Automatic control of anaerobic treatment with B-SMART technology

Jorien van Geest*, Kristof Cuadros Perez**


* Jorien.vangeest@veoliawater.com; ** Kristof.cuadrosperez@veoliawater.com

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Introduction

In the past decades anaerobic treatment has been successfully applied on wastewaters originating from various industries. The key to the success of anaerobic treatment is the conversion of organic pollutants into valuable biogas. In many cases this makes industrial wastewater treatment plants net energy producers, even when aerobic post-treatment is applied. Anaerobic reactors have a small surface area requirement due to the fact that high volumetric loading rates can be applied. And because of the low growth rate of the mixture of anaerobic bacteria and archaea, biomass production and nutrient requirement are low.

Due to the low growth rate of especially the methanogens, careful treatment of the anaerobic biomass is required. When disturbed by unforeseen changes in the environment in the reactor like the presence of toxic components, strong deviations in temperature and pH or an overload of organic matter, it can take a couple of weeks or months before the original treatment capacity of the reactor is reached again, unless the reactor is reseeded with biomass from an external source. Some of these issues are currently tackled by online measurement and control of pH and temperature in the reactor. Besides that the operators of anaerobic plants are normally trained to check the performance of the plant based on results of laboratory analysis of samples of raw wastewater, anaerobic effluent and biogas. When the operators have developed sufficient experience over a longer period of time, they are able to see ‘early indicators’ of a disturbed process based on these day to day analysis results.

Online monitoring techniques in anaerobic treatment and smart reactor control

Recently many new techniques have been introduced making it possible to monitor continuously various components in gas and liquid streams. For anaerobic treatment interesting parameters to be monitored
online are for instance: chemical oxygen demand (COD), volatile fatty acids (VFA), biogas composition, hydrogen (H2) and alkalinity (Spanjers and Lier 2006) (Steyer, Bernard et al. 2006). If the operators get a continuous input on important process parameters they can evaluate the performance of the process much quicker than based on daily laboratory results.

Even more benefits can be gained when the inputs from online measurements are integrated into the control system of the wastewater treatment plant. Process variables such as wastewater flow and chemical dosing rates can automatically be adjusted based on continuously measured process parameters. Operational adjustments can be done faster and more regularly, while judgment of the process parameters becomes less dependent on the knowledge and experience of the operators.

VFA measured online in the anaerobic effluent (Spanjers, Bouvier et al. 2006) has for example been shown to be a useful parameter to control the loading of the reactor. Volatile fatty acids accumulate if the conversion by methanogens is disturbed so an increased concentration gives an early indication of a disturbed process. Boe et al. (2008) successfully tested automatic reactor feeding based on propionate concentrations in the effluent. Guwy et al. (1997) had a similar approach by adjusting feed flow rate to the reactor based on the online measured hydrogen concentration in the biogas.

The benefits that online measurements combined with reactor control can bring in terms of process stability and reduction of operational costs were clearly shown by Warmenhoven (2011). Online total organic carbon (TOC) measurement of raw wastewater from a fruit juice packaging company was used to operate an anaerobic reactor at a stable organic load by continuously adjusting the feed flow. This resulted in a strongly improved process performance, increasing COD removal efficiency of the full scale plant from 50 to 82% and reducing the caustic and urea use by 58% and 26% respectively.

**B-SMART Technology**

In a large scale research project of Veolia a new control system for anaerobic treatment, B-SMART, has been developed and tested in a 7 m3 Biobed® STAR pilot plant. The pilot plant was operated at different industrial locations: a paper factory in Germany and a production facility for French fries in the Netherlands. At both locations full scale anaerobic reactors were present; Biobed® EGSB and Biothane® UASB. The performance of the pilot plant was compared to operational results of these full scale plants.

In the first stages of the project different online monitoring techniques were tested on the wastewater stream into the pilot plant, the effluent stream and the biogas. The measurements of the online sensors were compared to laboratory analyses on a daily basis and conclusions were drawn on suitability, reliability, required maintenance and operator attendance of the sensors. Also methods were tested to measure the sludge bed height in the reactor online.

Additionally, tests were done to define the anaerobic treatment capacity of the reactor by doing an in-situ biomass activity test according to a protocol patented by Biothane. The basic principle of the test is a defined deviation in reactor load which does not disturb the normal operation of the reactor. The
The effect of the increased load on different parameters is monitored and conclusions are drawn on activity of the biomass and total treatment capacity of the reactor. This test can be performed automatically without intervention of the operator. When the test is done regularly the operator gets a continuous understanding of the amount of COD that can be treated in the reactor.

Furthermore, the biomass in the pilot plant was regularly inspected by a video camera which was especially developed to visualize and monitor the biomass in the reactor (figure 1). Clear images and movies could be made of the biomass during the operation of the reactor. In this way the effect of biogas production on the movement of the granules in different places in the reactor could be studied, something that is normally invisible in a full scale reactor. The height of the sludge bed can be easily inspected via the computer screen of the operator and changes in appearance of the biomass can be observed early.

*Figure 1: Visualization of biomass in reactor by camera*

Based on the results of the pilot plant research, a combination of online monitoring techniques was made that is most suitable and reliable to give input to the B-SMART control system of the plant. The input of the online sensors is used in the B-SMART module for automatic control of the process and also process performance indicators are determined and presented to the operators (early warning signals). In this way the operation of the anaerobic reactor becomes less sensitive to external factors such as factory spills (peaks in COD concentration or flow, or a release of toxic chemicals) and is less dependent on experience and attendance of the operators of the wastewater treatment plant. This increases considerably the process performance and thus biogas production, and reduces operational costs related to chemical dosing and seed sludge supply. The B-SMART module was successfully tested over a longer period of time in the pilot plant.

**Literature**


**Authors**

Jorien van Geest, graduated at Delft University of Technology in the field of Biotechnology, works as a process engineer for Biothane since 2007. She worked on the design and engineering of various industrial wastewater treatment plants, supervised full scale start-ups and operation in many countries and did research and development in the field of anaerobic wastewater treatment.

Kristof Cuadros Perez, graduated at the Catholic University of Leuven in the field of bio-engineering, joined Biothane as a process engineer in 2010. He specialized in anaerobic wastewater treatment and worked on a large research and development project. In this R&D project a new high rate anaerobic treatment process was developed and tested on pilot scale.