HYPERSONIC FLOW EQUATIONS OVERVIEW

Limiting Hypersonic Shock

$\theta \equiv$ Turning Angle

$\beta \equiv$ Shock Angle

$$\beta = \frac{\gamma+1}{2}\theta$$

$$\frac{P_2}{P_1} = \frac{2\gamma M_1^2 \sin^2\beta}{\gamma+1}$$

$$\frac{\rho_2}{\rho_1} = \frac{(\gamma+1)}{(\gamma-1)}$$

$$\frac{T_2}{T_1} = \frac{2\gamma(\gamma-1)M_1^2 \sin^2\beta}{(\gamma+1)^2}$$

$$\frac{u_2}{V_1} = 1 - \frac{2\sin^2\beta}{\gamma+1}$$

$$\frac{v_2}{V_1} = \frac{\sin 2\beta}{\gamma+1}$$

Limiting Hypersonic Expansion

$\theta \equiv$ Turning Angle $\quad \theta = \frac{2}{\gamma-1}\left(\frac{1}{M_1} - \frac{1}{M_2}\right)$ $\qquad \frac{P_2}{P_1} = \left(1 - \frac{\gamma-1}{2}M_1\theta\right)^{\frac{2\gamma}{\gamma-1}}$

$$C_p = \frac{2\theta^2}{\gamma(M_1\theta)^2}\left[\left(1 - \frac{\gamma-1}{2}M_1\theta\right)^{\frac{2\gamma}{\gamma-1}} - 1\right]$$

Newtonian Flow Theory:

$$C_p = 2\sin^2\theta$$

Flat Plate: $\quad c_l = 2\sin^2(\alpha)\cos(\alpha) \quad c_d = 2\sin^3\alpha$

Modified Newtonian Flow Theory:

$$C_p = C_{p\max}\sin^2\theta \qquad C_{p\max} = \frac{2}{\gamma M_\infty^2}\left(\frac{P_{0_2}}{P_\infty} - 1\right)$$

$$\frac{P_{0_2}}{P_\infty} = \left[\frac{(\gamma+1)^2 M_\infty^2}{4\gamma M_\infty^2 - 2(\gamma-1)}\right]^{\frac{\gamma}{\gamma-1}}\left[\frac{1-\gamma+2\gamma M_\infty^2}{\gamma+1}\right]$$