MECHANICAL ENGINEERING COLLOQUIUM SERIES 2014-2015

Mechanical Engineering Lecture in Energy

High-Speed Laser Diagnostics in Turbulent Combustion Research:

Opportunities, Challenges, and New Insights

Jeffrey A. Sutton

Associate Professor
Department of Mechanical
and Aerospace Engineering
Ohio State University

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Turbulent combustion processes currently account for the majority of the world's energy usage and will continue to do so for the foreseeable future. Applications, which range from power generation to transportation, will rely on advancements in combustion systems that simultaneously increase efficiency, decrease emissions, and offer increased fuel flexibility. However, such advancements are quite challenging due to the complex (and dynamic) coupling of turbulent fluid dynamics and chemistry over a broad range of length and time scales. Over the last several years there has been a great deal of interest in "high-speed" laser-based imaging as it has the potential to provide new fundamental insight on the temporal evolution of important processes occurring in turbulent combustion environments. Such processes include reactant mixing, flame stabilization, ignition and extinction, dynamic instabilities, and the time-resolved identification of rare, but extremely important, events including engine misfire, flashback, and flame blowoff. While the appeal of high-repetition-rate measurements is obvious, the exact utilization of such measurements beyond qualitative visualization has not been as clear.

In this seminar, I will discuss the targeted application of quantitative, high-speed laser-based measurements for examining and understanding flow turbulence, mixing, and turbulence-chemistry interaction in turbulent and reacting flow environments. I will describe the development of our unique high-energy pulse burst laser system (HEPBLS), which allows the generation of ultra-high pulse energies at repetition rates >> 1 kHz. Such a system provides new opportunities to utilize many combustion diagnostics traditionally limited to low acquisition rates for the investigation of turbulence and combustion dynamics. Specifically I will focus on recent advancements in multi-kHz-rate Rayleigh/ Raman scattering and planar laser-induced fluorescence imaging in turbulent flows and flames. Results presented include space-time statistics of species and temperature fluctuations in turbulent flames and the role of temperature, mixture fraction, and scalar dissipation rate on the auto-ignition of transient fuel injection into hot, vitiated oxidizer streams.

Refreshments will be served before the seminar.
Please contact Tony Pulsone at pulsone@mit.edu with any questions.

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