Large-Eddy Simulations of a Pool Fire with a Galerkin Least-Squares Finite-Element Method

Thomas M. Smith
John N. Shadid
Computational Sciences Department
Sandia National Laboratories
Albuquerque, NM 87185

The prediction of unsteady heating due to accidental fires is of primary interest at Sandia. A turbulent pool fire serves as a good prototype of this problem. In this talk we present results from an investigation using a Galerkin least-squares finite-element method to simulate turbulent pool fires. A model of pool fires was developed based on the large-eddy simulation (LES) methodology. The six resulting transport equations; velocity, temperature, subgrid kinetic energy and mixture fraction, are solved in an implicit, fully coupled manner on unstructured meshes using a Newton-Krylov method and a massively parallel machine. Turbulence closure is modeled using a subgrid eddy viscosity assumption derived from the transport of subgrid kinetic energy. Performance of turbulence models was assessed from analysis of solutions of decaying isotropic turbulence. Combustion was modeled using a laminar flamelet model that assumes infinite-rate reactions, reduced chemistry (five species) and subgrid turbulent mixing governed by an assumed beta pdf which is parameterized by the mean mixture fraction and it's subgrid variance [DesJardin et al., AIAA 2001-0636]. A scale similarity assumption is used to determine the subgrid variance. Simulations of a 31 cm methanol pool fire were computed. The results for the mean velocity and temperature field and characteristic puffing frequency were compared with experimental data taken by Weckman and Strong [Comb.& Flame, vol. 105, pp. 245, 1996]. Simulations reveal the "natural inherent instabilities" of pool fires and demonstrate reasonable agreement with experimental data with this relatively simple description of turbulent combustion.