3-103 The power that could be produced by a water wheel is to be determined.

Properties The density of water is taken to be 1000 m^3/kg (Table A-3).

Analysis The power production is determined from

$$\dot{W} = \dot{m}g(z_2 - z_1) = \rho\dot{V}g(z_2 - z_1)$$

$$= (1000\ \text{kg/m}^3)(0.400/60\ \text{m}^3/\text{s})(9.81\ \text{m/s}^2)(10\ \text{m})\left(\frac{1\ \text{kJ/kg}}{1000\ \text{m}^2/\text{s}^2}\right) = \mathbf{0.654\ kW}$$

3-104 The flow of air through a flow channel is considered. The diameter of the wind channel downstream from the rotor and the power produced by the windmill are to be determined.

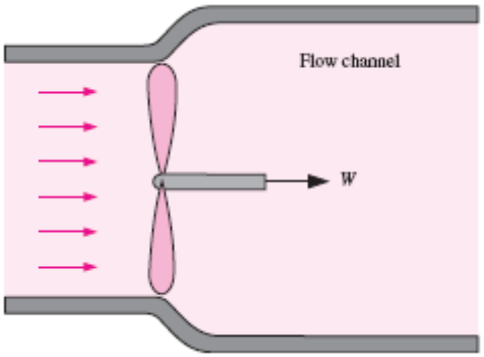
Analysis The specific volume of the air is

$$\upsilon = \frac{RT}{P} = \frac{(0.287\ \text{kPa}\cdot\text{m}^3/\text{kg}\cdot\text{K})(293\ \text{K})}{100\ \text{kPa}} = 0.8409\ \text{m}^3/\text{kg}$$

The diameter of the wind channel downstream from the rotor is

$$A_1V_1 = A_2V_2 \longrightarrow (\pi D_1^2/4)V_1 = (\pi D_2^2/4)V_2$$

$$\longrightarrow D_2 = D_1\sqrt{\frac{V_1}{V_2}} = (7\ \text{m})\sqrt{\frac{10\ \text{m/s}}{9\ \text{m/s}}} = \mathbf{7.38\ m}$$



The mass flow rate through the wind mill is

$$\dot{m} = \frac{A_1V_1}{\upsilon} = \frac{\pi(7\ \text{m})^2(10\ \text{m/s})}{4(0.8409\ \text{m}^3/\text{kg})} = 457.7\ \text{kg/s}$$

The power produced is then

$$\dot{W} = \dot{m}\frac{V_1^2 - V_2^2}{2} = (457.7\ \text{kg/s})\frac{(10\ \text{m/s})^2 - (9\ \text{m/s})^2}{2}\left(\frac{1\ \text{kJ/kg}}{1000\ \text{m}^2/\text{s}^2}\right) = \mathbf{4.35\ kW}$$