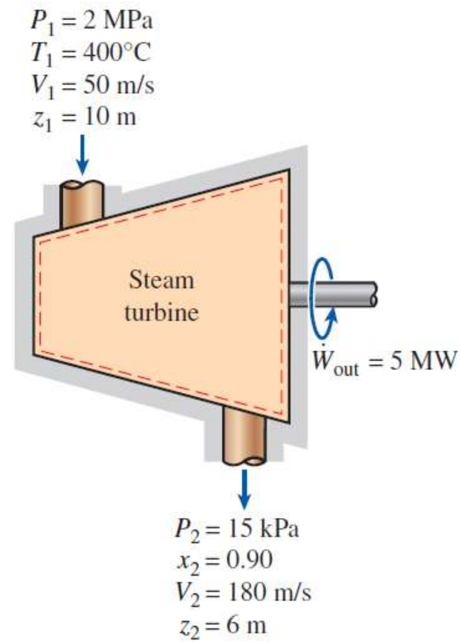

Given:
The power output of an adiabatic steam turbine is 5 MW. The inlet and the outlet conditions are shown in the figure below.

$$W'_{out} := 5 \text{ MW}$$

$$P_1 := 2 \text{ MPa} \qquad P_2 := 15 \text{ kPa}$$

$$T_1 := 400\ °C \qquad x_2 := 0.9$$

$$V_1 := 50 \frac{m}{s} \qquad V_2 := 180 \frac{m}{s}$$

$$z_1 := 10 \text{ m} \qquad z_2 := 6 \text{ m}$$

Required:
Determine
 (a) The changes in specific enthalpy, kinetic energy, and potential energy and
 (b) The mass flow rate of the steam.

Solution:
Going to Table A-5 @ $P := P_1 = 2 \text{ MPa}$ shows that the state is superheated.

Going to Table A-6 @ $P := P_1 = 2 \text{ MPa}$ and $T := T_1 = 400\ °C$ shows

$$h_1 := 3248.4 \frac{kJ}{kg}$$

Since a quality is given for the outlet, the state is in the two phase region. Going to Table A-5 @ $P := P_2 = 15 \text{ kPa}$ shows

$$h_f := 225.94 \frac{kJ}{kg} \qquad h_g := 2598.3 \frac{kJ}{kg}$$

$$h_2 := h_f + x_2 \cdot (h_g - h_f) = 2361 \frac{kJ}{kg}$$

The change in specific enthalpy is then given by

$$\boxed{\Delta h := h_2 - h_1 = -887.3 \frac{kJ}{kg}} \qquad \text{(a1)}$$

The change in specific kinetic energy is given by

$$\boxed{\Delta ke := \frac{V_2^{\,2} - V_1^{\,2}}{2} = 14.95 \frac{kJ}{kg}} \qquad \text{(a2)}$$

The change in specific potential energy is given by

$$\Delta pe := g_e \cdot (z_2 - z_1) = -0.03923 \frac{kJ}{kg} \qquad \text{(a3)}$$

Beginning with the 1st Law

$$\frac{d}{d\,t} E_{sys} = \Sigma E'_{in} - \Sigma E'_{out}$$

For a steady flow device the 1st Law becomes

$$0 = \Sigma E'_{in} - \Sigma E'_{out}$$

Solution (contd.):

For an adiabatic, rigid turbine the expression becomes

$$0 = m'_{in} \cdot \left(h_{in} + \frac{V_{in}^{2}}{2} + g_e \cdot z_{in} \right) - W'_{out} - m'_{out} \cdot \left(h_{out} + \frac{V_{out}^{2}}{2} + g_e \cdot z_{out} \right)$$

Knowing $m'_{in} = m'_{out}$ and rearraging yields

$$m' = \frac{-W'_{out}}{h_{out} - h_{in} + \frac{V_2^{2} - V_1^{2}}{2} + g_e \cdot \left(z_2 - z_1 \right)}$$

or

$$\boxed{m' := \frac{-W'_{out}}{\Delta h + \Delta ke + \Delta pe} = 5.731 \ \frac{\mathrm{kg}}{\mathrm{s}}} \qquad \text{(b)}$$