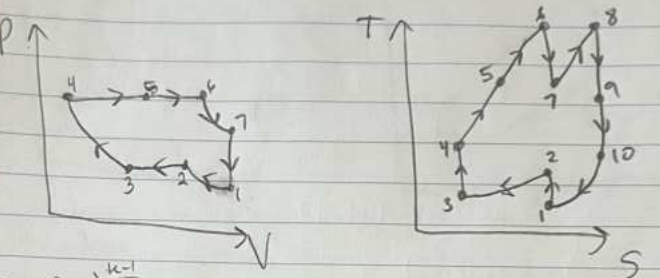
HW 1.5

Joshua Wore

9-123)



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

$T_3 = T_1$

$r_p = \sqrt{P_6 / P_9}$

$r_p = \frac{P_6}{P_7} = \frac{P_8}{P_9}$

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

$T_7 = 751\left(\frac{1}{4}\right)^{\frac{0.4}{1.4}}$

$T_7 = 505.4°K$

$T_5 = T_4 + 20°K$

$T_5 - T_4 = T_9 - T_{10}$

$T_{10} = T_9 - 20°K$

$T_{10} = 522°K$

$P_{out} = (522 - 290 + 431 - 240) = 373\ kJ/kg$

$P_{in} = 600\ kJ/kg$

$\eta_{th} = \frac{373}{600} = 62\%$

1 Isent → 2 const → 3 Isent → 4 const → 5 const → 6 Isent → 7 Isent → 8 const → 9 const → 10

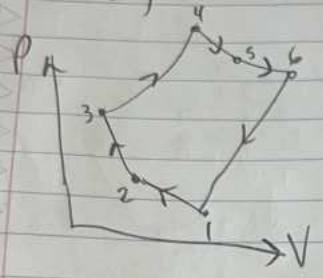
$P_1 = 100kPa$ $P_2 = 400kPa$ $P_3 = 400kPa$ $P_5 = 1600kPa$ $P_7 = 400kPa$ $P_9 = 100kPa$ $P_{10} = 100$

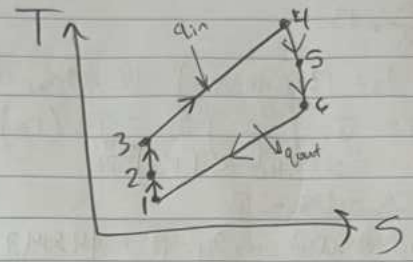
$T_1 = 290k$ $T_2 = 431k$ $T_3 = 290k$ $T_5 = 451k$ $T_7 = 505.4°k$ $T_9 = 542°k$ $T_{10} = 522$

$P_4 = 1600k$ $P_6 = 1600kPa$ $P_8 = 400kPa$

$T_4 = 431°k$ $T_6 = 751k$ $T_8 = 905°k$

9-129)





$P_1 = 7$ psia

$V_1 = 900$ ft/s

$T_1 = 10°F = 470R$

$r_p = 13$

$T_3 = 2500$ R

A) $E_{in} - E_{out} = \Delta E_{system}$

$$h_1 + \frac{V_1^2}{2} + gz_1 = h_2 + \frac{V_2^2}{2} + gz_2$$

$$T_2 = T_1 + \left(\frac{V_1^2}{2c_p}\right)$$

$$= 470R + \left(\frac{900^2 ft^2/s^2}{2(0.24 \frac{Btu}{lbmR})\left(\frac{25037 ft^2/s^2}{1 Btu}\right)}\right)$$

$T_2 = 537.40$ R

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

$$= 7psia\left(\frac{537.40}{470}\right)^{\frac{1.4}{1.4-1}}$$

$P_2 = 11.19$ psia

$r_p = 13$

$\frac{P_3}{P_2} = 13$

$P_3 = 13(11.19 \text{ psia}) = 145.47 \text{ psia}$

$T_3 = T_2 \left(\frac{P_3}{P_2}\right)^{\frac{k-1}{k}} = T_2 (r_p)^{\frac{k-1}{k}}$

$= 537.40 °R \, (13)^{\frac{0.4}{1.4}}$

$T_3 = 1118.32 °R$

$T_4 = 2400 °R \qquad P_4 = P_3 = 145.47$

$C_p(T_3 - T_2) = C_p(T_4 - T_5)$

$T_5 = T_4 - (T_3 - T_2)$

$= 2400 °R - 1118 °R + 537.40 °R$

$T_5 = 1819.08 °R$

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

$P_5 = 145.47 \left(\frac{1819.08}{2400}\right)^{1.4/0.4}$

$P_5 = 55.15 \text{ psia}$

b) $P_6 = 7 psia$

$$\frac{T_5}{T_6} = \left(\frac{P_5}{P_6}\right)^{\frac{k-1}{k}}$$

$$T_6 = 1819.08\ R \left(\frac{7}{55.15}\right)^{\frac{1.4-1}{1.4}}$$

$$T_6 = 1,008.61\ R$$

$$\sqrt{2c_p(T_5 - T_6)} = V_6$$

$$V_6 = \sqrt{2\left(0.24 \frac{Btu}{lbm \cdot R}\right)\left(\frac{25,037\ ft^2/s^2}{1\ Btu}\right)(1819.08 - 1008.61)R}$$

$$V_6 = 3120.9\ ft/s$$

c) $W_{comp} = (3120.9 - 900)\frac{ft}{s} \cdot 900\ ft/s$

$$= 1,998,810\ ft^2/s^2 \left(\frac{1\ Btu}{25,037}\right)$$

$$W_{pp} = 79.83\ Btu/lbm$$

$$Q_{in} = c_p(T_4 - T_3) = 0.24(2400 - 1118.32)R$$

$$= 307.60\ Btu/lbm$$

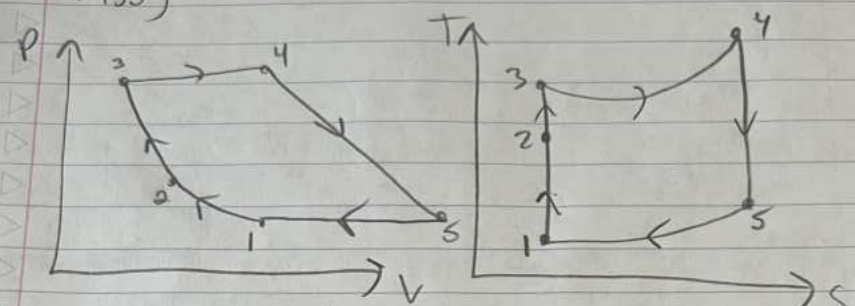
$$\eta = \frac{W_{prop}}{Q_{in}}$$

$$= \frac{79.834\ \frac{Btu}{lbm}}{307.6\ \frac{Btu}{lbm}}$$

$$= 0.2594$$

$$= 25.94\%$$

9-135)



1 → 2 → 3 → 4 → 5

$T_1 = 290\,K$ $T_2 = 540K$ $T_3 = 1480K$ $T_4 = 1268K$ $T_5 = 860K$

$P_1 = 95kPa$ $P_2 = 10.5\,kPa$ $P_3 = 855kPa$ $P_4 = 855\,kPa$ $P_5 = 95kPa$

$h_1 = 290.16$ $h_2 = 544.35$ $h_3 = 1611.85$ $h_4 = 1352.6$ $h_5 = 868.5$

$\phi_1 = 1.2314$ $P_{r2} = 11.08$ $P_{r3} = 568.8$

$$P_{r2} = \left(\frac{P_2}{P_1}\right) P_{r1}$$

$$= (9)(0.25)$$

$$P_{r2} = 11.08$$

$$q_{in} = \frac{21350}{20} = 1067.5$$

$$h_3 = h_2 + q_{in}$$

$$h_3 = 544.35 + 1067.5$$

$$h_3 = 1611.85$$

$$h_4 = h_3 - h_2 + h_1$$

$$h_4 = 1611.85 - 544 - 290$$

$$h_4 = 1357.66$$

$$P_{r5} = P_{r3}\left(\frac{P_5}{P_2}\right)$$

$$P_{r5} = 568.8\left(\frac{1}{9}\right)$$

$$P_{r5} = 63.2$$

$$V_5 = \sqrt{2(h_4 - h_5)}$$

$$V_5 = \sqrt{2(1357.66 - 888.56)\cdot 1000}$$

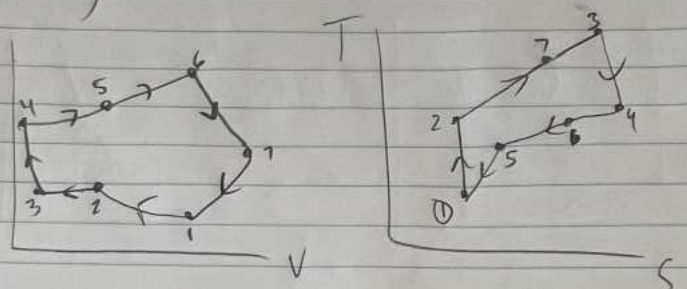
$$\boxed{V_5 = 968.6\,m/s}$$

$$F = \dot{m}(V_{exit} - V_{in})$$

$$F = 20(968.6 - 0)$$

$$\boxed{F = 19.37kN}$$

9-167)



$T_5 = T_2 = T_1 \left(\frac{P_2}{P_1}\right)$

$T_7 = T_4 = T_3 \left(\frac{P_4}{P_3}\right)^{k-1/k} = T_3 \left(\frac{1}{r_p}\right)^{\frac{k-1}{k}} = T_3 r_p^{1-k/2k}$

$T_6 = T_5 \left(\frac{P_6}{P_5}\right)^{\frac{k-1}{k}} = T_5 \left(1/\sqrt{r_p}\right)^{k-1/k} = T_2 r_p^{1-k/2k} =$

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

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

$\eta_{th} = 1 - \frac{T_1}{T_3} r_p^{(k-1)/k}$