**3-105** The available head, flow rate, and efficiency of a hydroelectric turbine are given. The electric power output is to be determined.

Assumptions **1** The flow is steady. **2** Water levels at the reservoir and the discharge site remain constant. **3** Frictional losses in piping are negligible.

Properties We take the density of water to be $\rho = 1000 \text{ kg/m}^3 = 1 \text{ kg/L}$.

Analysis The total mechanical energy the water in a dam possesses is equivalent to the potential energy of water at the free surface of the dam (relative to free surface of discharge water), and it can be converted to work entirely. Therefore, the power potential of water is its potential energy, which is gz per unit mass, and $\dot{m}gz$ for a given mass flow rate.
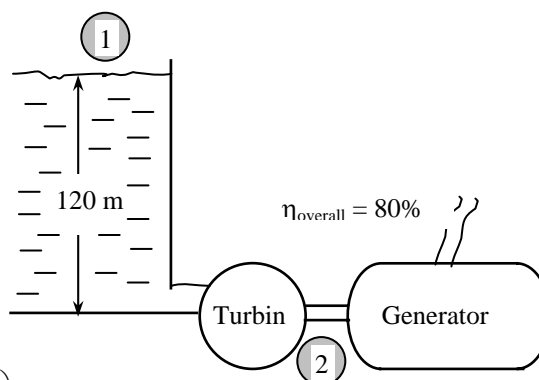
$$e_{mech} = pe = gz = (9.81 \text{ m/s}^2)(120 \text{ m})\left(\frac{1 \text{ kJ/kg}}{1000 \text{ m}^2/\text{s}^2}\right) = 1.177 \text{ kJ/kg}$$

The mass flow rate is

$$\dot{m} = \rho \dot{V} = (1000 \text{ kg/m}^3)(100 \text{ m}^3/\text{s}) = 100{,}000 \text{ kg/s}$$

Then the maximum and actual electric power generation become

$$\dot{W}_{max} = \dot{E}_{mech} = \dot{m}e_{mech} = (100{,}000 \text{ kg/s})(1.177 \text{ kJ/kg})\left(\frac{1 \text{ MW}}{1000 \text{ kJ/s}}\right) = 117.7 \text{ MW}$$

$$\dot{W}_{electric} = \eta_{overall}\dot{W}_{max} = 0.80(117.7 \text{ MW}) = \textbf{94.2 MW}$$

Discussion Note that the power generation would increase by more than 1 MW for each percentage point improvement in the efficiency of the turbine–generator unit.