Parametric Generation and Computational Analysis of a REST Inlet

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Considering practical applications of a scramjet module, the inlet of a scramjet is usually required to form a rectangular-like entrance and an elliptical throat for the combination with an elliptical combustor. As a result, this paper focus on the design of inward turning inlets with rectangular-to--elliptical shape transition (REST).

Parameterization is the foundation of further optimizations. A REST inlet is generated firstly using parametric methodologies. Figure 1 presents the parametric generation of a basic field through which a REST inlet will be traced. Each compression wall is represented with a 3 order quasi--uniform B-spline curve (QUBS) [2] which has 4 control points.

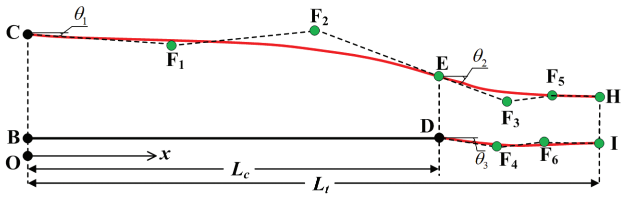

Figure 1. Parameterization of an axisymmetric basic flow field geometry.

With a basic flow field, a REST inlet is able to be generated according to steps demonstrated in Ref. [2]. Figure 2 shows the inviscid REST inlet, and design conditions are Ma = 6.0, p = 2549.2 Pa, T = 221.6 K. Inviscid computations were made firstly to confirm performances at the design point. Figure 3 shows the inviscid Mach contours of the REST inlet, the left one is the Mach contours at some selected cross sections, and the right one is at the symmetric plane.

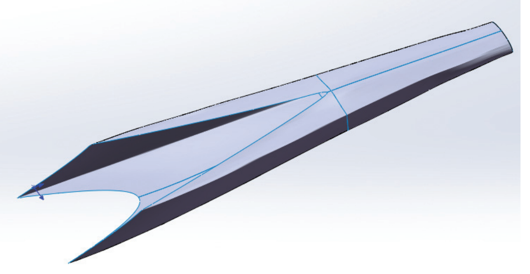

Figure 2. View of the Mach 6.0 REST inlet.

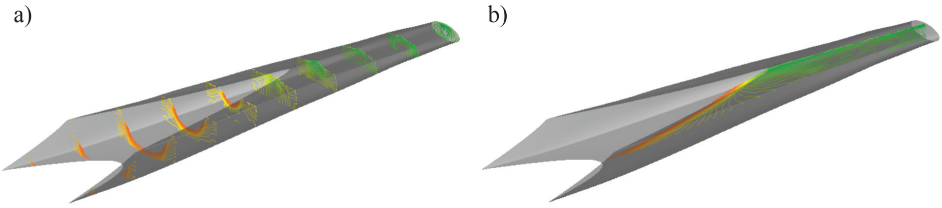

Figure 3. Inviscid Mach contours for the REST inlet.
a) some selected cross sections, b) symmetric plane

As presented in Figure 3, the leading shock incidents at the cowl point on the symmetric plane, and the conical shock fits perfectly with the inlet leading edge. It implies that the inviscid REST inlet has a full mass capture at the design point. Before making a viscous correction for the REST inlet, viscous computations were made for different incoming Mach numbers, and results were presente in Figure 4. At Mach 6.0, the REST inlet does not capture the full mass any more, its mass capture corfficient falls down to 97.2%, which is due to the boundary layer. As llustrated in Figure 4, the viscous REST inlet has more spill when Mach number decreases.

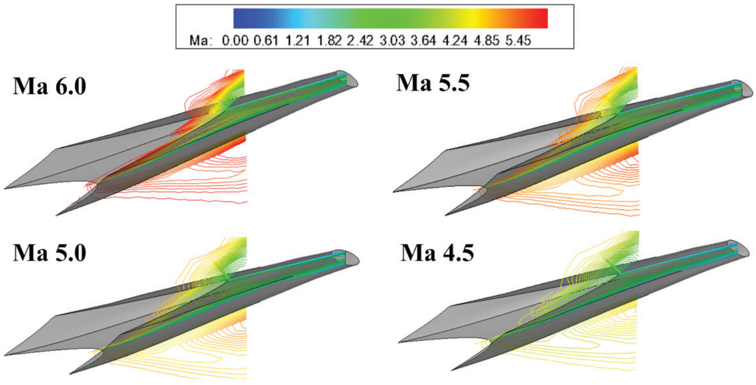

Figure 4. Flow fields of the viscous REST inlet under different Mach number conditions.

In order to obtain an actual inlet that contains a similar core region to the inviscid inlet shape. The next stage of the design procedure is the viscous correction of the inviscid inlet shape.

References

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2. Smart M.K.: *Design of Three-Dimensional Hypersonic Inlets with Rectangular-to-Elliptical Shape Transition*. Journal of Propulsion and Power, 1999, 15(3), 408–416.