Design of A Variable Area Diffuser For A 15-inch Mach 6 Open-Jet Tunnel

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The Langley 15-inch Mach 6 High Temperature Tunnel was recently converted from a Mach 10 Hypersonic Flow Apparatus. This conversion was effected to improve the capability of testing in Mach 6 air at relatively high reservoir temperatures not previously possible at Langley. Elevated temperatures allow the matching of the Mach numbers, Reynolds numbers, and ratio of wall-to-adiabatic-wall temperatures (T_W/T_{aw}) between this and the Langley 20-inch Mach 6 CF_4 Tunnel. This ratio is also matched for Langley's 31-inch Mach 10 Tunnel and is an important parameter useful in the simulation of slender bodies such as National Aerospace Plane (NASP) configurations currently being studied.

Having established the nozzle's operating characteristics, the decision was made to install another test section to provide model injection capability. This test section is an open-jet type, with an injection system capable of injecting a model from retracted position to nozzle centerline between 0.5 and 2 seconds.

Preliminary calibrations with the new test section resulted in Tunnel blockage. This blockage phenomenon was eliminated when the conical center body in the diffuser was replaced. The issue then, is to provide a new and more efficient variable area diffuser configuration with the capability to withstand testing of larger models without sending the Tunnel into an unstart condition.

Use of the 1-dimensional steady flow equation with due regard to friction and heat transfer was employed to estimate the required area ratios (exit area/ throat area) in a variable area diffuser. Correlations between diffuser exit Mach number and area ratios, relative to the stagnation pressure ratios and diffuser inlet Mach number were derived. From these correlations, one can set upper and lower operating pressures and temperatures for a given diffuser throat area. In addition, they will provide appropriate input conditions for the full 3-dimensional computational fluid dynamics (CFD) code for further simulation studies.