Engineering Thermodynamics homework(2)

March 2024

1 第二章: 能量与热力学第一定律

2-1:Knowing that $m = 0.5$kg, $p_1 = 0.7$MPa, $V_1 = 0.02m^3$, $V_2 = 0.04m^3$, and the process is a quasi-static process.

(1)Assuming the process is a constant pressure process:

$$
\begin{aligned}
p &\equiv 0.7\text{MPa} \\
W &= \int_{V_1}^{V_2} pdV = p(V_2 - V_1) \\
&= 0.7 \times 10^6 \times (0.04 - 0.02) = 14kJ \\
w &= \frac{W}{m} = 28\text{kJ/kg}
\end{aligned}
$$

(2)Assuming $pV^2 \equiv Constant$:

$$
\begin{aligned}
p_1V_1^2 &= 0.7 \times 10^6 \times 0.02^2 = 280J \\
W &= \int_{V_1}^{V_2} pdV = \int_{V_1}^{V_2} \frac{p_1V_1^2}{V^2}dV = p_1V_1^2(\frac{1}{V_1} - \frac{1}{V_2}) = 7kJ \\
w &= \frac{W}{m} = 14\text{kJ/kg}
\end{aligned}
$$

2-4:According to the question, $m = 1\text{kg}$, $p_1 = 1\text{MPa}$, $p_2 = 0.1\text{MPa}$, $t_1 = t_2 = 500°C$, $\delta Q_1 = 506\text{kJ}$, $W_1 = 506\text{kJ}$, $Q_a = 39.1\text{kJ}$.

(1)In the first expansion process, because $Q = \Delta U + W$, therefore $\Delta U = Q - W = 0\text{J}$.

(2)The same as (1) mentioned above, in the process, $\Delta U = 0\text{J}$.

(3)Due to $\Delta U = 0\text{J}$, $Q = \Delta U + W$, $Q = 39.1\text{kJ}$, therefore $W_{\text{air}} = 39.1\text{kJ}$.

2-7:Due to the $p - v$ graph, in the $a \to b$ process, $Q = +84kJ$, $W = +32kJ$, $\Delta U = Q - W = 52kJ$:

(1)Through the $a \to d \to b$ process, $W = 10kJ$, because $\Delta U = Q - W = 52kJ$, so $Q_{a\to d\to b} = \Delta U + W = 62kJ$.

(2)When the system returns through the curve $b \to a$, $W = -20kJ$, $\Delta U = -52kJ$, so $Q_{b\to a} = \Delta U + W = -72kJ$, which means that <u>the system releases heat to the outside</u>,

(3)$U_a = 0$, $U_d = 42\text{kJ}$, in the process $a \to d$:

$$W_{a\to d} = \int_a^d pdV + \int_d^b pdV = \int_{V_a}^{V_d} pdV = W_{a\to d\to b} = 10kJ$$

$$Q_{a\to d} = \Delta U + W_{a\to d}$$

$$\Delta U = U_d - U_a = 42kJ$$

By calculation, $Q_{a\to d} = 10 + 42 = 52\text{kJ}$.

In the process $d \to b$, $W_{d\to b} = \int_{V_d}^{V_d} pdV = 0$,therefore $Q_{d\to b} = \Delta U + W_{d\to b} = \Delta U = U_{d\to b} = U_b - U_d = 52 - 42 = 10\text{kJ}$, 2-8:Knowing that $Q_m = 4 \times 10^4$kg/h, $p_{in} = 9 \times 10^6 Pa$, $p_0 = 760mmHg$, $p_{out} = 730.6mmHg$, $h_{in} = 3440$kJ/kg, $h_{out} = 2245$kJ/kg, $P_Q = -6.85 \times 10^5$kJ/h.

(1)The local atmospheric pressure $p_0 = 760mmHg = 101080Pa$, $p_{out} = 730.6mmHg = 97169.8Pa$:

The inlet absolute pressure $p_{\mathrm{a,in}} = p_0 + p_{in} = 9.101\mathrm{MPa}$;

The absolute outlet pressure $p_{\mathrm{a,out}} = p_0 - p_{out} = 29.4mmHg = 0.00391\mathrm{MPa}$.

(2)Ignoring the ΔE_k, and ΔE_p from inlet to outlet, because The system is open, $Q = \Delta H + W$, so $P_Q = Q_m \times (h_{out} - h_{in}) + P_w$, $P_w = 13087kW$.

(3)$c_{in} = 70$m/s, $c_{out} = 140$m/s, due to $Q = \Delta H + \frac{1}{2} m \Delta c^2 + W$, therefore $P_Q = M \times (h_{out} - h_{in}) + P_w + \frac{1}{2} M (c_{out}^2 - c_{in}^2)$, , $\Delta P_w = \frac{1}{2} Q_m (c_{out}^2 - c_{in}^2) = 81.66kW$.

(4)$\Delta z = 1.6m$, due to $Q = \Delta H + mg\Delta z + W$, $\Delta P_w = Q_m g \Delta z = 0.174kW$.

2-10:Knowing that $h_1 = 286$kJ/kg, $c_1 = 20$m/s, $q = 879kJ/kg$, $h_3 = 502$kJ/kg, $c_{f4} = 150$m/s,

(1)$q_{1-3} = (h_3 - h_1) + \frac{1}{2}(c_3^2 - c_1^2)$, so $c_3 = \sqrt{2 \times (879 - 216) \times 10^3 + 400} = 1151.7kJ/kg$.

(2)$q_{3-4} = (h_4 - h_3) + \frac{1}{2}(c_4^2 - c_3^2) + w$, so $w = \frac{1}{2}(c_3^2 - c_4^2) = 651.95kJ/kg$.

(3)The mass flow $Q_m = 5.23kg/s$, $P_w = Q_m \times w = 651.95kJ/kg \times 5.23kg/s = 3409.69kW$.