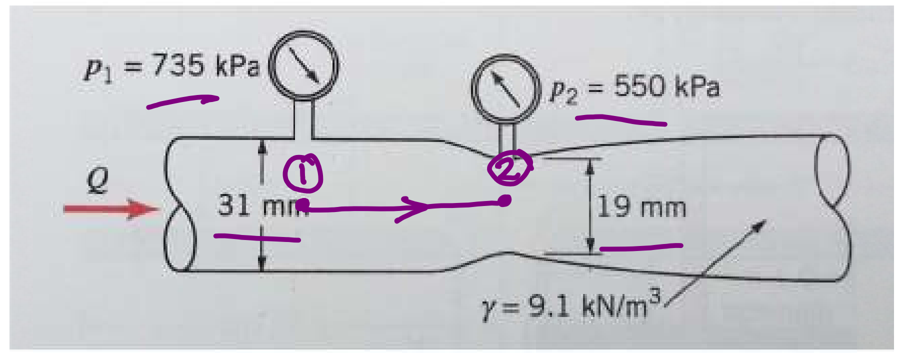
Example

The flow rate of fuel oil (γ=9100 N/m^3) is measured using a venturi flow meter at an oil refinery. The main pipe has an inside diameter of 31 mm and the throat of the meter has a diameter of 19 mm. Using the pressures shown in the sketch, calculate the volume flow (Q) rate of the oil.



B.E.

$$\frac{P_1}{\rho} + \frac{V_1^2}{2} + \cancel{g z_1} = \frac{P_2}{\rho} + \frac{V_2^2}{2} + \cancel{g z_2} \qquad (1)$$

$$z_1 = z_2$$

$$V_1 A_1 = V_2 A_2 \qquad \rho = const.$$

$$V_1 = \frac{A_2}{A_1} V_2 = \frac{D_2^2}{D_1^2} V_2 \qquad (2)$$

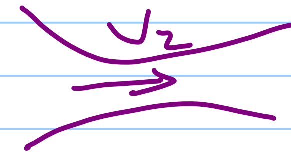
(2) → (1)

$$\frac{p_1}{\rho} + \left(\frac{D_2}{D_1}\right)^4 V_2^2 = \frac{P_2}{\rho} + \frac{V_2^2}{2}$$

Oops. Forgot the factor of 2 in denominator. But, I pick it up later. Final solution is ok.

$$\frac{V_2^2}{2}\left(1-\left(\frac{D_2}{D_1}\right)^4\right) = \frac{p_1 - p_2}{\rho} \qquad V_2 = \sqrt{\frac{\frac{2(p_1-p_2)}{\rho}}{1-\left(\frac{D_2}{D_1}\right)^4}}$$

$$\rho = \frac{\gamma}{g} = \frac{9100\ N/m^3 \ \left(\text{kg m}/s^2\right)}{9.81\ m/s^2} = 927.6\ kg/m^3 \quad \underline{\text{oil}}$$



$$V_2 = \sqrt{\frac{\frac{2(735-550)\times 10^3\ N/m^2}{927.6\ (kg/m^3)}}{\left(1-\left(\frac{19}{31}\right)^4\right)}} = \sqrt{464\ m^2/s^2} = 21.6\ m/s$$

$$Q = V_2 A_2 = 21.6\ m/s\ \frac{\left(\pi\,(0.019m)^2\right)}{4} = 0.00611\ m^3/s$$

$Q = \underline{6.11}\ l/s$ ANS//

IDEAL

DISCHARGE COEFFICIENT

$C_d = f(Re$

$C_d < 1$