131b Using a Dispersed Phase Model to Track Particle Paths and Deformation Rates in Complex Mixing Geometries

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Current CFD simulation techniques, coupled with velocity field measurement via Laser Doppler Anemometry (LDA) and Particle Image Velocimetry (PIV), allow reasonable assessment of turbulent flow fields for single phase flow in the complex mixing geometries found in high shear mixing devices. However, interpretation of the results, particularly with respect to how geometric details affect emulsification and dispersion processes, is difficult. The size of the resulting data set is not only inherently overwhelming, but direct interpretation of the generated Eulerian velocity field can often be misleading. These limitations can be circumvented by recasting the Eulerian field within a Lagrangian framework by tracking the trajectories of inertia-less particles through the flow field to visualize particle paths and yield statistics on residence time distribution and deformation history. This can be readily accomplished within a validated simulation using a commercial code such as Fluent, by using a dispersed phase model (DPM) with one way coupling to track small neutral density particles whose diameters are smaller than the Kolmogorov microscale.

The utility of this technique is demonstrated using a validated sliding mesh, RANS simulation for an in-line rotor-stator mixer with a slot and tooth geometry. The validity of the CFD model is shown by comparison to LDA and PIV data, and it is argued that tracking on the fluid mean velocity field yields information that is relevant to turbulent emulsification and dispersion processes. Conditional sampling criteria are developed that provide a meaningful assessment of the flow field. Visualized particle paths and calculated residence time and deformation statistics are presented to demonstrate the dispersion capabilities and limitations of the tested device. The broader utility of the technique is also discussed.