

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

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

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 $(H_{20}+0_{2} \leq CO_{2}+H)$

DTU Environment Department of Environmental Engineering

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.

2. The pressure drop along a sheet is constant.



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

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

2. Fixed cross flow velocity 10 cm/s

 $\Delta p \sim L$

Investigation of the number of envelopes for FO-SWM





• The number of membrane envelopes in FO-SWM matters.

OpenFOAM algorithm resembling FO processes:

The membraneFOAM algorithm

- 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

$$\mathbf{J}_{w} = A \left[\frac{\pi_{F} |\mathbf{J}_{W}| \left[\frac{c_{D}}{c_{F}} - exp(|\mathbf{J}_{w}|K) \right]}{(|\mathbf{J}_{w}| + B) exp(|\mathbf{J}_{w}|K) - B} - \Delta p \right] \mathbf{n}_{D}$$

(1) Gruber et al. Journal of Membrane Science, Vol. 379, No. 1-2, 2011, p. 488-495

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 Δc_M

 $c'_F \\ c_F$

 $\Delta c \sim \Delta \pi_{eff}$



×x

Mapping the water flux - optimization of spacer and baffle geometry



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!

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In the near future:

- Baffle design
- Curvature influence
- PRO-SWM

Bullet points

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