MET 330 TEST3 — Rami Switzer

$P_1 = 2\,MPa$

$T_1 = 320°C$

$h_1 = 3069.5\ kJ/kg$

$S_1 = 6.8444\ kJ/kg \cdot K$

$P_2 = .15\ MPa = 150\ kPa$

$h_f = 467.13\ kJ/kg$

$h_{fg} = 2226.0\ kJ/kg$

$S_f = 1.4337\ kJ/kg \cdot K$

$S_{fg} = 5.7894\ kJ/kg \cdot K$

$v_f = 1.053 \times 10^{-3}\ m^3/kg$

$P_3 = 0.06\ bar = 6E\text{-}4\ MPa$

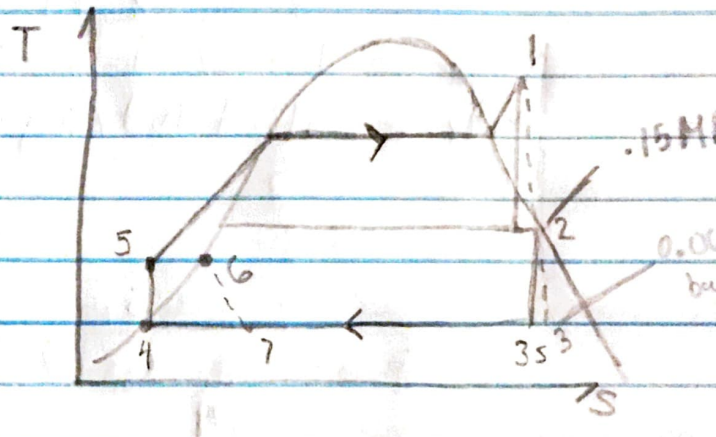
$h_f = 151.53\ kJ/kg$

$h_{fg} = 2415.9\ kJ/kg$

$S_f = .521\ kJ/kg \cdot K$

$S_{fg} = 7.8094\ kJ/kg \cdot K$

$v_f = 1.0064 \times 10^{-3}\ m^3/kg$



State 2

$S_1 = S_{2s}$

$= S_f + x_{2s} S_{fg}$

$6.8444 = 1.4337 + x_{2s}(5.7894)$

$x_{2s} = 0.9346$

$h_{2s} = h_f + x_{2s} h_{fg}$

$= 467.13 + 0.9346(2226)$

$h_{2s} = 2547.55\ kJ/kg$

$\eta_T = \frac{h_1 - h_2}{h_1 - h_{2s}} \rightarrow h_2 = \eta_T(h_1 - h_{2s}) + h_1$

$= |.8(3069.5 - 2547.55) - 3069.5|$

$h_2 = 2651.94$

$h_2 = h_f + x_2 h_{fg}$

$x_2 = h_2 - h_f / h_{fg}$

$= 2651.94 - 4167.13 / 2226$

$x_2 = .9814$

$S_2 = S_f + x_2 S_{fg}$

$= 1.4337 + .9814(5.7894)$

$S_2 = 7.1159 \text{ kJ/kg} \cdot \text{K}$

$S_2 = S_{3S}$ [state 3]

$= S_f + x_{3S} S_{fg}$

$7.1159 = .521 + x_{3S}(7.8094)$

$x_{3S} = .8444$

$h_{3S} = h_f + x_{3S} h_{fg}$

$= 151.53 + .8444(2415.9)$

$h_{3S} = 2191.52 \text{ kJ/kg}$

$.8 = 2651.94 - h_3 / 2651.94 - 2191.52$

$h_3 = 2283.6 \text{ kJ/kg}$

$h_4 = h_f$ at bar 0.06 [state 4]

$= 151.53$

$W_p = \int -v\,dp$; $W_p = -v_f(p_5 - p_4) \cdot 100$

$= -1.0064E\text{-}6\,(20 - 0.06) \cdot 100$

$W_p = -2.0067 \text{ kJ/kg}$

$h_5 = h_4 - W_p$ [state 5]

$= 151.53 - (-2.0067)$

$h_5 = 153.537 \text{ kJ/kg}$

at $T_6 = 60°C$ [State 6]

$h_6 = 251.13$ KJ/Kg

In Throttle [State 7]

$h_7 = h_6$

a)

$Q_{in} = \dot{m}_1(h_1 - h_5)$

$= 82(3069.5 - 153.537)$

$Q_{in} = 2391.09$ KJ/S

b)

$W_T = \dot{m}_1(h_1 - h_2) + (\dot{m}_1 - m_2)(h_2 - h_3)$

$= .82(3069.5 - 2651.94) + [(.82 - (.82)(.141)) \cdot (2651.94 - 2283.6)]$

$= 342 + (.70438)(368.34)$

$W_T = 601.45$ KJ/S

$W_p = m_1(h_5 - h_4)$

$= .82(153.537 - 151.53)$

$= 1.6457$ KJ/S

$W_{net} = 601.45 + (-1.6457)$

$= 599.8$ KJ/S

C)

$Q = m_2(h_2 - h_6)$

$= [(.82)(.141)] \cdot (2651.94 - 251.13)$

$Q = 277.58$ KJ/S

d) $Q_{out} = (m_1 - m_2)h_3 + m_2 h_7 - h_4 m_1$

$= (.82 - .11562)(2283.6) + (.11562)(251.13) - (151.53)(.82)$

$Q_{out} = 1513.3 \text{ kJ/s}$

e)

$\epsilon_u = 1 - Q_{out}/Q_{in}$

$= 1 -$

$\epsilon_u = .3671 = 36.71$

f)

$\eta = W_T / Q_{in} = 599.8 / 2391.09 = .2508$

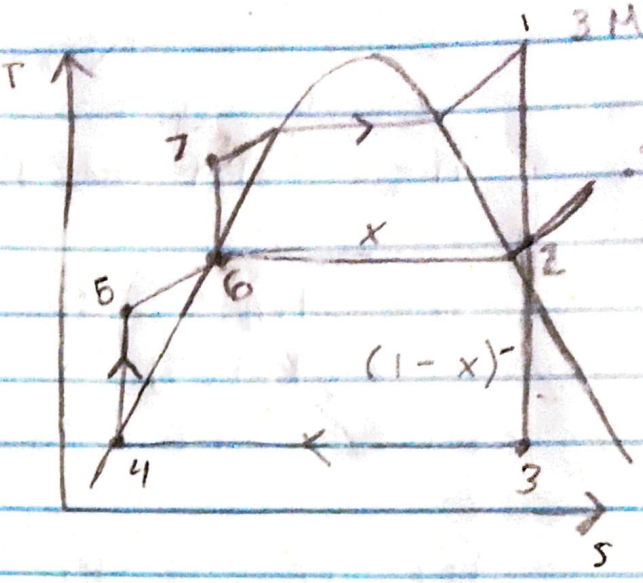
$\eta = 25.08\%$

$P_1 = 3\ MPa$

$T_1 = 400°C$

$h_1 = 3231.7\ kJ/kg$

$S_1 = 6.9235\ kJ/kg$



1-2 (isentropic)

$P_2 = 0.8\ MPa$

$S_1 = S_2$

$S_2 = S_f + x S_{fg}$

$V_f = V_6 = 0.001\ m^3/kg$ } at .8 MPa

$h_f = h_6 = 721.018\ kJ/kg$ }

$S_g = 6.662\ kJ/kg \cdot K$

$S_1 > S_g$

$T = 222.65°C$

$h_2 = 2890.78$

2-3 (isentropic)

$S_1 = S_3$

$h_g = 2583.88\ kJ/kg$ }

$S_g = 8.149\ kJ/kg \cdot K$

$S_f = 0.649$ at 10 kPa

$V_f = V_4 = .001\ m^3/kg$

$h_f = h_4 = 191.81\ kJ/kg$ }

$S_1 = S_f + x S_{fg}$: $x = S_1 - S_f / S_{fg}$

$x = 6.9235 - 0.649 / 7.5$

$h_3 = h_f + x h_{fg}$

$= 191.812 + 0.836(2386.075)$

$h_3 = 2191.58 \text{ kJ/kg}$

$h_5 = h_4 + v_4 dp$

$= 191.812 + .001(P_4 - P_3)$

$h_5 = 192.602$

$h_7 = h_6 + v_6 (P_1 - P_2)$

$= 721.018 + .001(3000 - 800)$

$h_7 = 723.218 \text{ kJ/kg}$

Energy balance

$x h_2 + (1-x) h_5 = h_6$

$x(2890.78) + (1-x)(192.602) = 721.018$

$x = .2 \text{ kg}$

$w_{net} = (h_1 - h_2) + (1-x)(h_2 - h_3) - (h_5 - h_4) - (h_7 - h_6)$

$= (3231.2 - 2890.78) + (1-.2)(2890.78 - 2191.584) - (192.602 - 191.8$

$- (723.218 - 721.018$

$w_{net} = 896.815 \text{ kJ/kg}$

$\eta = 896.815 / (3231.7 - 723.218) = 0.3575$

$\eta = 35.75\%$