Computational fluid dynamic analysis of concentration polarization and water flux optimization in spiral wound modules

Aschmoneit, Fynn Jerome; Hélix-Nielsen, Claus

Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Computational fluid dynamics analysis of concentration polarization and water flux optimization in spiral wound modules

Fynn Aschmoneit (a)
PhD student

Claus Hélix-Nielsen (a,b)
Associate professor

(a) Department of Environmental Engineering, Technical University of Denmark
(b) Aquaporin A/S
Investigation of the number of envelopes for FO-SWM

- A baffle inside the inner tube and the envelopes, forces the respective solution to flow around the baffle tip.
- The inhomogeneous flow field causes severe ECP.

- Investigation of pressure drop in FO-SWM configuration
- Spacer similar to Conwed '46 Mils' RO spacer: D = 2.55mm; H = 1.17mm
Investigation of the number of envelopes for FO-SWM

1. The overall pressure drop get smaller with the number of sheets, due to the reduced cross flow velocity.

\[
\frac{\Delta p}{L} = \mathcal{O}(U_{cross}^2)
\]

1. Fixed feed flow rate 1.26 e-2 m^3/s

2. The pressure drop along a sheet is constant.

\[
\Delta p \sim L
\]

2. Fixed cross flow velocity 10 cm/s

1. no. of sheets

2. sheet length L (cm)
Investigation of the number of envelopes for FO-SWM

1. While keeping the cross flow velocity constant, the pressure difference divided by the side length (relative pressure difference) is not constant.

The number of membrane envelopes in FO-SWM matters.
The membraneFOAM algorithm

OpenFOAM algorithm resembling FO processes:

• Modelling ICP, depending only on A,B,K
• Evaluating the consequent water and reverse salt fluxes
• Developed in (1)
• Modification include applicability to bent membrane surfaces and non-zero hydraulic pressure difference across membrane

\[
J_w = A \left[ \frac{\pi_F |J_W|}{(|J_w| + B) exp(|J_w|K) - B - \Delta p} \right] n_D
\]

The water flux map allows to spot zones of severe ECP:
• When the optimal spacer and baffle geometry is found, the optimization process is brought to the pressure optimization and the number of envelopes.
Thank you for your attention!

fyna@env.dtu.dk

Acknowledgements: MEMENTO, DHI, Aquaporin A/S
In the near future:

• Baffle design
• Curvature influence
• PRO-SWM
Bullet points

• Motivation
• What we do
• Spacer optimization
• Envelop sheets
• FO SWM
•