

Abstract: Progress in Biogas IV

Novel monitoring of AD process using low cost sensing platforms

Tanja Radu^{1*}, Richard Blanchard², James Taylor³ and Andrew Wheatley¹

¹School of Civil and Building Engineering, Loughborough University, Loughborough

²School of Mechanical, Electrical and Manufacturing Engineering, Loughborough University, Loughborough,

³Ambisense Ltd, Dublin, Ireland

*corresponding author, email: t.radu@lboro.ac.uk

Monitoring of biogas production and digesters performance is well developed on industrial scale. It uses sophisticated automated equipment for achieving full control of the process and optimal biogas yield. Continuous on-line monitoring of digester stability enables fast acting in cases where misbalance of the process occurs and prevention of greater problem and ultimately failure of the digester which can be expensive and time consuming to recover. However, these sophisticated industrial monitoring systems become too expensive for using for smaller, community scale digesters, especially in poor areas where every expense should be spared and very limited funds are available. There are millions of simple AD reactors installed worldwide (predominantly in Asian countries, e.g. China, India) which would benefit from simple, inexpensive monitoring.

Here, we are testing autonomous wireless gas sensing platform originally built for landfill gas detection for the new use as monitoring equipment for anaerobic digestion. Platform is equipped by sensors for O₂, CO₂, and CH₄ (infrared sensors), as well as pressure sensors (piezoelectric sensor).

The platform has been connected to a vertically stirred 10 liter digester which was fed by sewage sludge 5 days a week. Organic loading rate was 2.65 g VS/l/day with hydraulic retention time of 18 days. The digester was operated at 37°C. This was followed by two temperature increases to 42°C and 46°C (using hotplates and temperature controllers) to test platform's performance at elevated temperatures, as this is unlikely to happen in a typical landfill gas scenario. In addition to platform gas monitoring, gas quality was independently checked once per day using hand held device for comparison purposes. Cumulative gas production was continuously monitored. Digester stability was assessed by checking pH, volatile fatty acids (VFA), Ripley's Ratio and ammonia. In later phases of experiment, performance was also tested at the increased loading rate of 3.37 g VS/l/day.

Monitoring sensing platform was custom adjusted to do take samples 4 times per day. This sampling regime would provide 3 months of operation on single battery charge. The instrument can also be directly connected to power plug. Readings were sent to a cloud using GSM transmissions and recorded on an easily accessible online portal. The portal offers quick-vies of the system, but also possibility of downloading detailed datasets.

Overall performance of the wireless platform was good for the course of the experiment (3 months). Initial one month at 37°C was followed by one month at 42°C, two weeks at 46°C, two weeks back at 37°C and finally 3 weeks at increased loading rate. There was general reactor instability observed at 46°C and this was reflected in lower methane percentage in biogas, detected both by the platform and hand held device. The usual percentage of methane (close to 70%) dropped in this phase of experiment to approximately 50%. This instability was also reflected by the changes in pH and VFA of the digestate. Once the temperature was lowered back to 37°C, methane concentrations increased. Increase in loading rate did not have effect on instrument's performance. However, it was noted that humidity of the gas (especially at increased temperatures) was causing issues with evaporation. A water trap had to be installed to overcome this issue and prevent water vapor penetrating the instrument.

The platform proved to be useful tool for gas monitoring at a small scale for the fraction of cost for industrial monitoring instruments. It was concluded that with a few modifications it can be adopted for use in AD industry. This is a promising result which would enable remote control of decentralized digesters.