# *Tribology*
# Module5: Fluid film lubrication

**Q.1. What is the meaning of Squeeze Film Lubrication?**

**Ans:** Squeeze is English word, meaning act of gripping and pressing firmly. When two surfaces, containing viscous fluid in between, approach towards each other the viscosity of fluid resists this motion and builds fluid pressure to prevent contact between the surfaces. This type of lubrication is termed as Squeeze Film Lubrication Mechanism. Since a finite time is required to squeeze the viscous fluid out of the gap, therefore this mechanism may help to damp the vibrations.

**Q2. What are the applications of Aerostatic Lubrication?**

**Ans:** 1. Textile machines where contamination due to liquid lubricant needs to be avoided.

2. High speed applications (i.e. high speed grinding spindles, milling machines, and diamond turning spindles) where the liquid lubricant cannot be used as its relatively high viscosity increases the operating temperature.

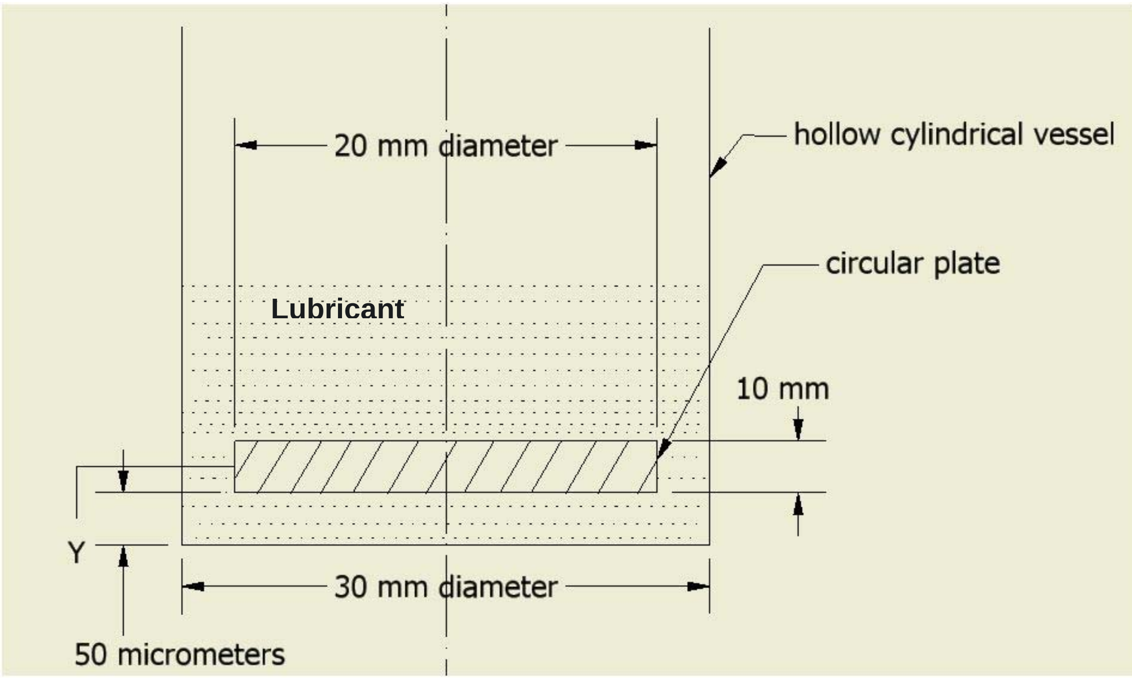
3. Precision machines (coordinate measuring machine, profile projection equipment, rotary, index tables) where gap between contacting elements is negligible.

**Q3. What is the importance of Reynolds equation?**

**Ans:** Reynolds equations a partial differential equation governing the pressure distribution in fluid film bearings. It contains Poiseuille, physical wedge, stretch, local compression, normal & transverse squeeze terms. Each of these describes a pressure source term. It is derived by coupling the mass-momentum equations with the continuity equation.

**Q4.** A hollow cylindrical vessel of 30 mm bore diameter contains a lubricant of 10 mPa.s viscosity. As shown in figure 1, a concentric plate of diameter 20 mm and thickness 10 mm is immersed in it. This plate is moving in vertically downward direction with a velocity of $y = 0.04 \sin 10t$. What will be the expression for the pressure distribution over its surface if the initial gap between the circular plate and base of vessel is 50 $\mu$m? How do we find the expression for load carrying capacity?

**Ans:** Please refer the notes where the Reynolds Equation for squeeze film lubrication is given by:




$$\frac{\partial}{\partial x}(\frac{h^3}{\eta}\frac{\partial p}{\partial x})+\frac{\partial}{\partial y}(\frac{h^3}{\eta}\frac{\partial p}{\partial y})=12(v_h-v_o) \ldots (1)$$

As the given geometries are cylindrical therefore equation (1) is represented in polar coordinates as:

$$\frac{\partial}{\partial r}\left(r\frac{h^3}{\eta}\frac{\partial p}{\partial r}\right)+\frac{1}{r}\frac{\partial}{\partial \theta}\left(\frac{h^3}{\eta}\frac{\partial p}{\partial \theta}\right)=12(v_h-v_o) \ldots (2)$$

Since the two surfaces are parallel, axial symmetryexists and the pressure is a function only of the radius. So equation (2) reduces to

$$\frac{d}{dr}\left(r\frac{h^3}{\eta}\frac{dp}{dr}\right)=12(v_h-v_o); \quad \text{where } v_o=0 \text{ and } v_h=\frac{dh}{dt}=0.04\ \cos(10t)$$

$$therefore\, 12\ (v_h-v_o)=12(0.4\ cos(10t)-0)=\ 4.8\sqrt{1-(\frac{h}{0.04})^2}$$

Integrating above equation, we obtain

$$\frac{dp}{dr} = \frac{6\eta v_h}{h^3} + \frac{A}{r\,h^3}$$

Since $\frac{dp}{dr}$ will not be infinite when r = o, then A = 0 Hence $\frac{dp}{dr} = \frac{6\,\eta v_h}{h^3}$; integrating this equation again, we obtain $p = \frac{6\eta r\, v_h}{h^3} + B$ at $r = r_o,\ p = 0$ therefore

$B = -\frac{6\eta r_o\, v_h}{h^3}$ So $p = \frac{6\eta\, v_h}{h^3}(r_o - r)$ ... (3)

The equation (3) represents the pressure distribution over the surface of circular plate. On integration of equation (3) over the area of circular plate, the normal load carrying capacity may be determined, as given below

Normal load component $W_z = \int_{r=0}^{r=r_o} 2\pi r\, p\, dr = \frac{12\,\pi\ \eta v_h}{h^3}\left(\frac{r_o^3}{6}\right)$