MEASURING FLOW RATE with a PITOT TUBE

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Example: A pitot tube is used to measure the flow rate of water at 20°C in the center of a pipe having an inside diameter of 102.3 mm. The manometer reading is 78 mm of carbon tetrachloride at 20°C. The pitot tube coefficient is 0.98. Calculate the velocity at the center of the tube, the average velocity, and the flow rate.
$\alpha = 1$, turbulent flow

\[ \frac{\Delta P}{\rho} + \frac{\Delta V^2}{2 \alpha} + g \frac{\Delta z}{2} + \frac{\mathbf{f}}{\rho} = \frac{\nu \Delta z}{\eta} \]

\[ \frac{P_2 - P_1}{\rho} + \frac{V_2^2 - V_1^2}{2} = 0 \]

\[ V_1 = V_{z, \text{max}} = \sqrt{\frac{2(P_2 - P_1)}{\rho_0}} \]
\[ P_a = P_b \]

\[ P_i + p_g x + p_g h + p_w = P_2 + p_g (x+h) \]

\[ P_2 - P_1 = p_c g h - p_w g h \]

\[ = \frac{(p_c - p_w)}{g h} \]
\[ V_{z,\text{max}} = \sqrt{\frac{2(P_c - P_w) g h}{P_w}} \]

To calculate \( \langle V \rangle \), see Fig 2.10-2 Grankoplis for data on \( \frac{\langle V \rangle}{V_{z,\text{max}}} \) as a function of Re based on \( V_{z,\text{max}} \). Finally, to get \( Q \),
\[ Q = \langle V \rangle \pi R^2 \]
Figure 2.10-1. Velocity distribution of a fluid across a pipe.

$\langle v \rangle = \frac{Q}{\pi R^2}$

Figure 2.10-2. Ratio $v_{av}/v_{max}$ as a function of Reynolds number.