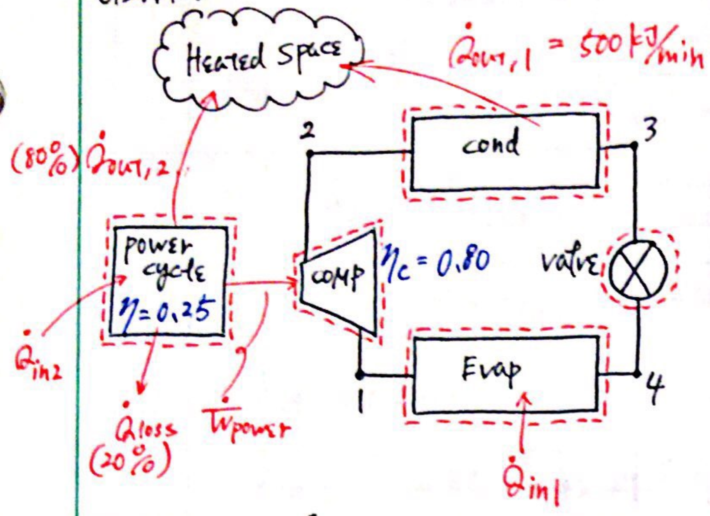
Tomoki Koike | HW36 | 3175 | 1

GIVEN:



state	P(bar)	T(°C)	h(kJ/kg)	s(kJ/kg-K)
1	2.011	-10	244.52	0.9378
2s	10	45.65	277.91	0.9377
2	10	53.33	286.26	0.9636
3	9.6	34	99.398	0.3667
4	2.011	-10	99.398	0.15502

FIND: (a) $\dot{W}_{HP}$ (power input to HP) kW

(b) ratio of total rate of Heat transfer to the heated space and the heat transfer into the power cycle

ASSUMP: SSSF, 1-DUF, open sys, $\Delta KE = \Delta PE = 0$, (comp, valve) $\dot{Q} = 0$, (cond, Evap) $\dot{W} = 0$

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

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

SOLN:

» first, we will find $\dot{m}$, using ⟨COM⟩

$$\dot{m}_1 = \dot{m}_2 = \dot{m}_3 = \dot{m}_4 = \dot{m}$$

and using ⟨COE⟩ for condenser

$$0 = \dot{Q}_{out1} + \dot{m}(h_2 - h_3)$$

$$\therefore \dot{m} = \frac{\dot{Q}_{out1}}{h_3 - h_2} = \frac{-8.3333\text{ kW}}{(99.398 - 286.26)\text{ kJ/kg}} \cong 4.4596 \times 10^{-2}\text{ kg/s}$$

» then, we find $\dot{Q}_{in1}$, using ⟨COE⟩

$$0 = \dot{Q}_{in1} + \dot{m}(h_4 - h_1)$$

$$\therefore \dot{Q}_{in1} = \dot{m}(h_1 - h_4) = (4.4596 \times 10^{-2}\text{ kg/s})(244.52\text{ kJ/kg} - 99.398\text{ kJ/kg})$$

$$\cong 6.4719\text{ kW}$$

» thus,

$$\dot{W}_{comp} = \dot{W}_{power} = |\dot{Q}_{in1} - \dot{Q}_{out1}| = |6.4719\text{ kW} - 8.3333\text{ kW}| = 1.8614\text{ kW}$$

$$\cong \boxed{1.86\text{ kW}} \text{ (a)}$$

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» next since η_{TH} of the power cycle is given

$$\eta_{TH} = \frac{\dot{W}_{power}}{\dot{Q}_{in2}} = \frac{\dot{W}_{power}}{\dot{W}_{power} + |\dot{Q}_{out2,all}|}$$

$$\dot{W}_{power} + |\dot{Q}_{out2,all}| = \frac{\dot{W}_{power}}{0.25}$$

$$|\dot{Q}_{out2,all}| = 3\dot{W}_{power} \cong 3 \cdot 1.8614\,kW = 5.5842\,kW$$

» so now we know

$$\dot{Q}_{out2} = 0.80\,\dot{Q}_{out2,all} \cong 4.4674\,kW$$

$$\dot{Q}_{loss} = 0.20\,\dot{Q}_{out2,all} \cong 1.1168\,kW$$

$$\dot{Q}_{in2} = 4\,\dot{W}_{power} = 7.4456\,kW$$

» therefore the ratio q is

$$q = \frac{\dot{Q}_{out1} + \dot{Q}_{out2}}{\dot{Q}_{in2}}$$

$$= \frac{(8.3333\,kW) + (4.4674\,kW)}{(7.4456\,kW)}$$

$$\cong 1.7192$$

$$\cong \boxed{1.72} \text{ (b)}$$

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