Procedure: Solve enthalpy of all states and use those values to set up energy balance equations to solve for the y value, and the change in temperature. And by plugging the solved state values in appropriately to find the rate of heat rejected, the net power produced, and the thermal efficiency.

Calculations

State 1 $P_1 = 20\ kPa$ $T_1 = 60.1°C$ $h_1 = 251\ \frac{kJ}{kg}$

State 2 $P_2 = 620\ kPa$ $T_2 = 160.1°C$ $h_2 = 676\ \frac{kJ}{kg}$

State 3 $P_3 = 620\ kPa$ $T_3 = T_2$ $h_3 = h_2$

State 4 $P_4 = 620\ kPa$ $T_4 = T_3$ $h_4 = h_3$

State 5 $P_5 = 5000\ kPa$ $T_5 = 263.9°C$ $h_5 = 1154\ \frac{kJ}{kg}$

State 6 $P_6 = 5000\ kPa$ $T_6 = T_5$ $h_6 = h_5$

State 7 $P_7 = 5000\ kPa$ $T_7 = 700°C$ $h_7 = 3900\ \frac{kJ}{kg}$

State 8 $P_8 = 1910\ kPa$ $h_8 = 3515\ \frac{kJ}{kg}$

State 9 $P_9 = 620\ kPa$ $h_9 = 3154\ \frac{kJ}{kg}$

State 10 $P_{10} = 140\ kPa$ $h_{10} = 2799\ \frac{kJ}{kg}$

State 11 $P_{11} = 20\ kPa$ $T_{11} = 60.1°C$ $h_{11} = 2478\ \frac{kJ}{kg}$

$q_{in} = h_7 - h_6 \Rightarrow 3900 - 1154 = 2746$

$W_{pumps} = (0.00102)(620-20) + (1154-676)(0.0011)$

$0.612 + 0.5258 = 1.1378\ kW$

$y = \frac{h_5 - h_2}{h_9 - h_2} = \frac{1154-676}{3154-676} = \frac{478}{2478} = \boxed{0.19}$

$W_{turb} = (h_7 - h_9) + (1-y)(h_9 - h_{11})$

$= (3900 - 3154) + (1-0.19)(3154-2478)$

$746 + (0.81)(676) = 1421.19\ kW$

$W_{net} = 1.1378\ kW + 1421.19\ kW = \boxed{1422.33\ kW}$

$\eta_{th} = \frac{1422.33}{2746} \approx 52\%$

Summary:

- Extracted mass fraction is 0.19
- The net power is 1422.33 kW
- The thermal efficiency is 52 %

Materials

Water