Soot Measurement and Species Simulation in Laminar Premixed Flames

By

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DECLARATION

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SUMMARY

This thesis reports on the study of laminar premixed ethylene/air flat flames, in both rich and lean conditions (Ø at 1.82 to 3.80) at atmospheric pressure. The work was divided into experimental measurements of soot particles and theoretical computations of chemical products. In the experimental part, both intrusive sampling probes and non-intrusive laser diagnostics techniques were applied. The experimental measurements cover soot volume fractions by laser extinction (LE) and laser-induced incandescence (LII), temperatures by thermocouple insertion and soot morphology by thermophoretic sampling/transmission electron microscopy (TEM). The theoretical computations were performed using a detailed reaction kinetic model consisting of 544 elementary reactions among 100 chemical species to describe the formation and growth of polycyclic aromatics hydrocarbons (PAHs) up to pyrene. Results arising from this research would create a potential database, combined with visualizations, to focus as an education tool for students and researchers alike.

Two-dimensional imaging by LII revealed relatively uniform soot distributions from Ø at 1.82 to 2.22. However, annular distributions were observed for fuel-rich conditions (Ø at 2.84 to 3.80) which were elucidated to ambient air mixing due to low nitrogen shroud. The calibrated soot volume fraction profiles were in close agreement with LE for slightly sooty flames but differ by a magnitude of three for much sootier circumstances. Variable changes to the refractive index of soot, *m* resulted in potential errors between 3 to 11 % for soot volume fractions. Thermophoretic sampling was employed to complement the above methods. From TEM images, it was evident that soot particles undergo coagulation and aggregation and is a function of fuel equivalence. No obvious trends were seen in the particle size distribution. The effect of a low premixed reactant velocity was found to influence the magnitude and shape of the temperature profiles due to burner plate heat transfer. Ceramic coating on thermocouple wires was demonstrated to affect estimated temperatures by 205 K. The kinetic model provided an insight into the concentration profiles of minor, intermediate and aromatic species as reported in literature. It also addressed the importance of propargyl recombination reaction ($C_3H_3+C_3H_3 \rightarrow C_6H_6$) into benzene as a fundamental step towards PAHs growth. Finally, a sensitivity analysis was carried out to tackle the influence of temperatures on chemical species.

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