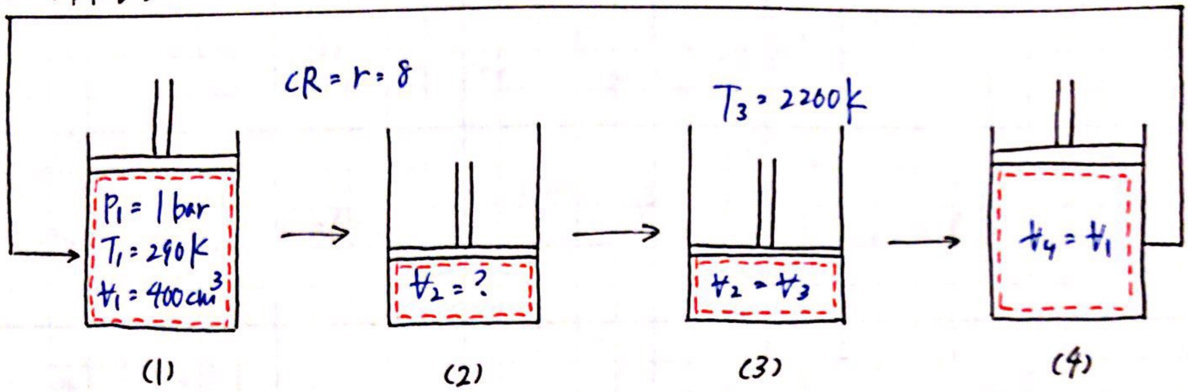
Tomoki Koike | HW37 | 3175 |

GIVEN:

<EFD>



FIND: (a) $\dot{Q}_{in}$, kJ

(b) W_{net}, kJ

(c) η_{TH}

(d) Mean Effective Pressure, P_{me}, bar

ASSUMP: closed sys., Quasiequilibrium, ideal gas, (1→2) & (3→4) adiabatic, (2→3) & (4→1) isovol., internally rev.

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

$PV = mRT$, $R = 0.287\ \mathrm{kJ/kg\cdot K}$, $CR = r = \frac{V_1}{V_2}$

SOLN: $m = \frac{(100\,kPa)(400\times10^{-6}\,m^3)}{(290\,K)(0.287\,kJ/kg\cdot K)} \cong 4.81\times10^{-4}\,kg$

	P (bar)	T(K)	u (kJ/kg)	V (m³)	v_r
1	1	290	206.9	400×10^{-6}	676.1
2			475.1	50×10^{-6}	84.51
3		2200	1873	50×10^{-6}	2.012
4			897.6	400×10^{-6}	16.096

since $r = 8 = \frac{V_1}{V_2} \Leftrightarrow V_2 = \frac{400\times10^{-6}}{8} = 50\times10^{-6}\,m^3$

$V_3 = V_2$ & $V_4 = V_1$

and because (1→2) & (3→4) are isentropic

$\frac{V_1}{V_2} = \frac{v_{r1}}{v_{r2}} \Leftrightarrow v_{r2} = \frac{1}{8}(676.1) \cong 84.51$

interpolate

$u_2 = (84.51 - 81.89)\frac{(473.2 - 481.0)\,kJ/kg}{(85.34 - 81.89)} + 481.0\,kJ/kg \cong 475.1\,kJ/kg$

samely, for $(3 \to 4)$

$$\frac{V_3}{V_4} = \frac{v_{r3}}{v_{r4}} \Leftrightarrow v_{r4} = \frac{400\times10^{-6}\,m^3}{50\times10^{-6}\,m^3}\cdot 2.012 \simeq 16.096$$

interpolate

$$u_4 = (16.096 - 16.064)\frac{(880.7-898.2)\,kJ/kg}{16.446-16.064} + 898.2\,kJ/kg \simeq 897.6\,kJ/kg$$

(a)

for $(2 \to 3)$

$$m(u_3 - u_2) = Q_{in} - \cancel{W_{23}}^{\,0}$$

$$Q_{in} = (4.81\times10^{-4}\,kg)(1873-475.1)\,kJ/kg \simeq \boxed{0.672\,kJ}$$

(b) for $(1 \to 2)$

$$m(u_2 - u_1) = \cancel{Q_{12}}^{\,0} - W_{12}$$

$$W_{12} = m(u_1 - u_2) = (4.81\times10^{-4}\,kg)(206.9-475.1)\,kJ/kg \simeq -0.1290\,kJ$$

for $(3 \to 4)$

$$m(u_4 - u_3) = \cancel{Q_{34}}^{\,0} - W_{34}$$

$$W_{34} = m(u_3 - u_4) = (4.81\times10^{-4}\,kg)(1873-897.6)\,kJ/kg \simeq 0.4692\,kJ$$

$$\therefore W_{net} = W_{12} + W_{34} = -0.1290\,kJ + 0.4692\,kJ \simeq \boxed{0.3402\,kJ}$$

(c) $$\eta_{TH} = \frac{W_{net}}{Q_{in}} = \frac{0.3402\,kJ}{0.672\,kJ} \simeq \boxed{0.506}$$

(d) $$P_{me} = \frac{\dot{W}_{out}}{\Delta V} = \frac{W_{41}}{V_1 - V_2} = \frac{0.340\,kJ}{(400\times10^{-6}-50\times10^{-6})\,m^3} \simeq 971\,kPa$$

$$= \boxed{9.71\,bar}$$