Module 1

MEE1004-FLUID MECHANICS

Problems related to Newton’s law of Viscosity

Problems related to Surface tension and Capillarity

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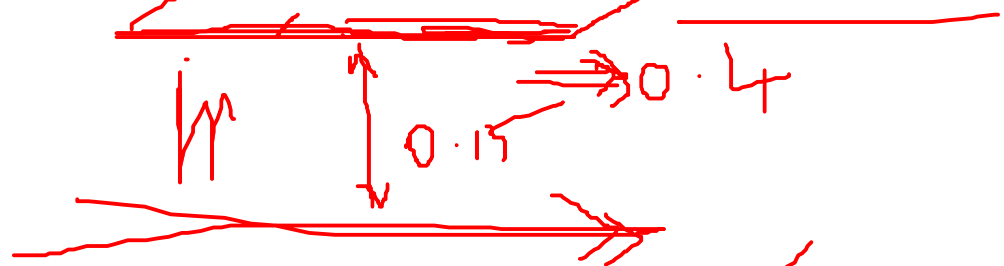
Newton's law of Viscosity

. A flat plate area 1.5×10^6 mm^2 is pulled with a speed of 0.4 m/s relative to another plate located at a distance of 0.15 mm from it. Find the force and power required to maintain this speed, if the fluid separating them is having viscosity as 1 poise.

. A flat plate area 1.5×10^6 mm² is pulled with a speed of 0.4 m/s relative to another plate located at a distance of 0.15 mm from it. Find the force and power required to maintain this speed, if the fluid separating them is having viscosity as 1 poise.



Solution:

Given:

Area of the plate, $A = 1.5 \times 10^6 \text{ mm}^2 = 1.5 \text{m}^2$

Speed of plate relative to another plate, $du = 0.4$ m/s

Distance between the plates, $dy = 0.15 \text{ mm} = 0.15 \times 10^{-3}$m

Viscosity $\mu = 1$ poise $\frac{1}{10}\frac{Ns}{m^2}$.

Using equation (1.2), we have

$$\tau = \mu\frac{du}{dy} = \frac{1}{10} \times \frac{0.4}{015 \times 10^{-3}} = 266.66\frac{N}{m^2}$$

(i) ∴ Shear force, F= τ x area =266.66 x 1.5 = 400 N.

(ii) Power* required to move he plate at the speed 0.4 m/sec

= F x u = 400 x 0.4 = 160 W.

Calculate the dynamic viscosity of an oil, which is used for lubrication between a square plate of size 0.8 m x0.8 m and an inclined plane with angle of inclination 30° as shown in Fig. The weight of the square plate is 300 N and it slides down the inclined plane with a uniform velocity of 0.3 m/s. The thickness of oil film is 1.5 mm.

Calculate the dynamic viscosity of an oil, which is used for lubrication between a square plate of size 0.8 m x0.8 m and an inclined plane with angle of inclination 30° as shown in Fig. The weight of the square plate is 300 N and it slides down the inclined plane with a uniform velocity of 0.3 m/s. The thickness of oil film is 1.5 mm.

Solution:

Given:

Area of plate,	$A = 0.8 \times 0.8 = 0.64\ m^2$
Angle of plane,	$\theta = 30°$
Weight of plate,	$W = 300$ N
Velocity of plate,	$u = dy$
Thickness of oil film,	$t = dy$
	$= 1.5$ mm $= 1.5 \times 10^{-3}$m

Let viscosity of fluid between plate and inclined plane is μ. Component of weight W, along the plane = W cos 60° =150 N

Thus the shear force, F, on the bottom surface of the plate = 150 N

And shears stress, $\tau = \dfrac{F}{Area} = \dfrac{150}{0.64} N/m^2$

Now using equation (1.2), we have

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

where du = Change of velocity = u-0=u=0.3 m/s

dy = t = 1.5 x 10^{-3} m

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

$$\therefore \qquad \mu = \frac{150 \times 1.5 \times 10^{-3}}{0.64 \times 0.3} = 1.17 Ns/m^2 = 1.17 \times 10 = 11.7 \; poise.$$