

열역학(다)

Report #2

기계공학부,

2022****,

2학년,

작성일 : 2025-12-27

R2 - 1

R2 - 2

R2 - 3

R2 - 4

[R2 - 1]

H_2O , steady flow ($\dot{m} = 12 \text{ kg/s}$), $Q = 0$

$P_1 = 4 \text{ MPa}$, $T_1 = 500^\circ\text{C}$, $V_1 = 80 \text{ m/s}$

$P_2 = 30 \text{ kPa}$, $x_2 = 0.92$, $V_2 = 50 \text{ m/s}$

- (a) Find Δke .
- (b) Find \dot{W} .
- (c) Find A_1 .

[Solution]

$$\Delta ke = \Delta \left(\frac{V^2}{2} \right) = \frac{V_2^2 - V_1^2}{2} = \frac{50^2}{2} - \frac{80^2}{2} = -1950.000 \approx -1.950 \text{ kJ/kg}$$

$T_{\text{sat}} @ 4 \text{ MPa} = 250.35^\circ\text{C} < T_1 \Rightarrow$ superheated vapor

$h_1 = h @ 4 \text{ MPa, } 500^\circ\text{C} = 3446.0 \text{ kJ/kg}$

$0 < x_2 < 1 \Rightarrow$ wet vapor

$h_{2f} = h_f @ 30 \text{ kPa} = 289.27 \text{ kJ/kg}$

$h_{2fg} = h_{fg} @ 30 \text{ kPa} = 2335.3 \text{ kJ/kg}$

$$h_2 = h_{2f} + x h_{2fg} = 289.27 + (0.92)(2335.4) = 2437.838000 \approx 2437.8 \text{ kJ/kg}$$

$$\dot{W} + \left(h_1 + \frac{V_1^2}{2} \right) = \left(h_2 + \frac{V_2^2}{2} \right) + w$$

$$\dot{W} = \dot{m}w = \dot{m}(h_1 - h_2 - \Delta ke) = (12)(3446.0 - 2437.8 + 1.950) = 12121.8000 \approx 12.122 \text{ MW}$$

$v_1 = v @ 4 \text{ MPa, } 500^\circ\text{C} = 0.08644 \text{ m}^3/\text{kg}$

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

$$A_1 = \frac{\dot{m}v_1}{V_1} = \frac{(12)(0.08644)}{80} = 0.012966000 \approx 0.01297 \text{ m}^2$$

[R2 - 2]

R-134a, $V = V_1 = V_3 = 0.05 \text{ m}^3$, $P_1 = 0.8 \text{ MPa}$

$x_1 = 1$, $P_2 = 1.2 \text{ MPa}$, $T_2 = 40^\circ\text{C}$, $P_3 = 1.2 \text{ MPa}$

- (a) Find m_2 .
- (b) Find Q .

[Solution]

$x_1 = 1 \Rightarrow$ saturated vapor

$v_1 = v_g @ 800 \text{ kPa} = 0.025645 \text{ m}^3/\text{kg}$

$$m_1 = \frac{V}{v_1} = \frac{0.05}{0.025645} = 1.9496977968 \approx 1.9497 \text{ kg}$$

$h_1 = h_f @ 800 \text{ kPa} = 95.48 \text{ kJ/kg}$

$T_{\text{sat}} @ 1.2 \text{ MPa} = 46.29^\circ\text{C} > T_2 \Rightarrow$ compressed liquid

$h_2 \approx h_f @ 40^\circ\text{C} = 108.28 \text{ kJ/kg}$

saturated liquid at state 3

$$\Rightarrow h_3 = h_f @ 1.2 \text{ MPa} = 117.79 \text{ kJ/kg}$$

$$\Rightarrow v_3 = v_f @ 1.2 \text{ MPa} = 0.0008935 \text{ m}^3/\text{kg}$$

$$m_3 = \frac{V}{v_3} = \frac{0.05}{0.0008935} = 55.9597090 \approx 55.960 \text{ kg}$$

$$m_3 = m_1 + m_2$$

$$m_2 = m_3 - m_1 = 55.960 - 1.9497 = 54.0103000 \approx 54.010 \text{ kg}$$

$$Q + m_1 h_1 + m_2 h_2 = m_3 h_3$$

$$Q = m_3 h_3 - m_1 h_1 - m_2 h_2$$

$$= (55.96)(117.79) - (1.9497)(95.48) - (54.01)(108.28)$$

$$= 557.168244 \approx 557.168 \text{ kJ}$$

[R2 - 3]

$\dot{m}_1 = 2\dot{m}_2$, $T_1 = 20^\circ\text{C}$, $T_2 = 45^\circ\text{C}$

$P = 100 \text{ kPa}$, $Q = 0$, steady flow

- (a) Find the eq. of conservation of energy and mass.
- (b) Find T_3 .

[Solution]

$$\sum_i \dot{m} = \sum_e \dot{m} \Rightarrow \dot{m}_1 + \dot{m}_2 = \dot{m}_3$$

$$\dot{Q} + \sum_i \dot{m}_j = \sum_e \dot{m}_j + \dot{W} \Rightarrow \dot{m}_1 h_1 + \dot{m}_2 h_2 = \dot{m}_3 h_3$$

$T_{\text{sat}} @ 100 \text{ kPa} = 99.61^\circ\text{C} > T_2 > T_1 \Rightarrow$ compressed liquid

$h_1 \approx h_f @ 20^\circ\text{C} = 83.915 \text{ kJ/kg}$

$h_2 \approx h_f @ 45^\circ\text{C} = 188.44 \text{ kJ/kg}$

These equations can be combined to an equation;

$$2\dot{m}_2 h_1 + \dot{m}_2 h_2 = 3\dot{m}_2 h_3$$

$$2h_1 + h_2 = 3h_3$$

$$h_3 = \frac{2h_1 + h_2}{3} = \frac{2(83.915) + (188.44)}{3} = 118.7566667 \approx 118.757 \text{ kJ/kg}$$

@ $P = 100 \text{ kPa}$

$T [\text{ }^{\circ}\text{C}]$	$h [\text{kJ/kg}]$
25	104.830
T_3	118.753
30	125.730

$$T_3 = \frac{118.753 - 104.83}{125.73 - 104.83} (30 - 25) + 25 = 28.33086124 \\ \approx 28.33^{\circ}\text{C}$$

[R2 - 4]

$$\text{Air, } m = 3 \text{ kg, } P_1 = 100 \text{ kPa, } T_1 = 310 \text{ K} \\ P_2 = 500 \text{ kPa, } T_2 = 490 \text{ K}$$

Determine ΔS

- (a) when $\kappa = 1.4 = \text{const.}$
- (b) using value from air table.
- (c) using average specific heat.

[Solution]

$$Pv = RT, \quad Tds = \delta q, \quad \delta q = dh - vdP \\ \Rightarrow ds = \frac{dh}{T} - \frac{v}{T}dP = \frac{c_p dT}{T} - \frac{R}{P}dP$$

(a) If $\kappa = 1.4 = \text{const.}$,

$$\begin{aligned} \Delta S &= m \int_1^2 ds = m \left(c_p \int_1^2 \frac{1}{T} dT - R \int_1^2 \frac{1}{P} dP \right) \\ &= m \left(\frac{\kappa R}{\kappa - 1} \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \right) \\ &= mR \left(\frac{\kappa}{\kappa - 1} \ln \frac{T_2}{T_1} - \ln \frac{P_2}{P_1} \right) \\ &= (3)(0.2870) \left\{ \frac{1.4}{1.4 - 1} \ln \frac{490}{310} - \ln \frac{500}{100} \right\} \\ &= -0.00604601 \approx -0.006046 \text{ kJ/K} \end{aligned}$$

(b) Using Table A-17, ΔS can be expressed to

$$\begin{aligned} \Delta S &= m \left\{ s^\circ(T_2) - s^\circ(T_1) - R \ln \frac{P_2}{P_1} \right\} \\ &= (3) \left\{ 2.19876 - 1.73498 - (0.2870) \ln \frac{500}{100} \right\} \\ &= 0.00561395 \approx 0.005614 \text{ kJ/K} \end{aligned}$$

(c) Using Table A-2,

$$\begin{aligned} \bar{c}_p(T_1) &= 28.11 + 0.1967 \times 10^{-2}(310) \\ &+ 0.4802 \times 10^{-5}(310)^2 - 1.966 \times 10^{-9}(310)^3 \\ &= 29.12267309 \approx 29.123 \text{ kJ/kmol} \cdot \text{K} \end{aligned}$$

$$\begin{aligned} \bar{c}_p(T_2) &= 28.11 + 0.1967 \times 10^{-2}(490) \\ &+ 0.4802 \times 10^{-5}(490)^2 - 1.966 \times 10^{-9}(490)^3 \\ &= 29.99549227 \approx 29.995 \text{ kJ/kmol} \cdot \text{K} \end{aligned}$$

$$c_p = \frac{\bar{c}_p(T_1) + \bar{c}_p(T_2)}{2M} = \frac{29.123 + 29.995}{2(28.97)} \\ = 1.020331377 \approx 1.020 \text{ kJ/kg} \cdot \text{K}$$

$$\begin{aligned} \Delta S &= m \left(c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \right) \\ &= (3) \left\{ (1.020) \ln \frac{490}{310} - (0.2870) \ln \frac{500}{100} \right\} \\ &= 0.0152432 \approx 0.01524 \text{ kJ/K} \end{aligned}$$