Desalination and Water Treatment
www.deswater.com
15 (2010) 256–266
March
1944-3994 / 1944-3986
doi: 10.5004/dwt.2010.1763

Reverse osmosis desalination with high permeability membranes — Cost optimization and research needs

Aihua Zhu[a], Anditya Rahardianto[b], Panagiotis D. Christofides[a], Yoram Cohen[a*]

[a]*Water Technology Research Center, Department of Chemical and Biomolecular Engineering, University of California, Los Angeles, CA 90095, USA*
Tel. +1 (310) 825 8766; Fax +1 (310) 477 3868; email: yoram@ucla.edu
[b]*Envirosoft Corporation, 3637 Motor Avenue, Suite 360, Los Angeles, CA 90034, USA*

Received 14 December 2009; Accepted 29 December 2009

ABSTRACT

Reverse osmosis (RO) water desalination is now well established as a mature water desalination technology. With the current generation of seawater and brackish-water RO membranes, it is now both economically and technically feasible to desalt brackish water and seawater on a large scale. In order to further expand the applications of RO desalting technologies, optimal process conditions must be selected to minimize water production costs associated with energy consumption, membrane replacement costs, chemical usage, and residual brine concentrate management. In the present review, a multi-pronged process-optimization approach for reverse osmosis desalination is presented. A theoretical framework discussed for optimizing energy consumption with and without energy recovery devices (ERDs), considering the impact of membrane replacement and brine management costs. The approach enables quantification of the optimal water recovery of RO desalting, considering various factors including the use of energy recovery devices, the topological arrangement of membrane modules (e.g., single stage, multi-stage and multi-pass processes), and the costs associated with membrane replacement, brine treatment and brine disposal. Comparative analyses of single vs. two-pass RO desalting operation subject to temporally varying feed salinity were carried out to demonstrate operational approaches for minimizing the specific energy consumption. In addition, the roles of brine treatment and disposal was analyzed to demonstrate the potential for optimizing RO desalting cost while taking into account the constraints imposed by antiscalant effectiveness against membrane scaling and the associated brine management challenge. The present analysis concludes that further reduction to RO desalination cost is less likely to arise from the development of membranes with higher permeability than the current generation, but is more likely to arise from optimal process configuration and control schemes, utilization of low-cost renewable energy sources, improvements in membranes' fouling resistance and rejection with respect to specific contaminants, and developments of less-chemical intensive feed and brine treatment strategies.

Keywords: Desalination; Reverse osmosis; Process economics; Membrane permeability; Thermodynamic restriction; Brine management; Chemical demineralization; Brine treatment

* Corresponding author.