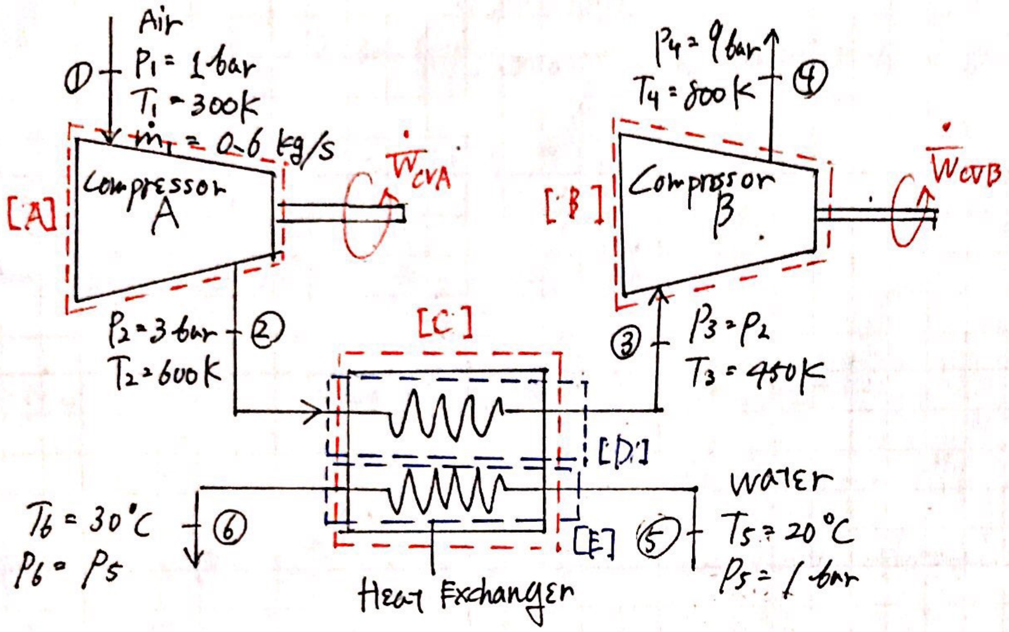
GIVEN

Separate Air & Water compressor & heat exchanger
Heat transfer with surrounding neglected.

EFD



ASSUMP open sys., SSSF, uniform flow, $\Delta PE = 0$, $\dot{Q} = 0$
* Heat Exchanger
>> $\dot{W} = 0$, $\Delta KE = 0$
* air → ideal gas

EQN
$$\cancel{\frac{dm}{dt}\Big|_{sys}}^{0} = \sum_i \dot{m} - \sum_e \dot{m}, \quad \cancel{\frac{dE}{dt}\Big|_{sys}}^{0} = \cancel{\dot{Q}}^{0} - \dot{W} + \sum_i \dot{m}(h + \cancel{pe}^{0} + ke) - \sum_e \dot{m}(h + \cancel{pe}^{0} + ke)$$

$Pv = R_{air}T$ ($R_{air} = 287.05$ J/kgK)

FIND
- Total Power of both compressor P_{total}, kW
- mass flow rate of water $\dot{m}_w$ $\frac{kg}{s}$

SOLN the sys. being EFD [A]

@ State 1 using ideal gas table $h_1 = 300.1$ kJ/kg

$$\text{and } v_1 = \frac{R_{air}T_1}{P_1} = \frac{(287.05 \frac{J}{kgK})(300K)}{(1 \times 10^5 \text{ Pa})} \approx 0.8612 \text{ m}^3/\text{kg}$$

@ State 2 from table

$$h_2 = 607.2 \text{ kJ/kg}$$

$$\text{and } v_2 = \frac{(287.05 \frac{J}{kgK})(600K)}{(3 \times 10^5 \text{ Pa})} = 0.5741 \text{ m}^3/\text{kg}$$

$$0 = -\dot{W}_{CVA} + \dot{m}_1 h_1 + \frac{\dot{m}_1 V_1^2}{2} - \dot{m}_2 h_2 - \frac{\dot{m}_2 V_2^2}{2}$$

$\because \dot{m}_1 = \dot{m}_2$
$$\dot{W}_{CVA} = \dot{m}_1 \left(h_1 - h_2 + \frac{V_1^2}{2} - \frac{V_2^2}{2}\right) \quad \cdots (i)$$

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for sys. EFD [B]

@ state 3 $P_3 = 3\,bar$ $T_3 = 450K$ from table $h_3 = 452.0\ kJ/kg$

$$v_3 = \frac{(287.05\ J/kgK)(450K)}{(3\times10^5 Pa)} \cong 0.4306\ m^3/kg$$

@ state 4 $P_4 = 9\ bar$. $T_4 = 800K$ from table $h_4 = 821.9\ kJ/kg$

$$v_4 \cong 0.2552\ m^3/kg$$

<from sys. EFD [D] $\dot{m}_2 = \dot{m}_3 = \dot{m}_1$>

$\because \dot{m}_3 = \dot{m}_4$ $\quad 0 = -\dot{W}_{cvB} + \dot{m}_3\left(h_3 + \frac{V_3^2}{2}\right) - \dot{m}_4\left(h_4 + \frac{V_4^2}{2}\right)$

$$\dot{W}_{cvB} = \dot{m}_1\left(h_3 - h_4 + \frac{V_3^2}{2} - \frac{V_4^2}{2}\right) \quad \cdots \text{(ii)}$$

for (i) & (ii) if velocity V is constant through $1 \to 4$

(i) + (ii)

$$\dot{W}_{cvA} + \dot{W}_{cvB} = \dot{m}_1(h_1 - h_2 + h_3 - h_4) = \boxed{-406.2\ kW}$$

(b) from sys. EFD [C]

$$\left.\frac{dE}{dt}\right|_{sys}^{\nearrow 0} = \cancel{\dot{Q}}^{0} - \cancel{\dot{W}}^{0} + \sum_i \dot{m}(h + \cancel{pe}^{0} + \cancel{ke}^{0}) - \sum_e \dot{m}(h + \cancel{pe}^{0} + \cancel{ke}^{0})$$

$$0 = \dot{m}_2 h_2 - \dot{m}_3 h_3 + \dot{m}_{w5} h_{w5} - \dot{m}_{6w} h_{6w}$$

from sys EFD [D] & [E]

$$\dot{m}_1 = \dot{m}_2 = \dot{m}_3 \quad \& \quad \dot{m}_{5w} = \dot{m}_{6w} = \dot{m}_w$$

$$0 = \dot{m}_1(h_2 - h_3) - \dot{m}_w(h_{6w} - h_{5w})$$

$$\dot{m}_w = \frac{h_2 - h_3}{h_{6w} - h_{5w}}\dot{m}_1$$

@ state ⑤ $P_5 = 1\,bar$, $T_5 = 20°C$ $\quad P_5 > P_{sat}$ so CL

$$h_{6w} - h_{5w} = h_f(30) + v_6(P_6 - P_{sat}) - h_f(20) - v_5(P_5 - P_{sat})$$

$\because P_5 = P_6$ $\quad h_{6w} - h_{5w} = 41.818\ kJ/kg$

$$\therefore \dot{m}_w = \frac{155.2\ kJ/kg}{41.818\ kJ/kg}\left(0.6\ \frac{kg}{s}\right) \cong 2.227\ \frac{kg}{s} \qquad \dot{m}_w = \boxed{2.23\ \frac{kg}{s}}$$

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