ABSTRACT

Throughout recent years, there has been various research studies on seawater RO membrane modelling concerned with analysing RO membrane transport theories and touching on significant issues of the unique molecular separation mechanism of reverse osmosis that affect areas of our everyday life. However, much of this research could be largely characterised as being empirical in nature. The scope of this flow transport modelling analysis was to develop a mathematical model that would determine variations in the transport of water (solvent) and salt (solute) species within a seawater RO membrane module during reverse osmosis. Hence, the modelling analysis was performed in terms of flow, pressure and concentration of the seawater feed, whilst traversing through the module from point of entry at the axial–centre along the length of module (travelling as feed) to the point of exit at outer periphery (exiting as retentate). The modelling analysis in this paper has been devised based on a generalised capillary diffusion model for the transport of “water” and “salt” through a seawater RO membrane combined with relevant performance evaluation expressions for a SWRO membrane using actual operating data of a SWRO membrane module. For this purpose, the essential first year operating data for a new seawater RO membrane module (DuPont HFF membrane B-10 6835TR, operated at the Addur SWRO Desalination Plant) were compiled; (Note: the essential operating data for one seasonal year from this new SWRO membrane module were used so as to obtain more accurate results). This modelling analysis work was performed by the Author of this technical paper at the University of Newcastle Upon Tyne in the UK as part of the Author’s PhD research work during 2000 (modified in 2007). It is undeniable that concentration polarisation has detrimental effects on the performance of any RO membrane process, with its magnitude being of a vital importance (though not been determined before as no literature cited). Likewise, the resulting concentrated boundary film thickness and salt concentration of boundary solution on the high pressure side of the membrane were also determined in the overall application of this modelling analysis. Thus, the correlations developed for this model, the concept of the generated model and the entirety of merging the expressions (as well as the results achieved) are to provide significance in determining the performance of a seawater RO membrane and to add novelty with a sense of innovation to this modelling work.

Keywords: Water and salt transport through a SWRO membrane; Mathematical model; Transport of water and salt species; SWRO membrane module; RO; Modelling analysis; Concentration polarisation; Concentrated boundary film thickness