

EQUATIONS

Conservation of Energy

$$\Delta E = Q - W \quad \frac{dE}{dt} = \dot{Q} - \dot{W} \quad (1)$$

$$\frac{dE_{C.V.}}{dt} = \dot{Q}_{C.V.} - \dot{W}_{C.V.} + \sum_i \dot{m}_i \left(h_i + \frac{V_i^2}{2} + gz_i \right) - \sum_e \dot{m}_e \left(h_e + \frac{V_e^2}{2} + gz_e \right) \quad (2)$$

Entropy Balance

$$\Delta S = \int_1^2 \left(\frac{\delta Q}{T} \right)_b + \sigma \quad \Delta S = \sum_j \frac{Q_j}{T_j} + \sigma \quad \frac{dS}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \dot{\sigma} \quad (3)$$

$$\frac{dS_{C.V.}}{dt} = \sum_j \frac{\dot{Q}_j}{T_j} + \sum_i \dot{m}_i s_i - \sum_e \dot{m}_e s_e + \dot{\sigma}_{C.V.} \quad (4)$$

$$v = (1-x)v_f + xv_g \quad \bar{R} = 8.314 \text{ kJ/kmol} \cdot \text{K} \quad (5)$$

$$c_p = \left(\frac{\partial h}{\partial T} \right)_p \quad c_v = \left(\frac{\partial u}{\partial T} \right)_v \quad (6)$$

$$\eta = \frac{W_{cycle}}{Q_H} = 1 - \frac{Q_C}{Q_H} \quad \eta_{max} = 1 - \frac{T_C}{T_H} \quad \beta = \frac{Q_C}{Q_H - Q_C} \quad \gamma = \frac{Q_H}{Q_H - Q_C} \quad (7)$$

$$Tds = du + pdv \quad Tds = dh - vdp \quad (8)$$

$$\eta_t = \frac{\dot{W}/\dot{m}}{(\dot{W}/\dot{m})_s} \quad \eta_c = \frac{(\dot{W}/\dot{m})_s}{\dot{W}/\dot{m}} \quad \eta_{nozzle} = \frac{V^2/2}{(V^2/2)_s} \quad \eta_{regen} = \frac{h_x - h_2}{h_4 - h_2} \quad (9)$$

Isentropic Relations, Ideal Gas

$$\frac{p_2}{p_1} = \frac{p_{r2}}{p_{r1}} \quad \frac{v_2}{v_1} = \frac{v_{r2}}{v_{r1}} \quad (10)$$

Isentropic Relations, Ideal Gas, Constant Specific Heats

$$\frac{T_2}{T_1} = \left(\frac{p_2}{p_1} \right)^{\frac{k-1}{k}} \quad \frac{T_2}{T_1} = \left(\frac{v_1}{v_2} \right)^{k-1} \quad (11)$$

Ideal Gas

$$c_p = \frac{kR}{k-1} \quad c_v = \frac{R}{k-1} \quad \Delta \bar{s} = \bar{s}^\circ(T_2) - \bar{s}^\circ(T_1) - \bar{R} \ln \frac{p_2}{p_1} \quad (12)$$

$$\Delta \bar{s} = \bar{c}_p \ln \frac{T_2}{T_1} - \bar{R} \ln \frac{p_2}{p_1} \quad (\text{only for constant specific heats}) \quad (13)$$

Chapter 11

$$\mu_J = \left(\frac{\partial T}{\partial p} \right)_h \quad c_p = \frac{1}{\mu_J} \left[T \left(\frac{\partial v}{\partial T} \right)_p - v \right] \quad (14)$$

Chapter 12

$$\omega = \frac{m_v}{m_a} = 0.622 \frac{p_v}{p - p_v} \quad \phi = \frac{p_v}{p} \quad p_i = y_i p \quad (15)$$