Mech 262
Assignment #4
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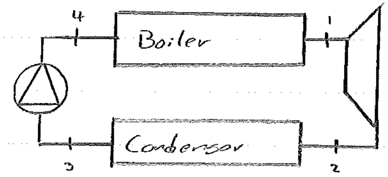
#1

Given: A Rankine Cycle producing 100×10^6 W



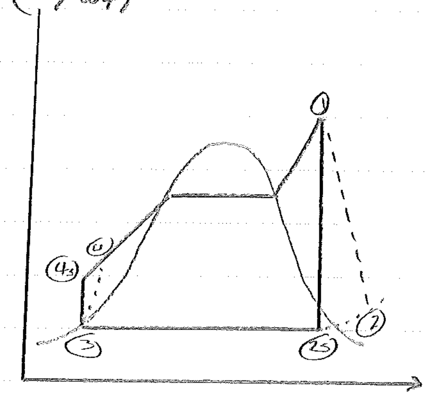
$P_1 = 15$ MPa, $T_1 = 600°C$, $P_2 = 10$ kPa, $\eta = 0.85$, $P_{4-1} = 5\%$

Find: a) Thermal Efficiency

b) Mass flow rate (kg/h)

c) Back work ratio (W_P/W_T)

State	T (°C)	P (kPa)	v	h	s	Cond
1	600 *	15000 *		3582.3	6.6776	Super
2s		10 *		2114.92	6.6776	
2		10		2335.03		
3		10	0.00101	191.83	0.6493	Sat. Liq.
4s		15750		207.73	0.6493	
4		15750		210.54		



h_1 and s_1 from table A-6 given T_1 and P_1, $P_2 = P_{2s} = P_1$, $P_4 = (105\%)(P_1) = 15750$, $s_{2s} = s_1$

$\eta_T = \frac{h_1 - h_2}{h_1 - h_{2s}} \Rightarrow \eta_T(h_1 - h_{2s}) = h_1 - h_2 \Rightarrow h_2 = h_1 - \eta_T(h_1 - h_{2s}) = 3582.3 - 0.85(3582.3 - 2114.92) = 2335.03$

$x_2 = \frac{s_2 - s_f}{s_g - s_f} = \frac{6.6776 - 0.6493}{8.1502 - 0.6493} = 0.803677$ $h_{2s} = h_f + x(h_g - h_f) = 191.83 + (0.803677)(2584.7 - 191.83) = 2114.92$

h_3, s_3 and v_3 from table A-5 given P_3 $h_{4s} = h_3 + v_3\Delta P = 191.83 + 0.00101(15750 - 10) = 207.73$

$s_{4s} = s_3$ $\eta_P = \frac{h_{4s} - h_3}{h_4 - h_3}$ $h_4 - h_3 = \frac{h_{4s} - h_3}{\eta_P}$ $h_4 = h_3 + \frac{h_{4s} - h_3}{\eta_P} = 191.83 + \frac{207.73 - 191.83}{0.85} = 210.536$

$\eta = \frac{W_{ant}}{Cost} = \frac{(h_1 - h_2) - (h_4 - h_3)}{h_1 - h_4} = \frac{(3582.3 - 2335.03) - (210.54 - 191.83)}{(3582.3 - 210.54)} = 0.3644 = \boxed{36.44\%}$ ✓

$W_{net} = W_{Turb} - W_{pump} = \dot{m}(h_1 - h_2) - \dot{m}(h_4 - h_3) \Rightarrow \dot{m} = \frac{W_{net}}{(h_1 - h_2) - (h_4 - h_3)}$

$\dot{m} = \frac{100\times10^6}{(3582.3 - 2335.03) - (210.54 - 191.83)} = 81396.1 \text{ kg/s} = \boxed{2.93\times10^8 \text{ kg/h}}$ ✓

$BWR = \frac{W_P}{W_T} = \frac{\dot{m}(h_4 - h_3)}{\dot{m}(h_1 - h_2)} = \frac{210.54 - 191.83}{3582.3 - 2335.03} = \boxed{0.015}$ ✓

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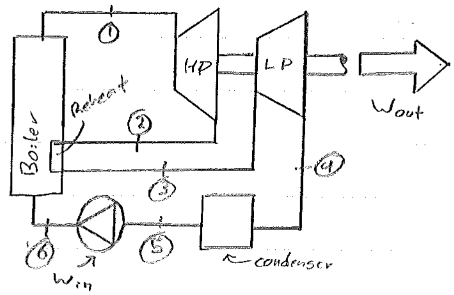
#2

Given: A Rankine Cycle:



$P_1 = 9$ MPa $T_1 = 600°C$ $T_3 = 500°C$

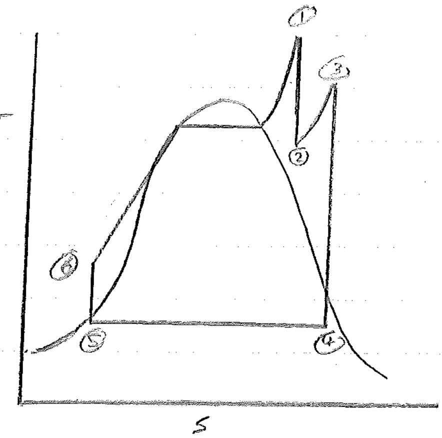
$P_4 = 7.5$ kPa $\dot{m} = 150$ kg/s

Find: a) Net Power,

b) Rate of heat transfer to working fluid in the reheat process

c) Thermal Efficiency d) Rate of heat transfer if reheated to 550°C

State	T °C	P kPa	V	h	s	Cond
1	600 *	9000 *		3633.7	6.9589	Super
2	138.88	331.4		2729.87	6.9589	Sat Vapor
3	500 *	331.4		3485.65	8.2831	Super
4		7.5 *		2584.1	8.2831	
5	40.29	7.5	0.001008	168.79	0.5764	Sat Liquid
6		9000		177.854		



$P_6 = P_1$, $P_5 = P_4$, h_1 and s_1 from Table A-6 given T_1 and P_1, $s_2 = s_1$

Since ② is saturated vapor T_2, P_2 and h_2 interpolated from table A-5 given s_2, $P_3 = P_2$

Given T_3 and P_3, interpolate from Table A-6 to find h_3 and s_3, $s_4 = s_3$

$x_4 = \frac{s_4 - s_f}{s_g - s_f} = \frac{8.2831 - 0.5764}{8.2515 - 0.5764} = 1.004$ $h = h_f + x(h_g - h_f) = 168.79 + (1.004)(2574.8 - 168.79) = 2584.71$

Since ⑤ is saturated liquid T_5, h_5 and s_5 from Table A-5

$h_6 = h_5 + v_5 \Delta P = 168.79 + 0.001006(9000 - 7.5) = 177.854$

$W_{net} = W_{HP} + W_{LP} - W_P = \dot{m}[(h_1 - h_2) + (h_3 - h_4) - (h_6 - h_5)] = 150[(3633.7 - 2729.87) + (3485.65 - 2584.1) - (177.854 - 168.79)]$

$= 269447$ kJ/s $=$ **269.4 MW**

$\dot{Q} = \dot{m}(h_3 - h_2) = 150(3485.65 - 2729.87) =$ **113367 kJ/s**

$\eta = \frac{(h_1 - h_2) + (h_3 - h_4) - (h_6 - h_5)}{(h_1 - h_6) + (h_3 - h_2)} = \frac{(3633.7 - 2729.87) + (3485.65 - 2584.1) - (177.854 - 168.79)}{(3633.7 - 177.854) + (3485.65 - 2729.87)} = 0.4895$

$= 0.398153$

$=$ **48.95%**

#2 cont...

State	T	P	v	h	s	Cond
✓ 1	600 *	9000 *		3633.7	6.9589	Super
✓ 2	138.88	331.4		2729.87	6.9589	Sat Vapor
3	550 *	331.4		3594.3	8.54731	Super
4		7.5 *		2667.53	8.54731	
✓ 5	40.29	7.5	0.001008	168.79	0.5764	Sat Liquid
✓ 6		9000		177.854		

Data for states ①, ②, ⑤ and ⑥ given ✓

Given P_2 and T_2 interpolate from Table A-6 to find

(0.30)

500	3486.0	8.3251
550	3594.8	8.5892
600	3703.2	8.5892

(0.40) →

500	3484.9	8.1913
550	3593.65	8.4558
600	3707.4	8.4558

300	3594.6	8.5892
331.4	3594.3	8.54731
400	3593.65	8.4558

$s_4 = s_3$ $\quad x_4 = \frac{s_4 - s_f}{s_g - s_f} = \frac{8.54731 - 0.5764}{8.2515 - 0.5764} = 1.03854$

$h_4 = h_f + x(h_g - h_f) = 168.79 + 1.03854(2576.8 - 168.79) = 2667.53$

$\dot{Q} = \dot{m}(h_3 - h_2) = 150(3594.3 - 2729.87) = \boxed{129665 \text{ kJ/s}}$ ✓

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