

DILUTION ZONE MIXING STUDIES

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Motivated by considerations of dilution zone mixing in gas turbine combustion chambers, NASA sponsored, in 1972 - 1975 contract and grant studies of the mixing characteristics of a row of jets injected normally into a duct flow of a different temperature (references 1, 2, & 3). Based on the favorable response to these studies, and the areas for further work which they identified, NASA Lewis is currently conducting a balanced program of contract, grant, and in-house research on various aspects of the 'jet in a confined crossflow' problem. Included in these are: 1) development of interactive computer codes for analysis of dilution jet mixing, and 2) extension of the experiments on jets in a confined crossflow.

From the data of References 1 & 2, an empirical model was developed (refs. 4 & 5) to describe the observed temperature distributions. The current interactive code provides a 3-D pictorial representation of the temperature, as given by these correlations, for any user-specified downstream location, flow, and orifice parameters. Although calculations can be performed for (almost) any flow and geometric conditions of interest, they are, of course, most reliable for conditions within the range of the experiments. These codes will be improved and extended, and options added, as new data become available.

The experiments in References 1 to 3 dealt primarily with a single row of jets mixing into an isothermal flow in a constant cross-section duct. Variations in the mixing were observed as a function of jet-to-mainstream momentum ratio, orifice size, and spacing. The current experiments examine perturbations of this problem characteristic to gas turbine combustion chambers, namely: flow area convergence, non-isothermal mainstream flow, and opposed in-line and staggered injection.

Papers discussing grant studies on free-stream turbulence effects and reverse flow geometries, and in-house analytical calculations of jets in crossflow will be presented at the Combustion Fundamentals Research Conference.

REFERENCES

1. Walker, R.E. and Kors, D.L.: Multiple Jet Study Final Report. NASA CR-121217, 1973.
2. Holdeman, J.D., Walker, R.E., and Kors, D.L.: Mixing of Multiple Dilution Jets with a Hot Primary Airstream for Gas Turbine Combustors. AIAA Paper 73-1249, 1973.
3. Kamotani, Y. and Greber, Isaac: Experiments on Confined Turbulent Jets in Cross Flow. NASA CR-2392, 1974.
4. Walker, R.E. and Eberhard, R.G.: Multiple Jet Study Data Correlations. NASA CR-134796, 1975.
5. Holdeman, J.D. and Walker, R.E.: Mixing of a Row of Jets with a Confined Crossflow. AIAA Journal, vol.15, no.2, Feb.1977, pp243-249.

DILUTION ZONE MIXING STUDIES

OBJECTIVE - TO CHARACTERIZE DILUTION
ZONE MIXING IN SUFFICIENT
DETAIL TO:

- * IDENTIFY AND UNDERSTAND THE
DOMINANT PHYSICAL MECHANISMS
GOVERNING THE MIXING PROCESS
- * REFINE AND EXTEND EMPIRICAL
MODELS TO PROVIDE A NEAR-TERM
COMBUSTOR DESIGN TOOL
- * PROVIDE A DATA BASE FOR
VERIFICATION OF ANALYTICAL
MODELS

DILUTION ZONE MIXING STUDIES

- * EXPERIMENTS ON EFFECTS OF FREE-STREAM TURBULENCE ON A JET IN CROSSFLOW (GRANT)
- * EXPERIMENTS ON DILUTION JETS IN REVERSE FLOW COMBUSTOR GEOMETRIES (GRANT)
- * DEVELOPMENT OF INTERACTIVE CODES FOR EVALUATION OF DESIGN ALTERNATIVES (HOST: IN-HOUSE)
- * EXPERIMENTS ON JETS IN A CONFINED CROSSFLOW (HOST: CONTRACT)
- * ANALYTICAL CALCULATIONS OF JETS IN CROSSFLOW (IN-HOUSE)

DILUTION ZONE DESIGN COMPUTER PROGRAMS

OBJECTIVE: DEVELOPMENT OF INTERACTIVE COMPUTER CODE FOR ANALYSIS OF MIXING OF JETS WITH A CONFINED CROSSFLOW

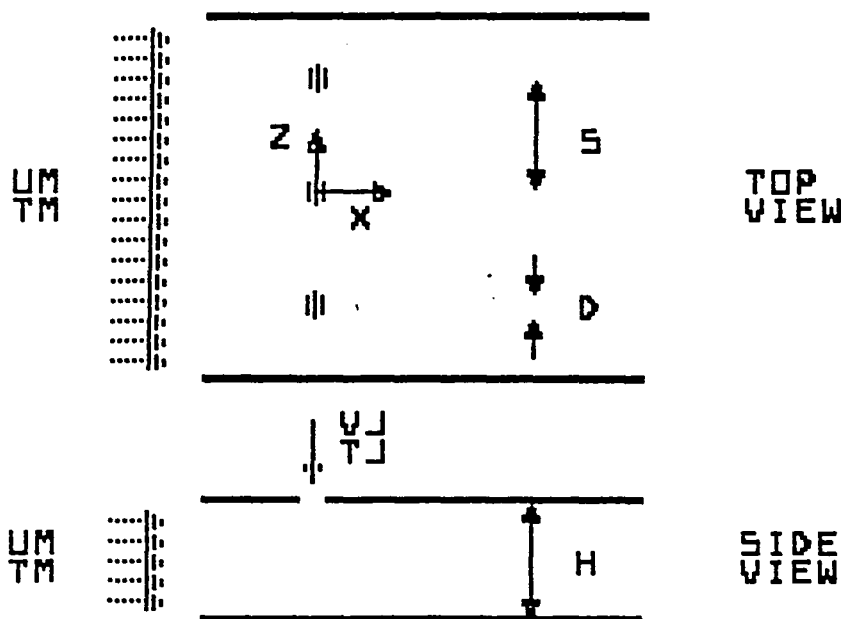
FEATURES: PROVIDES A 3-D PICTORIAL REPRESENTATION OF THE TEMPERATURE FIELD

PURPOSE: EVALUATE EFFECTS OF VARYING FLOW AND GEOMETRY

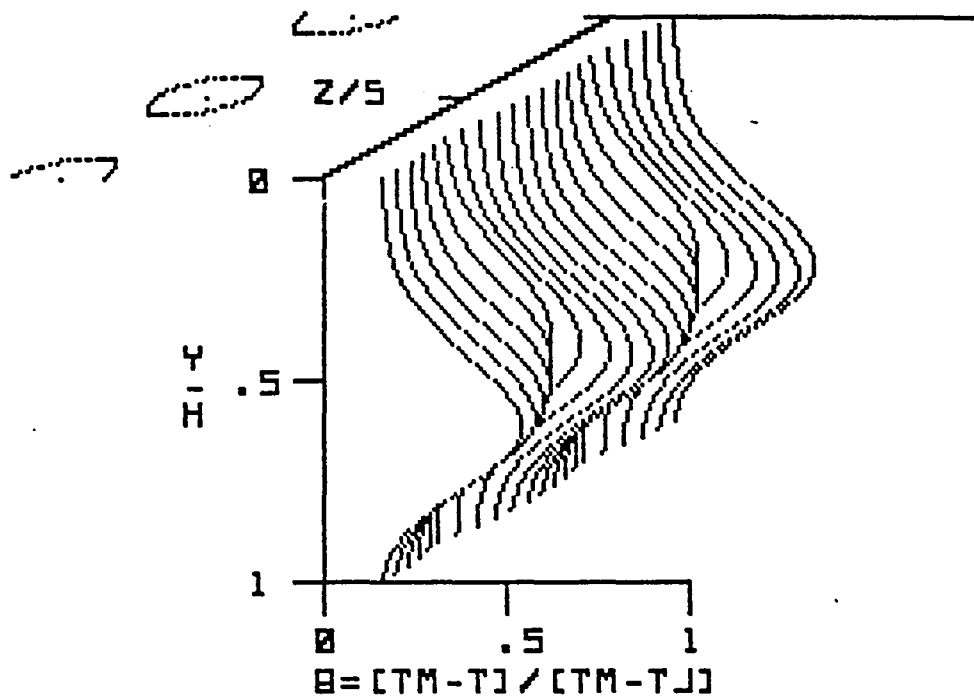
GUIDE DESIGN TO REDUCE DEVELOPMENT TIME AND COST

STATUS: CODES WILL BE IMPROVED AND OPTIONS ADDED AS NEW DATA BECOME AVAILABLE

FLOW SCHEMATIC



Jet in a Confined Crossflow

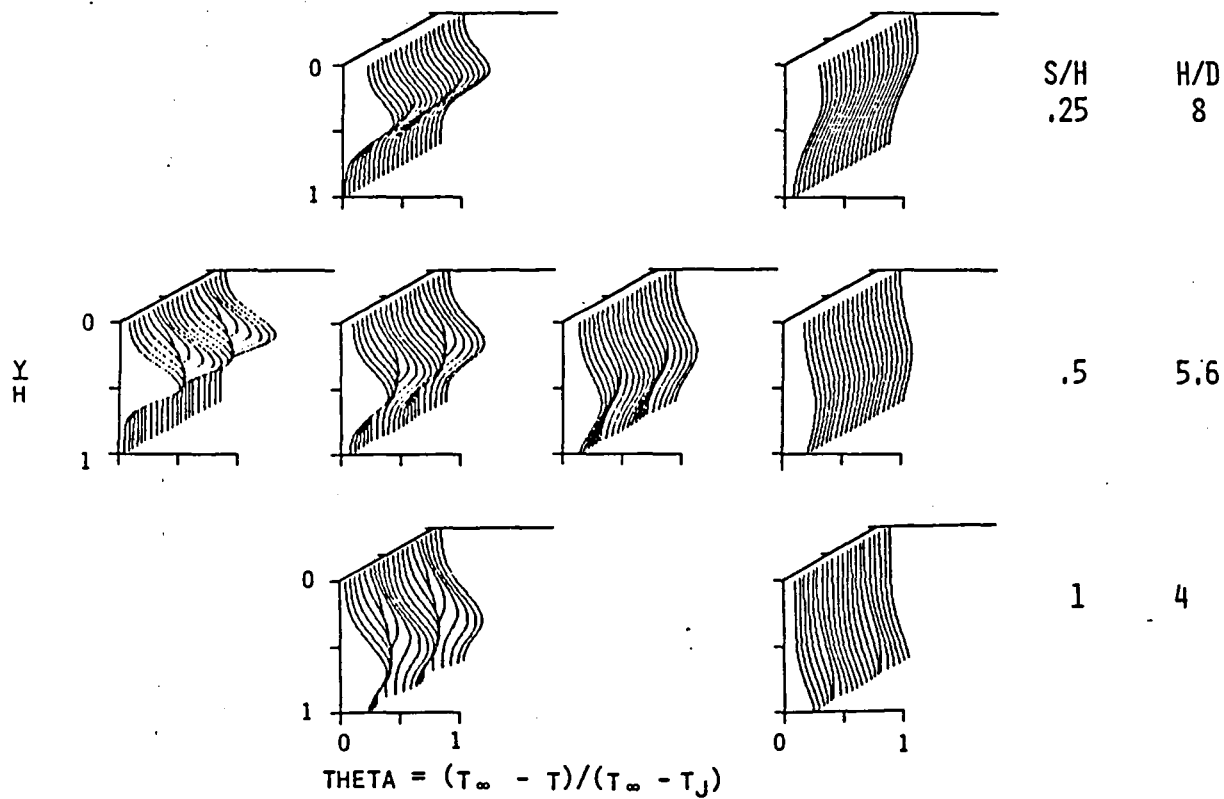


$S/D=2$ $H/D=4$ $J=32$ $DR=2$ $CD=.64$
 $X/H=.5$ $MR=.5$ $TB=.33$ $PF=.34$

Typical Temperature Profile Distribution in Y - Z Plane

$$M_J/M_\infty = .25 \quad (J = 32; (s/D)(H/D) = 16)$$

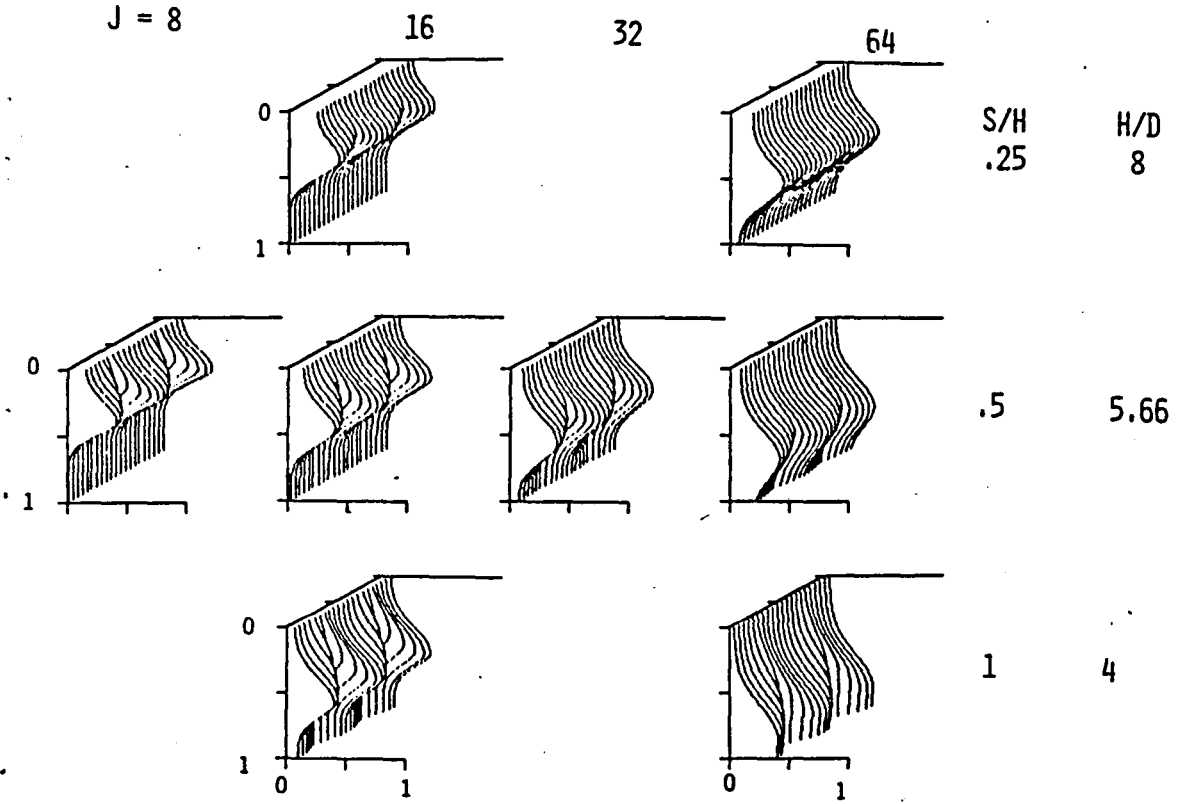
$$X/H = .25 \quad .5 \quad 1 \quad 2$$



Variation in Temperature Distributions with Downstream Distance

$X/H = .5; (S/D)(H/D) = 16$

$J = 8$



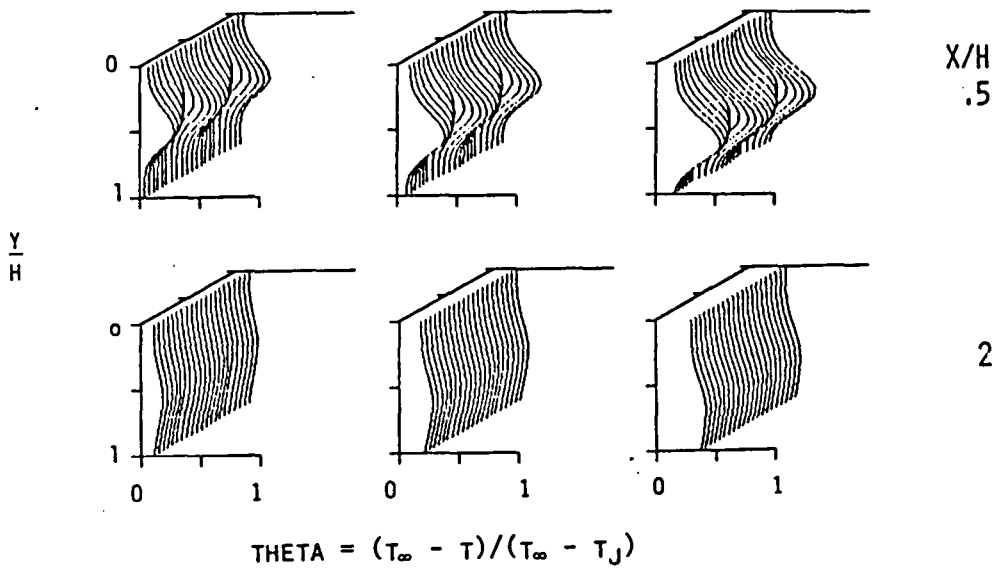
$$\text{THETA} = (T_{\infty} - T)/(T_{\infty} - T_J)$$

Varations in Temperature Distributions with Momentum Ratio

$H/D = 8$
 $\dot{M}_J/\dot{M}_\infty = .125$

5.66
.25

4
.5



Variation in Temperature Distributions with Orifice Size
at Constant Spacing to Height Ratio ($S/H = .5$; $J = 32$)