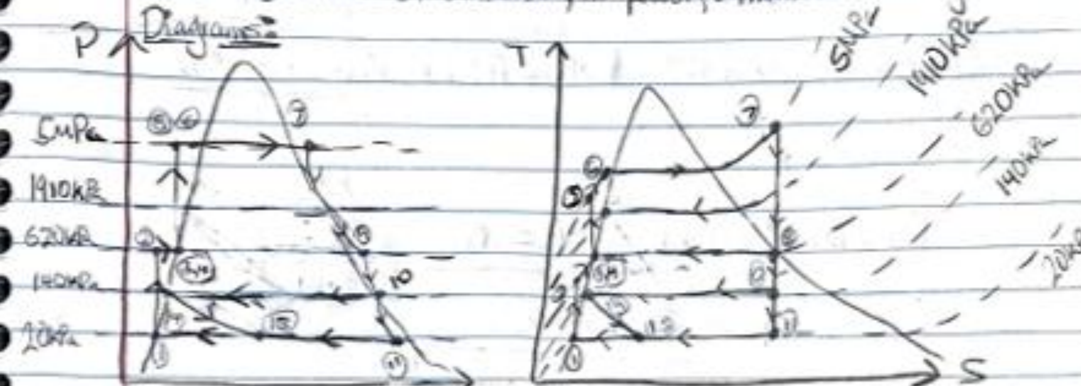
Part 1:

Purpose of question 1: The feedwater heater has a malfunction & completely blocked. Find the mass fraction of y & z for open & closed feedwater heater guarantees a proper cycle. Find cooling water temperature from condenser. Find the rate of heat rejected from the condenser, net power, & Thermal efficiency

Test 2

Purpose of question 2: Both steam traps malfunction. The goal is to find mass fraction of "y" that guarantees proper operation. Finding the temperature of condenser & finding heat rejection of condenser, net power, & Thermal efficiency.

Diagrams:



Source: Canvas slides of Cogeneration and Regenerative Rankine cycle. Also, chapter 10 problems from canvas.

Design Considerations:

I. No friction losses

II. Condensed steam & exit states are ideal states.

III. Mass flow rate of turbine is given.

Data and Variables: $-\dot{m}_T = 100\,kg/s$

- Process states & selected data; From states 1-11 all pressures are given, only temp @ 7, enthalpies are given through states 7-11, and all entropies are given from 7-11. Also all properties used in the problem are given for saturated tables.

Part 2:

Procedure & Calculation:

1 (Pump I)
$P_1 = 20 kPa$
$x_1 = 0$
$v_1 = 0.001017 \frac{m^3}{kg}$
$h_1 = 251.42 kJ/kg$

2
$P_2 = 620 kPa$

$P_2 = 620 kPa$

$h_2 - h_1 = v_1(P_2 - P_1)$ → $w_{I,in}$
↳ $h_2 = 252.0302 \frac{kJ}{kg}$
$w_{I,in} = .6102 \frac{kJ}{kg}$

3
$P_3 = 620 kPa$
$x_3 = 0$
$h_3 = 676$

4 (Pump II)
$P_4 = 620 kPa$
$x_4 = 0$
$h_4 = h_3$
$h_4 = 676 kJ/kg$
$V_4 = .001102 kJ/kg \cdot K$
$h_5 - h_4 = v_4(P_5 - P_4)$ → $w_{II,in} = 4.827 \frac{kJ}{kg}$
$h_5 = 680.815 \frac{kJ}{kg}$

5
$P_5 = 5 MPa$
$h_5 = 681 kJ/kg$

6
$P_6 = 5 MPa$
$h_6 = h_{12}$
$h_{12} = 898 \frac{kJ}{kg}$

7
$P_7 = 5 MPa$
$T_7 = 700°C$
$h_7 = 3400 \frac{kJ}{kg}$
$S_7 = 7.514 \frac{kJ}{kg \cdot K}$
$S_7 = S_8 = S_9 = S_{10} = S_{11}$
$\dot{m}_7 = 100 \frac{kg}{s}$

8 (w)
$P_8 = 1910 kPa$
$h_8 = 3515 \frac{kJ}{kg}$

9 (y)
$P_9 = 620 kPa$
$h_9 = 3154 \frac{kJ}{kg}$

10 (z)
$P_{10} = 140 kPa$
$h_{10} = 2799 \frac{kJ}{kg}$

11
$P_{11} = 20 kPa$
$h_{11} = 2478 \frac{kJ}{kg}$

12
$P_{12} = 1910 kPa$
$X_{12} = 0$
$h_{12} = h_{13}$
$h_{12} = 898 \frac{kJ}{kg}$

13
$P_{13} = 140 kPa$
$h_{13} = 898 \frac{kJ}{kg}$

14
$P_{14} = 140 kPa$
$x_{14} = 0$
$h_{14} = h_{15}$
$h_{14} = 458 \frac{kJ}{kg}$

15
$P_{15} = 20 kPa$
$h_{15} = 458 \frac{kJ}{kg}$

$W_{p,in} = W_{pI,in} + W_{pII,in} \Rightarrow W_{p,in} = 5.403$

Part 3:

Note for question 1:

In the problem it states how FWH at 1910kPa or "w" is blocked. Therefore is steam trap also is not needed.

a.) Find fraction mass of "y" & "z" for open/close FWH for proper cycle.

1st Law on FWH #1: $h_3 - h_2 = z(h_{10}) - h_{14} \Rightarrow$ $\boxed{z = 0.3151}$

1st Law on all mass fraction system:

$$h_4 = h_3 + y(h_9) \Rightarrow \boxed{y = \emptyset}$$

b.) Finding cooling water temperature rise in condenser (°C), water flowrate @ 4200 kg/s, $c_p = 4.18$ kJ/kg·K

$c_p \Delta T_w = h_{2w} - h_{1w}$ $\quad \dot{m}_w(h_{2w} - h_{1w}) = (1-y-z)h_{11} + (y+z)h_{15} - h_1 \Rightarrow$

$\dot{m}_w(c_p \times \Delta T) = \dot{m}_7[(1-z)h_{11} + (z)h_{15} - h_1]$

$$\Delta T_w = \frac{\dot{m}_7[(1-z)h_{11} + (z)h_{15} - h_1]}{\dot{m}_w \times c_p} \Rightarrow \Delta T_w = \frac{100\,\text{kg/s}((1-0.3151)\,[illegible]\,\text{kJ/kg} + (0.3151)\,[illegible]\,\text{kJ/kg} - 251.4\,\text{kJ/kg})}{4200\,\text{kg/s} \times 4.18\,\text{kJ/kg·K}}$$

$\boxed{\Delta T_w = 10.111\,°C}$

c.) Find rate of heat rejection in condenser, net power produced, & thermal efficiency

first [illegible] condenser:

$\dot{Q}_{out} = \dot{m}_7[(1-w-y-z)(h_{11} - h_1) + h_{15}(z)] = 166430.04\,\text{kW} \Rightarrow \boxed{\dot{Q}_{out} = 167\,\text{MW}}$

Net power: $w_{Tout} = h_7 - z(h_{10}) - (1-z)h_{11} \Rightarrow w_{Tout} = 1320.8529\,\text{kJ/kg}$

$w_{pin} = 5.403\,\text{kJ/kg}$

$w_{net} = w_{Tout} - w_{pin} \Rightarrow w_{net} = 1315.45\,\text{kJ/kg}$

$\dot{W}_{net} = \dot{m}_7(w_{net}) \Rightarrow \boxed{131.45\,\text{MW} = \dot{W}_{net}}$

$\dot{Q}_{in} = \dot{m}_7(h_7 - h_6) \Rightarrow 300.2\,\text{MW}$

$$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}} \Rightarrow \boxed{.438 \text{ or } 43.8\%}$$

Part 4:

Note for question 2: Both steam traps suddenly stop. Therefore, mass fraction "z" and states 14 and 15 are negligible.

a) Find mass fraction of "y" extracted on FWH guarantees proper cycle operation.

First law around states 3, 4, 19 to find mass fraction

$$h_4 = h_3 + y(h_{19}) \Rightarrow \boxed{y = \varnothing}$$

b) Find cooling water temp. in condenser °C. Flow rate is 4200 kg/s, $C_p = 4.18$ kJ/kg·K.

Note: First law around condenser, the steam trap going to condenser is negligible and there is no mass fractions.

$C_p \Delta T_w = h_{2w} - h_{1w}$ $\quad \dot{m}_w(h_{w2} - h_{w1}) = (1-y)(h_{11}) - h_1$

$\dot{m}_{cw} \times C_p \Delta T_w = h_{11} - h_1 \Rightarrow \Delta T_w = \dfrac{\dot{m}_7(h_{11} - h_1)}{\dot{m}_{cw} \times C_p} \Rightarrow \boxed{\Delta T_w = 12.68°C}$

c) Rate of heat rejection, produced Net Power, & Thermal efficiency:

$\dot{Q}_{out} = \dot{m}_7(1)(h_{11} - h_1) \Rightarrow \boxed{\dot{Q}_{out} = 222658\text{ kW or } 223\text{ MW}}$

Net Power: $w_{P,in} = 5.402$ kJ/kg $\quad w_{net} = w_{T,out} - w_{P,in}$

$w_{T,out} = h_7 - (1)(h_{11}) \Rightarrow w_{T,out} = 1422$ kJ/kg $\Rightarrow w_{net} = 1416.597$

$\dot{W}_{net} = \dot{m}_7(w_{net}) \Rightarrow \boxed{\dot{W}_{net} = 141654.7\text{ kW or } 142\text{ kW}}$

Thermal efficiency: $\quad \dot{Q}_{in} = \dot{m}_7(h_7 - h_6) \Rightarrow 300.2$ MW

$$\eta_{th} = \frac{\dot{W}_{net}}{\dot{Q}_{in}} \Rightarrow \boxed{\eta_{th} = .473 \text{ or } 47.3\%}$$

Part 5:

Summary:

	Problem 1	Problem 2
y	∅	∅
z	0.3151	Negligible
Temp. Rise (°C)	10.111	12.68
Rate of heat rejected	167 MW	223 MW
$\dot{W}_{net}$	131.45 MW	142 MW
η_{th}	43.8%	47.3%

Analysis: Eliminating the mass fractions caused a shift of everything increasing from question 1 to question 2. The rate of heat rejected or $\dot{Q}_{out}$ saw the greatest increase of 28.7% increase.