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A simplified model of a submerged membrane bioreactor

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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 \cite{1} and biological activity \cite{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 \cite{3}.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure1}
\caption{a)Simplified membrane bioreactor, $\phi = \frac{j(m(t)) \Delta}{A}$ is the permeate flux factor and $\alpha$ is the waste factor. b) Different representation for the same model.}
\end{figure}

\begin{equation}
\begin{cases}
\frac{dS}{dt} = -\frac{1}{\mu(S)}X + \frac{Q_{in}}{V_{S}}S_{in} - \frac{Q_{in}}{\alpha S} - \frac{j(m(t)) \Delta}{A} S \\
\frac{dX}{dt} = (\mu(S) - \frac{Q_{in}}{\alpha S}) X - \frac{j(m(t)) \Delta}{A} X + \beta \frac{j_{air} m^{2}}{K_{air} + m} \\
\frac{dm}{dt} = j(m(t)) \Delta X - \beta j_{air} \frac{m^{2}}{K_{air} + m}
\end{cases}
\end{equation}

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 \cite{4} and to Li and Wang’s model \cite{1}, implemented in Matlab/Simulink.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure2}
\caption{Comparison between the models. Red: Li Model, Blue: GPS-X model and Green: Proposed Model.}
\end{figure}

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