Exit boundary layer data for three rectangular nozzles at high subsonic Mach numbers

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Rectangular Nozzles (R2, R4 and R8)

The exit boundary layer data at high Mach numbers reported herein are addendums to NASA/TM—2012-217410 (“Flow-Field Surveys For Rectangular Nozzles”) **that presented hot-wire flow field data at low Mach number incompressible conditions for the same three nozzles.**

BL Pitot Probe

Flattened tip ~ 0.018” wide
Opening ~ 0.005” wide

R8
(NA8Z)

R4
(NA4Z)

R2
(NA2Z)

Velocity calculated from total pressure (p_0) assuming $p_{static} = p_{ambient}$

Data taken April 4, 7 and 13, 2022

Boundary layer profile data acquisition and analysis

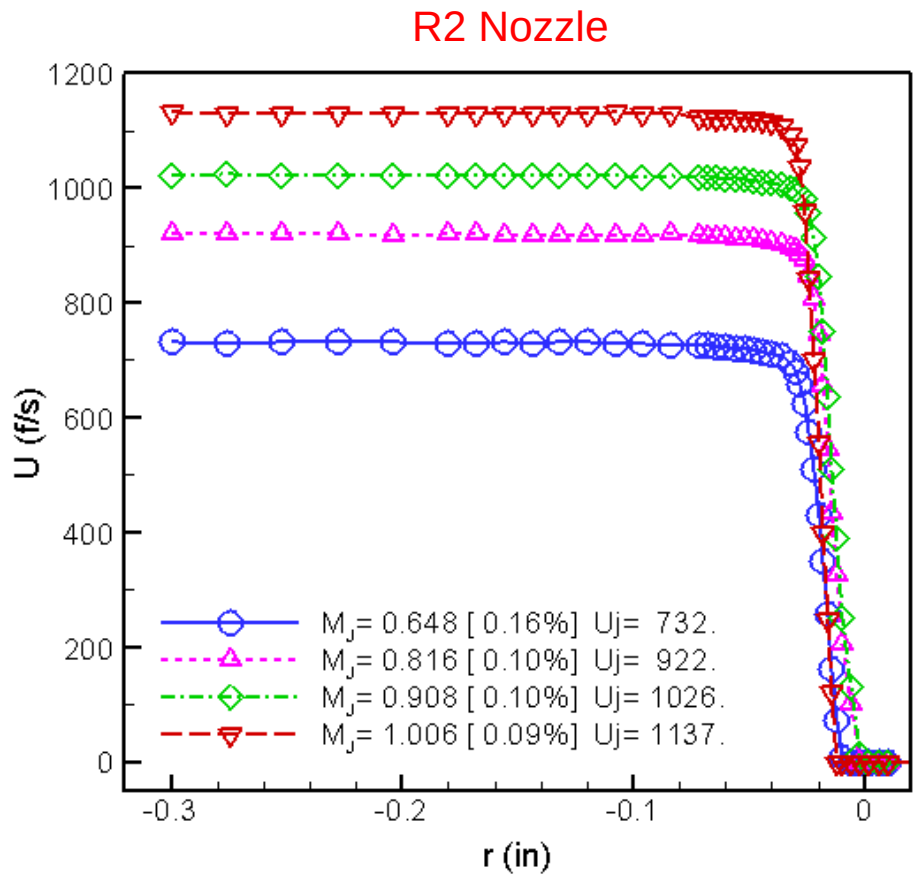
All profiles are measured, at 0.040” downstream of nozzle lip, with a stepping schedule having progressively smaller steps as the wall is approached. Because of radial entrainment flow just outside the jet, the Pitot probe senses negative pressures; there the axial velocities are called out as zeroes.

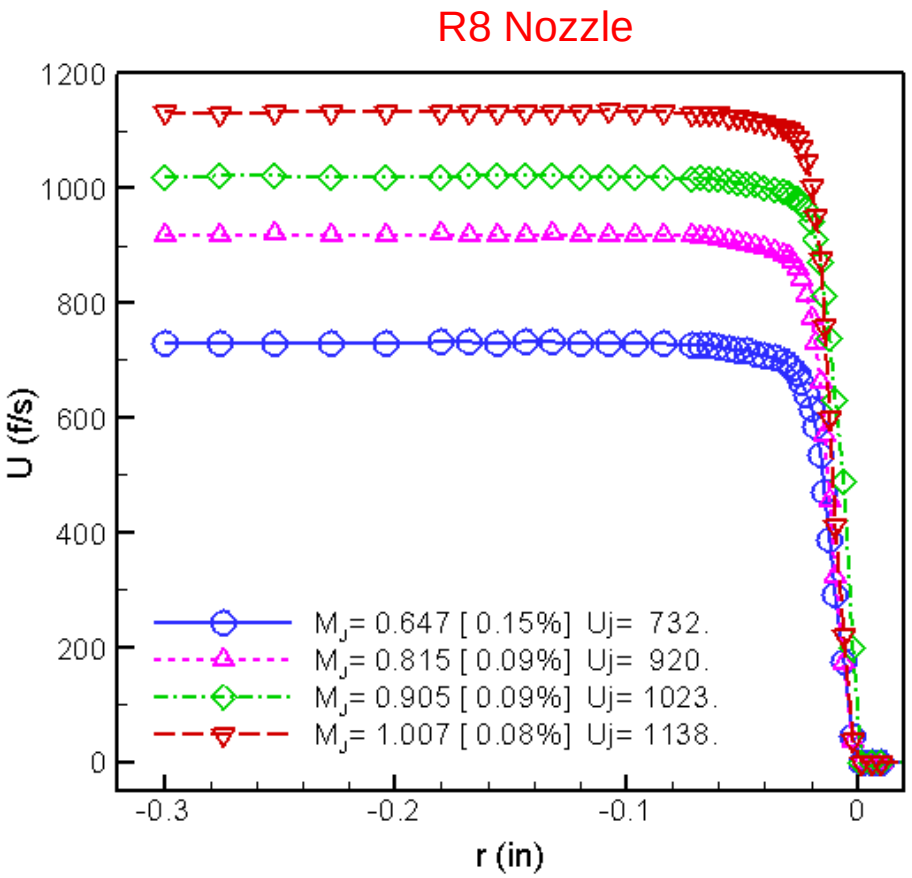
Smallest step used is 0.002” whereas the probe opening is approximately 0.005” wide. Thus, there is spatial averaging in the sharpest gradient region. However, boundary layer thickness is often 0.06” or more and thus spatial resolution should be adequate and the integral values, θ (momentum thickness), H_{12} (shape factor) and δ_ω (vorticity thickness) should be well represented. Because of the sharp gradients δ_ω has more uncertainty; relatively θ has better repeatability.

Wall location (y_w) is calculated based on 40% and 20% velocity locations. Momentum and displacement thicknesses are calculated between y_w and 98% velocity point. δ_ω is calculated based on average slope between 70% and 30% velocity points.

BL Profiles (dimensional) for R2 and R8 nozzles different M_J

At middle of long edge

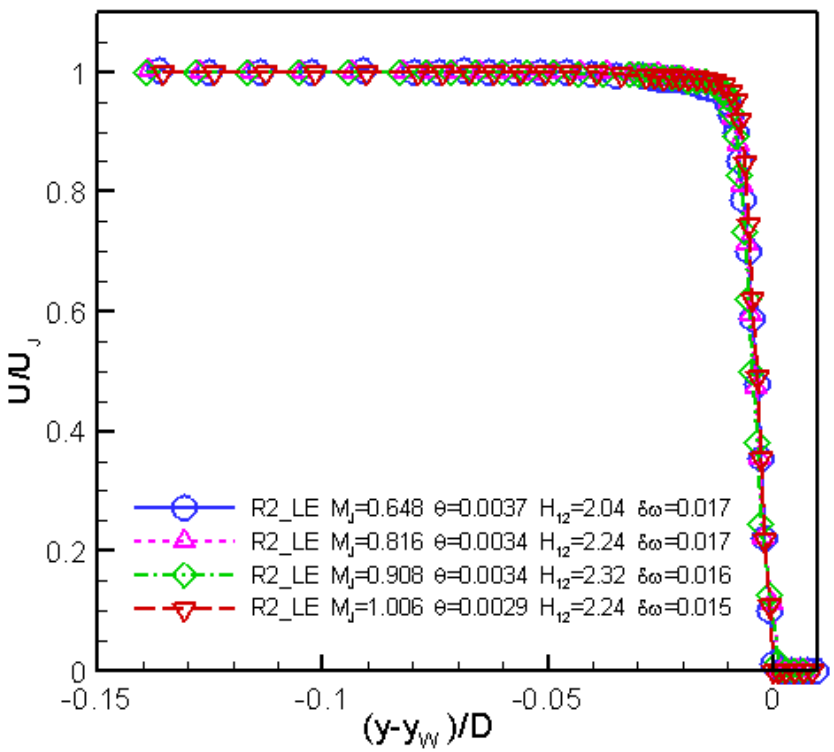




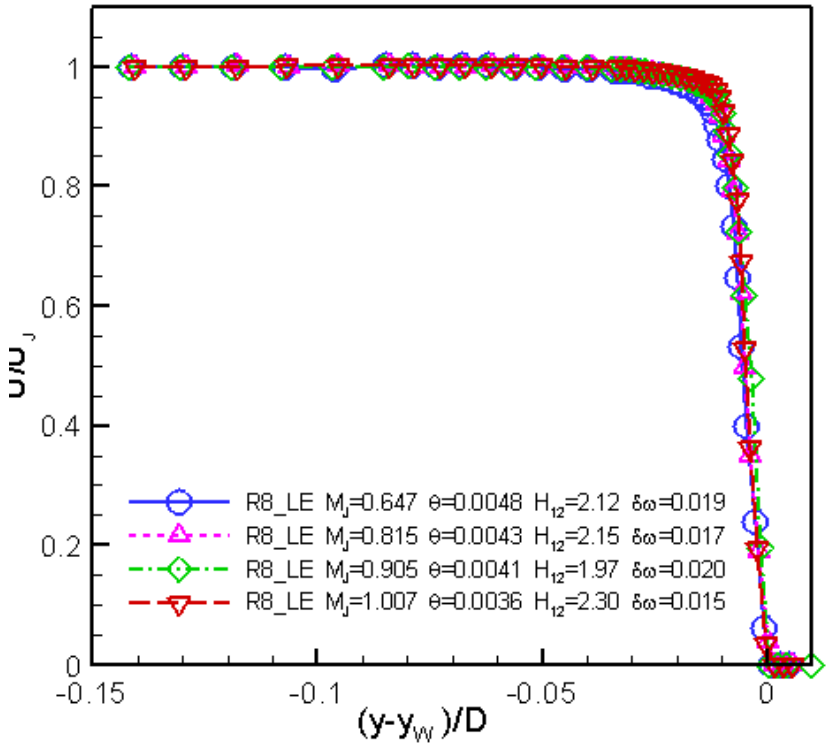
BL Profiles for R2 and R8 nozzles different M_J

At middle of long edge 

R2 Nozzle

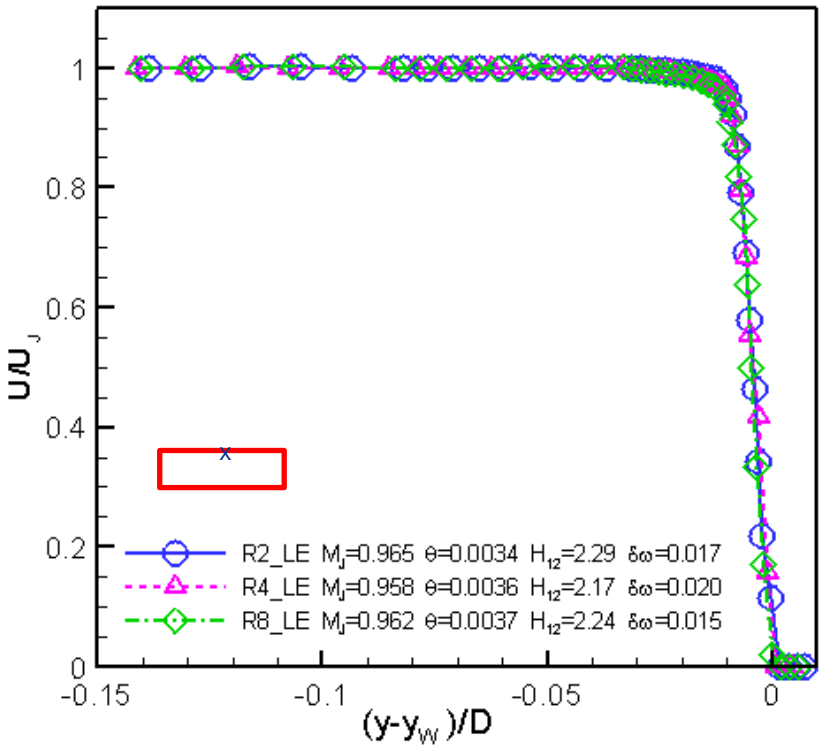


R8 Nozzle

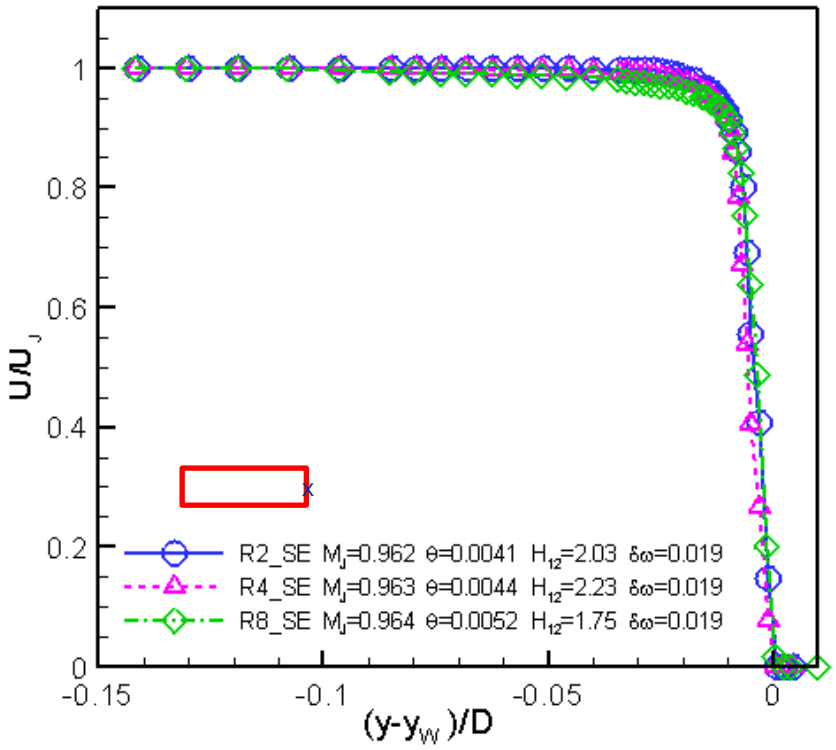


BL Profiles for R2 R4 and R8 nozzles M_J=0.96

Long Edge



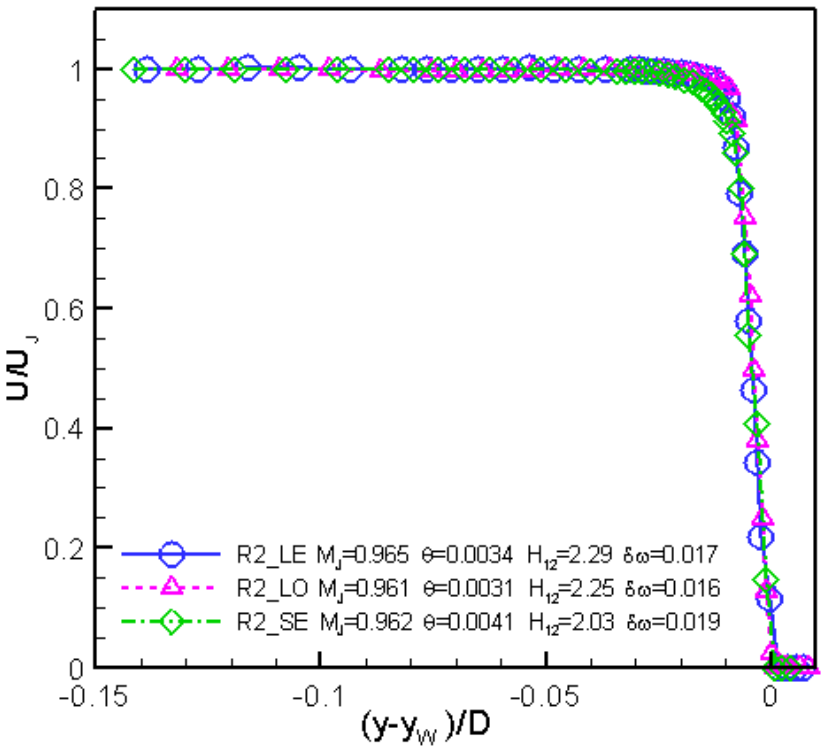
Short Edge



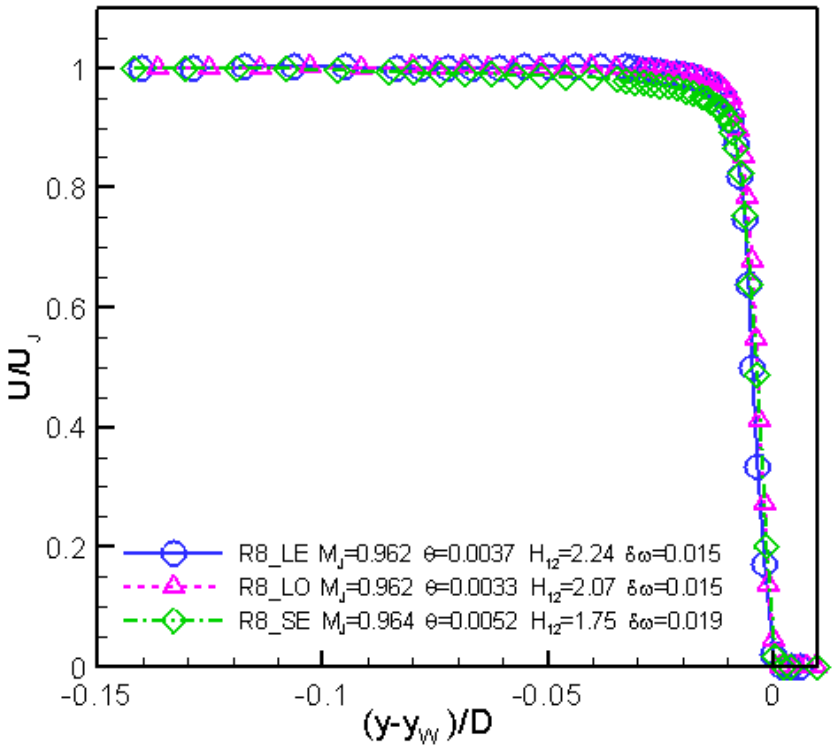
BL at three locations of each nozzle, M_J=0.96

LE: LO: SE:

R2 Nozzle



R8 Nozzle



Inferences

The BL thickness is larger on the short edge relative to that on the long edge.

The thicknesses are progressively (but slightly) larger for the higher aspect ratio nozzles probably because of the longer lengths.

All profiles are nominally laminar.