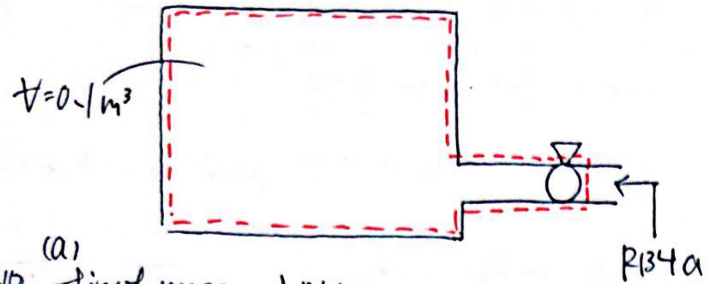
Tomoki Koike | HW-29 | 3175 | 1

GIVEN: <EFD>



$P_1 = 0$, $T_1 = 0$, $m_1 = 0$

$P_2 = 120\,kPa = 1.2\,bar$

$P_i = 700\,kPa = 7\,bar$ $T_i = 8°C$

FIND (a) final mass of R134a in tank m_f, kg

(b) σ_{gen}, kJ/K

ASSUMP open sys, unsteady state, $\Delta KE = \Delta PE = 0$, $\dot{Q} = 0$, $\dot{W} = 0$, only inlet, const. vol

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

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

SOLN

from conservation of mass $\frac{dm}{dt} = \dot{m}_i \overset{\int dt}{\Longleftrightarrow} m_2 - \cancel{m_1}^{\,0} = m_i$

$\therefore m_2 = m_i \quad \cdots ①$

from 1st law $\frac{dE}{dt} = \dot{m}_{in} h_{in} \overset{\int dt}{\Longleftrightarrow} m_2 u_2 - \cancel{m_1 u_1}^{\,0} = m_i h_i$

$\because ①\ u_2 = h_i \quad \cdots ②$

from 2nd law $\frac{ds}{dt} = \dot{m}_i s_i + \dot{\sigma}_{gen} \overset{\int dt}{\Longleftrightarrow} m_2 s_2 - \cancel{m_1 s_1}^{\,0} = m_i s_i + \sigma_{gen} \cdots ③$

specific volume of R134a in each stage

$v_1 = \frac{\forall}{m_1} = 0 \qquad v_i = \frac{\forall}{m_i} = \frac{0.1}{m_i} = v_2$

$v_2 = \frac{\forall}{m_2} = \frac{0.1}{m_2}$

from tables

since the state at inlet is compressed liquid

$h_i = h_{comp,liq}(7bar, 8°C) \approx h_f|_{T=8°C} + v_f|_{T=8°C}(P_i - P_{sat}|_{T=8°C})$

$62.694\ kJ/kg + (0.00078873\ m^3/kg)(700\,kPa - 387.61\,kPa) \cong 62.940\ kJ/kg$

and

$s_i = s_{comp,liq}(7bar, 8°C) \approx s_f|_{T=8°C} = 0.24323\ kJ/kg\text{-}K$

then

$\because ②\ u_2 = h_i = 62.940\ kJ/kg$

again from the table, since $u_f|_{p=1.2bar} < u_2 < u_g|_{p=1.2bar}$

the quality $x_2 = \dfrac{u_2 - u_f|_{p=1.2bar}}{u_g|_{p=1.2bar} - u_f|_{p=1.2bar}} = \dfrac{62.94 \, kJ/kg - 22.419 \, kJ/kg}{217.52 \, kJ/kg - 22.419 \, kJ/kg} \simeq 0.20769$

therefore, using the quality and tabulated values @ $p = 1.2 \, bar$

$$\begin{aligned}
v_2 &= v_f|_{p=1.2bar} + (v_g|_{p=1.2bar} - v_f|_{p=1.2bar})\, x_2 \\
&= 0.00073244 \, m^3/kg + (0.16214 \, m^3/kg - 0.00073244 \, m^3/kg)(0.2077) \\
&\simeq 0.034255 \, m^3/kg
\end{aligned}$$

$$\begin{aligned}
s_2 &= s_f|_{p=1.2bar} + (s_g|_{p=1.2bar} - s_f|_{p=1.2bar})\, x_2 \\
&= 0.09283 \, kJ/kg\text{-}K + (0.94784 \, kJ/kg\text{-}K - 0.09283 \, kJ/kg\text{-}K)(0.2077) \\
&\simeq 0.270407 \, kJ/kg\text{-}K
\end{aligned}$$

then

$$m_2 = \frac{0.1}{v_2} = \frac{0.1 \, m^3}{0.03426 \, m^3/kg} \simeq 2.91928 \, kg \simeq \boxed{2.9193 \, kg}$$

finally $\because$ ③

$$\begin{aligned}
\sigma_{gen} &= m_2 s_2 - m_i s_i \\
&= m_2 (s_2 - s_i) \\
&= (2.9193 \, kg)(0.270407 \, kJ/kg\text{-}K - 0.24323 \, kJ/kg\text{-}K) \\
&\simeq 0.0793378 \, kJ/K
\end{aligned}$$

$$\boxed{\sigma_{gen} = 0.079338 \, kJ/K}$$