Model based optimization of biogas plants

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Motivation

Increasing amount of energy derived from biogas plants will only be available if a wide variety of different substrates can be used. The feed to a biogas reactor will change according to the fluctuating supply demand scenario for various substrates. The plant has to deliver maximum gas yield and hence energy yield for various substrates. This can only be achieved if the process parameters are optimized continuously. The model should be able to predict optimized process parameters as well as energy yield for a given substrate mix. Therefore the model has to take biological processes into consideration which takes place during anaerobic digestion.

The aim of our research at the Emder Institut für Umwelttechnik (EUTEC) is to develop a sophisticated process model which is capable of predicting the behavior of an industrial sized biogas plant. The model should include:

> Simulation of biogas production for different substrate mixtures.
> Adaptation of appropriate modeling approaches for the simulation-based evaluation of complex substrates.
> Design of a control concept for biogas plants.

Experiments

Following experimental facilities have been used:

Batch experiments in 1 liter flasks at 37°C for 2-3 weeks. Aim was to evaluate gas generation rate for various substrates continuous reactor in 20 liter scale. Equipped with screw pumps and BlueSens analytics system to count gas quantity and gas composition (methane and carbon dioxide) in a continuous mode.

Simulation

Simulation studies have been performed using ADM1 model incorporated into Matlab/Simulink. Parameters of ADM1 kinetic model have been regressed to experimental data.

Results

Figure 1 shows experimental results in comparison with calculated results for the continous recator in semi-industrial scale. A very good agreement between both data can be observed indicating that the model is capable of describing the complex biological processes. As input parameters only readily available data for the substrates have been used.

In order to evaluate the capabilities of the model data from the biogas plant in Wittmund (Germany) have been

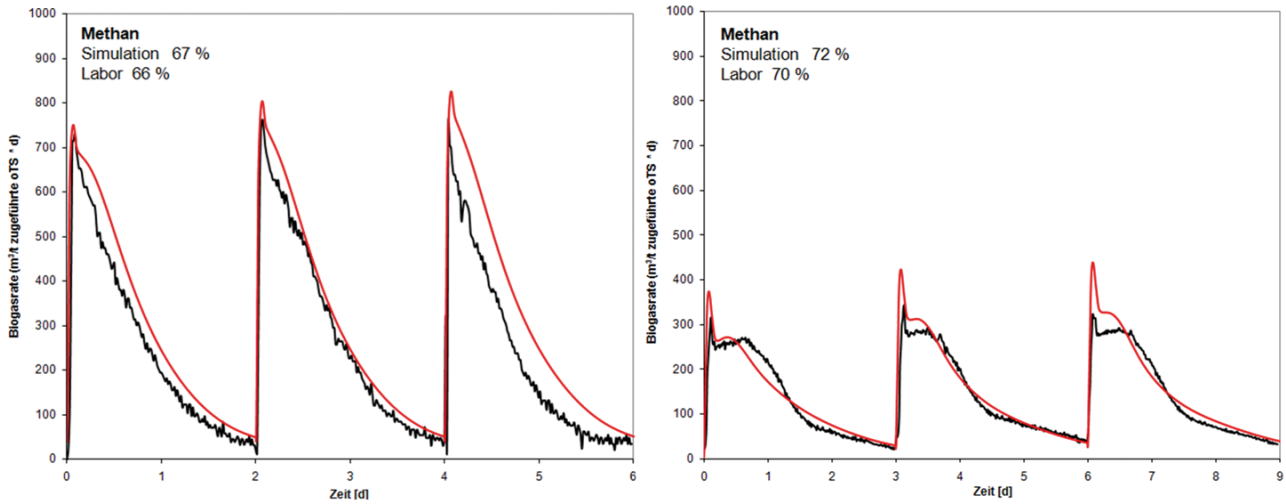

Figure 1 Comparison of experimental (black line) and simulated data (red line) for manure (left diagram) and fat mud (right diagram).

compared to results predicted by the model (figure 2). Again just readily available parameters describing the substrate and the biogas plant have been incorporated into the process model.

As can be seen a very good agreement between experimental data and data from the biogas plant have been achieved.

Further research will focus on incorporating a wide variety of different substrates, to account for substrate pre-treatment and for biogas purification.

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Dr. F. Uhlenhut, Prof. Dr. S. Steinigeweg, Prof. Dr. A. Borchert, Prof. Dr. Reiner Lohmüller, University of Applied Sciences Emden/Leer, EUTEC Institute. Research and development in the following areas:

> *Optimization of industrial processes with respect to high level of sustainability*
> *Technologies to reduce pollutants in soil water and air*
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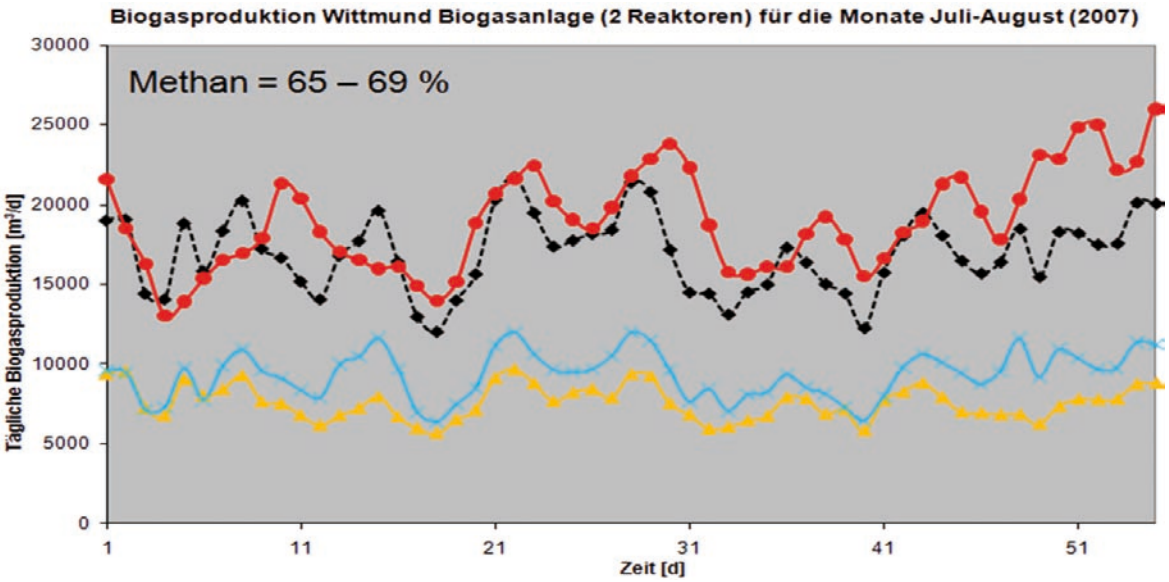

Figure 2 Calculated (red line) and experimental data (black line) from industrial sized biogas plant in Wittmund (Germany).