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 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.

Professor Chris Edwards led the final program in this area entitled "*Use of Mixed Combustion/Electrochemical Energy Conversion to Achieve Efficiencies in Excess of 70% for Transportation-scale Engines*". The objective of the work was 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%. The researchers showed that a low-temperature architecture could achieve efficiencies in excess of 50%. The high-temperature architecture was successful in reducing reaction-related losses and indicated there is a plausible path to 70%. Experimental investigation of the diesel-style rich combustion strategy and the use of rich engine exhaust in a catalytic reformer and fuel cell were conducted to understand if the modeling results were valid. The conclusion from both strategies is that there is no fundamental barrier to pursuing these approaches, and although further work is required, the results of the analysis reported appear to be achievable. These results suggest that the high-temperature architecture should be explored further to bring the concept closer to deployment.