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Influence of Interfacial Force Models and Population Balance Models on the k_La Value in Stirred Bioreactors

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Abstract:

Optimal oxygen supply is vitally important for the cultivation of aerobically growing cells, as it has a direct influence on cell growth and product formation. A process engineering parameter directly related to oxygen supply is the volumetric oxygen mass transfer coefficient k_La. It is the influences on k_La and computing time of different interfacial force and population balance models in stirred bioreactors that have been evaluated in this study. For this investigation, the OpenFOAM 7 open-source toolbox was utilized. Firstly, the Euler–Euler model with a constant bubble diameter was applied to a 2 L scale bioreactor to statistically examine the influence of different interfacial models on the k_La value. It was shown that the k_L model and the constant bubble diameter have the greatest influence on the calculated k_La value. To eliminate the problem of a constant bubble diameter and to take effects such as bubble breakup and coalescence into account, the Euler–Euler model was coupled with population balance models (PBM). For this purpose, four coalescence and five bubble breakup models were examined. Ultimately, it was established that, for all of the models tested, coupling computational fluid dynamics (CFD) with PBM resulted in better agreement with the experimental data than using the Euler–Euler model. However, it should be noted that the higher accuracy of the PBM coupled models requires twice the computation time.

Keywords: bioreactor characterization, CFD simulation, drag force, interfacial force, kLa value, lift force, multiphase modeling, numerical simulation, oxygen transfer rate, population balance model