Title: **Investigation of the Effects of Composition and Combustion Instabilities on the Flashback Propensity of Syngas Premixed Flames**

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Objectives:

The objective of this project is to understand the flashback propensity of syngas at different compositions. This proposed study concentrates on generating critical boundary velocity gradient maps (g_F) of different compositions of syngas with or without the presence of combustion oscillation. The influence of mixture composition and combustion oscillation (externally driven) on the flashback propensity is quantified. Of special interest of the project is to understand the effect of higher concentrations of H_2 in syngas on flashback.

Accomplishments To Date:

The design, fabrication and qualification of the experimental hardware have been completed. Unexcited syngas flashback data at different mixture compositions for 6.0, 7.0 and 10.6 mm tubes have been acquired and analyzed. The following sections delineate the details of the experimental hardware, experimental methodologies and preliminary results.

Figure 1. Components of the flashback rig: (top row and from left) honeycomb housing, honeycomb and wire mesh; (second row) c-clamps, final assembly and converging nozzle; (bottom row) glass tube adapters, base and injector mixing device.

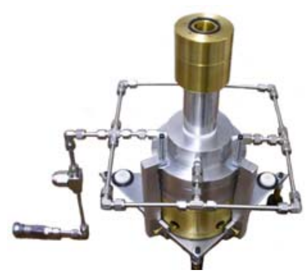

Figure 2: Burner Assembly (without the glass tube adaptor)

The burner system has four primary segments: (a) mixing manifold, (b) flow excitation hub (base, speaker and speaker housing), (b) flow conditioner (honeycomb, honeycomb housing and wire mesh), and (c) burner tube assembly (converging nozzle, glass tubes, glass tube adapters, adjustable supports, and c-clamps). Figure 1 and Figure 2 show the various parts and completed burner assembly of the burner respectively. The converging nozzle section seamlessly merges with the adapters to accommodate glass tubes of different diameters. The fuel and air enter into the manifold through four alternate injection holes. The fuel-air mixture then passes through the flow conditioning section to eliminate injection induced flow irregularities and to insure laminar flow through the burner tube. Since the burner the system is also designed to analyze the flashback with external excitation, the bottom part of the injection manifold opens to a flow excitation hub section. The flow excitation segment consists of a thin copper membrane vibration source fed by a 100W speaker. In the forced flow configuration, various synthesized signals are fed to the speaker by an amplifier and a signal synthesizer combination.

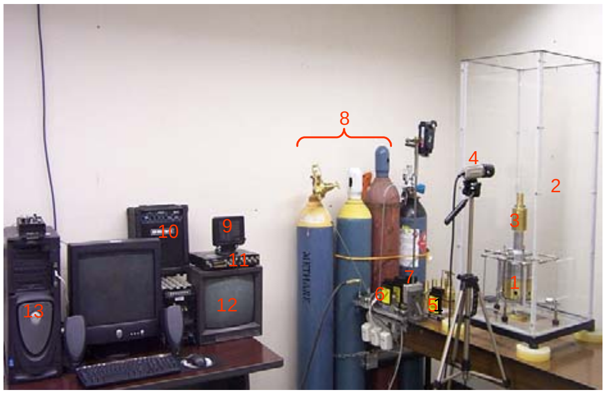

Figure 3. Experimental facility.

The experimental facility, as shown in Figure 3, consists of the burner, gas supply and monitoring equipment, an audio signal synthesis/amplification system, and a high-speed direct video imaging system (FASTCAM-Super 10K) to detect the flashback condition. High accuracy mass flow meters/controller are used to meter and control the fuel-air flow rates [(1) flashback test rig, (2) safety chamber, (3) glass tube adapters, (4) high-speed direct camera, (5) mass flow controller, (6) mass flow meters, (7) mixing manifold, (8) fuel/air cylinders, (9) monitoring equipment, (10) flow excitation system, (11) data acquisition board, (12) high speed controller and monitor and (13) a computer].

The critical flashback flow rates of H_2-CO (syngas), CH_4-H_2 and CH_4-C_3H_8 air mixture for 6.0, 7.0 and 10.6mm glass tube were measured. For a fixed burner diameter the flashback propensity of the H_2-CO mixture increases with the increase in hydrogen content in the fuel blend. Figure 4 shows the area under the critical flow curve widens with the increase in hydrogen concentrations. However, it is interesting to note that instead of the mixture stoichiometry the peak critical flow rates are sensitive to hydrogen stoiciometry only. This confirms that in H_2-CO kinetics, $H+O_2 \rightarrow OH+O$ reaction dominates the branched chain reaction processes. Detailed experimental results and discussions are presented elsewhere[1].

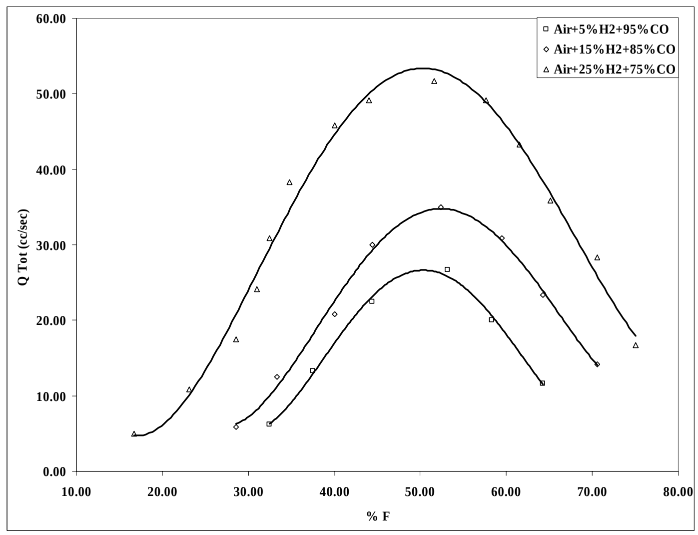

Figure 4. Critical flows for flashback of H_2-CO /Air flames (6.0 mm glass tube)

Future Work:

The effects of combustion instabilities on the flashback propensity of H_2-CO are currently being measured. To study the effect of external excitation on the critical velocity gradients, the incoming flow is forced over a range of frequencies (f = 10 to 900 Hz) using a sound synthesizer and speaker assembly.

List of Paper Published:

[1] Franco, R. and Choudhuri, A. "Investigation on the Flashback Propensity of Syngas Premixed Flames" AIAA 2005-3585.
[2] Franco, R., Subramanya, M., and Choudhuri, A., "Investigation on the Flame Extinction Limits of Fuel Blends," AIAA 2005-3586.
[3] Subramanya, M. and Choudhuri, A., "Experimental Investigation on the Flame Extinction Limits of Fuel Blends," AIAA 2005-0374.

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[1] Franco, R., Investigation on the Flashback Propensity of Fuel Blends, MS Thesis, Department of Mechanical Engineering, University of Texas at El Paso, 2005.