Maltese test-bed shows SalTec advantages

Bryan Orchard reports on behalf of KSB AG

Energy efficiency is unquestionably a key consideration in the design and operation of desalination plants, as this has a major impact on the final cost of the water produced.

Throughout the desalination industry, plant operators are looking for long-term solutions with lower lifecycle cost because of the link between water costs and energy costs. In order to meet operators' demands and requirements, equipment manufacturers are investing considerable resources in the development of new technologies that will reduce energy costs.

The Water Services Corporation (WSC) in Malta is one example of a forward-looking operator of a seawater reverse-osmosis (SWRO) plant seeking to ensure the production of high-quality drinking water at an affordable price. Established in 1993 to produce and distribute potable water on the islands of Malta and Gozo, WSC has an annual production target of 35 million m^3 to satisfy the needs of its 400,000 residents and in excess of one million tourists.

In all, WSC runs three RO plants, which produce approximately 55% of the total water needs. The Pembroke plant, first commissioned in 1991, produces some 57% of the RO water content.

Because it does not have any natural fuel resources, WSC is acutely aware that energy costs have to be kept to a minimum and over the years, it has taken every opportunity to keep water production costs in check. In 1999 it started an energy audit programme and this is still in operation.

Careful running of the plants has contributed to extended membrane life and a reduction in units costs. Achieving this at the flagship Pembroke plant has involved the employment of Francis turbines, followed by Pelton turbines for the high-pressure pumps and, in 2001, isobaric devices.

However, with the drive to produce greater efficiencies and water quality, WSC has undertaken to investigate and monitor the potential of a new technology from KSB, the SalTec pressure-boosting and energy-recovery system (Figure 1).

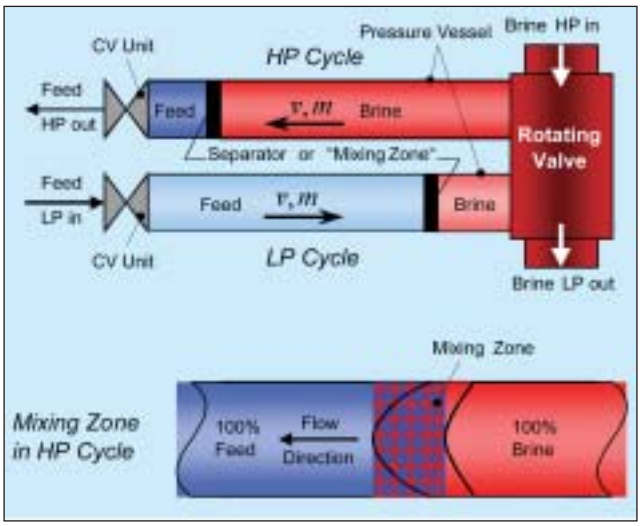

Figure 1. The SalTec DT system is an isobaric chamber (or work exchanger) technology that utilises hydraulic power transmission to reduce energy costs

Employing a pressure-exchanger in an RO process reduces specific energy costs considerably. This is because a pressure-exchanger is more efficient than a turbine solution, and it allows for a dramatic reduction in the size of high-pressure pumps.

In conventional systems, energy is recovered by turbines, and the specific energy consumption for pressure boosting is 3.5 kWh/m^3. The SalTec DT system is a radically different technology taking the form of an isobaric chamber (or work exchanger) technology that utilises hydraulic power transmission to reduce energy costs.

The SalTec system

The SalTec DT pressure exchanger, in combination with KSB's HGM RO high-pressure pump, creates an attractive proposition for RO plant designers and operators. It provides a nominal capacity of 250 m^3/h, giving it the capability to operate in plants with train sizes ranging between 4,400 m^3/d and 5,000 m^3/d of permeate at common recovery rates.

KSB's hydraulic-pressure energy-recovery system combines high-pressure pumps with work exchangers which transfer the brine's pressure energy directly to the incoming seawater. This eliminates the losses caused by converting hydraulic energy into mechanical energy inherent in the turbocharger and turbine.

At the heart of the SalTec DT system is a pressure-exchanger with an electronically controlled rotating valve (Figure 2), together with the HGM-RO high-pressure pump and volute casing RPH-RO booster pump. The control unit automatically adjusts the system to varying conditions resulting from scaling or fouling of the membranes.

On the brine side, a rotating valve driven by a servo-motor provides the cyclical pressure change in the pressure vessels, whereas the feedwater side is equipped with a check-valve.

The rotating valve is the prime component of the pressure-exchanger, and it comprises a rotating cylinder with integrated flow channels. The cylinder rotates in the stator and supplies the pressure vessels with high-pressure brine or releases high-pressure brine

Figure 2. At the heart of the SalTec DT system is a pressure exchanger with an electronically controlled rotating valve.

alternately, depending on the position of the flow channels in the stator. Increasing the volume of the stator brings with it a low flow-resistance in the rotating valve, which means that low pressure losses – the basis for excellent efficiency – can be achieved despite increased flow rates.

In the pressure vessels, a separating mechanism using pistons keeps the seawater and brine apart and ensures negligible mixing (considerably <1%/close to 0%) and, therefore, a constant salt concentration upstream of the membrane, as well as a consistently high recovery rate. Piston rings ensure sealing between the pistons and the pressure vessels, thereby preventing leakage (mixing) above the pistons.

Figure 3. The KSB HGM RO high pressure pump.

The position and speed of the pistons are determined by simple sensors and constitute the input signals for the relevant control unit. The control unit can be configured to control the pressure-exchanger alone or the entire system, including the variable-speed recirculation pump and the HGM-RO pump (Figure 3), thus ensuring optimum operating conditions.

The SalTec incorporates a purpose-designed control system, which minimises energy consumption and ensures the smooth interaction of all components. Furthermore, it gently accelerates and decelerates the water column in the work-exchanger vessels to remove pulsation during the opening and closing of the rotating valve, and ensures almost silent running without the use of any noise protection.

Pilot plant

KSB took the opportunity to utilise the expertise of WSC in RO operation to set up a pilot plant at the Pembroke plant that would operate in parallel with the existing energy-recovery devices. Such an opportunity would enable KSB to establish a reference plant and for WSC to have unfettered access to a wholly new technology. The result was a co-operation agreement whereby KSB and WSC would both gain from learning how effective the SalTec system would be in an active RO plant and WSC would benefit from energy savings that would accrue.

Finding a suitable location in the plant adjacent to the membrane trains was the first task. KSB provided WSC with the SalTec's design and installation requirements and the WSC engineers came up with an installation solution and a pipeline installation proposal.

The initial plan was for KSB to supply a SalTec DT160 system, but, because higher brine flows had to be accommodated, KSB reviewed the existing technology. The outcome was the development of the DT250 unit, which eventually became available in mid-2006.

At that time a decision was taken that it would be beneficial to both parties to put both units on trial. The DT160 was seen as an 'intermediate stage' of development, with the object being to find out if there would any problems in operating KSB pressure-exchangers in parallel. The eventual design comprised two identical DT250 units running in parallel (Figure 4).

During 2007, WSC commenced work on its EU-funded refurbishment programme at the Pembroke plant and, late in the year, the work schedule had reached a stage where it became possible for the SalTec's pipeline equipment to be constructed followed by the actual installation of the SalTec DT250 system. The final stage was the commissioning of the system in the first half of 2008.

Pembroke performance

KSB reports that after commissioning, it was found that the system could be operated at 2.98 kWh/m^3, a considerable reduction on the original target of 3.15 - 3.25 kWh/m^3 of permeate. However it was found that the quality of the permeate produced through the old membranes was unacceptable, so chemicals were introduced to improve the quality of the permeate.

Figure 4. The eventual design comprised two identical DT250 units running in parallel.

The downside to this was a slight reduction in the permeate recovery rate. Even though the SalTec is currently only running at partial load, this only has a partial detrimental effect on efficiency and the permeate flow achieved has been coming in at around 3.18 kWh/m^3.

With improved membranes, this figure could be reduced much further says KSB. In data produced in 2008 by WSC, the combination of high-pressure pumps and isobaric devices, coupled with the installation of the SalTec system on a trials basis at the Pembroke plant have helped to reduce energy costs to 2.7 kWh/m^3 of water, depending on the conductivity of the water.

Almost one year on since the SalTec was commissioned and the trials began, the system is now a permanent fixture, and it is making a positive contribution to the efficiency of the plant in terms of energy savings. The potential of the system has already been identified in relation to operations and maintenance, plus it is much quieter than alternative energy-recovery technologies being used.

Continuous monitoring has revealed clear lifecycle cost advantages over conventional energy-recovery systems, such as Pelton turbines and traditional pressure-exchangers without integrated control systems. Some 12 months on, the SalTec is now a permanent fixture at the Pembroke plant and, together with the replacement of ageing filter membranes to increase water quality and capacity, it is assisting WSC to lower its energy costs.

Significantly, entering into the co-operation programme with KSB has not incurred any capital investment costs for WSC. In fact it has generated savings.

For KSB, the exercise has been a major success. Two of the development targets were to see if it would be possible to operate systems in parallel without creating pulsation or surge problems, and basically to see if units could be synchronised without detrimental effects on performance. In both cases these objectives have been proven.

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