

T7 SOLUTIONS (WATZ)

(1 OF 2)

MY DATA WERE OBTAINED 9/16/03 16:50 hrs.

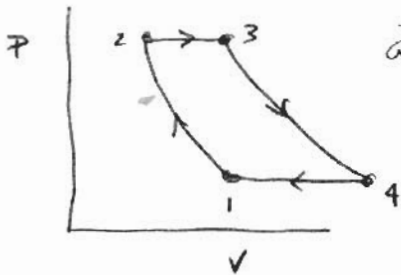
AMBIENT AIR TEMP = 75°F = 297 K

ATMOSPHERIC PRESSURE (ASSUMED) = 1 atm = 101.3 kPa

COMPRESSOR DELIVERY PRESSURE = 200 PSIG = 214.77 PSIA

↑
GAGE
(relative to atmospheric)

↑
ABSOLUTE

SO PRESSURE RATIO = $\frac{214.77}{14.77} = 14.54$ 

a) ① $P_1 = 101.3 \text{ kPa}, T_1 = 297 \text{ K}$

② $P_2 = 14.54 (101.3) = 1473 \text{ kPa}$

$\left(\frac{P_2}{P_1}\right)^{\gamma-1/\gamma} = \frac{T_2}{T_1} = 2.149 \therefore T_2 = 638 \text{ K}$

$\underbrace{\hspace{10em}}_{q \rightarrow \text{adiab.}}$

③ constant pressure heating

$\therefore P_3 = 1473 \text{ kPa}, T_3 = 1400 \text{ K (Given)}$

④ $q \rightarrow$ adiabatic expansion by $\frac{P_3}{P_4} = 14.54$

$\therefore P_4 = 101.3 \text{ kPa}$

$\left(\frac{P_4}{P_3}\right)^{\gamma-1/\gamma} = \frac{T_4}{T_3} = 0.465 \therefore T_4 = 652 \text{ K}$

b) THERMAL EFFICIENCY

$\eta_{TH} = 1 - \frac{T_1}{T_2} = 1 - \frac{297}{638} = 0.534$

$W = C_p (T_3 - T_2 + T_1 - T_4) = 1003.5 (1400 - 638 + 297 - 652) = 408 \text{ kJ/kg}$

c) T_2 FIXED, COLD DAY $T_1 = 273\text{K}$ (2 of 2)

HOT DAY $T_1 = 303\text{K}$

$$\eta_{\text{COLD}} = 1 - \frac{273}{638} = 0.57 \quad \eta_{\text{HOT}} = 1 - \frac{303}{638} = 0.525$$

d) TOTAL GAS ENERGY FLOW = $66 \times 10^3 \text{ BTU/s} = 69.63 \text{ MJ/s}$
= 69.63 MW

ACTIVE LOAD = 20 MW

$$\eta = \frac{20}{69.63} = \frac{W_{\text{cycle}}}{Q_{\text{in}}} = 0.287$$

A VARIETY OF NON-IDEAL PROCESSES CAUSE THE EFFICIENCY TO BE SIGNIFICANTLY LESS THAN THE VALUE OBTAINED FOR THE IDEAL CYCLE.

e) FOR PRESSURE RATIO OF 14.54, CALCULATED $\frac{T_2}{T_1} = 2.149$
SO $T_2 = 638 \text{ K}$ (IDEAL)

MEASURED T_2 (COMP DISCHARGE TEMP) = 730°F

* HIGHER THAN IDEAL γ -S, ADIAB PROCESS $T_{2 \text{ MEAS.}} = 661 \text{ K}$

BUT NOTE THERE IS ALSO SOME COOLING BETWEEN THE AMBIENT ($T_{\text{atm}} = 75^\circ\text{F}$) AND THE COMPRESSOR INLET (COMP INLET TEMP = 62°F) WHICH WAS NOT ACCOUNTED FOR. IF YOU ACCOUNT FOR THIS OUR γ -S, ADIABATIC MODEL IS EVEN WORSE (i.e. SHOWS A SMALLER ΔT THAN IN REAL DEVICE)