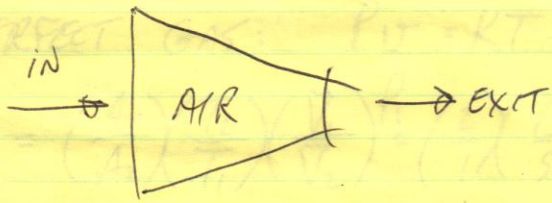
RETURN TO DR. THOMAS

HOMEWORK #5: ~~4.17, 4.29, 4.44, 4.51, 4.60~~ 78
~~4.83, 4.99~~ 4-66, 4-79, 4-96, 4-104, 4-114, 4-141
4-149

PROB. ~~4.000~~ 4-66



$P_{in} = 600\ kPa, \quad T_{in} = 500K$

$Q = 0$

$A_1 / A_2 = \frac{2}{1}$

$\vec{V}_{in} = 120\ \frac{m}{s}, \quad \vec{V}_{out} = 380\ \frac{m}{s}$

FIND T_e, P_e

FIRST LAW: STEADY

$\dot{Q}^{=0} - \dot{W}^{=0} = \sum \dot{m}_e \left(h_e + \frac{1}{2}V_e^2 + g z_e^{=0}\right) - \sum \dot{m}_i \left(h_i + \frac{1}{2}V_i^2 + g z\right.$

MACH - CONTINUITY: $\dot{m}_e = \dot{m}_i$

$h_2 = h_1 - \frac{1}{2}\left(V_2^2 - V_1^2\right)$

TABLE A-17 p. 923

$h_2 = \left(503.02\ \frac{kJ}{kg}\right) - \frac{1}{2}\left(380^2 - 120^2\ \frac{m^2}{s^2}\right)\left(\frac{kJ/kg}{1000\ m^2/s^2}\right) = 438\ \frac{kJ}{kg}$

4-66
PROB. 4-66 CONT

$T_2 = 436.5\ K$

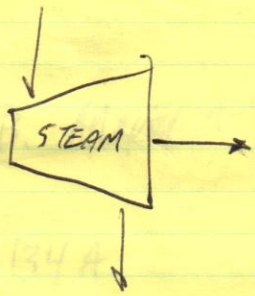
CONSERVE MASS:

$\frac{1}{v_2} A_2 V_2 = \frac{1}{v_1} A_1 V_1$ $\qquad m_2 = m_1, \quad \dot{m} = \rho \vec{V} A = \frac{1}{v} V$

PERFECT GAS: $Pv = RT$

$P_2 = \left(\frac{A_1}{A_2}\right)\left(\frac{T_2}{T_1}\right)\left(\frac{\vec{V}_1}{\vec{V}_2}\right) P_1 = \left(\frac{2}{1}\right)\left(\frac{436.5}{500}\right)\left(\frac{120}{380}\right)(600\,kPa) = 330.8\ kPa$

PROB. 4-79



$P_{IN} = 10\ MPa, \quad T_{in} = 450°C, \quad V_{in} = 80\ \frac{m}{s}$

$P_e = 10\ kPa, \quad X_e = 0.92, \quad V_e = 50\ \frac{m}{s}$

$\dot{m} = 12\ \frac{kg}{s}$

FIND ΔKE, $\dot{W}$, A_{in}

$\Delta KE = \frac{1}{2}\left(V_2^2 - V_1^2\right) = \frac{1}{2}\left(50^2 - 80^2\ \frac{m^2}{s^2}\right)\left(\frac{kJ/kg}{1000\ m^2/s^2}\right) = -1.95\ \frac{kJ}{kg}$

$h_e = h_f + X_e h_{fg} = (191.83) + (0.92)(2392.8) =$

PROB. 4-79 CONT.

FIRST LAW: STEADY

$\dot{Q}^{\,0} - \dot{W} = \dot{m}\left[(h_2 - h_1) + \frac{1}{2}(V_2^2 - V_1^2)\right]$

$\dot{W} = -\dot{m}\left[(h_2 - h_1) + \frac{1}{2}(V_2^2 - V_1^2)\right]$

$\dot{W} = -(12\ \frac{kg}{s})\left[(2393 - 3241\ \frac{kJ}{kg}) + (-1.95\ \frac{kJ}{kg})\right]$

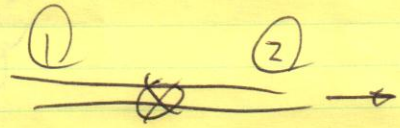
$\dot{W} = 10.2\ MW$

CONTINUITY: $\dot{m} = \rho V A$

$A = \frac{\dot{m} v_{in}}{V_{in}} = \frac{(12\ \frac{kg}{s})(0.02975\ \frac{m^3}{kg})}{(80\ \frac{m}{s})} = 0.00446\ m^2$

PROB. 4-96

R-134A



$X_1 = 0,\ P_1 = 800\ kPa$

$P_2 = 140\ kPa$

FIND $\Delta T = T_2 - T_1,\ v_2$

FIRST LAW:

$\dot{Q}^{\,0} - \dot{W}^{\,0} = \dot{m}(h_2 - h_1)$

$h_2 = h_1$

4-96

PROB. CONT.

$h_1 = h_f = 93.42 \frac{kJ}{kg}$ @ $P_1 = 800\ kPa$, $T_1 = T_{sat} = 31.33°C$

$h_2 = h_1 = 93.42$ @ $P_2 = 140\ kPa$

$h_f = 25.77$, $h_g = 236$ ∴ SAT. MIX

$T_2 = T_{sat} = -18.8°C$

$\Delta T = T_2 - T_1 = -18.8 - 31.33 = -50.13°C$

$x_2 = \frac{h_2 - h_f}{h_{fg}} = \frac{93.42 - 25.77}{210.27} = 0.3217$

~~$v_2 = v_f + x_2 v_{fg} = (0.0007381) + (0.3217)(0.1395)$~~

~~$v_2 = 0.04538 \frac{m^3}{kg}$~~

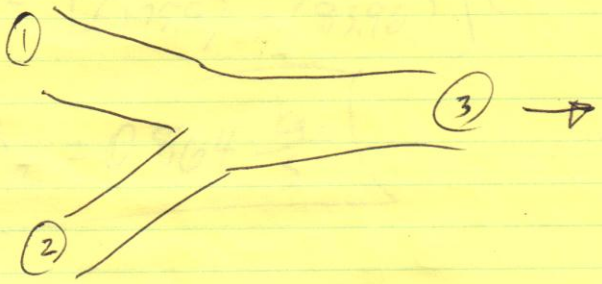
$v_2 = v_f + x_2(v_g - v_f)$

$v_2 = (0.0007381) + (0.3217)(0.1395 - 0.0007381)$

$v_2 = 0.04538 \frac{m^3}{kg}$

PROB. 4-104

H_2O,



$T_1 = 80°C$, $\dot{m}_1 = 0.5 \frac{kg}{s}$

$T_2 = 20°C$

$T_3 = 42°C$

$P = 250$ kPa

CONTINUITY: $\sum \dot{m}_i - \sum \dot{m}_e = \frac{dm}{dt}^{\to 0}$

$\dot{m}_1 + \dot{m}_2 = \dot{m}_3$

FIRST LAW:

$\dot{Q}^{\to 0} - \dot{W}^{\to 0} = \sum \dot{m}_e h_e - \sum \dot{m}_i h_i$

$\dot{m}_3 h_3 - \dot{m}_1 h_1 - \dot{m}_2 h_2 = 0$

$(\dot{m}_1 + \dot{m}_2) h_3 - \dot{m}_1 h_1 - \dot{m}_2 h_2 = 0$

$\dot{m}_2 = \left(\frac{h_1 - h_3}{h_3 - h_2}\right) \dot{m}_1$

$h_1 - h_3 = c_p (T_1 - T_3)$

$h_3 - h_2 = c_p (T_3 - T_2)$

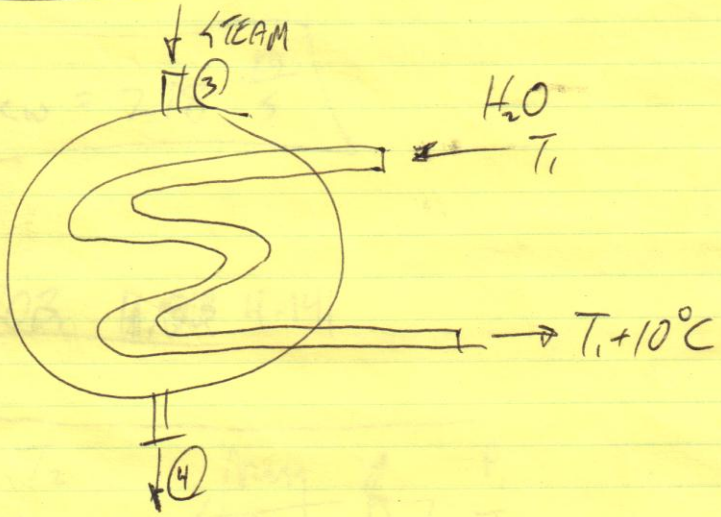
4-104

PROB. ~~4.104~~ CONT

$$\dot{m}_2 = \left[\frac{(334.9) - (175.9)}{(175.9) - (83.96)}\right]\left(0.5 \frac{kg}{s}\right)$$

$$\boxed{\dot{m}_2 = 0.864 \frac{kg}{s}}$$

PROB. ~~4.114~~ 4-114



$P_3 = 20 kPa$, $X_3 = 0.95$ $\quad \dot{m}_3 = \left(20{,}000 \frac{kg}{HR}\right)\left(\frac{HR}{3600 s}\right) = 5.55 \frac{kg}{s}$

$X_4 = 0$, ~~X~~ $P_4 = 20 kPa$

FIND $\dot{m}_{cw}$

FIRST LAW: STEADY

$\dot{Q}^{\circ} - \dot{W}^{\circ} = \Sigma \dot{m}_e h_e - \Sigma \dot{m}_i h_i$

PROB. 4-114 CONT.

$$\dot{m}_{cw} h_{cw,e} + \dot{m}_s h_4 - \dot{m}_{cw} h_{cw,i} - \dot{m}_s h_3 = 0$$

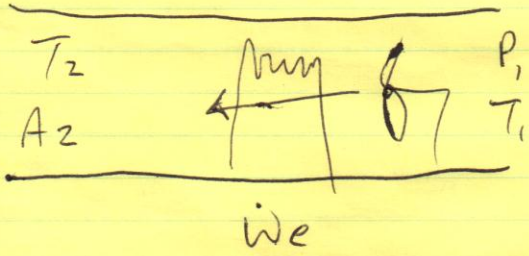
$$\dot{m}_{cw}[C_p(T_2 - T_1)] = \dot{m}_s(h_3 - h_4)$$

$$\dot{m}_{cw} = \frac{\dot{m}_s(h_3 - h_4)}{C_p(T_2 - T_1)}$$

$$\dot{m}_{cw} = \frac{\left(5.55 \frac{kg}{s}\right)\left(2491.8 - 251.4 \frac{kJ}{kg}\right)}{\left(4.18 \frac{kJ}{kg \cdot K}\right)(10°C)}$$

$$\boxed{\dot{m}_{cw} = 298 \frac{kg}{s}}$$

PROB. 4-141



FIRST LAW:

$$\dot{Q} - \dot{W}^{0} = \dot{m}(h_2 - h_1)$$

$$\dot{m} = \frac{\dot{Q}}{h_2 - h_1} = \frac{\dot{Q}}{C_p(T_2 - T_1)}$$

4-141

PROB. ~~4.80~~ CONT.

$$\dot{m} = \frac{1.2 \ \frac{KJ}{s}}{\left(1.005 \ \frac{KJ}{Kg\text{-}K}\right)(47-22 \ K)} = 0.04776 \ \frac{Kg}{s}$$

$\dot{V}_1 = \dot{m} v_1 = \dot{m}\left(\frac{RT_1}{P_1}\right)$ VOLUMETRIC FLOW RATE

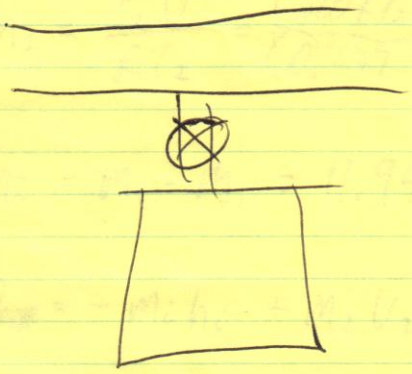
$$\dot{V}_1 = \left(0.04776 \ \frac{Kg}{s}\right)\frac{\left(0.287 \ \frac{KJ}{Kg\text{-}K}\right)([redacted])}{(100 \ KPa)} = [redacted] \ \frac{m^3}{Kg \ s}$$

$$v_2 = \frac{RT_2}{P_2} = \frac{\left(0.287 \ \frac{KJ}{Kg\text{-}K}\right)(320 K)}{(100 \ KPa)} = 0.9184 \ \frac{m^3}{Kg}$$

$\dot{m} = \frac{1}{v_2} A_2 \vec{V}_2$

$$\vec{V}_2 = \frac{\dot{m} v_2}{A_2} = \frac{\left(0.04776 \ \frac{Kg}{s}\right)\left(0.9187 \ \frac{m^3}{Kg}\right)}{(60 \times 10^{-4} \ m^2)} = 7.31 \ \frac{m}{s}$$

PROB. ~~4.99~~ 4-149



$V = 2\,m^3$, $P_1 = 100\ KPa$, $T_1 = 22°C$

$P_i = 600\ KPa$, $T_i = 22°C$

$P_2 = 600\ KPa$

$T_2 = 77°C$

FIND m_i, Q

~~FIND~~ CONTINUITY:

$$m_{in} - \cancel{m_{out}}^{\,0} = m_2 - m_1$$

$$m_i = m_2 - m_1$$

FIRST LAW:

$$Q - \cancel{W}^{\,0} = \Sigma m_e \cancel{h_e}^{\,0} - \Sigma m_i h_i + (m_2 u_2 - m_1 u_1)_{CV}$$

$$Q = -m_i h_i + m_2 u_2 - m_1 u_1$$

$$m_1 = \frac{P_1 V}{R T_1} = \frac{(100\ KPa)(2\ m^3)}{(0.287\ \frac{KJ}{Kg\text{-}K})(295\ K)} = 2.362\ kg$$

4-149

PROB. 4-149 CONT.

$$m_2 = \frac{P_2 V}{R T_2} = \frac{(600\ kPa)(2\ m^3)}{(0.287\ \frac{kJ}{kg\cdot K})(350\ K)} = 11.94\ kg$$

$$m_i = m_2 - m_1 = 11.94 - 2.362 = 9.584\ kg$$

$$Q_{in} = -m_i h_i + m_2 u_2 - m_1 u_1$$

$$Q_{in} = -(9.584\ kg)(295.17\ \tfrac{kJ}{kg}) + (11.946\ kg)(250.02\ \tfrac{kJ}{kg}) - (2.362\ kg)(210.49\ \tfrac{kJ}{kg})$$

$$Q = -339.3\ kJ$$