Author's Accepted Manuscript

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PII: S0376-7388(17)32700-X
DOI: https://doi.org/10.1016/j.memsci.2018.02.058
Reference: MEMSCI15983

To appear in: *Journal of Membrane Science*

Received date: 19 September 2017
Revised date: 14 February 2018
Accepted date: 26 February 2018

Cite this article as: Elham Radaei, Xuefei Liu, Keng Han Tng, Yuan Wang, Francisco J. Trujillo and Greg Leslie, Insights on pulsed bubble control of membrane fouling: Effect of bubble size and frequency, *Journal of Membrane Science,* https://doi.org/10.1016/j.memsci.2018.02.058

Insights on pulsed bubble control of membrane fouling: Effect of bubble size and frequency

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Abstract

A three-dimensional Computational Fluid Dynamics (CFD) model was developed to study the shear stress induced by spherical cap bubbles on industrial scale hollow fibres. Simulations and experimental data were compared for water and a 0.5 g/L xanthan gum solution that mimicked the rheological behaviour of activated sludge. The model was built on a pilot-scale membrane tank configured with five 1.5 m long hollow fibre membranes. 58 to 290 ml spherical cap bubbles were sparged into the system at frequencies from 0.2 to 1 Hz. The Volume of Fluid (VOF) method coupled with the Realizable $k - \varepsilon$ turbulent model was used to simulate the transient behaviour of cap bubbles rising in a Newtonian and a viscous shear-thinning liquid. CFD prediction of root mean square (RMS) shear stress induced by pulsed bubbles exhibited an inverse relationship with experimental observations of membrane fouling. At a constant flux of 25 $L/m^2/h$ (LMH), fouling decreased from 5.1 to 3.9 kPa/min as simulated RMS shear stress increased from 0.04 to 0.25 Pa. Shear fluctuations, which are considered to be beneficial for the cleaning of membranes, were less pronounced for a non-Newtonian fluid compared to in water. Increasing pulse bubble size from 115 ml to 290 ml led to a 80% increase of RMS shear stress, and therefore improved the fouling control efficiency.

Keywords: Shear stress; Spherical cap bubble; Non-Newtonian flow; Computational Fluid dynamics; Immersed Hollow Fibre membrane