Online control of the biogas process

photo: torben skøtt/biopress

The biogas plant in Ribe is one of the places where the researchers have carried out full-scale tests.

Control and regulation of biogas plants will be an interesting market in the years to come. In Germany, where there are currently 3,800 biogas plans, monitoring and control of the biogas process is one of the areas that attract significant research funds, and in Denmark, we are also catching up quite well.

By Jens Bo Holm-Nielsen

At the Centre of Bioenergy belonging to University of Aalborg, we are for example working on online control of the biogas process using so-called process-analytical technologies. The work partially takes place at the University of Aalborg's laboratories in Esbjerg, partially at Aarhus University, and finally, a number of full-scale tests have been carried out at the biogas plants in Lintrup and Ribe.

One of the areas that we are focused on is how to extract samples that provide an accurate representation of the composition of the biomass. As we all know, the raw materials are rather non-uniform, as they consist of organic waste as well as livestock manure, and therefore, the aim is to get a representative cross section of the various types of biomass.

Another area that we are working on is online monitoring of the biological process. Production of biogas involves thousands of bacteria groups, and the individual process steps have not yet been described in detail.

Continuous collection of dependable data is vital in order to be able to control the process. This applies to biogas plants as well as the many new biorefineries, which are supposed to be able to supply liquid fuel for the transport sector in the future. Therefore, new research results can easily have a spillover effect on other types of bioenergy, just as the opposite can be the case, of course.

Process-analytical technologies

A necessary precondition for being able to optimise the biogas production is much better monitoring and analysis of the biological process than is the case today.

For that purpose, we are working on developing a number of technologies that give the plant managers of the biogas plants a much better change of intervening quickly in case of imbalances in the process (see figure 1). The methods used today are imprecise as well as slow, and there are countless examples of biogas plants that have suffered great losses because the biological process has gotten out of balance.

A deeper understanding of the dynamics in the process often generates new information that can help optimise the systems in the future. Researchers are currently working intensively on developing process-analytical technologies for the medicine, feed and foodstuff industries, but the biogas sector can definitely take part in that development process.

Tests and sensors

In order to overcome the difficulties of extracting a correct sample of the biomass, a research group at the University of Aalborg has developed a concept where you transform the content of a 3-dimensional bioreactor into a 1-dimension al pump loop (see figure 2). This provides a much better possibility of carrying out a

correct analysis of the biomass in the reactor.

Next, it is vital to choose sensors carefully. We have chosen to work with a so-called near infrared spectroscopy (NIR), where light rays with wave lengths from 780 nm to 2500 nm are used.

This system has turned out to be very useful for characterisation of the organic material in a biogas reactor. In practice, it takes place through the light rays hitting the liquid from the biogas reactor, which causes the molecules that contain organic acid (VFA) to start vibrating. Some of the light is absorbed, while other light rays are thrown back. A lot of information is available from these light spectres, and on the basis of different light bands, you can estimate the content of VFA in the biomass.

Throughout the last decades, NIR spectroscopy has been used to characterise the quality of various foodstuffs and feeds, and today, this is routine at the large laboratories.

Apart from the NIR spectroscopy, we are working on research and development within the mid-infrared spectrum (MIR), where the light rays have a wave length from 2500 nm to 6,000 nm.

Finally, we are working on being able to characterise differences in organic dry matter with acoustic sensors. In practice, this means small accelerators that measure vibration differences of the individual pump-in and pump-out places.

Process-analytical chemometrics

Process-analytical chemometrics are vital in any type of fermentation industry, including the production of biogas. It consists of commercial software programmes that can handle large amounts of data. What is most important is that the information about for example VFA and ammonium exhibits a certain breadth. Because, you need low, medium as well as high values for the development of the models.

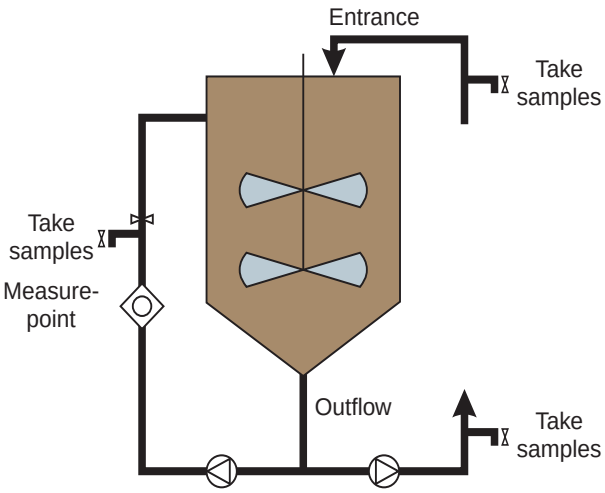

Figure 2. Biogas reactor with location of measuring points and drawing taps for tests. The concept has been developed for full-scale reactors within fermentation industries and biogas plants.

Current results

The researchers have succeeded in making good and sturdy calibration models of all VFA acids, including a strong model for propionate. However, it has not been possible to model organic acids with very low levels in a full-scale plant, where the levels are often between 0 - 1,000 mg per litre.

On the basis of tests at the biogas plant in Lintrup in Southern Jutland, the researchers have been able to create models of total VFA, acetate, propionate and NH4, which are very interesting control parameters that can warn the plant manager of any imbalance in the process.

A critical parameter is that well-functioning biogas plants that do not get near the critical limit for overload cannot get particularly good control models. Thus, there will be a need for follow-up and further development of the tools and not least to make the systems sturdy and simple to handle and maintain.

The main thing is to continuously monitor the VFA level of the biogas plant. Is it increasing, decreasing or stable. Active measures have to be taken if online measurements reach a pre-set level of for example 3,500 mg VFA per litre of biomass.

Jens Bo Holm-Nielsen is employed at the Centre of Bioenergy belonging to the University of Aalborg and made a PhD thesis about online control of the biogas process using process-analytical technologies (PAT). An electronic version of the thesis can be obtained by sending an e-mail to jhn@aaue.dk.

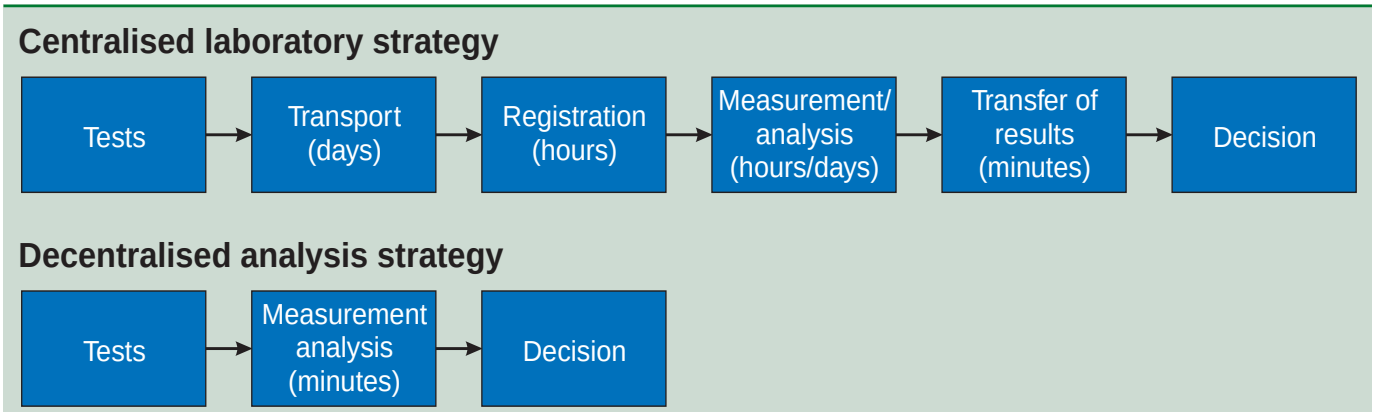

Figure 1. Different strategies for monitoring and control of the biogas process. With the decentralized strategy that the researchers are working on developing, the plant managers will have a much better change of intervening quickly if the process shows signs of an imbalance.