Benchmarking Multiphase CFD Results via Sophisticated Experimental Measurement Techniques and Methodologies

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Abstract

Computational fluid dynamics have been increasingly used to simulate, design and scale up various processes. Multiphase flow systems and complicated geometries are characterized by complex interaction of their phases. Hence, most (if not all) of the used models and closures in the CFD to simulate these systems have not been based on proper physics or first principles. Accordingly advanced measurement techniques, facilities and methodologies are needed to provide the detailed local hydrodynamics parameters in order to benchmark CFD results for validation (i.e., CFD grade validation data). In our laboratory such needed sophisticated measurement techniques, facilities and methodologies have been developed, verified and implement to provide benchmark data for various complex flow systems such as single phase with complex geometry and gas-liquid, gas-solid, gas-liquid-solid, liquid-solid, liquid-liquid systems. These measurement techniques are: I) techniques that are based on radioisotopes – radioactive particle tracking (RPT), dual source gamma ray tomography (DSCT), gamma ray densitometry (GRD) for 3D flow field, velocity and turbulent parameters, phases distribution and flow pattern identification measurements, and II) techniques that are not based on radioisotopes: 4-point optical probe for bubble dynamics, heat transfer probe, combination of bubble dynamics and heat transfer probe, optical probes for solids dynamics that measure simultaneously solids velocity and holdups and their fluctuations, gas tracer dynamics, optical probe for local mass transfer, gas tracer technique for global mass transfer, mesh conductivity and optical probe for liquid velocity distribution in packed beds, pressure transducers, and others. These techniques are augmented with sophisticated mathematical algorithms and programs that have been developed in our laboratory for data gathering, processing and image reconstruction. Furthermore, statistical methods, artificial neural network and chaotic analyses have been developed and used to further analyze the obtained results for

flow pattern identification and for mechanistic approaches that we have developed for scale-up methodologies of these complex multiphase flow systems.

In this presentation, these will be discussed with selected examples and findings.