Aalborg Universitet

Fouling in a MBR system with rotating membrane discs

Influence of concentration and shear

Jørgensen, Mads Koustrup; Bentzen, Thomas Ruby; Christensen, Morten Lykkegaard

Publication date:
2014

Document Version
Early version, also known as pre-print

Link to publication from Aalborg University

Citation for published version (APA):
Jørgensen, M. K., Bentzen, T. R., & Christensen, M. L. (2014). *Fouling in a MBR system with rotating membrane discs: Influence of concentration and shear*. Poster presented at ICOM 2014, Suzhou, China.

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal -

Take down policy
If you believe that this document breaches copyright please contact us at vbn@aub.aau.dk providing details, and we will remove access to the work immediately and investigate your claim.

Downloaded from vbn.aau.dk on: April 24, 2024

Fouling in a MBR system with Rotating membrane discs – influence of concentration and shear

Mads Koustrup Jørgensen[1*], Thomas Ruby Bentzen[2], and Morten Lykkegaard Christensen[1].

[1] Department of Biotechnology, Chemistry and Environmental Engineering, Aalborg University, Sohngaardsholmvej 57, 9000 Aalborg, Denmark

[2] Department of Civil Engineering, Aalborg University, Sohngaardsholmvej 57, 9000 Aalborg, Denmark

*(*mkj@bio.aau.dk)*

Introduction

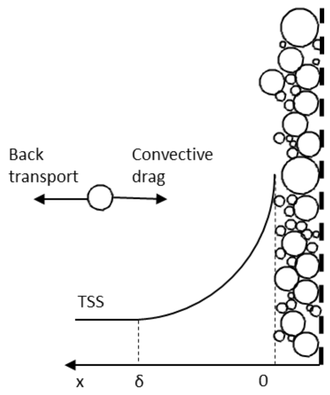
The functionality of a membrane bioreactor (MBR) is limited by fouling, which places demands for fouling reduction and membrane cleaning. Membrane fouling can be reduced by rotating membrane discs which enables stable operation at high sludge concentrations. As membrane rotation is associated with high energy consumption the gain in permeability by higher membrane rotation should compensate for the additional energy requirements. Therefore, it is essential to understand the impact of enhanced shear on filtration performance.

Aim

- Study limiting flux distribution at varying rotation speed and sludge concentration.
- Develop a mathematical model to describe limiting flux as function of membrane disc rotation speed and sludge concentration.
- Describe and simulate flux as a function of rotation speed, sludge concentration and the radial distance from the center of rotation.

Theoretical Background

- The limiting flux is used to describe the back transport, depending on operating conditions such as concentration and shear.
- Fouling is assumed to be due to reversible cake formation
- A mass balance for particle transport to the membrane is solved to give the limiting flux [1].
- For larger particles (< 1 µm), e.g. sludge flocs and colloids, back transport is a result of shear induced diffusion



Model

The following empirical expression for the limiting flux is proposed:

$$J_{\mathrm{LIM}} = A \cdot \tau_m{}^{B} \mathrm{TSS}^{-1/2}$$

Shear stress (τ) is related to shear rate (γ) with the following expression for non-Newtonian fluids [2]:

$$\tau = m\dot{\gamma}^{n}$$

With m and n representing the concentration dependent flow consistency and behavior index. The local shear rate is determined as a function of rotation speed (Ω) and kinematic viscosity (υ) [3]:

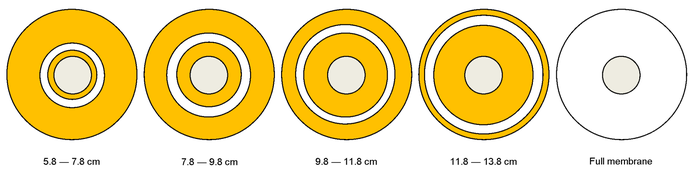
$$\dot{\gamma}_m = 0.5133\upsilon^{-0.5}(k\Omega)^{1.5}\frac{r_o^3 - r_i^3}{r_o^2 - r_i^2}$$

The shear dependency of the dynamic viscosity (μ) is determined as

$$\mu_a = \exp\left(2\mathrm{TSS}^{0.41}\right)\dot{\gamma}^{-0.23\mathrm{TSS}^{0.37}}$$

Experimental

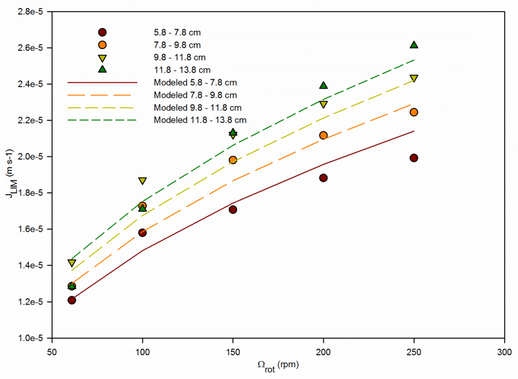
- Four membranes were blinded to have concentric rings at different radii open for filtration and used to filter 10 g/L MBR sludge at rotation speeds varying from 100-280 rpm.

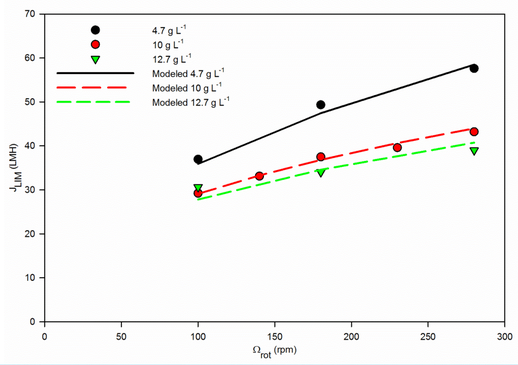


- The influence of concentration was studied filtering 4.7, 10 and 12.7 g/L SS with varying rotation speeds and TMP.
- For each operational condition, TMP-step filtrations in the range of 0.3 – 2.5 bar were performed to determine the limiting flux [1].

Results

- Due to higher shear, the limiting flux increases at higher rotation speed and higher radial distance from center of rotation.
- The limiting flux decreases with higher sludge concentration.
- The model fits experimental limiting fluxes
- The proposed model can describe the limiting flux from concentration and rotation speed locally on the membrane discs.





Conclusion

- The developed model describes the limiting flux (back transport) as function of disc rotation speed and sludge concentration.
- The limiting flux increases with higher radius from the center of rotation and higher membrane rotation speed due to enhanced shear
- The limiting flux decreases at high concentrations;
- From the proposed model, the filtration performance can be estimated as a function of shear (rotation speed) and concentration and used to improve filtration performance and productivity.

REFERENCES

1. M.K. Jørgensen, T.V. Bugge, M.L. Christensen, K. Keiding, *J. Membr. Sci.*, **409-410**, 335-345, (2012).
2. S. Rosenberger, K. Kubin, M. Kraume, Eng. Life Sci., **2**, 269-275 (2002).
3. R. Bouzerar, L. Ding, M. Jaffrin, *J. Membr. Sci.*, **170**, 127-141 (2000).

ACKNOWLEDGEMENTS

This study is funded by the EcoDesign MBR strategic research center. Malene Thostrup Pedersen is acknowledged for experimental assistance.