Design and CFD analysis of mass transfer and distributions of shear stresses in Airlift reactor

R. Bannari[a], B. Selma[a,*], A Bannari[b], P. Proulx[a],

[a] *Département de génie chimique et de génie biotechnologique*

[b] *Département de génie mécanique*

Université de sherbrooke, 2500 bd université, sherbrooke (QC) J1K2R1 Canada

Abstract

The design, scale-up and performance evaluation of biological reactors require accurate information about the gas-liquid flow dynamics. In this study, we use CFD techniques to investigate important parameters of the multiphase flow dynamics on an initial airlift bioreactor in order to improve its design. Such parameters are distributions of shear stresses and mass transfer.

Our initial proposed design of the airlift bioreactor was used for biomass growing. Specifically to produce cellulase enzyme using the fungus Trichoderma Reesei. However, the morphology of the microorganism obtained in this bioreactor was not appropriated to produce cellulase. Since the microorganism morphology presented a small hyphae length and small number of tips, the enzyme productivity was affected. Indeed, several studies (Cui et al.,1997; Berzins et al., 2001) have shown a strong relationship between morphology and agitation which is very important to ensure the availability of nutrients, oxygen and other essential substances to the

growing cells. On the other hand, agitation results in high shear forces on the cells thus either rupturing them or changing the morphology, growth and productivity of the culture.

In the light of results of the distributions of shear stresses and mass transfer we propose a new design which improve the productivity of cellulase by increasing total mycelial biomass and the number of hyphae tips. In this work, we present a two-fluid model at high phase fractions coupled with the population balance and $k-\epsilon$ equations. The model is validated on a bubble column reactor issued from our previous work (Bannari et al. 2008) with the additional Multiple Reference Frame (MRF) model implemented to predict the flow field induced by agitation when we use the impeller in airlift reactor.

All these models are implemented in the open source package OpenFOAM.

Key words: Population Balance Equation, Coalescence , Break-up, Mass Transfer, Computational Fluid Dynamics, Airlift, OpenFOAM.

---

* Corresponding author. Tel.:+1 (819) 821 8000 ext. 65076; Fax:+1 (819) 821 7955
E-mail address: rachid.bannari@usherbrooke.ca (R. Bannari)