Flameholding Propensities of Small Feature Stabilized Hydrogen and Natural Gas Flames at High Temperatures and Pressures

MOTIVATION

Interest in renewable fuel sources has led to increased attention to high hydrogen content fuels. One significant issue in the combustion of hydrogen containing fuels is the greatly increased propensity for flashback and subsequent flame anchoring within the premixing passage of premixed gas turbine engines. Flame anchoring within the premixing passage can rapidly result in engine damage. While there is extensive work that characterizes the flameholding tendencies higher hydrocarbon fuels in geometries designed to anchor flames, very limited work has been done on the flame holding of geometries that were not designed to hold flames or with hydrogen and natural gas. Focus of this work is to establish criteria that can be used to design engines which are more fuel flexible with respect to high hydrogen content fuels.

Goal

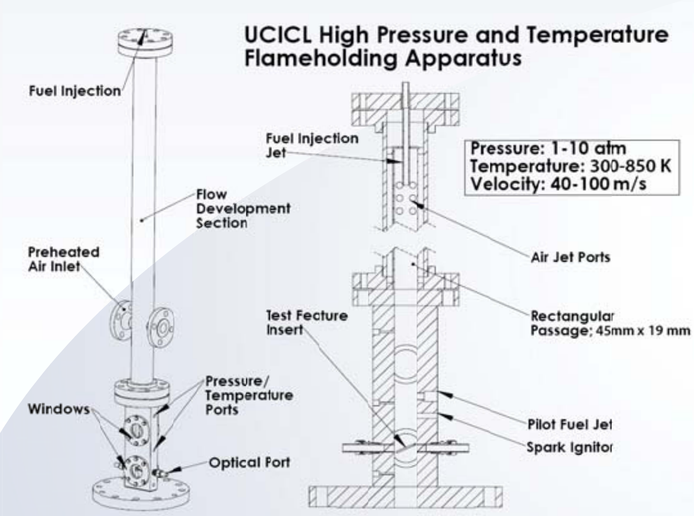
The aim of this research is to develop criteria for the flameholding tendencies of hydrogen and natural gas in the wakes of features typical of a gas turbine premixer.

EXPERIMENT

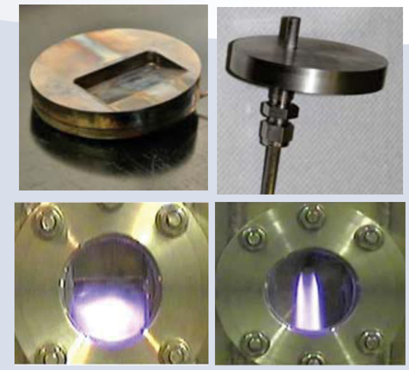
A new test apparatus was constructed that is capable of operating at conditions relevant to gas turbines. [F1 and F2]

RESULTS

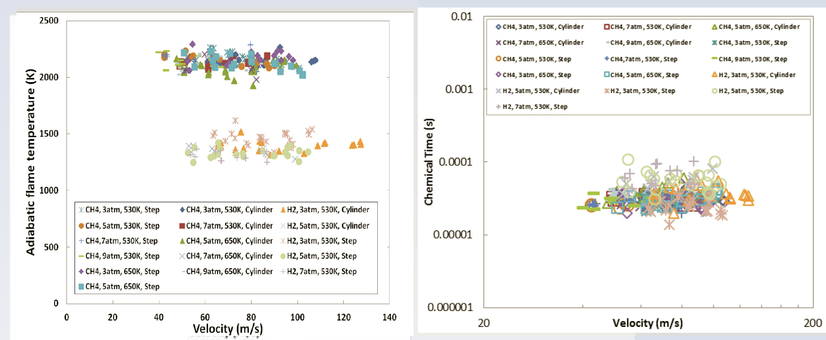
Experiments have been conducted with two flameholders, a cylinder and a reverse facing step. Both flameholders have the same characteristic dimension of 6.3mm. Tests have been done at temperatures as high as 750K, and pressures up to 9 atm. Chemical time scale has been shown to collapse blow off data for both hydrogen and natural gas.[F3] Flow velocity was shown to have no effect on flameholding.[F3] This is attributed to increasing turbulence fluctuation magnitude, which result in higher turbulent flame speeds.



F1: UCI Combustion Lab Flameholding Apparatus



F2: Clockwise from Left: Test Apparatus, Reverse Step Flameholder, Cylindrical Flameholder, Natural Gas Flame with Cylinder, Natural Gas Flame with Reverse Step



F3: Flameholding Limits. (L) Adiabatic flame temperature vs. Velocity, (R) Chemical timescale vs. Velocity

CONCLUSIONS

- Temperature and fuel type were found to affect flameholding propensity more than any other parameter.
- Adiabatic flame temperature can be used as the characteristic temperature
- Characteristic chemical time predicts flameholding propensity for a given flameholder, regardless of fuel type, pressure, temperature or velocity.
- Velocity was not found to be a significant factor in flameholding propensity over the range studied.

RECENT PUBLICATION

E. Sullivan-Lewis, and V.G. McDonell, Flameholding Tendencies of Natural Gas and Hydrogen Flames at Gas Turbine Premixer Conditions, Proceedings of ASME Turbo Expo 2014, Düsseldorf Germany, June 16-20, 2014. (accepted for publication, ASME J. Engr Gas Turb and Power

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