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Validation of a generic steady state model for full-scale Reverse Osmosis

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CAPTURE

GHENT UNIVERSITY

Introduction

Supply of process water in industry is challenged by decline of water resources

- Changing feed water properties
- Requirements vary by sector

A lot of data is collected in industry

Development of models to anticipate on these challenges

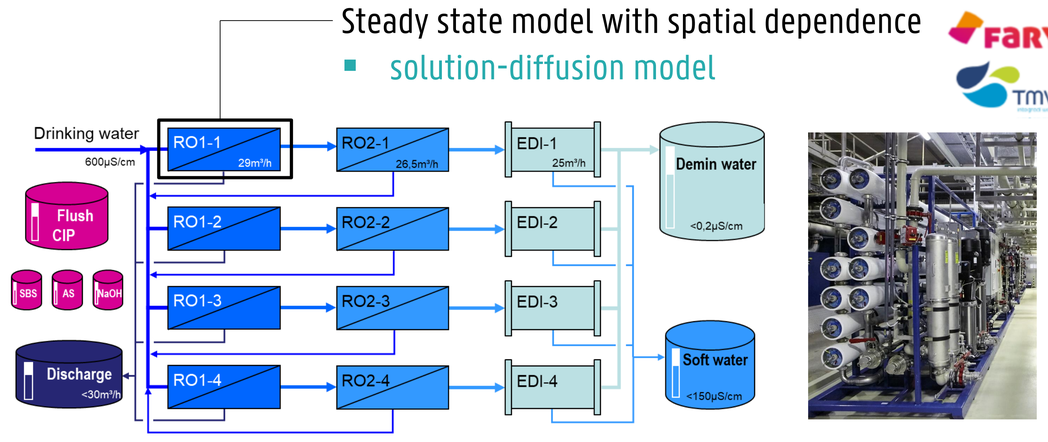
First unit process: reverse osmosis (RO)

Full-scale RO

Steady state model with spatial dependence

- solution-diffusion model

FARYS TMVW



Production of 400000 m³/year ultrapure boiler feed water for a combined heat and power system: data from online sensors e.g. conductivity

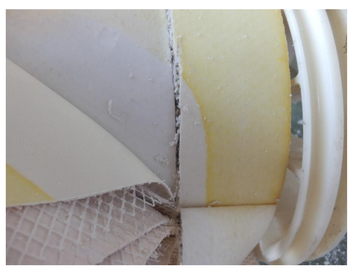
PARAMETER RANGES

Membrane properties

- water permeability L_p
- solute permeability B

Design properties

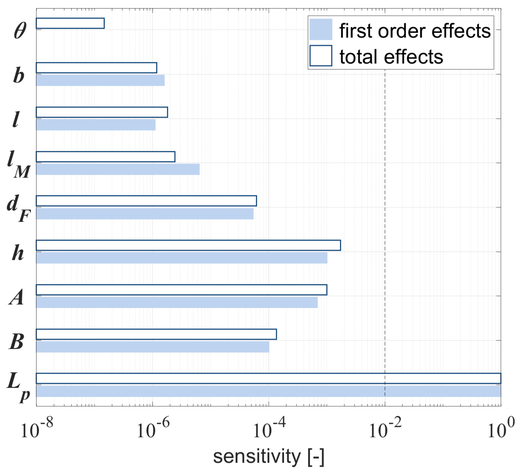
- active area A
- length/width envelope l, b
- spacer properties d_F, l_M, h



Membrane autopsy to define the range for the design properties

GLOBAL SENSITIVITY ANALYSIS

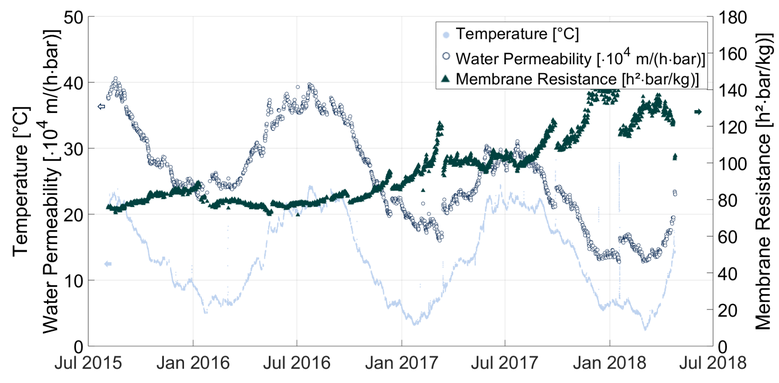
output: recovery



- highest sensitivity: water permeability

CALIBRATION

parameter: water permeability L_p

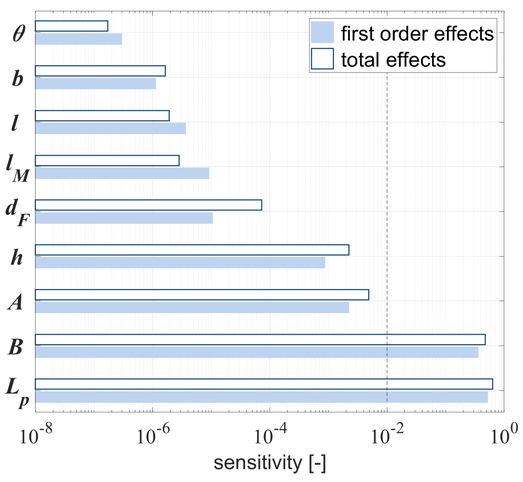


- The water permeability is correlated to the water temperature: calculation of membrane resistance
- Membrane resistance increases: presence of fouling

calibrated L_p

GLOBAL SENSITIVITY ANALYSIS

output: permeate solute concentration



- highest sensitivity: water and solute permeability

CALIBRATION

parameter: solute permeability B

Main ions	Calibrated solute permeability [· 10^{-4} m/h] (average ± stdev)
Na^+	5.07 ± 0.50
Ca^{2+}	2.80 ± 0.85
Mg^{2+}	2.34 ± 0.63
Cl^-	4.01 ± 1.33
NO^{3-}	10.95 ± 8.39
SO_4^{2-}	1.83 ± 0.53
HCO^{3-}	3.18 ± 1.19

calibrated B

Conclusions

A steady state model for RO was calibrated and validated with data from a full-scale installation.

The deviations between model and data can be partly explained by uncertainties in the model input and the data.

Yet, there are some shortcomings in the current model structure:

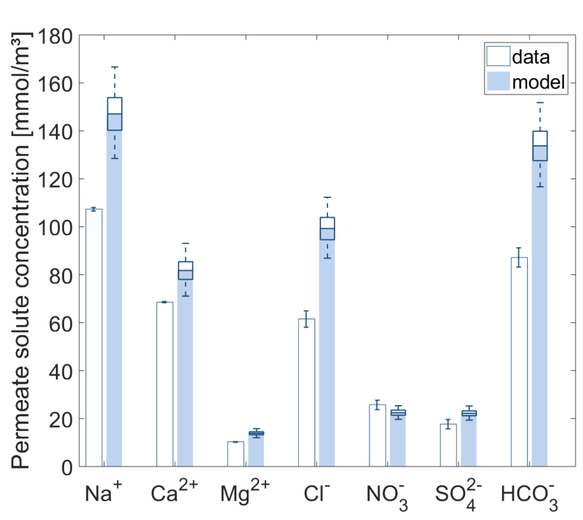
- Estimation of ion concentrations in the feed based on conductivity
- Influence of fouling

VALIDATION

model input: data from online sensors

uncertainties accounted for in uncertainty analysis (represented by boxplot on the model output)

Permeate solute concentration



Concentrate solute concentration