HW 1.4

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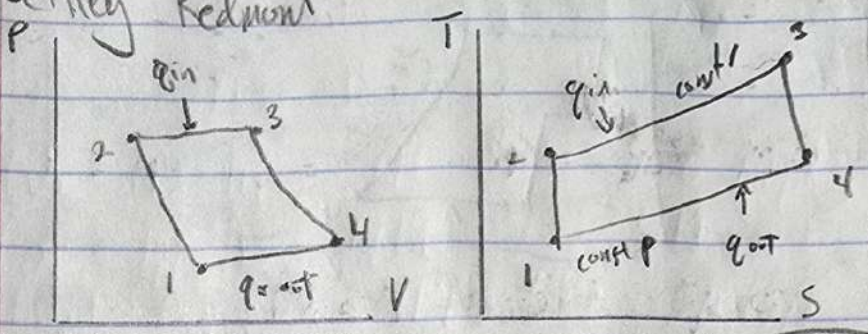
9-88



① → ② → ③ → ④

$P_1 = 70\ kPa$ $P_2 = 1760\ kPa$ $P_3 = 1760\ kPa$ $P_4 = 70\ kPa$

$T_1 = 273\ k$ $T_2 = 527\ k$ $T_3 = 1025\ K$ $T_4 = 531\ K$

$$P_2 = P_1 r_p^{k} = 70(10)^{1.4}$$

$$T_2 = T_1 r_p^{\frac{k-1}{k}} = 273\ (10)^{\frac{1.4-1}{1.4}} = 527\ k$$

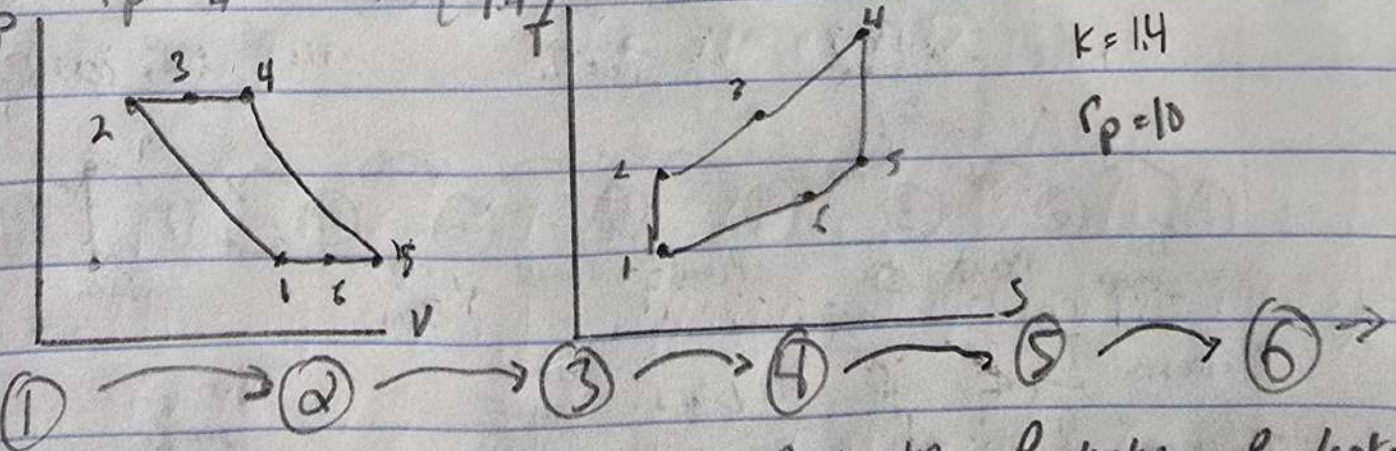
$$T_3 = T_2 + \frac{q_{in}}{c_p} \qquad 527\ k + \frac{500\ kW}{1.005} = 1025\ K$$

$$\eta_{th} = 1 - \frac{1}{r_p^{\frac{(k-1)}{k}}} = 1 - \frac{1}{10^{\left(\frac{1.4-1}{1.4}\right)}} = 0.482 \quad 48\%$$

$$T_4 = \frac{T_3}{r_p^{\frac{(k-1)}{4}}} = \frac{1025}{10^{\left(\frac{1.4-1}{1.4}\right)}} = 531\ k \qquad W = \eta \cdot q_{in}$$

$$W = 0.482 \cdot 500\ kW = 241\ W$$

9-99



$k = 1.4$

$r_p = 10$

① → ② → ③ → ④ → ⑤ → ⑥

P_1 100 kPa $P_2 = 1000\ kPa$ $P_3 = 1000\ kPa$ $P_4 = 1000\ kPa$ $P_5 = 100\ kPa$ $P_6 = 100\ kPa$

T_1 303 k $T_2 = 585.7\ k$ $T_3 = 546\ k$ $T_4 = 1073\ k$ $T_5 = 556\ k$ $T_6 = 595\ k$

$T_2 = T_1 \cdot r_p^{\frac{k-1}{k}} = 303$ $\quad T_5 = \frac{T_4}{r_p^{\frac{(k-1)}{k}}} = \frac{1073}{10^{\frac{1.4-1}{1.4}}} = 556k$

$P_2 = P_1 \cdot r_p = 100kpa \cdot 10 = 1000\ KPa$

$T_3 = T_4 \cdot \frac{P_3}{P_4} = 1073 \frac{1000}{1000} = 1073$ $\quad T_6 = T_5 + T_3 - T_2 = 556 + 39 = 596k$

$w_c = c_p(T_2 - T_1) = 1.005(585 - 303) = 283\ kJ/kg$

$w_T = c_p(T_4 - T_5) = 1.005(1073 - 556) = 520\ kJ/kg$

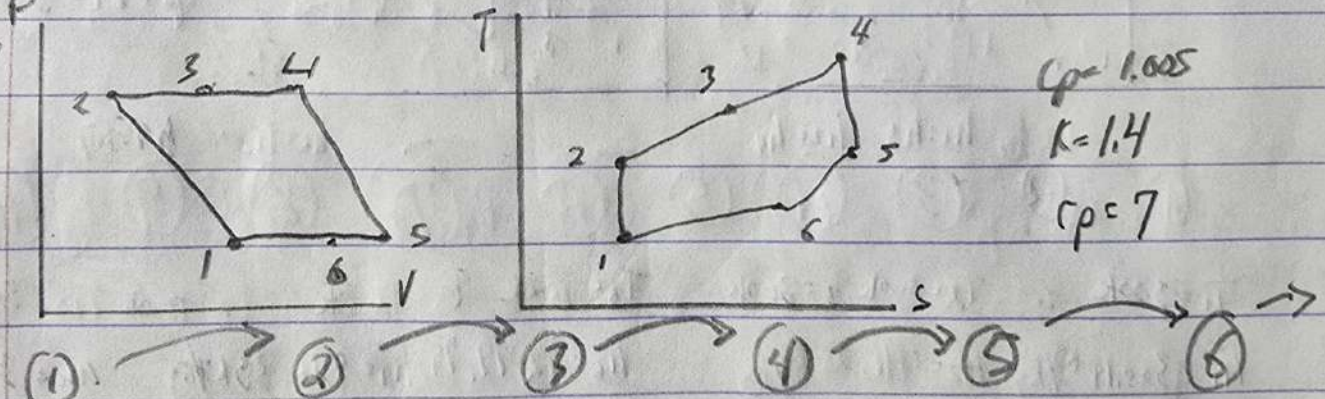
$w_{net} = w_T - w_c = 520 - 283 = 237\ kJ/kg$

$\dot{m} = \frac{\dot{W}_{net}}{w_{net}} = \frac{115}{237} = 0.485\ kg/s$

$Q_{in} = \dot{m} c_p (T_4 - T_3) = 0.485(1.005)(1073 - 546) = 257\ kW$

$Q_{out} = \dot{m} c_p (T_6 - T_1) = 0.485(1.005)(596 - 303) = 142\ kW$

9-107



$c_p = 1.005$

$k = 1.4$

$r_p = 7$

① ② ③ ④ ⑤ ⑥

$h_1 = 310$ $\quad h_2 = 692$ $\quad h_3 = 740$ $\quad h_4 = 1219$ $\quad h_5 = 800$ $\quad h_6 = 477$

$T_1 = 310$ $\quad T_2 = 618k$ $\quad T_3 = 725k$ $\quad T_4 = 1150k$ $\quad T_5 = 783k$ $\quad T_6 = 476k$

$T_{2s} = T_1 r_p^{\frac{k-1}{k}} = 310 \cdot 7^{\frac{1.4-1}{1.4}} = 541k$

$T_2 = 310 + \frac{541 - 310}{0.75} = 618k$

$T_{5s} = T_4 r_p^{\frac{-(k-1)}{k}} = 1150 \cdot 7^{\frac{-(1.4-1)}{1.4}} = 659k$

a) $0.82 = \frac{1150 - T_5}{1150 - 659} \Rightarrow T_5 = 1150 - 420 = 783k$

$T_6 = T_1 + (T_5 - T_1)(1 - \epsilon) = 310 + (783 - 310)(1 - 0.65) = 476k$

$0.65 = \frac{T_3 - 618}{783 - 618}$ $T_3 = 618 + 107 = 725K$

$W_c = h_2 - h_1 = 692 - 310 = 382$ KJ/kg

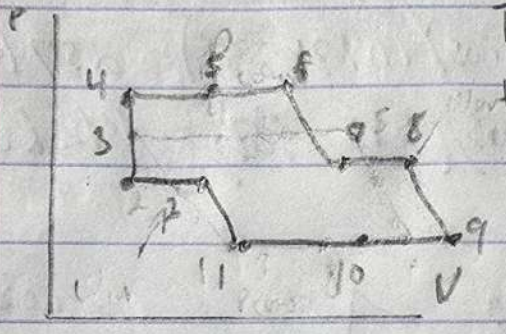
$W_T = h_4 - h_5 = 1219 - 800 = 419$ KJ/kg

b) $W_{net} = W_T - W_c = 419 - 382 = 37$ KJ/kg

$q_{in} = h_3 - h_5 = 740 - 800 = 60$ KJ/kg

c) $\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{37}{60} = 0.616 = 61.6\%$

9-119



$r_p = \sqrt{9} = 3$

$h_1 = h_3$ $h_2 = h_4$ $h_6 = h_8$ $h_9 = h_7$

① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

$T_1 = 300K$ $T_2 = 300K$ $T_6 = 800K$ $T_{10} = 300K$

$h_1 = 300.19$ KJ/kg $h_2 = 411.25$ KJ/kg $h_6 = 1277.79$ $h_7 = 946.35$ KJ/kg $h_{10} = 300.19$

$P_{r1} = 1.386$ $P_{r2} = 4.158$ $P_{r6} = .238$ $P_{r7} = 79.33$

$P_{r2} = 3 \cdot 1.386 = 4.158$ $P_{r7} = \frac{1}{r_p} \cdot P_{r6} = \frac{1}{3} \cdot .238 = 79.33$

$W_T = (h_6 - h_7) + (h_8 - h_9) = r_p(1277.79 - 946.35) + (1277.79 - 946.35) =$

$W_T = 662.88$ KJ/kg

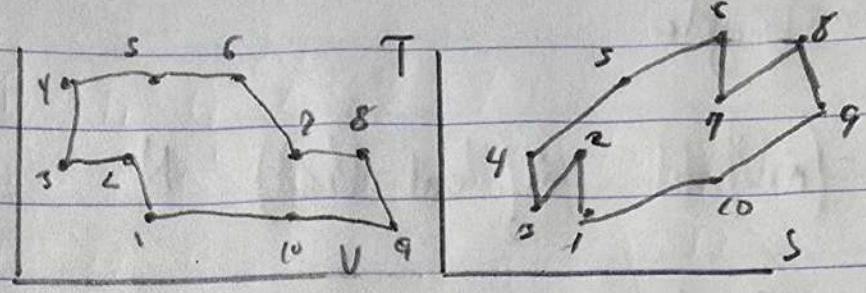
$W_c = (h_2 - h_1) + (h_4 - h_3) = (411.25 - 300.19) + (411.25 - 300.19) =$

$W_c = 222.12$ KJ/kg

$W_{net} = W_T - W_c = 662.88 - 222.12 = 440.76$ KJ/kg

$\dot{m} = \frac{\dot{W}_{out}}{W_{net}} = \frac{110000 \text{ kW}}{440.76 \text{ KJ/kg}} = 249.56$ kg/s

9-121



① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

$T_1 = 300K$ $T_5 = 1200K$

$h_1 = 300.19$ $P_{r2} = P_{r4}$ $h_5 = 1277.79$ $h_6 = h_8$ $h_5 = h_7$ ^{he} 946.36

$P_{r1} = 1.386$ $P_{r2} = 4.158$ $P_{r5} = 238$ $P_{r6} = 79.33$

$P_{r2} = 3 \cdot 1.386 = 4.158$ $P_{r6} = \frac{1}{3} \cdot P_{r5} = \frac{1}{3} \cdot 238 = 79.33$

$W_T = (h_5 - h_7) + (h_8 - h_6) = (1277.79 - 946.36) + (1277.79 - 946.36)$

$W_T = 662.86$ kJ/kg

$W_c = (h_2 - h_1) + (h_4 - h_3) = (411.25 - 300.19) + (411.25 - 300.19) =$

$W_c = 222.12$ kJ/kg

$r_{bw} = \frac{W_c}{W_T} = \frac{222.12}{662.86} = 0.335$ 33.5%

$q_{in} = (h_5 - h_4) + (h_7 - h_6) = (1277.79 - 411.26) + (1277.79 - 946.36)$

$q_{in} = 1197.96$ kJ/kg

$W_{net} = W_T - W_c$ $662.86 - 222.14 = 440.72$ kJ/kg

a) $\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{440.72}{1197.96} = 0.3678$ 36.8%

b) $\varepsilon(h_8 - h_4) = 0.75 (943.36 - 411.26) = 401.33$ kJ/kg

$q_{in} = 1197.96 - 401.33 = 796.63$ kJ/kg

$\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{440.72}{796.63} = 0.5532 = 55.32\%$