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Observation of cake layer formation and removal on microporous hollow-fibre membranes

S. Buetehorn[a],*, M. Brannock[b], P. Le-Clech[b], G. Leslie[b], D. Volmering[c], K. Vossenkaul[c], T. Wintgens[a], T. Melin[a]

[a]*Chemical Process Engineering, AVT, RWTH Aachen University, Aachen, Germany*
email: steffen.buetehorn@avt.rwth-aachen.de
[b]*UNESCO Centre for Membrane Science and Technology, University of New South Wales, Sydney, Australia*
[c]*Koch Membrane Systems GmbH, Aachen, Germany*

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ABSTRACT

The cake layer in submerged membrane bioreactor (sMBR) processes is leading to an additional flow resistance and it is through this that the long-term filtration performance of the system is affected. Therefore, air is injected into the suspension to induce flow and to generate shear in order to partly remove the cake layer. Furthermore, the bubble-induced movement of hollow-fibres has been identified to significantly improve the shear production with air bubbling . Hence, this paper will report about experiments conducted on different scales and in different operating modes including novel magnetic resonance imaging (MRI) techniques to visualise the cake layer and quantify the local permeate production. Within the first part of this study, experiments have been performed with a number of model substances to characterise the impact of operating parameters on the filtration performance of stationary hollow-fibre membranes of the PURON® system. The setup consists of a tubular test cell equipped with a single hollow-fibre and is operated with a constant TMP in cross-flow mode without air bubbling. Suspensions containing silica particles of different particle size distributions dispersed in solutions of xanthan gum, with different dynamic viscosities, were filtrated for approximately 30 min while the permeate flux was measured. It was shown that the dynamic viscosity and the shear thinning characteristics of the suspensions are similar compared to established viscosity models of activated sludge . Moreover, the filtration tests have shown that the long-term permeate flux is increasing with an increasing cross-flow velocity, a decreasing solids concentration, a decreasing average particle size and an increasing dynamic viscosity, whereas the long-term permeate flux is independent from the feed pressure. These trends are consistent with published theories which demonstrate that the thickness of the reversible cake layer increases with a decreasing cross-flow velocity and an increasing feed pressure. While an increase in cross-flow velocity is leading to an enhanced entrainment of deposited matter, and thereby to a higher permeate flux, a higher feed pressure is leading to a temporary increase in permeate flux only. However, this benefit is compensated by an increased filtration resistance due to a thicker cake layer, so that the long-term permeate flux is independent from the feed pressure. The contribution to the conference will further include experiments with two different setups operated in submerged mode covering a variation of operating parameters, fluid characteristics, and membrane bundle design. The objectives of these studies are (i) to validate the above-mentioned theory by measuring the cake layer thickness via MRI respectively to (ii) estimate the impact of packing density on the filtration performance of a hollow-fibre bundle. While the first approach is limited to single and not-moving fibres, the latter is complementary to previous studies since both fibre movement and fibre-fibre interactions are taken into account. Hence, in conclusion, the findings out of cross-flow and submerged single fibre tests will be compared to trials with more complex configurations.

* Corresponding author.

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