8-58 Steam is expanded in an isentropic turbine. The work produced is to be determined.

Assumptions **1** This is a steady-flow process since there is no change with time. **2** The process is isentropic (i.e., reversible-adiabatic).

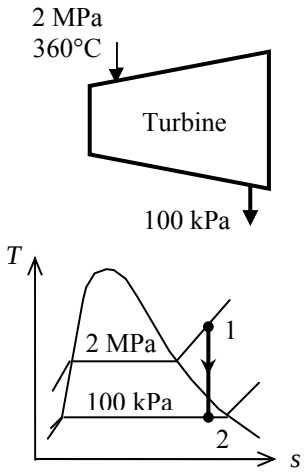
Analysis There is only one inlet and one exit, and thus $\dot{m}_1 = \dot{m}_2 = \dot{m}$. We take the turbine as the system, which is a control volume since mass crosses the boundary. The energy balance for this steady-flow system can be expressed in the rate form as

$$\underbrace{\dot{E}_{\text{in}} - \dot{E}_{\text{out}}}_{\substack{\text{Rate of net energy transfer} \\ \text{by heat, work, and mass}}} = \underbrace{\Delta \dot{E}_{\text{system}}^{\nearrow 0 \text{ (steady)}}}_{\substack{\text{Rate of change in internal, kinetic,} \\ \text{potential, etc. energies}}} = 0$$

$$\dot{E}_{\text{in}} = \dot{E}_{\text{out}}$$

$$\dot{m}h_1 = \dot{m}h_2 + \dot{W}_{\text{out}}$$

$$\dot{W}_{\text{out}} = \dot{m}(h_1 - h_2)$$



The inlet state properties are

$$\left.\begin{array}{l} P_1 = 2\ \text{MPa} \\ T_1 = 360°\text{C} \end{array}\right\} \begin{array}{l} h_1 = 3159.9\ \text{kJ/kg} \\ s_1 = 6.9938\ \text{kJ/kg}\cdot\text{K} \end{array} \quad \text{(Table A - 6)}$$

For this isentropic process, the final state properties are (Table A-5)

$$\left.\begin{array}{l} P_2 = 100\ \text{kPa} \\ s_2 = s_1 = 6.9938\ \text{kJ/kg}\cdot\text{K} \end{array}\right\} \begin{array}{l} x_2 = \dfrac{s_2 - s_f}{s_{fg}} = \dfrac{6.9938 - 1.3028}{6.0562} = 0.9397 \\ h_2 = h_f + x_2 h_{fg} = 417.51 + (0.9397)(2257.5) = 2538.9\ \text{kJ/kg} \end{array}$$

Substituting,

$$w_{\text{out}} = h_1 - h_2 = (3159.9 - 2538.9)\ \text{kJ/kg} = \mathbf{621.0\ kJ/kg}$$

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