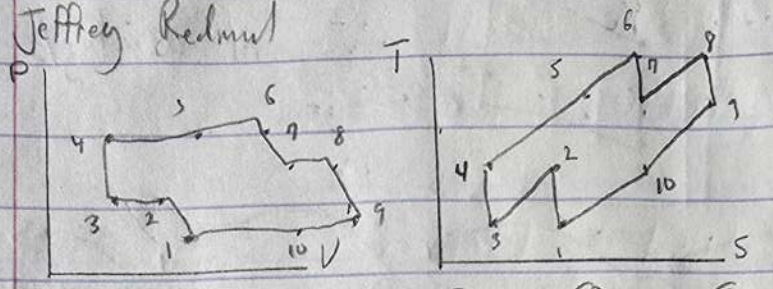
R=4

HW 1.5

Jeffrey Redmond

9-123



① ② ③ ④ ⑤ ⑥ ⑦ ⑧ ⑨ ⑩

P_1=100kPa, P_2=400kPa, P_3=400kPa, P_4=160kPa, P_5=160kPa, P_6=160kPa, P_7=400kPa, P_8=400kPa, P_9=100kPa, P_{10}=100

T_1=290k, T_2=431k, T_3=290k, T_4=431k, T_5=451k, T_6=749k, T_7=504k, T_8=803k, T_9=540k, T_{10}=320.1k

$T_2 = T_1\left(R\right)^{\frac{k-1}{k}} = 290(4)^{\frac{1.4-1}{1.4}}$ $T_5 = T_4 + 20 = 431 + 20 = 451$

$q_{in} = C_p(T_6 - T_5)$ $T_6 = T_5 + q_{in} = 451 + \frac{300\,kJ/kg}{1.005} = 749k$

$T_7 = T_6\left(\frac{1}{r_p}\right)^{\frac{k-1}{k}} = 749\left(\frac{1}{4}\right)^{\frac{1.4-1}{1.4}} = 504k$

$T_8 = T_7 + \frac{q_{in}}{} = 504 \frac{300}{1.005} = 803K$

$T_9 = T_8\left(\frac{1}{C_p}\right)^{\frac{k-1}{k}} = 803\left(\frac{1}{4}\right)^{\frac{1.4-1}{1.4}} = 540k$

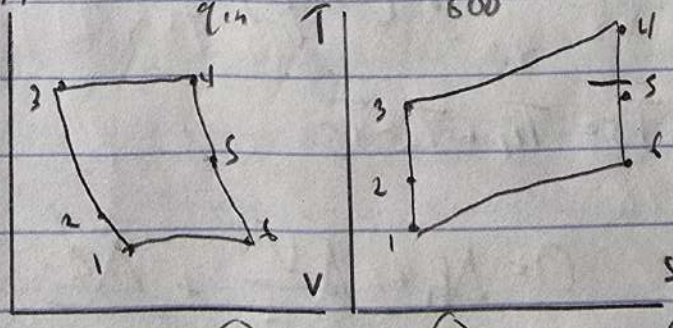
$q_{in} = 300\,kJ/kg + 300\,kJ/kg = 600\,kJ/kg$

$q_{out} = C_p(T_{10} - T_1) + (\,)(T_2 - T_3) = 1.005(540k - 290k) + 1.005(431 - 290)$

$q_{out} = 371.85$

$\eta_{th} = 1 - \frac{q_{out}}{q_{in}} = 1 - \frac{371.85}{600} = 0.381 = 38\%$

9-129E



① ② ③ ④ ⑤ ⑥

$r_p = 13$

$c_p = 0.24$

P_1=7psi, P_2=11.17psi, P_3=145.5psi, P_4=145.5psi, P_5=55.2psi, 7psi

T_1=470R, T_2=537R, T_3=1118.3R, T_4=2400R, T_5=1819R, T_6=1008.6R

V_1=900ft/s, V_2=0ft/s, V_6=0

$$T_2 = T_1 + \frac{V_1^2}{2c_p} = 470 + \frac{900^2}{2(0.24)}\left(\frac{1\,BTU}{25{,}037\,\frac{ft^2}{s^2}}\right) = 537$$

$$P_2 = P_1\left(\frac{T_2}{T_1}\right)^{\frac{k}{k-1}} = 7\left(\frac{537}{470}\right)^{\frac{1.4}{1.4-1}} = 11.19\ psi$$

$$P_4 = P_3 \cdot r_p = 11.19 \cdot 13 = 145.5\ psi$$

$$T_3 = T_2\left(r_p\right)^{\frac{k-1}{k}} = 537(13)^{\frac{1.4-1}{1.4}} = 1118.3\,R$$

$$T_5 = T_4 - T_3 + T_2 = 2400 - 1118.3 + 537 = 1819$$

a) $$P_5 = P_4\left(\frac{T_5}{T_4}\right)^{\frac{k}{k-1}} = 145.5\left(\frac{1819.1}{2400}\right)^{\frac{1.4}{1.4-1}} = 55.2\ psi$$

$$T_6 = T_5\left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}} = 1819\left(\frac{7}{55.2}\right)^{\frac{1.4-1}{1.4}} = 1008.6\,R$$

b) $$V_6 = \sqrt{2c_p(T_5 - T_6)} = \sqrt{(2)(0.24)(1819-1008.6)\left(\frac{25037\,\frac{ft^2}{s^2}}{1\,\frac{BTU}{lbm}}\right)} = 3121\,\frac{ft}{s}$$

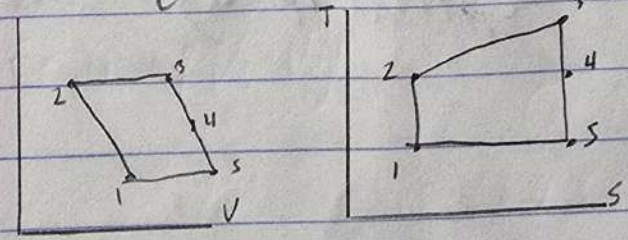
$$w_p = (V_{exit} - V_{inlet})\,V_{airmass\,ft} = (3121-900)(900)\left(\frac{1\,\frac{BTU}{lbm}}{25{,}037\,\frac{ft^2}{s^2}}\right) = 79.8\,\frac{BTU}{lbm}$$

$$q_{in} = c_p(T_4 - T_3) = 0.24(2400 - 1118.3)$$

$$q_{in} = 307.6\ BTU/lbm$$

c) $$\eta_p = \frac{w_p}{q_{in}} = \frac{79.8}{307.6} = 0.259 = 25.9\%$$

9-135



$P_{r5} = 60.426$

$P_{r4} = 290.07$

① ② ③

$T_1 = 298K$ $P_{r1} = 1.0584$ $T_2 = 521K$ $P_{r2} = 9.8001$ $T_3 = 1599K$ $P_{r3} = 543.85$ $T_4 = 1259.2K$ $T_5 = 280K$

$P_1 = 95\,kPa$ $P_2 = 855\,kPa$ $P_3 = 8551\,kPa$ $P_5 = 75\,kPa$

$h_1 = 280.13\,kJ/kg$ $h_2 = 525.38\,kJ/kg$ $h_3 = 1592.18$ $h_4 = 1347.63\,kJ/kg$ $h_5 = 877.50\,kJ/kg$

$\dot{Q}_{in} = \dot{m}_f \cdot H_f = 0.5 \cdot 42{,}700 = 21{,}350\ kW$

$q_{in} = \frac{\dot{Q}_{in}}{\dot{m}_a} = \frac{21{,}350}{20} = 1{,}067.5\ kJ/kg$

$h_3 = h_2 + q_{in} = 525.38 + 1067.5 = 1592.88\ kJ/kg$

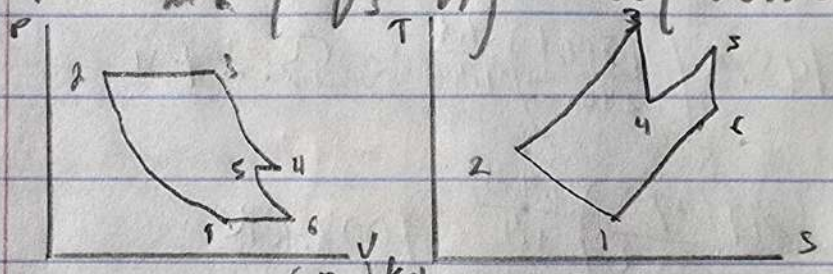
$h_4 = h_3 - (h_2 - h_1) = 1592.88 - (525.38 - 280.13) = 1347.63\ kJ/kg$

$V_5 = \sqrt{2(h_4 - h_5) \cdot 1000} = \sqrt{2(1347.63 - 877.50) \cdot 1000}$

$V_5 = 969.67\ m/s$

$F = \dot{m}_a \left(V_5 - V_1 \right) = 20(969.67 - 0) = 19393\ N$

9-167



$T_5 = T_2 = T_1 \left(\frac{P_2}{P_1} \right)^{\frac{k-1}{k}}$

$T_7 = T_4 = T_3 \left(\frac{P_4}{P_3} \right)^{\frac{k-1}{k}} = T_3 \left(\frac{1}{\sqrt{r_p}} \right)^{\frac{(k-1)}{k}}$

$q_{in} = h_3 - h_7 = c_p \left(T_3 - T_7 \right) = c_p (T_3) \left(1 - r_p^{\frac{1-k}{2k}} \right)$

$q_{out} = h_6 - h_1 = c_p \left(T_6 - T_1 \right) = c_p (T_1) \left(r_p^{\frac{k-1}{2k}} - 1 \right)$

$\eta_{th} = 1 - q_{out} / q_{in} \quad 1 - \frac{c_p (T_1) \left(r_p^{\frac{k-1}{2k}} - 1 \right)}{c_p (T_3) \left(1 - r_p^{\frac{-k}{2k}} \right)}$