

# Clay Mills STW

## optimising the sludge treatment facilities with an innovative 'bagel' acid phase digester

by Adrian Bancroft & Richard Thomson

Clay Mills STW is Severn Trent Water's largest filter works serving a domestic population of around 100,000 in Burton-on-Trent, Staffordshire. The works receives a very significant trade load, mainly from breweries and associated industry, resulting in a population equivalent (PE) of 421,879 with FFT 112,665m<sup>3</sup>/d and DWF 47,000m<sup>3</sup>/d. As part of AMP5, Clay Mills has been given a more stringent quality obligation under the UWWTD P removal legislation. The new limit is 1mg/l or 80% removal of phosphorous and this consent level is the principal driver for the upgrade. As well as the new activated sludge plant the scheme also includes filter refurbishment, a new sludge thickening plant, acid phase digester to improve the performance of the digestion plant and CHP to increase the green energy generated from biogas. The £45m scheme is being delivered by MWH Treatment as part of the £200m e5 programme of large projects for Severn Trent Water.



Bagel APD - Courtesy of MWH Treatment

### Acid phase digestion increases renewable energy generation

Acid phase digestion (APD) is an advanced technology which increases volatile solids destruction and gas production from anaerobic digestion processes. Anaerobic digestion takes place in three stages; hydrolysis, acetogenesis, and methanogenesis. The bacteria responsible for the first two stages prefer an environment of pH 5 and 1-2 days retention whilst methanogenic bacteria prefer pH 7.5 and 7+ days retention.

APD works on the principle of physically separating the two stages, hence providing optimal conditions for the two sets of bacteria improving process efficiency. This process has been retro-fitted to

Clay Mills to enhance the performance of the existing digestion plant with an increase in energy recovery from the 1.8 MW CHP and a reduction in sludge dewatering costs.

### 'Bagel' acid phase digester reduces construction footprint

The e5 designers worked closely with Severn Trent process design group to develop an optimised template for the acid phase digester. The e5 sludge core team won an ICE East Midlands Merit Award 2014 in the Team Achievement Category for the APD collaboration. By adopting the 'factory thinking' approach the major components were manufactured off-site and capital cost was reduced by 30% without compromise.

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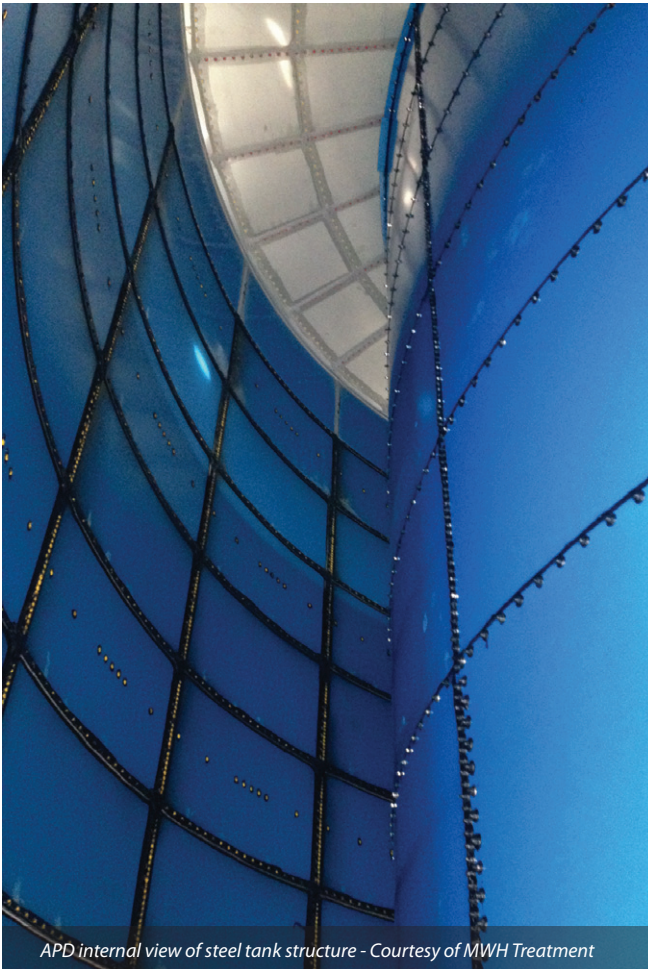
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APD internal view of steel tank structure - Courtesy of MWH Treatment

This standardised design has been constructed at Clay Mills, Wanlip and Worksop and features a number of innovations:

- The 2 (No.) APD reactors are configured as a 'tank within a tank' to give a more compact footprint as all sites had limited available land.
- The 'Bagel' APD is constructed from epoxy coated steel (efusion™ 1500) with a stainless steel roof for maximum corrosion resistance. A detailed evaluation of digester materials of construction was undertaken by e5 to compare concrete versus steel with the full support of the supply chain. The Severn Trent Water sludge community of practice (SCOP) was fully consulted and endorsed the steel tank approach.
- The buffer tank was value engineered out by designing APD 2 as a plug flow tank.
- The transfer pumps were deleted by designing filling ports between APD 1&2. Computational fluid dynamic (CFD) modelling was used to analyse the complex interactions between the liquids and gasses to verify only 2% short circuiting which was deemed acceptable.

The APD is gas mixed to give a 90% effective volume and heated to 42° C. HRS heat exchangers are in a bank of four to facilitate cleaning and the hot water loop is restricted to 60°C to minimise the risk of Vivienite build-up. The APD process is predicted to increase the gas yield by 23%.

#### Sludge thickening plant designed for safe operation

The gravity belt thickeners and polymer dosing plant are housed in a building to provide a secure and safe working environment which is well ventilated and odour controlled to protect the operations team. The design concept was to give clear access to equipment with few changes in level, minimising risk of slips and trips.



Heat exchangers, acoustic enclosure and pipe bridge  
Courtesy of MWH Treatment

A hot washing spraybar and pressure washer is incorporated to clear fat from the belts. The plant processes 5,186m<sup>3</sup> of primary sludge and SAS per day with the presses achieving 6% dry solids reliably. The new sludge stream will allow the site to accept an increased volume of industrial waste which will improve digester output.

The sludge building 3D model was used for design reviews with the suppliers, site construction team and the plant operators. This collaborative approach not only provided an effective design, but also resulted in zero reported pipe work clashes under the slab.

The 3D model was issued to the site team during construction allowing them to check levels, dimensions and feedback as-built information. The MWH BIM approach to design-build is focussed on managing the complex interfaces.

The sludge holding tanks are air mixed to keep the sludge fresh and this has the benefit of stripping H<sub>2</sub>S which negates the need to dose ferric chloride saving TOTEX (whole life cost). A fully equipped laboratory has been provided which includes a SCADA terminal so the service delivery team can monitor the process performance and control the plant from a central location.

#### Nitrifying filter refurbishment marching ahead

The huge filter beds (135m wide x 200m long) are being extensively refurbished to convert the process to nitrification. The media (comprising 40-70mm & 70-120mm gravel) has been removed, cleaned and graded to remove 40 years of bacteria growth and fouling.

The filter floor slab joints have been repaired and sealed using site applied over-banding by Adler and Allen. Sections of the external wall had subsided sand so 90 (No.) stainless steel support tie-rods have been fitted to stabilise the structure.



Sludge thickener plant room - Courtesy of MWH Treatment

A new design of precast concrete tile has been developed in partnership with Carlow Precast which is more robust and can be installed with a fork lift to minimise manual handling. Approximately 166,000 tiles (measuring 500mm x 250mm x 105mm and each weighing 12.5kg) have been manufactured and this product will now be competitively marketed.

Alfa Laval ASH was selected for the 12 (No.) new distributor arms due to their robust and well proven design and the high quality installation continues to progress apace. New crane rails are being installed to BS466F to ensure excellent alignment which is fundamental in minimising wear assuring long asset life.

A Simbal festoon system will deliver a reliable power supply to the distributor E3 high efficiency motors with variable speed drives which allows adjustment of the wetting rates. Auto-lubrication has been fitted to reduce operator intervention for maintenance by 20 days per annum. GRP walkways and step-overs have been fitted to greatly improve the safe access to equipment whilst eliminating the risk of slips and trips associated with walking on media.

#### Intelligent telemetry via fibre network

A significant part of the project was to upgrade the site's telemetry and eSCADA. This included installing 4 (No.) iMCC's (intelligent motor control centres), located in a 3km ring. This telemetry would provide critical monitoring and security for the new treatment processes. A major challenge was to bring over 400 new digital and analogue signals to a central point and onto a new telemetry outstation.

The traditional method of hardwiring these signals would be costly, due to the long cable lengths and ducting required. However, a new HV ring main was being laid around site and this provided the team with a unique opportunity to install a fibre-optic cable along the same route, networking the 4 (No.) intelligent motor control centres with a telemetry PLC. These signals were then passed along a short four-wire communications cable to a new Schneider telemetry outstation.

Developed in collaboration with colleagues in Severn Trent Water and our specialist supply chain Boultings and Sterling, this innovative solution delivered a £46,000 cost reduction and shortened the programme. It significantly reduced the H&S risks associated with cable installation. It will facilitate future O&M, including condition monitoring and fault finding.

#### £1m HV upgrade: Contestable approach minimises disruption to Burton residents

The team were concerned about the new 4.5MVA supply cables running down the A5121 into Burton-on-Trent, which would cause major traffic disruption. It was decided that by employing a 'contestable' approach, an alternative route could be found which would minimise the impact on local residents, businesses and commuters.

Utility consultant UPL and Matrix Networks were engaged and two years were spent proactively evaluating alternative routes involving negotiations with local landowners and stakeholders.

Whilst this greatly added to the project team's workload it was crucial to minimise the impact on Severn Trent Water's customers. Disruption to 165 terraced properties was avoided by not digging up both pavements along Wetmore Road.

New pavements were re-instated along Bramling Cross Road (with 80 properties) to facilitate Staffordshire County Highways adoption of the road. Thrust boring under the Network Rail main line was avoided. The investment has paid dividend and the team have installed the 6km of HV cable across the fields with little disruption to the local community demonstrating real customer focus.



Filter tile and media installation - Courtesy of MWH Treatment



Bio-P carbonaceous ASP - Courtesy of MWH Treatment



Air Mains - Courtesy of MWH Treatment

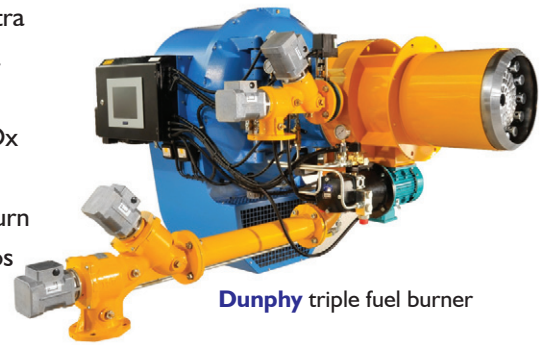


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CCS Silver Award - Courtesy of MWH Treatment

### Considerate Constructors Silver Award 2014

The Clay Mills STW project has been well rewarded with a second Silver Award from the Considerate Constructors Scheme:

*"The site has been held up as an exemplar of management and construction in the water industry and its approach to exceptional performance is maintained in all 5 categories with an impressive score of 44 out of 50."*

### e5 supplier awards

e5 believe in recognising outstanding performance in the supply chain and the following Clay Mills sub-contractors have won supplier of the quarter, each receiving a certificate and cheque for £500 for a charity of their choice; Roger Bullivant (piling), Hillcrest Structural Ltd (buildings), and Servomac (pipework). Hawk Plant, Carlow Precast, Bell Formwork, Lloyd Morris Electrical and Bedford Pumps were all runners up.

### e5 invested £80m in UK manufacturing

The e5 team is pleased to report that a significant proportion of the process equipment installed on the e5 sites was manufactured in the United Kingdom, sustaining employment in the engineering sector.

### Summary

The Clay Mills Scheme is progressing very well due to the attention to detail of all involved.

- Turn of flows was achieved in February 2014 and the process maturation of the carbonaceous Bio-P ASP only took 4 weeks with the process achieving stable performance. There was a period of sloughing as the filter biology converted to nitrification but the process is now established and ammonia levels are consistently low.
- The sludge thickening plant went into beneficial use in January 2014 and is running reliably.
- The APD was commissioned in May 2014 and is being optimised for maximum gas yield. Completion forecast for June 2014, three months ahead of the regulatory Q date.
- The filter refurbishment is ahead of schedule and runs on a rolling programme until March 2015.
- The 60,000 tons of redundant filter media has been recycled for site landscaping and is also being sold to various outlets.

The close collaboration and knowledge sharing between the STW Asset Creation & Service Delivery teams, e5 partners and supply chain has benefited the scheme in many ways including innovations which have generated value engineering savings of £3m.

A workshop was held to 'Celebrate e5 Successes' with all site teams presenting the best features of their schemes which demonstrated the benefits of collaborative working in driving efficiency.

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