A Comparison Of Real World and Modelled Performance for an Osmotic Brine Concentration System

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Introduction

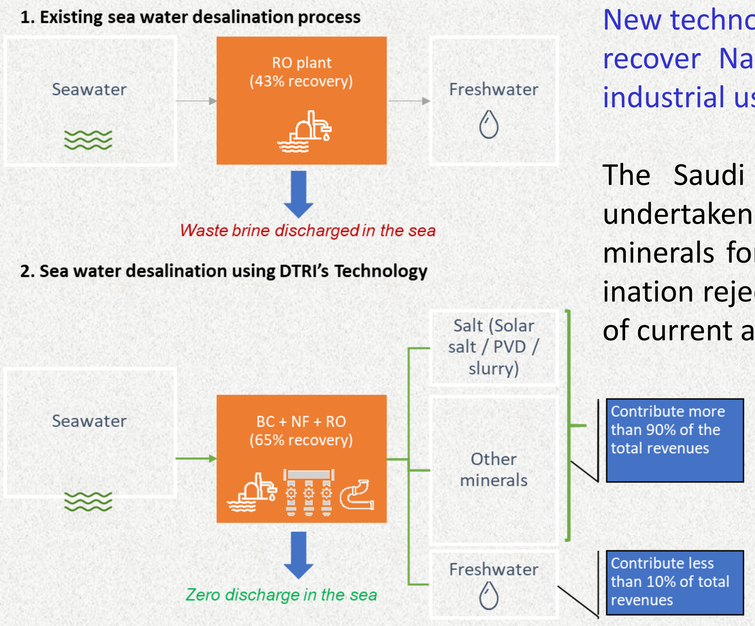

Figure 1: Recovering valuable minerals from a desalination plant waste stream

New technologies are being adopted to recover NaCl and other minerals for industrial use from SWRO reject

The Saudi Arabian government has undertaken a bold project to recover minerals for industrial use from desalination reject streams across their fleet of current and planned desal plants.

Membrane based brine concentration (MBC) with Osmotically Assisted RO (OARO) is being used at pilot scale to demonstrate that the process can be reliable and economical.

Methodology

Figure 2: OARO pilot system at start-up

Comparing modelled system parameters with actual system performance

A modelled system design based on earlier work was developed for concentration of SWRO reject at 78 g/l TDS and 2.5 m^3/h flow. Two pumped stages and a total of 48 each, 4040, spiral design, OARO elements were projected, to reach 220 g/l final brine and 65% fresh water recovery.

The system has been running full time at an SWCC pilot facility and operating data are shared below.

Results & Discussion

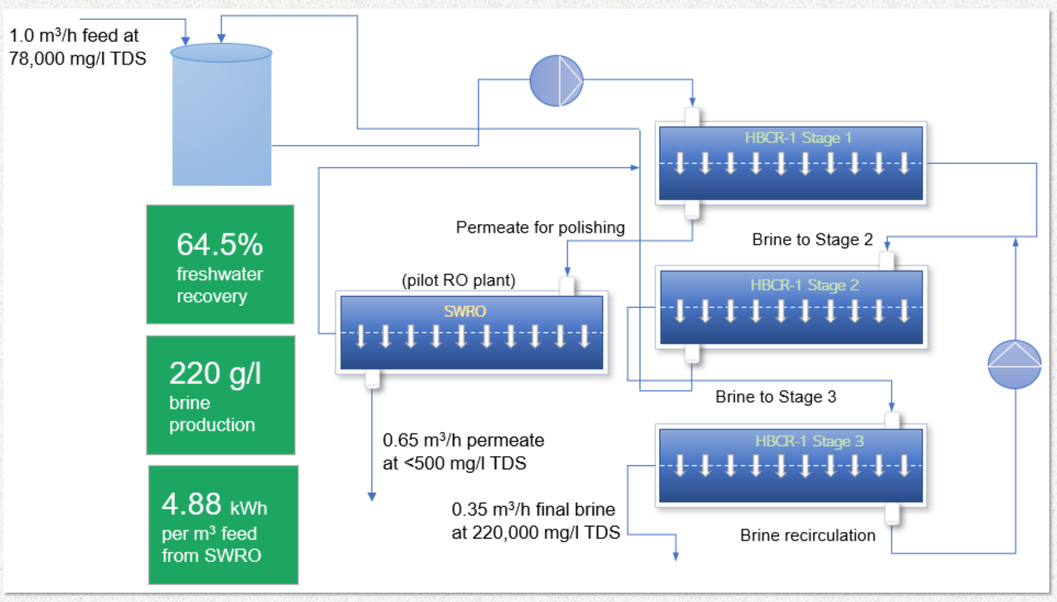

Figure 3: Process flow of the MBC pilot system as modelled

The OARO based membrane brine concentration system was designed based on earlier pilot operating data, membrane performance test data, and proprietary flow and concentration projection software. The defined target parameters were as follows:

- Feed flow of 1.0 m^3/h
- 78,000 mg/l TDS SWRO reject
- SWRO feed was nanofiltration permeate with >80% divalent rejection
- Final brine concentration of 220,000 mg/l TDS
  - Therefore, freshwater recovery of 64.5%
- Max operating pressure of 80 bar
- Max operating temperature of 40°C
- An existing SWRO system is used for HBCR permeate polishing
- Antiscalant feed to the SWRO

A system, with three stages of proprietary "High Brine Concentration and Rejection" (HBCR) membrane elements of 4040 size and spiral wound, flat sheet membrane, and two stages of pumping, was designed as illustrated in Figure 3. The system was fabricated in Saudi Arabia and delivered to site in December 2020.

The MBC system was started up in January 2021 and was initially operated at the target design parameters, producing salt brine at the target design parameters, producing salt brine at 220 g/l and the target flow of 0.35 m^3/h. With new membranes in service, the pumping pressure was lower than modeled, at 62 – 63 bar. Energy consumption of the complete system was not initially measured. Instruments to collect this data are currently being installed.

In January 2021, the system operating conditions were modified in order to test the MBC system performance over time when producing final brine of 250 – 260 g/l TDS. The following operating parameter changes were made:

- Final brine output flow reduced to 0.30 m^3/h
- System recovery increased to 70% and permeate flow of 0.7 m^3/h
- System operated with heat exchangers in service to remove heat from the system (36°C temp. at Stage II feed was observed)

As the system ran continuously over a 1-week observation period, final brine of 250 g/l was produced on a continuous basis, as shown in Figure 4. The system was run in this mode over a 3-month period with stable performance.

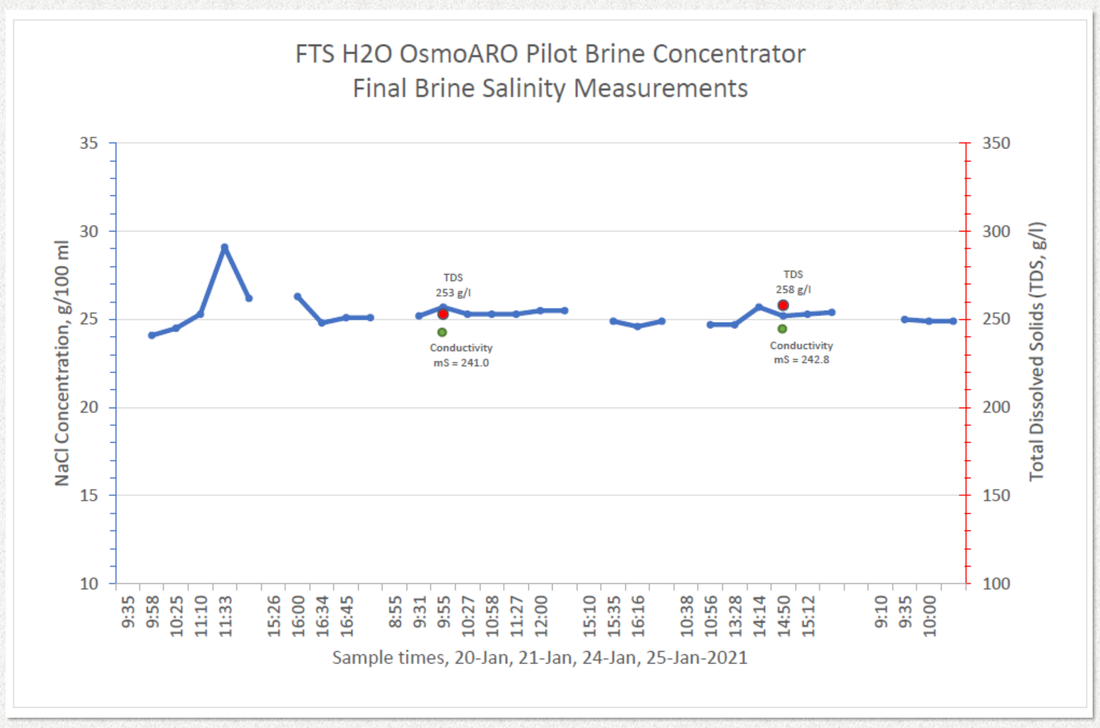

Figure 4: MBC system producing brine concentrate at 250 g/l TDS

Updated energy usage estimated for a system operating to produce 225 g/l TDS NaCl brine, based on pump packages at 80 – 84% efficiency and energy recovery from the final concentrate, is at 4.85 kWh per unit hourly m^3 feed.

Conclusions

The MBC pilot unit was collectively designed, fabricated, and operated by WTRI and FTS staff and has shown stable performance and high reliability over the initial testing period of January - May 2021. The MBC System is a component of a dual brine concentrator technology recently patented by SWCC, which produces crystalized sodium chloride of very high purity, suitable for use as a source material for the chlor-alkali industry. This project opens the opportunity for beneficial and cost-effective mining of minerals of high commercial value from brine generated by seawater desalination plants worldwide.

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