Detailed Simulations of the Breakup Processes of Turbulent Liquid Jets in Subsonic Crossflows

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Abstract

This paper presents numerical simulation results of the primary atomization of a turbulent liquid jet injected into a gaseous crossflow. Simulations are performed using the balanced force Refined Level Set Grid method. The phase interface during the initial breakup phase is tracked by a level set method on a separate refined grid. A balanced force finite volume algorithm together with an interface projected curvature evaluation is used to ensure the stable and accurate treatment of surface tension forces even on small scales. Broken off, small scale nearly spherical drops are transferred into a Lagrangian point particle description allowing for full two-way coupling and continued secondary atomization. The numerical method is applied to the simulation of the primary atomization region of a turbulent liquid jet (q=6.6, We=330, Re=14,000) injected into a gaseous crossflow (Re=570,000), analyzed experimentally by Brown and McDonell (2006). The simulations take the actual geometry of the injector into account. Grid converged simulation results of the jet penetration agree well with experimentally obtained correlations. Both column/bag breakup and shear/ligament breakup modes can be observed on the liquid jet. A grid refinement study shows that on the finest employed grids (flow solver 64 points per injector diameter, level set solver 128 points per injector diameter), grid converged drop sizes are achieved for drops as small as one-hundredth the size of the injector diameter.

Key words: jet in crossflow; atomization; simulation; level set method; turbulence

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