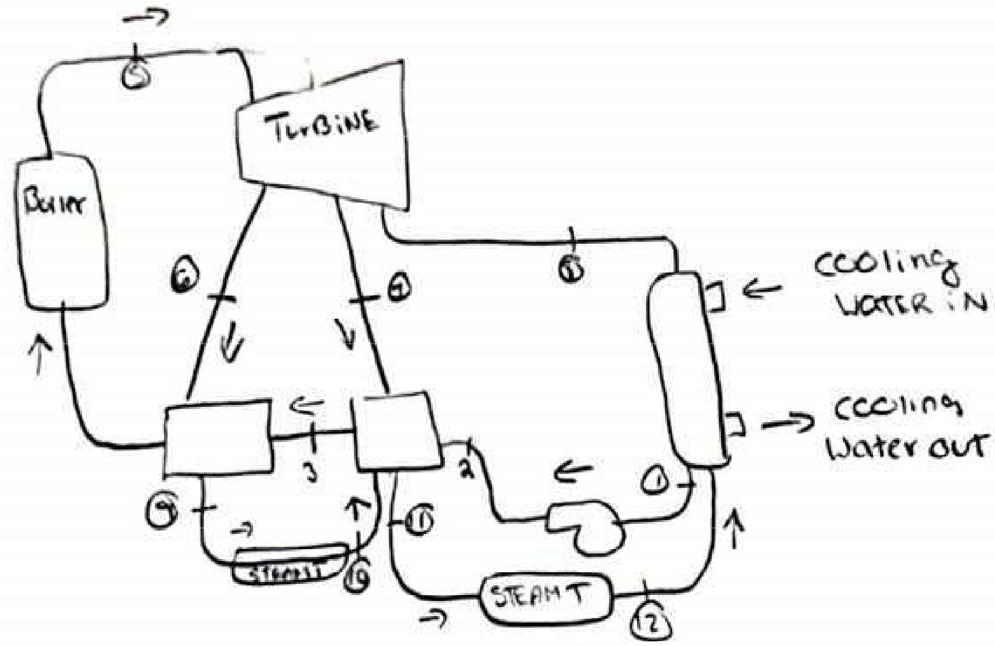
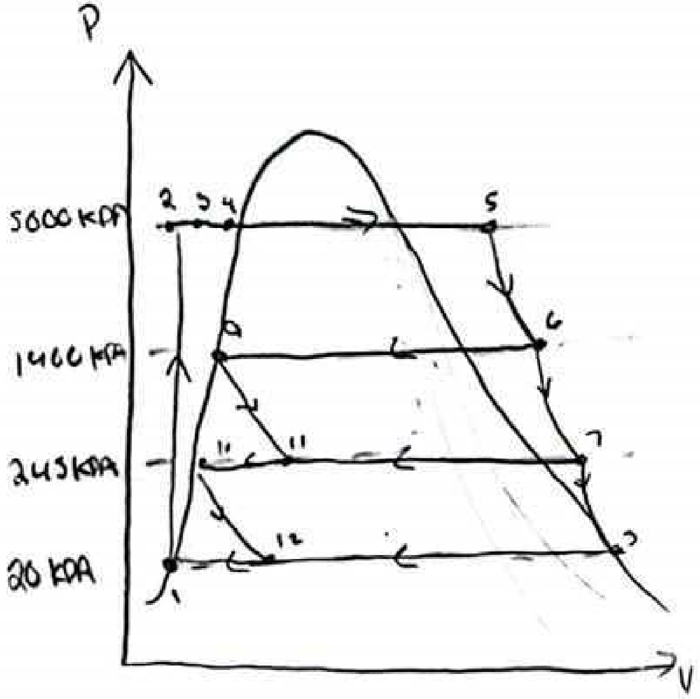
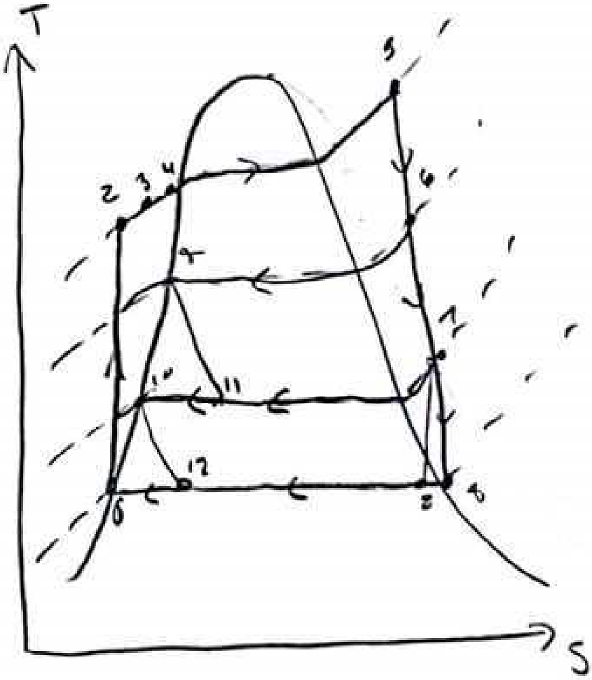
10-51


TURBINE
Boiler
cooling water in
cooling water out
STEAM T
STEAM T


P
5000 KPA
1400 KPA
245 KPA
20 KPA
v


T
S

... and 500°C. $\frac{1}{4}$ of steam is extracted from

1	2	3	4	5	6	7	8	9	10	11	12
$P_1 = 20\text{ kPa}$	$P_2 = 5\text{ MPa}$	$P_3 = P_2$	$P_4 = P_2$	$P_5 = P_2$	$P_6 = 1.4\text{ MPa}$	$P_7 = 245\text{ kPa}$	$P_8 = 20\text{ kPa}$	$P_9 = 1.4\text{ MPa}$	$P_{10} = 245$	$P_{11} = P_{10}$	$P_{12} = P_1$
$h_1 = 251.42$	$h_2 = 256.49$	$h_3 = 533$	$h_4 = 829.96$	$T_5 = 700°C$	$h_6 = 3406$	$h_7 = 2910$	$h_8 = 2477$	$h_9 = 829.96$	$h_{10} = 3289.6$	$h_{11} = 533$	$h_{12} = 533$
				$h_5 = 3900.3$							

$$3h_5 - h_2 = z(h_7) + y(h_{10}) - (7 + y)(h_{11})$$

$$h_4 - h_3 = y(h_6 - h_9)$$

$$y(h_{10}) + z(h_7) + h_2 = (y+z)h_{11} + h_4$$

$$z = 0.0981 \qquad h_4 = 829.96$$

$$h_3 = 533$$

$$\dot m_{water} = \frac{\dot m_s(1-y-z)h_8 + (y+z)h_{12} - h_1}{C_p \Delta T} = \frac{75(1875.93 + 129.251.42)}{419.10}$$

$$\boxed{\dot m_{water} = 3146.7\ \tfrac{kg}{s}}$$

$$W_{out} = h_5 - yh_6 - zh_7 - (1-z-y)h_8 = 3900.3 - 492.5 - 286.28 - 1875.8321$$

$$W_{out} = 1245.712\ \tfrac{kJ}{kg}$$

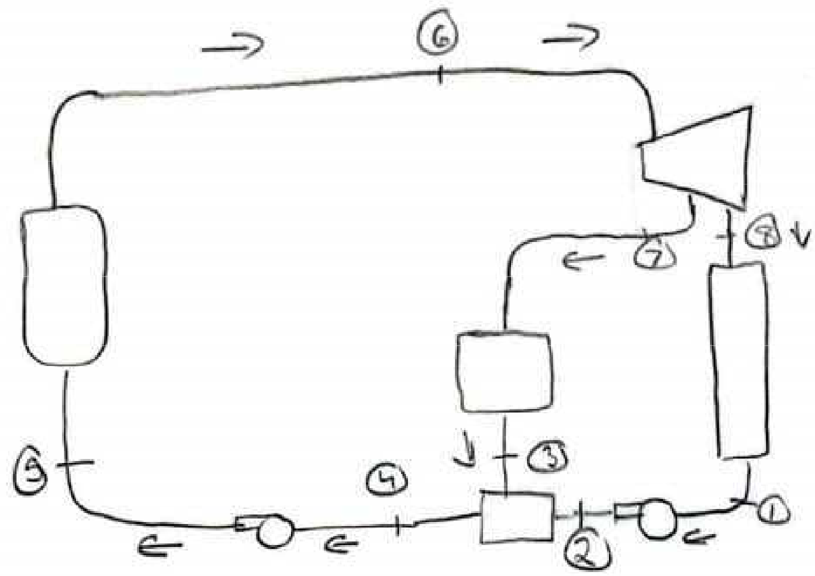
$$W_{net} = W_{out} - W_{in} = 1245.712 - 5.065 = \boxed{1240.6464}$$

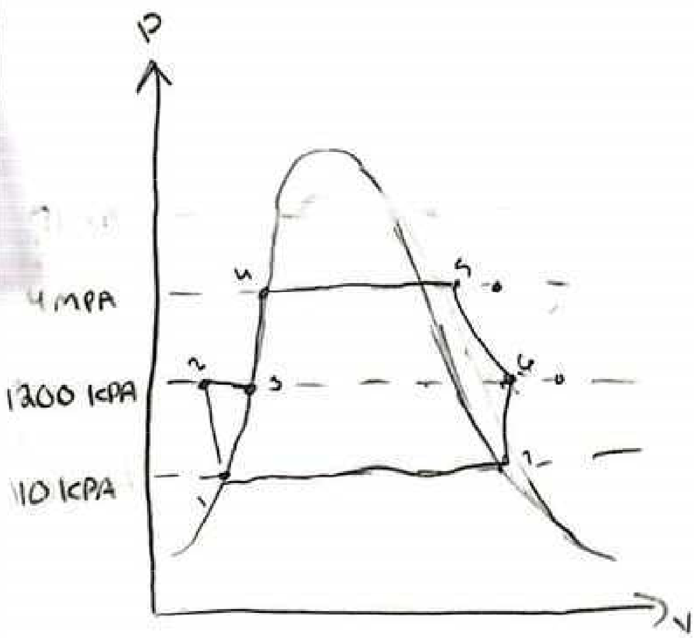
$$\eta_{th} = \frac{W_{net}}{q_{in}}$$

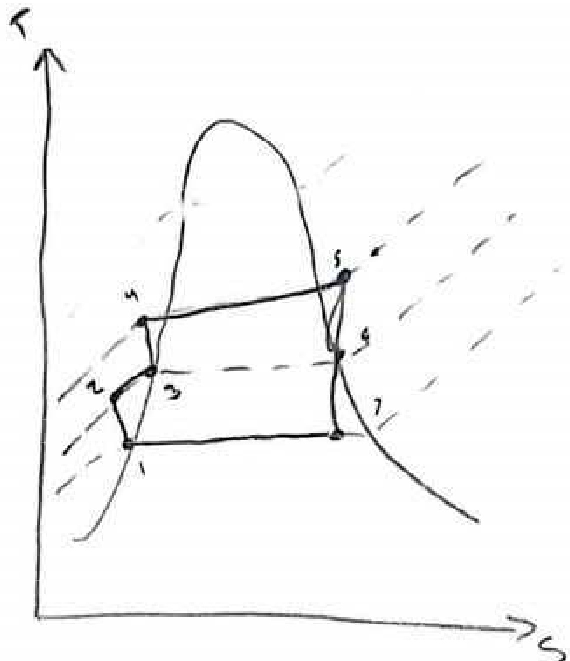
$$q_{in} = h_5 - h_4 = 3900.3 - 829.96 = 3070.34$$

$$\eta_{th} = \frac{1240.6469}{3070.39} = \boxed{0.404 = \eta}$$

10-69) STEAM enters a cogeneration Plant @ 4 MPA and 500°C. $\frac{1}{4}$ of Steam is extracted from the turbine @ 1200 kPA for Process heating. The remaining steam expands to 10 kPA. The extracted steam is then condensed and mixed w/ feedwater @ constant pressure and the mixture is pumped to the boiler @ P = 7 MPa. Mass flow rate through Boiler is 55 kg/s







Given:

$P_6 = 4$ MPa, $P_7 = 1200$ kPa, $x_3 = 0$, $T_6 = 500$, $P_1 = 10$ kPa

$\dot{m}_6 = 55 \frac{kg}{s}$, $\dot{m}_7 = \frac{1}{4}\dot{m}_6$, $\dot{m}_8 = \frac{3}{4}\dot{m}_6$

1 → 2 → 3 → 4 → 5 → 6 → 7 → 8

1	2	3	4	5	6	7	8
$P_1 = 10$ kPa	$P_2 = 1200$ kPa	$P_3 = 1200$ kPa	$P_4 = 1200$ kPa	$P_5 = 4000$ kPa	$P_6 = 4$ MPa	$P_7 = 1200$ kPa	$P_8 = 10$ kPa
$x_1 = 0$	$S_2 = 0.6492$	$x_3 = 0$	$h_4 = 344.3$	$h_5 = 347.2$	$T_6 = 500°C$	$S_7 = S_6$	$S_8 = 7.0922$
$h_1 = 191.81$	$h_2 = 193.0$	$h_3 = 798.33$	$V_4 = 0.001831$		$h_6 = 3446$	$h_7 = 3081$	
$S_1 = 0.6492$					$S_6 = 7.0922$		

V_4: interpolate App

h_7: interpolation App

$x_8 = \frac{S_8 - S_F}{S_{fg}} = \frac{(7.0922) - (0.6492)}{(7.4996)}$

$\boxed{x_8 = 0.8591}$

$v_1 = 0.00101$ Pump

$h_2 - h_1 = V_1(P_2 - P_1)$

$h_2 = (191.81) + (0.00101)(1200 - 10)$

$\boxed{h_2 = 193.0}$

$\boxed{\dot{W}_{P1} = -\frac{3}{4}(55)(193 - 191.81) = -49.58 \text{ kW}}$

$h_5 - h_4 = V_4(P_5 - P_4)$

$h_5 = (344.3) + (0.001831)(4000 - 1200)$

$\boxed{h_5 = 347.2}$

$h_8 = h_f + x_8 \cdot h_{fg}$

$= (191.81) + (0.8591)(2392.1)$

$\boxed{h_8 = 2247}$

$W_{P2} = -(55)(347.2 - 344.3)$

$\boxed{W_{P2} = -158.7 \text{ kW}}$

$\cancel{\dot{Q}_T}^{0} - \dot{W}_T = \sum_{out} \dot{m}h - \sum_{in} \dot{m}h$

$\dot{W}_T = -(\dot{m}_7 h_7 + \dot{m}_8 h_8 - \dot{m}_6 h_6)$

$\dot{W}_T = -\dot{m}_6(\frac{1}{4}h_7 + \frac{3}{4}h_8 - h_6)$

$\dot{W}_T = -(55)(\frac{1}{4}(3081) + \frac{3}{4}(2247) - (3446))$

$W_T = 5.448 \times 10^4$ kW

$\cancel{\dot{Q}}^{0} - \cancel{\dot{W}}^{0} = \sum_{out} \dot{m}h - \sum_{in} \dot{m}h$

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

$\dot{m}_6 h_6 = \dot{m}_8 h_2 + \dot{m}_7 h_3$

$h_4 = \left(\frac{\dot{m}_8}{\dot{m}_6}\right)h_2 + \left(\frac{\dot{m}_7}{\dot{m}_6}\right)h_3 = \frac{3}{4}h_2 + \frac{1}{4}h_3$

$h_4 = \frac{3}{4}(193) + \frac{1}{4}(798.33) \boxed{= 344.3}$

$\dot{W}_{net} = \dot{W}_T + \dot{W}_{P1} + \dot{W}_{P2}$

$= (5.448 \times 10^4 - 49.58 - 158.7)$

$\boxed{\dot{W}_{net} = 5.427 \times 10^4 \text{ kW}}$

Process heater

$\dot{Q}_{PH} - \cancel{\dot{W}}^{0} = \dot{m}_7(h_3 - h_7)$

$\dot{Q}_{PH} = \frac{1}{4}(55)(798.33 - 3081) \boxed{= -3.139 \times 10^4 \text{ kW}}$

$\dot{Q}_C - \cancel{\dot{W}}^{0} = \dot{m}_8(h_1 - h_8)$

$\dot{Q}_C = \frac{3}{4}(55)(191.81 - 2247)$

$\boxed{= -8.478 \times 10^4 \text{ kW}}$

$\dot{Q}_B - \cancel{\dot{W}_B}^{0} = \dot{m}_6(h_6 - h_5)$

$\dot{Q}_{5-6} = (55)(3446 - 347.2)$

$\dot{Q}_{5-6} = 1.704 \times 10^5$ kW

$\epsilon_u = \frac{W_{net} + Q_{PH}}{Q_B}$

$= \frac{(5.427 \times 10^4) + (3.139 \times 10^4)}{(1.704 \times 10^5)} \boxed{= 0.5027}$