A simplified model of a submerged membrane bioreactor

Guilherme ARAUJO PIMENTEL [a], Alain VANDE WOUWER [a],
Alain RAPAPORT [b], Jérôme HARMAND [b c]

[a]Service d'Automatique, Université de Mons, Bd. Dolez 31, 7000 Mons - Belgique

[b]UMR 'MISTEA' Mathmatique, Informatique et STatistique pour l'Environnement et l'Agronomie
(INRA/SupAgro), 2, place P.Viala, 34060 Montpellier - France

[c]INRA, UR050, Laboratoire de Biotechnologie de l'Environnement
Avenue des Etangs, F-11100 Narbonne, France

guilherme.araujopimentel@umons.ac.be, alain.vandewouwer@umons.ac.be

1 Introduction

Nowadays, there is a rich literature about mathematical modeling of membrane bioreactors (MBR), mostly based on a detailed physical description, including aeration, cake formation, filtration, fouling [1] and biological activity [2]. These models however contain a large number of parameters to estimate and are too complex for process control. In this connection, there are only a few proposals based on empirical approaches or artificial neural network models. The motivation of this study is to derive a simplified model of a submerged MBR based on first principles and to analyze its dynamical behavior.

2 Simplified Model

A simple bioreactor model (equation 1), assuming a single biomass at this preliminary stage, is coupled with a dynamic model representing the cake formation. Most authors agree on the fact that the most important factor is the cake resistance [3].

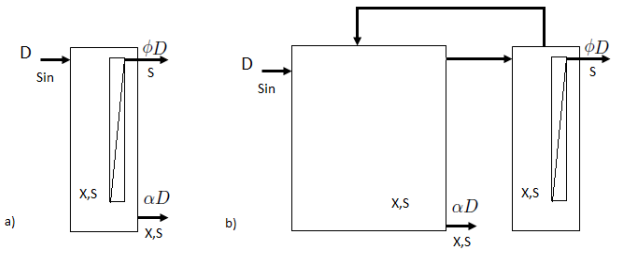

Figure 1: a)Simplified membrane bioreactor, $\phi = \frac{J(m(t))A}{V}$ is the permeate flux factor and α is the waste factor. b)Different representation for the same model.

$$\begin{cases} \frac{dS}{dt} = -\frac{1}{Y}\mu(S)X + \frac{Q_{in}}{V}S_{in} - \frac{Q_{in}}{V}\alpha S - \frac{J(m(t))A}{V}S \\ \frac{dX}{dt} = (\mu(S) - \alpha\frac{Q_{in}}{V})X - \frac{J(m(t))A}{V}X + \beta\frac{J_{air}}{V}\frac{m^2}{K_{air}+m} \\ \frac{dm}{dt} = J(m(t))AX - \beta J_{air}\frac{m^2}{K_{air}+m} \end{cases} \quad (1)$$

3 Validation

Figure 2 shows the cake dynamics with and without air cross flow. As a first validation the proposed model has been compared to results of the GPS-X software [4] and to Li and Wang's model [1], implemented in *Matlab/Simulink*.

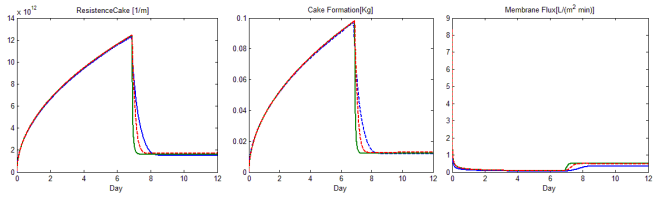

Figure 2: Comparison between the models. Red: Li Model, Blue: GPS-X model and Green: Proposed Model.

4 Acknowledgments

This paper presents research results of the Belgian Network DYSCO (Dynamical Systems, Control, and Optimization, funded by the Interuniversity Attraction Poles Programme and initiated by the Belgian State and Supagro-INRA INRIA 'MODEMIC' (Modeling and Optimisation of the Dynamics of Ecosystems with MICro-organisms), France.

References

[1] Li Xy, Wang Xm. *Modelling of membrane fouling in a submerged membrane bioreactor*, Journal of Membrane Science. 2006;278:151-161.

[2] Di Bella G, Mannina G, Viviani G. *An integrated model for physical-biological wastewater organic removal in a submerged membrane bioreactor: Model development and parameter estimation*. J. Mem. Sci. 2008;322:1-12.

[3] Mannina G,Di Bella G, Viviani G. *An integrated model for biological and physical process simulation in membrane bioreactor (MBRs)*, J. Mem. Sci. 2011;376:56-69.

[4] Hydromantis - Environmental Software Solutions,Inc. *GPS-X* V6.1,2011.