Closed circuit desalination series no-12: the use of 4, 5 and 6 element modules with the BWRO-CCD technology for high recovery, low energy and reduced fouling applications

Avi Efraty
Desalitech Ltd, P.O. Box 132, Har Adar 90836, Israel
Email: avi@desalitech.com
Received 29 June 2013; Accepted 17 October 2013

ABSTRACT

The newly emerging closed circuit desalination (CCD) technologies of high recovery and low energy for seawater (SWRO-CCD) and brackish water (BWRO-CCD) have been demonstrated thus far with short modules comprising one to four elements (ME; n = 1–4). The present study explores the plausible application of longer modules of five to six elements each (ME5 and ME6) in the context of the BWRO-CCD technology on the basis of theoretical model simulations with emphasis on recovery, energy consumption, permeates quality and membrane fouling aspects. The plausibility of the ME4 (MR = 40–50%), ME5 (MR = 40–60%) and ME6 (MR = 40–65%) modules in the cited Module Recovery (MR) ranges (in parentheses) for BWRO-CCD application has been confirmed by IMS Design results on such modules with ESPA2-MAX elements using 2,500 ppm NaCl feed at flux of 24.5 lmh. In order to establish the relationships between conventional BWRO and BWRO-CCD which operates on the basis of different principles, a comprehensive theoretical model analysis was performed on the 4ME6 + 2ME5 + ME6 conventional system compared with the 7ME6 BWRO-CCD unit design of the same number of modules and elements (ESPA2-MAX) under similar and different flux conditions for recovery of ~90% using the same feed source (2,500 ppm NaCl) and identical theoretical equations to generate the compared data. The noteworthy conclusions reached from the results of the comparative theoretical study are as follows: (1) BWRO-CCD may reach any desired high recovery made possible by the composition and quality of the source without need of staged pressure vessels and booster pumps and with greater facility and flexibility compared with conventional techniques. (2) The energy consumption of BWRO-CCD is considerably lower compared with that of conventional techniques under same flux conditions, especially in the 80–90% recovery range, without any need for energy recovery. (3) The quality of BWRO-CCD permeates in the 80–90% recovery range is somewhat inferior to that of conventional techniques under the same flux conditions. (4) BWRO-CCD flux increase of ~25% compared with that of conventional techniques will lead to similar quality permeates in the 80–90% recovery range with lower energy consumption by the former despite the flux increase. (5) Convention multi-stage BWRO techniques require high MR in the first stage (up to ~65%) in order to reach ultimate high process recovery and this implies increased probability of fouling and scaling of tail elements due to decreased average cross-flow; whereas, MR in BWRO-CCD is independent of sequence recovery and this implies the ability to select MR of desired cross-flow to minimize fouling and scaling effects.

Keywords: Closed circuit desalination; CCD; High recovery; High flux; Low energy; Reduced fouling; Brackish water desalination; Staged BWRO system designs