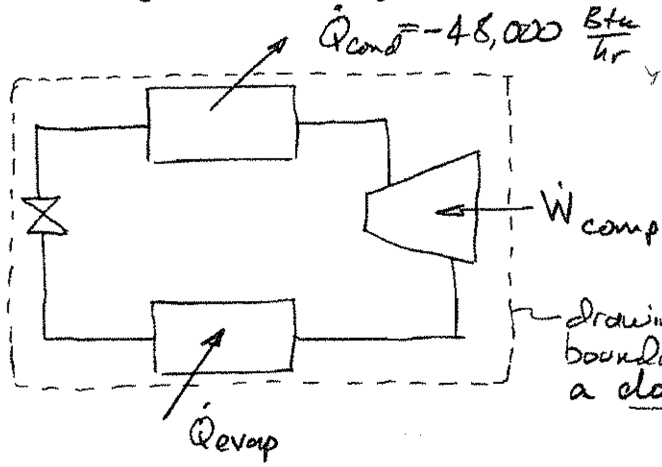
Given: A refrigeration cycle used for cooling



$COP_c = 3.0$

$COP_c = \dfrac{\dot{Q}_{evap}}{-\dot{W}_{comp}}$

drawing the system boundary here creates a closed system!

Find: a) $\dot{Q}_{evap}$ (Btu/hr)
b) $\dot{W}_{comp}$ (hp and kW)

Solution: Treating the entire cycle as a system,

$$\dot{Q} - \dot{W} = \underbrace{m(\cancel{u_2 - u_1}) + \cancel{\Delta KE} + \cancel{\Delta PE}}_{\dot{E}_G = 0 \text{ (steady)}}$$

$$\therefore \quad \dot{Q} = \dot{W} \rightarrow \dot{Q}_{evap} + \dot{Q}_{cond} = \dot{W}_{comp}$$

The COP_c is given,

$$COP_c = \frac{\dot{Q}_{evap}}{-\dot{W}_{comp}} \rightarrow \dot{W}_{comp} = \frac{-\dot{Q}_{evap}}{COP_c}$$

Therefore

$$\dot{Q}_{evap} + \dot{Q}_{cond} = \frac{-\dot{Q}_{evap}}{COP_c} \quad \text{(1 unknown!)}$$

Algebra...

$$(COP_c)\dot{Q}_{evap} + (COP_c)\dot{Q}_{cond} = -\dot{Q}_{evap}$$

$$(COP_c)\dot{Q}_{cond} = -\dot{Q}_{evap} - (COP_c)\dot{Q}_{evap}$$

$$-(COP_c)\dot{Q}_{cond} = (1 + COP_c)\dot{Q}_{evap}$$

$$\therefore \quad \dot{Q}_{evap} = \frac{-(COP_c)\dot{Q}_{cond}}{(1 + COP_c)}$$

Then, $\dot{Q}_{evap} = \dfrac{-(3)(-48{,}000\ \text{Btu/hr})}{(1+3)} = \underline{\underline{36{,}000}}\ \dfrac{\text{Btu}}{\text{hr}}$

Now, the power input can be found,

$$\dot{W}_{comp} = \dot{Q}_{evap} + \dot{Q}_{cond} = (36{,}000 - 48{,}000)\ \frac{\text{Btu}}{\text{hr}}$$

$$\dot{W}_{comp} = -12{,}000\ \frac{\text{Btu}}{\text{hr}} \left| \frac{\text{hp}\cdot\text{hr}}{2545\ \text{Btu}} \right. = \underline{\underline{-4.7\ \text{hp}}}$$

$$\dot{W}_{comp} = -12{,}000\ \frac{\text{Btu}}{\text{hr}} \left| \frac{\text{kW}\cdot\text{hr}}{3412\ \text{Btu}} \right. = \underline{\underline{-3.5\ \text{kW}}}$$

<u>Reflection</u>

- Using a closed system to analyze the cycle allows for the calculation of energy transfer rates without dealing with individual components of the cycle.
- Very interesting cycle! Only 12,000 Btu/hr of electrical power input is required, but the net result is 36,000 Btu/hr of cooling!