ROY SHEPARD TEST 2

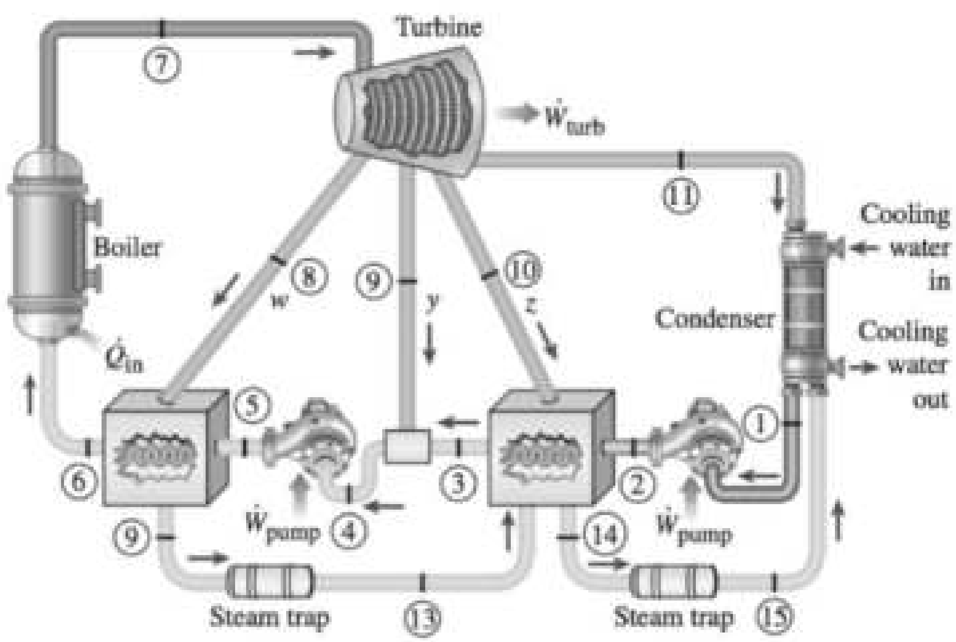
Purpose:

Part 1

Calculate the fraction of extracted mass "y" and "z" for the open & closed feed water heater. Find the cooling water temp when the flow rate is 4200 kg/s with an assumed Cp of 4.18 kJ/kg.K. Find the rate of rejected heat rejected in the condenser the provided net power and the thermal efficiency of the plant

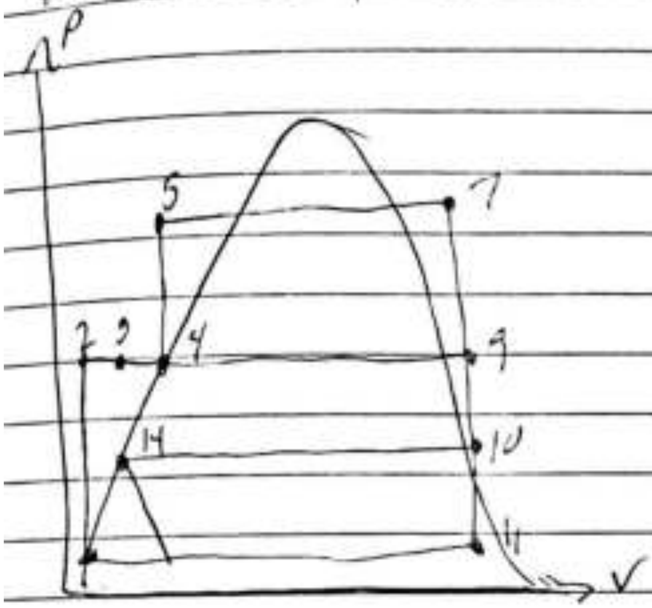
Part 2

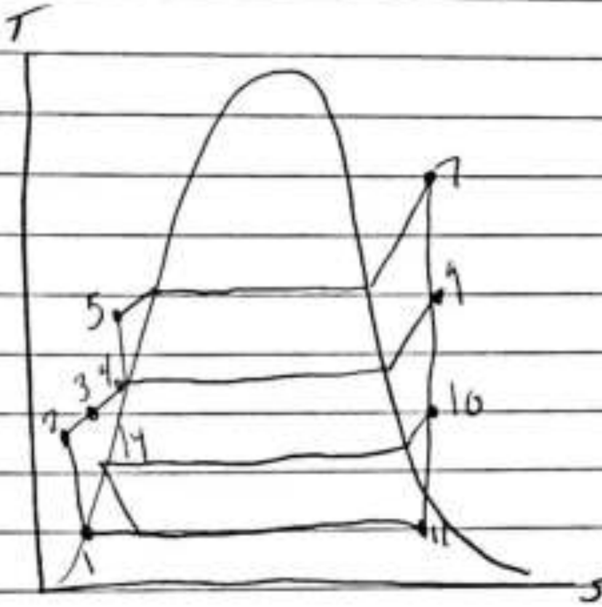
Find the fraction mass "y" for the open feedwater heater in a malfunctioning system. Determine the cooling water temperature in the condenser in °C when the flow rate is 4200 kg/s with an assumed Cp of 4.18 kJ/kg.K. Find the rate of rejection, heat rejection in the condenser the produced net power and the thermal efficiency



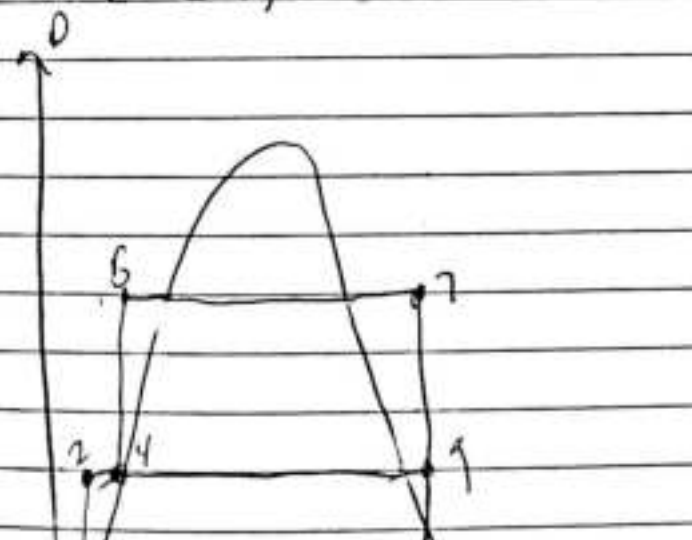
Drawings & Diagrams:

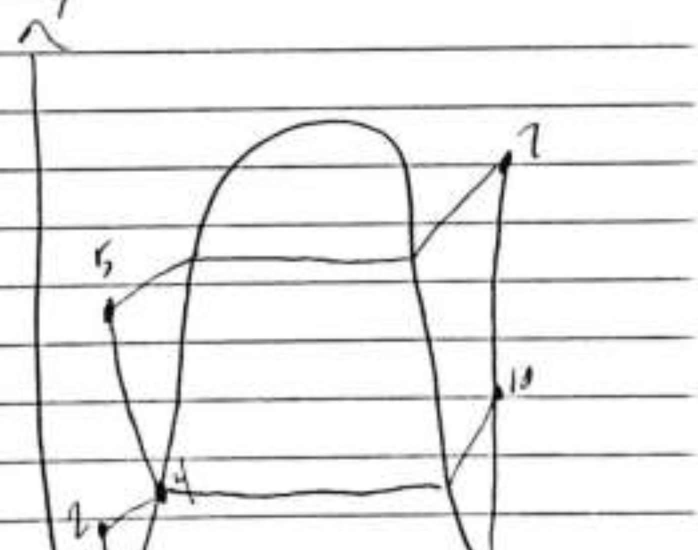
Part 1 Diagrams





Part 2 Diagrams





Source:

- Cengal & Boles "Thermodynamics - An Engineering Approach" 8th Edition, McGraw Hill 2015
- ODU MET 350/351 notes, Homework, lectures & labs

DESIGN CONSIDERATIONS:

1) WATER IS CLEAN & PURE
2) NO HEAT LOSS IN PIPES OF FLUID FLOW.

MATERIALS:

WATER

DATA & VARIABLES:

POWER CYCLE 100 kg/s
NORMAL OPERATING 1910 kPa
FLOW RATE 4200 kg/s
$C_P = 4.18$ kJ/kg·K

Process states and selected data

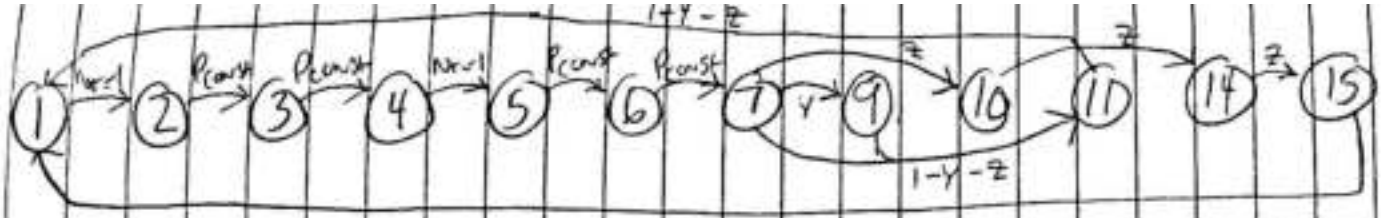
State	P, kPa	T, °C	h, kJ/kg	s, kJ/kg·K
1	20			
2	620			
3	620			
4	620			
5	5000			
6	5000			
7	5000	700	3900	7.514
8	1910		3515	7.514
9	620		3154	7.514
10	140		2799	7.514
11	20		2478	7.514

Saturation data

P, kPa	T_{sat}, °C	v_f, m³/kg	h_f, kJ/kg	s_g, kJ/kg·K
20	60.1	0.00102	251	7.907
140	109.3	0.00105	458	7.246
620	160.1	0.00110	676	6.748
1910	210.1	0.00117	898	6.356
5000	263.9	0.00129	1154	5.973

Procedure & Calculations:

Part 1:



$P_1 = 20\ kPa$
$h_1 = 251\ kJ/kg$
$s_1 = 7.907\ kJ/kg\cdot K$
$s_{f1} = 0.8320\ kJ/kg\cdot K$
$\dot{m} = \dot{m}_y + \dot{m}_z$
$\dot{m}_1 = 1 - \dot{m}_y$

$P_2 = 620\ kPa$
$h_2 = 251.422\ kJ/kg$
$h_2 = h_1 + w_p$
$= 251 + 20(0.00110 - 0.00107)$
$h_2 = 251.422\ kJ/kg$

$P_3 = 620\ kPa$
$T_3 \le T_{sat}$
$T_3 < T_{14}$
$T_3 = 106°C$
$h_3 = C_P(T_3)$
$h_3 = 443.08$

$P_4 = 620\ kPa$
$T_{sat} = 160°C$
$h_4 = h_f$
$h_4 = 676\ kJ/kg$

$P_5 = 5000\ kPa$

$P_6 = 5000\ kPa$

$P_7 = 5000\ kPa$
$T_7 = 700°C$
$\dot{m}_7 = 100\ kg/s$
$h_7 = 3900\ kJ/kg$

$P_9 = 620\ kPa$
$h_9 = 3151\ kJ/kg$

$\dot{m}_7 = \dot{m}_y + \dot{m}_z + \dot{m}_{11}$
$\dot{m}_7 = \dot{m}_y + \dot{m}_1$
$\dot{m}_1 = 91.408\ kg/s$

$\dot{m}_y h_9 + \dot{m}_1 h_3 = (\dot{m}_y + \dot{m}_1) h_4$
$\dot{m}_y h_9 + (\dot{m}_7 - \dot{m}_y) h_3 = \dot{m}_7 h_4$
$\dot{m}_y(3151) + (100 - \dot{m}_y)(443.08) =$
$\boxed{\dot{m}_y = 8.592\ kg/s \quad m_y = 0.0859}$

$\dot{m}_z(h_{10} - h_{14}) = \dot{m}_1(h_3 - h_2)$
$m_z(2799 - 458) = 91.408(443 - 251)$
$\boxed{m_z = 7.484\ kg/s \quad m_z = 0.07484}$

$P_{10} = 140\ kPa$
$h_{10} = 2799\ kJ/kg$

$P_{11} = 20\ kPa$
$h_{11} = 2478\ kJ/kg$
$s_{11} = 7.514$
$x_{11} = \frac{s_{11} - s_f}{s_g - s_f} = 0.944$

$P_{14} = 140\ kPa$
$h_{14} = h_f = 458\ \frac{kJ}{kg}$
$T_{14} = T_{sat} = 109.3°C$

$P_{15} = 20\ kPa$

$\dot{m}_{11} \cdot x_{11}(h_{11} - h_1) + \dot{m}_z(h_{14} - h_1) = \dot{m}_c\, C_P(\Delta T)$
$83.924 \times 0.944(2478 - 251) + 7.484(458 - 251) = 4200 \cdot 4.18\,\Delta T$
$\boxed{\Delta T = 10.14°C}$

$\dot{m} = \dot{m}_{11} + \dot{m}_z$
$91.408 = m_{11} + 7.484$
$\boxed{\dot{m}_{11} = 83.924\ kg/s \quad M_{11}\ 0.83924}$

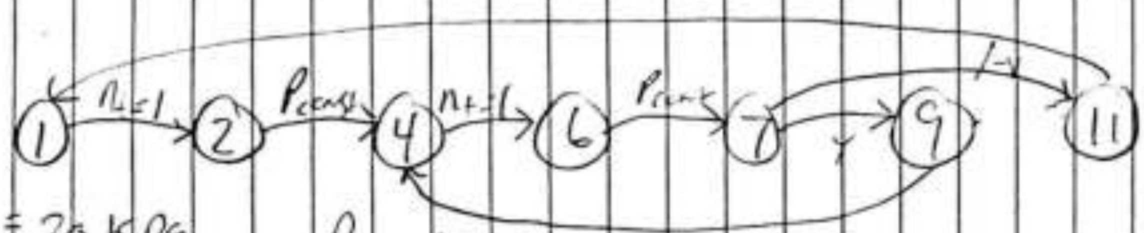
$Q = \dot{m}_c C_P \Delta T$
$Q = (4200)(4.18)(10.14)$
$\boxed{Q = 178.018\ MW}$

$P = m_7(3900 - 3151) + \dot{m}_1(3154 - 2799) + m_{11}(2799 - 2478)$
$\boxed{P = 134\ MW}$

$w = 620(0.00129 - 0.00110)\dot{m}_7 + \dot{m}_1 \times 20(0.00110 - 0.00107)$
$w = 11.93\ kW$

$\eta_{th} = \frac{P - w}{\dot{m}_7(3900 - 1154)} = \boxed{48.79\%}$

Part 2 :



$P_1 = 20$ kPa
$h_1 = h_f = 251$ kJ/kg

$P_2 = 620$ kPa
$h_2 = 251.422$ kJ/kg

$h_{sat} = 676$ kJ/kg @ 620 kPa
$h_2 = h_3 < h_{sat}$

$P_4 = 620$ kPa
$h_4 = 676$ kJ/kg

$P_6 = 5000$ kPa
$h_6 = h_4 + P_6(v_6 - v_4)$
$h_6 = 676 + 62(5000)(0.001)$
$h_6 = 676.12$ kJ/kg

$P_7 = 5000$ kPa
$T_7 = 700°C$
$\dot{m}_7 = 100$ kg/s
$h_7 = 3900$ kJ/kg

$P_9 = 620$ kPa
$h_9 = 3154$ kJ/kg

$P_{11} = 20$ kPa
$h_{11} = 2478$ kJ/kg
$x = 0.944$

$100 = 14.63 + \dot{m}_{11}$
$\boxed{\dot{m}_{11} = 85.37 \text{ kg/s}}$

$\dot{m}_7 = \dot{m}_y + \dot{m}_{11}$
$\dot{m}_7(h_4) = \dot{m}_y(h_9) + \dot{m}_{11}(h_2)$
$\dot{m}_7(h_4) = \dot{m}_y(h_9) + (\dot{m}_7 - \dot{m}_y)(h_2)$
$100(676) = \dot{m}_y(3154) + (100 - \dot{m}_y)(251)$
$\boxed{\dot{m}_y = 14.63 \text{ kg/s}}$

$\dot{m}_{11} x_{11}(h_{11} - h_1) = \dot{m}_w C_P \Delta T =$
$(85.37)(0.944)(2478)(251) = (4200)(4.18)(\Delta T)$
$\boxed{\Delta T = 10.23°C}$

$Q = \dot{m}_w C_P \Delta T$
$(4200)(4.18)(10.23)$
$\boxed{Q = 21593.9 \text{ kW}}$

$Q_{IN} = \dot{m}_7(h_7 - h_6)$
$= 100(3900 - 676)$
$= 322358$ kW

$P = \dot{m}_7(h_7 - h_9) + \dot{m}_{11}(h_9 - h_{11})$
$= 100(3900 - 3154) + 85.37(3154 - 2478)$
$\boxed{P = 132316.12 \text{ kW}}$

$\eta_{th} = \dfrac{P}{Q_{IN}} = \dfrac{132316.12}{322358}$

$\boxed{\eta_{th} = 41.04\%}$

SUMMARY

Part 1

(a) $Y = 0.0859$
$Z = 0.07484$

(b) $\Delta T = 10.14°C$

(c) $Q = 178.018\ MW$
$P = 134\ MW$
$\eta_{th} = 48.79\%$

Part 2

(a) $Y = 0.1463$

(b) $\Delta T = 10.23°C$

(c) $Q = 21593.9\ kW$
$P = 132310.12\ kW$
$\eta_{th} = 41.04\%$

ANALYSIS:

AS ARE CALCULATION Show the First CASE where there is only one malfunction issue we CAN See that the thermal efficiency is much less than we would expect For A Fully functioning systems. NOW For part 2 CASE we Add Another malfunction issue AS we CAN see the thermal efficiency get even worse I would expect this to happen with two issues A tile trap. I believe my calculation Are Able to show How more issue CAN have AN effect on your efficiency.