

**7-88** A geothermal power plant uses geothermal liquid water at 160°C at a specified rate as the heat source. The actual and maximum possible thermal efficiencies and the rate of heat rejected from this power plant are to be determined.

**Assumptions** **1** The power plant operates steadily. **2** The kinetic and potential energy changes are zero. **3** Steam properties are used for geothermal water.

**Properties** Using saturated liquid properties, the source and the sink state enthalpies of geothermal water are (Table A-4)

$$\left. \begin{array}{l} T_{\text{source}} = 160^{\circ}\text{C} \\ x_{\text{source}} = 0 \end{array} \right\} h_{\text{source}} = 675.47 \text{ kJ/kg}$$

$$\left. \begin{array}{l} T_{\text{sink}} = 25^{\circ}\text{C} \\ x_{\text{sink}} = 0 \end{array} \right\} h_{\text{sink}} = 104.83 \text{ kJ/kg}$$

**Analysis** (a) The rate of heat input to the plant may be taken as the enthalpy difference between the source and the sink for the power plant

$$\dot{Q}_{\text{in}} = \dot{m}_{\text{geo}} (h_{\text{source}} - h_{\text{sink}}) = (440 \text{ kg/s})(675.47 - 104.83) \text{ kJ/kg} = 251,083 \text{ kW}$$

The actual thermal efficiency is

$$\eta_{\text{th}} = \frac{\dot{W}_{\text{net,out}}}{\dot{Q}_{\text{in}}} = \frac{22 \text{ MW}}{251.083 \text{ MW}} = \mathbf{0.0876} = \mathbf{8.8\%}$$

(b) The maximum thermal efficiency is the thermal efficiency of a reversible heat engine operating between the source and sink temperatures

$$\eta_{\text{th,max}} = 1 - \frac{T_L}{T_H} = 1 - \frac{(25 + 273) \text{ K}}{(160 + 273) \text{ K}} = \mathbf{0.312} = \mathbf{31.2\%}$$

(c) Finally, the rate of heat rejection is

$$\dot{Q}_{\text{out}} = \dot{Q}_{\text{in}} - \dot{W}_{\text{net,out}} = 251.1 - 22 = \mathbf{229.1 \text{ MW}}$$