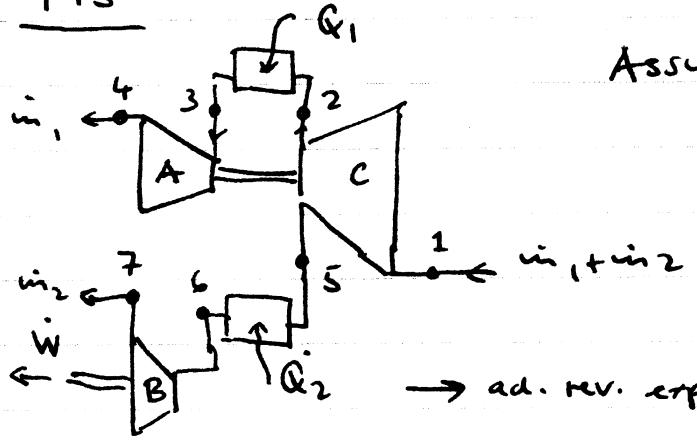
T13

16. Unified Fall 07



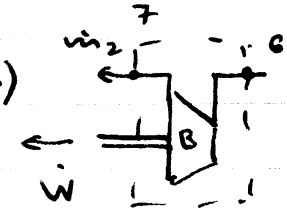
Assume:
- ideal turbomachinery
- adiabatic flow except in combustor
- ideal gas with const. spec. heats
- neglect KE, PE effects

→ ad. rev. exp in turbines, ad. rev. compr. in compr.

a)

$P_1 = 1\,bar$	$P_2 = 5\,bar$	$P_3 = 5\,bar$	$P_4 = 1\,bar$
$T_1 = 300\,K$	$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = 475\,K$	$T_3 = 1000\,K$	$T_4 = T_3\left(\frac{P_4}{P_3}\right)^{\frac{k-1}{k}} = 631\,K$
	$P_5 = 5\,bar$	$P_6 = 5\,bar$	$P_7 = 1\,bar$
	$T_5 = 475\,K$	$T_6 = 1000\,K$	$T_7 = 631\,K$

b)

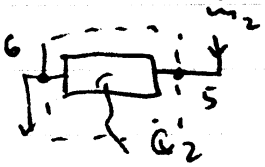


$$\frac{dE_{cv}}{dt} = \sum \dot{Q} + \sum \dot{W} + \sum \dot{m} h$$

$$0 = -\dot{W} + \dot{m}_2 h_6 - \dot{m}_2 h_7$$

$$\dot{m}_2 = \frac{\dot{W}}{c_p(T_6 - T_7)} = 4.65\ kg/s$$

c)

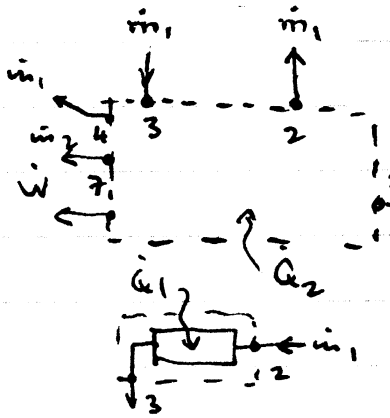


$$\frac{dE_{cv}}{dt} = \sum \dot{Q} + \sum \dot{W} + \sum \dot{m} h$$

$$0 = \dot{Q}_2 + \dot{m}_2 h_5 - \dot{m}_2 h_6$$

$$\dot{Q}_2 = \dot{m}_2 c_p (T_6 - T_5) = 2.14\,MW$$

d)



$$\frac{dE_{cv}}{dt} = \sum \dot{Q} + \sum \dot{W} + \sum \dot{m} h$$

$$0 = \dot{Q}_2 - \dot{W} + (\dot{m}_1 + \dot{m}_2) h_1 - \dot{m}_1 h_2 + \dot{m}_1 h_3 - \dot{m}_1 h_4 - \dot{m}_2 h_7$$

$$\dot{m}_1 = \frac{\dot{W} - \dot{Q}_2 + \dot{m}_2 c_p (T_7 - T_1)}{c_p (T_1 - T_2 + T_3 - T_4)} = 3.63\ kg/s$$

$$\dot{Q}_1 = \dot{m}_1 c_p (T_3 - T_2) \qquad \dot{Q}_1 = 1.91\,MW$$

e) $$\eta_{th} = \frac{\dot{W}}{\dot{Q}_1 + \dot{Q}_2} \qquad \eta_{th} = 0.37$$