SC'11 Scientific Visualization

Large Eddy Simulation of Industrial Flares

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ABSTRACT

At the Institute for Clean and Secure Energy at the University of Utah we are focused on education through interdisciplinary research on high-temperature fuel-utilization processes for energy generation, and the associated health, environmental, policy and performance issues. We also work closely with the government agencies and private industry companies to promote rapid deployment of new technologies through the use of high performance computational tools.

Industrial flare simulation can provide important information on combustion efficiency, pollutant emissions, and operational parameter sensitivities for design or operation that cannot be measured. These simulations provide information that may help design or operate flares so as to reduce or eliminate harmful pollutants and increase combustion efficiency.

Fires and flares have been particularly difficult to simulate with traditional computational fluid dynamics (CFD) simulation tools that are based on Reynolds-Averaged Navier-Stokes (RANS) approaches. The large-scale mixing due to vortical coherent structures in these flames is not readily reduced to steady-state CFD calculations with RANS.

Simulation of combustion using Large Eddy Simulations (LES) has made it possible to more accurately simulate the complex combustion seen in these flares. Resolution of all length and time scales is not possible even for the largest supercomputers. LES gives a numerical technique which resolves the large length and time scales while using models for more homogenous smaller scales. By using LES, the combustion dynamics capture the puffing created by buoyancy in industrial flare simulation.

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All of our simulations were performed using either the University of Utah's ARCHES simulation tool or the commercially available Star-CCM+ software. ARCHES is a finite-volume Large Eddy Simulation code built within the Uintah framework, which is a set of software components and libraries that facilitate the solution of partial differential equations on structured adaptive mesh refinement grids using thousands of processors. Uintah is the product of a ten-year partnership with the Department of Energy's Advanced Simulation and Computing (ASC) program through the University of Utah's Center for Simulation of Accidental Fires and Explosions (C-SAFE). The ARCHES component was initially designed for predicting the heat-flux from large buoyant pool fires with potential hazards immersed in or near a pool fire of transportation fuel. Since then, this component has been extended to solve many industrially relevant problems such as industrial flares, oxy-coal combustion processes, and fuel gasification.

In this report we showcase selected results that help us visualize and understand the physical processes occurring in the simulated systems.

Most of the simulations were completed on the University of Utah's Updraft and Ember high performance computing clusters, which are managed by the Center for High Performance Computing. High performance computational tools are essential in our effort to successfully answer all aspects of our research areas and we promote the use of high performance computational tools beyond the research environment by directly working with our industry partners.