

DILUTION JET EXPERIMENTS IN COMPACT COMBUSTOR CONFIGURATIONS

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This project concerns the effects of cooling jets on the velocity and temperature fields in a compact reverse flow combustor. The work is motivated by the need to limit the temperatures of post-combustion gases in jet engines to values within the endurance capabilities of turbine blades. The application requires not only that the temperature be kept sufficiently low but also that a suitably tailored temperature profile be provided at the combustor exit, with higher temperatures generally permissible at the blade tip than at the blade root because of higher centrifugal loads at the root.

Flows in reverse flow combustors accelerate both longitudinally because of area changes and transversely because of flow turning. The current project started with flow visualization experiments in water, using aqueous solutions of zinc bromide to model the relatively higher density of cooling jets. These flow visualization experiments were conducted in simple two dimensional configurations designed to examine separately the effects of longitudinal and transverse acceleration. The next phase of the work consisted of temperature measurements in a model reverse flow combustor, using a rake of thermocouples which could be moved both longitudinally and transversely to provide transverse temperature profiles at a number of longitudinal stations. Single jets, and rows of cooling jets of different spacing, were injected at several locations with varying flow rates and temperatures, to produce a useful range of momentum ratios and density ratios. In addition, a semi-empirical calculational model was developed to predict the behavior of a single cooling jet in the reverse flow combustor configuration.

Results to date show that single jet temperature trajectories are swept toward the inner wall of the turn, whether injection is from the inner or outer wall. A widely spaced row of jets produces a trajectory similar to that of

a single jet. As spacing is reduced, jet penetration is also reduced, and the cooling jets tend to remain close to the wall from which they are injected. The results to date suggest that suitable cooling and temperature distribution tailoring can be accomplished without injecting cooling jets upstream of the turn, and thus it appears that combustors can be made significantly smaller than current designs.

The current phase of this work is directed at the acquisition of velocity measurements as well as temperature measurements in the combustor. To this end, a combined pitot-static tube and thermocouple probe has been constructed and tested, and a rake of such tubes has been designed and is being constructed. In order to keep new temperature measurements to a minimum, testing will be carried out in such a way as to attempt to reproduce earlier temperature conditions.

An attempt to develop a semi-empirical calculational model for a row of jets, similar to that for a single jet, was limited by the absence of fundamental mixing information for rows of jets. Consequently, experiments were performed to obtain entrainment rates for rows of jets; the results are currently being analyzed. Using these results, an attempt will be made to complete the calculational model.

Throughout this work we have been fortunate to have the support and advice of Steve Riddlebaugh of the NASA Lewis Research Center, and we are pleased here to thank him.

PUBLICATIONS

Lipshitz, A. and Greber, I., "Turbulent Jet Patterns in Accelerating Flows," AIAA Paper 81-0348, 1982.

Lipshitz, A., "Dilution Jets in Accelerated Cross Flows," CWRU, 1981.

Riddlebaugh, S., Lipshitz, A. and Greber, I., "Dilution Jet Behavior in the Turn Section of a Reverse Flow Combustor," AIAA Paper 82-0192, 1982.

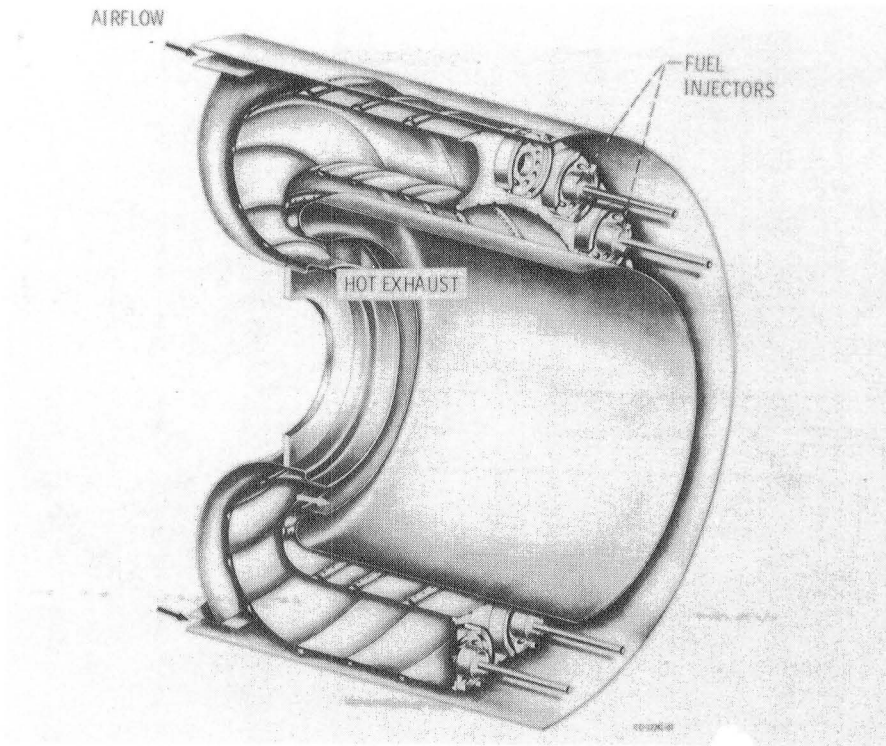
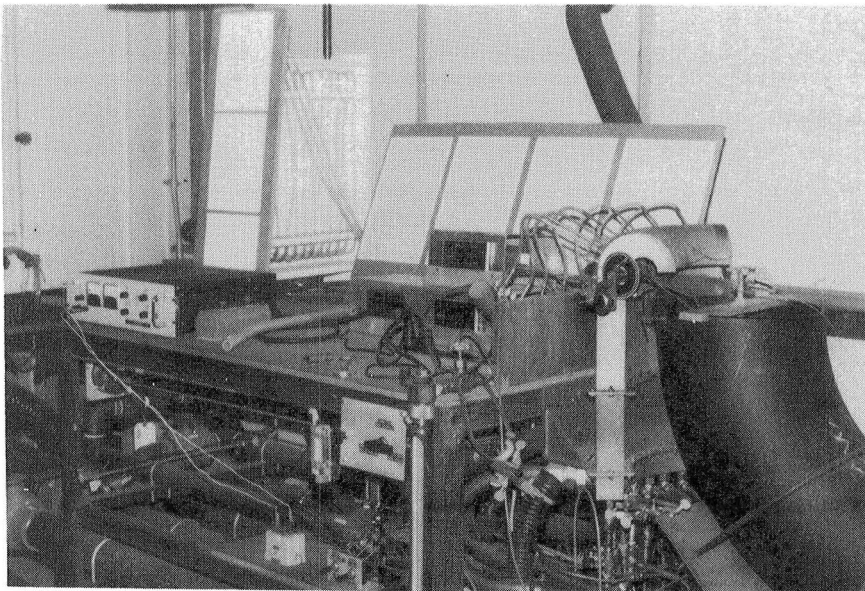


Figure 1. - Reverse flow combustor.



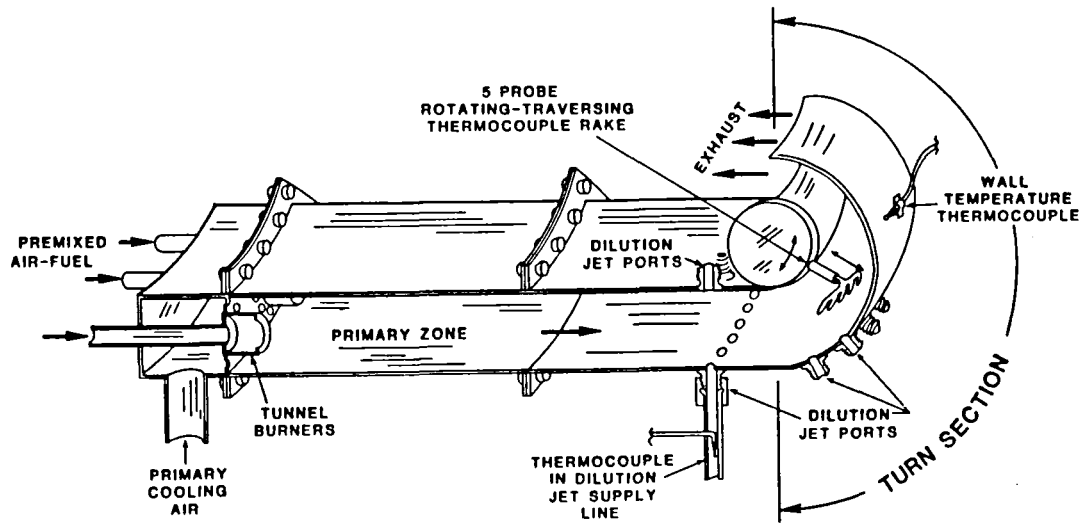


Figure 3. - Cutaway sketch of test combustor.

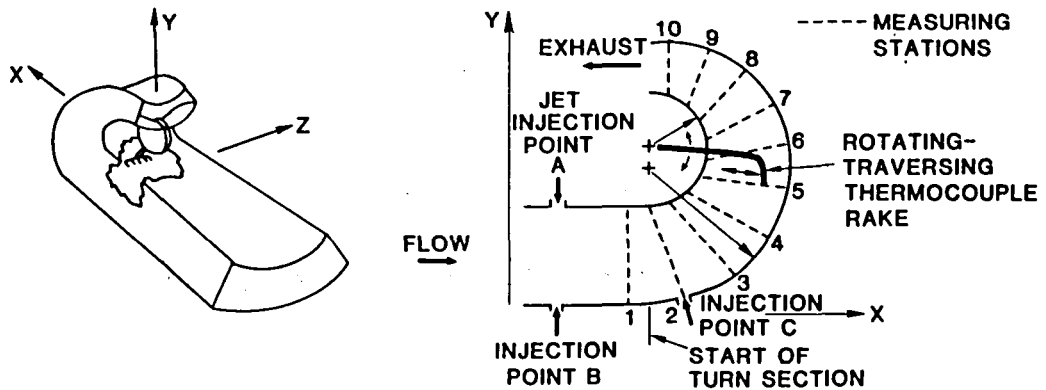


Figure 4. - Combustor turn section geometry and temperature measuring stations.

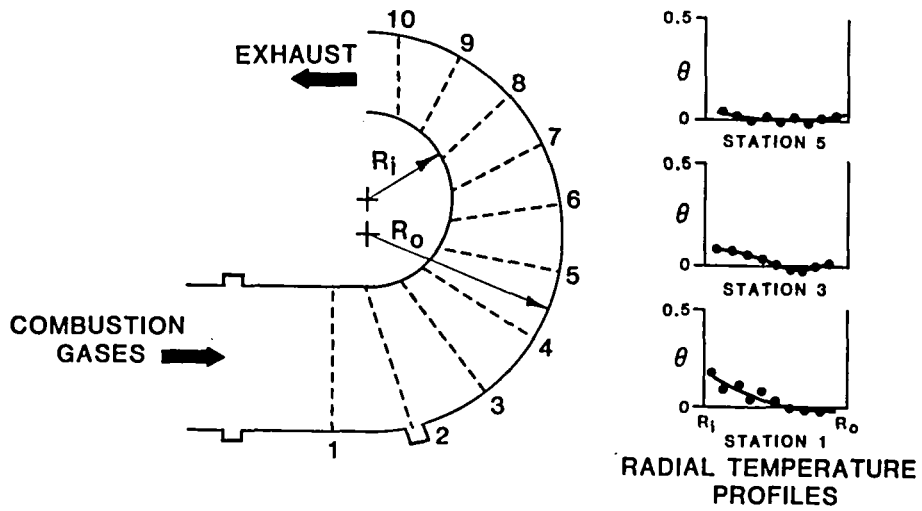


Figure 5 - Temperature distribution in the combustor turn without dilution jets.

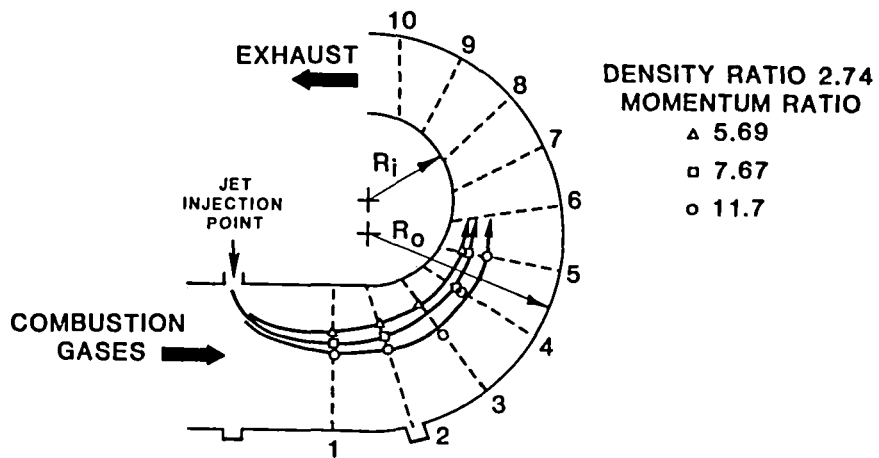


Figure 6. - Jet trajectories showing effect of momentum ratio on a jet injected from the inner wall.

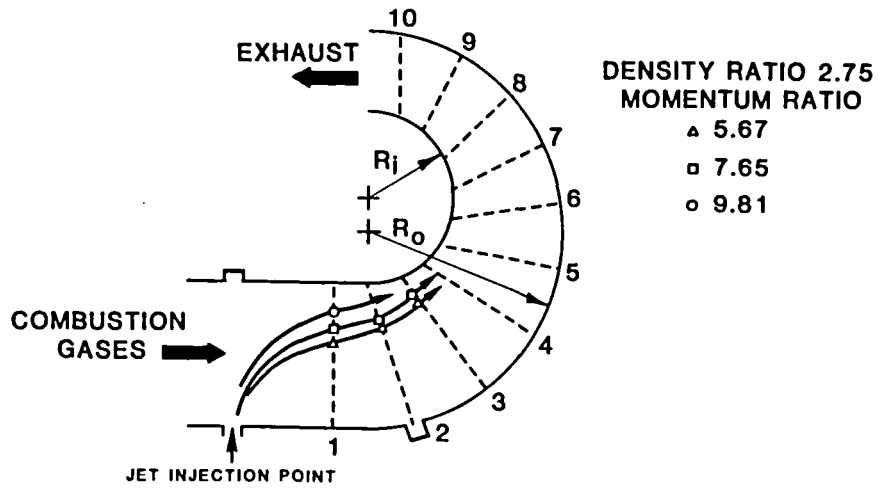


Figure 7. - Jet trajectories showing effect of momentum ratio on jet injected from the outer wall.

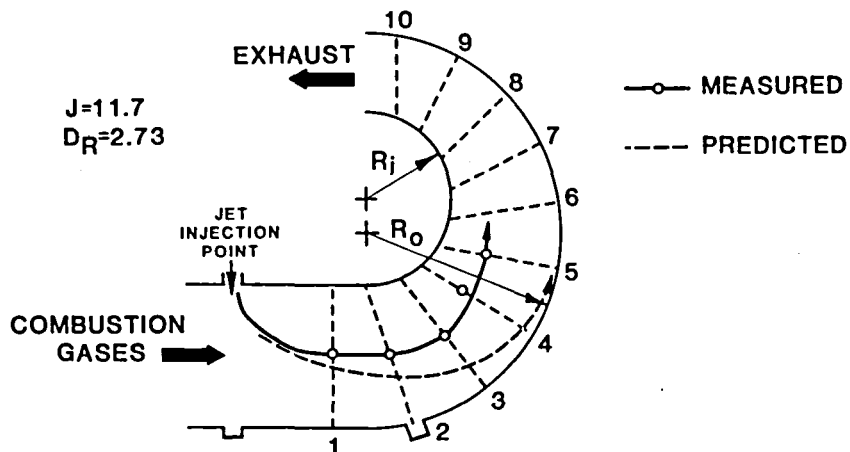


Figure 8. - Comparison with model for a single jet injected from the inner wall.

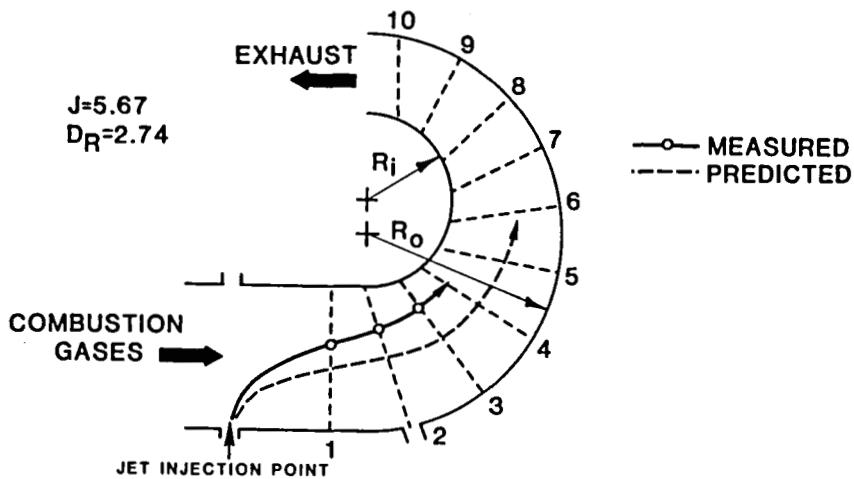


Figure 9. - Comparison with model for a single jet injected from the outer wall.

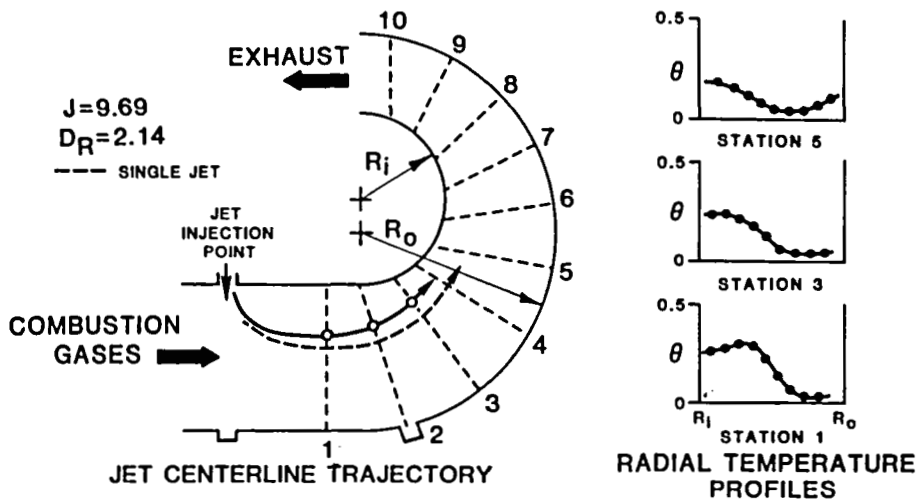


Figure 10. - Behavior of a widely spaced row of jets (spacing ratio of 7.41) injected from the inside wall.

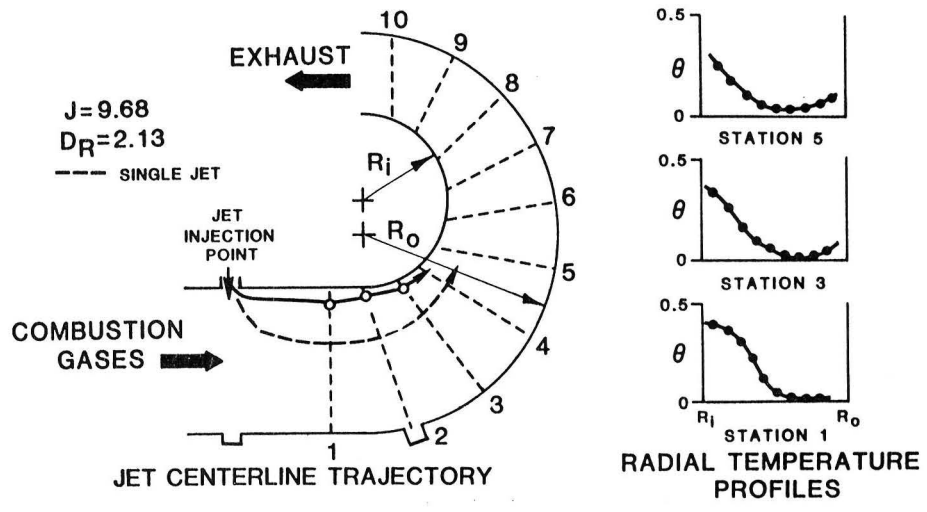


Figure 11. - Behavior of a closely spaced row of jets (spacing ratio 2.47) injected from the inside wall.

