Introduction to Advanced Combustion

Services provided in modern societies are driven, in large part, by energy liberated during the combustion of carbon-containing fuels. Historically, combustion devices have been inexpensive to build, fuels have been readily available, and the major atmospheric emissions (CO_2, H_2O) have been considered benign. Despite recent oil price increases and ever tightening emissions controls, combustion driven engines remain the most economical source of useful work.

Constraints on CO_2 emissions will change the competitive environment for combustion-driven devices. With today's technology, the thermodynamic efficiency of combustion devices is between 20% and 60%. The systems at the high end of this range are subject to high capital cost (combined cycles) or unacceptable criteria pollutant levels (diesel). Improving efficiency, reducing emissions and decreasing complexity could all have significant impact on total greenhouse gas emissions, possibly with modest capital outlay.

Since its inception, GCEP has conducted research in the area of advanced combustion. Research activities in combustion informatics, controlled combustion, combustion sensors, low-irreversibility combustion, and on oxygenated fuels have all been completed. Information on those efforts may be found in GCEP's technical reports from 2006 to 2009.

Professor Chris Edwards' program began by pursuing engines that reduce exergy loss by conducting combustion at states of extreme energy density. The team successfully constructed a free-piston device that can achieve compression ratios in excess of 100:1. Over the past year, the group received additional funding to use the device to pursue Combustion Testing and Analysis of an Extreme-States Approach to Low-Irreversibility Engines. These tests are addressing the high efficiency levels first reported (60% indicated), addition of a gas emissions measurement system for collection of NO, CO, and HC emissions, addition of an *in-situ* soot measurement system for particulates, and measurement of combustion efficiency and emissions with isooctane and diesel fuels under direct-injection conditions.