Avonmouth WwTW

sludge digestion enhancement using ultrasound technology

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Avonmouth WwTW is Wessex Water's principal wastewater treatment works. As well as providing secondary treatment for approximately 1.1 million people, the works accounts for in excess of 50% of the region's sludge treatment. It currently produces 15,000 tonnes of primary and 9,500 tonnes of SBR derived SAS. Secondary sludge quantities are set to rise by a further 50% to 14,500 tpa as further secondary treatment capacity is added over the next 18 months to comply with UWWD requirements. Currently sludges are thickened and digested in six twelve day mesophilic digesters prior to dewatering and disposal – drying as appropriate. However, the digesters are unable to handle feed quantities in excess of 20-30% SAS by wt becoming unstable above this and all surplus is currently treated by lime stabilisation. This incurs significant operational costs leading Wessex Water to investigate other options

Sonix plant arrives in a container *(courtesy Purac Ltd)*

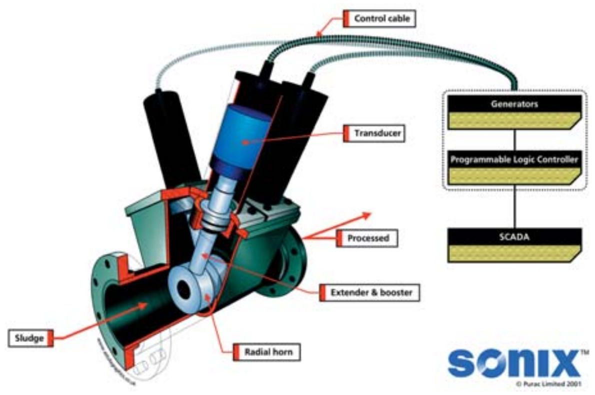
Recent financial incentives for renewable energy generation in the form of ROCs (Renewable Obligation Credits) and enhanced capital allowances (ECAs) are changing the way we see sludge digestion. Some sludge managers are realising that making better use of biogas from sludge digestion centres with CHP rather than using it to generate hot water via boiler plant can provide significant savings.

Any technology that can increase the amount of biogas generated from sludge digestion can reap the benefits of these incentives, which in conjunction with the commensurate greater solids destruction and thereby reduced disposal costs provides sludge managers with significant overall reduction in treatment costs.

Ultrasound

The initial drivers for enhancing digestion through developing Ultrasound were greater solids destruction and rendering the problematic secondary sludge amenable to digestion. On the back of these more obvious benefits the various incentives open to renewable energy generation have meant that **sonix™** is set to become an essential weapon in any sludge managers armoury in his fight to combat escalating sludge treatment/disposal costs.

Wessex Water has been part funding R & D on ultrasound treatment of sludges carried out by *WS Atkins* and, being party to the results and as a company open to emerging technologies, decided to undergo trials on their Avonmouth site. This follows the successful outcome of earlier trials in Orange County in the USA where *WS Atkins* had demonstrated that sonicating secondary sludge enabled significantly higher proportions of SAS to be treated in the digesters in addition to increasing dry solids destruction and enhancing gas yields. The equipment used in the US had, whilst demonstrating the process advantages to the works, had been prone to regular mechanical failure of the **sonix™** stacks and cooling plant. These failings were viewed as largely mechanical engineering design issues and before any new projects were carried out, further development work would be required.



The Theory

Ultrasound is the term given to sound energies of frequencies in excess of 20kHz but below 10Mhz, outside the audible range (16Hz to 16kHz). The origin of the power of Ultrasound in a liquid is primarily cavitation. At sufficiently high power densities bubbles will form, these grow in size until at the high pressure part of the cycle, the bubble reaches its critical size and implodes exerting violent forces sufficient to provide cleaning/rupturing action as required, additionally extremely high temperatures at the foci are believed to aid in the action. The **sonix™** configuration/geometry enables the cavitation energy to be focused by the horn face thereby increasing the cavitation intensity and ultimately reducing the required exposure times.This new ability to intensely focus cavitation energy is used in this instance to enhance anaerobic digestion by causing cellular rupture, reducing particle size and thereby increasing the amount of available substrate to the anaerobic biomass.

sonix™ developments

Early in 2001, *Purac Ltd* was selected as exclusive **sonix™** licensees for the UK and Ireland and set about developing the technology into a robust engineering solution for the water industry. The US prototype plant had required regular shut downs to repair/replace connecting studs between **sonix™** stack components. These were failing for a number of reasons; overheating, variable fabrication tolerances, variable stud quality, incorrect adjustments etc. Additionally as these components were repeatedly removed from service, thereby requiring regular cleaning, inappropriate electric crystal housing meant that the piezoelectrics also failed from time to time. Furthermore, the continuous duty required for **sonix™** had also revealed that the cooling measures normally sufficient for the short bursts of activity typical of conventional high-powered Ultrasound applications such as plastic welding were completely inadequate. Other areas requiring development included control and instrumentation, reactor design and materials of construction.

sonix™ plant description

The new **sonix™** plant consists of a 10 Bar(g) rated polished stainless steel reactor with 5 titanium radial horns installed in series. Each horn is part of an individual stack that includes an extender, a booster and transducer. On earlier models these were bolted together by means of threaded studs, which were very prone to breakage. A key aspect of the new design is that each of the stack components are welded to each other to minimise the risk of mechanical fatigue. Each stack is bolted into the reactor in such a manner that the whole assembly resembles a V5 engine, hence, the term “V5 Reactor”. The horns are placed perpendicular to the flow so that the sludge fluid moves through the centre and to a lesser extent around the edges of the horn. An individual 3kW generator running at 20kHz operates each stack. The generators are kept in a chilled cabinet and the transducers are cooled using dried and pre-cooled compressed air. Transducer temperature is detected and controlled separately to improve the operational lifetime. The rated duty of the basic V5 unit is 8 m^3/h of sludge at 6% DS running up to 24 hours per day. This is equivalent to processing the SAS from a conventional works with primary treatment of 340,000 people. The effective volume of the reactor equates to approximately 1.5 secs retention time. This standard configuration is modular such that multiple units accommodate higher sludge throughputs.

Sonix plant – stainless steel reactor under installation *(courtesy Purac Ltd)*

Running costs of the **sonix™** plant range between 30p and 52p per m^3 of sludge treated. Cost variations are due to ambient temperatures on account of cooling requirements and size of plant. Annual running costs are therefore anything up to £18,000 pa excluding maintenance and spares. Further developments are also under investigation, chiefly associated with materials of construction, various inserts materials and cooling methods to further increase component life and reduce costs.

Trials

Clearly the design of the trials needed to demonstrate that; sonicated secondary sludge was more amenable to digestion, the improved **sonix™** equipment would operate reliably with minimal operational input, the cost of a full scale system could be recovered from operational and disposal savings within an attractive time period and, if possible, the installation of the plant in the interim period would help to alleviate present operational difficulties.

The demonstration plant was, therefore, installed on a new feed line to one of 6 digesters (digester No.5) drawing from the thickened SAS tank. The existing thickened SAS tank feeds the digester ring main and therefore as the quantity of sonicated SAS was increased to the trial digester as the trials progressed less SAS would be available for other digesters, thereby improving their performance. As the maximum rated duty of the **sonix™** plant would enable processing of the test digesters entire feed, SAS proportions to the other five digesters could be reduced from a maximum of 39% feed down to 23% and thereby potentially alleviate their problems.

Containerised plant

The 340,000 PE containerised sonix™ plant arrived at the Avonmouth works on the 11th July. The entire plant is held inside a mobile ISO container and once on site only needed coupling up to the SAS tank and digester inlet pipework. The plant started running 24 hrs/day on 23rd July. Over a period of weeks the feed rate was ramped up in order not to overload the digester up to a maximum of 100% SAS feed. Latterly, the sonicated SAS has been directed into the digester feed ring main such that all digesters are receiving a proportion of sonicated feed though comparisons have to be made with historical data rather than direct control plant.

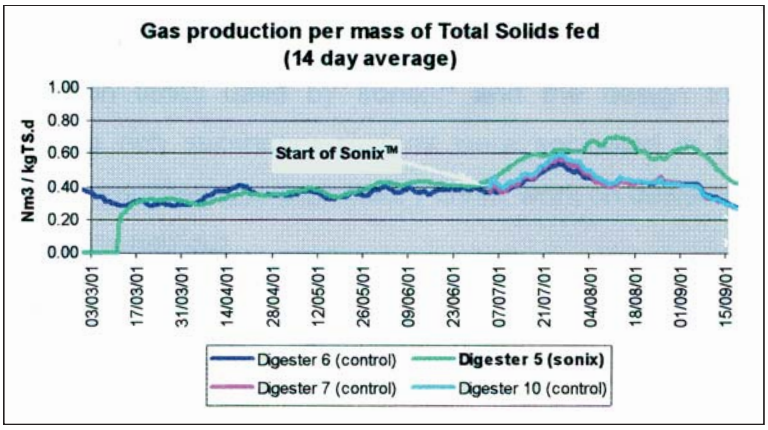
For a fair comparison gas production/solids destruction and digester stability were assessed for Digester 5 (**sonix™)** and Digesters 6,7 & 10 (controls). As can be seen from Fig 1, gas production from control and test digesters closely matched one another prior to the trial and then clearly diverged illustrating enhanced destruction in the sonicated digester. Measurements of digester stability, even when SAS proportions increased beyond 60% revealed that good stability was obtained, higher alkalinity levels as one would expected were evident in the sonicated digester and consistently low levels of volatile Fatty Acids in control and test digesters. (Fig.2) Additionally, no discernable difference in ammonia concentration was detected in either control or test digested sludges.

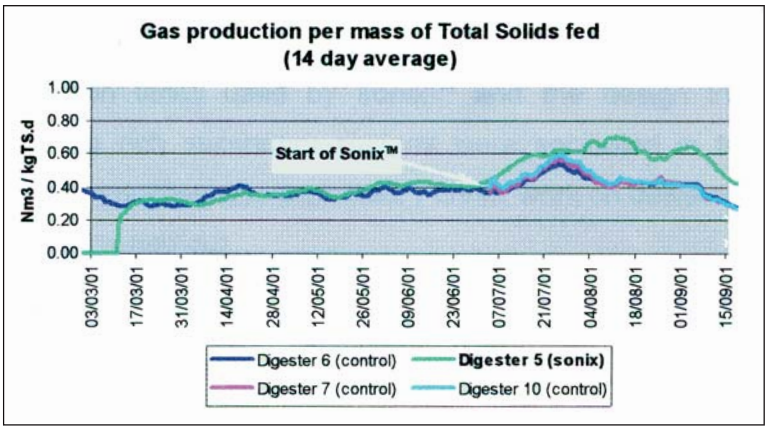
Comparisons

Comparisons with control digesters suggest that in terms of solids destruction the largely SAS fed digester performed slightly better than the now entirely Primary sludge fed control digesters. Surplus SAS produced by the SBR plants that could not be directed through the **sonix™** plant was blended with primary sludge and treated by alkaline stabilisation. As a general conclusion from the trials we can say that **"sonix™** makes a secondary sludge digest like a primary sludge. Additionally, levels exceeding 70% SAS can be fed to a conventional mesosphilic digester and very stable operation obtained. This was witnessed both at Avonmouth and at Orange County Sanitation District, CA. Preliminary results are suggesting that the greater reduction in volatile solids exiting the **sonix™** fed digester produces a more dewaterable product. This is borne out by dewatering experience reported by *Purac Ltd* and others that, with lower levels of feed volatile solids fed to dewatering plant, greater cake dryness can be obtained, perhaps by as much as 5 percentage points. Some degree of pathogen reduction was demonstrated (0.25-0.5 log) but, at the low sonification times used by sonix™ and the design intention that only the less pathogen rich secondary sludges were sonicated in both large scale trials, only minimal reduction was expected. Further work on dewatering and pathogen reduction is being carried out.

Ongoing trials

Extension to the trials was requested in early February 2002. These further trials were to demonstrate the enhanced gas production and solids destruction with sonicated SAS proportions at the expected future 50% w/w digester feed blend. Results at the time of writing are serving to conform earlier findings with between 50% and 100%. increase in gas production over the control digesters fed 100%. primary sludge,, and a further 10%age points total solids destruction over the control digesters, again fed 100% primary sludge only. Preliminary findings from dewaterability tests suggest that dewaterability of the test digester contents fed 50-50 blend is equal or better than the control digesters fed 100% primary sludge.





From Wessex Water's perspective, by treating all the site's secondary sludges with **sonix™** will likely mean:

* removal of liming requirements;
* reduced final disposal quantities;
* less vehicle movements for final cake disposal;
* greater gas production for on site CHP generation;
* greater capital revenue savings associated with significant income from ROCs and eligibility for ECA
* lower drier operating costs on account of reduced throughput and greater feed dryness.

These savings to Wessex Water translate into a simplified pay back period of 1-1.5 years on their capital investment, excluding potential additional revenue from ROCs. The other less tangible benefits of odour reduction as a result of less liming activities, better use of digester assets and better green credentials through greater utilisation of biogas for CHP generation mean that sonix™ pretreatment for digestion enhancement is now a valuable tool for sludge managers. ■

Note: *The author of this article, Fergus Rooksby, is product manager – Bioslids, with Purac Ltd.*