Final Notes Thermo 1 Revised Back

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$R = R_u / MM$

Quality x

$v = v_f + x \cdot v_{fg}$

$u = u_f + x \cdot u_{fg}$

$h = h_f + x \cdot h_{fg}$

$x = \frac{m_g}{m_f + m_g}$

$s = s_f + x\, s_{fg}$

Isobar

$W = P \Delta V$

$Q = \Delta H$

Isotherm

$W_b = RT \ln\left(\frac{V_f}{V_i}\right)$ Ideal

$\Delta S = \frac{1}{T_0} \Delta Q$

Polytropic

$W_b = \frac{P_2 V_2 - P_1 V_1}{1-n}$

Specific Heats

$C_v = \frac{du}{dT}\Big|_v \quad C_p = \frac{\partial h}{\partial T}\Big|_P$

$\Delta U = U_2 - U_1 = \int C_v dT$

$\Delta h = h_2 - h_1 = \int C_p dT$

$C_v = C_p + R$

$k = C_v / C_p$ or liquids

solids $C_v = C_p = C$

$\Delta h = \Delta U + V \Delta P$

Isentropic

$\Delta S = S_2 - S_1 = \emptyset$

$Pv^k = \text{Const.}$

$TP^{\frac{1-k}{k}} = \text{Const.}$

$Tv^{k-1} = \text{Const.}$

Ideal ?

Solids/Liq's

$S = C_{avg} \ln\left|\frac{T_f}{T_i}\right|$

$T_2 = T_1$ for isentropic

Reservoirs

$S = \frac{Q}{T}$

Ideal Gas

$Pv = RT$

$S_2 - S_1 = \int \frac{C_p}{T} dT - R \ln\left|\frac{P_2}{P_1}\right|$

$S_2 - S_1 = C_{v\,avg} \ln\left|\frac{T_f}{T_i}\right| + R \ln\left|\frac{V_f}{V_i}\right|$

$S_2 - S_1 = S_2^\circ - S_1^\circ - R \ln\left|\frac{P_2}{P_1}\right|$

Flow Energy

$\theta = h + ke + pe$

Efficiency

$\eta_{therm} = \frac{W_{net\,out}}{Q_{in}} = \frac{Q_{in} - Q_{out}}{Q_{in}} = 1 - \frac{Q_{out}}{Q_{in}}$

$COP_{ref} = \frac{Q_L}{W_{in}} = \frac{Q_L}{Q_H - Q_L} \qquad \frac{T_L}{T_H - T_L}$

$COP_{HP} = \frac{Q_H}{W_{in}} = \frac{Q_H}{Q_H - Q_L} \qquad \frac{T_H}{T_H - T_L}$

$\eta_{carnot} = 1 - \frac{T_L}{T_H}$

Carnot

Steady flow work rev

$W = -\int P dv - \Delta ke - \Delta Pe$

Entropy

$dS = \frac{dQ}{T}\Big|_{\text{Int Rev}}$

$S_{gen} = \Delta S_{sys} + \Delta S_{surr}$

$T ds = du + P dv$

$T ds = dh - v dP$

$ds = \frac{dh}{T} - \frac{v dP}{T} = \frac{du}{T} + \frac{P dv}{T}$

$S_2^\circ - S_1^\circ = \int C_p(T) \frac{dT}{T}$

$S_{in} - S_{out} + S_{gen} = \Delta S_{sys}$

The reversible work inputs to a compressor compressing an ideal gas from T_1, P_1 to P_2 in an isentropic (Pv^k = constant), polytropic (Pv^n = constant), or isothermal (Pv = constant) manner, are determined by integration for each case with the following results:

Isentropic: $w_{comp,in} = \frac{kR(T_2 - T_1)}{k-1} = \frac{kRT_1}{k-1}\left[\left(\frac{P_2}{P_1}\right)^{(k-1)/k} - 1\right]$

Polytropic: $w_{comp,in} = \frac{nR(T_2 - T_1)}{n-1} = \frac{nRT_1}{n-1}\left[\left(\frac{P_2}{P_1}\right)^{(n-1)/n} - 1\right]$

Isothermal: $w_{comp,in} = RT \ln \frac{P_2}{P_1}$

Isentropic Efficiency

Turbine $\eta_T = \frac{\text{Actual Work}}{\text{isentropic W}} = \frac{h_1 - h_{2a}}{h_1 - h_{2s}}$

Compressor $\eta_C = \frac{h_{2s} - h_1}{h_{2a} - h_1}$

Pump $\eta_P = \frac{W_s}{W_a} = \frac{v(P_2 - P_1)}{h_{2a} - h_1}$