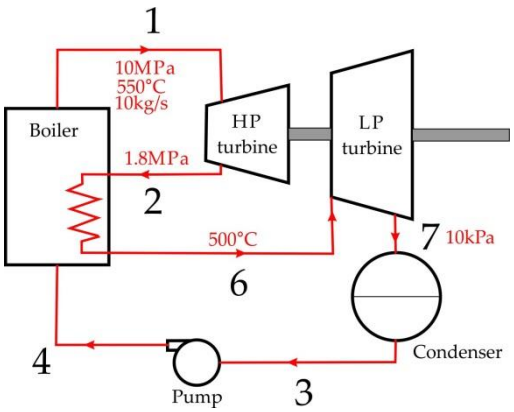
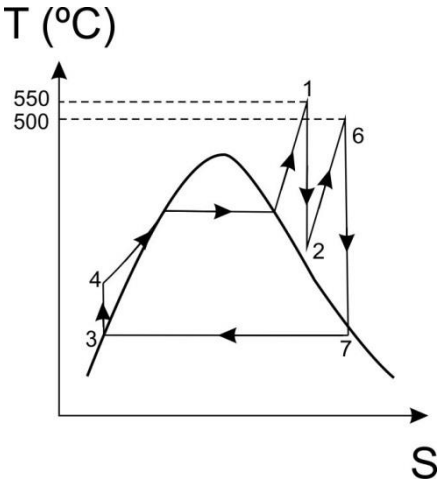
Question

A steam power plant operates on a reheat Rankine cycle. Steam enters the HP turbine at a pressure of 10 MPa and temperature of 550°C at a rate of 10kg/s. It leaves the HP turbine at a pressure of 1.8 MPa. The steam is then reheated at a constant pressure of 1.8MPa to a temperature of 500°C before it expands in the LP turbine at a pressure of 10 kPa. The steam leaves the condenser as saturated liquid. The expansion process in both turbines can be assumed as isentropic Sketch the schematic diagram of the plant and the T-s diagram. Please determine;

i. Net power output of the plant, in kW
ii. Rate of heat supplied to the plant, in kW
iii. Thermal efficiency, in %
iv. Specific steam consumption, in kg/kWh

Solution





$h_{1@550°C@10MPa} = 3502\,kJ/kg$

Considering;

$s_1 = s_2 = 6.7585\,kJ/kg.K$

$T_{2@1.8MPa@s_2=6.7585} = 284.68°C$

$h_{2@g@1725425°C} = 2993.695\,kJ/kg$

$h_{6@500°C@1.8MPa} = 3470.4\,kJ/kg$

Considering;

$s_6 = s_7 = 7.4845\,kJ/kg.K$

$s_{7@10kPa} = s_f + xs_{fg} \Rightarrow 7.4845 = 0.6492 + x7.4996 \Rightarrow x = 0.91142$

$h_{7@10kPa} = h_f + xh_{fg} \Rightarrow h_7 = 191.81 + (0.91142 \times 2392.1) = 2372.02\,kJ/kg$

$$h_{3@\text{fluid}} = 191.81\,\text{kJ/kg}$$

$$W_{out} = (h_1 - h_2) + (h_6 - h_7) = (3502 - 2993.695) + (3470.4 - 2372.02)$$
$$= (508.305) + (1098.38) = 1606.69\,\text{kJ/kg}$$
$$W_{in} = v_f(P_4 - P_3) = h_4 - h_3 = 0.001(10\text{MPa} - 10\text{kPa}) = 9.99\,\text{kJ/kg}$$

$$h_4 - h_3 = 9.99$$
$$\Rightarrow h_4 = 9.99 + 191.81 = 201.8\,\text{kJ/kg}$$

$$q_{in} = (h_1 - h_4) + (h_6 - h_2) = (3502 - 201.8) + (3470.4 - 2993.695)$$
$$= (3300.2) + (476.705) = 3776.905\,\text{kJ/kg}$$

$$P_{out} = W_{out} \times \dot{m} = (1606.69) \times 10 = 16066.9\text{kW}$$

$$P_{\dot{q}_{in}} = q_{in} \times \dot{m} = (3776.905) \times 10 = 37769.05\text{kW}$$

$$W_{net} = W_{out} - W_{in} = 1606.69 - 9.99 = 1596.7\text{kJ / kg}$$

$$\eta_{cycle} = \frac{W_{net}}{q_{in}} = \frac{1596.7}{3776.905} = 0.4227 \text{or } 42.27\%$$

$$SSC = \frac{3600}{W_{net}} = \frac{3600}{1596.7} = 2.254\,\text{kg/kWh}$$