Chapter 6

Vortex Injection Hybrid Rockets

Joseph Majdalani*

University of Tennessee Space Institute, Tullahoma, Tennessee 37388

Nomenclature

\[ A_i = \text{inlet area of incoming swirl flow} \]
\[ a = \text{chamber radius} \]
\[ b = \text{chamber discharge radius}, \beta a \]
\[ L = \text{chamber aspect ratio, } L_0/a \]
\[ \rho = \text{normalized pressure, } \bar{p}/(\rho U^2) \]
\[ Q_i = \text{normalized flow rate, } \sigma^{-1} = \bar{Q}_i/(Ua^2) = A_i/a^2 \]
\[ \bar{Q}_i = \text{inlet volumetric flow rate at the base} \]
\[ \bar{Q}_m = \text{total incoming flow rate, } \bar{Q}_i + \bar{Q}_w \]
\[ \bar{Q}_w = \text{wall-injected flow rate, } 2\pi aL \bar{u}_w \]
\[ Re = \text{injection Reynolds number, } Ua/\nu \]
\[ Re_w = \text{sidewall injection Reynolds number, } U_w a/\nu \]
\[ r = \text{normalized radial coordinate, } \bar{r}/a \]
\[ S = \text{unidirectional swirl number, } \pi ab/A_i = \pi \beta \sigma \]
\[ U = \text{tangential injection velocity, } \bar{u}_\theta(a, \bar{z}) \]
\[ U_w = \text{sidewall injection velocity, } -\bar{u}_r(a, \bar{z}) = \bar{Q}_w/(2\pi aL) \]
\[ \bar{u} = \text{normalized velocity, } (\bar{u}_r, \bar{u}_z, \bar{u}_\theta)/U \]
\[ z = \text{normalized axial coordinate, } \bar{z}/a \]
\[ \beta = \text{normalized discharge radius, } b/a \]
\[ \delta = \text{reciprocal of the Reynolds number, } \nu/(Ua) \]
\[ \varepsilon = \text{sidewall injection parameter, } U_w/U \]
\[ \eta = \text{action variable, } \pi r^2 \]
\[ \kappa = \text{tangential inflow parameter, } (2\pi \sigma L)^{-1} \]

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*Jack D. Whitfield Professor of High Speed Flows, Department of Mechanical, Aerospace and Biomedical Engineering, maji@utsi.edu. Member AIAA.