Mosswood WTW Hydropower Turbine

Northumbrian Water's first retro-fit hydroelectric installation into an operational water treatment works

by Alan Morritt

Mosswood WTW located near Consett, not far from the city of Durham in North East England, is a Northumbrian Water Limited (NWL) site operating at a maximum flow of 160ML/d, with an average flow of 136ML/d. The site supplies water to the network in Sunderland, South Shields and Washington, with an additional pumped supply feeding Castleside, serving a total of 800,000 customers.

Mosswood Hydroturbine - Courtesy of North News & Pictures / NWL

The scheme at Mosswood WTW comprised of the design and construction of a new hydroturbine. NWL approached JN Bentley with an invitation to offer proposals for a hydroelectric installation to the intake of the Mosswood WTW site, using the head derived from Derwent Reservoir. A major requirement of the scheme was to maintain the operational workings of the site during the development, which resulted in a phased installation process being initiated. This was derived out of highly successful collaborative 'one team' planning approach at the design stage to ensure the seamless continuity of service for NWL and their customers. The £1m design and construct project commenced in March 2011, and was commissioned and operational by March 2012.

Background

The existing site was constructed in the late 1960s, with twin-inlet mains leading into a two stage flash mixing process feeding into clarification stage. Mosswood is one of NWL's largest water treatment works, with a high risk to the supply network if the site is taken out of service.

Investment in renewable energy production is part of NWL's Environmental Strategy in addition to NWL's over-arching drive for efficient operations. The concept of hydropower generation at the site had been considered several times previously, but had continually failed to offer a commercially attractive investment opportunity. All previous proposals required the erection of new building structures to house the turbine, and could not offer as high efficiency turbine on low head high flow conditions. This fundamental problem was overcome by the use of a double regulated Z-axial flow turbine, which was derived from the detailed feasibility study and data collection period undertaken by the delivery team to determine the best option, offering NWL a commercially viable solution for investment.

Hydroturbine installation - Courtesy of North News & Pictures / NWL

Control valve installation - Courtesy of JN Bentley

Hydroturbine installation - Courtesy of North News & Pictures / NWL

Drivers for the scheme included the potential for savings on energy costs; reduction in site grid-demand and the application of Feed-in Tariff (FiT) payments (reducing the payback period significantly); and the positive effect on NWL's drive towards sustainable solutions.

Scope of works

The existing inlet pipe work consisted of two mains; north and south, running in parallel from the Derwent Reservoir to the works. A cross connection on site allowed the flow from either main to feed into the first stage of treatment (flash mixer No 1). The flows in each of the existing mains were not balanced, with the greater portion of flow in the south main. At the cross connection, the south main flow joined the north main and this fed into the flash mixer via a butterfly valve which was electrically actuated and responded to a set point from the site SCADA system. A connection from the sludge supernatant return pipe work returned top water from the sludge system at that point, to be reused in the process.

The hydroturbine unit was installed into the existing north main inlet pipe work as it enters flash mixer No 1. The turbine connects to a bespoke MCC panel and provides approximately one third of the power demand for the site. Modifications to the existing building's structure were required to allow the turbine unit to be installed in the existing inlet room basement. The reinforced concrete floor slab was removed and replaced with a removable open mesh GMS deck. The control panel was also housed at ground floor level in the same building, which controls the turbines operation (the existing instrumentation was relocated to a new kiosk outside the room). The second inlet main (south main) was modified and a new flow control valve installed in the inlet room basement. A manual isolation valve was installed in this main near to the existing cross connection and the new equipment was connected to the existing site SCADA.

Engineering sustainable outcomes

The hydroturbine scheme provides Mosswood WTW with approximately 150kW of its base load electrical demand, through renewable means, using the natural 11.5m (minimum) head of water into the works from Derwent Reservoir. JN Bentley's proposal was to install a 185kW rated axial flow turbine on the existing 36" inlet main upstream of the flash mixer, including a control valve on the bypass.

The design placed the turbine unit and MCC panel within the existing inlet control house; the reuse of existing assets negated the need for major additional building works to house the equipment, providing a cost and programme saving for the client. The only structure to be visible outside of the building's lines was to be a small enclosure over a new valve actuator; but even this was designed out by changing valve orientation. The door and surrounding brickwork was removed to allow the efficient installation of the turbine, MCC and bypass main control valve. All of the original materials were then reused to reduce waste and to maintain the aesthetics of the building.

The existing north main butterfly control valve was replaced by the turbine, which was designed to accommodate all of the flow into the works flows through this main (as it did originally). The south main has a Larner-Johnson flow control valve installed which comes into operation automatically should the turbine shut down for any reason. This valve also takes any additional flows if conditions restrict the flows through the turbine. All generated power is used on site; the output from the turbine is fed into the site electrical system, effectively reducing the site's demand on the network, thus reducing on-going power costs.

Close liaison and collaboration between the client and the project team during invasive works to maintain programme was critical, as system demands varied with weather conditions. Engineering and workmanship was critical in constructing the pipework

modifications, incorporating time-critical tasks and minimal space in work areas. The system was designed to pass entire flow to the works through the turbine when in operation.

Supply Chain Interaction

There were a number of supply chain partners working collaboratively to deliver the hydroelectric scheme at Mosswood WTW, including; turbine design and construction undertaken by Newmills Engineering in Northern Ireland and the bypass valve was manufactured and commissioned by Blackhall Engineering. Mechanical, electrical and instrumentation installations and integration were designed and implemented by JN Bentley and Northumbrian Water framework sub-contractors; Armah Switchgear, IDEC Technical Services Ltd and Dimewest Ltd.

The extended delivery team collaborated together to enable tasks to be completed with minimal impact to the existing site operations. Flexibility in working and commitment to project was displayed throughout the works delivery to achieve the proposed end date, which was achieved. This close collaboration with sub-contractors and client personnel to deliver the project successfully resulted in 'Team of the Year Award' at NWL's *Annual Going the Extra Mile (GEM) Awards*.

Engineering Challenges

The project team encountered a number of challenges throughout the delivering of the scheme, which were overcome due to close collaboration throughout the delivery team. Challenges included:

- *Maintaining the required throughput to the works during the construction*: Detailed planning with client operations and distribution teams, in addition to enabling works undertaken on site allowed the diversion of incoming flow onto clarification stage and ensured that throughput was maintained.
- *Further work done in the distribution network for alternative supplies:* The result of which is now also available for future work and provides additional security of supply by the modification of a link main.
- *The physical dimensions of equipment to be installed relative to space in the building and close tolerances also provided logistical challenges:* This was negated through careful sequencing of work and the skill demonstrated by the installation teams.
- *Weight of kit in excess of available lifting equipment:* External means of uprating the facility needed to be designed and installed.
- *Control system had to provide automatic "bumpless" transfer of flow from turbine to bypass in the event of a shutdown while maintaining control of flows into the flash mixer*: Achieved using a PLC to monitor the turbine and flow control valve conditions, along with inputs from newly installed ultrasonic level instruments and existing site flow-meters.

Health & Safety

Health and safety was a high priority from the scheme's inception due to the fact that confined space working, lifting operations involving large items of equipment in restricted spaces, large excavations and working at height were all present on the scheme, which was conducted in a live operational environment. Control and planning of tasks involving a multi-disciplined team in limited space was a priority, with daily briefings being a valuable tool in highlighting the risks and undertaking the processes safely.

The team demonstrated exemplary health and safety performance, including; 21,290 hours worked, 365 persons working on the project on site, 0 reportable injuries, 0 dangerous occurrences, an Accident Frequency Rate (AFR) of 0 and only 1 minor injury.

Eighty-eight behavioural discussions were carried out by the project management team, which are observations of workplace behaviours followed by discussions intended to challenge unsafe behaviours, to reinforce safe behaviours and provide trend analysis information.

Conclusion

The installed hydroturbine at Mosswood provides the facility with approximately 150kW of its base load electrical demand, through entirely renewable means. Using the natural 11.5m head of water into the works from Derwent Reservoir the turbine is producing more power than stated output under most head/flow conditions.

The project at Mosswood WTW was NWL's first retro-fit hydroturbine installation into an operational water treatment works.

The scheme was also recognised by NWL's Water Production Manager, Noel Cooper who stated:

> *"From the outset this project was a challenge as we always knew we were up against the clock…the attitude, focus and passion shown by all involved has been first class."*

The scheme was commissioned within the planned programme and the system produces power to offset site demand and accrue FITS payments, whilst not impacting the primary function of the site – producing high quality potable water for Sunderland, South Shields and Washington.

The Editor & Publishers would like to thank Alan Morritt, Project Leader with JN Bentley, for providing the above article for publication.

The author thanks Colin Nichol, Operations Manager with JN Bentley, David McDermott, Project Manager and Alistair Baker, Communications both with Northumbrian Water Limited, for their input and assistance with this paper.