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Radiation Measurements and Data Analysis of Turbulent Premixed Lean Flame

Student researcher: Yunzhe Yang, Senior

An accurate understanding of the radiation transfer in turbulent premixed lean flame is critical for improving the energy efficiencies of combustion systems and controlling temperature-sensitive pollutants. This research studied planar radiation from turbulent premixed lean methane/air flame utilizing a high-speed infrared, with different equivalence ratios (0.6, 0.8, and 1.0), heat-release rates (2.1 kW, 4.2 kW, and 8.4 kW), hydrogen pilot flame rates (2 mg/s, 3 mg/s, and 4 mg/s), and co-flow rates (0 g/s, 0.1 g/s, and 0.3 g/s). Time-dependent and time-averaged flame images were acquired and radiation statistics were compared to investigate the effects of different parameters on the radiation intensity of the flame. With the different equivalence ratio and heat release rate, time-averaged images varied in configuration and radiation intensity from the flame. However, changes of hydrogen pilot flame rate and co-flow rate had little impact on the flame configuration and radiation intensity. Statistical analysis showed that the radiation intensity followed normal distribution, and the fluctuation of temporal correlation depended on not only radial position, but also on equivalence ratio and heat release rate. These experimental data are essential for the study of turbulent premixed lean flame and the calibration of empirical relations in simulation models. Quantitative infrared imaging can be remotely utilized to quantify global pollution releases, and radiation intensity measurements are useful for measuring thermal load on structures. Future work will be focused on turbulent statistics of radiation intensity fluctuations, which is useful for suppressing combustion instabilities.

Research advisor Dong Han writes, "Lean premixed combustion receives great interest from industry because of its NOx reduction advantage. An accurate and convenient method for measuring temperature distribution, which plays the most significant role in NOx emission, is demanded in the design and improvement of low NOx combustion devices. A non-intrusive technique using infrared radiation emission is introduced in this research to gain a better understanding of temperature distribution inside a lean premixed flame. Yunzhe Yang conducted multiple experiments with various conditions to support the development of this technique. His carefulness and professionalism in experimental work ensure a promising database created for further study."

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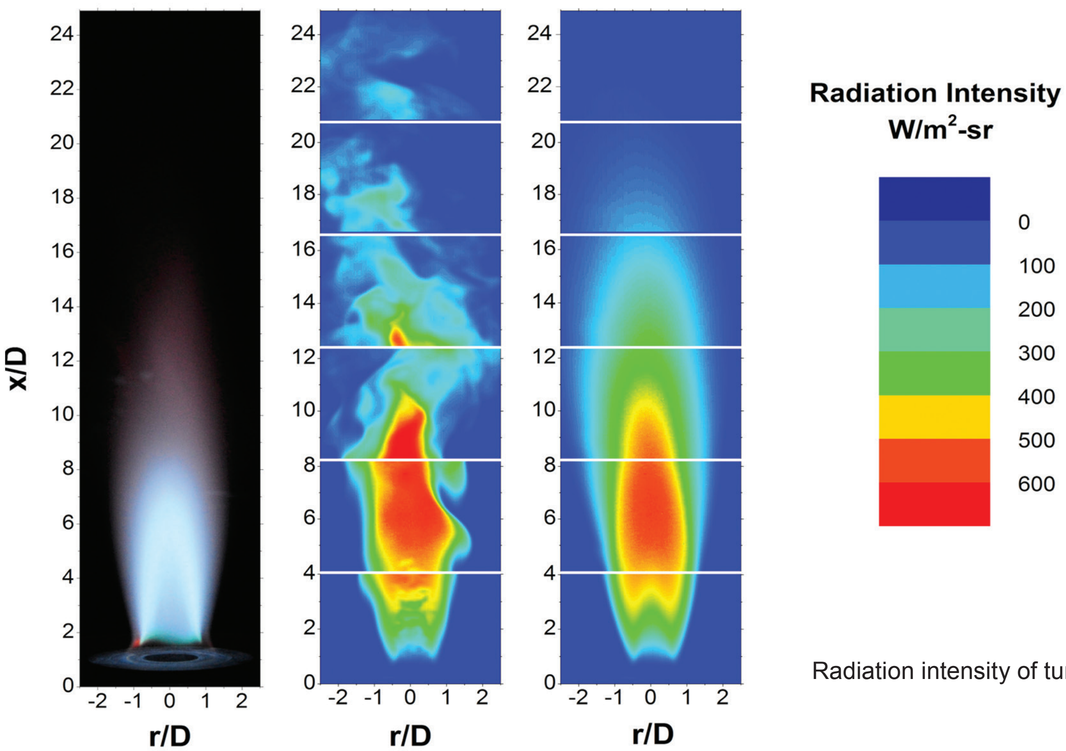

Radiation intensity of turbulent premixed lean flame.

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