mae 431 Energy Systems Fall 2009 Quiz 1

3 lbs of liquid water and 1 lb of water vapor are contained in a piston cylinder mechanism at 20 psi. The mixture is heated at constant volume to 80 psi. The mixture is then expanded at constant pressure to a final temperature of 360 F. Sketch a property diagram of the processes. What is the temperature at the end of the constant volume process? How much heat and work are transferred in the constant volume and constant pressure processes?

mae 431 Fall 2009 Quiz 1

Grade	No
100	2
90	5
80	2
70	5

Ave 84

$x_1 = m_g/m_{total} = 1/4 = .25$

$u_1 = u_f \text{ @ } 20 \text{ psi} + x \times u_{fg} \text{ @ } 20 \text{ psi}$

$u_1 = 196.21 + .25 \times (1081.8 - 196.27) = 417.59 \text{ Btu/lb}$

$v_1 = v_f \text{ @ } 20 \text{ psi} + x \times v_{fg} \text{ @ } 20 \text{ psi}$

$v_1 = .01683 + .25 \times (20.093 - .01683) = 5.036 \text{ ft}^3/\text{lb}$

$v_1 = v_2$

$x_2 = \dfrac{v_3 - v_f \text{ @ } 80 \text{ psi}}{v_{fg} \text{ @ } 80 \text{ psi}} = \dfrac{5.036 - .01757}{5.4733 - .01757} = .9198$

$T_2 = T_g \text{ @ } 80 \text{ psi} = 312.02 \text{ F}$

$u_2 = u_f \text{ @ } 80 \text{ psi} + x \times u_{fg} \text{ @ } 80 \text{ psi}$

$u_2 = 281.87. + .9198 \times (1102.3 - 281.87)$

$u_2 = 1036.5 \text{ Btu/lb}$

$h_2 = h_f \text{ @ } 80 \text{ psi} + x \times f_{fg} \text{ @ } 80 \text{ psi}$

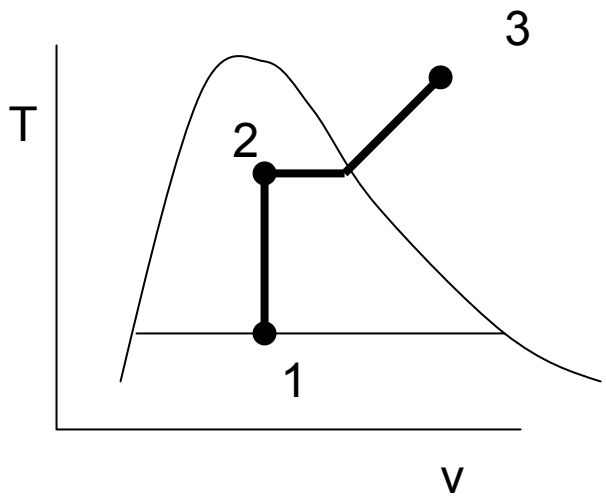
$h_2 = 282.13 + .9198 \times (901.22) = 1111.07 \text{ Btu/lb}$

@ 80 psi, 360 F Superheat Table

$u_3 = 1122.7 \text{ Btu/lb}$

$h_3 = 1209.9 \text{ Btu/lb}$

$v_3 = 5.8876$



process $1 \Rightarrow 2$

$Q_{12} = E_2 - E_1 + W_{12}, \quad v = \text{constant} \Rightarrow W_{12} = 0$

$Q_{12} = E_2 - E_1 = m \times (u_2 - u_1)$

$Q_{12} = 4 \times (1036.5 - 417.59) = 2475.64 \text{ Btu}$

process $2 \Rightarrow 3$

$Q_{23} = E_3 - E_2 + W_{23} = m \times (u_3 - u_2) + m \times (p_3 v_3 - p_2 v_2)$

$Q_{23} = m \times (h_3 - h_2) = 4 \times (1209.9 - 1111.07) = +395.32 \text{ Btu}$

$W_{23} = Q_{23} - (E_3 - E_2) = Q_{23} - m \times (u_3 - u_2)$

$W_{23} = 395.32 - 4 \times (1122.7 - 1036.5) = 50.52. \text{ Btu}$

also, $W_{23} = m \times (p_3 v_3 - p_2 v_2)$

$W_{23} = 4 \times 80 \times 144 \times (5.8876 - 5.036)/778 = 50.43 \text{ Btu}$

mae 431 Energy Systems Fall 2009 Quiz 2

Steam is expanded in a turbine from 10 MPa, 600 C to 5 kPa, 80 C. Determine the work done in kJ/kg, the turbine isentropic efficiency and The exergy destroyed by the expansion process. Ambient conditions are 25 C and 100 kPa.

Pt	T	p	h	s
1	600	10 MPa	3625.3	6.9045
2 iss		5 kPa		6.90452

$$h_2 = h_g\,@\,5\,\text{kPa} + c_p \times (80 - T_{sat}\,@\,5\,\text{kPa})$$

$$h_2 = 2560.7 + 1.8723 \times (80 - 32.87) = 2648.94\ \text{kJ/kg}$$

$$(h_2 \approx h_g\,@\,80\,\text{C} = 2643)$$

$$s_2 = s_g\,@\,5\,\text{kPa} + c_p \times \ln\left(\frac{80}{T_{sat}\,@\,5\,\text{kPa})}\right)$$

$$s_2 = 8.3938 + 1.8723 \times \ln\left(\frac{80}{32.87}\right) = 8.662\ \text{kJ/kg K}$$

$$x_{2iss} = \frac{s_1 - s_f}{s_{fg}} = \frac{6.9045 - .4762}{8.3938 - .4762} = .8119$$

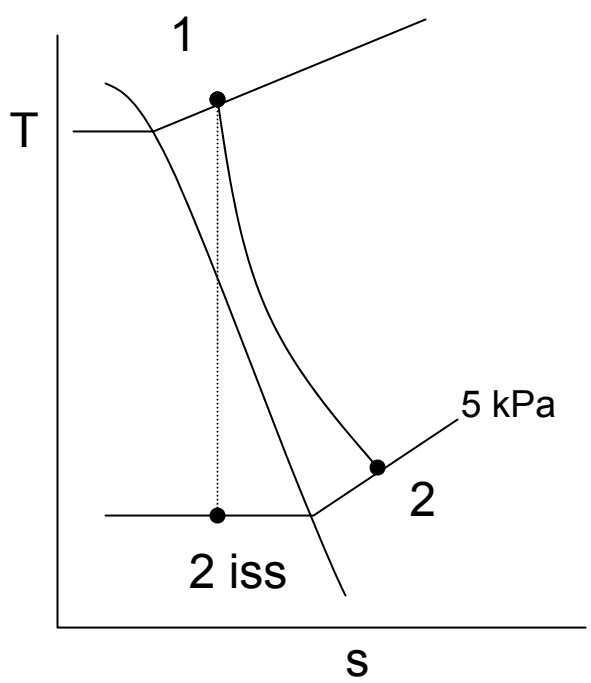
$$h_{2iss} = h_f + x \times h_{fg} = 137.75 + .8119 \times 2423 = 2104.98$$

$$\eta_{issentropic} = \frac{h_1 - h_2}{h_1 - h_{2iss}} = \frac{3625.3 - 2648.94}{3625.3 - 2104.98} = 64.23\%$$

$$W = h_1 - h_2 = 3625.3 - 2648.94 = 976.86\ \text{kJ/kg}$$

$$e_{x\,destroyed} = T_O \times (s_2 - s_1) = (25 + 273.15) \times (8.622 - 6.9045)$$

$$e_{x\,destroyed} = 5\,24\ \text{kJ/kg}$$



Grade	No
90	2
80	1
70	1
60	2
50	3
40	3
30	1
20	3

ave 54

mae 431 Energy Systems Fall 2009 Quiz 3

Steam extracted from a turbine at .7 MPa, 280 C, h= 3017.1 kJ/kg is used to heat feed water in a closed feed water heater. The steam condensed in the heater is pumped at 100 % efficiency into the feed water stream leaving the closed heater. Feed water is heated from 18 MPa, h=180 kJ/kg to a temperature 5 C less than the steam condensate temperature. What is the ratio of steam flow to feed water flow? What is the enthalpy of the feed water after it is mixed with the steam condensate? Sketch a schematic and a property diagram.

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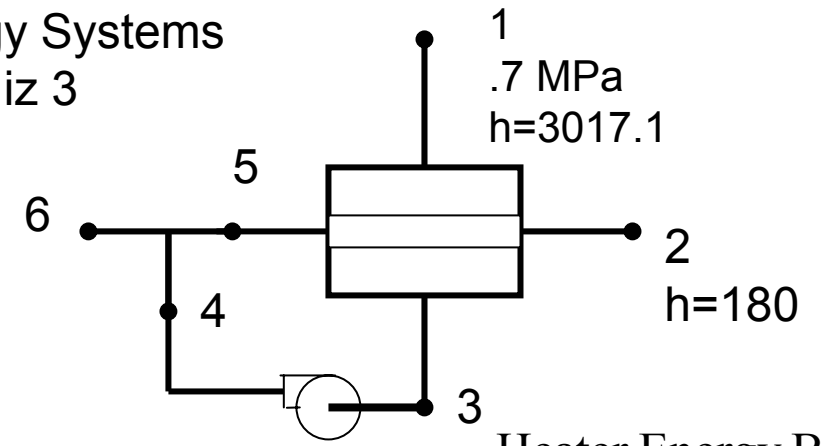
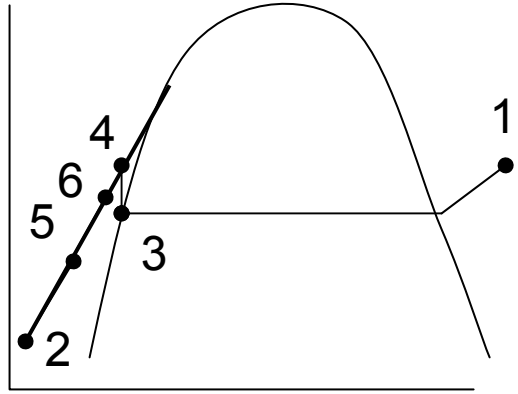
Fall 2009 Quiz 3





$h_3 = h_f\ @\ .7\text{MPa} = 697.\ \text{kJ/kg}$

$T_3 = 165\,\text{C}$

$v_3 = .001108\ \text{m}^3/\text{kg}$

$W_p = h_4 - h_3 = v_3 \times (p_4 - p_3)$

$W_p = .001108 \times (18{,}000 - 700)$

$W_p = 19.17\ \text{kJ/kg}$

$h_4 = h_3 + W_p = 697. + 19.17$

$h_4 = 716.17\ \ \text{kJ/kg}$

$T_5 = T_3 - 5 = 160$

$h_5 = h_f @ 160 = 675.47\ \text{kJ/kg}$

Heater Energy Balance

$$m_s \times (h_1 - h_3) = m_w \times (h_2 - h_5)$$

$$\frac{m_s}{m_w} = \frac{675.47 - 180}{3017.1 - 675.47} = .2116$$

Mixing Energy Balance

$$(m_w + m_s)h_6 = m_w h_5 + m_s h_4$$

$$\left(1 + \frac{m_s}{m_w}\right)h_6 = h_5 + \frac{m_s}{m_w} h_4$$

$$h_6 = \frac{675.47 + .2116 \times 716.17}{1 + .2116}$$

$$h_6 = 682.57\ \text{kJ/kg}$$

Grade	No
80	1
70	
60	
50	2
40	
30	3
20	1
10	4

ave 33