Q

A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of dia 100mm and of length 10m. calculate diffn of Pressure at the two ends of the pipe if 100 kg of the oil is collected in a tank. in 30 sec.

Solution →

Given that

μ = 0.97 poise $= \frac{0.97}{10}$ = 0.097 NS/m²

Relative density = 0.9

ρ_o = 0.9 × 1000 = 900 kg/m3

Dia of pipe = D = 100 mm = 0.1m

Mass of oil collated M = 100 kg

t = 30 sec

Calculate difference of Pressure $(P_1 - P_2)$

$$P_1 - P_2 = \frac{32 \mu \bar{u} L}{D^2}$$

$\bar{u}$ = avg velocity $= \frac{Q}{\text{Area}}$

mass of oil/sec $= \frac{100}{30}$ kg/sec

$= \rho_o \times Q$

$= 900 \times Q$

$$\frac{100}{30} = 900 \times Q$$

$$Q = \frac{100}{30} \times \frac{1}{900} = 0.0037 \, m^3/sec$$

$$\bar{u} = \frac{Q}{Area} = \frac{0.0037}{\frac{\pi}{4}(0.1)^2} = 0.471 \, m/sec$$

Let us calculate Reynold number

$$R_e = \frac{\rho V D}{\mu}$$

$$R_e = \frac{900 \times 0.471 \times 0.1}{0.097} = 436.91$$

As Reynolds no. is less than 2000, the flow is laminar

$$P_1 - P_2 = \frac{32 \mu \bar{u} L}{D^2} = \frac{32 \times 0.097 \times 0.471 \times 10}{(0.1)^2}$$

$= 1462.28 \, N/m^2$

$= 1462.28 \times 10^{-4} \, N/cm^2$

$= 0.1462 \, N/cm^2$

PAGE NO.
DATE: / /

Q An oil of viscosity 0.1 NS/m^2 and relative density 0.9 is flowing through a circular pipe of dia 50 mm and of length 300m the rate of flow of fluid through the pipe is 3.5 lit/sec.
find the Pressure drop in a length of 300 m. and also the shear stress at the pipe wall.

Sol

Given that

Viscosity $\mu = 0.1$ NS/m^2

Relative density $= 0.9$

So or density of oil $= 0.9 \times 1000$

$= 900$ kg/m3

$D = 50$ mm $= 0.05$ m

$L = 300$ m

$Q = 3.5$ lit/se $= \frac{3.5}{1000}$ m3/s

find

(i) Pressure drop, $P_1 - P_2$

(ii) Shear Stress at pipe wall τ_0

(1) Pressure drop $(P_1 - P_2)$

$$(P_1 - P_2) = \frac{32 \mu \bar{u} L}{D^2}$$

$$\bar{u} = \frac{Q}{Area} = \frac{0.0035}{\frac{\pi}{4}(0.05)^2}$$

$$= 1.782 \ m/s$$

$$Re = \frac{900 \times 1.782 \times 0.05}{0.1}$$

$$= 801.9$$

$$P_1 - P_2 = \frac{32 \times 0.1 \times 1.782 \times 3000}{(0.05)^2}$$

$$= 68.43 N/cm^2 \ \underline{Ans}$$

(ii) Shear Stress at the pipe wall (τ_0)

$$\tau = -\frac{\partial p}{\partial x} \cdot \frac{r}{2}$$

Shear Stress at any radius r is given by the eqn

$r = R$

$$\tau_0 = -\frac{\partial p}{\partial x} \cdot \frac{r}{2}$$

$$-\frac{\partial p}{\partial x} = \frac{-(P_2 - P_1)}{x_2 - x_1} = \frac{P_1 - P_2}{x_2 - x_1} = \frac{P_1 - P_2}{L}$$

$$= \frac{684288}{300} \frac{N/m^2}{m} = 2280.96 N/m^3$$

$$\tau_0 = 2280.96 \times \frac{0.025}{2} = 28.512 N/m^2$$