326c Frontiers in Multiphase Flow Reaction Engineering

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A large fraction of chemical reactors used in engineering practice involve multiphase flows. In many of these applications, where the processing rates are very large, economy of scale remains the driving factor and the reactors are enormous in size. Practical design considerations dictate two conflicting requirements. On the one hand, one would like to achieve good contacting between the various phases, thus promoting good interphase transport of species and energy – smaller size of the dispersed phase favors this objective. On the other hand, separation of the various phases downstream of the reaction zone is favored by a larger size of the dispersed phase material. Millimeter sized gas bubbles in bubble columns and 50 – 100 micron sized particles in gas fluidized beds and slurry bubble columns are common, and these sizes often represent a compromise between good contacting and easy separation. With such dispersed phase dimensions, it is generally hard to achieve a state of uniform spatial distribution of the various phases, as it happens to be inherently unstable, giving way to non-uniform structures spanning a wide range of length and time scales. Macroscale coherent structures, interacting with mesoscale and microscale structures, are commonly present, making multi-scale analysis a natural approach for studying the performance of these reactors. From the point of view of reactor performance, scale-up and modification, one is most interested in the macroscale flow structures, as they determine the large-scale mixing behavior. The current trend in modeling the performance of multiphase flow reactors is to integrate detailed chemistry and transport models. Coarse-grained hydrodynamic models that can be used to simulate the macroscale structures, without having to resolve the smaller scale structures, are at the heart of these next-generation reactor models. Experimental data of high-quality that can be used to validate these models are critical in the effort to build the next-generation models. Need for coarse-grained heat and mass transport and reaction rate models then arise naturally.

Structured beds, monoliths and micro-reactors present potential opportunities as possible alternatives to conventional multiphase contacting devices. When suitable, they can relieve some of the scale-up problems associated with the conventional devices.

These will be reviewed in this presentation.