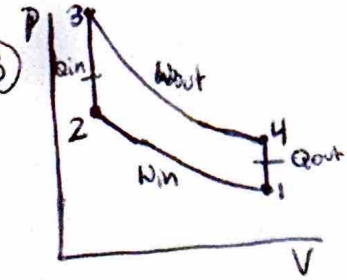
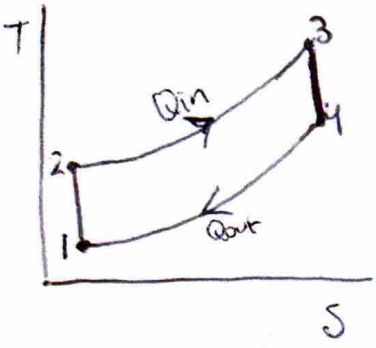
Ramzie Abbas

HW 1.3 - 33, 36, 46, 57, 59, 80

33)




isentropic 1→2, V const 2→3, isentropic 3→4, V const 4→1

① $T_1 = 300K$, $P_1 = 95 kPa$

From A-17: $U_1 = 214.07 \frac{kJ}{kg}$, $V_{r1} = 621.2$

$V_{r2} = \frac{V_{r1}}{cr}$ (comp ratio) $= \frac{621.2}{8}$

$V_{r2} = 77.65$

② $T_2 = 673K$, $P_2 = ?$

$P_2 = P_1 cr \frac{T_2}{T_1}$ (comp ratio)

$= 95.8 \cdot \frac{673}{300}$

$P_2 = 1705 kPa$

$U_2 = 491.2 \frac{kJ}{kg}$

$V_{r2} = 77.65$

③ $T_3 = 1540K$, $P_3 = 3899 kPa$

$V_{r3} = 6.588$

$\Delta U_{2-3} = q_{in}$

$U_3 = U_2 + q_{in}$

$U_3 = 1241.2 \frac{kJ}{kg}$

from A-17 we can get $T_3$

$T_3 = 1540K$

$V_{r3} = 6.588$

$P_3 = P_2 \frac{T_3}{T_2}$

$= 1705 \cdot \frac{1540}{673} kPa$

$P_3 = 3899 kPa$

④ $T_4 = 780K$

$U_4 = 576.12 \frac{kJ}{kg}$

$V_{r4} = 52.7$

$V_{r4} = \hat{cr} \cdot V_{r3}$ ($\hat{cr}$ = comp ratio)

$= 8 \cdot 6.588$

$= 52.7$

from A-17 we can get $T_4 = 780K$

$U_4 = 576.12 \frac{kJ}{kg}$

a) $T_3 = 1539K$

$P_3 = 3899 kPa$

b) $w = q_{in} - q_{out}$

$= q_{in} - (u_4 - u_1)$

$= (750 - (576.12 - 214.07))$

$w = 387.95 \frac{kJ}{kg}$

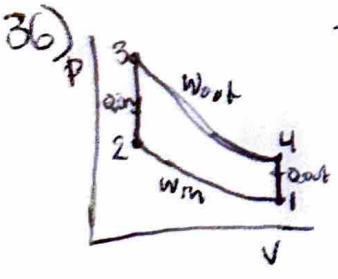
c) $\eta = \frac{w}{q_{in}} = \frac{387.95}{750}$

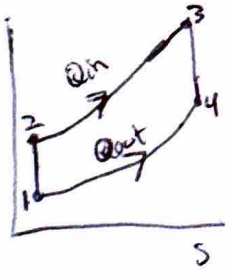
$\eta = 0.517$ or $52\%$

d) $MEP = \frac{8 \cdot 387.95 \cdot 95}{0.287 \cdot 300 (8-1)}$

$MEP = 495 kPa$

36)




isentropic 1→2, V const 2→3, isentropic 3→4, V const 4→1

① $T_1 = 565R$, $P_1 = 14 psia$

② $T_2 = 1430.5R$

③ $T_3 = 2860R$

④ $T_4 = 1129.6R$

$T_2 = T_1 r^{k-1}$

$= 565 \cdot \left(\frac{1}{0.098}\right)^{1.4-1}$

$= 1430.5R$

$T_4 = T_3 r^{1-k}$

$= 2860 \cdot 10.2^{1-1.4}$

$= 1129.6R$

$M = \frac{P_1 N \pi B^2 S}{4 R T_1}$

$= \frac{14.6 \cdot \pi \cdot 3.5^2 \cdot 3.9 \cdot \left(\frac{1}{12}\right)^3}{4 \cdot 0.3704 \cdot 565} lbm$

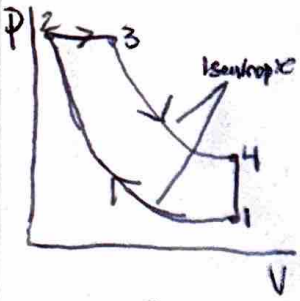
$= 8.72 \cdot 10^{-3} lbm$

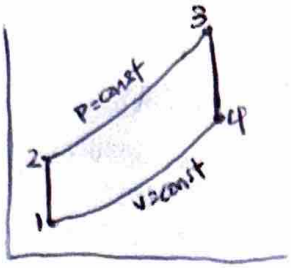
$W = \frac{mn c_v}{N_{rev}} (T_3 - T_4 - (T_2 - T_1))$

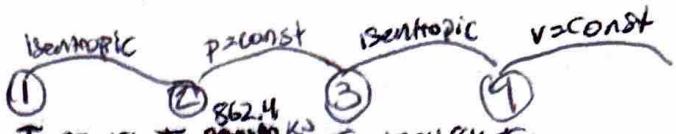
$= \frac{8.72 \cdot 10^{-3} \cdot 2500 \cdot 0.171}{60 \cdot 2 \cdot 0.7068} (2860 - 1129.6 - (1430.5 - 565)) hp$

$W = 38 hp$

46)




$T_1 = 300.15K$ $T_2 = 862.4$ $T_3 = 1724.8K$ $T_4 =$

$P_1 = 95kPa$ $h_2 = 890.89$ (from A-17)

$U_1 = 214.07 \frac{kJ}{kg}$ $h_3 = 1910.6 \frac{kJ}{kg}$ $v_{r4} = 36.37$

$v_{r1} = 621.2$ $v_{r2} = 38.825$ $v_{r3} = 4.546$ $u_4 = 659.69$

$T_3 = T_2 r_c$ (cutoff ratio) $v_{r4} = \frac{r}{r_c} v_{r3}$

$v_{r2} = \frac{v_{r1}}{r}$ $= 862.4 \cdot 2K$ $= \frac{16}{2} \cdot 4.546$

$= \frac{621.2}{16}$ $T_3 = 1724.8K$ $= 36.37$

$= 38.825$

$\eta = 1 - \frac{q_{out}}{q_{in}}$

$= 1 - \frac{u_4 - u_1}{h_3 - h_2}$

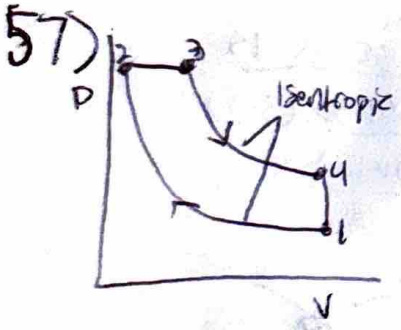
$= 1 - \frac{659.69 - 214.07}{1910.6 - 890.89}$

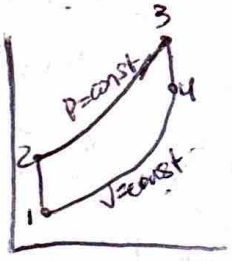
$\eta = 0.563$ or $56.3\%$

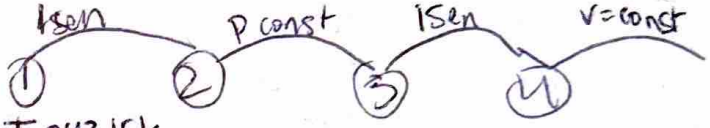
$MEP = \frac{0.563(1910.6 - 890.89)}{\frac{0.287 \cdot 300}{95}\left(1 - \frac{1}{16}\right)}$

$MEP = 675.7 kPa$

57)




$T_1 = 343.15K$

$P_1 = 97kPa$ [redacted]

$w = \eta \cdot q_{in}$

$= \left(1 - \frac{1}{k} \frac{r_c^k - 1}{r^{k-1}(r_c - 1)}\right) c_p T_1 r^{k-1}(r_c - 1)$

$= \left(1 - \frac{1}{1.4} \frac{1.8^{1.4} - 1}{22^{1.4-1}(1.8-1)}\right) \cdot 1.005 \cdot 343 \cdot 22^{1.4-1}(1.8-1) \frac{kJ}{kg}$

$= 635 \frac{kJ}{kg}$

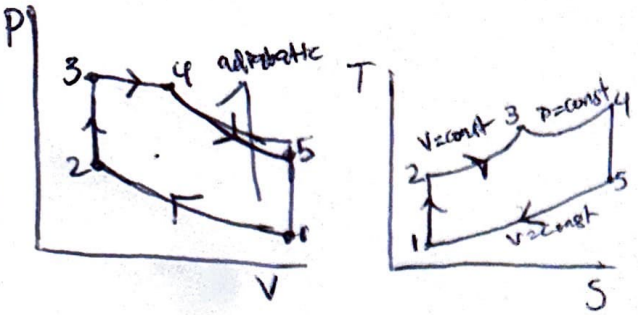
$\dot{W} = \dot{m} w$

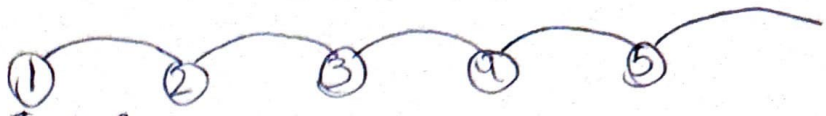
$= N \frac{P_1 V}{R T_1} w$

$= \frac{3600}{60} \frac{97 \cdot 2.5 \cdot 10^{-3}}{0.287 \cdot 343} \cdot 635 kW$

$= 91.2 kW$

59)




$T_1 = 535R$

$P_1 = 14.2 psia$

$$q_{in} = c_v T_1 r_c^{k-1}\left(\frac{P_x}{P_2} - 1\right) + c_p \frac{P_x}{P_2} T_1 r_c^{k-1}(r_c - 1)$$

$$= \left(0.171 \cdot 535 \cdot 15^{1.4-1}(1.1-1) + 0.24 \cdot 1.1 \cdot 535 \cdot 15^{1.4-1}(1.4-1)\right)\frac{Btu}{lbm}$$

$$q_{in} = 193.9 \frac{Btu}{lbm}$$

$$\eta_{th} = \frac{w}{q_{in}} = \frac{124.2}{193.9}$$

$$\eta_{th} = 0.646 \text{ or } 64.6\%$$

$$w = q_{in} - q_{out}$$

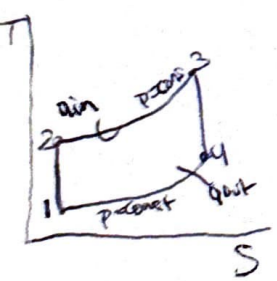
$$= q_{in} - c_v(T_4 - T_1)$$

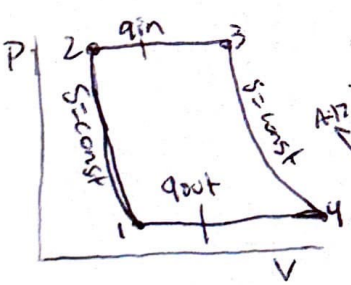
$$= q_{in} - c_v T_1\left(r_c^k \frac{P_x}{P_2} - 1\right)$$

$$= \left(193.9 - 0.171 \cdot 535\left(1.4^{1.4} \cdot 1.1 - 1\right)\right)\frac{Btu}{lbm}$$

$$w = 124.2 \frac{Btu}{lbm}$$

80)





A-17

$T_1 = 520R$ $\quad T_2 = 996R$ $\quad T_3 = 2000R$

$P_{r1} = 1.2147$ $\quad P_{r2} = 12.147$ $\quad P_{r3} = 174$ $\quad P_{r4} = 17.4$

$h_1 = 124.27 \frac{Btu}{lbm}$ $\quad h_2 = 240.11 \frac{Btu}{lbm}$ $\quad h_3 = 504.71 \frac{Btu}{lbm}$ $\quad h_4 = 265.83 \frac{Btu}{lbm}$

$$P_{r2} = r_p P_{r1}$$

$$= 10 \cdot 1.2147$$

$$P_{r2} = 12.147$$

$$P_{r4} = \frac{P_{r3}}{r_p}$$

$$= \frac{174}{10}$$

$$= 17.4$$

Backwork Ratio:

$$r_{bw} = \frac{w_{c\,in}}{w_{t\,out}}$$

$$= \frac{h_2 - h_1}{h_3 - h_4}$$

$$= \frac{240.11 - 124.27}{504.71 - 265.83}$$

$$r_{bw} = 0.485$$

$$\eta = \frac{w}{q_{in}} = \frac{w}{h_3 - h_2}$$

$$= 1 + \frac{h_1 - h_4}{h_3 - h_2}$$

$$= 1 + \frac{124.27 - 265.83}{504.71 - 240.11}$$

$$= 0.465$$

$$\eta_{th} = 0.465$$