SNS COLLEGE OF TECHNOLOGY, COIMBATORE-35
DEPARTMENT OF MECHANICAL ENGINEERING

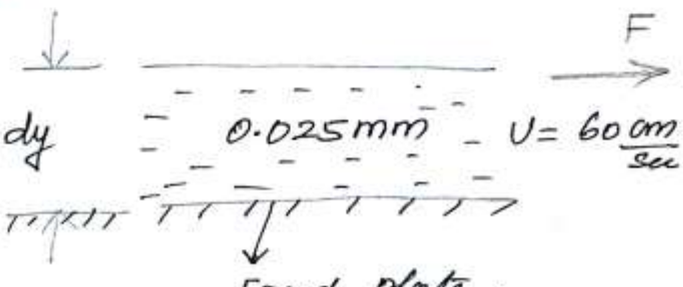
Fluid Mechanics and Machineries

VISCOSITY NUMERICALS

(1)

(1) A plate 0.025 mm distance from a fixed plate, moves at 60 cm/s and requires a force of 2N per unit area i.e. 2 N/m² to maintain this speed. Determine the fluid viscosity between the plates.

Given:



$dy = 0.025\ mm$

$dy = 0.025 \times 10^{-3}\ m$

$u = 60\ cm/s$

$u = 0.6\ m/sec$

$F = 2\ \frac{N}{m^2}$ To find: μ – Dynamic viscosity

This is the value of shear stress i.e τ

The fluid viscosity between the plates is μ.

W.K.T. $\tau = \mu \cdot \frac{du}{dy}$ | $\mu \Rightarrow$ Dynamic viscosity.

where du = change of velocity $= u - 0 = 0.6\ m/s$

dy = change of distance $= 0.025 \times 10^{-3}\ m$

τ = Force per unit area $= 2\ \frac{N}{m^2}$

$2 = \mu \frac{0.60}{0.025 \times 10^{-3}} \Rightarrow \mu = \frac{2 \times 0.025 \times 10^{-3}}{0.60}$

$\boxed{\mu = 8.33 \times 10^{-5}\ \frac{Ns}{m^2}}$ | $1\ \frac{Ns}{m^2} = 10\ poise$

$\mu = 8.33 \times 10^{-5} \times 10\ poise$

Answer: $\boxed{\mu = 8.33 \times 10^{-4}\ poise}$

(2) Determine the intensity of shear of an oil having viscosity = 1 poise. The oil is used for lubricating the clearance between a shaft of diameter 10cm and its Journal bearing. The clearance is 1.5 mm and the shaft rotates at 150 r.p.m.

Given:

$\mu = 1$ poise (Dynamic viscosity)

$d = 10$ cm (Diameter of the shaft)

$dy = 1.5$ mm (Clearance)

$N = 150$ rpm (Speed)

To find:

τ - Intensity of shear N/m^2.

Solution:

W.K.T Tangential speed of shaft

$$u = \frac{\pi D N}{60} = \frac{\pi \times 10 \times 10^{-2} \times 150}{60}$$

rpm → 60 → Convert from minute to second. 1 minute = 60 sec.

$$u = 0.785 \text{ m/s.}$$

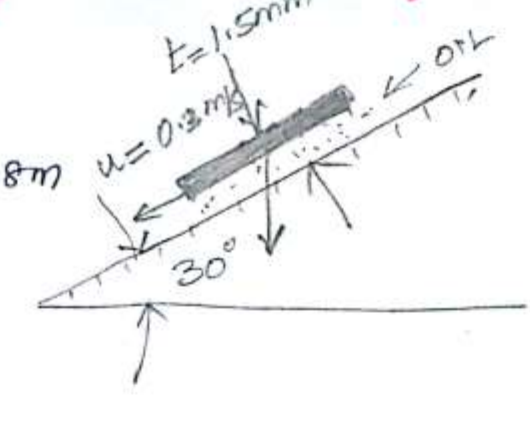
W.K.T $$\tau = \mu \cdot \frac{du}{dy} = \frac{1}{10} \times \frac{0.785}{1.5 \times 10^{-3}}$$

$1 \text{ poise} = \frac{1}{10} \frac{Ns}{m^2}$

Answer:

$$\tau = 52.33 \text{ N/m}^2$$

(3) Calculate the dynamic viscosity of an oil, which is used for lubrication between a square plate of size 0.8m x 0.8m and an inclined plane with angle of inclination 30° as shown in Fig. The weight of the square plate is 300N and it slides down the inclined plane with a uniform velocity of 0.3 m/s. The thickness of oil film is 1.5m. (2)



Given:

Plate Area = 0.8m x 0.8m

Angle $\theta = 30°$

weight $W = 300N$

velocity $u = 0.3 m/s$

thickness $t = 1.5m$

To find: μ - dynamic viscosity

Solution: viscosity between plate and inclined plane is μ.

Component of weight W, along the plane = W cos60

$= 300 \cos 60° = 150N$

Thus the shear stress Force F, on the bottom surface of the plate is 150N

$$\tau = \frac{F}{Area} = \frac{150}{0.8 \times 0.8} \frac{N}{m^2}$$

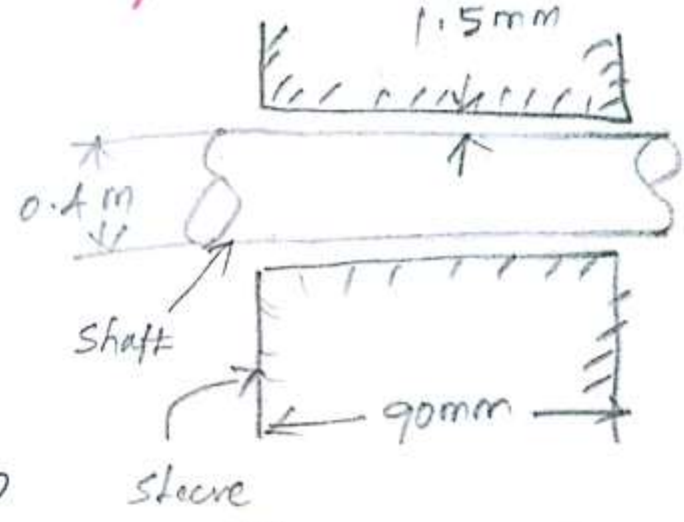
use $\tau = \mu \frac{du}{dy} = \mu \cdot \frac{u-0}{t} = \frac{0.3 m/s}{1.5 \times 10^{-3}} \Rightarrow \frac{150}{0.64} = \mu \frac{0.3}{1.5 \times 10^{-3}}$

$$\mu = \frac{150 \times 1.5 \times 10^{-3}}{0.64 \times 0.3}$$

$\mu = 1.17 \frac{Ns}{m^2} = 1.17 \times 10$

$\boxed{\mu = 11.7 \text{ poise}}$

The dynamic viscosity of an oil, used for lubrication between a shaft and sleeve is 6 poise. The shaft is of diameter 0.4 m and rotates at 190 rpm. Calculate the power loss in the bearing for a sleeve length of 90mm. The thickness of the oil film is 1.5mm.



Given: $\mu = 6$ poise

$= \frac{6}{10} \frac{Ns}{m^2}$

$= 0.6 \frac{Ns}{m^2}$

$D = 0.4m$

$N = 190 rpm$

$L = 90 \times 10^{-3} m$

$t = 1.5 \times 10^{-3} m$

$u = \frac{\pi N D}{60} = \frac{\pi \times 0.4 \times 190}{60} = 3.98 \ m/s$

$\tau = \mu \frac{du}{dy}$ du - change in velocity $= u - 0 = 3.98 m/s$
dy - change in distance $= t = 1.5 \times 10^{-3} m$

$\tau = 0.6 \times \frac{3.98}{1.5 \times 10^{-3}} = 1592 \ N/m^2$

This is shear stress on shaft

shear force on the shaft F = Shear stress × Area

$F = 1592 \times \pi D L = 1592 \times \pi \times 0.4 \times 90 \times 10^{-3}$

$F = 180.05N.$

Torque of the shaft: $T = Force \times \frac{D}{2} = 180 \times \frac{0.4}{2}$

$T = 36.01 \ Nm.$

Power: $= \frac{2\pi N T}{60} = \frac{2 \times \pi \times 190 \times 36}{60} = 716.48W$