Proceedings of the 10th World Congress on Momentum, Heat and Mass Transfer (MHMT 2025)
Barcelona, Spain - April 10 - 12, 2025
DOI: 10.11159/icmfht25.003

Simulations and Modeling of Multiphase Flows

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ABSTRACT

Direct numerical simulations of multiphase flows, where every continuum temporal and spatial scale are fully resolved, are now relatively routine, at least for relatively simple disperse flows of bubbles, drops and solid particles, and we show a few examples. The challenges now are twofold: How to use the results to increase our ability to predict industrial scale flows and how to conduct direct numerical simulations of much more complex systems. For predictions, we need coarse models that describe the dynamics of the large-scale flow and in many cases the presence of a sharp phase boundary is the most important feature of the flow. We discuss formal ways to coarsen results from fully resolved simulations while preserving a sharp, but simplified phase boundary. We describe efforts to predict evolution of the coarse flow using machine learning combined with trajectory modeling, where the conservation equations are augmented in such a way that the coarse flow evolves correctly. We also discuss briefly efforts to simulate complex flows, including three-phase liquid-gas-solid disperse flows where the solid particles are either hydrophobic or hydrophilic.