230d Electrodialysis as an Alternative Seawater Desalination Method

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Different methods for seawater desalination are currently used, namely reverse osmosis (RO), thermal techniques, and electrodialysis (ED). Utilization of electrodialysis in seawater desalination is marginal in comparison to the other methods, because ED is commonly presented to be economically most viable only under low feedwater salinity condition (TDS lower than 10 g/L). In addition, it was reported that the exergy loss in seawater reverse osmosis systems (0.983 kWh/m3) is much lower than in electrodialysis (12.87 kWh/m3). The main reasons for avoiding electrodialytic desalination of high salinity waters (i. e. seawater) reported are: back diffusion resulting from high diluate and concentrate salinity differences and high ion-exchange membranes and diluate chamber ohmic loss. Also the direct proportionality between energy consumption and the mass of the salt to be transferred is commonly shown as the disadvantage of ED desalination. The authors present that the above listed values of minimum work requirement to be erroneous since they were calculated based on the improper assumptions, namely high ED stack excess voltage and fixed RO excess pressure. The authors have proven, based on the analysis of the Japanese operation plant data, that the considerable value of minimum work required for electrodialytic desalination is approximately 5.26 kWh/m3. Moreover the authors conducted comprehensive studies addressed to mitigate the abovelisted obstacles of electrodialytic seawater desalination. The efforts applied were: flow management design addressed to avoid high diluate and concentrate TDS differences, namely counter-flow mode operation and multi stage desalination; and ED stack chamber design conducted to minimize the diluate ohmic loss, namely small inter-membrane distance operation with a new type of spacer that affects the boundary layer thickness. The applicability of the above modification was then tested in laboratory. The relatively low energy demand (6.6 kWh/m3) and desalted water cost ($1.05 /m3) found, proved the technical and economical feasibility of electrodialytic seawater desalination and led the authors to the conclusion that ED can successfully compete with other desalination processes. The authors also believe that further optimization of the ED desalination process will lead to as low energy consumption as 5 kWh/m3. Finally, the dual purpose: desalted water and salt from seawater production integrated system involving electrodialysis and electrodialysis reversal in the seawater preconcentration step will be discussed. Based on our laboratory data a relatively small production cost ($0.44/m3), as compared to that of potable water obtained by RO or thermal methods, was estimated. This work was partially supported by Polish Ministry of Science and Information Society Technologies, grant No. 3 T09D 085 28 during 2005 – 2008 period.