Combustion Instability and Blowout Characteristics of Fuel Flexible Combustors

FACT SHEET

I. PROJECT PARTICIPANTS

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II. PROJECT DESCRIPTION

A. Objectives

The objective of this proposed program is to improve the state of the art in understanding and modeling two issues that will be of acute significance in realization of low emissions, fuel-flexible gas turbines: lean blowout and combustion instabilities.

B. Background/Relevancy

Background.

This work is motivated by the fact that the inherent variability in composition and heating value of coal derived and other alternative fuels provides one of the largest barriers towards their usage. This fuel composition variability is of concern because low emissions combustion systems are generally optimized to operate with fuels that meet tight specifications.

Relevancy.

Successful completion of this project will benefit the gas turbine and energy industry in several ways. It will remove barriers toward the usage of coal derived gaseous fuels through improved understanding of their combustion characteristics. It will also improve the development of modeling tools needed by OEM's to design fuel-flexible combustion systems. Ultimately, these benefits will increase the air quality and energy security of the USA, by allowing power plants to operate efficiently and with minimal pollution, using a variety of domestic fuel sources.

Period of Performance.
07/01/2003 - present

C. Project Summary

Under the University Turbine Research (UTSR) program, Georgia Institute of Technology is investigating the blowout and combustion instability characteristics of fuel-flexible combustors. Particular attention is given to coal-derived gaseous fuels which are of interest to the program. The first task will develop the test matrix that will form the basis for the experiments performed under this program. Because of the significant number of independent parameters that need to be examined (e.g., fuel composition, pressure, temperature, premixer design), a systematic effort to develop this test matrix is needed so that the resulting parameter studies are of sufficient breadth and detail, yet still realistic enough in scope to be performed in a university program. The second and third tasks are measuring the combustor's stability characteristics. So far, the key variables that represent effects of fuel compositions and mechanism that describe static lean blowout have been studied and determined (see attachments). In addition, we duplicated an experimental rig developed at Sandia National Laboratories by Dr. Bob Schefer and Dr. Joe Oefelein. High speed visualizations of the flame near blowoff were obtained as a function of fuel composition revealing some fundamental changes in blowoff dynamics as the hydrogen concentration in the fuel increases. A complementary modeling program is also being performed that uses kinetic computations to predict relative changes in combustor stability with variations in fuel composition. These studies are performed upon a high pressure, swirl stabilized combustor that closely resembles typical combustors used by OEM's.

III. PROJECT COSTS

$376,722

IV. MAJOR ACCOMPLISHMENTS SINCE BEGINNING OF PROJECT

1. Developed computational tool for analyzing fuel composition effects on combustor performance

2. Designed and fabricated a gas mixing, storage, and safety system for arbitrary compositions of H_2, CO, CH_4, N_2, and CO_2

3. Determined key variables that represent effects of fuel compositions and mechanism that describe lean blowout

4. Developed a swirling stabilized dump combustor for visualization of dynamic blowoff process

5. Visualizations of dynamic extinction-reignition process near blowoff for several fuel compositions

V. MAJOR ACTIVITIES PLANNED DURING THE NEXT 6 MONTHS

1. Detailed flame visualizations with high speed camera and flow field with PIV of dynamic blowoff process with several fuel compositions

2. Experimental studies of geometry effects (exhaust nozzle and aspect ratio of the combustor) upon lean blowout

3. Detailed analysis of models to describe dynamic process of lean blowoff.

VI. MAJOR ACCOMPLISHMENTS PLANNED IN OUTYEARS (6-18 MONTHS)

1. Developing a model to predict static lean blowoff with higher accuracy

2. Improved understanding of the effects of fuel compositions on dynamic blowoff process

VII. ISSUES

List any schedule issues and/or any issues with respect to accomplishing the tasks that were listed in the original proposal for the project. If none, state "None".

VIII. ATTACHMENTS

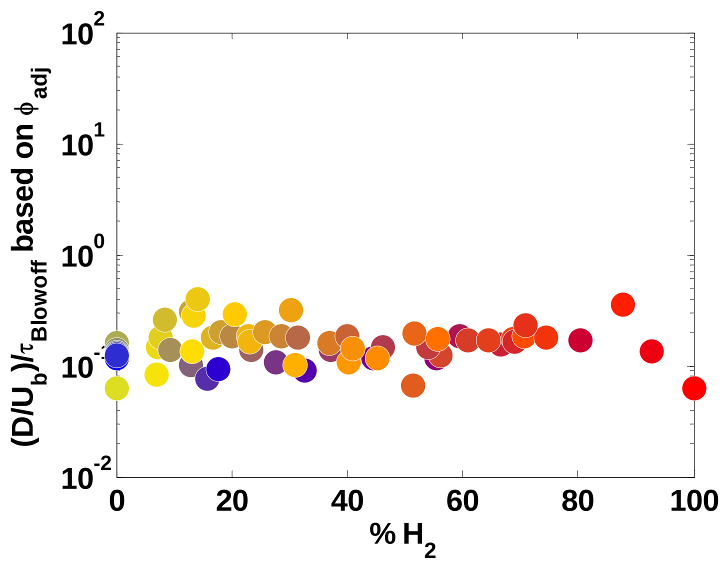

Figure 1: Damköhler numbers of mixtures based on local equivalence ratio at premixer flow velocities of 59 m/s at 458K reactants temperature and 4.4 atm combustor pressure

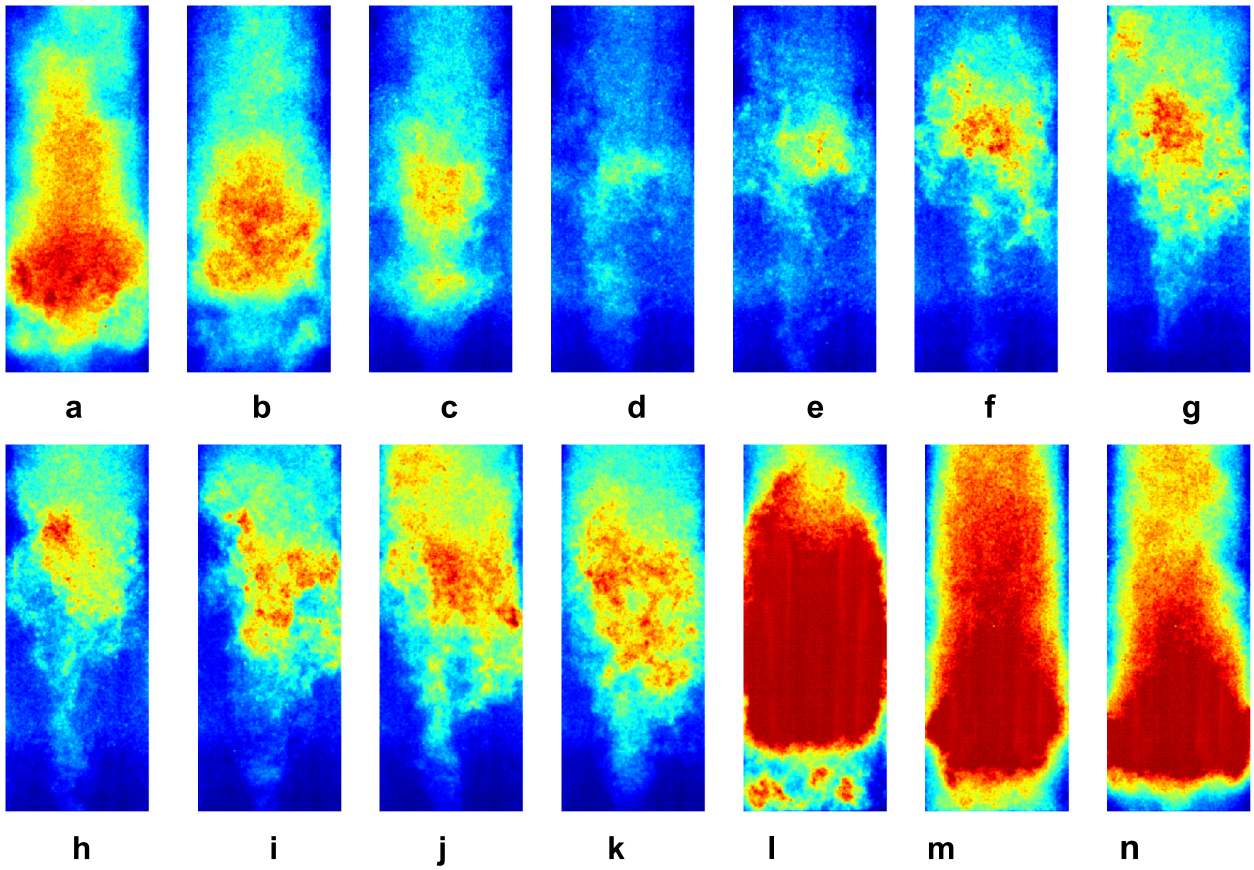

Figure 2: Images of flame chemiluminescence of 80%CH_4 --20% H2 flame at phi=0.42; images separated by 2ms