Colby Watts
Professor Ayala
01/30/24
MET 350 HW 1.3

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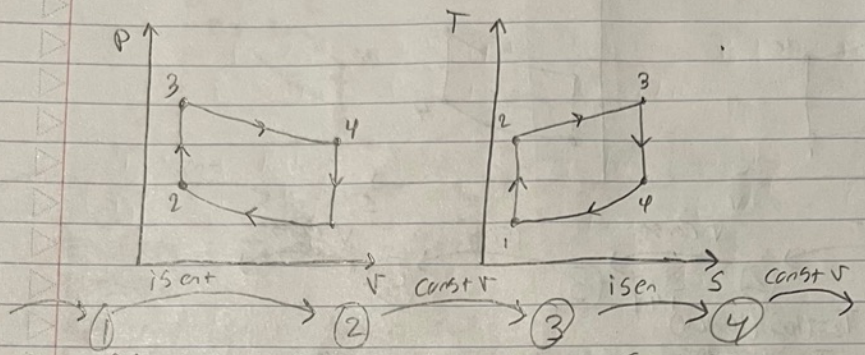
$R = 0.287 \ kJ/kg \cdot K$

$Q_{in} = 750 \ kJ/kg$

9.33 $\frac{P_2}{P_1} = 8 = \frac{P_4}{P_3}$



$P_1 = 95 kPa$ $P_2 = 1705 kPa$ $V_3 = 72.6$ ✓ $T_4 = 774.5 K$

$T_1 = 300 K$ $V_2 = 72.60$ $T_3 = 1,539 K$

$P_3 = 3898.37$ ✓

$P_2 = 8 \cdot \frac{673.1 K}{300}$ $V_{r_2} = \frac{V_2}{V_1} \cdot V_1 = \frac{V_{r_1}}{r} = V_3$ ✓

$u_1 = 214.07$ $T_2 = 673.1 K$ $P_3 = 3898.4 \ kPa$

$u_2 = 491.2 \ kJ/kg$

$q_{in\ 2-3} = u_3 - u_2 = q_{in\ 2-3} + u_2 = 750 + 491.2 = 1,241 \ kJ/kg$

$T_3 = \boxed{1539 K}$

$P_3 = \frac{T_3}{T_2} P_2$ ✓ Table $u_4 = 571.69 \ kJ/kg$

$v_{r4} = \frac{V_4}{V_2} \cdot v_{r3} = 8 \cdot 6.581 = 52.70$ $T_4 = 774.5 K$

$W_{net} = q_{in} - q_{out} = 750 - 357.62 = \boxed{392.4 \ kJ/kg}$

$\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{392.4}{750} \cdot 100 = \boxed{52.32\%}$

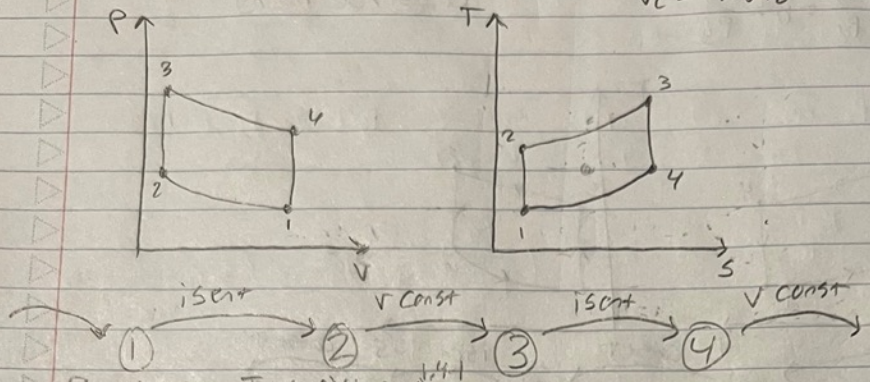
$V_{max} = R \frac{T_1}{P_1} = 0.287 \cdot \frac{300}{95} = 0.09063 \ m^3/kg$

$V_{min} = V_2 = 72.60$

mean eff $P = \frac{W_{net}}{(V_1)(1 - \frac{1}{r})} = \frac{392.4}{(0.09063)(1 - \frac{1}{8})} = \boxed{495 \ kPa}$

9.36 - Engine speed = 2500 rpm

$V_c = 9.8\%$



$P_1 = 14$ psia $\quad T_1 = 105°F$

$T_2 = (105)(10.204)^{1.4-1} \quad T_2 = 265.89°F \quad T_3 = 2400°F$

$r_c = \frac{V_1}{V_2} = \frac{100}{9.8}$

$Q_s = m c_v (T_3 - T_2) = 0.176(2400 - 265.88) = 366.214 \frac{Btu}{lbm}$

$\eta_{th} = \left(1 - \frac{1}{r^{(k-1)}}\right) = 1 - \frac{1}{(10.204)^{1.4-1}} \cdot 100 = 60.5\%$

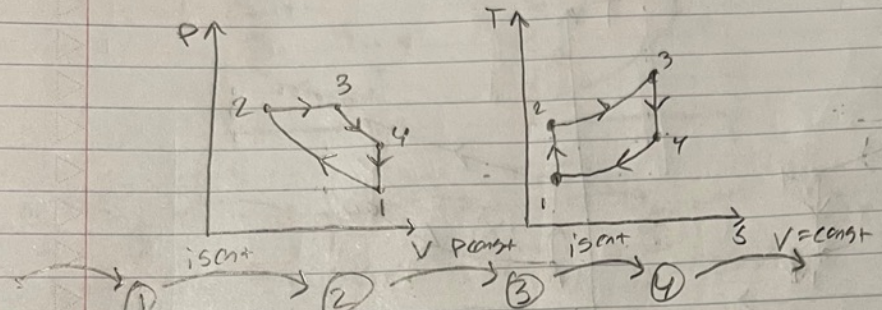
$n = \frac{N}{2} = \frac{2500}{2} = 1250$

$0.605 = \frac{W_{net}}{366.214} \quad W_{net} = 221.5 \ Btu/lbm$

$\text{Power} = \frac{W_{net} \cdot n \cdot r}{60} = \frac{(221.5 \ Btu/lbm)(1250 rpm)(6)}{60}$

$\boxed{P = 27,687 \ Btu/s}$

9.46 $r = 16$ $r_c = 2$



$P_1 = 95$ kPa $T_2 = 300$ K $T_3 = T_2$

$T_1 = 300$ K

(a) temp after heat addition

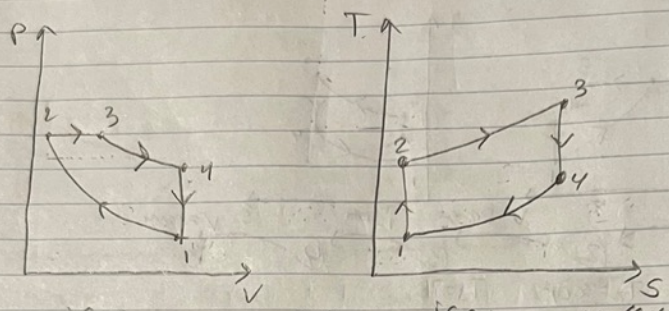
$T_3 = T_2\left(\frac{r^k - 1}{r_c k - 1}\right)$ $300\left(\frac{16^{1.4} - 1}{2^{1.4} - 1}\right) = \boxed{1,725\ K}$

(b) $\eta_{th} = 1 - \frac{1}{r^k - r_c^k - 1}\left(\frac{k-1}{r-1}\right) = 1 - \frac{1}{16^{1.4} - 2^{1.4} - 1}\left(\frac{0.4}{16-1}\right) \cdot 100$

$= \boxed{56.3\%}$

(c) Mean eff $P = \frac{P_1 V_1}{r-1} \cdot \frac{r_c^k - 1}{k \cdot r^k - 1} = \frac{(95)(1000)}{16-1} \cdot \frac{2^{1.4} - 1}{(1.4)(16^{1.4} - 1)} = \boxed{675.9\ kPa}$

9.57 $R = 0.287$ $r = 22$ $r_c = 1.8$



isent $P = \text{const}$ isent $V = \text{const}$

① ② ③ ④

$P_1 = 97 \text{ kPa}$
$T_1 = 343 \text{ K}$
$V_1 = \frac{RT_1}{P_1} = \frac{(0.287)(343)}{97} = 1.014$

$V_2 = \frac{1.014}{22} = 0.04613$

$T_2 = 343(22)^{1.4-1} = 1181 \text{ K}$

$P_3 = 7347.64 \text{ kPa}$
$T_3 = 2125.9 \text{ K}$
$V_3 = 0.083034$

$T_4 = \left(\frac{V_3}{V_1}\right)^{1.4-1}$
$T_4 = 780.95 \text{ K}$

$W_{1-2} = -C_v(T_2 - T_1) = -0.718(1181 - 343) = -601.68 \text{ kJ/kg}$

$P_3 = \frac{RT_2}{V_2} = \frac{(0.287)(1181)}{0.04613} = 7347.64 \text{ kPa}$

$V_3 = r_c(V_2) = (1.8)(0.04613) = 0.083034$

$T_3 = \frac{P_2 V_3}{R} = \left(\frac{7347.64 \cdot 0.083034}{0.287}\right) = 2125.9 \text{ K}$

$W_{2-3} = P_3(V_3 - V_2) = 7347.64 \text{ kPa}(0.083034 - 0.04613) = 271.1 \text{ kJ/kg}$

$W_{net} = m(W_{1-2} + W_{2-3} + W_{3-1} + W_{4-1})$ $W_{3-4} = C_v(T_3 - T_4)$ $m = \frac{V_d}{V_1} = \frac{2.4}{1.015} = 2.36$

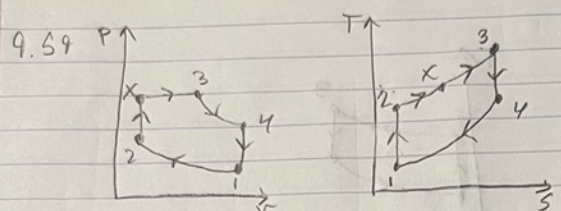
$W_{net} = (2.36)(-601.68 + 271.1 + 965.6 + 0)$ $W_{3-4} = 0.718(2125.9 - 780.95)$

$W_{3-4} = 965 \text{ kJ/kg}$

$W_{4-1} = 0$

$\boxed{W_{net} = 1.501 \text{ kJ}}$

9.59



$r = 15 \quad r_c = 1.4$

Isen → ① V=const → ② → ⊗ P=const → ③ isent → ④ V=const

$P_1 = 14.2 \text{ psia} \quad T_2 = 877.39 \text{ K} \quad T_x = 965.13 \text{ K} \quad T_3 = 1,351.19 \text{ K} \quad T_4 = 523.27 \text{ K}$

$T_1 = 298 \text{ K}$

$T_2 = T_1(r)^{1.4-1}$ ✓ $\quad T_x = (1.1)(T_2)$ ✓ $\quad T_4 = (1.1)(1.4^{1.4})(298)$ ✓

$T_3 = \rho T_x$ ✓

Specific heat addition $= C_v(T_x - T_2) + C_p(T_3 - T_x)$

$(0.718)(965.13 - 877.39) + (1.005)(1,351.19 - 965.13)$

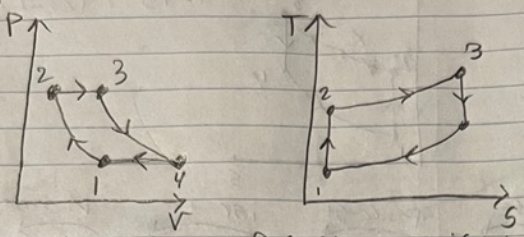
$\boxed{Q_{in} = 450.988 \text{ KJ/kg}}$

$W_{net} = Q_{in} - Q_{out} \qquad 450.988 - C_v(T_4 - T_1)$

$450.988 - 0.718(523.27 - 298) = \boxed{288.42 \frac{\text{KJ}}{\text{kg}}}$

$\eta_{th} = \frac{W_{net}}{q_{in}} = \frac{288.42}{450.988} \cdot 100 = \boxed{63.98\%}$

9.60



$\frac{P_2}{P_1} = 10$

$\frac{P_4}{P_3} = 10$

isent → P const → isent → P const

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used converter $T_1 = 520\,R = 290K$ $P_2 = 12.31$ $T_2 = 2000R = 1100K$ $P_{r4} = 16.71$

A-17 $h_1 = 290.16\ kJ/kg$ $h_3 = 1161.07\ kJ/kg$

$P_{r1} = 1.2311$ $P_{r3} = 167.1$

$P_{r2} = \frac{P_2}{P_1} P_{r1}$ $P_{r4} = \frac{P_4}{P_3}(167.1) = 16.71$

Compressor → $w_c = h_2 - h_1 = (560.62 - 290.16) = 270.46\ kJ/kg$

Turbine → $w_T = h_3 - h_4 = (1161.07 - 611.451) = 549.62\ kJ/kg$

→ $q_{in} = h_3 - h_2 = (1161.07 - 560.62) = 600.45\ kJ/kg$

$B.W.R. = \frac{w_c}{w_T} = \frac{270.46\ kJ/kg}{549.62\ kJ/kg} \cdot 100 = \boxed{49.21\%}$

$\eta_{th} = \frac{w_T - w_c}{q_{in}} = \boxed{46.49\%}$