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BOOK OF ABSTRACTS

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Title: Fluid-Structure Interaction in Reverse Osmosis membrane modules

Authors: Giuseppe Battaglia*[1], Luigi Ranieri[2], Bastiaan Blankert[2], Giorgio Micale[1], Cristian Picioreanu[2]

[1] *Dipartimento di Ingegneria, Università degli Studi di Palermo, Palermo, Viale delle Scienze, 90128, Italy*
[2] *Water Desalination and Reuse Center (WDRC), Biological and Environmental Science and Engineering Division (BESE), King Abdullah University of Science and Technology (KAUST), Thuwal, 23955-6900, Saudi Arabia*

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Abstract
Reverse osmosis (RO) is the most efficient desalination technology that produces up to 65.5 million m^3/day of clean water from seawater or brackish water [1]. In the process, an applied pressure is employed to overcome the osmotic pressure arising at the surfaces of a semi-permeable membrane placed between a concentrated and a dilute aqueous solution. The net pressure induces a water passage from the concentrated solution (feed solution) into the dilute one (permeate solution). In RO units, spacers are adopted to keep membranes separated and define the channels where solutions flow. However, spacers induce hydraulic pressure drops that influence the net pressure driving force of the process. In the literature, numerous studies were mainly focused on feed spacer geometries. Conversely, the permeate-side characteristics have been mainly ignored. Membrane compaction and membrane intrusion in permeate channels (or membrane deformation) can occur in RO units. Membrane compaction has been investigated, while membrane deformation has always been neglected. Kleffner et al. have debated the impact of membrane deformation on RO performances, estimating a possible water flux reduction of ~15 % during High-Pressure RO operations (120 bar) [2]. The present work aims at developing the first fluid-structure interaction modelling tool able to assess the influence of membrane deformation on the permeate side of RO units and its impact on process performance. One-way coupled 3-D mechanical and fluid dynamics simulations were conducted using a Finite Element/Finite Volume method (Ansys Mechanical® and Ansys Fluent®). The study was performed at the low scale of a periodic repetitive unit of a membrane-permeate spacer assembly. Membrane and spacer mechanical characteristics were determined by conducting a parametric study exploiting experimental data. Specifically, a purposely designed experimental set-up was developed at the Water Desalination and Reuse Center of the King Abdullah University of Science and Technology to measure pressure losses in permeate channels and, at the same time, to optically record pressure-induced membrane deformations at different applied pressures. Permeate channel volume decreased by 2.3 times under an applied pressure of 57 bar, causing pressure losses to increase up to 20 times with respect to the undeformed configuration. In future works, the low-scale data will be implemented into higher-scale models (treating the membranes as porous media) to address the impact of membrane deformation on RO performance.

References
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