RANS simulation of a confined turbulent jet diffusion flame using Conditional Source Estimation

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Turbulent combustion models and the codes that implement them have significant applications in industry, particularly those used to accurately predict combustion. For example, it allows users to design internal combustion engines and gas turbines using Computational Fluid Dynamics (CFD) models. Such simulations are cost effective in that they require the building of fewer prototypes, the construction of which is both time and resource intensive. Our research focuses on non-premixed turbulent combustion making use of the Conditional Source Estimation (CSE) combustion model. This model has been applied to premixed and non-premixed turbulent combustion with promising results. The flame being investigated in this research is the confined non-premixed turbulent combustion methane flame studied by Brookes and Moss [1]. This flame is simulated using the CFD code, OpenFoam, based on a Reynolds-averaged Navier Stokes (RANS) turbulence solver and CSE combustion model. Detailed chemical kinetics is included by using Trajectory Generated Low Dimensional Manifolds (TGLDM) with a GRI mechanism. The temperature and mixture fraction obtained from these simulations have been compared to experimental results. In addition, our simulation results have been compared to simulation results using the Flamelet and Conditional Moment Closure combustion models [2,3]. Finally, a sensitivity analysis has been completed in order to determine how sensitive the simulation is to different CSE and model parameters.

[1] Brookes, S.j., and J.b. Moss. "Measurements of Soot Production and Thermal Radiation from Confined Turbulent Jet Diffusion Flames of Methane." Combustion and Flame 116.1-2 (1999): 49-61.

[2] Brookes, S., and J. Moss. "Predictions of Soot and Thermal Radiation Properties in Confined Turbulent Jet Diffusion Flames." Combustion and Flame 116.4 (1999): 486-503.

[3] Kronenburg, A., R.w Bilger, and J.h Kent. "Modeling Soot Formation in Turbulent Methaneair Jet Diffusion Flames." Combustion and Flame 121.1-2 (2000): 24-40.