

Optimisation of Anaerobic Digestion Using Online Measurements

Eccleston, Robin.^{1*}, Wolf, Christian². and Bongards, Michael¹.

¹ TH Köln (University of Applied Sciences), Steinmüllerallee 1, 51643 Gummersbach, Germany.

² Bergische Waste Management Association. * robin.eccleston@th-koeln.de

Introduction

This project began by investigating the use of newly developed MEMS (MicroElectroMechanical systems) sensor technology for the measurement of key process parameters in the anaerobic digestion process. Once the process parameters have been measured, the traditional approach is to attempt to bring the process parameters to a safe level which produces a reasonable amount of methane. However this level is rarely the optimal level, as the optimum is different for each digester. Consequently the next stage of this project is to investigate methods of determining the optimal level for each individual digester.

Work has already been performed in the case of continuously fed reactors where a 30% increase was made to the feeding rate and the gas production rate was monitored [1]. The work had good results and was able to observe a difference in the digester response which allowed an improved feeding rate to be determined. This project will build upon this research and will investigate the use of other changes to the feeding rate and different response parameters. One possibility is the case of intermittently fed reactors, which attempt to produce biogas to match demand, and can sell generated electricity at a premium. This already provides a source of fluctuation of the feeding rate which could be used to select an optimum operating point by monitoring the rate of change as the gas production increases following a feeding increase.



Figure 1: CSTR laboratory test setup showing 8 x 5L reactors and heater units.

Testing

Initial testing has been completed using a laboratory CSTR (Continuous Stirred Tank Reactor) setup. The setup, shown in Figure 1, consists of 8 individual 5L CSTR reactors. The reactors have been fed on one of three substrates, either milled barley, milled grass silage, or cattle slurry. Half of the reactors are the control reactors being fed a constant amount, and the remainder are the test reactors being fed variable amounts for testing purposes. Parameters which are being measured during the laboratory testing are VFA (volatile fatty acid) concentrations, total gas volume, and gas composition.

The feeding rate for the test reactors is doubled each time that the reactors are fed to observe the change in process parameters as the reactors approach inhibition. In addition to the laboratory testing, computer simulations are being ran using the ADM1 [2]. Initially the laboratory results are being replicated in the simulations, and then the next experiments will be simulated and later validated using the laboratory testing.

Initial Results

The laboratory testing has shown promising results so far. The plots of the rate of change of gas production for barley are shown in Figure 2. In the plot, the red dotted lines show the feeding events. For the test reactors (#3 and #4) the feeding amount was doubled for each feeding event. In the plot, a clear repeatable profile when fed can be seen. This profile increases with an increased feed rate, before the reactors reached inhibition. For the final peak, with the highest feeding rate, the response profile starts to take a different shape. Ongoing work is investigating how this appears for other substrate types and at what feeding rates.

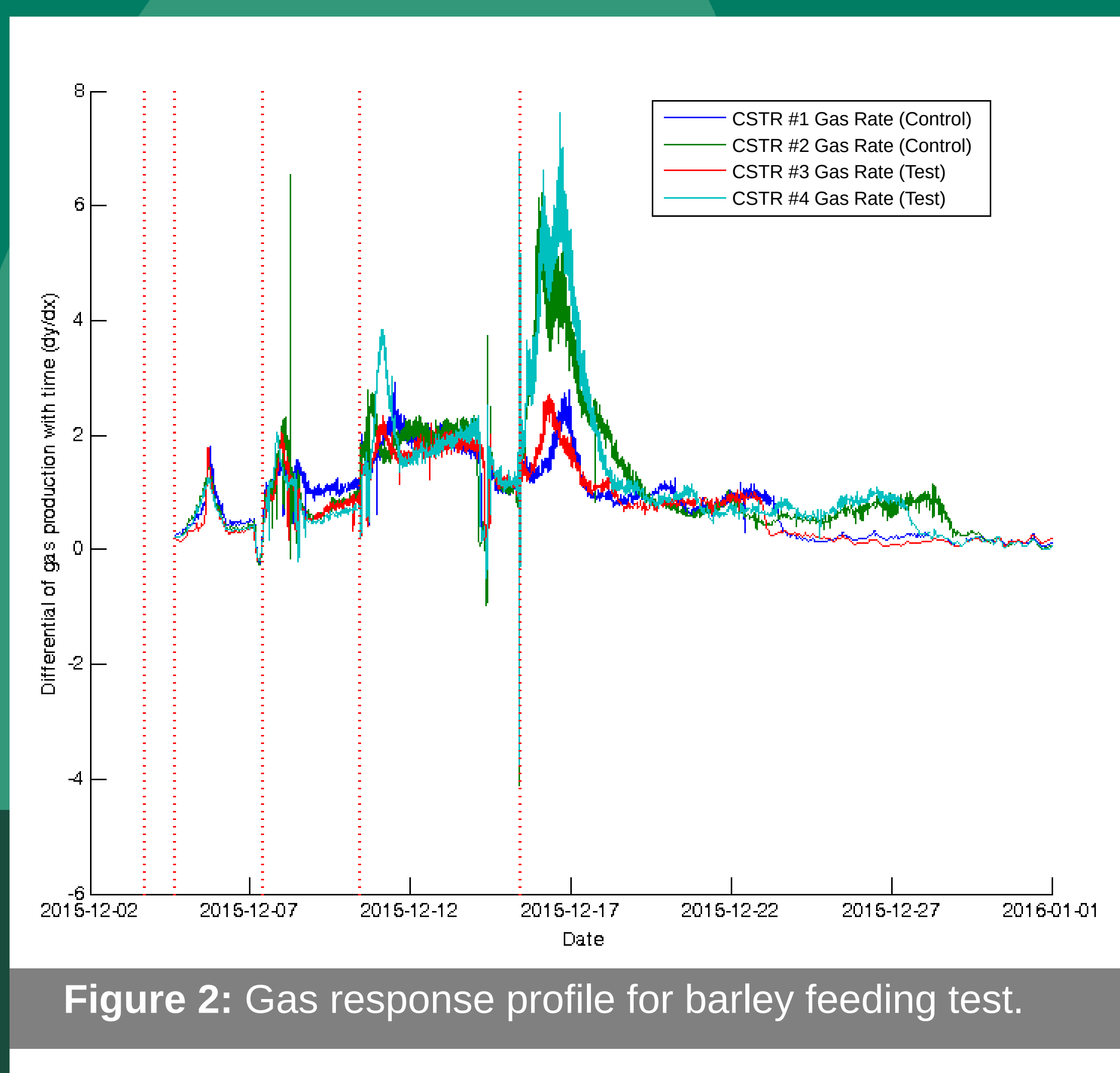


Figure 2: Gas response profile for barley feeding test.

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