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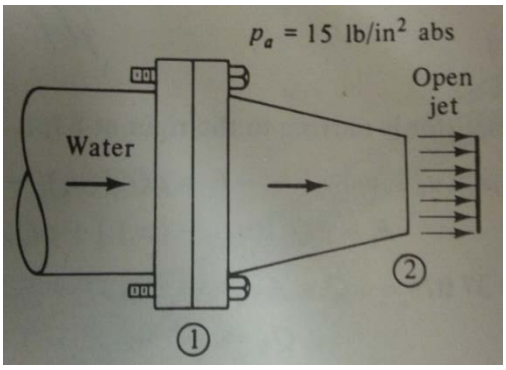
NAME

Fluids-ID

Quiz 7. The horizontal nozzle in the Figure has D_1=10 in and D_2 =6 in. The inlet pressure p_1=60 psia (absolute pressure), and the exit velocity V_2=85 fps. Compute the tensile force on the flange bolts, F_B. Assume incompressible steady flow. Density of the fluid flowing through the nozzle is $\rho = 1.94\ slugs/ft^3$.



- Linear momentum equation:

$$\frac{\partial}{\partial t}\int_{CV}\underline{V}\rho d\forall + \sum_{CS}\dot{m}_{out}\underline{V}_{out} - \sum_{CS}\dot{m}_{in}\underline{V}_{in} = \sum\underline{F}$$

Note: Attendance (+2 points), format (+1 point)

Solution:

$\sum F_x = (V_x\dot{m})_{out} - (V_x\dot{m})_{in}$ (+3 points)

Where

$$\sum F_x = F_B + p_{1,gage}A_1 - p_{2,gage}A_2$$

$$(V_x\dot{m})_{in} = (V_1)(\rho V_1 A_1) = \rho A_1 V_1^2$$

$$(V_x\dot{m})_{out} = (V_2)(\rho V_2 A_2) = \rho A_2 V_2^2$$

Thus,

$$F_B + p_{1,gage}A_1 - p_{2,gage}A_2 = \rho(A_2V_2^2 - A_1V_1^2)$$

or

$F_B = \rho(A_2V_2^2 - A_1V_1^2) - p_{1,gage}A_1 + p_{2,gage}A_2$ (+1 point)

From continuity eq.

$V_1A_1 = V_2A_2$ (+1 point)

$\therefore V_1 = \left(\frac{A_2}{A_1}\right)V_2 = \left(\frac{D_2}{D_1}\right)^2 V_2 = \left(\frac{6}{10}\right)^2(85) = 30.6\ \frac{ft}{s}$ (+1 point)

Thus,

$$F_B = (1.94)\left(\pi\left(\frac{3}{12}\right)^2 85^2 - \pi\left(\frac{5}{12}\right)^2 30.6^2\right) - (60-15)(\pi(5)^2) \ = -1773\ lb$$ (+1 point)