Given: Spray nozzle designed to produce a flat radial sheet of water of thickness \( t = 0.5 \text{mm} \). The inlet pipe has diameter \( D = 20 \text{mm} \).

Find: Evaluate the minimum pressure, \( p_1 \), to produce volume flow rate, \( Q = 3.0 \text{m}^3/\text{hr} \) through the nozzle.

Solution:

The minimum pressure occurs when friction is neglected, and so we apply the Bernoulli equation.

Basic equation: \[ \frac{p_1}{ho} + \frac{v_1^2}{2} + gh_1 = \frac{p_2}{ho} + \frac{v_2^2}{2} + gh_2 \]

Assumptions:
1. steady flow
2. incompressible flow
3. no friction
4. flow along a streamline
5. \( p_2 = p_\text{atm} \)
6. uniform flow at \( 0^\circ \Theta \)

Then \[ p_{ig} = p_1 - p_\text{atm} = \frac{Q^2}{2} \left( \frac{D_1^2}{D_2^2} - 1 \right) \]

From continuity,

\[ \frac{V_1}{\rho_1} = \frac{V_2}{\rho_2} \]

\[ \frac{V_1}{\rho_1} = \frac{V_2}{\rho_2} = \frac{3.0}{2} \times \frac{3}{6000} \times \frac{1}{0.025} = 2.05 \text{ m}^3/\text{sec} \]

\[ \frac{V_1}{\rho_1} = \frac{V_2}{\rho_2} = \frac{3.0}{2} \times \frac{1}{0.05} = 10.6 \text{ m}^3/\text{sec} \]

and

\[ p_{ig} = \frac{1}{2} \rho (v_2^2 - v_1^2) \]

\[ = \frac{1}{2} \times 1000 \times [10.6^2 - 2.05^2] \times \frac{2.5}{1.3} \times \frac{1.3}{6000} = 52.6 \text{ kPa(gas)} \]

The actual pressure would be slightly higher.