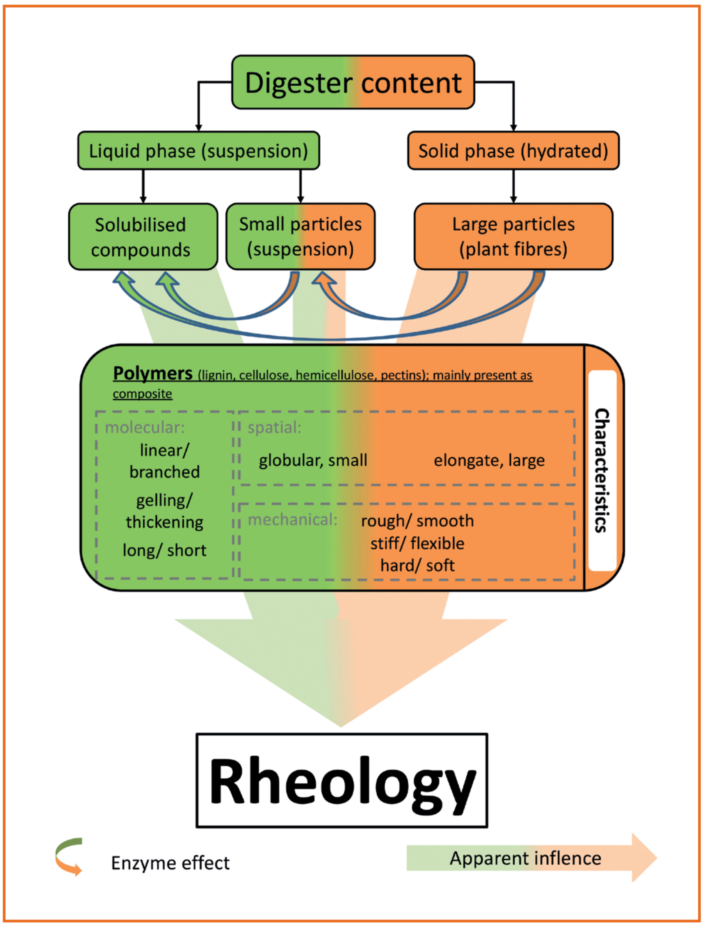


Figure 2: Factors that influence the flowability of digester contents

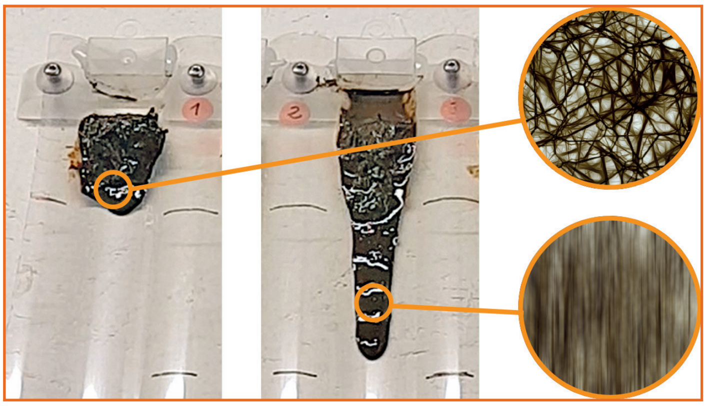

Figure 3: Fibre structures in the digester content (schematic representation)

Figure 4: Results of the inclined channel test (Example with four lanes. Start / 20 / 40 / 60 / 100 seconds.)

to maintain the enzyme concentration at target level. Within the first week a clear improvement of the flowability of the fermenter content could be observed. After three weeks, the floating layer was completely dissolved, the plant stabilized, the original feeding regime re-established and the gas production corresponded to the expected values.

## Examining the fermenter content

The flowability of the fermenter content cannot be reduced to the viscosity of the liquid phase, but must be understood as a mixed parameter that takes into account the influence of the liquid and solid phases (Figure 2).

The viscosity of a liquid is determined by the substances dissolved in it. If, for example, low-molecular sugar is dissolved in water, the concentration of free water decreases. Examples of this are honey or molasses. In addition, soluble long-chain molecules from plant fibres, i.e. soluble polymers bind water on their surface and swell. Depending on their microstructure, the soluble polymers can also crosslink with each other, resulting in an increase in viscosity. Viscous polymers in biogas substrates are hemicelluloses and pectins, whose content and composition depends on the plant species and harvest time. Hemicelluloses are of primary relevance, since the pectin content of grain-based silages is rather low (Table 1).

Rye, triticale or barley-containing WPS (whole plant silages) have a significantly higher content of soluble, beta-glucans than maize silage. They are responsible for the regulation of the water content of the plants in dry periods and can strongly influence the flowability of the substrate mix in the fermenter. Particularly viscogenic substrates are oilseed press cakes (soy, rapeseed) and WPS (barley, rye).

The solid phase of the fermenter medium is heterogeneous. It comprises very small, partly hydrated particles from µm to mm, up to decimetre long plant fibres. It is well known that long fibre components can lead to considerable process disturbances. For example, the attachment to agitators can cause mechanical failures and the entanglement of the fibres can cause the formation of floating layers. The structural and mechanical properties of solid plant fibres, e.g. from grasses or straw, are also determined by water-binding polymers. These swell within the cellulose-lignin network and keep it rigid. Brush-like structures consisting of complex, partly branched molecular chains can also be formed along the main strands of the plant fibre.

| | Flowering plants silages | Grain WPS, grass silages |
|---|---|---|
| Main fibre components | cellulose, xyloglucans[H], pectins | cellulose, xylans[H], partly beta-glucan[H] |
| Secondary components | xylans[H], mannane[H] | pectins, xyloglucans[H] |
| Viscous, soluble polymers | pectins, mannane[H] | beta-glucan[H], pectins |
| Insoluble polymers | cellulose, xyloglucans[H], xylans[H] | cellulose, xylanes[x] |

[H]Hemicellulose

Table 1: Viscous components of different substrates

**Figure 5: The inclined channel test system (Setup, sample application, in action)**

As a result, the reinforced plant fibres become entangled in a mat-like manner (Figure 3). Enzymatic degradation can facilitate the accessibility of the solid phase for microbial degradation and accelerate mass transfer.

### How do enzymes work in the system?

Since there is a direct correlation between the length of the molecular chain and the viscosity of soluble polymers, the viscosity of the liquid phase can be halved by dividing the chain length in half with a single enzyme cut. Targeted enzymatic catalysis at the branching points of insoluble polymers makes the remaining fibre structures soft and supple. This is comparable to the "depilling effect" in enzymatic textile treatment. Fibres disentangle, floating layers and clumping are prevented. Here, as well, a few enzymatic cuts are sufficient to achieve strong effects.

### How does the inclined channel test function?

The inclined channel test uses a construction with inclined channels in which six samples slide or flow in parallel (Figure 3, 4 and 5). For sample preparation, representative portions are taken from untreated and undiluted fermenter media with fibre lengths of up to 60 mm. They are then incubated for 72 hours at the respective plant operating temperature with the addition of various enzyme products or test blends. Subsequently their flowability is evaluated in the inclined channel test. Repeat measurements are possible if the results appear ambiguous.

The test results allow an evaluation of the flowability based on running times, quantity ratios, the degree of liquefaction and the change in the water retention capacity of the feed material (Figure 4). In addition, the flow behaviour of the samples is documented by video.

### Inclined channel tests: always find the right solution

Between September 2017 and September 2018 samples from 51 biogas plants were analysed representing a wide range of different feeding regimes. The dry matter

## Key results:

Two thirds of the plant operators followed the indications of the inclined channel tests. In all cases, the chosen enzyme product secured a significant improvement in flowability and, as a result, a sustained improvement in plant performance.

With one exception, an inclined channel test should be carried out before selecting a specific enzyme for improvement of media flowability.

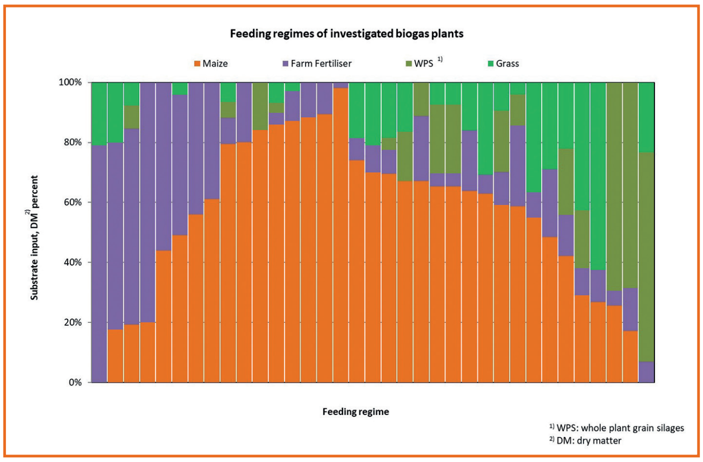


**Figure 6: Substrate composition of the digesters analysed (FF=farm fertiliser)**

in the fermenter medium varied in the range of 7 to 20%. A total of 88 incubations were prepared with six enzyme products. By adjusting the channel board angle and the observation time both, slightly liquid and almost solid fermenter contents could be tested. Two essential questions should be answered:

1. Does the Inclined Channel Test enable prediction of which enzyme preparation will show the best effects in practical application?
2. Could the most suitable enzyme product be chosen on the basis of the substrate composition?

Up to three runs were performed to find the appropriate running angle for the different types of fermenter contents. The evaluation was calculated for the selected run as the ratio between the lengths of the individual run and the control sample. Thus, the enzyme effect for the different combinations versus the untreated control could be evaluated by a number.

Not surprisingly, 76% of the tests identified ViscoPract® CX and ViscoPract® CP as the most effective enzyme mixtures. In addition, it was found that other enzyme profiles, such as the Biopract products MethaPract® CS, UltraPract® HP or MethaPract® CG, should be preferred for certain substrate combinations.

The tested plants use a variety of substrate mixtures. They could be typified in five groups (Figure 6). Only plants clustered in group 5 using significant proportions of grass silage or WPS permit a clear recommendation in favour of the product ViscoPract® CP. For all other substrate mixtures, a clear assessment can only be made once an inclined channel test has been carried out. ●

**For more information:**

The presented results are part of a research project funded by the German Federal Ministry of Economics and Energy.
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