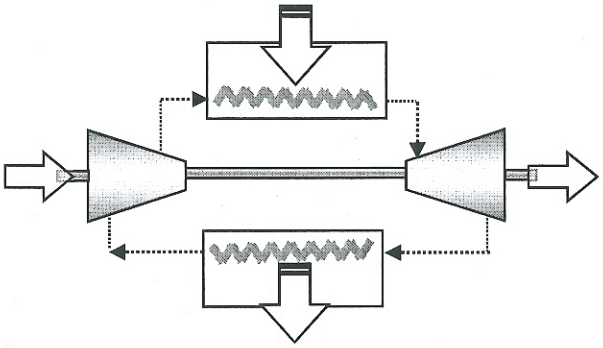
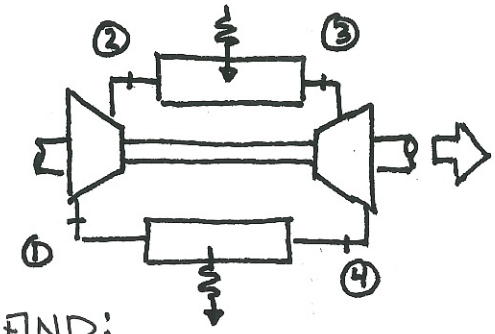
Example

An **air-standard** Brayton cycle operates under the following conditions: compressor inlet: 100 kPa, 300 K; turbine inlet, 1 MPa, 1300 K.

(a) Find the heat transfer rate and power (per unit mass flow rate) for each device in the cycle.
(b) Find the cycle efficiency.
(c) What is the pressure ratio for the cycle?



AIR-STANDARD BRAYTON CYCLE



① 100 kPa, 300 K ③ 1MPa, 1300 K

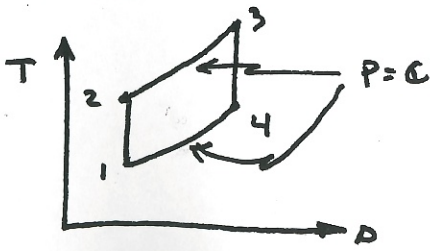
$T_H = 1400$ K

$T_L = T_0 = 280$ K

FIND:

- $\dot{w}_{NET}$
- η_{TH}
- $r_p = P_2/P_1 =$ 10 ← PART (c)

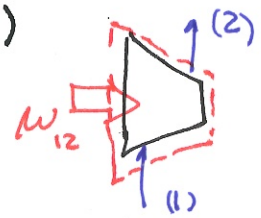
SOL'N:



①-② Energy - Bal → (/mass)

$0 = \cancel{q_{12}}^{0} + w_{12} + (h_1 + \ldots) - (h_2 + \ldots)$

$w_{12} = -(h_1 - h_2)$



$P_{r2} = \left(\frac{P_2}{P_1}\right) P_{r1}$

↑ (isentropic)

$h_1 = 300.19$ kJ/kg

$s_1^\circ = 1.70203$ kJ/kg-K

$P_{r1} = 1.3800$

$P_{r2} = \left(\frac{1000}{100}\right)(1.38) = 13.8 \quad \therefore \; T_2 = 573.4\ K$

$h_2 = 579.2$

$\Delta^\circ_2 = 2.3615$

$w_{12} = -(300.19 - 579.2) = \underline{+279.0\ kJ/kg}$

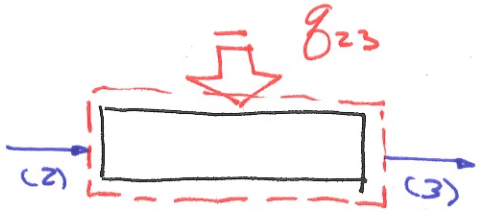
② - ③ Energy bal →

$q_{23} + w_{23} = h_3 - h_2 \qquad h_3 = 1395.97 kJ/kg$

$\Delta^\circ_3 = 3.27245\ kJ/kg\text{-}K$

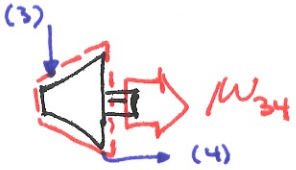
$P_{r3} = 330.9$

$q_{23} = 1395.97 - 579.2 = \underline{815.8\ kJ/kg}$



③ - ④

$w_{34} = -(h_3 - h_4)$



$P_{r4} = \left(\frac{P_4}{P_3}\right) P_{r3} = \left(\frac{100}{1000}\right)(330.9) = 33.1 \qquad$ (ISENTROPIC)

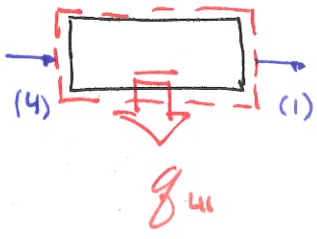
$\therefore T_4 = 725.8\ K$

$h_4 = 741.1 \qquad w_{34} = -(1395.9 - 741.1) = \underline{-654.8\ kJ/kg}$

$\Delta^\circ_4 = 2.6117$

④ - ① $q_{41} = h_1 - h_4 = 300.19 - 741.1 = \underline{-440.9\ kJ/kg}$

$w_{NET_{OUT}} = -(w_{12} + w_{34}) = -(279.2 - 654.8) = \boxed{375.6\ kJ/kg}$



$\eta_{TH} = \frac{w_{NET}}{q_{IN}} = \frac{w_{NET}}{q_{23}} = \frac{375.6}{815.8} = \boxed{0.460}$