FACT SHEET

Advanced Combustion Systems for Next Generation Gas Turbines

I.) Participants:

Principal Investigator: General Electric, Air Force Research Lab

II.) Description

A. Objective: Develop a new gas turbine combustion system design with 50% lower emissions, and demonstrate it at sub-scale. The system will be compared with state-of-the-art lean premixed gas turbine NOx emissions at temperatures and pressures comparable to GE F-Class turbines.

B. Background/Relevancy: Next generation turbine power plants will require high efficiency gas turbines with higher combustor pressures and firing temperatures than is currently available. These increases in the severity of gas turbine operating conditions will tend to increase NOx emissions. As the desire for higher efficiency drives combustor pressures and turbine inlet temperatures ever higher, gas turbines equipped with both lean premixed combustors and catalytic reduction eventually will be unable to meet the new emission goals of sub-3 ppm NOx with sub-ppm ammonia slip. New gas turbine combustors are needed with lower emissions than the current state-of-the-art lean premixed combustors.

The trapped vortex combustor (TVC) is a novel combustor geometry which offers stable performance over a wider range of fuel flow rates than current technology. The trapped vortex combustor maintains a vortex of burning fuel and air in a chamber adjacent to the main burner ports. The hot vortex acts as a pilot to the main burner, stabilizing its operation. This enables the combustor to operate at leaner premixes with improved stability and lower NOx.

C. Period of Performance: June, 2001 – June, 2004

D. Project Summary: Trapped vortex combustor concepts will be evaluated up to 1/4 scale in three phases. First, prototypes will be used to evaluate diffusion and premixed fuel injection performance differences, Next two high temperature and pressure prototype designs will be used to evaluate design criteria and low emission performance for heavy-duty gas turbines & aeroderivatives. Lastly, a larger scale prototype will be used to evaluate the criteria for scaling the combustor. Following these evaluations, a full-scale conceptual design of a heavy-duty gas turbine combustor will be completed.

Computer simulations will be used in the design process. Detailed flow measurements in an atmospheric combustor will be used to validate and refine the computational models. The models will then be used to design the first high pressure and temperature prototype. Experimental data will be used to further refine the computational models and anchor them to the operating conditions of interest. The validated tools will then be used in the development of high pressure and temperature designs

Date of last revision: 10/9/03

High pressure and temperature combustion experiments will be conducted at the GE Global Research Facility. Combustor emissions, dynamics, minimum fuel flow rates, and component temperatures will be monitored during the experimental program. Combustor operability and emission performance maps will be generated from a systematic evaluation of the combustors' operation.

III.) Project Costs

A. DOE Costs: The DOE is providing funds for this project to cover 60% of the costs.

Total: $1,182,510

B. Prime Contractor Cost Sharing: The General Electric Company, as prime contractor, is providing a 40% cost share for this project.

Total: $788,340

IV.) Major Accomplishments:

- Evaluated diffusion and premixed fuel injection in atmospheric trapped vortex combustors (TVC's) to screen for valid design approaches, December 2001.
  Evaluation of combustor fueling strategies early in the program provided valuable feedback on the potential for low-emission TVC technology. NOx emissions 50% below those of an aeroderivative at the same firing temperature were demonstrated. The low emissions potential of various fuel injection configurations were demonstrated.

- Obtained detailed flowfield measurements, January 2002.
  CFD modeling must be grounded in experimental data to validate models. Detailed flow data were obtained in three planes to provide a clear reference to computational models. The validation of the CFD is critical to successful design of the first prototype.

- Validated CFD models with experimental data, August 2002.
  CFD models have been developed and a combustion modeling approach has been identified which captures the significant flow-field features of the TVC. The validated model provides the basis for developing a TVC prototype in a different geometric configuration.

- Developed CFD model of first TVC prototype combustor, March 2003.
  Developed prototype-1 design with critical flow-field features using CFD modeling tool. This model was essential to validating the design before manufacturing the first prototype.

- Characterized first heavy-duty gas turbine prototype combustor, September 2003.
  Critical design parameters were explored through a series of four experimental configurations. The program's combustor performance goal of 50% reduction in NOx from current technology while maintaining the CO performance continues to look promising for the TVC following the elevated pressure tests. From the experiments it was also concluded that the design can be further optimized for low emission and turndown performance.

V.) Planned Accomplishments in the next 6 Months:

- Evaluate second heavy-duty gas turbine prototype , Nov 2003 - Jan 2004.

The second prototype must demonstrate lower emission performance at actual gas turbine conditions before progressing to larger scale designs. The cavity design is being altered as well as some of the components in an effort to achieve this. This demonstration provides data critical for understanding the capabilities of TVC as a low emission combustor technology.

VI.) Planned Accomplishments in the next 6 to 18 Months:

- Evaluate scaled-up heavy-duty gas turbine prototype, April 2004.
  To develop a successful full-scale conceptual design, scaling criteria for the combustor must be understood. This set of experiments will refine our understanding of critical scaling parameters in relation to the emission performance. The outcome will be a prioritized list of scaling criteria to guide the development of the full-scale conceptual design.

- Generate full-scale conceptual design, August 2004.
  The pinnacle of this research program is to develop a feasible combustor design that can meet the performance requirements of a next generation gas turbine. This design provides the basis for full-scale evaluation of the concept on the pathway to production and brings closure to the lessons learned at sub-scale.

VII.) Major Milestones

- Atmospheric TVC experimental evaluation. 10/2001 -12/2001
- Develop aerodynamic design tool. 5/2002 – 8/2002
- Demonstrate 1st combustor prototype. 9/2003 – 10/2003
- Demonstrate 2nd combustor prototype. 11/2003 – 12/2003
- Demonstrate scaled performance. 3/2004 -4/2004
- Produce full-scale conceptual design. 5/2004 -8/2004

VIII.) Issues:

IX.) Attachments:

Date of last revision: 10/9/03

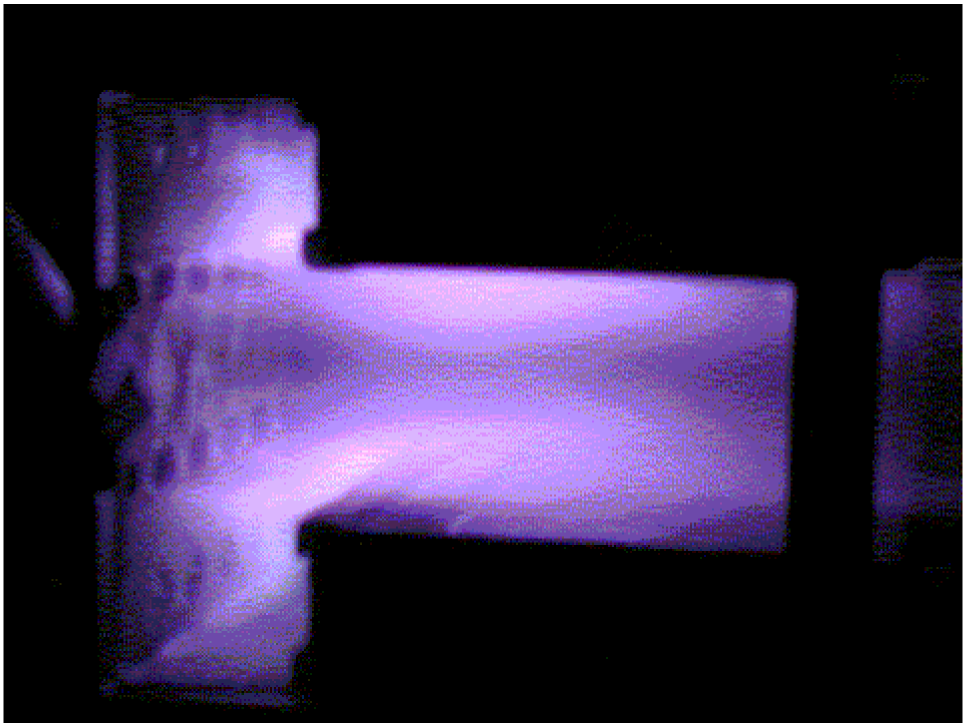

Figure 1: Demonstration of Low Emission TVC with Natural Gas at Atmospheric Pressure