TEST 2 - MET350

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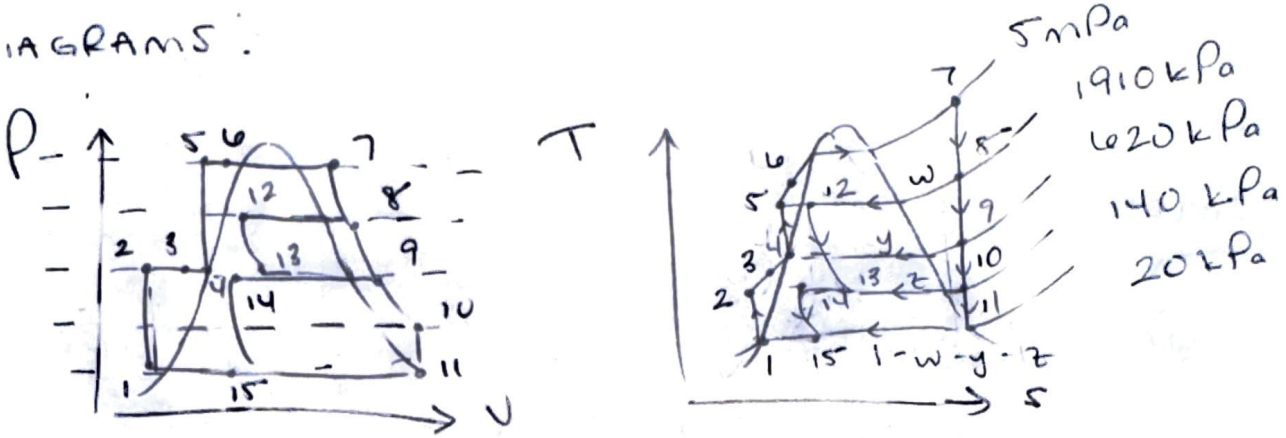
PURPOSE:

DETERMINING EXTRACTED MASS 'y' AND 'z', COOLING WATER TEMP (°C), RATE OF HEAT REJECTED, PRODUCED NET POWER, AND THERMAL EFFICIENCY OF A PLANT W/ ONE THEN TWO STEAM TRAP MALFUNCTIONS.

DIAGRAMS:



SOURCES:

THERMALDYNAMICS AN ENGINEERING APPROACH, 9TH EDITION

DESIGN CONSIDERATION:

STEAM TRAP (12 & 13) MALFUNCTIONS

STEAM TRAP (14 & 15) MALFUNCTIONS

ASSUME 'w' = 0

DATA & VARIABLES:

$\dot{m}_F = 100\ kg/s$

STATE 1 - $P_1 = 20\ kPa$

STATE 2 - $P_2 = 620\ kPa$

STATE 3 - $P_3 = 620\ kPa$

STATE 4 - $P_4 = 620\ kPa$

STATE 5 - $P_5 = 5\ mPa$

STATE 6 - $P_6 = 5\ mPa$

STATE 7 - $P_7 = 5\ mPa$ $T_7 = 700°C$ $h_7 = 3900\ \frac{kJ}{kg}$ $s_7 = 7.514\ \frac{kJ}{kg \cdot k}$

STATE 8 - $P_8 = 1910\ kPa$ $h_8 = 3515\ \frac{kJ}{kg}$ $s_8 = s_7$

STATE 9 - $P_9 = 620\ kPa$ $h_9 = 3154\ \frac{kJ}{kg}$ $s_9 = s_7$

STATE 10 - $P_{10} = 140\ kPa$ $h_{10} = 2799\ \frac{kJ}{kg}$ $s_{10} = s_7$

STATE 11 - $P_{11} = 20\ kPa$ $h_{11} = 2478\ \frac{kJ}{kg}$ $s_{11} = s_7$

DATA TABLE: (SATURATED)

P, kPa	T_{SAT}, °C	v_f, m^3/kg	h_f, kJ/kg	s_g, $kJ/kg \cdot K$
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

MATERIALS:

- WATER

PROCEDURE & CALCULATIONS:

START W/ FINDING ALL 15 STATES,
THEN SOLVE SYSTEM W/ ONE
STEAM TRAP MALFUNCTION

P = CONST.

Processes: 1 →(ISENT)→ 2 →(P CONST.)→ 3 →(MIX)→ 4 →(ISENT)→ 5 →(P CONST.)→ 6 →(P CONST.)→ 7 →(ISENT.)→ 8 →(ISENT.)→ 9 →(ISENT.)→ 10 →(ISENT)→ 11 → 12 → 13 → 14 → 15

1	2	3	4	5	6	7	8	9	10	11	12 / 13	14	15
$P_1 = 20$ kPa	$P_2 = 620$ kPa	$P_3 = 620$ kPa	$P_4 = 620$ kPa	$P_5 = 5$ MPa	$P_6 = 5$ MPa	$P_7 = 5$ MPa	$P_8 = 1910$ kPa	$P_9 = 620$ kPa	$P_{10} = 140$ kPa	$P_{11} = 20$ kPa	MALFUNCTION	$P_{14} = 140$ kPa	$P_{15} = 20$ kPa
$x_1 = 0$		$h_3 = 676\ \frac{kJ}{kg}$	$h_4 = h_3$		$h_6 = 1154.5\ \frac{kJ}{kg}$	$T_7 = 700°C$	$h_8 = 3575\ \frac{kJ}{kg}$	$h_9 = 3154\ \frac{kJ}{kg}$	$h_{10} = 2799\ \frac{kJ}{kg}$	$h_{11} = 2478\ \frac{kJ}{kg}$		$h_{14} = 458\ \frac{kJ}{kg}$	$h_{15} = 676$
$h_1 = 251\ \frac{kJ}{kg}$			$v_4 = 0.001102$			$h_7 = 3900\ \frac{kJ}{kg}$						$x_{14} = 0$	
$T_1 = 60.1°C$													
$v_1 = 0.001017$													

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

$= 251.62\ \frac{kJ}{kg}$

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

$= 680.83\ \frac{kJ}{kg}$

$s_7 = s_8 = s_9 = s_{10} = s_{11} = 7.514\ \frac{kJ}{kg \cdot K}$

* Assuming 'w' is 0 *
due to 12 & 13
malfunction

FIND 'y' AND 'z':

$$y = \frac{h_4 - h_3 (1-w)}{h_9 - h_3}$$

$$y = \frac{0}{3154 - 676} = \boxed{0}$$

1ST LAW CLOSED FWH

$$z (h_{10} - h_{14}) = (1-z)(h_3 - h_2)$$

$$z = \frac{h_3 - h_2}{h_2 + h_{10} - h_{14} - h_3}$$

$$= \boxed{0.2214}$$

COOLING WATER TEMP

$$\dot{m}_f(1-w-y-z)h_{11} + (w+z)h_{15} - (1-y)h_1 = \dot{m}\, C_p \Delta T$$

$$\Delta T = \frac{\dot{m}_f(1-w-y-z)h_{11} + (w+z)h_{15} - (1-y)h_1}{\dot{m}\, C_p}$$

$$= \frac{100(1-0.2214)2478 + (0.2214)676 - (1)251}{4200(4.18)}$$

$$= \boxed{10.984\,^\circ C}$$

HEAT REJECTED

$$Q_{REJECT} = \dot{m}_f C_p \Delta T$$

$$= 4200(4.18)10.984$$

$$= \boxed{192835.104\ kW}$$

W_{NET}

$$= \dot{m}_f\left(\underbrace{W_{out\,7-9}}_{(h_7-h_9)} + \underbrace{W_{out\,9-10}}_{(h_9-h_{10})} + \underbrace{W_{out\,10-11}}_{(h_{10}-h_{11})} - (1-y-z)\underbrace{W_{in\,1-2}}_{(h_2-h_1)} - \underbrace{W_{in\,4-5}}_{(}\right)$$

$$= 100((3900-3154)+(3154-2799)+(2799-2478)-(1-0.2214)*(251-251.61)-(680.48-676))$$

$$= \boxed{141669.51\ kW}$$

$$Q_{IN} = \dot{m}(h_7-h_6)$$

$$= 100(3900-1154.5)$$

$$= 274550\ kW$$

THEMAL EFFICIENCY:

$$\eta_{TH} = \frac{W_{NET}}{Q_{IN}} = \frac{141669.51}{274550} = 0.5160 \rightarrow \boxed{51.60\%}$$

2. * 2ND STEAM TRAP MALFUNCTIONS (14 & 15) *

– y will remain zero –

$$y = \frac{h_4 - h_2}{h_4 - h_3}(1-w)$$

$$\boxed{y = 0}$$

COOLING WATER TEMP.

$$\Delta T = \frac{m_f(1-w-y-z)h_{11} + (w+z)h_{15} - (1-y)h_1}{\dot{m} C_p}$$

(0)

$$= \frac{m_f(1-w-y-z)h_{11} - (1-y)h_1}{\dot{m} C_p}$$

$$= \frac{100(1-0-0-0)2478 - (1-0)251}{4200(4.18)}$$

$$\boxed{\Delta T = 14.101\,^{\circ}C}$$

HEAT REJECTION

$$Q_{REJECTION} = \dot{m}_f C_p \Delta T$$

$$= 4200(4.18)14.101$$

$$= 247557.156\ kW$$

W_{NET}:

$= \dot{m}_f((h_7 - h_{11}) - (h_2 - h_1) - (h_5 - h_4))$

$= 100((3900 - 2478) - (257.62 - 257) - (680.83 - 676))$

$= 141656\ kW$

Q_{IN}: $\dot{m}_f(h_7 - h_6)$

$= 100(3900 - 1184.5)$

$= 274550\ kW$

THERMAL EFFICIENCY:

$\eta_{TH} = \frac{W_{NET}}{Q_{IN}} = \frac{141656}{274550} = 0.5159 \rightarrow 51.59\%$

SUMMARY:

FROM STATEMENT 1 TO 2, WE WATCH THE PLANT BECOME LESS EFFICIENT DUE TO HAVING MALFUNCTIONS IN ITS STEAM TRAPS.

ANALYSIS:

DUE TO THE TWO STEAM TRAPS MALFUNCTIONING, WE KNOW THE 'w' AND 'y' VALUES TO GO TO ZERO. (USING ENERGY BALANCE EQ.) FROM PROBLEM 1 TO 2, OR 'z' VALUE WOULD ALSO FALL TO ZERO. THERE WOULD BE A SLIGHT DECREASE IN NET POWER BETWEEN 1 AND 2 TRAP MALFUNCTIONS. (ALSO IN THE THERMAL EFFICIENCIES)