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Analyses and Modelling of Filtration Processes in MBR and test cells

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Introduction

One of the major problems associated with membrane separation processes, which restricts the widespread application of the process in the industry, is the reduction in permeability. This phenomenon is commonly known as 'membrane fouling' and makes the process more complex because the membrane has to be cleaned frequently. Membrane fouling includes adsorption, pore blocking, concentration polarization and cake layer formation.

During the design of a membrane process the characterization of the suspension is needed for prediction of required membrane area and/or optimal operating conditions. Furthermore the knowledge of the filtration mechanisms can help to find an appropriate method to avoid fouling. The filterability of a suspension can be described by the Modified Fouling Index (MFI), the Silt Density Index (SDI) or with experiments in a test cell. The disadvantage of the indices is that they result from a dead-end filtration, which is rarely used in membrane plants. In general, filtration tests are carried out at ΔP=const while plants operate mostly at J=const. Therefore it is more appropriate to apply filtration tests where filtration and fouling phenomena are the same as in the plant.

In this work the filtration mechanisms in a test cell and in pilot membrane bioreactors (MBR) are analysed and compared.

Theory and Experimental

Various experimental results obtained with different activated sludges and model suspensions as well as data from pilot membrane bioreactors were used to analyse the dominant fouling mechanism. Experiments were performed in a crossflow filtration module with a membrane area of 0.0088 m^2.

To analyse the filtration mechanism several mechanistic models were examined. The considered models at constant transmembrane pressure (ΔP) are the models by Hermia [1] for dead-end cake filtration and pore blockage, the model by Elmaleh et al. [2] for crossflow cake filtration and the model of Fradin and Field [3] also for crossflow cake filtration.

The models used for the operational mode of constant flux are those of Hlavacek and Bouchet [4] for dead-end cake filtration and pore blockage and the model of Fradin and Field [3] for crossflow cake filtration.

Results and Discussion

Figure 1 shows the different behaviours of activated sludges. The various types of activated sludge are extremely different in their filtration resistances. Despite a lower biomass concentration, activated sludge from a MBR with industrial wastewater has a much higher filtration resistance than activated sludge from MBR plants for domestic or municipal wastewater. Although all the experiments are performed in a crossflow module, most of the activated sludge show dead-end cake filtration behaviour. In the MBR plant, the filtration mechanism are completely different. Further analyses show that real crossflow cake filtration occurs there. This mechanism can be attained by experiments with aeration (see curve for kaolin xanthan with aeration). The third mechanism that we observed in test cell experiments is a change from pore blockage to cake filtration.

Further filtration mechanisms at constant flux are also analysed. The filtration mechanisms were different there and could not be described by one of the considered models, so it was assumed that the filtration mechanism is more complex for J=const than for ΔP=const.

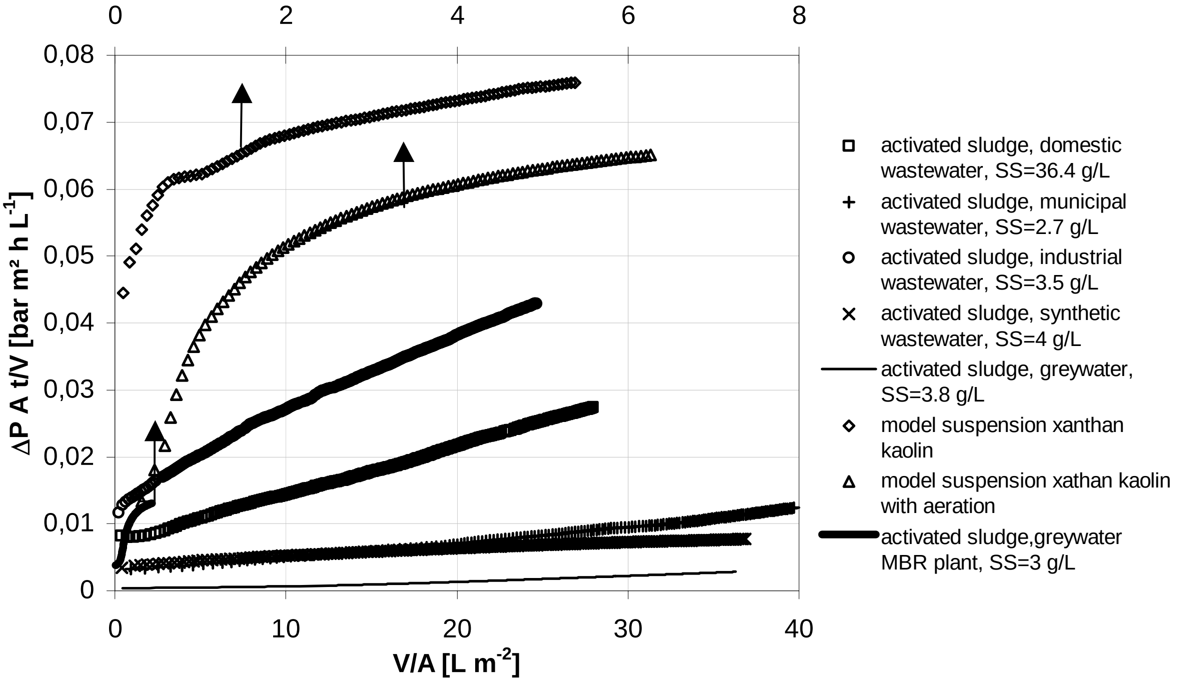

Figure 1: Representation of data according to the dead-end cake filtration model (SS-suspended solids)

Conclusion

Although the filterability of activated sludge was determined in a crossflow test cell, we usually observed the mechanism of dead-end cake filtration. The crossflow filtration mechanism, which is found in MBRs with immersed membrane module, was attained only with additional aeration. Therefore standardized and aerated test cell experiments are required to characterize the filterability of suspensions.

In addition, the filtration mechanisms at constant ΔP are different from those at constant flux. At design stage of a membrane unit, the characterisation of the suspension should be done at the same operating conditions as in the plant.

References

[1] J. Hermia, Constant Pressure Blocking Filtration Laws – Application to Power-law Non Newtonian Fluids, Trans IChemE 60 (1982) 183-187

[2] S. Elmaleh and N. Ghaffor, Cross-flow ultrafiltration of hydrocarbon an biological solid mixed suspensions, Journal of Membrane Science 118 (1996) 111-120

[3] B. Fradin and R.W. Field, Crossflow microfiltration of magnesium hydroxide suspensions: determination of critical fluxes, measurement and modelling of fouling, Separation and Purification Technology 16 (1999) 25-45

[4] M. Hlavacek and F. Bouchet, Constant flowrate blocking laws and an example of their application to dead-end microfiltration of protein solutions, Journal of Membrane Science 82 (1993) 285-295