FUEL INJECTION AND MIXING

H2 MIXING

OVERVIEW

Hydrogen as a fuel has many benefits ranging from its ability to be created from water to its minimal emissions due to its simplified composition chemistry, but with these advantages come challenges. Hydrogen has a low molecular weight and high mass diffusivity giving it a behavior different from other fuels. This behavior makes hydrogen mixing different and a better understanding, characterization, and modeling is required for hydrogen and high hydrogen content fuels for proper utilization in combustion systems.

In this program hydrogen mixing with be studied through a variety of fuel compositions, injection configurations, and flow field properties. In particular the effects of injection type, injection momentum, hydrogen content, air flow, and swirl effects will be studied. For the program there are two goals which combine experimental and numerical approaches. On the experimental side an fuel concentration profiles downstream of the injection will be determined on a time average and instantaneous basis. The numerical study will involve modeling the same hardware and conditions using CFD software and comparing numerical solutions to data obtained experimentally to determine the simulation effectiveness. For this aspect of the program a variety of turbulence models will be considered as well as adjustments within these models to determine if they can be used to effectively simulate flows involving hydrogen.

APPROACH

- **Experimental Methods:** Modular Test Stand. Allows variations of injection type and momentum, swirl, fuel composition, and air flow. Diagnostic methods include Raman Scattering and gas analyzers. A cutaway of the test stand can be seen in figure 1 and 2.
- **Numerical Tools**: Computation Fluid Dynamics (CFD) and Design of Experiment

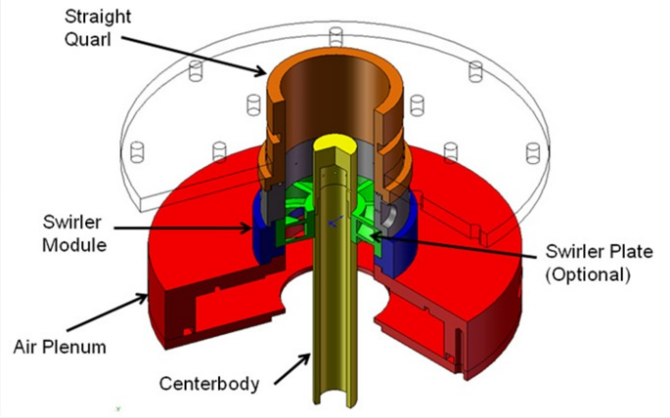

Figure 1. Modular Test Stand Sectioned View

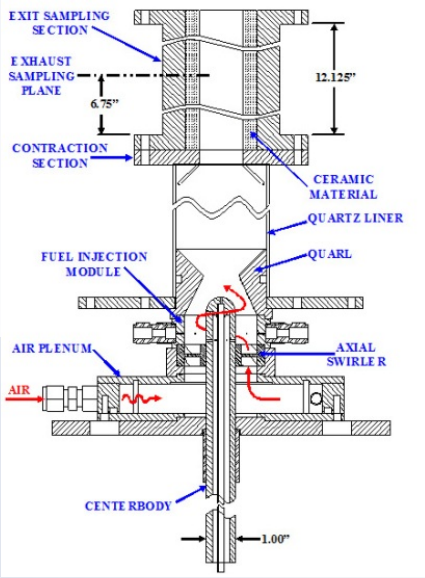

Figure 2. Test Stand, Liner, and Exhaust Cross Section

GOALS

The goal of this program is to establish accurate and reliable measurement and simulation strategies for mixing processes with high hydrogen content fuels subjected to various flow and injection characteristics. This research will:

- Establish accurate measurement techniques for hydrogen mixing processes
- Determine instantaneous and time averaged fuel concentrations downstream of injection
- Evaluate how computational fluid dynamics (CFD) software models and model coefficients effect the overall accuracy of numerical simulations

RESULTS

The experimental hardware has been prepared for the current study with modifications to hardware better facilitate the numerical side of this study. The test hardware has also been modeled for the numerical study with some simulations being run to provide preliminary data. This preliminary data provides insight into the flow and can be used for rapid comparison with experimental data as the study continues. Some of the initial data can be seen below in figure 3 and 4.

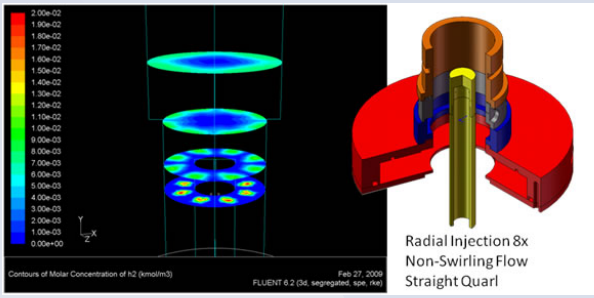

Figure 3. Hydrogen concentration contour plots at various downstream injections

This above figure shows hydrogen concentration contour plots at various downstream injections. The plots are colored by hydrogen concentration with blue being a void and red being very high concentrations. This data is from a k-epsilon simulation for radial injection with no swirl and a straight quarl module.

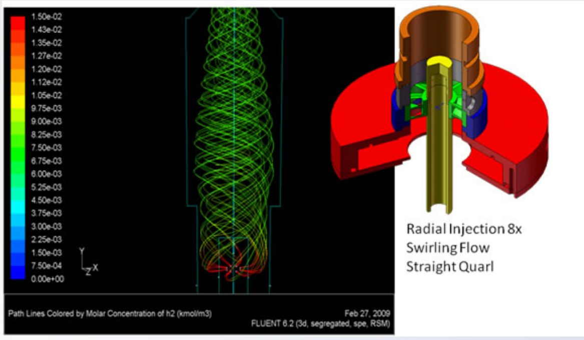

Figure 4. A path line originated from fuel injection port configures a radial injection with swirl.

This figure shows a path line which originated from the fuel injection port for a configuration of radial injection with swirl. The path line is the flow path a particle follows throughout the domain. These lines are not the path hydrogen due to mixing that occurs. These path lines are also colored by hydrogen content with red being pure hydrogen down to blue for no hydrogen.

These initial results at this point are simply predictions by the simulation, but can be validated or contradicted by the experimental studies that will follow. They show characteristics of the flow and when compared to experimental data can provide insight into the effectiveness or lack of effectiveness of the simulation and model.

PERSONNEL

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