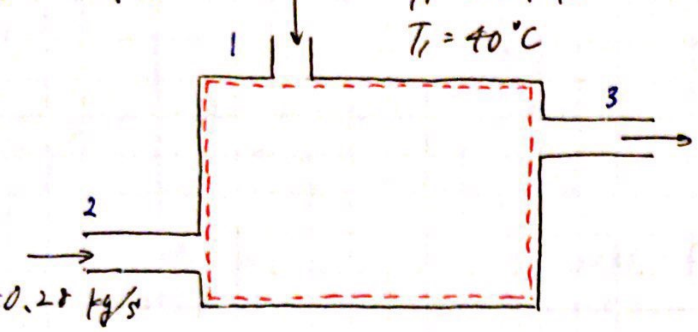
(i) **GIVEN** & <EFD>

liquid water $P_1 = 2.5\,MPa$

$T_1 = 40\,°C$



sat. vap.

$P_3 = 2.5MPa$

$T_3 = 223.95\,°C$ (from tables)

SHV

$\dot m_2 = 0.28\ kg/s$

$P_2 = 3.0MPa$

$T_2 = 320\,°C$

FIND

(a) locate states 1 ~ 3 on T-s diagram

(b) $\dot\sigma_{cv}$, in kW/K

ASSUMP

open sys, SSSF, IDUF, $\Delta KE = \Delta PE = 0$, $\dot Q = 0$, $\dot W = 0$

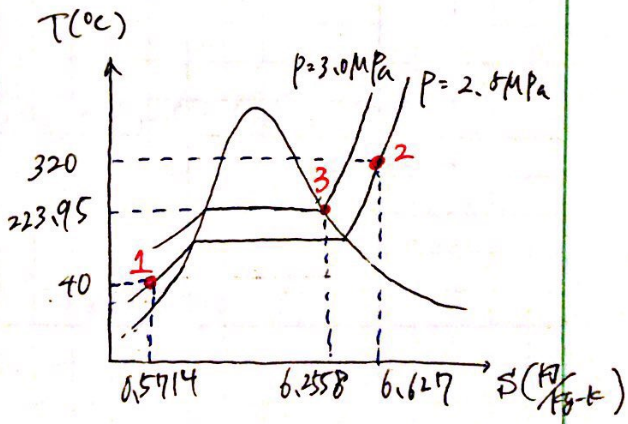
EQN $\cancel{\frac{dm}{dt}\Big|_{sys}}^{\,0} = \sum_i \dot m - \sum_e \dot m$, $\quad \cancel{\frac{dE}{dt}\Big|_{sys}}^{\,0} = \cancel{\dot Q}^{\,0} - \cancel{\dot W}^{\,0} + \sum_i \dot m(h + \cancel{pe}^{\,0} + \cancel{ke}^{\,0}) - \sum_e \dot m(h + \cancel{pe}^{\,0} + \cancel{ke}^{\,0})$

$$\cancel{\frac{ds}{dt}\Big|_{sys}}^{\,0} = \sum \frac{\dot Q}{T} + \sum_i \dot m s_i - \sum_e \dot m s_e + \dot\sigma_{cv}$$

SOLN

(a) from conservation of mass $\dot m_1 + \dot m_2 = \dot m_3 \Leftrightarrow \dot m_1 + 0.28\,kg/s = \dot m_3$

from tables $\begin{cases} s_1 = 0.5714\ kJ/kg\text{-}K \\ s_2 = 6.627\ kJ/kg\text{-}K \\ s_3 = 6.2558\ kJ/kg\text{-}K \end{cases}$



(b) from tables $\begin{cases} h_1 = 169.74\ kJ/kg \\ h_2 = 3044.2\ kJ/kg \\ h_3 = 2801.9\ kJ/kg \end{cases}$

$$0 = \dot m_1 h_1 + \dot m_2 h_2 - \dot m_3 h_3$$

since $\dot m_3 = \dot m_1 + 0.28$

$$0 = \dot m_1(h_1 - h_3) - 0.28 h_3 + 0.28 h_2$$

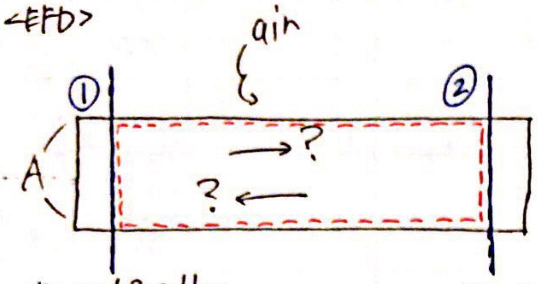
$$\therefore \dot m_1 = \frac{(0.28\,kg/s)(h_2 - h_3)}{(h_3 - h_1)} = (0.28\,kg/s)\frac{3044.2\,kJ/kg - 2801.9\,kJ/kg}{2801.9\,kJ/kg - 169.74\,kJ/kg} \simeq 0.02578\ kg/s$$

$\dot m_3 = 0.30578\ kg/s$

$$\therefore \dot\sigma_{cv} = \dot m_3 h_3 - \dot m_1 h_1 - \dot m_2 h_2 = (0.30578\,\tfrac{kg}{s})(6.2558\,\tfrac{kJ}{kgK}) - (0.02578\,\tfrac{kg}{s})(\tfrac{0.5714\,kJ}{kg\text{-}K}) - (0.28\,\tfrac{kg}{s})(\tfrac{6.627\,kJ}{kgK}) \simeq \boxed{0.042608\ \frac{kW}{K}}$$

<9>

GIVEN $\emptyset$ <EFD>



Area $\equiv A = \pi\left(\frac{2}{2}\times10^{-2}\right)^2 = 3.142\times10^{-4}\,m^2$

$P_1 = 100\,kPa = 1\,bar$
$T_1 = 295\,K$

$P_2 = 500\,kPa = 5\,bar$
$T_2 = 325\,K$

FIND
(a) the direction of flow
(b) velocity of air (m/s) @ each location
(c) $\dot m$ (kg/s)

ASSUMP open sys, SSSF, 1DUF, $\Delta PE = 0$, $\dot Q = 0$, $\dot W = 0$ ideal gas

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

$\cancel{\frac{dS}{dt}\Big|_{sys}}^{0} = \cancel{\sum\frac{\dot Q}{T}}^{0} + \sum_i \dot m s_i - \sum_e \dot m s_e + \sigma_{cv}$, $Pv = R_{air}T$, $R_{air} = 0.287\,\frac{kJ}{kg\text{-}K}$

SOLN

from table $\begin{cases} h_1 = 295.1\ kJ/kg & s_1 = 1.686\ kJ/kg\text{-}K \\ h_2 = 325.3\ kJ/kg & s_2 = 1.783\ kJ/kg\text{-}K \end{cases}$

(a)

$\dot m_1 = \dot m_2 = \dot m \cdots ①$

assume flow is from left to right ($1 \to 2$)

$\sigma_{cv} = \dot m_2 s_2 - \dot m_1 s_1 = \dot m(s_2 - s_1)$

$\Leftrightarrow \frac{\sigma_{cv}}{\dot m} = s_2 - s_1 = 1.783\,kJ/kg\text{-}K - 1.686\,kJ/kg\text{-}K = 0.097\,kJ/kg\text{-}K > 0$

$\boxed{1 \to 2}$

(b)

from 1st law

$0 = h_1 + \frac{V_1^2}{2}\times10^{-3} - h_2 - \frac{V_2^2}{2}\times10^{-3} \Longleftrightarrow V_1^2 - V_2^2 = 60400\ \frac{J}{kg}$

using equation of state

$v_1 = \frac{R_{air}T_1}{P_1} = \frac{(287\,J/kg\text{-}K)(295\,K)}{1\times10^5\,Pa} \simeq 0.8467\ m^3/kg$

samely

$v_2 \simeq 0.1866\ m^3/kg$

Scanned with CamScanner

because

$$\dot{m} = \frac{AV}{v}$$

$$\Leftrightarrow \frac{AV_1}{v_1} = \frac{V_2}{v_2} \Rightarrow V_2 = \frac{v_2}{v_1} V_1 = \frac{0.1866 \ m^3/kg}{0.8467 \ m^3/kg} V_1 \simeq 0.2204 V_1$$

plug these into ②

$$V_1^2 - 0.2204^2 V_1^2 = 60400$$

$$V_1 = \sqrt{\frac{60400}{0.9514}} \ m/s \simeq 251.96 \ m/s$$

$$V_2 = 0.2204 (251.96 \ m/s) \simeq 55.53 \ m/s$$

$$\boxed{\begin{aligned} V_1 &= 252 \ m/s \\ V_2 &= 55.5 \ m/s \end{aligned}}$$

c,

$$\dot{m} = \frac{AV_1}{v_1}$$

$$= \frac{(3.142 \times 10^{-2} m^2)(251.96 \ m/s)}{0.8467 \ m^3/kg} \simeq \boxed{0.0934 \ kg/s}$$