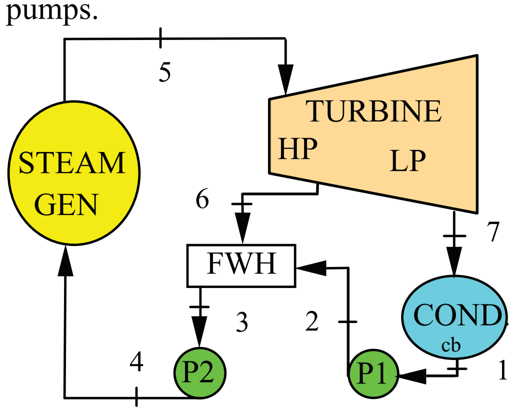
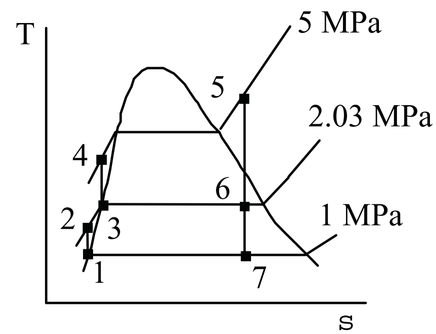
جلسه اول کلاس حل تمرین درس ترمودینامیک

منبع : کتاب ون وایلن

11.43

A Rankine cycle operating with ammonia is heated by some low temperature source so the highest T is 120^{o}C at a pressure of 5000 kPa. Its low pressure is 1003 kPa and it operates with one open feedwater heater at 2033 kPa. The total flow rate is 5 kg/s. Find the extraction flow rate to the feedwater heater assuming its outlet state is saturated liquid at 2033 kPa. Find the total power to the two pumps.





State 1: $x_1 = 0$, $h_1 = 298.25$ kJ/kg, $v_1 = 0.001658$ m^3/kg

State 3: $x_3 = 0$, $h_3 = 421.48$ kJ/kg, $v_3 = 0.001777$ m^3/kg

State 5: $h_5 = 421.48$ kJ/kg, $s_5 = 4.7306$ kJ/kg K

State 6: $s_6 = s_5$ => $x_6 = (s_6 - s_f)/s_{fg} = 0.99052$, $h_6 = 1461.53$ kJ/kg

C.V Pump P1

$$w_{P1} = h_2 - h_1 = v_1(P_2 - P_1) = 0.001658(2033 - 1003) = 1.708 \text{ kJ/kg}$$

$$\Rightarrow h_2 = h_1 + w_{P1} = 298.25 + 1.708 = 299.96 \text{ kJ/kg}$$

C.V. Feedwater heater: Call $\dot{m}_6 / \dot{m}_{tot} = x$ (the extraction fraction)

Energy Eq.: $(1 - x)\, h_2 + x\, h_6 = 1\, h_3$

$$x = \frac{h_3 - h_2}{h_6 - h_2} = \frac{762.79 - 189.42}{3640.6 - 189.42} = \mathbf{0.1046}$$

$$\dot{m}_{extr} = x\, \dot{m}_{tot} = 0.1046 \times 5 = \mathbf{0.523\ kg/s}$$

$$\dot{m}_1 = (1\text{-}x)\, \dot{m}_{tot} = (1 - 0.1046)\, 5 = 4.477 \text{ kg/s}$$

C.V Pump P2

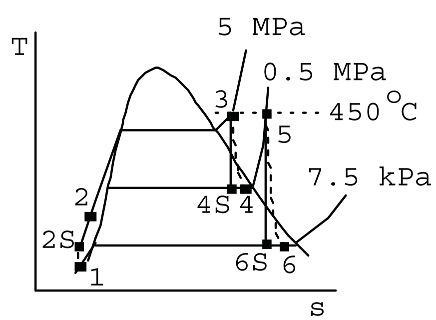
$$w_{P2} = h_4 - h_3 = v_3(P_4 - P_3) = 0.001777(5000 - 2033) = 5.272 \text{ kJ/kg}$$

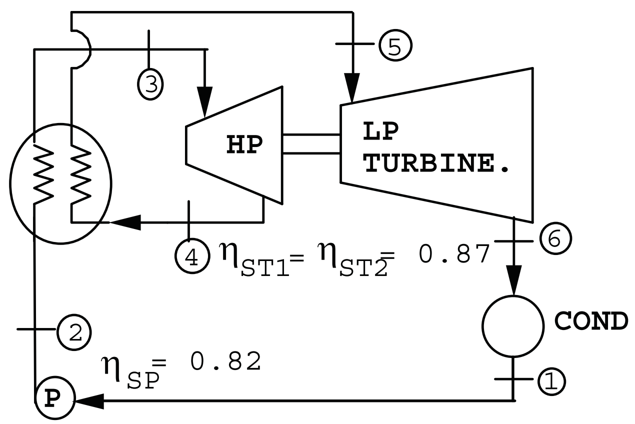
Total pump work

$$\dot{W}_p = \dot{m}_1 w_{P1} + \dot{m}_{tot}\, w_{P2} = 4.477 \times 1.708 + 5 \times 5.272 = \mathbf{34\ kW}$$

11.61

In a particular reheat-cycle power plant, steam enters the high-pressure turbine at 5 MPa, 450°C and expands to 0.5 MPa, after which it is reheated to 450°C. The steam is then expanded through the low-pressure turbine to 7.5 kPa. Liquid water leaves the condenser at 30°C, is pumped to 5 MPa, and then returned to the steam generator. Each turbine is adiabatic with an isentropic efficiency of 87% and the pump efficiency is 82%. If the total power output of the turbines is 10 MW, determine the mass flow rate of steam, the pump power input and the thermal efficiency of the power plant.





a) $s_{4S} = s_3 = 6.8185 = 1.8606 + x_{4S} \times 4.9606 \quad => \quad x_{4S} = 0.999$

$h_{4S} = 640.21 + 0.999 \times 2108.5 = 2746.6$ kJ/kg

$w_{T1,S} = h_3 - h_{4S} = 3316.1 - 2746.6 = 569.5$ kJ/kg

$w_{T1} = \eta_{T1,S} \times w_{T1,S} = 0.87 \times 569.5 = 495.5$ kJ/kg

$h_{4ac} = 3316.1 - 495.5 = 2820.6$ kJ/kg

$s_{6S} = s_5 = 7.9406 = 0.5764 + x_{6S} \times 7.675 \quad \Rightarrow \quad x_{6S} = 0.9595$

$h_{6S} = 168.79 + 0.9595 \times 2406 = 2477.3$ kJ/kg

$w_{T2,S} = h_5 - h_{6S} = 3377.9 - 2477.3 = 900.6$ kJ/kg

$w_{T2} = 0.87 \times 900.6 = 783.5$ kJ/kg

$\dot{m} = \dot{W}_T/(w_{T1} + w_{T2}) = 10000/(783.5 + 495.5) =$ **7.82 kg/s**

b) $-w_{P,S} = (0.001004)(5000 - 7.5) = 5.01$ kJ/kg

$-w_P = -w_{SP}/\eta_{SP} = 5.01/0.82 = 6.11$ kJ/kg

$\dot{W}_P = w_P\dot{m} = -7.82 \times 6.11 =$ **-47.8 kW**

c) $q_H = (h_3 - h_2) + (h_5 - h_4) = 3316.1 - 130.2 + 3377.9 - 2820.6 = 3743.2$ kJ/kg

$w_N = 1279.0 - 6.11 = 1272.9$ kJ/kg

$\eta_{TH} = w_N/q_H = 1272.9/3743.2 =$ **0.34**