Simulation of Jets with a Finite Element Navier-Stokes Solver and a Multilevel VOF Approach

A. Cervone, S. Manservisi* and R. Scardovelli
DIENCA, Laboratorio di Montecuccolino, Università di Bologna
Via dei Colli 16, 40136 Bologna, Italy

Abstract

An accurate finite element Navier-Stokes solver is presented to simulate axis-symmetric and three-dimensional incompressible jets. It is based on a multilevel approach where the Volume-of-Fluid (VOF) scalar function is defined on a high resolution grid and then is projected on a coarser grid where the velocity field is computed. With this approach it is possible to consider grid spacings that ensure a high value of the ratio between the local radius of the interface curvature and the cell size even for three-dimensional computational domains. Since the number of cut cells is usually much smaller than the total number of cells in the computational domain, we have implemented a compact memorization of the VOF data based on a sparse matrix storage approach. In order to prove the validity of this numerical method we have computed the growth rate of several linear instability modes of a viscous liquid jet surrounded by a gas and compared them to the analytical results for inviscid fluids derived in axis-symmetric geometry. A number of jet simulations with a sinusoidal oscillation of the inlet velocity are presented. At low Weber and Reynolds numbers the simulations are axis-symmetric and we show the time evolution of drops, threads and satellite droplets. At higher Weber numbers, with $We > We_c$, asymmetric modes are excited and the jet evolution is followed with the three-dimensional version of the model.

Key words: Computational modeling, Volume-of-Fluid method, finite element method, simulation of jets

*Corresponding author, sandro.manservisi@mail.ing.unibo.it