Introduction

Scientists and engineers both need models for their work. However they have different ideas about models and use them for different purposes. While scientists use them for analysis, i.e. for a better understanding of a physical phenomenon, engineers are interested in their application for different purposes. Models enable him to calculate and design plants and to optimise their operation and design. There are three principle types of models:

- Empirical or "Black Box" models, which mathematically describe experimental results without considering the real phenomena taking place in the system, e.g. by regression analysis.
- Semi-empirical models, which are based on scientific laws. Since the phenomena taking place in a real system are usually quite complex and it is almost impossible to describe them exactly, the semi-empirical models use simplified forms of scientific laws.
- Physical models, which describe the phenomena accurately without need for experimental results, e.g. by solving the Navier-Stokes-equations.

While purely empirical models have the disadvantage of permitting no extrapolation into regions where no experiments have been performed, the main disadvantage of physical models is the extremely large effort which is required for more complicated systems. Semi-empirical models are neither a perfect solution. Often it is difficult to find a model which is accurate enough and does have a sufficiently small number of parameters, i.e. requires only a few experiments to determine the parameter values.

Approach

A semi-empirical model for the description of the mass transfer in pore membranes (ultrafilration and microfiltration membranes) is the pore model. The pore model assumes the membrane to be a system of pipes in a material which itself is impermeable for the permeating substances. The transported substances flow through the pipes. The pore model consists of two parts. A first part deals with the flow of the liquid through the membrane while a second part deals with the rejection coefficient for the macromolecules which are dissolved in the liquid. In order to model the flux in pore membranes the membrane is considered as a system of parallel capillaries with all the capillaries having the same diameter. Three parameters are introduced to characterise the membrane: porosity ε, surface area per unit volume $S_{(V)}$, and the ´detour´ factor τ.

The level of the pressure difference (TMP: Trans-Membrane Pressure) depends on the membrane system used. Submerged systems are normally operated with low TMP, while crossflow and dead-end systems are operated with higher pressures. Within WA 5 of the TECHNEAU project a survey on operational strategies of UF in the field of drinking water production was conducted, and the results were published in D. 5.3.5a and D.5.3.6.a. The results show that the TMP for submerged systems are normally within the range of 0.13 - 0.4 bar and for the other membrane systems 0.13 - 2.0 bar.

However, in practice the ultrafiltration is normally surface layer controlled. In operation, rejected compounds can lead to fouling of the membrane. This fouling can affect the flux and retention behaviour much more than the membrane.

A few authors have reported that beside of semi-empirical models also empiric models can be used for the modelling of micro- and ultrafiltration processes. An important group of these modelling tools are artificial neural networks (ANNs). ANNs are adaptive systems that changes their structure based on external or internal information that flows through the network during a learning phase. It is reported that the water flux in ultrafiltration membranes can be well described by ANNs. Based on experimental data, ANNs were used in this study to describe flux during ultrafiltration in hollow fibre membranes. Orther studies have shown that the transmembrane pressure (TMP) in coagulation/microfiltration processes can be predicted by using ANNs with input water quality parameters such as temperature and turbidity as well as process parameters such as flocculation pH and backwashing conditions.

More information

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