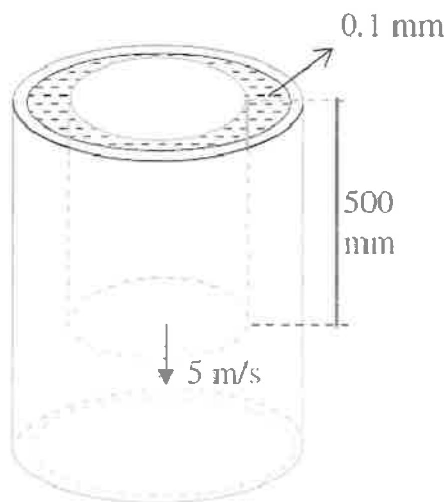
(1) (27047)

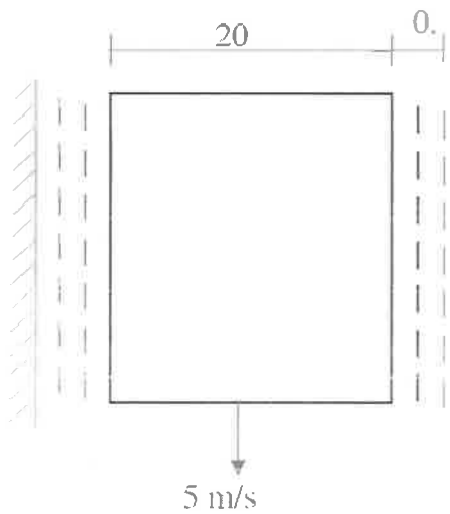
S.E (Production) Sem-III (Rev.) CBGS, 29/11/17

Subject: **FLUID MEHANICS AND FLUID POWER** Marks: 80

SYNOPTIC

Q.6 c A shaft of 20 mm and mass 15 kg slides vertically in a sleeve with a velocity of 5 m/s. The gap between the shaft and the sleeve is 0.1mm and is filled with oil. Calculate the viscosity of oil if the length of the shaft is 500 mm. 08





$D = 20mm = 20x10^{-3}m$

$M = 15$ kg

$W = 15x\ 9.81$

$W = 147.15N$

$y = 0.1mm$

$y = 0.1\ x\ 10^{-3}mm$

$U = 5m/s$

$F = W$

$F = 147.15N$

$\mu = ?$

$A = \Pi D L$

$A = \Pi \times 20 \times 10^{-3} \times 0.$

$A = 0.031\ m^2$

$$\tau = \mu . \frac{U}{Y}$$

$$4746.7 = \mu\ x \frac{5}{0.1x10^{-3}}$$

$$\mu = 0.095\ \frac{NS}{m^2}$$

$$\tau = \frac{F}{A}$$

$$= \frac{147.15}{0.031}$$

$$\tau = 4746.7N/m^2$$

Q.2 c A large tank of sea water has a door in the side 1 m square. The top of the door is 5 m below the free surface. The door is hinged on the bottom edge. Calculate the total pressure force and centre of pressure.. The density of the sea water is 1033 kg/m^3. 8

Solution: The total hydrostatic force $F = \gamma_{sea\ \ water} A\ h_c$

$$\gamma_{sea\ \ water} = 1033\ x9.81 = 10133.73$$

Given $A = 1m\ X\ 1m = 1m^2$

$$h_c = 5 + \frac{1}{2} = 5.5m$$

$$F = 10133.73X1X5.5 = 55735.5N$$

Acting at centre of pressure $(y_{c.p})$:

From the above $h_c = 5.5m,\ A = 1m^2$

$$(I_c)_{xx} = \frac{BD^3}{12} = \frac{1X1^3}{12} = 0.08333m^4$$

$$h_{C.P.} = h_c + \frac{(I_c)_{xx}}{Ah_c} = 5.5 + \frac{0.08333}{1X5.5} = 5.515m$$

Q.3 c A venturimeter has its axis vertical, the inlet & throat diameter being 150 mm & 75 mm respectively. The throat is 225 mm above inlet and Cd = 0.96. Petrol of 10 specific gravity 0.78 flowsup through the meter at a rate of 0.029 m^3 /sec. find the pressure difference between the inlet and throat.

Solution:

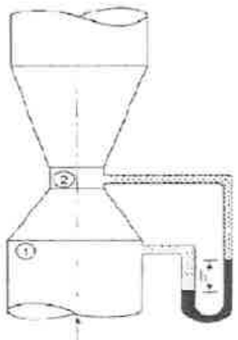


Fig. 1: venturimeter with its axis vertical

The discharge through a venturimeter is given by

$Q = C_d [a_1 a_2 / \sqrt{(a_1^2 - a_2^2)}] * \sqrt{(2gh)}$

Given:

$C_d = 0.96$

$d_1 = 150mm = 0.015m$

$d_2 = 75mm = 0.0075m$

$a_1 = (\pi/4) * 0.015^2 = 0.0177 m^2$

$a_2 = (\pi/4) * 0.0075^2 = 0.0044 m^2$

$Q = 0.029\ m^3/sec$

By substitution, we have

$0.029 = 0.96[0.0177*0.0044 / \sqrt{(0.0177^2 - 0.0044^2)}] * \sqrt{(2*9.81*h)}$

$h = 2.254m$ of oil

$h = (p_1/w + z_1) - (p_2/w + z_2)$

$2.254 = [(p_1/w) - (p_2/w)] - [z_2 - z_1]$

$2.254 = [(p_1/w) - (p_2/w)] - [0.225]$

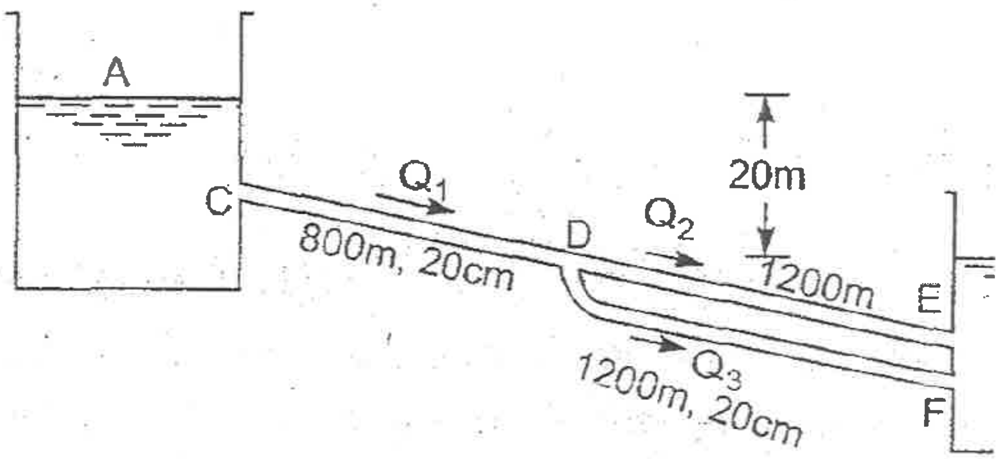
$p_1/\rho g - p_2/\rho g = 2.479$

Therefore, $p_1 - p_2 = 2.479*0.78*9810$

$= 18969\ N/m^2 = 18.969k\ N/m^2 = 18969\ Pa$

Pr. Difference, $p_1 - p_2 = 18.96$ kPa

Q.5 c A pipe of diameter 20 cm and length 2000 m connects two reservoirs, having difference of water levels as 20 m. Determine the discharge through the pipe. If an additional pipe of diameter 20 cm and length 2000 m is attached to the last 1200 m length of the existing pipe, find the increase in the discharge. Take f = 0.015 and Neglect minor losses 08



P.T.O →

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1[st] case: When a single pipe connects the reservoirs

$H = 4 f L v^2/2gd = 4f LV^2/2gd (Q/ \pi /4 d^2)^2$

[as $V = Q/ \pi \times d^2/4$]

$= 32 f L Q^2/ \pi^2 g d^5$

$20 = 32 \times 0.015 \times 2000 \times Q^2/\pi^2 \times 9.81 \times (0.2)5$

$Q = 0.0254 \ m^3/s$

2[nd] case:

Let Q_1 = discharge through pipe CD

Q_2 = discharge through pipe DE

Q_3 = discharge through pipe DF

Length of pipe CD, $L_1 = 800m$ and its dia. $d_1 = 0.20$ m

Length of pipe DE, $L_2 = 800m$ and its dia. $d_2 = 0.20$ m

Length of pipe DF $L_3 = 800m$ and its dia. $d_3 = 0.20$ m

Since the diameters and lengths of the pipes DE and DF are equal. Henc
to Q_3.

Also, for parallel pipes, we have

$Q_1 = Q_2 + Q_3 = Q_2 + Q_2 = 2Q_2$ [as Q_2 =

Therefore ,$Q_2 = Q_1/2$

Applying Bernoulli's equation to points A and B and the flow through CDE, we have

$20 = 4 \times f \times L_1 \times v_1^2 / d_1 \times 2 \times 9.81 + 4 \times f \times L_2 \times v_2^2 / d_2 \times 2 \times$

Where $v_1 = Q_1/ \pi \times 0.2^2/4 = 4 \times Q_1 / \pi \times 0.04$

$v_2 = Q_2/ \pi \times 0.2^2/4 = 4 \times Q_2 / \pi \times 0.04 = 4 \times Q_1/2 / \pi$

$= 2 \times Q_1/2 / \pi$

$= 4 \times .015 \times 800/0.2 \times 2 \times 9.81 \times (4 \times Q_1 / \pi \times 0.04)^2 +$
$4 \times .015 \times 1200/0.2 \times 2 \times 9.81 \times (2 \times Q_1 / \pi \times 0.04)$

$= 12394 \ Q_1^2 + 4647 \ Q_1^2 = 17041 \ Q_1^2$

$Q_1 = \sqrt{20/17041}$

Increase in discharge $= Q_1 - Q = 0.0342 - 0.0254$
$= 0.0088 \ m^3/s$

Q.4 c Oil of viscosity 8 Poise and specific gravity 1.2 flows through a horizontal pipe 80 mm in diameter. If the pressure drop in 100 m length of the pipe is 1500 kN/m^2, determine, 08

1. Rate of flow of oil in lpm.
2. The maximum velocity
3. The velocity and shear stress at 10 mm from the wall.

We have $(-\partial p/\partial x)$

$= 1500\times1000/100 = 15{,}000\ N/m^2/m$

Average velocity = $u_{av}=(R^2/8\mu)(-\partial p/\partial x) = (0.04^2/8\times0.8)(15{,}000) = 3$

Discharge (q) = $(\pi D^2/4)u_{av} = 0.01885\ m^3/s$

= 18.85 lps = 1131 lpm. (D=0.08m)

Max. Velocity (u_{max}) = 2 u_{av} = 7.0 m/s (at the center line)

Wall shear stress $(\tau_o) = -(\partial p/\partial x)(R/2) = 300 N/m^2$

Total frictional drag for 100m-pipe length (F_D)

$= \tau_o\ \pi DL = 7540N = 7.54kN$ (L=100m)

Power required to maintain flow (P) = $F_D \times u_{av} = 28.275$ kW ;

Also, $P = q\Delta P = 0.01885\times1500 = 28.275$ kW.

Velocity gradient at pipe wall

$\tau_o = \mu(\partial u/\partial y)_{y=0}$

$(\partial u/\partial y)_{y=0} = (\tau_o/\mu) = 300/0.8 = 3.75/s$

(10P = 1 $N\text{-}m/s^2$)

Velocity and shear stress at 10mm from the wall (y=10mm, r=30mm)

At r=30mm, shear stress $(\tau) = \tau_o\ (30/40) = 225N/m^2$

OR $(\tau) = (-\partial p/\partial x)(r/2) = 225N/m^2$

Local velocity (at r=30mm)

$u = u_{max}\ [1-(r/R)^2] = 3.28m/s.$