Midterm 1

Wednesday, September 25, 2024 3:09 PM

Inlet Nozzle Equations

$$\frac{A_0}{A_{cr}} = \frac{1}{M_0}\left[\frac{2}{\gamma+1}\left(1+\frac{\gamma-1}{2}M_0^2\right)\right]^{\frac{\gamma+1}{2(\gamma-1)}}$$

$$T_{01} = T_1 + \frac{u^2}{2C_p}$$

$$\frac{P_{01}}{P_{0a}} = \eta_I$$

Outlet Nozzle Equations

$$P_{04,cr} = \frac{P_{04}}{P_a}$$

$$\pi_{cr} = \left[1 - \frac{1}{\eta_j}\left(\frac{\gamma-1}{\gamma+1}\right)\right]^{\frac{-\gamma}{\gamma-1}}$$

$$C_8 = [2C_p(T_{02} - T_8)]^{1/2}$$

$$If\ P_{04,cr} > \pi_{cr} \rightarrow Choked$$

$$T_5 = \frac{2T_{04}}{\gamma+1}$$

$$P_5 = \frac{P_{04}}{\pi_{cr}}$$

$$\rho_5 = \frac{P_5}{R_5}$$

$$a_5 = \sqrt{\gamma R T_5}$$

Combustion Chamber

$$f = \frac{h_{02} - h_{03}}{h_{03} - \xi_{comb} LHV}$$

$$f_{real} = \frac{f_{ideal}}{n_{comb}}$$

Turbofan Equations

$$B = \frac{m_c}{m_h}$$

$$m_c = \frac{mB}{B+1}, m_h = \frac{m}{B+1}$$

Engine Parameters

$$TSFC = \frac{\dot{m}_f}{T}$$

$$u_{e_{eq}} = u_e\left[1 + \frac{1}{\gamma M_e^2}(1 - p_a/p_e)\right]$$

$$T = \dot{m}(v_e - v_a) + A_b(P_b - P_a)$$

Compressor Equations

$$\frac{P_{02}}{P_{01}} = \pi_c$$

$$\frac{T_{02,s}}{T_{01}} = \left(\frac{P_{02}}{P_{01}}\right)^{\frac{\gamma-1}{\gamma}}$$

$$\eta_c = \frac{T_{02,s} - T_{01}}{T_{02} - T_{01}}$$

$$W_c = C_{p_a}(T_{02} - T_{01})$$

Turbine Equations

$$\eta_m \dot{m}_g W_T = \dot{m}_a W_c$$

$$W_T = C_{p_g}(T_{03} - T_{04})$$

$$\eta_T = \frac{T_{03} - T_{04}}{T_{03} - T_{04,s}}$$

$$\frac{P_4}{P_3} = \left(\frac{T_{04,s}}{T_{03}}\right)^{\frac{\gamma}{\gamma-1}}$$

Polytrophic Equations

$$\frac{T_{02}}{T_{01}} = \left(\frac{P_{02}}{P_{01}}\right)^{\frac{n-1}{n}}$$

$$\frac{n-1}{n} = \frac{1}{\eta_{\infty c}}\left(\frac{\gamma-1}{\gamma}\right)$$

$$\frac{n-1}{n} = \eta_{\infty T}\left(\frac{\gamma-1}{\gamma}\right)$$

Isentropic Equations

$$\frac{T_0}{T} = \left(1 + \frac{\gamma-1}{2}M^2\right)^{-1}$$

$$\frac{p_0}{p} = \left(\frac{T_0}{T}\right)^{\frac{\gamma}{\gamma-1}}$$

$$\frac{\rho_0}{\rho} = \left(\frac{T_0}{T}\right)^{\frac{1}{\gamma-1}}$$

Velocity Triangles

$$A_1 = \pi(r_t^2 - r_h^2)$$

$$\rho_1 = \frac{P_{01}}{RT_{01}}$$

$$v_a = \frac{\dot{m}}{\rho_1 A_1}$$

$$T_1 = T_{01} - \frac{v_a^2}{2C_p}$$

$$P_1 = P_{01}\left(\frac{T_1}{T_{01}}\right)^{\frac{\gamma}{\gamma-1}}$$

$$\rho_1 = \frac{P_1}{RT_1}$$

$$U_t = \frac{2\pi N r_t}{60}$$

$$\beta_{1t} = \tan^{-1}\left(\frac{U_t}{v_a}\right)$$

$$U_h = \frac{2\pi N r_h}{60}$$

$$\beta_{1h} = \tan^{-1}\left(\frac{U_h}{v_a}\right)$$

$$a_1 = \sqrt{\gamma R T_1}$$

$$W_t = \sqrt{U_t^2 + V_a^2}$$

$$M_t = \frac{W_t}{a_1}$$

$$W_h = \sqrt{U_h^2 + V_a^2}$$

$$M_h = \frac{W_h}{a_1}$$

$$\phi = \frac{V_a}{U}$$

$$W = \frac{P}{\dot{m}} = U_1 V_{1_u} - U_{1.5} V_{1.5_u}$$

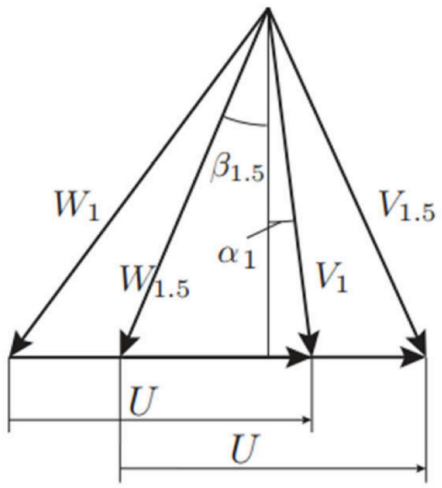
$$R' = \frac{h_{1.5} - h_1}{h_2 - h_1} \rightarrow \frac{p_{1.5} - p_1}{p_2 - p_1}$$

$$h_{1.5} - h_1 = \frac{W_1^2 + W_{1.5}^2}{2}$$

$$h_2 - h_1 = U(V_{1_u} - U_{1.5} V_{1.5_u})$$

$$R' = \frac{1}{2} - \frac{V_a}{2U}(\tan\alpha_1 + \tan\beta_{1.5})$$

$$\psi = \frac{2(V_a \tan\alpha_1 + V_a \tan\alpha_{1.5})}{U}$$


W_1
$\beta_{1.5}$
$V_{1.5}$
α_1
$W_{1.5}$
V_1
U
U