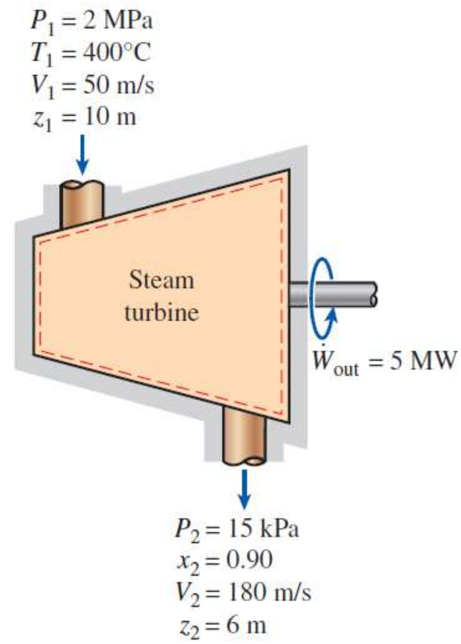
Given:
The power output of an adiabatic steam turbine is 5 MW. The inlet and the outlet conditions are shown in the figure below.



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

$P_1 := 2\ \mathrm{MPa}$ $\quad P_2 := 15\ \mathrm{kPa}$

$T_1 := 400\ \mathrm{°C}$ $\quad x_2 := 0.9$

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

$z_1 := 10\ \mathrm{m}$ $\quad z_2 := 6\ \mathrm{m}$

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 @ $P := P_1 = 2\ \mathrm{MPa}$ shows that the state is superheated.

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

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

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

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

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

The change in specific enthalpy is then given by

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

The change in specific kinetic energy is given by

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

The change in specific potential energy is given by

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

Beginning with the 1st Law

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

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

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