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MET 350
TEST 2
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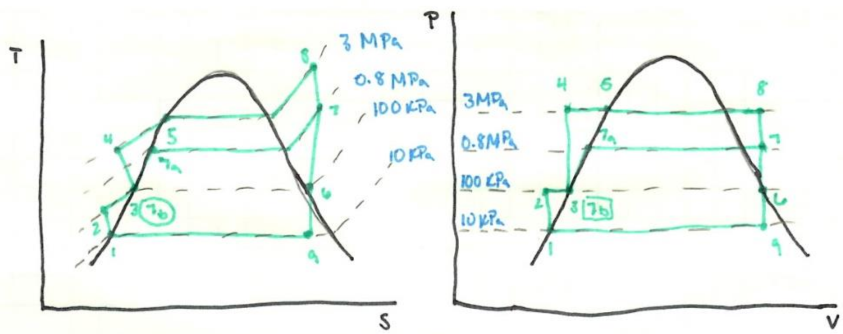
PURPOSE: CALCULATE THE THERMAL EFFICIENCY & SPECIFIC NET WORK OF THE:

1. FULLY OPERATIONAL POWER PLANT
2. POWER PLANT WITH A MALFUNCTIONING CLOSED FEEDWATER HEATER & SUBSEQUENT LINES

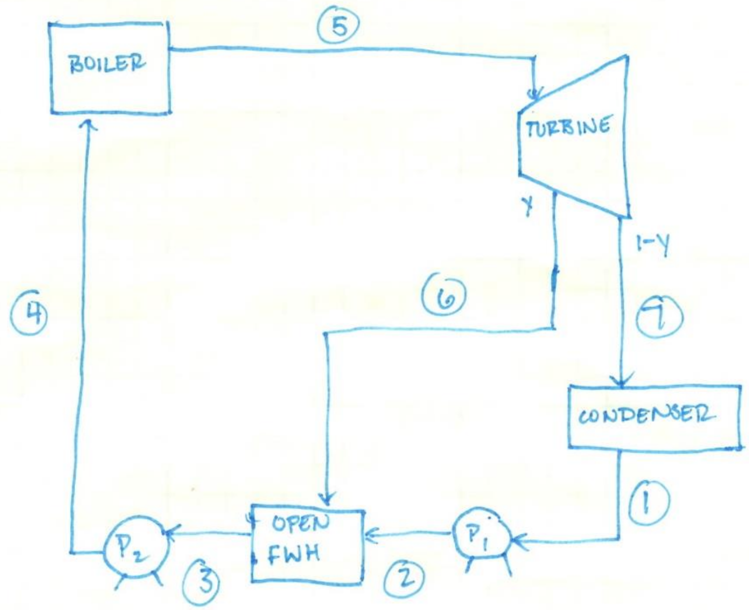
SOURCES: CENGEL & BOLES. "THERMODYNAMICS - AN ENGINEERING APPROACH" 8TH EDITION, McGRAW HILL. 2015

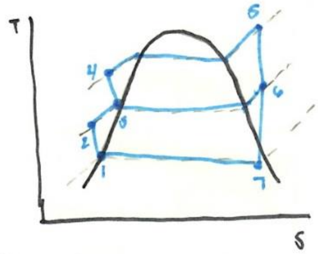
DRAWINGS & DIAGRAMS:

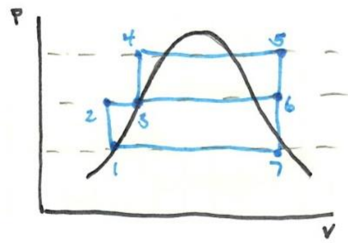
1.



2.







DESIGN CONSIDERATIONS:

1. WATER IS PURE
2. NO HEAT LOSSES IN CONNECTIONS, PIPES
3. NO FRICTION LOSSES FROM FLUID FLOW

DATA + VARIABLES

$P_{TURB\ INLET} = 3\ MPa$ $T_{TURB\ INLET} = 400°C$

$P_{TURB\ EXIT} = 10\ kPa$

$P_{1ST\ EXTRACTION} = 0.8\ MPa$

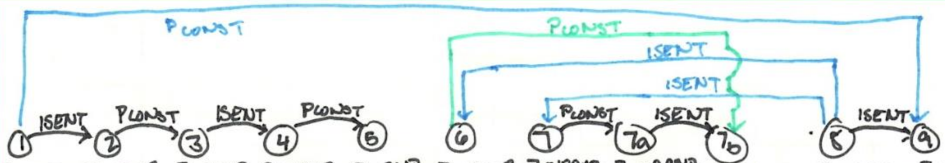
$P_{2ND\ EXTRACTION} = 100\ kPa$

MATERIALS:

WATER

PROCEDURE:

1. FOCUS ON PART 1
2. FIND ALL STATES
3. FIND q_{in} + q_{OUT}
4. DETERMINE η_{TH} + W_{NET}
5. REPEAT FOR ~~PART~~ 2



$P_1 = 10$ kPa, $P_2 = 100$ kPa, $P_3 = 100$ kPa, $P_4 = 3$ MPa, $P_5 = 3$ MPa, $P_6 = 100$ kPa, $P_7 = 100$ kPa, $P_{7a} = 0.8$ MPa, $P_{7b} = 100$ kPa, $P_8 = 3$ MPa, $P_9 = 10$ kPa

State 1: SAT LIQUID
$h_1 = 191.81$ kJ/kg
$v_1 = 0.001010$ m³/kg
$s_1 = 0.6492$ kJ/kg·K

State 3: SAT LIQUID
$h_3 = 417.51$ kJ/kg
$v_3 = 0.001043$ m³/kg
$s_3 = 1.3028$ kJ/kg·K

State 5: SAT LIQUID
$h_5 = 1008.3$ kJ/kg
$v_5 = 0.066667$ m³/kg
$s_5 = 2.6454$ kJ/kg·K

State 7a: SAT LIQUID
$h_{7a} = 720.87$ kJ/kg
$s_{7a} = 2.0457$ kJ/kg·K
$v_{7a} = 0.001115$ m³/kg

State 7b: SAT LIQ
$h_{7b} = 417.51$ kJ/kg
$s_{7b} = 1.3028$ kJ/kg·K
$v_{7b} = 0.001043$ m³/kg

State 8: $T_8 = 400°C$
SUPERHEATED
$h_8 = 3231.7$ kJ/kg
$s_8 = 6.9235$ kJ/kg·K
$v_8 = 0.09938$ m³/kg

$s_2 = s_1$
$s_2 = 0.6492$ kJ/kg·K
$h_2 = h_1 + w_{p1,in}$
$w_{p1,in} = v_1(P_2 - P_1)$
$= 0.00101(100-10)$
$= 0.0909$ kJ/kg
$h_2 = 191.81 + 0.0909$
$= 191.901$ kJ/kg

$s_4 = s_3$
$s_4 = 1.3028$ kJ/kg·K
$h_4 = h_3 + w_{pII,in}$
$w_{pII,in} = 0.001043(3000-100)$
$= 3.0247$ kJ/kg
$h_4 = 417.51 + 3.0247$
$= 420.5347$ kJ/kg

$s_7 = s_8$
$= 6.9235$ kJ/kg·K
SUPERHEATED
$h_7 = 2892.4$ kJ/kg

$s_6 = s_8$
$s_6 = 6.9235$ kJ/kg·K
$x_6 = \frac{s_6 - s_f}{s_{fg}}$
$= \frac{6.9235 - 1.3028}{6.0562}$
$= 0.9281$
$h_6 = 417.51 + (0.9281)(2257.5)$
$= 2512.67$ kJ/kg

$s_9 = s_8$
$= 6.9235$ kJ/kg·K
$x_9 = \frac{s_9 - s_f}{s_{fg}}$
$= \frac{6.9235 - .6492}{7.4996}$
$= 0.83661$
$h_9 = h_f + x_9 h_{fg}$
$= 191.81 + (0.83661)2392.1$
$= 2193.08$

$$y = \frac{h_5 - h_4}{h_7 - h_{7a}} = \frac{1008.3 - 420.5347}{2892.4 - 720.87}$$
$= .2704$

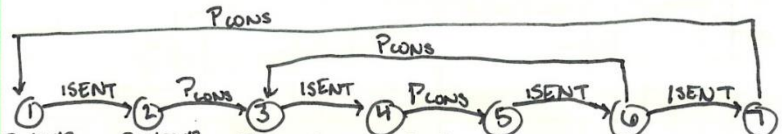
$$z = \frac{(h_3 - h_2) - y(h_{7b} - h_2)}{h_6 - h_2}$$
$$= \frac{(417.51 - 191.901) - (.2706)(417.51 - 191.901)}{2612.67 - 191.901}$$
$= 0.07091$

$q_{in} = h_8 - h_5$
$= 3231.7 - 1008.3$
$= 2223.4$ kJ/kg
$q_{out} = (1 - y - z)(h_9 - h_1)$
$= 1317.76$ kJ/kg

$w_{net} = q_{in} - q_{out}$
$= 2223.4 - 1317.76$
$=$ **905.64 kJ/kg**

$\eta_{TH} = 1 - \frac{q_{out}}{q_{in}}$
$=$ **40.73 %**

2



$P_1 = 10\ KPa$ $P_2 = 100\ KPa$ $P_3 = 100\ KPa$ $P_4 = 3\ MPa$ $P_5 = 3\ MPa$ $P_6 = 100\ KPa$ $P_7 = 10\ KPa$

SAT LIQUID
$h_1 = 191.81\ KJ/Kg$
$S_1 = 0.6492\ KJ/Kg \cdot K$
$V_1 = 0.00101\ m^3/Kg$

SAT LIQUID
$h_3 = 417.51\ KJ/Kg$
$S_3 = 1.3028\ KJ/Kg \cdot K$
$V_3 = 0.001043\ m^3/Kg$

$T_5 = 400°C$
SUPERHEATED
$h_5 = 3231.7\ KJ/Kg$
$S_5 = 6.9235\ KJ/Kg \cdot K$
$V_5 = 0.09938\ m^3/Kg$

$S_7 = S_6$
$S_7 = 6.9235\ KJ/Kg \cdot K$
$x_7 = \frac{S_7 - S_f}{S_{fg}}$
$= \frac{6.9235 - .6492}{7.4996}$
$= .836618$
$h_7 = h_f + x_7 h_{fg}$
$= 2193.1\ KJ/Kg$

$w_{p_I,in} = V_1 (P_2 - P_1)$
$= .0909$
$h_2 = h_1 + w_{p_I in}$
$= 191.901\ KJ/Kg$
$S_2 = S_1$
$S_2 = 0.6492\ KJ/Kg \cdot K$

$w_{p_{II},in} = V_3 (P_4 - P_3)$
$= 3.0247$
$h_4 = h_3 + w_{p_{II} in}$
$= 420.535\ KJ/Kg$
$S_4 = S_3$
$S_4 = 1.3028\ KJ/Kg \cdot K$

$S_6 = S_5$
$S_6 = 6.9235\ KJ/Kg \cdot K$
$x_6 = \frac{S_6 - S_f}{S_{fg}}$
$= \frac{6.9235 - 1.3028}{6.0562}$
$= .9281$
$h_6 = h_f + x_6 h_{fg}$
$= 2612.69$

$y = \frac{\dot{m}_6}{\dot{m}_5}$

$q_{in} = h_5 - h_4$
$= 3231.7 - 420.535$
$= 2811.165$

$y = \frac{h_3 - h_2}{h_6 - h_3}$
$= \frac{417.51 - 191.902}{2612.69 - 417.51}$
$= .10768$

$q_{OUT} = (1 - y)(h_7 - h_1)$
$= .89231 (2193.1 - 191.81)$
$= 1785.79\ KJ/Kg$

$W_{NET} = q_{in} - q_{OUT}$
$= 2811.165 - 1787.79$
$= \boxed{1025.37\ KJ/Kg}$

$\eta_{TH} = 1 - \frac{q_{OUT}}{q_{in}}$
$= \boxed{36.4\%}$

SUMMARY:

	FULLY FUNCTIONAL	MALFUNCTION
w_{net}	906.64 KJ/Kg	1025.37 KJ/Kg
η_{TH}	40.73 %	36.4%

ANALYSIS:

THE MALFUNCTIONING SYSTEM WAS LESS EFFICIENT THAN THE FULLY FUNCTIONAL SYSTEM. IT HELPS TO PREHEAT THE WATER BEFORE ENTERING THE BOILER. IT ALLOWS THE SYSTEM TO BECOME MORE EFFICIENT AS IT ~~REQUIRES~~ ~~DOES NOT REQUIRE~~ DOES NOT MIX.