Simulation of an Opposed Jet, Process Flow Geometry and its Experimental Verification

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Abstract

Parallel computational and experimental measurements were made using an opposed jet mixer to provide a 3-D validation of CFD results. Our goal is to model mixing so that computations can make experiments unnecessary. Our view must be well based in fundamentals, but be directed to solving real-world problems. To contribute to the solution, our attention is focused on the opposed jet system, which is simplistic, but of industrial importance. We view this system as key to the validation of computational results.

Our unique experimental measurements have modest resolution, but the results are full-field and time-resolved. Our stereoscopic, multi-particle tracking development has been described elsewhere; however, it will be briefly described again. For the computations, the inlet jets were set as boundary conditions at the inlets: an inlet parabolic velocity distribution as expected for laminar flow, a $1/7^{th}$ power law for an average turbulent profile inlet, and a plug flow at the inlet. For the initial time, all velocities are set to zero and the inlets are the driving force for the flow.

Tests of time steps, vertical space resolutions etc. were investigated. The comparisons are adequate. The computations were divided into two time zones: the first was an initial zone from zero until we judged that pseudo-steady state turbulent conditions were established. This initial time period had the most interesting fluid dynamics. The laminar inlet is different than the others. The second time zone was a much longer period to establish pseudo-steady state values of the moments. The long times needed when compared to pipe flow are caused by low frequency jet flapping of the jets.

The flow was then divided into primary or jets, secondary or pancake, and tertiary regions (very low velocities areas) for further comparison. The long-time-average results for selected regions are essentially independent of the inlet jet conditions. The highest moment values are along the edges of the jets and in the central pancake region. There are limitations in the experimental results for low values of moments, which is associated with the low resolution for experiments. We had no success in comparing computations and experiments in time as a result of the 100 fold difference in resolution and an inability to satisfy continuity when an experimental initial time conditions is used.