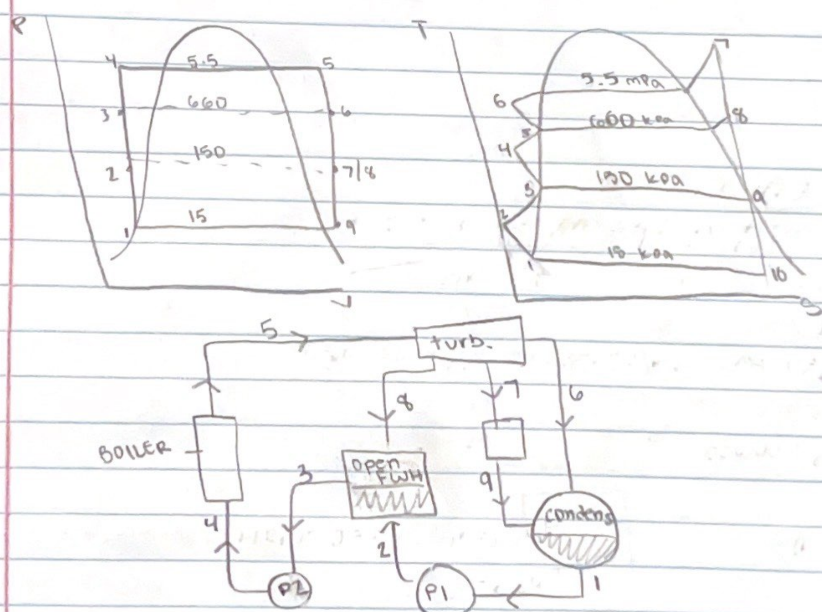
TEST 2 - MET 350 - KAYLA DAVIES

PURPOSE: A manufacturing plant is using steam & the regenerative cycle... determine A, the utilization factor, B, Pv/Ts diagrams, C, turbine work per kg, D, mass flow steam, e, heat supplied, f, all states, g, mass fractions y_2 & y_1, and h, rate of heat removed.

DIAGRAMS



SOURCES

Cengel & Boles. Thermodynamics - An Engineering approach 8th edition. Mcgraw hill. 2015.

DESIGN CONSIDERATIONS

- pumps & turbines are isentropic
- no heat losses in pipes / fluid friction losses

DATA + VARIABLES:

$P_{out} = 50000$ kW, $P_1 = 15$ kPa, $P_8 = 150$ kPa, $P_4 = 660$ kPa $P_4 = P_5$ $P_8 = P_4$ $P_9 = P_1$

$P_7 = 5.5$ $T_5 = 500°C$ $x_2 = x_1$

MATERIALS:

- Air as an ideal gas, steam

PROCEDURE & CALCULATIONS

First, I will start by finding all states for part f.

①	②	③	④	⑤	⑥	⑦
$P_1 = 15$ kPa	$h_2 = 0.1369 + 225.9$	$P_3 = 150$ kPa	$h_4 = 0.474 + 467.13$	$P_5 = 660$ kPa	$h_6 = 5.4 - 670.38$	$P_7 = 5.5$ MPa $= 5500$ kPa
$h_1 = 225.94$ kJ/kg	$h_2 = 226.007$	$h_3 = 467.13$ kJ/kg	$h_4 = 467.6$	$h_5 = 670.38$	$h_6 = 675.77$ kJ/kg	$h_7 = 3429$ kJ/kg
$v_1 = 0.00101$ m3/kg		$v_3 = 0.001053$	$P_4 = 660$ kPa	$v_5 = 0.001101$		$s_7 = 6.93$ kJ/kg

⑧	⑨	⑩
$P_8 = 660$ kPa	$P_9 = 150$ kPa	
$h_8 = 2846.22$	$s_f = 1.434$ kJ/kg	
$s_8 = 6.93$	$s_{fg} = 5.7894$	

$w_{1-2} = v_1(P_2 - P_1) = 0.001014(150 - 15) = 0.137$ kJ/kg

$w_{3-4} = v_3(P_4 - P_3) = 0.001053(660 - 150) = 0.537$ kJ/kg

$w_{5-6} = 0.001101(5500 - 660) = 5.328$ kJ/kg

$6.93 = 1.4337 + x(5.7894) \Rightarrow x = 0.9494$

$h_9 = h_f + h_{fg} = 467.13 + 0.9494 \times 2226 = 2580.5$

$6.93 = 0.7549 + x(7.2522) \Rightarrow x = 0.8515$

$h_{10} = 225.94 + 0.8518(2372.3) = 2246.67$

a) now I am calculating the utilization using the input, output, and fraction of steam extracted.

$Q_{in} = h_5 - h_4 = 670.38 - 467.6 = 202.78$ kJ/kg

$Q_{out} = (1-y)(h_7 - h_1) = (1-0.459)(3429 - 225.14) = 1733.29$

$y = \frac{h_{10} - h_2}{h_8 - h_3 + h_{10} - h_2} = \frac{2246.67 - 226.07}{2846.22 - 467.13 + 2246.07 - 226.07} = \boxed{0.459}$ ← (g) mass fraction $y_2 = y_1$

$E_U = 1 - \frac{Q_{out}}{Q_{in}} = \frac{1733.29}{202.78} = \boxed{7.54}$

c) to find the turbine work per kg, I will use the Wturb equation

$w_{turb_{out}} = (h_5 - h_6) + (1-y)(h_6 - h_7)$
$= (670.38 - 657.77) + (1 - 0.459)(657.77 - 3429)$
$\boxed{= -1486.6 \text{ kJ/kg}}$

d) to find the mass flow of steam, I will use an equation from problem 10-77 using 50000 kW as W_{net}.

$W_{net} = \dot{m}_T(h_6 - h_7) + (1-0.459)(h_7 - h_8) - (1-y)(h_2 - h_1) - (h_5 - h_4)$

$50000 = \dot{m}_T(657.77 - 3429) + (1-0.459)(3429 - 2846.22) - (1-0.459)(226.07 - 225.14) - (202.78)$

$50000 = \dot{m}_T(-2659.23)$

$\boxed{\dot{m}_T = -18.8}$

e) TO FIND THE HEAT SUPPLIED TO THE TURBINE, I WILL USE Qin from states 4 to 5.

$Q_{turb} = Q_{in} = h_5 - h_4 = \boxed{202.78 \text{ kJ/kg}}$

h) to find the rate of heat removed, I will use the mass flow and enthalpies.

$Q_{removed} = \dot{m}(h_9 - h_1)$
$= -18.8(2580.5 - 2846.22)$
$\boxed{= 4995.5 \text{ kJ/kg}}$

SUMMARY:

A manufacturing facility using steam power plants to generate electricity operates on a regenerative cycle. The utilization, diagrams, turbine work, mass flow steam, heat supplied, the states, as well as the mass fractions & heat removed. They were done a little out of order due to the states needing to be found first, and then the mass friction factor needing to be calculated to find the Qout.

ANALYSIS

For some reason, most of my numbers were negative, but I found the utilization to be 7.54, the turbine work to be -1486.6, the mass flow of steam to be -18.8 and the heat supplied to the turbine to be 202.78.1 used equations from the regenerative rankine cycle & cogeneration powerpoints.