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Closed circuit desalination series no-4: high recovery low energy desalination of brackish water by a new single stage method without any loss of brine energy

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ABSTRACT

Brackish Water sources of 6800 and of 4000 μS cm^{-1} were desalinated in closed circuit by single stage consecutive sequential process with 80% and 88% recovery, respectively, using an apparatus comprising eight modules (8″), each of four elements (ESPA2+), with their inlets and outlets connected in parallel, wherein recycled concentrate mixed with fresh pressurized feed admitted at inlet to modules. The exemplified apparatus, named REIM-I, was operated with fixed permeate flow under variable pressure conditions and the brine in the closed circuit was occasionally replaced by fresh feed through the engagement a side conduit and this without stopping desalination and without any energy loss. The operation of the REIM-I unit is exemplified with 80% recovery of a high salinity (6,800 μS cm^{-1}) feed source at fixed flux of 19 lmh; fixed permeate flow of 24.4 m^3 h^{-1} (586 m^3 d^{-1}) of an average 625 μS cm^{-1} conductivity; a variable pressure range of 11–22 bar with an average of 17.7 bar, and an overall specific energy consumption of 0.82 kWh m^{-3} with high pressure pump efficiency of ≈55%. The operation of the REIM-I unit is also exemplified with 88% recovery of a medium salinity (4000 μS cm^{-1}) feed source remove off at fixed flux of 27 lmh; fixed permeate flow of 35.0 m^3 h^{-1} (840 m^3 d^{-1}) of an average 482 μS cm^{-1} conductivity; a variable pressure range of 12–21 bar with an average of 16.2 bar, and an overall specific energy consumption of 0.80 kWh m^{-3} with high pressure pump efficiency of ≈60%. The new technology under review, which enables the attainment of any desired recovery made possible by the constituents of the source in the presence of suitable anti-scaling agents without any loss of brine energy, has been operated commercially for the past two years continuously providing some 400,000 m^3 of permeates under 1300 μS cm^{-1} for irrigation in the dry Negev district of Israel. The application of the new technology for Brackish Water desalination of high recovery and low energy, reported herein for the first time, was recently demonstrated to allow desalination of Mediterranean Water (4.1%) with a record low RO energy (1.85 kWh m^{-3}, 13 lmh flux, and 85% efficiency of high pressure positive displacement pump) which manifests energy saving of ≈30% compared with the reported RO energy consumption of large desalination plants equipped with modern energy recovery means.

Keywords: High salinity brackish water; Closed circuit desalination with a side conduit; Low energy without energy recovery; High recovery; Reduced fouling; Commercial unit performance

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