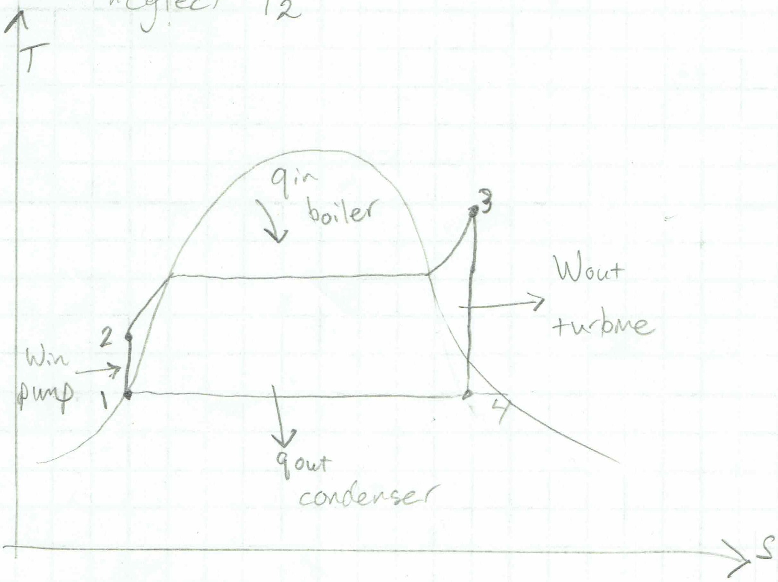
100%

1) a) Draw T-S diagram of steam turbine cycle. (Rankine)

b) What is temp, pressure, enthalpy at each state?

neglect T_2

Max Power out = 300 kW



1	2	3	4
$T_1 = 45.81$ (°C) (sat. liq)	~~T_2~~	$T_3 = 400$	
$P_1 = 10$ (kPa)	$P_2 = 4000$	$P_3 = P_2 = 4000$	$P_4 = P_1 = 10$
$h_1 = h_f = 191.81$ (kJ/kg)	$h_2 = .195.8$	$h_3 = 3214$	$h_4 = 2144.6$
$s_1 = s_f = .6492$ (kJ/kgK)	$s_2 = s_1 = .6492$	$s_3 = 6.7714$	$s_4 = 6.7714$
$v_1 = .00101$			

units?

$$h_2 = v_1(P_2 - P_1) + h_1$$
$$= .00101(3{,}990{,}000) + 191.81$$
$$= 195.8$$

$$\frac{h_4 - 191.81}{2392.1} = \frac{6.7714 - .6492}{7.4996}$$

$$h_4 = 2144.6$$

c) What is the quality of steam exhausted from turbine

$$\boxed{x = .816}$$

d) What is the efficiency of this cycle?

$$\eta = \frac{(h_3 - h_4) - (h_2 - h_1)}{h_3 - h_2} = \frac{(3214 - 2145) - (195 - 192)}{3214 - 195.8} = \frac{1065}{3018.2} = \boxed{35.3\%}$$

e) What $\dot{m}_{steam}$ is req in the cycle?

$$\dot{W}_T = \dot{m}(h_3 - h_4)$$
$$\dot{W}_p = \dot{m}(h_2 - h_1)$$

$$\dot{W}_{net} = \dot{W}_T - \dot{W}_p = 300\text{ KW} = \dot{m}\left[(h_3 - h_4) - (h_2 - h_1)\right]$$

$$\dot{m} = 300.\text{ KW} / (3214 - 2144) - (195.8 - 191.8)$$

$$\boxed{\dot{m} = .2814 \frac{kg}{s}}$$

f) What power is req. by the pump.

$$\dot{W}_{pump} = \dot{m}(h_2 - h_1) = .2814 \tfrac{kg}{s}(195.8 - 191.8)\tfrac{kJ}{kg} = \boxed{1.126\text{ kW}}$$

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2) If turbine from #1 has isentropic efficiency of $90\% = \eta_T$

what $\dot{m}$ is req for max power output?

$$.9 = \frac{h_3 - h_{4a}}{h_3 - h_{4s}} = \frac{3214 - h_{4a}}{3214 - 2144.6} \quad \therefore \quad h_{4a} = 2251 \frac{kJ}{kg}$$

$$\dot{m} = \dot{W}_{net} / (h_3 - h_{4a}) - (h_2 - h_1) = 300\text{ KW} / (3214 - 2251) - 4 \Rightarrow \boxed{\dot{m} = .3128 \frac{kg}{s}}$$

3) A company is dev. concentrating solar troughs, heat R-134a for a Rankine cycle.

Single trough rated for 400 psia can heat R134a 100 → 300 °F @ 8.8 lbm/hr

- assume ideal Rankine cycle

a) What $\dot{m}$ req to produce 10 kW from turbine? What assumptions have you made?

$$\frac{10\ \text{kW}}{} \left| \frac{3412.14\ \frac{Btu}{hr}}{1\ \text{kW}} \right. = 34121.4\ \frac{Btu}{hr}$$

1	2	3	4
$P_1 = 139$ psia	$P = 400$ psia	$P = 400$ psia	$P_4 = P_1 = 139$ psia
	$T = 100$ °F	$T = 300$ °F	
$h_1 = 45.13$	$h_2 = 45.13$ Btu/lbm	$h = 159.95$	$h_4 = 146.91$
$s = .09183$ ⟷	$s = s_f = 0.09183$	$s = .26853$ ⟷	$s_4 = .26853$
$v_1 = .01386$			

- assume the R-134a is a sat. liquid at point 2 b/c we don't have tables for the compressed liquid. Use the S value that correspond to [100°F and 139 psia]
- assume R-134a is sat. liq. @ point 1, so find values based on $s_1 = s_2$
  ↳ h_1, s_1, v_1

h_4 @ 139 psia

140 psia: $\frac{.26853 - .26731}{.27457 - .26731} = \frac{h - 146.22}{151.22 - 146.22}$

$h_{140} = 147$

120 psia: $\frac{.26853 - .2637}{.27102 - .2637} = \frac{h - 141.96}{146.86 - 141.96}$

$h_{120} = 145.19$

@ 139 psia: $\frac{19}{20} = \frac{h - 145.19}{147 - 145.19}$

$h_4 = 146.91$

$$\dot{m} = \dot{W}_{net} / (h_3 - h_4) - (h_2 - h_1) = \frac{34121.4\ \frac{Btu}{hr}}{(159.95 - 146.91) - (0)\ \frac{Btu}{lbm}}$$

$(h_2 - h_1)$:
- zero b/c our assumption made it so
- small value anyway

$$\boxed{\dot{m} = 2617\ \frac{lbm}{hr}}$$

b) How many troughs are req. to produce 10 kW net?

$$\frac{2617\ \frac{lbm}{hr}}{8.8\ \frac{lbm}{hr}} = \boxed{297\ \text{troughs}}$$

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