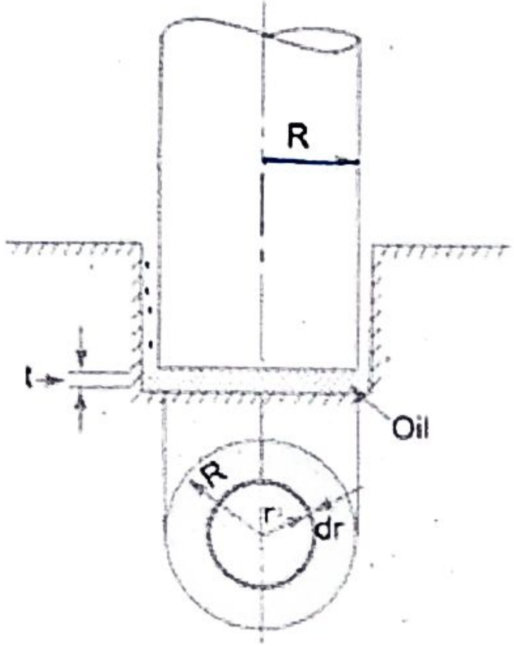
Power Absorbed in Viscous Flow - Foot Step Bearing



Let D = Diameter of shaft

t = thickness of oil film

N = speed of shaft in rpm

Considering elementary ring at radius r, width dr

Area of elementary ring

$$dA = 2\pi r\,dr$$

Shear stress

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

$$\tau = \mu \frac{V-0}{t}$$

V is tangential velocity of shaft

$$V = R \times \omega$$

$$= R \times \frac{2\pi N}{60}$$

$$\tau = \frac{\mu V r}{t}$$

$$= \frac{\mu}{t} \times \frac{2\pi N r}{60}$$

Shear force acting on elementary ring

$$dF = \tau \times dA$$

$$dF = \frac{\mu}{t} \times \frac{2\pi N}{60} \times 2\pi r\,dr$$

$$dF = \frac{\mu 4 \pi^2 N r^2 dr}{60 t}$$

Torque Required to overcome viscous Resistance

$$dT = dF \times r$$

$$= \frac{4\mu\pi^2 N r^2 dr \times r}{60 t}$$

$$dT = \frac{4\mu\pi^2 N r^3 dr}{60 t}$$

$$T = \int_0^R dT$$

T = Total Torque Required

$$T = \int_0^R dT$$

$$= \int_0^R \frac{4\mu \pi^2 N r^3 dr}{60t}$$

$$= \frac{4\mu \pi^2 N}{60t} \int_0^R r^3 dr$$

$$= \frac{4\mu \pi^2 N}{60t} \cdot \left[\frac{R^4}{4} \right]$$

$$T = \frac{\mu \pi^2 N R^4}{60t}$$

Power Absorbed

$$P = \frac{2\pi N T}{60}$$

$$= \frac{2\pi N}{60} \times \frac{\mu \pi^2 N R^4}{60t}$$

$$\boxed{P = \frac{\mu \pi^3 N^2 R^4}{30 \times 60t}}$$