Mechanical Engineering Doctoral Defense

Detailed Numerical Simulation of Liquid Jet in Crossflow Atomization with High Density Ratios

School for Engineering of Matter, Transport and Energy

Sina Ghods

Advisor: Dr. Marcus Herrmann

abstract

The atomization of a liquid jet by a high speed cross-flowing gas has many applications such as gas turbines and augmentors. The mechanisms by which the liquid jet initially breaks up, however, are not well understood. Experimental studies suggest the dependence of spray properties on operating conditions and nozzle geometry. Detailed numerical simulations can offer better understanding of the underlying physical mechanisms that lead to the breakup of the injected liquid jet.

In this work, we present detailed numerical simulation results of turbulent liquid jets injected into turbulent gaseous cross flows for different density ratios. We employ a finite volume, balanced force fractional step flow solver to solve the Navier-Stokes equations coupled to a Refined Level Set Grid method to follow the phase interface. To enable the simulation of atomization of high density ratio fluids, we ensure discrete consistency between the solution of the conservative momentum equation and the level set based continuity equation by employing the Consistent Rescaled Momentum Transport (CRMT) method. We analyze the impact of different inflow jet boundary conditions on different jet properties including jet penetration and compare the results to those obtained experimentally by Brown and McDonell(2006).

In addition, instability analysis is performed to find the most dominant instability mechanism that causes the liquid jet to breakup. Linear instability analysis is achieved using linear theories for Rayleigh-Taylor and Kelvin- Helmholtz instabilities and non-linear analysis is performed using our flow solver with different inflow jet boundary conditions.

May 13, 2013; 3:00 PM; ERC 490