KATHMANDU UNIVERSITY

DHULIKHEL, KAVRE

Subject: ENG111

Assignment No: 2

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SUBMISSION DATE: / 05 / 2023

Date
Page

<Q.1>: Classify and describe different types of Newtonian and non-Newtonian fluid with examples.

Ans:

Newtonian fluids are the fluids that obey Newton's law of viscocity.

Eg: It has constant viscocity and independent of stress.

Eg: Water, air, alcohol, glycerol, thin motor oil.

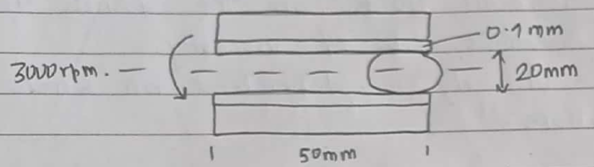
Non-newtonian fluids are the fluids that don't obey Newton's law of viscosity.

It's viscocity is dependent on stress.

It's classifications:

Types	Behaviour	Examples.
Dilatant	Viscosity increases with increased stress	suspension of cornstarch in water.
Pseudoplastic	Viscosity decreases with increased stress	ketchup, whipped cream, nailpolish.
Thixotropic	Viscosity reduces with time as result of stress	Peanut butter, yogurt, castor oil
Rheopectic	Viscocity rises with time as result of stress	gypsum paste, synovial fluid, printer ink.

<Q.2): In a 50mm long journal class bearing arrangement, the clearance between the two shafts in concentric condition is 0.1 mm. The shaft is 20mm in diameter and rotates at 3000 rpm. The dynamic viscosity of lubricant is 0.01 Pas and the velocity variation in the lubricant is linear. Considering the lubricant is Newtonian, calculate the frictional torque, the journal has to overcome and the corresponding power loss.



Sol^n:

Given,

length $(l) = 50mm$

revolution $(n) = 3000$ rpm

dynamic viscocity $(\mu) = 0.01$ Pas

clearance $(c) = 0.1$ mm

diameter $(D) = 20mm$

Now,

(i): Thickness of oil film $= 0.0015 \times D$

$= 0.0015 \times 20$

$\therefore h = 0.03$ mm.

(ii): We know,

$$Re = \frac{VD}{v}$$

Now,

$$V = \frac{\pi DN}{60}$$

$$= \frac{\pi \times 20 \times 3000}{60} \qquad \therefore V = 628.32 \text{ mm/s.}$$

So,

$$Re = \frac{628.32 \times 20}{0.01} = 1.256 \times 10^{6}$$

(iii): Now,

Frictional torque $(T) = (\pi \mu N/60)W$

and

$W = \pi h L (P_1 - P_2)$

Since Pressure is uniform, $P_1 - P_2 = \frac{F}{A}$

$A = \pi D l$

$F = Wg = \rho g A L$

Putting all together,

$$W = \pi h L \cancel{P_1 - P_2} \frac{F}{A} = \pi h L (\rho g A)$$

$$T = \left(\frac{\pi \mu N}{60}\right) \pi h L (\rho g A)$$

$$= 0.5 \pi^2 \mu N L D^2 \rho g h$$

$\therefore T = 31.04$ Nm.

(iv): Now

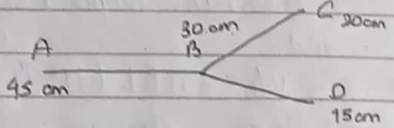
Power loss (P) = $\frac{2\pi N T}{60}$

$= \frac{2\times\pi\times 3000\times 91.4}{60}$

$\therefore P = 3293.04\ W$

<Q.3>: A pipe AB branches into two pieces C and D as shown in figure. The ~~dia~~ diameter at A is 45 cm, 30cm at B, 20cm at C and 15cm at D. Determine discharge at A, B, D, C if velocity at A is ~~...~~ 2m/s. and C is 4m/s.

Soln:



Given,

At A,	At B,
$d_A = 45cm$	$d_B = 30cm$
$V_A = 2m/s$	$V_B = ?$
At C,	At D,
$d_c = 20cm$	$d_D = 15cm$
$V_c = 4m/s$	$V_D = ?$

From AB,

Using continuity eqn,

$Q_A = Q_B$

$1.27 = \pi\times(30\times10^{-2})^2\times V_B$ $\quad \therefore Q_A = ((45\times10^{-2})^2\times\pi\times 2) = 1.27\ m^3/s$

$\therefore V_B = 4.49\ m/s$

From BCD,

$Q_B = Q_C + Q_D$

or, $\cancel{d_B V}\ A_B\cdot V_B = A_C V_C + A_D\cdot V_D$

or, $\pi\times d_B^2\times 4.49 = \pi\times d_c^2\times \cancel{v_c}\,4 + \pi\times d_D^2\times V_D$

$\frac{(30\times10^{-2})^2\times 4.49 - 4\times(20\times10^{-2})^2}{(15\times10^{-2})^2} = V_D$

$\therefore V_D = 10.84\ m/s.$

<Q.4>: A horizontal pipe of diameter 15 cm converges to 7.5 cm. If the pressure at the two sections is 400 kPa and 150 kPa respectively, calculate rate flow of water.

Soln:

Given,

At A	At B,
$d_A = 15cm = 15\times10^{-2}\ m$	$d_B = 7.5cm = 7.5\times10^{-2}\ m$
$P_A = 400\ kPa = 400\times10^3\ Pa$	$P_B = 150\ kPa = 150\times10^3\ Pa.$

From continuity eqn,

$A_A V_A = A_B V_B$

or, $\pi\times d_A^2\times V_A = \pi\times d_B^2\times V_B$

or $\frac{V_A}{V_B} = \frac{(7.5\times10^{-2})^2}{(15\times10^{-2})^2}$

$\therefore V_B = 4V_A.$

For horizontal pipe, Using Bernoulli's principle,

$P_A + \frac{1}{2}\times \rho \times V_A^2 = P_B + \frac{1}{2}\times \rho \times V_B^2$

or, $400\times10^3 + \frac{1}{2}\times1000\times V_A^2 = 150\times10^3 \times \frac{1}{2}\times1000\times 8V_A^2$

or, $400\times10^3 - 150\times10^3 = 3500 V_A^2$

or, $V_A = \sqrt{\frac{400\times10^3 - 150\times10^3}{\cancel{750}\ 3500}}$

∴ $V_A = 8.45$ m/s

So, $V_B = 8.45\times4 = 33.8$ m/s.

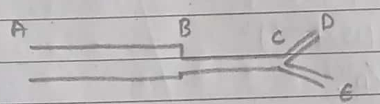
$Q_A = 8.45\times\pi\times(d_A^2$

$= 8.45\times\pi\times(15\times10^{-2})^2$

∴ $Q_A = 0.59\ m^3/s. = Q_B.$

(5): Water flows through a pipe AB 1.2m diameter at 3m/s and then passes through a pipe BC 1.5 m diameter. At C, the pipe branches. CD is 0.8m in diameter and carries one-third of flow of AB. Velocity in CE is 2.5m/s. Find volume rate of flow in AB, the velocity at BC, the velocity at CD and diameter of CE.

Sol^n:



For AB → BC,

$A_{AB}V_{AB} = A_{BC}V_{BC}$

or, $\pi\times d_{AB}^2\times V_{AB} = \pi\times d_{BC}^2\times V_{BC}$

or, $(1.2)^2\times3 = (1.5)^2\times V_{BC}$

∴ $V_{BC} = \frac{(1.2)^2\times3}{(1.5)^2} = 1.92$ m/s.

$Q_{AB} = \pi\times(1.2)^2\times3 = 13.57\ m^3/s$

For BC → CD+CE,

$Q_{CD} = \frac{1}{3}Q_{AB} = 4.57\ m^3/s$

$Q_{BC} = Q_{CD} + Q_{CE}$

or, $\pi\times(d_{BC})^2\times V_{BC} = 4.57 + \pi\times(d_{CE})^2\times V_{CE}$

or, $\sqrt{\frac{3.14\times(1.5)^2\times1.92 - 4.57}{\pi\times\cancel{V_{CE}}\ 2.5}} = d_{CE}$

∴ $d_{CE} = 1.07\ m^2$

Now,

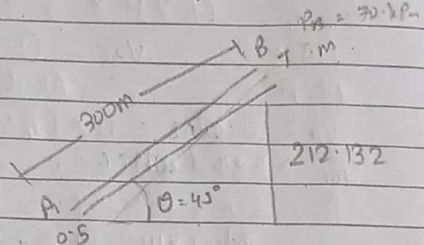
$\frac{Q_{CD}}{\pi\times(d_{CD})^2} = V_{CD}$

∴ $V_{CD} = \frac{4.57}{\pi\times(0.8)^2} = 2.273$ m/s

Date
Page

(6): A pipe 300 m long has a slope of 1 in 100 and tapers from 1 m diameter at high end to 0.5 m diameter at low end. Quantity of water flow is 5400 litres/min. If pressure at high end is 70 kPa, find pressure at lower end.

Soln:



Given,
slope = 1
or, $\tan\theta = 1$ $\therefore \theta = 45°$
So,
$\sin\theta = \frac{p}{h}$

$\therefore p = \frac{300}{\sqrt{2}} = 212.132$ m = height of point B.

Here,
$Q = 5400$ litres/min = 90 litres/sec.
So,
$Q_B = 90$ $Q_A = 90$

$\therefore V_A = \frac{90}{3.14 \times 1^2} = \cancel{28.66}$ 0.028 m/s. $\therefore V_B = \cancel{114.65}$ 0.114 m/s

From Bernoulli's theorem,

$P_A + \frac{1}{2}\rho V_A^2 + \rho g h_A = P_B + \frac{1}{2}\rho V_B^2 + \rho g h_B$

or, $P_A = P_B + \frac{1}{2}\rho V_B^2 + \rho g h_B - \frac{1}{2}\rho V_A^2 - \rho g h_A$

$= 70 \times 10^3 + \frac{1}{2} \times 1000 \times (0.028)^2 + (1000 \times 9.8) \times (212.132) - \frac{1}{2} \times 1000 \times (0.114)^2 - 0$

$\therefore P_A = \cancel{8312628.37\ Pa}$ 2151008 Pa

$= \cancel{83 \times 10^5\ Pa = 83.12\ MPa}$ 21.51 MPa.

Date
Page

(7): Water flows through a horizontal pipeline having varying cross-section. If the pressure of water equals 6 cm of mercury at a point where velocity is 30 cm/s, what is pressure at point of velocity 50 cm/s?

Soln:

Given,
At A,
$V_A = 30$ cm/s
$= 30 \times 10^{-2}$ m/s
$P_A = 6$ cm of mercury
$= 7.97 \times 10^4$ Pa

At B,
$V_B = 50$ cm/s
$= 50 \times 10^{-2}$ m/s
$P_B = ?$

Using Bernoulli's theorem,

$P_A + \frac{1}{2}\rho V_A^2 = P_B + \frac{1}{2}\rho V_B^2$

or $7.97 \times 10^4 + \frac{1}{2} \times 1000 \times 30 \times 10^{-2} - \frac{1}{2} \times 1000 \times (50 \times 10^{-2}) = P_B$

$\therefore P_B = 79600$ Pa