Introduction to Advanced Combustion

Many industries and services 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 fluctuating prices in fossil fuels 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 supported a variety of research in the area of advanced combustion. Research activities in combustion informatics, controlled combustion, combustion sensors, low-irreversibility combustion, oxygenated fuels and combustion at extreme states have all been completed. Information on those efforts may be found in GCEP's technical reports from 2006 to 2012.

As part of Professor Chris Edwards' program on an approach using extreme-states for low-irreversibility engines, there was an *in-situ* soot measurement system for particulates and measurement of combustion efficiency and emissions with isooctane and diesel fuels under direct-injection conditions. Results from the previous GCEP project led to the follow-on research for "Using Extreme Compression to Promote Fuel Reformation with a Reacting Jet: The Path Towards a Sootless Diesel Engine". The objective of the work is to use extremely high temperatures and a moderator species to manipulate the local atom ratios and fuel species such that no soot is produced, only carbon monoxide and hydrogen. Results to date are promising and show that the inclusion of water may reduce particulate formation and/or improve efficiency. Also particulates from alcohol fuels using multi-pulse injection scheduling in diesel engines may potentially eliminate after-treatment. Future work will be the further validation and integration of experimental and simulation research on different engine devices and fuels.