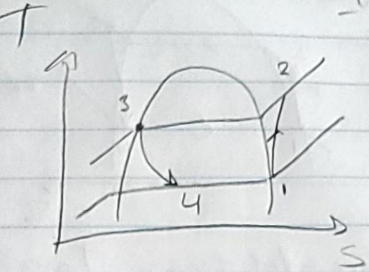
Home work 10. I pledge my honor that I have abided by the Stevens Honor System



1. condenser pressure = 900 kPa
temp (inlet) = $-5°C$, R-134a.

$COP_R = \frac{q_L}{w_{net,in}} = \frac{h_1 - h_4}{h_2 - h_1}$

$h_1 = h_{sat\ vapor @ -5°C} \approx 247.3$ kJ/kg.

$s_2 = s_1 \approx 0.93475$ kJ/kg·k

$P_2 = 900 kPa \Rightarrow h_2 \approx 274$ kJ/kg

$h_3 = h_{sat\ liq @ 900kPa} = 101.62$ kJ/kg
$h_4 = h_3 = 101.62$ kJ/kg

$\frac{h_1 - h_4}{h_2 - h_1} =$

$COP_R = \frac{247.3 - 101.62}{274 - 247.63} = 5.524$

$COP_{R,max} = \frac{1}{T_H/T_L - 1} = \frac{1}{0.15} = 6.62$

$T_L = -5°C = 268.15K$
$T_H = 35.51°C = 308.66K$

$\boxed{\begin{array}{l}\text{Actual COP} = 5.524 \\ \text{Theoretical COP} = 6.62\end{array}}$

2. $2000\ lbm \times \frac{144\ Btu}{1\ lbm\ ice} = 288000$ Btu reached $= Q_L$

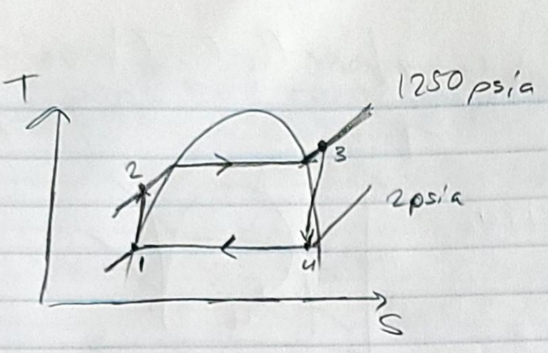
$COP_{R,max} = \frac{1}{T_H/T_L - 1} = \frac{1}{\frac{531.67}{491.67} - 1} = 12.292$
$T_H = 72°F = 531.67R$
$T_L = 32°F = 491.67R$

$COP_R = \frac{q_L}{w_{net,in}} \Rightarrow 12.292 = \frac{288000}{w_{net,in}} \Rightarrow w_{net,in} = \frac{288000}{12.292} = 23429$ Btu

$\frac{23429\ Btu}{1\ hr} = \frac{1\ hp}{2544.5\ Btu/h} = \boxed{9.21\ hp}$

$9.21\ hp \times \frac{0.74570\ kW}{1\ hp} = \boxed{6.87\ kW.}$

3,



(a) Turbine inlet temp = $T@3$.

$S_3 = S_4 = x_4 \cdot S_{fg} + S_f = (0.9 \cdot 1.74444) + 0.17499 = 1.7450 \frac{Btu}{lbm \cdot R}$

$T_3 = 1200 + 200 \cdot \frac{1.7450 - 1.6993}{1.7649 - 1.6993} = \boxed{1339.28\ °F}$

(b) Heat addition in boiler = Rate of $\frac{\Delta h}{\dot{m}}$, $\Delta h = h_3 - h_2$

$h_3 = 1614.5 + (1729.8 - 1614.5) \cdot \frac{1339.28 - 1200}{200} = 1694.80 \frac{Btu}{lbm}$

$\dot{W}_{pump,in} = \dot{m}(h_2 - h_1)$

$h_1 = h_f @ 2_{psia} = 94.02\ Btu/lbm$

$3.75 = (h_2 - 94.02) \Rightarrow h_2 = 3.75 + 94.02 = 97.77 \frac{Btu}{lbm}$

$\frac{\Delta h}{\dot{m}} = \frac{1694.80 - 97.77 \frac{Btu}{lbm}}{75 \frac{lbm}{s}} = \boxed{21.294\ Btu/s}$

(c) $\eta = \frac{w_{net}}{q_{in}} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{h_4 - h_1}{h_3 - h_2}$

$h_3 = 1694.80$ $\quad h_2 = 97.77$

$h_1 = 94.02$ $\quad h_4 = h_f + x_4 \cdot h_{fg} = 94.02 + 0.9 \cdot 1021.7 = 1013.55$

$\eta = 1 - \frac{1013.55 - 94.02}{1694.80 - 97.77} = 0.424 = \boxed{42.4\%}$

4. $\dot{Q}_{cond} = -kA\frac{dT}{dx}$, $k = 0.69$, $A = 4 \times 7 = 28 m^2$, $dT = 8 - 26 = -18$, $dx = 0.3$.

$= -0.69 \cdot 28 \cdot \frac{(-18)}{0.3} = \boxed{1159.2 W}$

5. $\dot{Q}_{conv} = 2{,}190 \frac{kJ}{kg \cdot K} \cdot 30 K \cdot 0.3 \frac{kg}{s} = 19.71 \frac{kJ}{s} = 19.71\ kW$

$A_s = \pi d \cdot l = \pi(0.05) \cdot 10 = 1.57 m^2$.

$T_s - T_\infty = 100 - 20 = 80 K$

$19710 = 80 \cdot 1.57 \cdot h$

$\boxed{h = 156.85 \frac{W}{m^2 \cdot K}}$

It can be increased by changing the fluid velocity, which would increase $\dot{Q}$.

6. $\dot{Q}_{total} = h_{combined} \cdot A_s \cdot (T_s - T_\infty)$

$A_s = 1.7\,m^2$, $T_s = 32°C$ $T_{surr} = 18°C$

$h_{combined} = h_{conv} + \varepsilon\sigma(T_s + T_{surr})(T_s^2 - T_{surr}^2)$, $h_{conv} = 5\,W/m^2.K$

$= 5 + 0.9 \cdot 5.670 \cdot 10^{-8}(32-18)((32+273.15)^2 + (18+273,15)^2)$

$h_{combined} = 5 + 0,005964 = 5,00596\ W/m^2.K$

$\dot{Q}_{total} = 5,00596 \cdot 1.7 \cdot (32-18) = \boxed{119,142\ W}$