Cycle Review

Over the past several weeks we've discussed cycles for power generation and providing heating or cooling. The basics behind the solution for any of these cycles:

1) Look at the temperatures of the reservoirs that the system is operating between, from this you can calculate the maximum efficiency or performance of the cycle relative to Carnot.

2) Draw a table and fix the states of the cycle, then plot these states to make sure they make sense.

3) Analyze the components of the system.

4) Compare ideal system performance with actual system performance found in #3.

If you can accomplish these, you've transfixed ME301 down.

Basically, the only thing holding you back is the size & of components some of these cycles can have.
Example: Heat powered refrigeration cycle with R134a:

1. Rankine Cycle
   \( q = 0.75 \), \( n = 0.72 \)

2. Upper Compression Refrigeration
   \( T = 40^\circ C \)

3. \( T = 40^\circ C \)
   \( T_{\text{in}} = 0 \)

4. Condenser
   \( T = 0^\circ C \)

5. Evaporator
   \( T = -10^\circ C \)
   \( Q = 54.6 \text{ kW} \)

Find:
   A) Mass flow rate through Evaporator.
   B) Mass flow rate through Boiler.
   C) Mass flow rate through cycle.
   D) COP for cycle.
   E) Max possible COP for cycle.

Max COP for cycle... is this a heat engine or a fridge? Well both.

\[ \text{COP}_{\text{Max}} = \frac{\text{COP}_R}{\text{COP}_E} \]

\[ \text{COP}_R = \frac{T_c}{1/4 - T_c} = \frac{283}{3/14 - 283} = 5.26 \]

\[ \text{COP}_E = 1 - \frac{T_c}{1/4} = 1 - \frac{313}{368} \Rightarrow \text{COP}_E = 0.15 \]

\[ \text{COP}_{\text{Max}} = 0.789 \] Wow low

Let's see what we can actually get.
\[
\begin{align*}
\text{States: } & S_0, S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}, S_{13}, S_{14}, S_{15} \\
\text{Condition: } & P = 10, Q = 20, R = 30, S = 40, T = 50, U = 60, V = 70, W = 80, X = 90, Y = 100 \\
\text{Solution: } & x = 1, y = 2, z = 3, w = 4, v = 5, u = 6, t = 7, s = 8, r = 9, q = 10, p = 11 \\
\end{align*}
\]
\[ P_2 = 0.48 = \frac{h_{45} - h_3}{h_4 - h_3} \]

\[ \frac{S_4}{S_3} = \frac{45}{90} \]

\[ \text{In this case, you estimate } h_4 \text{ and } h_5 \]

\[ h_4 = 23.54 \]

\[ \text{Fluid model } \Rightarrow \text{This can be done} \]

\[ W = \frac{m (h_f - P)}{3} \]

\[ \text{Purpose is to find the work required by pump in this another way} \]

\[ W = \frac{m v_2 (P_f - P)}{3} \]

\[ \text{We need } m \]

\[ \text{We've got enough, let's analyze components} \]

\[ \text{For the piston: } E_{\text{in}} = F \Delta x + \frac{1}{2} m \frac{\Delta v^2}{\Delta t} \Rightarrow \tilde{A} + m(h_f) = m(h_i) \]

\[ \text{Compute} \]

\[ \frac{\Delta v}{\Delta t} = \frac{54\text{ kN}}{2442 \text{ kN}} \Rightarrow \tilde{m}_{\text{exp}} = 0.386 \text{ kgs} \]

\[ W_{\text{exp}} = \tilde{m}_{\text{exp}} \cdot (h_i - h_f) = 0.386 \text{ kgs} \cdot (29.12 - 24.47) \]

\[ W_{\text{exp}} = 18.42 \text{ kJ} \]

\[ W = \tilde{m} (h_i - h_f) \]

\[ \tilde{m} = \tilde{m}_{\text{exp}} = 0.386 \text{ kgs} \]

\[ W = 1.1(0.005872)(3.94400 - 10.177) \]

\[ = 7.8 \text{ kJ} \]

\[ \tilde{m}_{\text{exp}} = \tilde{m} (h_i - h_f) = \tilde{m}_{\text{exp}} \text{ kgs} \]

\[ \tilde{m}_{\text{exp}} = 0.386 \text{ kgs} \]

\[ W_{\text{exp}} = \tilde{m}_{\text{exp}} (h_i - h_f) = 0.386 \text{ kgs} \cdot (29.12 - 24.47) \]

\[ W_{\text{exp}} = 18.42 \text{ kJ} \]

\[ \tilde{m}_{\text{exp}} = \tilde{m} (h_i - h_f) \]

\[ \tilde{m}_{\text{exp}} = 0.386 \text{ kgs} \]

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\[ W_{\text{exp}} = 18.42 \text{ kJ} \]

\[ \text{Correct} \]

\[ \text{Needed} \]

\[ \text{Compressed liquid again, no to bales!!} \]

\[ \text{In effect, liquid again, no to bales!!} \]

\[ \text{less than } S_2 \text{ @ } 95 \text{ so} \]

\[ \text{Compressed liquid again, no to bales!!} \]