International Conference on Numerical Combustion
Rome, Italy, October 14-17, 2025
www.icnc2025.com

Characterization of a Bluff-Body Stabilized Ethylene-Air Flame in a Supersonic Coflow

Joseph C. Oefelein[1]*, Dhruv Purushotham[1]
*Lead presenter: joseph.oefelein@gatech.edu
[1] Georgia Institute of Technology, USA

The unsteady behavior of a bluff-body stabilized ethylene-air flame in a supersonic coflow is characterized using Large Eddy Simulation (LES). The geometry consists of a cylindrical centerbody that extends through a converging-diverging supersonic nozzle to form a coflow of air. Ethylene is injected axially through a single port centered at the tip of the centerbody. The centerbody diameter is much larger than the injector port diameter to create a large recirculation region for flameholding. Combustion is modeled using a well-established 22-species, 206-step finite-rate reaction mechanism with detailed thermodynamics and transport. The recirculation zone created by the centerbody wake promotes turbulent mixing and stabilizes the flame. Results provide a quantitative description of the unsteady and mean field statistics of the fluid dynamics and related compressibility effects; pressure, temperature, and species mass fraction distributions; local variations in key thermodynamic and transport properties; heat release rate; mixture fraction, and scalar dissipation rate. Relevant length and time scales are extracted such as the variation in Damköhler and Karlovitz numbers. Numerical schlieren images highlight regions of strong density gradient, which when correlated with regions of high pressure gradient provide insights into the impact of turbulent vortex dynamics on flame structure. Correlations between the flame index and reaction progress variable are shown to identify local flame structure characteristics. The collective results are used to understand the sensitivity of flame stabilization relative to the dynamics of the fuel injection conditions and implications with respect to efficiently modeling the collective processes accurately.