BASIC EQUATIONS FOR ME 200

Mass Conservation, 1st Law and 2nd Law Relations

$$\left.\frac{dm}{dt}\right|_{system} = \sum_{in} \dot{m}_{in} - \sum_{out} \dot{m}_{out}$$

$$\left.\frac{dE}{dt}\right|_{system} = \sum_{in} \dot{m}_{in}\,(h + ke + pe)_{in} - \sum_{out} \dot{m}_{out}\,(h + ke + pe)_{out} + \dot{Q} - \dot{W}$$

$$\left.\frac{dS}{dt}\right|_{system} = \sum_{in} \dot{m}_{in}\, s_{in} - \sum_{out} \dot{m}_{out}\, s_{out} + \sum_{j} \frac{\dot{Q}_j}{T_{j,boundary}} + \dot{\sigma}_{generation}$$

Work and Heat Transfer Relations

$$W_{boundary} = \int p\, dV \qquad W_{electrical} = \int \varepsilon\, i\, dt \qquad W_{spring} = \int k_{spring}\, x\, dx \qquad W_{rot} = \int \tau\, d\theta$$

$$w_{int,rev,flow} = -\int_1^2 v\, dp + (V_1^2 - V_2^2)/2 + g(z_1 - z_2) \qquad q_{int,rev} = \int T\, ds$$

PROPERTY RELATIONS FOR ME 200

General Relations

$$h = u + pv \qquad c_v = \left(\frac{\partial u}{\partial T}\right)_v \qquad c_p = \left(\frac{\partial h}{\partial T}\right)_p \qquad E = m(u + ke + pe), ke = V^2/2\,, pe = gZ$$

$$Tds = du + pdv \qquad Tds = dh - vdp \qquad z_{mixture} = x\, z_g + (1 - x)z_f, z = property$$

Models

$$pV = mRT \qquad R = \frac{\bar{R}}{M} \qquad R = c_p - c_v \qquad k = \frac{c_p}{c_v}$$

$$du = c_v dT \quad dh = c_P dT \qquad ds = c_v \frac{dT}{T} + R\frac{dv}{v} \qquad ds = c_p \frac{dT}{T} - R\frac{dp}{p} \qquad s_2 - s_1 = s_2^o - s_1^o - R\ln\left(\frac{p_2}{p_1}\right)$$

$$\left(\frac{p_2}{p_1}\right)_s = \left(\frac{p_{r2}}{p_{r1}}\right)_s \qquad \left(\frac{v_2}{v_1}\right)_s = \left(\frac{v_{r2}}{v_{r1}}\right)_s \qquad \left(\frac{T_2}{T_1}\right)_s = \left(\frac{p_2}{p_1}\right)_s^{\frac{k-1}{k}} \qquad \left(\frac{T_2}{T_1}\right)_s = \left(\frac{v_1}{v_2}\right)_s^{k-1}$$

$$du = cdT \qquad dh = cdT + vdP \qquad ds = c\frac{dT}{T} \qquad h_{comp\,liq}(p, T) = h_f(T) + v_f(T)[p - p_{sat}(T)]$$

EFFICIENCY AND CYCLE RELATIONS FOR ME 200

$$\eta_{turbine} = \frac{w_{act}}{w_s} \qquad \eta_{compressor} = \eta_{pump} = \frac{w_s}{w_{act}} \qquad \eta_{HX} = \frac{(h_{H,in} - h_{H,out})}{(h_{H,in} - h_{C,in})} \qquad \eta_{nozzle} = \frac{V_{2,act}^2}{V_{2,s}^2}$$

$$\eta_{th} = \left|\frac{W_{net}}{Q_H}\right| \qquad COP_R = \left|\frac{Q_C}{W_{net}}\right| \qquad COP_{HP} = \left|\frac{Q_H}{W_{net}}\right| \qquad mep = \frac{w_{net}}{v_{max} - v_{min}} \qquad bwr = \frac{|w_c|}{w_t}$$

$$\eta_{th,rev} = 1 - \frac{T_C}{T_H} \qquad COP_{R,rev} = \frac{T_C}{T_H - T_C} \qquad COP_{HP,rev} = \frac{T_H}{T_H - T_C} \qquad \left(\frac{T_C}{T_H}\right)_{rev} = \left(\frac{Q_C}{Q_H}\right)_{rev}$$

UNIT CONVERSION RELATIONS

Density	1 g/cm^3 = 10^3 kg/m^3
Length	10^2 cm = 1 m
Velocity	1 km/h = 0.621 mile/h
Volume	10^6 cm^3 = 1 m^3 1 L = 10^{-3} m^3
Force	1 N = 1 kg-m/s^2
Pressure	1 Pa = 1 N/m^2 1 bar = 10^5 N/m^2
Energy	1 J = 1 N-m

Energy Transfer Rate	1 W = 1 J/s 1 kW = 1.34 hp
Specific Heat	1 kJ/(kg-K) = 0.239 kcal/(kg-K)
Universal Gas Constant	$\bar{R}$=8.314 kJ/(kmol-K)
Standard Gravity Acceleration	g=9.81 m/s^2
Standard Atmospheric Pressure	1 atm = 1.01 bar
Temperature Relations	T (°R) = 1.8 T (K) T (°C) = T (K) – 273.15 T (°F) = T (°R) – 459.67