Particulate Emissions

OVERVIEW

The Rich-burn/Quick-mix/Lean-burn (RQL) combustor is a fuel-mixing concept being considered for advanced gas turbine engines in the High Speed Civilian Transport (HSCT) program. The next generation supersonic aircraft for the HSCT program are designed to fly in the stratosphere, where nitric oxide (NO) emissions from the engines will potentially destroy the ozone layer. By burning at fuel-rich and fuel-lean conditions, the combustion temperatures will remain at relatively low levels such that NO production is reduced. Optimizing the transitional mixing section where air jets are added to the fuel-rich reaction becomes important in the design of the RQL combustor because rapid and thorough mixing is required to ensure that high temperature packets of combusting fuel conducive to NO production are not generated.

GOALS

The aim of this program is to obtain an understanding of the mixing processes in the quick-mix section of the Rich-burn/Quick-mix/Lean-burn (RQL) combustor by achieving the following:

- **Optimize mixing under non-reacting conditions by varying the orifice number and geometry for certain flow conditions.**
- **Validate non-reacting optimization principles under reacting conditions.**

RESULTS

In the reacting experiments (see Figure 1), temperature as well as species concentrations such as CO, CO2, O2, and unburned hydrocarbons have been directly measured. The species concentrations are used to derive fuel-air equivalence ratio fields, which show the extent of mixing in the system. Figure 2 shows an example of temperature and fuel-air equivalence ratio profiles obtained for a 10 round hole configuration, under experimental conditions of a jet-to-mainstream momentum-flux ratio J of 57, a jet-to-mainstream mass flow rate ratio of 2.5, and a starting fuel-rich equivalence ratio of 1.7. The entrance of the jets, represented by the blue bands, indicates relatively cooler fluid in the temperature plot on the left, and pure air fluid in the equivalence ratio plot on the right. Mixing and reaction processes cause the jet fluid to dissipate and disappear

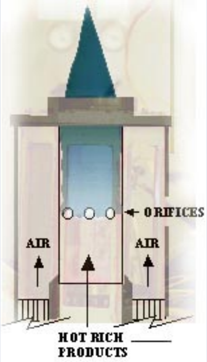

Figure 1: Jet Mixing and reaction with a hot rich crossflow.

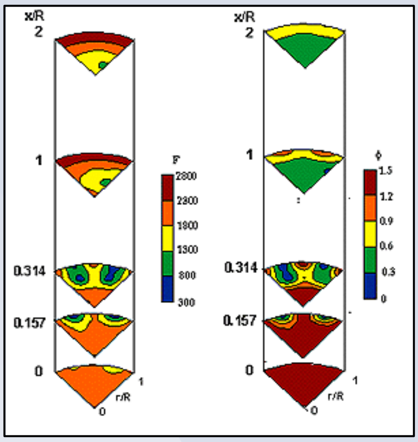

Figure 2: Temperature and equivalence ratio profiles for the 10-hole module.

To determine the optimal orifice configuration, a spatial unmixedness parameter (US) based on the mixture fraction value is calculated at planes downstream of the orifice region. As the US value tends to zero, complete mixing is achieved. Figure 3 shows the US values that were obtained for various round hole configurations obtained in the reacting experiment. The 14-orifice case yields the best mixing within two-duct radii of the entrance of the jets.

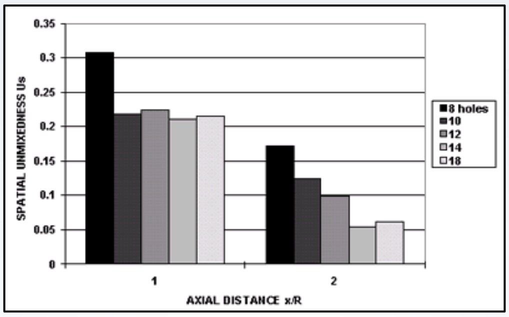

Figure 3: Spatial unmixedness values calculated at planes downstream of the orifices.

RECENT PUBLICATIONS

OPTIMIZATION OF JET MIXING INTO A RICH, REACTING CROSSFLOW (2000). AIAA Journal of Propulsion and Power, Vol. 16, No. 5, pp. 729-735. (M.Y. Leong, G. S. Samuelsen, and J. D. Holdeman).

OPTIMIZATION OF ORIFICE GEOMETRY FOR CROSS-FLOW MIXING IN A CYLINDRICAL DUCT (2000). AIAA Journal of Propulsion and Power. Vol. 16, No. 6, pp. 929-938. (J.T. Kroll, W.A. Sowa, G.S. Samuelsen, and J.D. Holdeman)

ASSESSING JET-INDUCED SPATIAL MIXING IN A RICH, REACTING CROSSFLOW (2003). AIAA Journal of Propulsion and Power, Vol. 19, No. 1, pp. 14-21 (T.N. Demayo, M.Y. Leong, G.S. Samuelsen, and J.D. Holdeman).

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