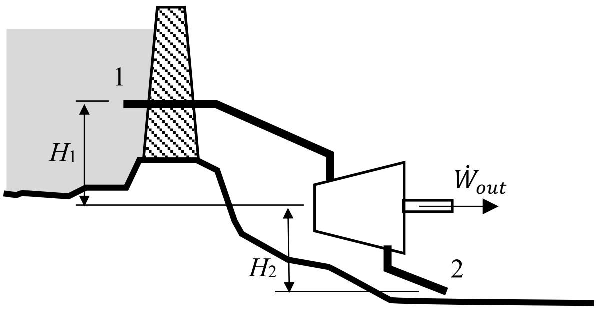
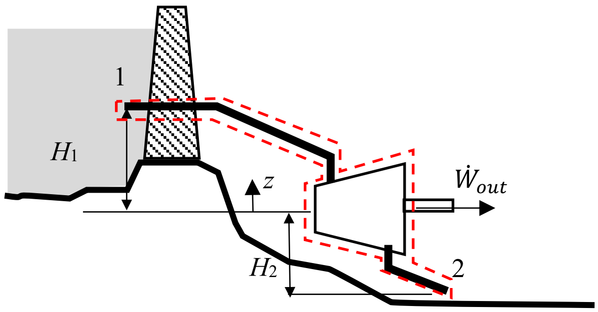
Water, with a specific volume of 0.001 m^3/kg, flows from an elevated reservoir through a turbine operating at steady state. The inlet and exit diameters are equal. Determine the maximum power output associated with a mass flow rate of 950 kg/s.



H_1 = 160 m
H_2 = 10 m
p_1 = 1.5 bar (abs)
p_2 = 1.0 bar (abs)
$D_1 = D_2$ (pipe diameters)

SOLUTION:



The maximum power from the turbine will correspond to when the flow through the system is internally reversible. If we assume that the water is incompressible (v = constant), then from a combination of the 1st Law and the Entropy Equation applied to a CV that surrounds the entire pipe system,

$$\frac{\dot{W}_{out,max}}{\dot{m}} = \frac{\dot{W}_{out,int.rev.}}{\dot{m}} = v(p_1 - p_2) + \frac{1}{2}(V_1^2 - V_2^2) + g(z_1 - z_2). \tag{1}$$

Since the water is incompressible and the inlet and exit pipe diameters are identical, from COM we find $V_2 = V_1$. Equation (1) now becomes,

$$\frac{\dot{W}_{out,max}}{\dot{m}} = v(p_1 - p_2) + g(z_1 - z_2). \tag{2}$$

Using the given values,

$v = 0.001\ \text{m}^3/\text{kg}$,
$p_1 = 1.5$ bar (abs) = 150,000 Pa (abs),
$p_2 = 1$ bar (abs) = 100,000 Pa (abs),
$g = 9.81\ \text{m/s}^2$,
$z_1 = 160$ m,
$z_2 = -10$ m,
$\dot{m} = 950$ kg/s,
⇨ $\boxed{\dot{W}_{out,max} = 1.63\ \text{MW}}$.

This is the maximum possible power output. The actual power output will be less than this value.