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Extension of the Flamelet-Generated Manifold (FGM) model to diluted conditions for MILD combustion of aviation fuels in a cyclonic burner

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Traditional Flamelet-Generated Manifold (FGM) models often overlook explicit variations in dilution and sensible-enthalpy losses, limiting accuracy under highly diluted, recirculating MILD conditions. This work extends FGM to such regimes by constructing a five-dimensional manifold parameterized by mixture fraction Z, progress variable C, their variances, and dilution level α (mean only). The manifold is assembled from families of diluted, extinguished counterflow diffusion flamelets, enabling a unified treatment of dilution effects. Reynolds-Averaged Navier–Stokes (RANS) simulations of CH_4 in a cyclonic burner are carried out with a commercial CFD solver and validated against experiments. The same framework is then applied to predict burner behaviour for Sustainable Aviation Fuel (SAF) and Jet A. A baseline two-control-variable FGM (Z, C) is included to isolate the impact of adding α as a manifold dimension.
The proposed 5-D FGM reproduces the distributed reaction zone, moderate peak temperatures 1600-1800 K, and key species fields characteristic of MILD combustion, with good agreement to measurements. Incorporating dilution as a control variable is essential for predicting flame stabilization and spatially uniform heat release, while helping to reduce pollutants—particularly NO_x. The approach improves predictive accuracy while retaining computational efficiency suitable for high-fidelity combustion simulations. Future work will extend applicability to variable pressures and complex real-fuel blends for industrial low-emission systems.