

Large Eddy Simulation of Thermal and Fire Plumes Based on OpenFOAM Toolbox

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Large eddy simulation (LES) studies of non-reacting thermal plume and fire plume are presented in this paper. This work is the initial step of a research program at FM Global to develop a CFD tool that has predictive capability of fire growth and water based fire suppression. An LES solver for fire application, called “FireFOAM”, is developed based on OpenFOAM, an open source CFD toolbox (<http://www.open CFD.co.uk/openfoam/index.html>).

FireFOAM is a low Mach number, variable density flow solver that is capable of treating buoyancy driven turbulent flow and non-premixed combustion. Turbulent non-premixed combustion is modeled through a mixture fraction based approach, where the chemical reactions are assumed infinitely fast. Sub-grid scale (SGS) turbulence closure for the chemical reaction source term is achieved by assuming that the probability density function of SGS mixture fraction fluctuation follows a beta distribution.

As a part of the model validation, two canonical flows are studied numerically in detail. For non-reacting flows, simulations of a buoyancy-driven thermal plume have been performed and compared against experimental data presented by A. Shabbir and W. K. George (*J. Fluid Mech.*, 275: 1-32, 1994). For reacting flows, turbulent buoyant diffusion flames are studied; and a comparison of the simulation results with experimental measurements by B. J. McCaffrey (NBSIR 79-1910) and by S. R. Tieszen, et al. (*Combust. Flame*, 129: 378-391, 2002) is presented.

Present work has shown initial success in our efforts towards developing a fire modeling solver based on OpenFOAM. This CFD platform, OpenFOAM, is technically sound in numerics and versatile enough to take the challenges of treating a wide range of physical problems associated with fire growth and suppression. Currently, efforts are underway in developing solid fuel pyrolysis models, soot formation/oxidation and radiation models in FireFOAM. Further extension of the code to include water based suppression capability will be undertaken as well.