Conditional analysis of lifted hydrogen jet diffusion flame experimental data and comparison to laminar solutions

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Abstract

Simultaneous point measurements of temperature, mixture fraction, major species, and OH concentrations in a lifted turbulent hydrogen jet flame are reprocessed to obtain the Favre average and conditional mean profiles. Large discrepancies between the Favre average and ensemble average temperature, H2O, and OH mole fractions are found at the lifted flame base, due to density weighting of fairly large samples of unreacted mixtures. Conditional statistics are used to reveal the reaction zone structure in mixture fraction coordinates. The cross-stream dependence of conditional reactive scalars, that is most notable at the lifted flame base and decreases to negligible levels with increasing streamwise positions, could be attributed to radial differences in both Damköhler number and the level of partial premixing. Conditional results indicate that the lifted flame is stabilized at outer region of the jet with low strain rates and lean mixtures. Comparison of the measured conditional mean OH vs. H2O with a series of stretched laminar partially premixed flame and diffusion flame calculations reveals that strong partial premixing takes place at the lifted flame base and the strain rates vary from a = 14,000 to 100 s-1. The level of partial premixing and the

strain rate decrease
with increasing downstream locations. The range of estimated scalar dissipation rates (χ
1~0.13 s-1) at further downstream location (x/D = 33.3) is in agreement with reported values
and the flame composition reaches an equilibrium condition at x/D = 194.4. These results
combined with previously reported data provide a benchmark data set for evaluation and
refinement of turbulent combustion models for lifted hydrogen jet flame predictions.

Keyword：Lifted jet flame; Raman scattering; Conditional means; Laminar flame
calculations