OPTIMISING THERMAL HYDROLYSIS FOR RELIABLE HIGH DIGESTER SOLIDS LOADING AND PERFORMANCE

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ABSTRACT

Chertsey (Thames Water) Cambi thermal hydrolysis was refurbished during the early part of 2005 and started operation in August 2005 under a separate contract to Cambi operations. The plant has run continuously since that time except for planned shut downs (inspection and Christmas day) with 2 hours of unplanned shut down.

Initially it was envisaged the plant would achieve an average of 22 dry tonnes per day. However when sludge is available the plant treats over 25 dry tonnes per day. The sludge is fed at about 10.5% DS to two diegsters at 1,600 m^3. Assuming 90% EDV and average VS of 75% the VS loading is 6.5kg VS per m^3 digester capacity per day with an HRT of just over 12 days. The digestion process is extremely stable and an average of 400m^3 of biogas is generated per dry tonne at 68% methane. This is well above typical performance despite the high VS loading and short HRT.

The plant acts as a test bed for engineering improvements on process equipment and process control. The aim has been to improve the reliability and the energy efficiency of future plants by testing the limits of equipment and process at Chertsey

Three new hydrolysis plants are in construction or design in the UK. Two for Anglian Water Services for 20,000 dry tonnes each and one for Northumbrian Water Ltd for 40,000 dry tonnes. All these plants will operate at high VS loading.

The first project for AWS at Cotton Valley, Milton Keynes is mechanically complete. The paper presents the developments from Chertsey and elsewhere that have been applied in this process plant and describes the construction process.

CHERTSEY STW RETROFITS

The Chertsey plant was built in 1998 in response to the need to provide treatment for a number of STWs in the SW quadrant of Thames Water. Liquid sludge was imported to a new STC where the sludge was stored, dewatered, hydrolysed and digested before storage in lagoons and recycling. The original digestion plant treating 7 tds of sludge per day was upgraded to treat up to 22tds per day by the addition of a 2-reactor thermal hydrolysis plant (THP). However the plant suffered some problems due to the original early design. These were corrected and installed in the early part of 2005 by Cambi UK as part of 7-year mini DBO contract.

The main process areas that were corrected were:

Upgrade of all pumps .

Some of the pumps were undersized and the current pump provider did not give adequate service. The new pumps are larger and operated on a continuous basis that avoids stator swelling/shrinkage due to heat cycles.

The slow continuous running has extended stator replacements to acceptable intervals – typically 6-8,000 hours.

Installation of special elastomer for "hot pumps".

The pump supplier Seepex has developed special elastomer that tolerates the higher temperatures well (up to 103^oC). This has extended the life of the digester feed pump to greater than 8,000 hours.

Additional leak proofing using bursting discs on pressure relief valves .

The existing arrangement could leak gradually if not maintained. The bursting discs give an absolute level of control. There have been no odour complaints from the plant in operation in the last two years.

Replace original odour control system with gas recompression unit.

The original oxidisers were unstable and failed from time to time. The sulphur treatment package also failed. This led to odour complaints on the site. The new unit quenched process gas and adds the liquid back to the sludge in the digester feed line.

The system is compact, cheap to run and once again there have been no odour complaints from the plant in operation in the last two years.

Installation of digester recirculation line to THP main cooling unit.

The original cooler was subject to pressure spikes due to some variation in DS% feed from the THP and long uphill feed line (300m). The addition of recirculated digested sludge 3:1 to hydrolysed sludge reduces the viscosity, increases the pH and gives the cooler a constant scouring flow. The main cooler is now trouble free.

Addition of digester trim cooler with adiabatic heat dump using original heating circuit.

The existing cooler could not cope with the hot summer months near London. The existing sludge heat exchangers were reversed and in addition a fin fan cooler with water spray was added to give extra cooling when needed. The digester temperature is now very stable as is biogas production.

CHERTSEY STW PERFORMANCE

The plant was recommissioned in August 2005. The charts below show the performance from commissioning up to the end of 2006.

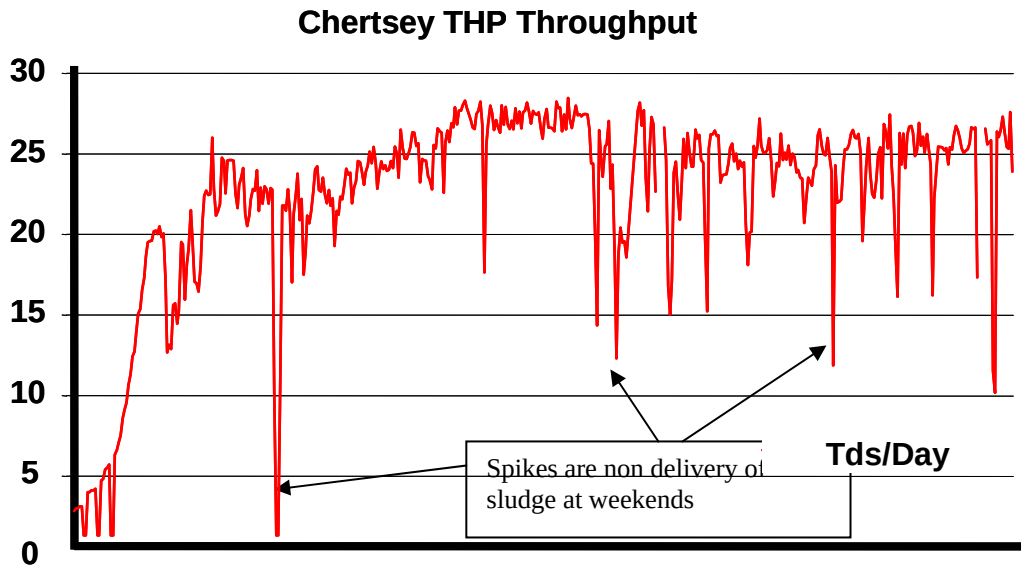

Figure 1 - Throughput in tds per day

The figure shows a rapid start up and after the Chrtistams 2005 break an increase of throughput up to 25 tds per day. The THP plant is capable of producing 32 tds per day – but the limitation is digester loading which is currently operating at about 26 tds per day. Occasionally Thames Water run out of sludge at the weekend.

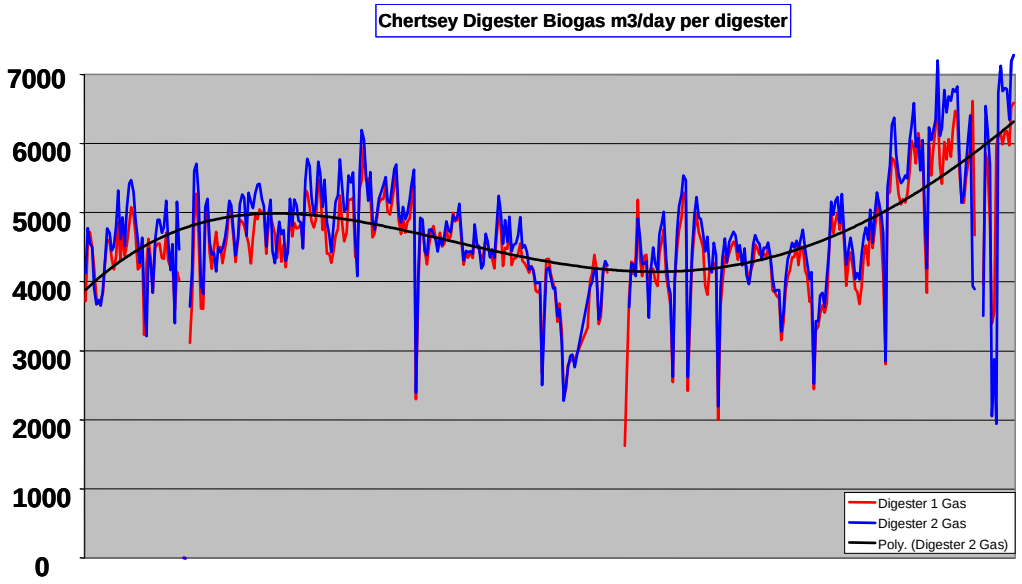

Figure 2 - Biogas per day per digester.

The sludge is split evenly between the digesters and they behave identically. There was a noticeable trend in the biogas production to higher levels in the winter.

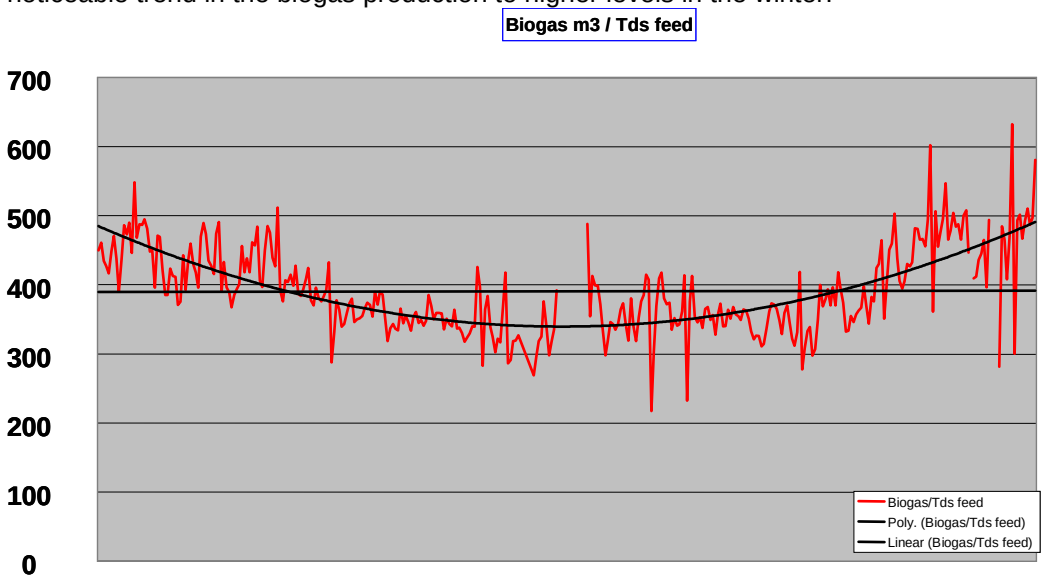

Figure 3 - Specific biogas production.

Figure 3 shows that there is a seasonal trend in specific biogas production that must be due to the changing nature of the import sludge.

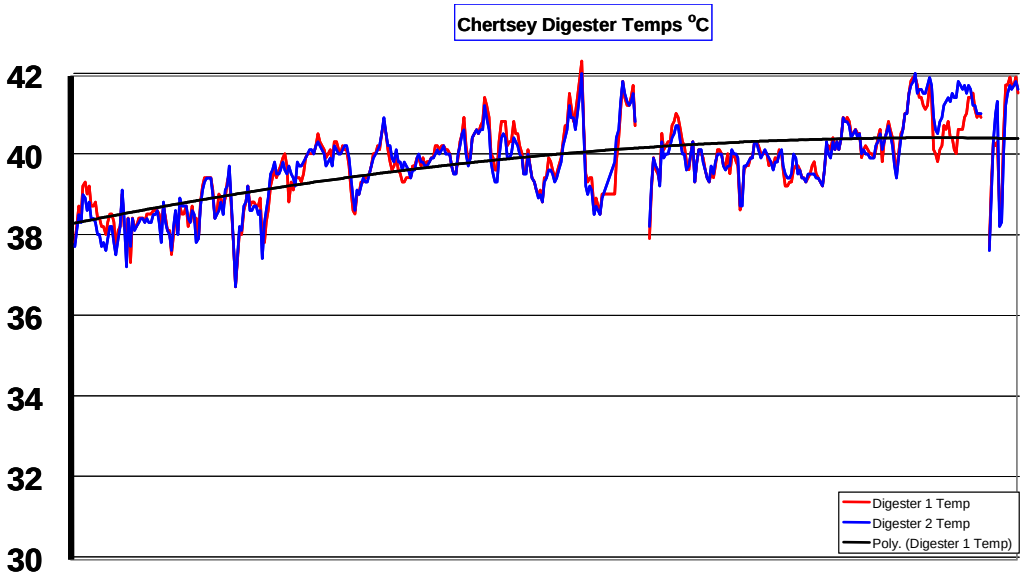

Figure 4 Digester temperatures.

The temperature is stable. The digesters are stable up to at least 42°C.

The sludge is fed at about 10.5% DS to two digesters at 1,600 m^3 each. Assuming 90% EDV and average VS of 75% the VS loading is 6.5kg VS per m^3 digester capacity per day with an HRT of just over 12 days. The digestion process is extremely stable. An average of 400m^3 of biogas is generated per dry tonne at 68% methane per dry tonne treated. This is well above typical performance despite the high VS loading and short HRT. This is equivalent to over 60% VSR. The plant as operated for two years and has only has 2 hours of unplanned downtime.

COTTON VALLEY

Three new hydrolysis plants are in construction or design in the UK. Two for Anglian Water Services for 20,000 dry tonnes each and one for Northumbrian Water Ltd for 40,000 dry tonnes. All these plants will operate at high VS loading.

The first project for AWS at Cotton Valley, Milton Keynes is complete. Based on the original business plan for AWS the decision for Cotton Valley would have had a simple pasteurisation system built for 13,700tds per year of mainly indigenous sludge with a typical UK digester loading. However, further work by the project team showed that installing Cambi Thermal Hydrolysis at the site, up-front of the existing digesters, gave best value when treating 20,618tds of sludge as an enlarged STC. This is mainly because the plant can operate at sustained 6kgVS/m^3 day organic loading (average UK loading is about 2kgVS/m3/day) and can greatly increase the throughput of existing digesters.

The other big advantage of Cambi in this case was that the THP process is proven to produce cake that is typically 8-12% points higher than cakes from other processes and therefore the quantity of final biosolids would be no more than in the original design.

The STC will treat indigenous primary and secondary sludge from Milton Keynes plus liquid imports and raw cake from the surrounding area.

Black and Veatch were responsible for the delivery of the overall project and the scope summarised in the Summary of Works panel. Cambi were the main subcontractor to B&V and started on site at the beginning of this year. Construction is now complete and commissioning is under way at the time of writing. In Cheshire, the construction process was streamlined by pre-fabricating all major plant items and bringing them to site as needed.

A Summary of the Works:

- Installation of reception for liquid and cake sludge for 10,000 dry tonnes of sludge per year.
- Addition of pre-digestion centrifuge dewatering, following 6 mm screening, for all liquid sludge, including 10,500 dry tonnes of indigenous sludge.
- New raw sludge cake silo for sludge blended to 16% DS – pre Cambi Thermal Hydrolysis Plant (THP)
- Installation of a 4 reactor Cambi THP and ancillary boiler plant – capacity 20,618 dry tonnes per year (with a peak capacity equivalent of 22,240 dry tonnes per year)
- Refurbishment of existing digesters and mixing systems (2 x 3750 m3) - 11% DS feed at 14 days HRT maximum.
- Dewatering using existing centrifuges to make a pasteurised cake at greater than 30% DS to new cake pad.
- Increase of digestion rate – approximately 60% organics conversion – new gas holder and gas train.
- Upgrade of CHP (additional 1.4 MWs) and addition of steam recovery plant to supply the bulk of the steam required for the THP.

The plant has some other features and improvements that are not built into the Chertsey plant due to its earlier design. For instance the pulper recirculation is done with positive displacement pumps and the pipe runs are shorter and wider. This means the system can handle higher dry solids feed. The steam consumption is directly related to the DS% feed and every 1% increase in THP feed reduces the steam consumption by about 6%. This is particularly important when integrating the system with CHP waste heat.

Also the pulper tank is now rated for pressure operations that means where waste heat can be used to pre-heat the pulper feed, the sludge pulper can operate above atmospheric pressure. This enables the pulper to work above boiling point and reduces the overall need for steam consumption to reach the desired hydrolysis temperature.

Overall using high DS% feed with pre-heating the steam consumption can be lowered by about 12% and this makes the system nearly autothermic with engine waste heat.

SUMMARY

There has been 10 years of continuing development of the Cambi THP process. The system now is very robust and easy to maintain. Odour issues have been all but eliminated allowing outdoor installation. Digester throughput and dewatering performance have been demonstrated many times. The lessons learnt in the first Cambi projects have been applied to the Chertsey 2005 upgrade. This has been a very successful project and has exceeded the customer's expectation. There are further improvements being made in the current generation of THP plants being built in the UK. All the Cambi THP plants built work and there are now repeat orders and upgrades being placed by existing owners.

Figure 5 – Cotton Valley THP plant September 2007