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From industrial fermentor to CFD-guided downscaling: what have we learned?

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Abstract

Euler-Lagrange computational fluid dynamics simulations offer great potential for the integration of transport dynamics and metabolic dynamics in fermentation systems. Since the seminal work of Lapin et al. [1, 2], progress has been made, mainly in the analysis of CFD data and translation to laboratory setup designs. Different large-scale processes require different analysis methods; in this paper we discuss which analysis methods are best suited for given reactor types, by reviewing prior simulation cases as well as introducing new test cases. Furthermore, we address challenges in the translation from Euler-Lagrange simulations to laboratory scale systems, and propose methods to work around these shortcomings. Based on the current state of the art, we propose guidelines for the selection of data analysis methods, and we discuss the design of rational scale-down simulators. We conclude with a brief discussion regarding the requirements and possibilities of next-generation scale-down simulators, such as microfluidic single-cell analysis, and possible ways to approximate cellular lifelines from invasive intra-cellular measurements.

Keywords: CFD, Euler-Lagrange, Fermentation, Downscaling, Metabolic modeling

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