

A new theoretical approach to estimate the specific energy consumption of reverse osmosis and other pressure-driven liquid-phase membrane processes

A.O. Sharif*, A.A. Merdaw, H. Al-Bahadili, A. Al-Tae, S. Al-Aibi, Z. Rahal, G.A.W. Derwish

Centre for Osmosis Research and Applications (CORA), Faculty of Engineering and Physical Sciences, University of Surrey, Guildford GU2 7XH, UK
Tel. +44 1483 686584; Fax: +44 1483 686581; email: a.sharif@surrey.ac.uk

Received 25 July 2008; Accepted 8 December 2008

ABSTRACT

The specific energy consumption (SEC) of pressure-driven liquid-phase membrane processes, in particular the reverse osmosis (RO) process, has usually been estimated using a phenomenological approach, which does not explicitly consider the membrane properties and operating parameters. This paper presents a new analytical approach that has been derived, from a well-established theory, to estimate the SEC and to quantify the effect of membrane properties; namely, membrane permeability and surface area as well as the effect of process parameters such as feed pressure, recovery rate, membrane element permeate rate, and feed osmotic pressure. The SEC is also presented in terms of a dimensionless parameter, namely, the specific energy indicator (SEI), which can be used as a membrane property to indicate the SEC of the membrane element for a given process recovery rate and feed osmotic pressure. The SEC calculations are presented for desalting a NaCl solution with a salinity of 35,000 mg/L over a wide range of recovery rates and membrane element permeate flow rates. The calculations showed that for a membrane element with a permeate flow rate of 2 m³/h operating at 50% system recovery rate, the SEC of the RO process can be reduced by more than 35% if the membrane element flow rate factor is doubled, for example, from a value of 20 to 40 L/h.bar.

Keywords: Specific energy consumption; Reverse osmosis; Pressure-driven membrane separation; Desalination

* Corresponding author.