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SUBMERGED MEMBRANE BIOREACTOR FOR WASTE WATER TREATMENT: DETERMINATION OF THE SHEAR STRESSES PRODUCED BY COARSE BUBBLES

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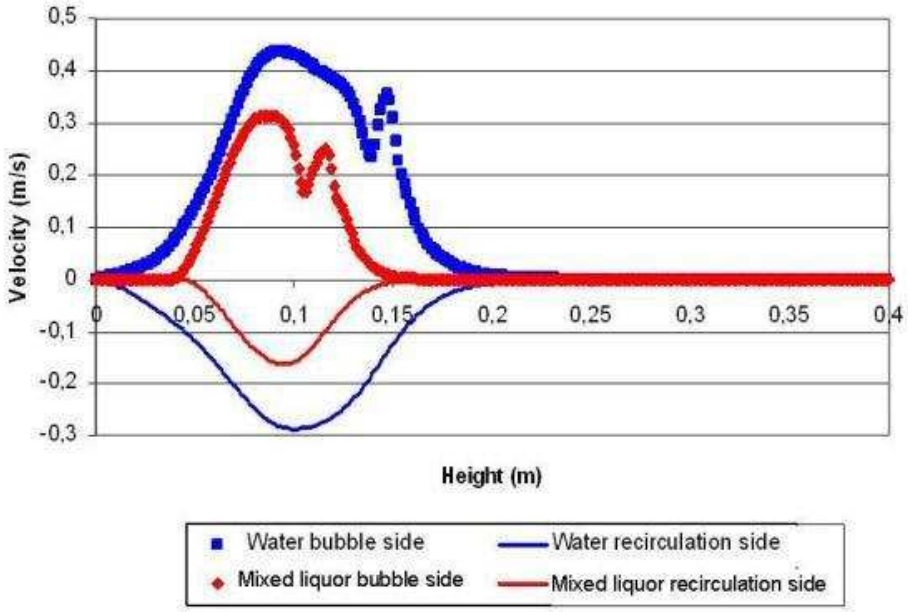
Submerged Membrane Bioreactors (sMBR) are more and more used for waste water treatment. Improvement of membranes materials makes the energy cost more significant (Kraume and Drew 2010), which is due for half to the coarse bubbles used for the limitation of the fouling. However a too high air flow rate may also increase the fouling (Meng et al. 2008). An assumption for this last phenomenon is the rupture of flocs due to the shear stresses produced by these coarse bubbles.
The aim of this work is to evaluate the shear stresses produced in the fluid by the aeration in the membrane module around the hollow fibre bundle of an externalised sMBR. This was done by the use of a computational fluid dynamics code that solves the Reynolds-Averaged Navier Stokes (RANS) equations, Fluent®, with the following modelling assumptions:
- the hollow fibbers membranes are modelised by an over all cylinder
- the turbulence closing equations model is the RNG k-e
- for the biphasic part, an Euler/Euler approach with the volume of fluid (VOF) method is used, and the bubbles are initialised by a patch method
- in a first approach, the influence of bubble swarm is considered through the analyze of the flow around the second bubble of two,
- for the mixed liquor, the Carreau rheological model has been fitted on experimental data
These assumptions are validated using theory and experimental measures on bubbles sizes and velocities.
The axial velocities presented in Figure 1 show that highest velocities are observed in the bubble trail and that the downstream flow opposite to the bubbles is important too. As expected the bubbles are slower in the mixed liquor than in water.
The shear stresses presented in Table 1 are around ten times higher with mixed liquor than with water, both for mean and maximum values.
This work shows an evaluation of the shear stresses in the liquid on the membrane module around the hollow fibre bundle. The mixed liquor rheology model has a huge influence on the evaluation, due to the higher average viscosity and to the non-Newtonian behaviour, especially with the high suspended solid concentration used in sMBR.

References:
Kraume, M., Drews, A., 2010. Membrane Bioreactors in Waste Water Treatment - Status and Trends. Chemical Engineering & Technology 33, 1251-1259.
Meng, F., Yang, F., Shi, B., Zhang, H., 2008. A comprehensive study on membrane fouling in submerged membrane bioreactors operated under different aeration intensities. Separation and Purification Technology 59, 91-100.



Axial velocities on vertical lines located in the middle of the initialisation of the bubble and at the opposite side of the membrane obtained by CFD

Water			Mixed liquor		
Bubble velocity (m/s)	Shear stress (Pa)		Bubble velocity (m/s)	Shear stress (Pa)	
	Average	Maximum		Average	Maximum
0.369	0.07	1.20	0.282	0.98	8.86
0.455	0.09	1.31	0.399	1.05	6.88
0.507	0.11	1.35	0.462	1.09	9.75
0.618	0.16	1.65	0.561	1.14	11.1

Comparison of bubbles velocity, average and maximum shear stresses for a 5cm bubble following a 2 cm bubble, obtained by CFD