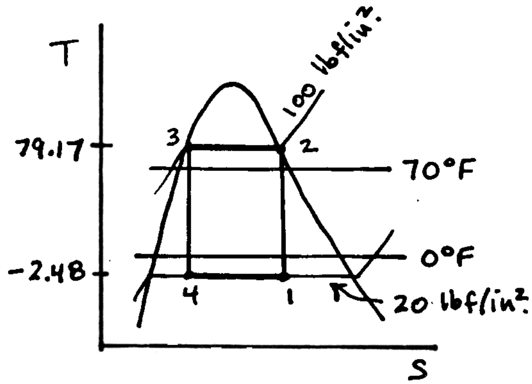
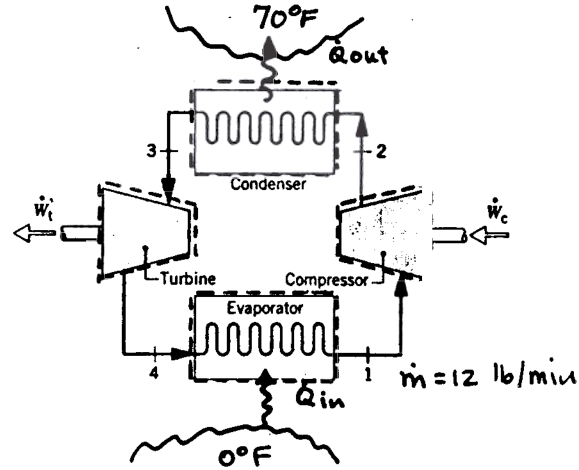
PROBLEM

KNOWN: Refrigerant 134a is the working fluid in a Carnot vapor refrigeration cycle. Operating data are specified.

FIND: Determine (a) the compressor and turbine power and (b) the coefficient of performance.

SCHEMATIC & GIVEN DATA:





ASSUMPTIONS: (1) Each component is analyzed as a control volume at steady state. (2) All processes are internally reversible. (3) The compression and expansion are adiabatic. (4) Kinetic and potential energy effects are negligible.

ANALYSIS: First, fix each of the principal states (Table A-11E).

State 2 $p_2 = 100$ lbf/in², sat. vapor $\Rightarrow h_2 = 112.46 \frac{Btu}{lb}$, $s_2 = 0.2169 \frac{Btu}{lb \cdot °R}$

State 1 $p_1 = 20$ lbf/in², $s_1 = s_2 \Rightarrow x_1 = 0.9707$, $h_1 = 98.74$ Btu/lb

State 3 $p_3 = 100$ lbf/in², sat. liquid $\Rightarrow h_3 = 36.99 \frac{Btu}{lb}$, $s_3 = 0.0768 \frac{Btu}{lb \cdot °R}$

State 4 $p_4 = 20$ lbf/in², $s_4 = s_3 \Rightarrow x_3 = 0.2628$, $h_4 = 34.673$ Btu/lb

(a) The compressor power is

$$\dot{W}_c = \dot{m}(h_2 - h_1) = 12 \frac{lb}{min}(112.46 - 98.74)\frac{Btu}{lb}$$

$$= 164.6 \text{ Btu/min}$$ ← $\dot{W}_c$

The turbine power is

$$\dot{W}_t = \dot{m}(h_3 - h_4) = (12)(36.99 - 34.673) = 27.80 \text{ Btu/min}$$ ← $\dot{W}_t$

(b) The evaporator heat transfer rate is

$$\dot{Q}_{in} = \dot{m}(h_1 - h_4) = 768.8 \text{ Btu/min}$$

thus

$$\beta = \frac{\dot{Q}_{in}}{\dot{W}_c - \dot{W}_t} = 5.62$$ ← β