the ENERGY lab

PROJECT FACTS

Hydrogen Turbines

Development of Criteria for Flame-holding Tendencies within Premixer Passages for High Hydrogen Content Fuels—University of California, Irvine

Background

The gas turbine community must develop low emissions systems while increasing overall efficiency for a widening source of fuels. In this work, the University of California, Irvine (UCI) will acquire the fundamental knowledge and understanding to facilitate the development of robust, reliable, and low emissions combustion systems with expanded high hydrogen content (HHC) fuel flexibility. Specifically, understanding flashback and the subsequent flameholding tendencies associated with geometric features found within combustor fuel/air premixers will enable the development of design guides to estimate flame holding tendencies for lean, premixed emission combustion systems for HHC fuels. Industry can use these guides to help design robust premixing passages for combustors that can accommodate a wide range of fuel types.

This project was competitively selected under the University Turbine Systems Research (UTSR) Program that permits academic research and student fellowships between participating universities and gas turbine manufacturers. Both are managed by the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL). NETL is researching advanced turbine technology with the goal of producing reliable, affordable, and environmentally friendly electric power in response to the nation's increasing energy challenges. With the Hydrogen Turbine Program, NETL is leading the research, development, and demonstration of these technologies to achieve power production from high hydrogen content fuels derived from coal that is clean, efficient, and cost-effective; minimizes carbon dioxide emissions; and will help maintain the nation's leadership in the export of gas turbine equipment.

Project Description

This research will provide a systematic evaluation of flameholding tendencies in various combustor fuel/air premixer passage geometries. This evaluation will be completed for different fuel types (including HHC fuels) at operating conditions (temperature, pressure, etc.) typical of those encountered in industrial-scale turbines. The observations made relative to flameholding tendencies will be analyzed and used to develop design guides that can be used to infer when flameholding will occur as a function of the parameters studied.

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PARTNERS

None

PROJECT DURATION

Start Date	End Date
10/01/2011	09/30/2014

COST

Total Project Value
$624,999

DOE/Non-DOE Share
$499,999/$125,000

AWARD NUMBER

FE0007045

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The high pressures and temperatures required to simulate the environment of a premixing passage for a natural gas-fired gas turbine will be generated at the University of California, Irvine Combustion Lab high pressure facility. The facility is capable of generating a preheated airflow at temperatures up to 1200 degrees Fahrenheit, pressures exceeding ten atmospheres, and a maximum flow rate that exceeds three pounds per second. To provide the planned conditions, a modular test apparatus (Figure 1) will be used.

Figure 1: Completed test apparatus

Goals and Objectives

The goal of this project is to develop design guides that can be used to predict flameholding tendencies within combustor can premixer passages as a function of pressure, temperature, fuel composition, percentage of oxygen in the air, and feature geometries found within the passages such as steps, gaps, or vanes/struts. The project objectives include:

- The project objectives include:Carrying out an experimental study using a continuous flow rig that allows various premixer features (i.e., steps, gaps, vanes, gas jets) to be investigated for various operating conditions (velocity profiles, temperature, fuel composition, pressure).
- Correlating the results with respect to local flow conditions.

Accomplishments

- Completed modifications to facility to allow new test section to be constructed.
- Completed construction of new test apparatus with input from OEMs (original equipment manufacturers) Data acquisition hardware has been installed and instruments calibrated. Apparatus commissioning tests have been completed.

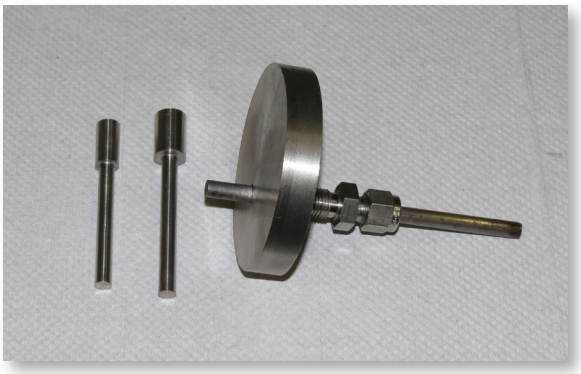

Figure 2: Cylindrical rod flameholder test feature with interchangeable rods of varying diameters

- Constructed 4 baseline flameholding test features: cylindrical rod, reverse step, airfoil, and flat strut.
- Ran tests with the cylindrical rod, located in the center of the flow, as a means to compare results from the new rig with literature findings for comparable conditions. The results for the rod were in excellent agreement with literature, effectively validating the rig operation.
- Results for the reverse step have demonstrated pressure dependency not explained with previous correlations.

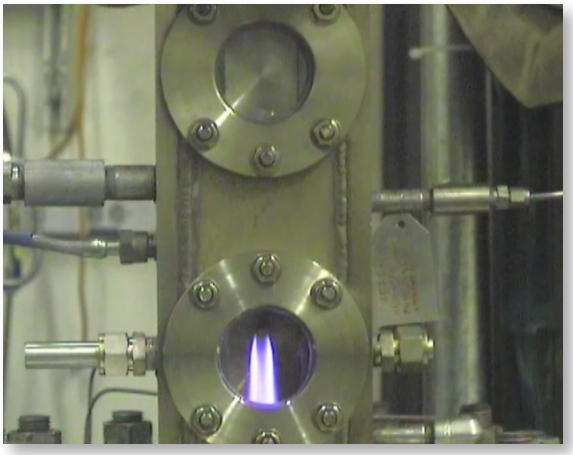

Figure 3: Natural gas flame stabilized behind ¼" diameter rod at 500 degrees F, 3 ATM, and 40 m/s

Benefits

This UTSR project supports DOE's Hydrogen Turbine Program that is striving to show that gas turbines can operate on coal-based hydrogen fuels, increase combined cycle efficiency by three to five percentage points over baseline, and reduce emissions. Data gathered in this project will aid in new designs for syngas-fueled turbines.