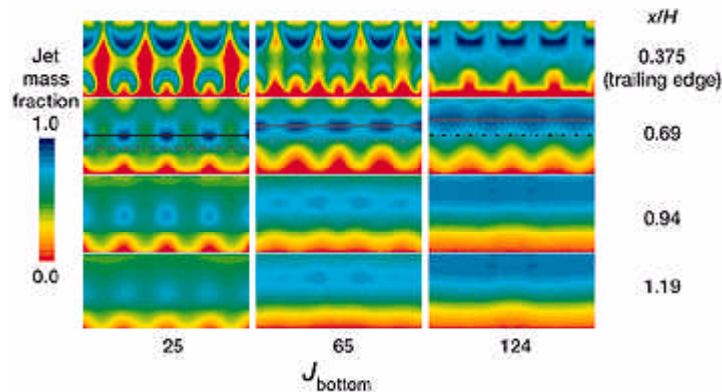


Mixing of Multiple Jets With a Confined Subsonic Crossflow

Results from a recently completed enhanced mixing program are summarized in the two technical papers in references 1 and 2. These studies were parts of a High Speed Research (HSR)-supported joint Government/industry/university program that involved, in addition to the NASA Lewis Research Center, researchers at United Technologies Research Center, Allison Engine Company, CFD Research Corporation, and the University of California, Irvine. The studies investigated the mixing of jets injected normal to a confined subsonic mainstream in both rectangular and cylindrical ducts. Experimental and computational studies were performed in both nonreacting and reacting flows. The orifice geometries and flow conditions were selected as typical of the complex three-dimensional flows in the combustion chambers in low-emission gas turbine engines.

The principal conclusion from both the experiments and modeling was that the momentum-flux ratio J and orifice spacing S/H were the most significant flow and geometry variables, respectively. Conserved scalar distributions were similar-independent of reaction, orifice diameter H/d , and shape-when the orifice spacing and the square root of the momentum-flux ratio were inversely proportional. Jet penetration was critical, and penetration decreased as either momentum-flux ratio or orifice spacing decreased. We found that planar averages must be considered in context with the distributions.

The mass-flow ratios and the orifices investigated were often very large. The jet-to-mainstream mass-flow ratio was varied from significantly less than 1 to greater than 1. The orifice-area to mainstream-cross-sectional-area was varied from ~ 0 to 0.5, and the axial planes of interest were often just downstream of the orifice trailing edge. Three-dimensional flow was a key part of efficient mixing and was observed for all configurations. As an example of the results, the accompanying figure shows the effects of different rates of mass addition on the opposite walls of a rectangular duct.



Effect of nonsymmetric mass addition. $J_{\text{top}} = 25$; $H/d_{\text{top}} = 2.67$; $H/d_{\text{bottom}} = 4.0$; $S/H = 0.5$.

References

1. Holdeman, J.D., et al.: Mixing of Multiple Jets With a Confined Subsonic Crossflow: Part I-Cylindrical Duct. J. Eng. Gas Turbines Power (ASME Paper 96-GT-482 and NASA TM-107185), vol. 119, Oct. 1997.
2. Holdeman, J.D.: Liscinsky, D.S.; and Bain, D.B.: Mixing of Multiple Jets With a Confined Crossflow: Part II-Opposed Rows of Orifices in Rectangular Ducts. ASME Paper 97-GT-439 (NASA TM-107461), 1997.

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