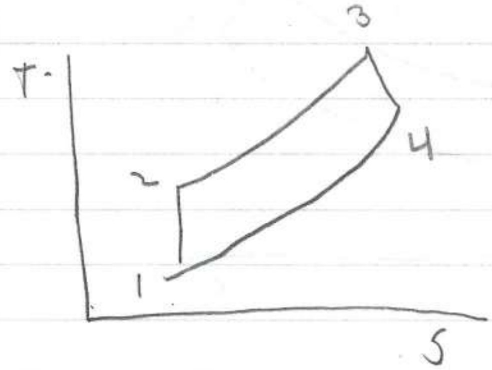
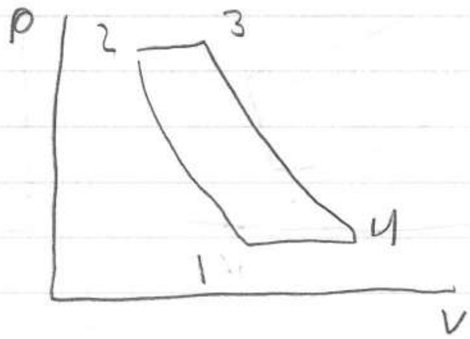
Thermal applications HW 1.5 Ben Smithson

88, 99, 107, 119, 121

88





① ② ③ ④

$T_1 = 273\,K$ $\quad T_2 = 527\,K$ $\quad T_3 = 1025\,K$ $\quad T_4 = 530.7\,K$

$P_1 = 70\,kPa$

$$\left(\frac{T_2}{T_1}\right)_s = \left(\frac{P_2}{P_1}\right)^{(k-1)/k}$$

$$T_2 = (273)(10)^{0.4/1.4} = 527\,K$$

$${}_1W_2 = m\,c_p(T_1 - T_2) = 1\left(1.005\,\frac{kJ}{kg\text{-}K}\right)(273-527) = -255.3$$

$$T_3 = T_2 + \frac{{}_2Q_3}{m\,c_p} \qquad {}_2Q_3 = c_p(T_3 - T_2) = 500 \text{ given}$$

$$T_3 = 527 + \frac{500\,kW}{(1)(1.005)}\left(\frac{kJ/s}{kW}\right) = 1025\,K$$

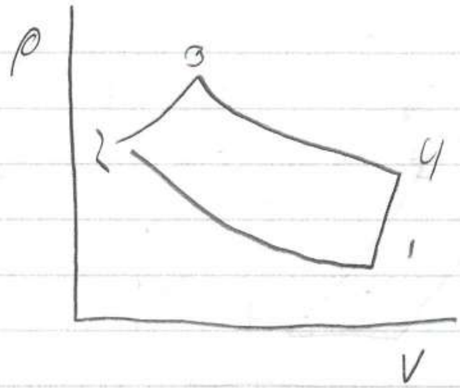
$$\left(\frac{T_4}{T_3}\right) = \left(\frac{P_4}{P_3}\right)^{(k-1)/k} = (1025)\left(\frac{1}{10}\right)^{(0.4/1.4)} = 530.7\,K$$

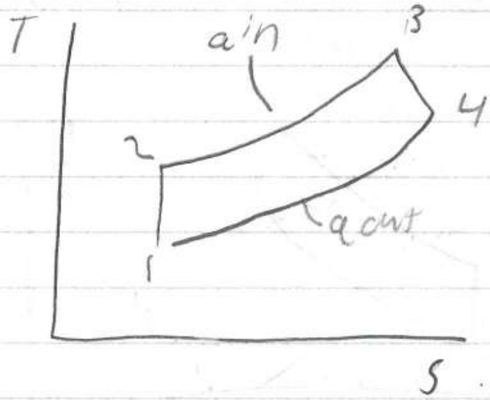
$${}_3W_4 = m\,c_p(T_3 - T_4) = 1(1.005)(1025 - 530.7) = 496$$

$$W_{net} = {}_1W_2\ {}_3W_4 = (-255.3) + (496) = \boxed{241\,\frac{kJ}{s}}$$

$$\eta_{th} = \frac{W_{net}}{Q_{in}} = 241./500 = 0.48 = \boxed{48\%}$$

99





(1) $t_1 = 303\ K$

$P_1 = 100 kPa$

(2) $T_2 = 585$

(3) $T_3 = 545.9$

(4) $T4 = 1073K$

T_5

$$\frac{T_2}{T_1} = \frac{P_2}{P_1}^{\left(\frac{1.4-1}{1.4}\right)} = 10\left(\frac{0.4}{1.4}\right)$$

$303($

$T_2 = 585K$

$$\frac{T_4}{T_5} = \left(\frac{P_4}{P_5}\right)^{\left(\frac{1.4-1}{1.4}\right)}$$

$$T_5 = \frac{1073}{10^{(0.2857)}} = 555.9\ K$$

$t_5 - t_3 = 10$

$T_3 = 10 - 555.9$

$$m = \frac{115 kw}{236.3}$$

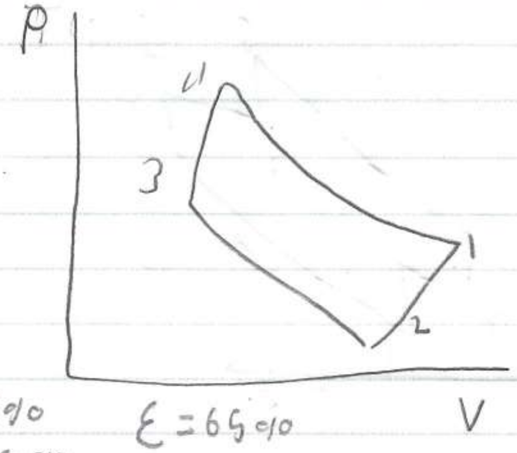
$Q_{in} = m\ cp\ (t_4 - t_3) = (0.48)(1.005)(1073 - 545.8) = \boxed{257 Kw}$

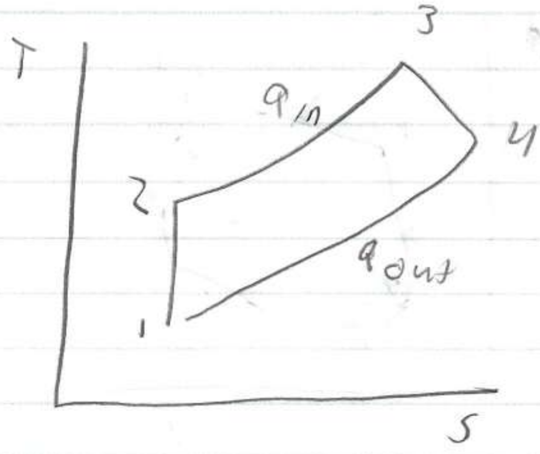
$T_5 - T_6 = t_3 - T_2 = 245.8 - 585 - 555.9 = 595K$

$Q_{out} = 0.48(1.005) \cdot (595 - 303) = \boxed{142 Kw}$

Thermal applications HW 1.5 Ben Smithson

107





$R_c = 55\%$ $\quad \varepsilon = 65\%$

$R_t = 82\%$

① $T_1 = 310K$ ② $T_2 = 617.3K$ ③ $T_3 = 1150K$ ④ $T_4 = 750K$

$$T_2 = 310 \cdot 7^{\frac{1.4-1}{1.4}} = 540.3 =$$

$$\frac{T_2 - T_1}{T_2' - T_1} = \frac{540.3 - 310}{T_2' - 310} = 617.3$$

$$\frac{T_4}{T_3} = \left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}}$$

$$T_4 = \frac{T_3}{r^{\frac{k-1}{k}}} = \frac{1150}{7^{\frac{0.4}{1.4}}} = 659.5K$$

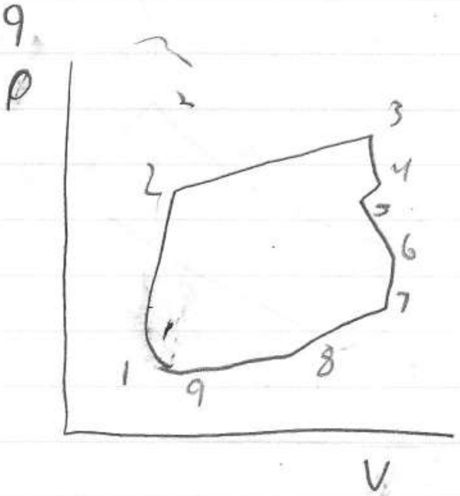
$$\frac{T_3 - T_4'}{T_3 - T_4} = 0.82 = \frac{1150 - T_4'}{1150 - 659.5} = \boxed{750K}$$

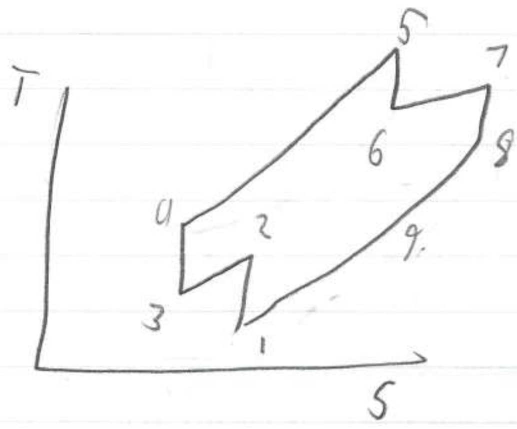
$$w_{net} = 1.005(1150 - 750) - (617.3 - 310) = \boxed{98 kJ/kg}$$

$$\varepsilon = \frac{T_6 - T_2'}{T_4' - T_2'} = \frac{T_6 - 617.3}{750 - 617.3} = 700K$$

$$\eta_{th} = \frac{98}{1.005(1150 - 700K)} = \boxed{22\%}$$

119.





① ② ③ ④ ⑤ ⑥ ⑦ ⑧

$T_1 = 300K$

$h_1 = 300.19 \, kJ/kg$

$P_{r1} = 1.38$

$P_{r2} = 4.15$

$h_2 = 411.25$

$P_{r3} = 4.52$

$h_3 = 421.2$

$T_5 = 1200K$

$h_5 = 1277.8 \, kJ/kg$

$P_{r5} = 238$

$P_{r6} = 80$

Pressure ratio = 3

$$P_{r2} = \frac{P_2}{P_1} = 3 \cdot 1.38 = 4.15$$

$$\frac{h_2 - 411.12}{421.26 - 411.12} = \frac{4.16 - 4.19}{4.52 - 4.15} = 411.25 \, kJ/kg$$

$$P_{r6} = \frac{P_6}{P_5} P_{r5} = \frac{1}{3} \cdot 238 = 80$$

$P_r = 75$

$h = 932$

$P_r = 82$

$h = 955$

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$$\frac{h_6 - 932.9}{955.3 - 932.9} = \frac{79.3 - 75.3}{82.0 - 75.3} = h_6 - 932.9 = (955.3 - 932.9)$$

?

$$\frac{79.3 - 75.3}{82.05 - 75.3} = 946.35$$

$w_{in} = 2(h_2 - h_1) = 2(411.25 - 300) = 222.13$ KJ/Kg

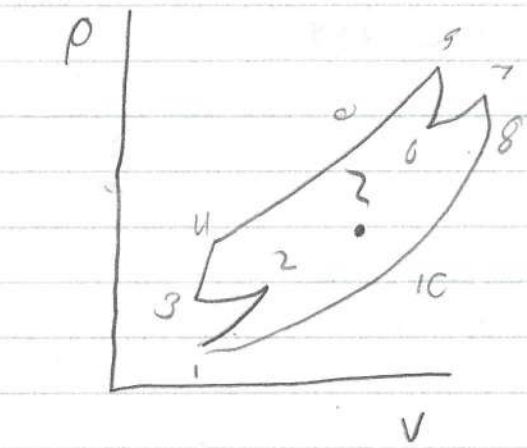
$w_{out} = 2(h_5 - h_6) = 2(1277.8 - 946.3) = 662.86$ KJ/Kg

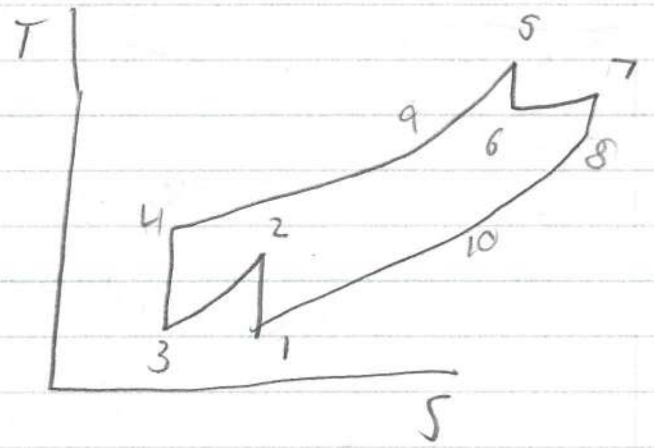
$w_{net} = w_{out} - w_{in} = 662.8 - 222.13 = 440.73$

$W = m w_{net} = (110 \times 10^3) = m(440.73) =$

$m = 250$ Kg/s

121





① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨

$h_1 = 300.19$ $P_{r1} = 1.38$

$P_{r2} = 4.15$ $h_2 = 411.26$

$h_4 = 411.26$

$T_5 = 1200K$ $P_{r5} = 238$ $h_5 = 1277.8$

$P_{r6} = 79.3$ $h_6 = 946$

$T_7 = 1200K$ $h_5 = 1277.9$

$h_8 = 946$

$P_{r2} = \frac{P_2}{P_1} P_{r1} = 3(1.38) = 4.15$

$h_2 = h_4 = 411.26$

$T_5 = T_7 = 1200K$ A-17

$h_5 = h_7 = 1277.79$ kJ/kg

$P_{r5} = 238$

$P_{r6} = \frac{P_6}{P_5} P_{r5} = \frac{1}{3} 1238 = 79.3$

$h_6 = h_8 = 946.136$

$w_{in} = 2(h_2 - h_1) = 2(411.26 - 300.19) = 222.14$ kJ/kg

$w_{out} = 2(h_5 - h_6) = 2(1277.8 - 944.3) = 662.8$ kJ/kg

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$\frac{w_{in}}{w_{out}} = \frac{222.14}{662.8} = 0.335 = 33.5\%$

$q_{in} = (h_5 - h_4) + (h_7 - h_6) = 1277.79 - 411.2) + (1277.7 - 946.3)$
$= 1197 kJ/kg$

$n_{th} = \frac{w_{net}}{q_{in}} = \frac{(662.86 - 222.14)}{1197} = \boxed{36.8\%}$

$\frac{w_{in}}{w_{out}} = 33.5\%$

$\epsilon(h_8 - h_4) = 0.75 \ (946.36 - 411.26) = 401.33 \ kJ/kg$

$q_{in} = q_{in} - q_{out} = (1197 - 401.3) = 796 kJ/kg$

$n_{th} = \frac{w_{net}}{q_{in}} = \frac{(662.8 - 222.14)}{796.6} = 0.553 = \boxed{55.3\%}$