Investigation of H_2 Concentration and Combustion Instability Effects on the Kinetics of Strained Syngas Flames

Ahsan R Choudhuri
Combustion and Propulsion Research Laboratory
Department of Mechanical and Industrial Engineering
The University of Texas at El Paso
500 West University, Mail Stop: 0521, El Paso, Texas 79968
Tel: 915 747 6905, Fax: 915 747 5019
E-mail: ahsan@utep.edu
DE-FG26-05NT42495
08/08/05-02/07/06

OBJECTIVE(s)

There are two primary objectives of this study: The *first objective* is to systematically investigate *flame extinction strain rates* and *flame structures* of H_2-CO/air flames using a counterflow burner. Spectroscopic measurements of OH, H, O and CH radical/atom concentrations along the flame axis will be used to characterize the interaction of the kinetics and the stretch field. The *second objective* is to systematically investigate the *effects of combustion oscillation on flame extinction strain rates* and *flame structures* of H_2-CO/air flames. The counterflow flames will be acoustically forced with different frequencies (representative of actual combustor acoustic instabilities) and the perturbed flame characteristics (extinction strain rates and flame structures) will be measured.

ACCOMPLISHMENTS TO DATE

The flame extinction limits of hydrogen (H_2-CO and H_2-CH_4) fuel blends have been measured using a twin-flame-counter-flow burner. Plots of Extinction limits vs. global stretch rates have been generated at different mixture compositions and an extrapolation method was used to calculate the flame extinction limit corresponding to an experimentally unattainable zero-stretch condition. The zero-stretch extinction limits of H_2-CO and H_2-CH_4 fuel mixtures exhibit a second order ($\% f_{ext} = a_2 x_{H_2}^2 + a_1 x_{H_2} + f_0$) polynomial relation with the volumetric concentration of hydrogen in the mixture. Flame extinction limits of H_2-CO and H_2-CH_4 mixtures determined in a flat-flame burner configuration also show a similar relation.

Additionally, the measured laminar flame velocity close to the extinction indicates that regardless of fuel composition the premixed flame of hydrogen fuel blends extinguishes when the mixture laminar flame velocity falls below a critical value. The critical laminar flame velocities at extinction for H_2-CO and H_2-CH_4 premixed flames (measured in the flat flame burner configuration) are found to be 3.77(±0.38) cm/s and 4.88(±0.87) cm/s respectively.

Planar laser induced fluorescence images of OH radical concentration in a one-dimensional flame have also been captured for different compositions of H_2-CO mixture. The OH radical concentration decreases significantly as the flame approaches the extinction value. In addition it was observed that close to the extinction point, flames of different compositions of H_2-CO have similar distribution of OH radicals.

FUTURE WORK

For a given global stretch rate, the extinction equivalence ratio for a H_2/CO and H_2/CH_4 at different H_2 concentration levels will be determined at acoustically forced flow conditions. The Twin-Flame-Counter-Flow Burner has been modified to accommodate speakers for creating acoustically disturbed flows. The experiments will be repeated to generate an extinction equivalence ratio vs global stretch rate plot and an extrapolation method will be used to identify the equivalence ratio corresponding to an experimentally unattainable zero-stretch condition at different forcing frequencies.

Spectroscopic measurements of OH radicals will be done along the flame axis for a given stretch and H_2 concentration at forced flow conditions. The measurements will be repeated for both forced and unforced conditions. By changing the stretch rate (by moving the top burner) and H_2 concentration in the fuel-air picture the synergetic effects of flame stretch and H_2 concentration on the flame kinetics will be assessed.

LIST OF PAPER PUBLISHED AND STUDENTS SUPPORTED UNDER THIS GRANT

Journal Paper:

Choudhuri, A. R., Subramanya, M., and Gollahalli, S. R., 2006, “Flame Extinction in Hydrogen Fuel Blends, *Journal of Engineering for Gas Turbine and Power*, in review

Students Supported:

Hector Olvera, Doctoral Students
Mahesh Subramanya, Doctoral Student
Masud Sharif, Doctoral Student
Deepthi Davu, Masters Student