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.

Currently Professor Chris Edwards leads a program entitled "*Use of Mixed Combustion/Electrochemical Energy Conversion to Achieve Efficiencies in Excess of 70% for Transportation-scale Engines*". The objective of the work is to use modeling and experimental studies on a hybrid system of an internal combustion engine and a fuel cell to achieve exergy efficiencies near 70%. Modeling results show that large efficiency gains are possible using a high-temperature approach that would employ a solid-oxide fuel cell and a low-heat rejection Diesel engine. The result provides guidance on how an extremely efficient system could be designed and highlights the need for further experimental investigation into unique operating conditions. The past year of work has led to increased measurement capabilities to characterize the rich combustion regime in terms of its performance and emissions allowing testing of the assumptions in the model to inform the combustion strategy. Progress made on modeling injection, has given insight into the dynamics of the injector that is critical to a multiple injection strategy. Future work will be focused on rich-combustion experiments using the optical-access research engine. The combination of all of these efforts will extend knowledge of the overall mixed combustion/electrochemical space and deliver a robust understanding of the prospects of using such a strategy to achieve efficiencies above 60% for transportation scale power generation.