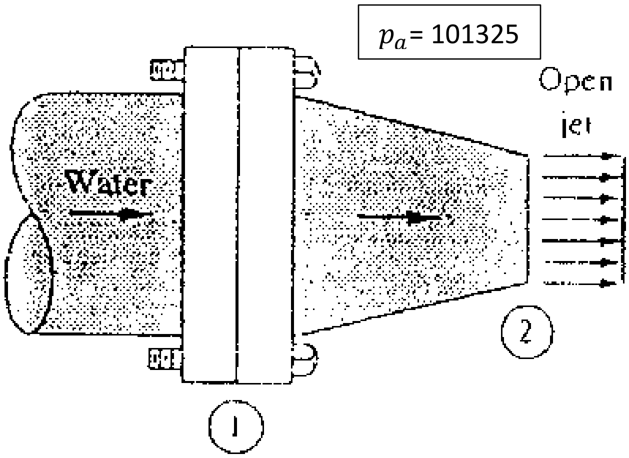
Name :__________________ **Quiz: No. 3** **Time: 15minutes**

Student ID# : _____________ **Course: ME 5160, Fall 2022**

The exam is closed book and closed notes.

The horizontal nozzle in Fig. has D_1= 30cm, D_2 = 15cm, with p_1 = 262kPa and V_2 = 17 m/s. For water at 20°C, find the force provided by the flange bolts to hold the nozzle fixed.



Continuity Equation:

$$-\frac{d}{dt}\int_{CV}\rho d\forall = \int_{CS}\rho \underline{V}_R.\underline{n}\,dA$$

Momentum Equation:

$$\sum \underline{F} = \frac{d}{dt}\int_{CV}\underline{V}\rho d\forall + \int_{CS}\underline{V}\rho \underline{V}_R.\underline{n}\,dA$$

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Solution: For an open jet, $p_2 = p_a = 101325$ Pa. Subtract p_a everywhere so the only nonzero pressure is $p_1 = 262\text{kPa} - 101\text{kPa} = 160675$ Pa.

a) Continuity:

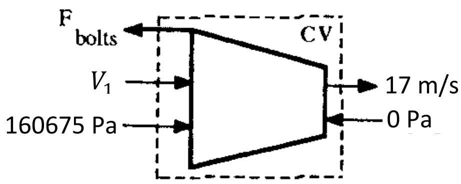
$$Q = V_1 A_1 = V_2 A_2 \qquad \textbf{(+2)}$$

$$Q = (17\text{m/s})\frac{\pi}{4}(0.15m)^2 = 0.3m^3/s \qquad \textbf{(+1)}$$

$$V_1 = \frac{Q}{A_1} = \frac{0.3}{\left(\frac{\pi}{4}\right)(0.30)^2} = 4.25\ m/s \qquad \textbf{(+1)}$$

b) x-Momentum:

The density of water is 998 kg/m^3. Then the horizontal force balance is



$$\sum F_x = \dot{m}u_2 - \dot{m}u_1 \qquad \textbf{(+2)}$$

$$-F_{x,bolts} + p_1 A_1 = \dot{m}(V_2 - V_1) \qquad \textbf{(+3)}$$

$$F_{x,bolts} = (160675Pa)\frac{\pi}{4}(0.30m)^2 - (998)\frac{\pi}{4}(0.30m)^2(4.25\ m/s)(17 - 4.25m/s) \approx 7531N \qquad \textbf{(+1)}$$

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