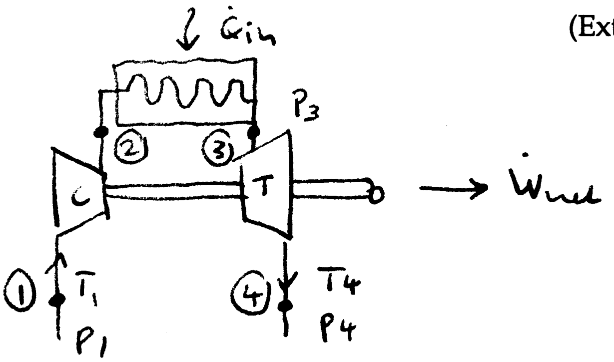
Unified Engineering
Thermo Quiz 2

MIT ID# (last four digits):
Fall 2007

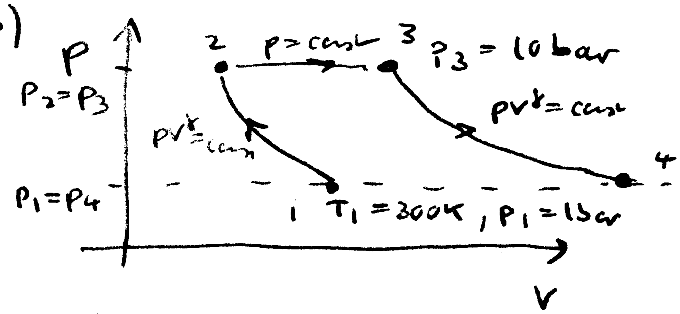
(Extra page for solutions)




Assumptions:
- adiabatic compressor, turbine
- steady operation
- heat addition @ const. pressure
- neglect $\Delta KE$, $\Delta PE$ effects
- reversible turbomachinery (ideal)
- ideal gas with const. spec. heats

a) 1 → 2 : adiabatic reversible compression
2 → 3 : heat addition at const. pressure (isobaric)
3 → 4 : adiabatic reversible expansion

b)




$T_4 = 500K$
$P_1 = P_4 = 1$ bar

one isobaric process
two adiabatic reversible processes

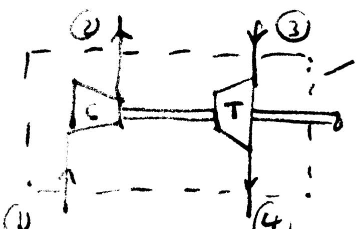
c) Adiabatic reversible expansion through turbine : $\left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}} = \frac{T_3}{T_4}$

$T_3 = T_4 \left(\frac{P_3}{P_4}\right)^{\frac{\gamma-1}{\gamma}}$ ; $\underline{T_3 = 965 \text{ K}}$

d) Isobaric heat addition : $P_2 = P_3$ $\quad \underline{P_2 = 10 \text{ bar}}$

Adiabatic reversible compression $\quad T_2 = T_1 \left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$ , $\underline{T_2 = 579 \text{ K}}$

e)

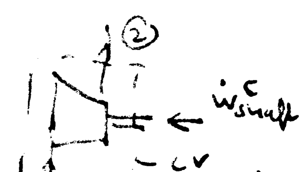



$$\frac{dE_{cv}}{dt} = \Sigma \dot{Q} + \Sigma \dot{W} + \Sigma \dot{m}\left(h + \frac{c^2}{2} + gz\right)$$

$$0 = 0 - \dot{W}_{net} + \dot{m}(h_1 - h_2 + h_3 - h_4)$$

$$\dot{m} = \frac{\dot{W}_{net}}{c_p(T_1 - T_2 + T_3 - T_4)} \; ; \; \underline{\dot{m} = 5.35 \text{ kg/s}}$$

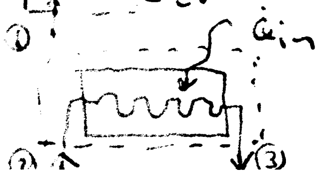
f)




1st law CV form : $0 = \dot{W}^c_{shaft} + \dot{m}(h_1 - h_2)$ ; $w^c_{shaft} = c_p(T_2 - T_1)$ ,

$\underline{w^c_{shaft} = 280 \text{ kJ/kg}}$

g)




1st law CV form : $0 = \dot{Q}_{in} + \dot{m}(h_2 - h_3)$

$\dot{Q}_{in} = \dot{m} c_p (T_3 - T_2)$

$\underline{\dot{Q}_{in} = 2.07 \text{ MW}}$