

# 2010-2011 Graduate Seminar Series

## The Department of Mechanical Engineering – Engineering Mechanics

Proudly Presents

**Dr. Sreenath Gupta**  
Argonne National Laboratory

Sreenath holds a B. Tech. in Mechanical Engineering from IIT-Chennai, a M.S. and a Ph.D. in Mechanical Engineering from Penn State. After graduation he



has held various research positions in the industry before joining Argonne in 1998. At Argonne he has carried out numerous projects related to diesel fuel sprays, laser diagnostics, and particulate emissions from engines.

Sreenath currently works as a researcher engineer at Distributed Energy Research Center of Argonne National Laboratory. In this position he develops various technologies for improving the performance of natural gas fueled engines. The current focus of his research is in the efficient use of alternate gaseous fuels.

Sreenath is credited with over 36 technical publications, and 4 patents.

**Thursday, Oct. 28, 2010      4:00 – 5:00 p.m.      Room 112, ME-EM Bldg.**

### Laser ignition and associated diagnostics for natural gas fueled engines

Lean-burn operation is very popular with natural gas fueled stationary engines as it offers simultaneous low- $\text{NO}_x$  emissions and high engine efficiencies, while not requiring the use of any aftertreatment devices. Though engines operating on lean-burn operation are capable of even better performance, they are currently limited by the inability to sustain reliable ignition under lean conditions. Addressing such an issue, Argonne has evaluated the use of laser ignition as an alternative to the conventional Capacitance Discharge Ignition (CDI). Initial tests in a static chamber and a rapid compression machine have shown laser ignition to be capable of ignition at very higher pressures and leaner conditions than those ignitable using CDI. Subsequent tests in a lean-burn single cylinder engine have shown  $\text{NO}_x$  reductions up to 70% for a given efficiency, or efficiency improvements up to 3% for a given  $\text{NO}_x$  emission. Though efforts continue worldwide to reduce laser ignition to practice, further improvement in fiber optics' performance and laser technology are required.

In the meantime, two diagnostics were developed as a part of this effort:

The first diagnostic relies on measuring the flame chemiluminescence, which has been acknowledged in premixed turbulent flames to be correlated to local/ global heat release rate. Results from tests conducted in a single-cylinder engine equipped with a EGR system show that over 90% of the luminous signal can be attributed to  $\text{CO}_2^*$  emission. Also, the effect of dilution on  $\text{CO}_2^*$  chemiluminescence intensities was studied, by varying the global equivalence ratio (0.6 – 1.0) and by varying the Exhaust Gas Recirculation rate. The flame luminosity signals, did not correlate on a crank angle resolved basis with temperatures and heat release rates obtained from in-cylinder pressure measurements. However, the peak luminous signals correlated very well with both peak cycle heat release rates as well as peak cycle temperatures. Such observations point towards the potential use of flame chemiluminescence to monitor peak bulk gas temperatures as well as peak heat release rates in natural gas fired reciprocating engines.

A second diagnostic based on Laser Induced Breakdown Spectroscopy (LIBS) was developed to measure in-cylinder equivalence ratio. Following the laser induced spark ignition event, the broadband emission from the spark kernel was collected and spectrally resolved. The peaks corresponding to  $\text{H}_\alpha$ , N and O atoms were measured for a range of conditions with global equivalence ratios ranging between 0.6 and 1.0, and for Exhaust Gas Recirculation fractions up to 29%. The  $(\text{H}_\alpha/\text{O})$  and  $(\text{H}_\alpha/\text{N})$  peak intensity ratios from the spectral scans correlated extremely well ( $R^2 > 0.97$ ) with local oxygen based equivalence ratios. From the flow relations, it appears that for homogenous intake charge, such a LIBS diagnostic enables estimation of EGR rate with the knowledge of the global equivalence ratio.

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