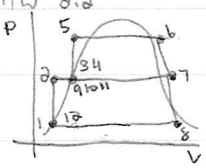
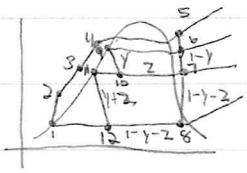
Jordan Whitaker

HW 2.2

(5)

(a)





$P_1 = 20\ kPa$

$h_1 = 251\ kJ/kg$ } Sat. water Pressure T_1

$V_1 = 0.00102\ m^3/kg$ }

$h_2 = 256.1\ kJ/kg$

$P_{11} = 245\ kPa$

$h_{11} = 533\ kJ/kg$ (Sat. Water Pressure T_5)

$P_9 = 1400\ kPa$

$h_9 = 830\ kJ/kg$ (Sat. Water Press. T_5)

$h_9 = h_{10}$

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

$= 0.00102\,(5000-10)\left(\frac{1\ kJ}{1\ kPa \cdot m^3}\right)$

$= 5.1\ kJ/kg$

$h_2 = h_1 + W_{p,in}$

$= 251 + 5.1$

$= 256.1\ kJ/kg$

(b) $h_2 + z h_7 + y h_{10} = h_3 + (y+z) h_{11}$

$z = \frac{(h_3 - h_2) + y(h_{11} - h_{10})}{h_7 - h_{11}}$

$= \frac{(533 - 256.1) + 0.1446(533 - 830)}{2918 - 533}$

$z = 0.0981$

(c)

$\dot{m}_8 h_8 + \dot{m}_w h_{w1} + \dot{m}_{12} h_{12} = \dot{m}_1 h_1 + \dot{m}_w h_{w2}$

$\dot{m}_w (h_{w2} - h_{w1}) = \dot{m}_8 h_8 + \dot{m}_{12} h_{12} - \dot{m}_1 h_1$

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

$= \frac{75[(1-0.1446-0.0981)(247.7) + (0.1446+0.0981)(533) - 251]}{4.18 \times 10}$

$\dot{m}_w = 31.17\ kg/s$

$W_{T,out} = h_5 - y h_6 - z h_7 - (1-y-z) h_8$

$= 3900 - (0.1446(3406)) - (0.0981(2918)) - (1 - 0.1446 - 0.0981)(247.7)$

$W_{T,out} = 1245.4\ kJ/kg$

$W_{net} = W_{T,out} - W_{T,in}$

$= 1245.4 - 5.1$

$W_{net} = 1240.3\ kJ/kg$

$\dot{W}_{net} = \dot{m} W_{net}$

$= 75(1240.3)$

$\dot{W}_{net} = 93023\ kW$

$\dot{Q} = \dot{m}(h_5 - h_4)$

$= 75(3900 - 830)$

$\dot{Q} = 230250\ kW$

$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{net}} \times 100$

$= \frac{93023}{230250} \times 100$

$\eta_{th} = 40.4\%$

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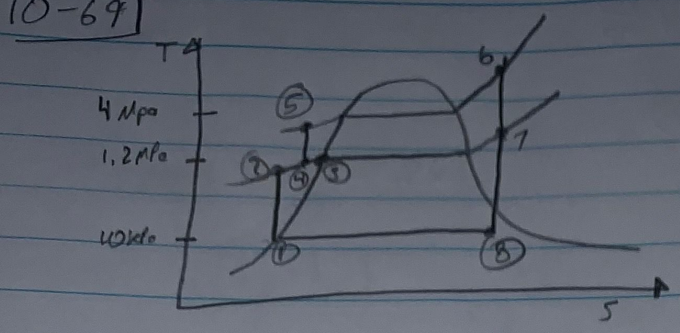

T-s diagram

$P_1 = 10\,kPa$

$P_2 = 1200\,kPa$

From tables

$h_1 = h_f = 191.81\,kJ/kg$

$v_1 = v_f = 0.00101\,\frac{m^3}{kg}$

$w_{p1,in} = v_1 (P_2 - P_1)$

$\Rightarrow 1.20\,kJ/kg$

$h_2 = h_1 + w_{p1,in}$

$\Rightarrow h_2 = 193.01\,kJ/kg$

From tables

$h_3 = h_f$

$= 798.33\,kJ/kg$

$\dot{m}_4 = 55\,kg/s \quad y = 0.25$

$\dot{m}_3 = y \cdot \dot{m}_4$

$\dot{m}_3 = 13.75\,kg/s$

$h_4 = \dfrac{\dot{m}_2 h_2 + \dot{m}_3 h_3}{\dot{m}_4}$

$\dot{m}_2 = \dot{m}_4 - \dot{m}_3$

$\dot{m}_2 = 41.25\,kg/s$

$\Rightarrow h_4 = 349.34\,kJ/kg$

$v_4 = v_f = 0.001081 \frac{m^3}{kg}$

$W_{pII,in} = v_4 (P_5 - P_4)$

$\Rightarrow 2.89 kJ/kg$

$h_5 = h_4 + W_{pII,in}$

$\Rightarrow h_5 = 347.23 \frac{kJ}{kg}$

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

$\Rightarrow x_8 = 0.8591$

$h_{fg} = 2,392.1 kJ/kg$
$h_f = 191.81 \frac{kJ}{kg}$

$h_8 = h_f + x_8 h_{fg}$

$\Rightarrow 2,246.85 \frac{kJ}{kg}$

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

$\Rightarrow \dot{W}_{Tout} = 54,478.2 kW$

$\dot{W}_{p,in} = \dot{m}_1 W_{pI,in} + \dot{m}_4 W_{pII,in}$

$\Rightarrow \dot{W}_{p,in} = 208.45 kW$

$\dot{W}_{net} = \dot{W}_{Tout} - \dot{W}_{pin}$

$\Rightarrow$ **54,269.75 kW** — net power output

$\dot{Q}_{process} = \dot{m}_7 (h_7 - h_3)$ $\quad \dot{m}_7 = (0.25)(55 kg/s)$

$h_7 = 3081.4 kJ/kg$

$h_3 = 796.33 kJ/kg$

$\Rightarrow \dot{Q}_{process} = 31392.2 kW$

$\dot{Q}_{in} = \dot{m}_5 (h_6 - h_5)$ $\quad \dot{m}_5 = 55 kg/s$

$h_6 = 3446 kJ/kg$

$h_5 = 347.23 kJ/kg$

$\Rightarrow \dot{Q}_{in} = 170432.35 kW$

$$\varepsilon_u = \frac{\dot{W}_{net} + \dot{Q}_{process}}{\dot{Q}_{in}}$$

$\Rightarrow 0.5026$

$\Rightarrow \boxed{50.26\%}$ — utilization factor for the plant

MET 350

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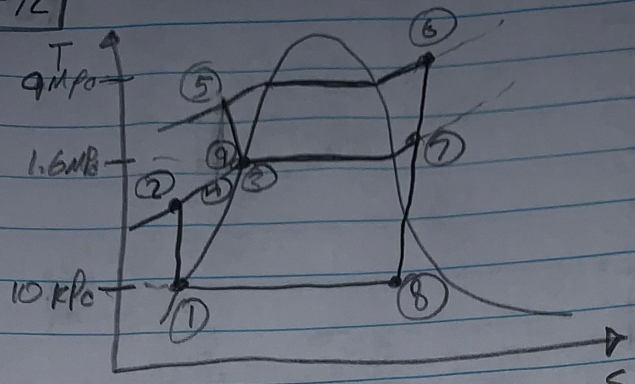
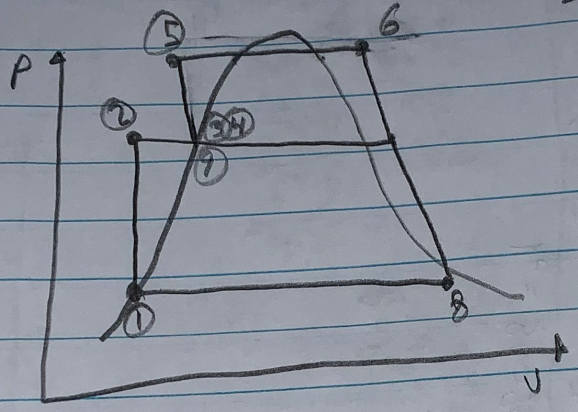
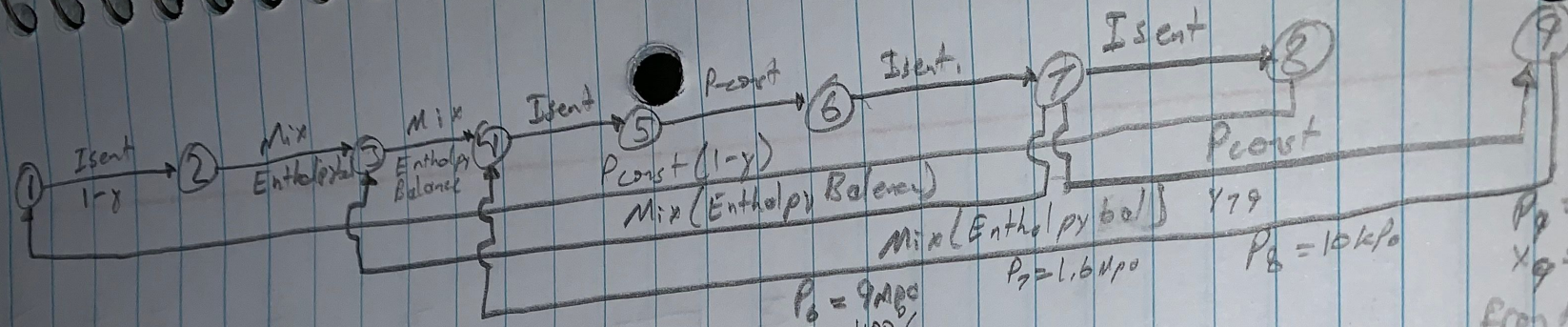




PV + TS Diagrams



$P_1 = P_8 = 10\,kPa$

From Tables

$T_1 = 45.81^\circ C$

$h_1 = 191.8 \frac{kJ}{kg}$

$v_1 = 0.001010 \frac{m^3}{kg}$

$P_2 = P_3 = 1.6\,MPa$

$h_2 = h_1 + v_1(P_2 - P_1)$

$\Rightarrow h_2 = 193.416 \frac{kJ}{kg}$

$P_6 = 9\,MPa$

$T_6 = 400^\circ C$

From tables

$h_6 = 3118.8 \frac{kJ}{kg}$

$s_6 = 6.2876 \frac{kJ}{kg \cdot K}$

$P_7 = 1.6\,MPa$

$P_8 = 10\,kPa$

$P_9 = 1.6\,MPa$

$x_9 = 0$

From tables

$T_9 = 201.262^\circ C$

$h_9 = 857.994 \frac{kJ}{kg}$

$P_3 = P_2 = P_7 = 1.6\,MPa$

$P_4 = P_2 = P_9 = 1.6\,MPa$

$h_3 = h_4 = h_9 = 857.994 \frac{kJ}{kg}$

$P_5 = P_6 = 9\,MPa$

$h_5 = h_4 + v_4(P_5 - P_4)$

$h_5 = 866.569 \frac{kJ}{kg}$

$s_7 = s_6 = 6.2876 \frac{kJ}{kg \cdot K}$

$s_7 > s_{g@1.6MPa}$

$\therefore$ Mixture

$x_7 = \frac{s_7 - s_{f7}}{s_{fg7}}$

$x_7 = 0.967314$

$h_7 = h_{f7} + x_7 h_{fg7}$

$h_7 = 2729.4371 \frac{kJ}{kg}$

$s_8 = s_6 = 6.2876 \frac{kJ}{kg}$

$x_8 = \frac{s_8 - s_{f8}}{s_{fg8}}$

$x_8 = 0.75183$

$h_8 = h_{f8} + x_8 h_{fg8}$

$h_8 = 1990.263 \frac{kJ}{kg}$

$\dot{W}_{net} = \dot{m}_7 [(h_6 - h_7) + (1-y)(h_7 - h_8) - (1-y)(h_2 - h_1) - (h_5 - h_4)]$

$= \dot{m}_7 [389.36 + 0.65 \times 739.174 - 0.65 \times 1.606 - 8.575]$

$\Rightarrow \dot{m}_7 = 29.063 \frac{kg}{s}$