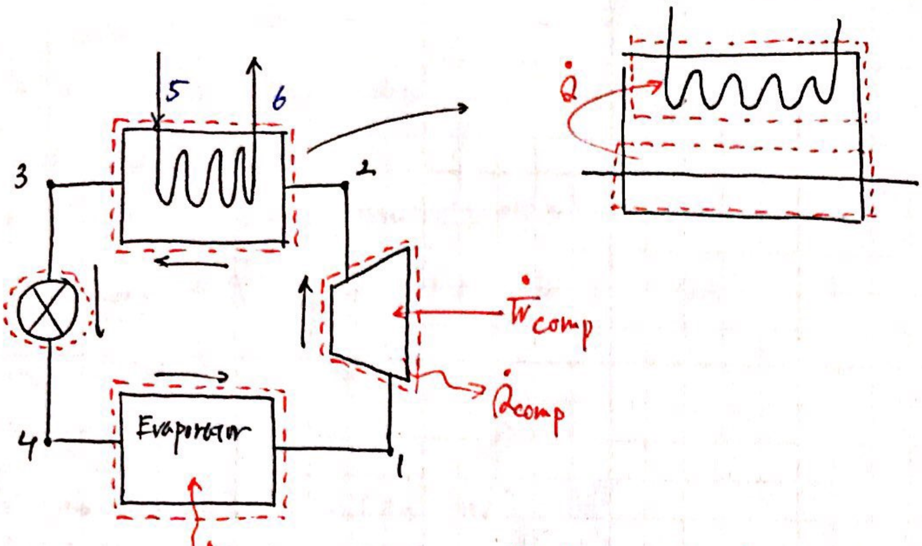
Tomoki Koike | HW-35 | 3175 | 1

GIVEN



$\dot{Q}_c = 10$ tons $\cong 35.167$ kW ≈ 35.2 kW

State	P(bar)	T(°C)	v (m³/kg)	h(kJ/kg)	s (kJ/kg-K)
1	4	15	0.05258	258.15	0.9348
2	12	54.88	0.01772	281.33	0.9341
3	11.6	44	0.0008847	112.22	0.4054
4	4	8.93	0.01401	112.22	0.4179
5		20		83.96	0.2966
6		30		125.99	0.4369

FIND (a) $\dot{m}$, kg/s

(b) $\dot{W}_{comp}$, $\dot{Q}_{comp}$ kW

(c) cop

(d) $\dot{m}_w$ kg/s

(e) $\dot{\sigma}_{cond}$, $\dot{\sigma}_{valve}$ kW/K

ASSUMP

SSSF, IDUF, open-sys, $\Delta KE = \Delta PE = 0$, Evaporator & condenser: $\dot{W} = 0$,
valve: $\dot{W} = 0$ $\dot{Q} = 0$, $pv^{1.01} = c$

EQN

$$\left.\frac{dm}{dt}\right|_{sys} = \sum_i \dot{m} - \sum_e \dot{m}, \quad \left.\frac{dE}{dt}\right|_{sys} = \dot{Q} - \dot{W} + \sum_i \dot{m}(h+pe+ke) - \sum_e \dot{m}(h+pe+ke)$$

$$\left.\frac{ds}{dt}\right|_{sys} = \sum \frac{\dot{Q}}{T} + \sum_i \dot{m} s_i - \sum_e \dot{m} s_e + \dot{\sigma}_{gen}$$

SOLN

>> from <COM>

$\longrightarrow \dot{m} = \dot{m}_1 = \dot{m}_2 = \dot{m}_3 = \dot{m}_4$

$\dot{m}_5 = \dot{m}_6 = \dot{m}_w$

>> for the compressor from <COE>

$\longrightarrow 0 = \dot{Q}_{comp} - \dot{W}_{comp} + \dot{m}(h_1 - h_2) \quad \cdots ①$

>> for the condensor <COE>

$\longrightarrow 0 = \dot{Q}_{int} + \dot{m}(h_2 - h_3) \quad \cdots ②$

$\longrightarrow 0 = \dot{m}(h_2 - h_3) + \dot{m}_w(h_5 - h_6) \quad \cdots ③$

>> for the evaporator <COE>

$\longrightarrow 0 = \dot{Q}_c + \dot{m}(h_4 - h_1)$

$\therefore \dot{m} = \dfrac{\dot{Q}_c}{h_1 - h_4} = \dfrac{35.167\text{ kW}}{(258.15 - 112.22)\text{ kJ/kg}} \cong 0.24099\text{ kg/s} \approx \boxed{0.241\text{ kg/s}}$ —(a)

then

>> for the condensor

$\longrightarrow 0 = \dot{Q}_{cond} + \dot{m}(h_2 - h_3)$

$\therefore \dot{Q}_{cond} = (0.24099\text{ kg/s})(112.22 - 281.33)\text{ kJ/kg} \cong -40.754\text{ kW}$

>> for compressor

$\longrightarrow \dot{W}_{comp} = \dot{m}\int \dfrac{C}{v^{1.01}}dv = \dot{m}\dfrac{P_2v_2 - P_1v_1}{1-1.01}$

$= \dfrac{(0.24099\text{ kg/s})\left[(12\times10^2\text{ kPa})(0.01772\text{ m}^3/\text{kg}) - (4\times10^2\text{ kPa})(0.05258\text{ m}^3/\text{kg})\right]}{-0.01}$

$\cong -5.5910\text{ kW} \approx \boxed{-5.59\text{ kW}}$ —(b)

now

$\longrightarrow 0 = \dot{Q}_{comp} - \dot{W}_{comp} + \dot{m}(h_1 - h_2)$

$\dot{Q}_{comp} = \dot{W}_{comp} + \dot{m}(h_2 - h_1) = -5.5910\text{ kW} + (0.24099\text{ kg/s})(23.18\text{ kJ/kg})$

$\cong -4.8518\times10^{-3}\text{ kW} \approx \boxed{-4.85\times10^{-3}\text{ kW}}$ —(b)

>> To solve COP

$\longrightarrow COP = \dfrac{\dot{Q}_c}{|\dot{W}_{net}|} = \dfrac{\dot{Q}_c}{|\dot{W}_{comp}|} = \dfrac{35.167\text{ kW}}{5.5910\text{ kW}} \cong 6.289 \approx \boxed{6.29}$ —(c)

>> for the condenser since we already have $\dot{Q}_{cond}$

$$0 = -\dot{Q}_{cond} + \dot{m}_w(h_5 - h_6) \quad \because (\dot{Q}_{cond} < 0)$$

$$\dot{m}_w = \frac{\dot{Q}_{cond}}{h_6 - h_5} = \frac{40.754\,kW}{(125.79 - 83.96)\,kJ/kg} \cong 0.97428\,kg/s$$

$$\approx \boxed{0.974\,kg/s} - (d)$$

>> for the condenser

$$0 = \cancel{\Sigma \frac{\dot{Q}}{T}}^{\,0} + \dot{m}(s_2 - s_3) + \dot{m}_w(s_5 - s_6) + \dot{\sigma}_{cond}$$

$$\dot{\sigma}_{cond} = \dot{m}(s_3 - s_2) + \dot{m}_w(s_6 - s_5)$$

$$= (0.24099\,kg/s)(0.4054 - 0.9341)\,kJ/kg\text{-}K$$
$$+ (0.97428\,kg/s)(0.4369 - 0.2966)\,kJ/kg\text{-}K$$

$$\cong \boxed{9.2801 \times 10^{-3}\,kW/K} - (e)$$

>> and, for the valve

$$0 = \dot{m}(s_3 - s_4) + \dot{\sigma}_{valve}$$

$$\dot{\sigma}_{valve} = \dot{m}(s_4 - s_3)$$

$$= (0.24099\,kg/s)(0.4179 - 0.4054)\,kJ/kg\text{-}K$$

$$\cong 3.01237 \times 10^{-3}\,kW/K$$

$$\approx \boxed{3.0124 \times 10^{-3}\,kW/K} - (e)$$

I did all the calculations with 5 sig-figs so the answers might be slightly off.