Problem Set #9

5.144

$$m_{in} - m_{out} = \Delta m_{system}$$

$$m_i = m_2 - m_1$$

$$E_{in} - E_{out} = \Delta E_{system}$$

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

$PV = mRT$ – gas law

$$m_1 = \frac{P_1 V_1}{R T_1} = \frac{(100)(65)}{(2.077)(295)} = 10.6\ kg$$

$$m_2 = \frac{P_2 V_2}{R T_2} = \frac{(150)(V_2)}{(2.707)(T_2)} = \frac{(150)(1.5 \times 65)}{2.707\, T_2}$$

$$m_2 = \frac{7041}{T_2}\ kg$$

Linear P vs V.

$$W = \left(\frac{P_1 + P_2}{2}\right)(V_2 - V_1) \Rightarrow$$

$$= \left(\frac{100 + 150}{2}\right)(32.5) = \underline{4063}\ kJ$$

$$m_i = m_2 - m_1 = \left(\frac{7041}{T_2} - 10.6\right) kg$$

Energy Balance

$$W_b + m_i h_i = m_2 c_v T_2 - m_1 c_v T_1$$

$$-4062 = m_2 c_v T_2 - m_1 c_v T_1 - m_i h_i$$

$$4062 = (10.6)(3.116)(295) - \left(\frac{7041}{T_2}\right)(3.116) T_2$$

$$+ \left[\frac{7041}{T_2} - 10.6\right][5.192][298]$$

<u>Solve for T_2</u> (quadratic equation)

5.145 R-134a

$P_1 = 1.2\ MPa$
$T_1 = 120^\circ C$ → Tables superheated

$v_1 = .02423\ m^3/kg$
$u_1 = 325.03\ kJ/kg$
$h_1 = 354.11\ kJ/kg$

$m_{in} - m_{out} = \Delta m_{system} = \cancel{m_1 - m_2}$
$= m_2 - m_1$

Mass
$m_e = m_1 - m_2$

Energy:
$W_b - m_e h_e = m_2 u_2 - m_1 u_1$

$m_1 = \frac{V_1}{v_1} = \frac{0.8\ m^3}{0.02423\ m^3/kg} = 33.02\ kg$

$m_2 = \frac{V_2}{v_2} = \frac{0.5\ m^3}{v_2} \Rightarrow m_e = 33.02 - \frac{0.5}{v_2}$

Spring Work $= \left(\frac{P_1 + P_2}{2}\right)(V_2 - V_1)$

$= -\frac{(1200 + 600)}{2}(-0.3)$

$= 900 \times 0.3 = 270\ kJ$

Energy:
$270 - \left(33.02 - \frac{0.5}{v_2}\right) h_e = \left(\frac{0.5}{v_2}\right) u_2 - (33.02)(325.03\ kJ/kg)$

$h_e \simeq \frac{h_1 + h_2}{2}$

$= \frac{354.11 + h_2}{2}\ kJ/kg.$

solve by trial & error.

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a) $V = \sqrt{\dfrac{2gz}{1.5 + fL/D}} = \sqrt{\dfrac{2gz}{1.5 + \dfrac{0.015\,(100)}{0.1}}}$

$= \sqrt{0.1212gz}$

calculate V_1 for $g = 9.8$, $z = 2$ m

(b) $\dot{V} = \left(\dfrac{\pi D^2}{4}\right)\sqrt{0.1212gz} = \dfrac{dV}{dt}$ dV = dvolume

$dV = -A_o\,(dz)$ where A_o = Area of tank

$= -\dfrac{\pi D_o^2}{4}\,dz$

$-\dfrac{\pi D_o^2}{4}\,dz = \dfrac{\pi D^2}{4}\sqrt{0.1212gz}$

Integrating. $\dfrac{2 D_o^2}{D^2\sqrt{0.1212g}}\sqrt{z_1} = t_f$

$t_f = \dfrac{2}{1}\left(\dfrac{D_o^2}{D^2}\right)\sqrt{\dfrac{z_1}{0.1212g}}$

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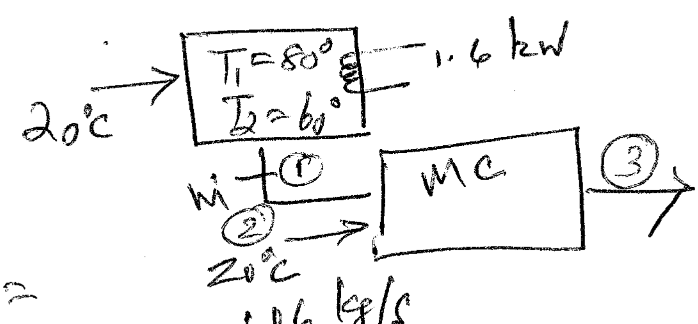

MC

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

Having the same reference Temp T^*,

$\left(\dot{m}\,\hat{T}_{\text{tank}\,(1)} + \dot{m}_1 T_2\right) c_p = (\dot{m} + \dot{m}_1)\, c_p\, T_3$

Energy Balance on Tank yields

$$-m_i(70-20)c_p + 1.6 = \cancel{m_e}\ m_{tank}(60-80)c_p$$

$$m_{tank} = 0.06 \times 1000 = 60\,kg$$

$$+\cancel{(\dot{m}_i \Delta t)} \rightarrow \dot{m}_i c_p (0)$$

Ref Temp $= 70°C$

$$m_i = \left(\frac{m_{tank}(-20)c_p - 1.6}{(50)(c_p)}\right) \quad \frac{\dot{m}_i}{\cancel{\Delta t}}$$

$$= 27.7\,kg.$$

$$\dot{m}_{\cancel{e}} = \frac{m_e}{\Delta t} = \frac{m_i}{\Delta t} = \frac{27.7}{480} = 0.058\,kg/s$$

$$(0.05\cancel{80})(70) + 0.06(20)$$

$$= (0.05\cancel{80})(T_3)$$

$$\underline{\underline{T_3 = 45°C}}.$$

175 $\dot{m}_{H_2O} = \cancel{1000}\ (1000)(2)\left(\frac{\pi(0.03)^2}{4}\right)$

$$= \underline{\underline{1.41}}\ kg/s$$

Energy Balance

$$\dot{m}_{steam} h_{fg} = \dot{m}_{H_2O} c_p (10)$$

$$\dot{m}_{steam} = \frac{\dot{m}_{H_2O} c_p (10)}{h_{fg}} = \frac{(1.41)(4.18)(10)}{2406}$$

$$= .025\,kg/s.$$

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$m_{in} - m_{out} = \Delta m_{system}$

$-m_e = m_2 - m_1$

$Q_{in} - m_e h_e = m_2 u_2 - m_1 u_1$

$Q_{in} = m_2 u_2 - m_1 u_1 + (m_1 - m_2) h_e$

$v_1 = V/m_1 = \frac{.001\ m^3}{0.4\ kg} = 0.0025\ m^3/kg$

$T_1 = 26°C$, $v_1 = 0.0025\ m^3/kg$ $\Big\rangle$ $x_1 = \frac{.0025 - 0.000831}{0.02997 - .0008313}$

$= 0.05726$

$u_1 = u_f + x u_{fg} = 96.2\ kJ/kg$

$h_e = 264.68\ kJ/kg$

$v_2 = \frac{V}{m_2} = \frac{0.001\ m^3}{0.1\ kg} = .01\ m^3/kg$

$T_2 = 26°C$, $v_2 = .01\ m^3/kg$ $\Big\rangle$ $x_2 = \frac{.01 - .0008313}{.029976 - .0008313}$

$= .3146$

$u_2 = 136.6\ kJ/kg$

$Q_{in} = 54.6\ kJ$

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$\dot{W}_{Turbine} = (0.02)(1.063)(400-350) = 1.063\ kW$

$\dot{W}_C = \dot{m}_a c_p (\Delta T) = \dot{W}_{Turbine}$

$1.06\ kW = (018)(1.008)(T_2 - 50) \Rightarrow T_2 = 108.6°C$

$\dot{m}_h c_p (\Delta T)_{hot} = \dot{m}_c c_p (\Delta T)_{cold}$

$\dot{m}_c = .05\ kg/s$; $\dot{V}_c = \dot{m} v_a = .0449\ m^3/s$

44.9 L/s