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17/ENG05/013
MECHATRONIC ENGINEERING

1 Viscosity, $M = 0.9 NS/m^2$

Density, $\rho = 1260 kg/m^3$

Specific gravity $= 1.26$

Diameter, $D = 0.01m$

Length, $L = 65m$

Area of the Pipe, $A = \frac{\pi D^2}{4} = \frac{\pi (0.01)^2}{4}$

$A = 7.9 \times 10^{-5} m^2$

a) Rate of flow, $Q = A\bar{u}$

where $\bar{u} = -\frac{1}{8\mu}\frac{\partial P}{\partial x} R^2$

$Q = A\bar{u}$

$180 = (7.9 \times 10^{-5}) \times \bar{u}$

$\therefore \bar{u} = 180/7.9 \times 10^{-5}$

$= 2278481.013 m/s$

$Re = \frac{\rho u D}{\mu} = \frac{1260 \times 2278481.013 \times 0.01}{0.9}$

$Re = 31898734.18$

Because Renault number is greater than 2000, the flow is turbulent.

b) Pressure loss due to friction ΔP

$\Delta P = \frac{32 \mu \bar{u} L}{D^2}$

$\Delta P = \frac{32(0.9)(2278481.01) \times 65}{(0.01)^2}$

$\Delta P = 4.3 \times 10^{13} KN/m^2$

2) Viscosity, $\mu = 800$ Centipoise

$= \frac{800}{1000} = 0.8 NS/m^2$

Specific grav $= 0.85$

~~Density~~ Density, $\rho = 0.85 \times 10^3 kg/m^2$

Pressure Drop, $\Delta P = 2000 KN/m^2$

Length, $L = 95$ metres

Diameter, $D = 65mm = 0.065m$

$A = \frac{\pi D^2}{4} = \frac{\pi(0.065)^2}{4} = 0.00332$

a) Rate of flow, $Q = A\bar{u}$

But it is known that

$\Delta P = \frac{32 \mu \bar{u} L}{D^2}$

$\frac{\Delta P \times D^2}{32 \times \mu \times L} = \bar{u}$

$\bar{u} = \frac{2000 \times (0.065)^2}{32 \times 0.8 \times 95}$

$\bar{u} = 3.495065789 \times 10^{-3} m/s$

$\bar{u} = 3.5 \times 10^{-3} m/s$

$Q = A\bar{u}$

$= 0.00332 \times (3.5)$ ~~x10^-3~~

$Q = 0.01162 m^3/s$

$Re = \frac{\rho u D}{\mu} = \frac{0.85 \times 10^3 \times 3.47 \times 0.065}{0.8}$

$Re = 239.646875$

Because Renault number is ~~greater~~ less than 2000, the flow is Laminar

b) Centre line viscosity, U_{max}

$U_{max} = 2\bar{u}$

$= 2 \times 3.5$

$= 7 m/s$

c) Total frictional drag, F_D

$F_D = \pi D L$

$\frac{\partial P}{\partial x} = \frac{2000 \times 10^3}{95}$,

$r = D/2 = 0.0325$

$$\tau_0 = -\frac{\partial P r}{\partial x \, 2} = \frac{2000 \times 10^3 \times 0.0325}{95 \times 2}$$

$\tau_0 = 342.11 N/m^2$

$F_D = 342.11 \times 3.142 \times 0.065 \times 95$

$F_D = 6636.706372$

$F_D = 6636.7N$

$F_D = 6.637 kN$

d) Power to maintain flow, $P = F_D \times \bar{u}$

$= 6636.7 \times 3.5$

$= 23228.45$ watt

$P = 23.2 kW$

e) Velocity gradient at pipe wall

$$\tau_0 = \mu \frac{du}{dy}$$

$@ \, y = 0$

$$\frac{\partial u}{\partial y} = \frac{\tau_0}{\mu} = \frac{342.11}{0.8}$$

$= 427.6375 s^{-1}$

f) Velocity at 60mm from the wall

$y = \cancel{60mm}$ 0.06m

$y = R - r$

$\therefore \; r = R - y$

$r = 0.0325 - 0.06$

$r = -0.0275$

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

$$u = \frac{-1}{4(0.8)} \left(\frac{-2000 \times 10^3}{95} \right) (0.06^2 - (-0.0275)^2)$$

$u = 18.70888158$

$u = 18.7 m/s$

9) Shear stress 1

$$\frac{\tau_{max}}{r} = \frac{\tau_0}{R}$$

$$\tau_{max} = \frac{342.11 \times 0.0275}{0.0325}$$

$$\tau_{max} = 289.4776923$$

$$\tau_{max} = 289.5 N/m^2$$