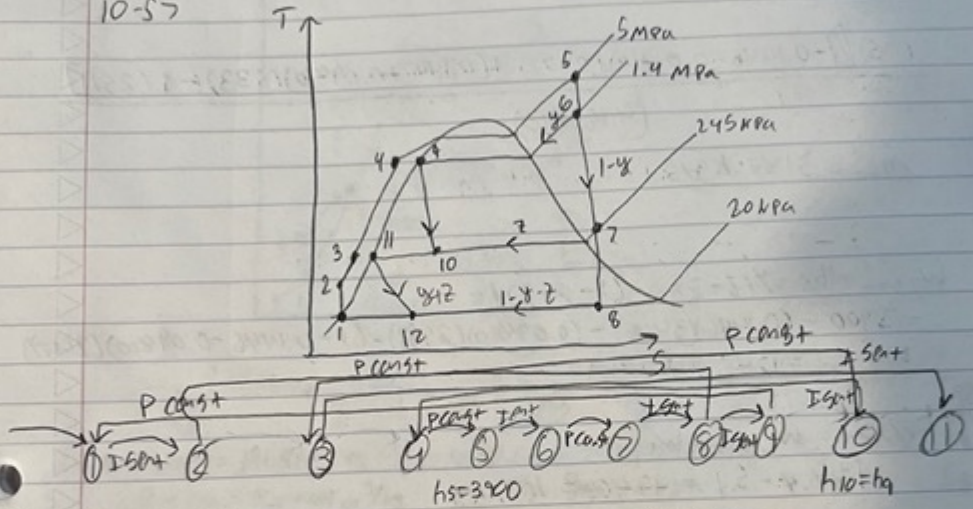
Colby Watts

Professor Ayala

Thermal applications HW 2.2

HW 2.2 Ch 10-57, 69, 72

10-57



$h_1 = h_f @ 20\text{kPa} = 215\ \text{kJ/kg}$ $h_4 = h_9 = h_f @ 1400\text{kPa} = 830\ \text{kJ/kg}$ $h_{12} = h_{11}$

$V_1 = V_f @ 20\text{kPa} = 0.00102\ m^3/\text{kg}$ $h_7 = 2918$

$h_8 = 2477$

$$W_{PI,in} = V_1(P_2 - P_1)$$

$$(0.00102)(5000-20)\left(\frac{1\ \text{kJ}}{1\ \text{kPa}\cdot m^3}\right) = 5.1\ \text{kJ/kg}$$

$$h_2 = h_1 + W_{PI,in} = 251 + 5.1 = 256.1\ \text{kJ/kg}$$

$$h_3 = h_{11} = h_f @ 245\text{kPa} = 533\ \text{kJ/kg}$$

$$y = \frac{(h_3 - h_2) + y(h_{11} - h_{10})}{h_7 - h_{11}} = \frac{(533 - 256.1) + (.1446)(533 - 830)}{2918 - 533} = 0.09810$$

$$\dot{m}_w = \frac{\dot{m}_5[(1-y-z)h_8 + (y+z)h_{12} - 1h_1]}{C_{P_w}\Delta T_w}$$

$$\frac{(75)[(1-0.1446-0.09810)(2477) + (0.1446+0.09810)(533) - 1(251)]}{(4.18)(10)}$$

$\dot{m}_w = 3147$ kg/s

$$W_{T,out} = h_5 - yh_6 - zh_7 - (1-y-z)h_8$$
$$= 3900 - (0.1446)(3406) - (0.09810)(2918) - (1-0.1446-0.09810)(2477)$$
$$W_{T,out} = 1245.4 \text{ kJ/kg}$$

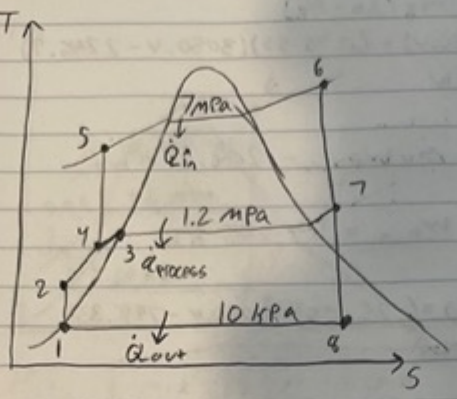
$$\dot{W}_{net} = W_{T,out} - W_{P,in}$$
$$1245.4 - 5.1 = 1240.3 \text{ kJ/kg}$$

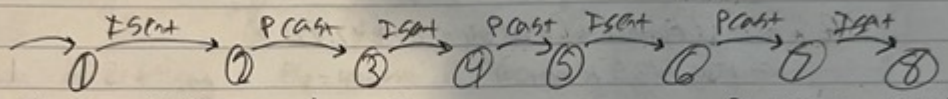
$$\dot{W}_{net} = \dot{m} W_{net} = (75)(1240.3) = 93 \text{ MW}$$

$$\dot{Q}_{in} = \dot{m}(h_5 - h_4) = (75)(3900 - 830) = 230,250 \text{ kW}$$

$$\eta_{th} = \frac{93,024 \text{ kW}}{230,250 \text{ kW}} = 40.4\%$$

10-69





$h_1 = h_f @ 10\,kPa = 191.81\,kJ/kg$ $h_3 = h_f @ 1.2\,MPa = 798.33\,kJ/kg$ $P_7 = 1.2\,MPa$ $P_8 = 10\,kPa$

$V_1 = V_f @ 10\,kPa = 0.00101\,m^3/kg$ $h_4 = 344.34\,kJ/kg$ $s_7 = s_6$ $s_8 = s_6$

P_1 10kPa $P_2 = 1200$ $V_4 = V_f @ h_f = h_4$ $h_7 = 3080.4\,kJ/kg$

$W_{PI,in} = V_1 (P_2 - P_1)$ $V_f = 0.001031\,m^3/kg$

$= (0.00101)(1200 - 10)$ $P_5 = 4000\,kPa$

$W_{PI,in} = 1.20\,kJ/kg$ $P_4 = 1200\,kPa$

$h_2 = h_1 + W_{PI,in}$ $P_6 = 4\,MPa$, $h_6 = 3446\,kJ/kg$

$h_2 = 193.01\,kJ/kg$ $T_6 = 500°C$, $s_6 = 7.0922\,kJ/kg \cdot K$

$$h_4 = \frac{\dot{m}_2 h_2 + \dot{m}_3 h_3}{\dot{m}_4} = \frac{(22.50)(192.41) + (7.50)(798.33)}{30}$$

$h_4 = 344.34\,kJ/kg$

$W_{PII,in} = V_4 (P_5 - P_4)$

$(0.001031)(4000 - 1200)\left(\frac{1kJ}{1kPa \cdot m^3}\right)$

$W_{PII,in} = 2.89\,kJ/kg$

$$x_8 = \frac{s_8 - s_f}{s_{fg}} = 0.8591$$

$h_8 = h_f + x_8 h_{fg} = 2246.9\,kJ/kg$

$$\dot{W}_{T,out} = \dot{m}_6(h_6 - h_7) + \dot{m}_8(h_7 - h_8)$$

$$(55)(3446 - 3080.4) + (0.75 \cdot 55)(3080.4 - 2246.9)$$

$$\dot{W}_{T,out} = 54,494 \text{ kW}$$

$$\dot{W}_{P,in} = \dot{m}_1 W_{PI,in} + \dot{m}_4 W_{PII,in} = 208.3 \text{ kW}$$

$$\dot{W}_{net} = \dot{W}_{T,out} - \dot{W}_{P,in} = 54,285 \text{ kW}$$

$$\dot{Q}_{Process} = \dot{m}_7(h_7 - h_3) = (.25 \cdot 55)(3080.4 - 798.33)$$

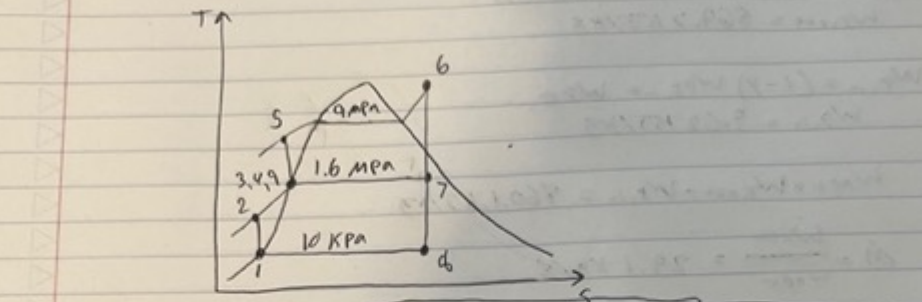
$$= 31,379 \text{ kW}$$

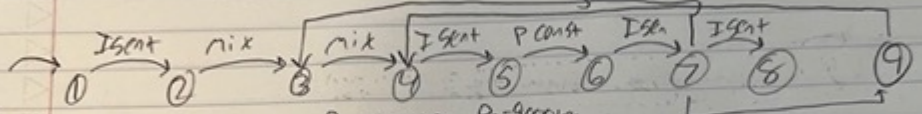
$$\dot{Q}_{in} = \dot{m}_5(h_6 - h_5) = (55)(3446.0 - 347.22)$$

$$= 170,435 \text{ kW}$$

$$\eta_{th} = \frac{\dot{W}_{net} + \dot{Q}_{Process}}{\dot{Q}_{in}} = 50\%$$

10-72





$h_1 = h_f @ 10\text{kPa} = 191.81\ \text{kJ/kg}$ $P_4 = 400\text{kPa}$ $P_5 = 9000\text{kPa}$

$V_1 = V_f @ 10\text{kPa} = 0.00101\ m^3/\text{kg}$ $P_6 = 9\text{mPa}$

$P_1 = 10\text{kPa}$ $P_2 = 1600$ $V_4 = V_f @ 1.6\text{mPa}$ $T_6 = 400°C$

$W_{PI,in} = V_1(P_2 - P_1)$ $V_4 = 0.001159\ m^3/\text{kg}$ $h_6 = 3118.8\ \text{kJ/kg}$

$= (0.00101)(1600 - 10)$ $s_6 = 6.2876\ \text{kJ/kg·K}$

$W_{PI,in} = 1.61\ \text{kJ/kg}$ $h_5 = h_4 + W_{PII,in} = 867.02\ \text{kJ/kg}$

$h_2 = h_1 + W_{PI,in} = 193.41\ \text{kJ/kg}$

$h_3 = h_4 = h_9 = h_f @ 1.6\text{mPa} = 858.44\ \text{kJ/kg}$

$W_{PII,in} = V_4(P_5 - P_4) = 8.57\ \text{kJ/kg}$

$P_7 = 1.6\ \text{MPa}$, $s_7 = s_6$ $\Rightarrow$ $x_7 = \dfrac{s_7 - s_f}{s_{fg}} = 0.9675$

$h_7 = h_f + x_7 h_{fg} = (858) + (.9675)(1934.4)$

$h_7 = 2730.0\ \text{kJ/kg}$

$P_8 = 10\text{kPa}$, $s_8 = s_6$ $\Rightarrow$ $x_8 = \dfrac{s_8 - s_f}{s_{fg}} = \dfrac{6.26 - 0.64}{7.5} = .7518$

$h_8 = h_f + x_8 h_{fg} = 1990.2\ \text{kJ/kg}$

$$W_{T,out} = (h_6 - h_7) + (1-y)(h_7 - h_8)$$

$$W_{T,out} = 869.7 \text{ kJ/kg}$$

$$W_{P,in} = (1-y) W_{PI,in} + W_{PII,in}$$

$$W_{P,in} = 9.62 \text{ kJ/kg}$$

$$W_{net} = W_{T,out} - W_{P,in} = 860.1 \text{ kJ/kg}$$

$$\dot{m} = \frac{\dot{W}_{net}}{W_{net}} = 29.1 \text{ kg/s}$$