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MATRIC NO: 17/ENG06/028

DEPT: MECHANICAL ENGINEERING

ASSIGNMENT 3

1. Given μ= $0.9Ns/m^2$, $\rho = 1260kg/m^3$, $L = 65m$, $D = 10mm = 0.01m$, $q = 180lt/min = 0.003m^3/s$
   a. From continuity equation

      q = A.u

      where $A = \frac{\pi D^2}{4} = \frac{\pi \times (0.01)^2}{4} = 7.855 \times 10^{-5} m^2$

      $$\therefore\ u = \frac{q}{A} = \frac{0.003}{7.855 \times 10^{-5}} = 38.19 m/s$$

      $$\therefore\ Re = \frac{\rho u D}{\mu} = \frac{1260 \times 38.19 \times 0.01}{0.9} = 534.66$$

      Because R_e < 2000, the flow is laminar

   b. $\Delta P = \frac{32 \mu u L}{D^2} = \frac{32 \times 0.9 \times 38.19 \times 65}{(0.01)^2} = \frac{71491.68}{0.0001} = 7.15 \times 10^8 N/m^2$

2. Given $\mu = 800cp = 0.8Ns/m^2$, G = 0.85, $\rho = 850kg/m^3$, $dp = 2000 \times 10^3 N/m^3$, D = 65mm = 0.065m , L = 95m
   a. $A = \frac{\pi D^2}{4} = \frac{\pi \times (0.065)^2}{4} = 3.319 \times 10^{-3} m^2$

      $$\frac{dp}{dx} = \frac{-2000 \times 10^3}{95} = -21.05 \times 10^3$$

      Rate of flow, Q = A.u

      Where $u = \frac{-1}{8\mu} \frac{dp}{dx} R^2$

$$= \left(\frac{-1}{8\times 0.8}\right)(-21.05\times 10^3)(0.0325)^2 = 3.474 m/s$$

$$\therefore Q = 3.474\times 3.319\times 10^{-3} = 0.0115 m^3/s$$

b. Centre line velocity $= u_{max}$

But, $u_{max} = 2\ \times u$

$$= 2\times 3.474 = 6.948 m/s$$

c. Total frictional drag, f_D

$$f_D = \tau_0 \pi D L$$

Where $\tau_0 = \frac{-\partial p}{\partial x}\frac{r}{2} = 21.05\times 10^3 \times \frac{0.0325}{2}$

$$\tau_0 = 342.0625 N/m^2$$

$$\therefore\ f_D = 342.0625\times \pi \times 0.065\times 95 = 6636.645 N \cong 6.637 kN$$

d. Power required to maintain flow

$$P = f_D \times u$$

$$= 6636.645\times 3.474$$

$$P = 23055.7 Watts$$

$$P = 23 kW$$

e. Velocity gradient at the pipe wall

$$\tau_0 = \frac{\mu \partial u}{\partial y}\ @\, y = 0$$

$$\therefore\ \frac{\partial u}{\partial y} = \frac{\tau_0}{\mu} = \frac{342.0625}{0.8} = 427.584 s^{-1}$$

f. Velocity and shear stress 60mm from wall

$$u = \frac{-1}{4\mu}\frac{\partial p}{\partial x}(R^2 - r^2)$$

$$but\ y = R - r\ and\ y = 60mm = 0.06m$$

$$\therefore\ 0.06 = 0.065 - r$$

$$r = 0.005$$

$$\therefore u = \frac{-1}{(4 \times 0.8)}(-21.05 \times 10^3)(0.065^2 - 0.005^2)$$

$$u = 27.628m/s$$

The shear stress can be found as;

$$\frac{\tau}{r} = \frac{\tau_0}{R}$$

$$\therefore \tau = \frac{r \times \tau_0}{R} = \frac{0.005 \times 342.0625}{0.065} = 26.3125N/m^2$$