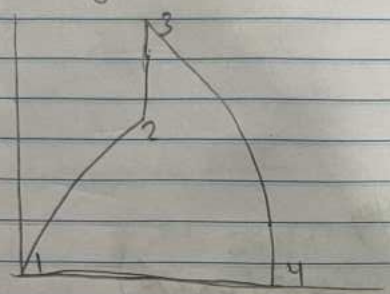
HW 1.2 Thermal Applications

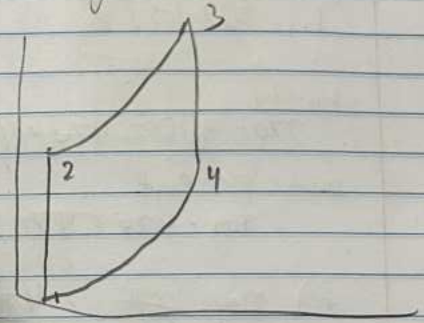
Joshua Ware

9.13) $P_1 = 100$ kPa $T_1 = 22^\circ C = 295$ K
$P_2 = 600$ kPa $T_3 = 1500$ K
$P_4 = 100$ kPa

Pv Diagram



Ts Diagram



b) $P_{r1} = 1.386$

$$\frac{P_2}{P_1} = \frac{P_{r2}}{P_{r1}} = P_{r2} = 6(1.386) = 8.316$$

$= 510$ K

$T_3 = 1500$ K
$u_2 = 368$ kJ/kg
$u_3 = 1277$ kJ/kg

$q_{in} = u_3 - u_2 = 1277 - 368 = 909$ kJ/kg

At 1500 K
$P_{r3} = 330$

$$\frac{P_4}{P_3} = \frac{P_{r4}}{P_{r3}}$$

$P_3 = P_2 \frac{T_3}{T_2} = 600\left(\frac{1300}{310}\right) = 1765$ kPA

$\frac{100}{1765} = \frac{P_{r4}}{330} = 18.7$

Tables

$T_4 = 720k$

$h_4 = 770$ kJ/kg

$h_1 = 300$ kJ/kg

$h_4 - h_1$

$770 - 300 = 470$ kJ/kg

$w_{net} = q_{in} - q_{out}$

$= 909 - 470 = 439$ kJ/kg

c) $\eta_{th} = \frac{w_{net}}{q_{in}} = \frac{439}{909} \rightarrow 0.483$ (48.3%)

9.18) $T_H = 1200$ k $T_L = 350$ k $W_{net} = 0.5$ kJ

$\eta = 1 - \frac{T_L}{T_H} = 1 - \frac{350}{1200} = 0.708$

b) $\eta = \frac{W_{net}}{Q_H} \therefore Q_H = \frac{W_{net}}{\eta} = \frac{0.5}{0.708} = 0.706$ kJ

Max pressure = 30 MPA

c) Mass of Ar

$$m = \frac{Q_H}{RT_H \ln(P_2/P_1)}$$

$R = 0.287$ kJ/kgk

$m = 0.00296$ kg

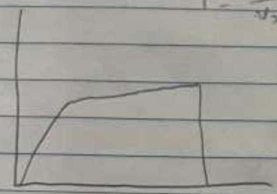
9.22) $C_v = 0.7$, $R = 0.3$

$c_p = C_v + R = 1$

$k = \frac{c_p}{C_v} = \frac{1}{0.7} = 1.4$

$T_1 = 20°C = 293k$

$r = \frac{v_1}{v_2} = 5$



b) $T_2 = T_1 r^{k-1} = 293(5^{0.4}) = 560k$

$1 \to 2$ $q_{12} = 0$ $w_{12} = C_v(T_1 - T_2) = 0.7(293 - 560) = -187$

$2 \to 3$ $q_{23} = C_p(T_3 - T_2)$

$w_{23} = R(T_3 - T_2)$

$3 \to 1$ $W = 0$

$q_{31} = C_p(T_1 - T_3)$

$W_{net} = q_{net}$

$(-187 + R(T_3 - T_2)) = C_p(T_3 - T_2) + C_v(T_1 - T_3)$

$T_3 = 1000k$

$q_{23} = 1(1000 - 560) = 440$

$w_{23} = 0.3(440) = 132$

$q_{31} = 0.7(293 - 1000) = -495$

$w_{net} = -187 + 132 = -55$

c) $\eta = \frac{55}{440} = 0.125$

D) $\eta = 1 - \frac{1}{r^{k-1}}$

9.31) $r = 10.5$
$P_1 = 90\ kPa$ $T_1 = 40^{\circ}C = 313\ K$
2500 cycles/min $= \frac{2500}{60} = 41.67$ cycle/sec

$W_{net} = 90\ kW$
$k = 1.4$ $c_v = 0.718\ kJ/kg\,K$

A) $n = 1 - \frac{1}{r^{k-1}}$

$= 1 - \frac{1}{(10.5)^{1.4-1}}$

$= 1 - \frac{1}{10.5^{0.4}}$

$10.5^{0.4} = 2.56$

$= 1 - 0.391$

$n = 0.609$ or **60.9%**

B) $n = \frac{W_{net}}{Q_{in}}$

$Q_{in} = \frac{90}{0.609}$

$Q_{in} =$ **147.8 kW**