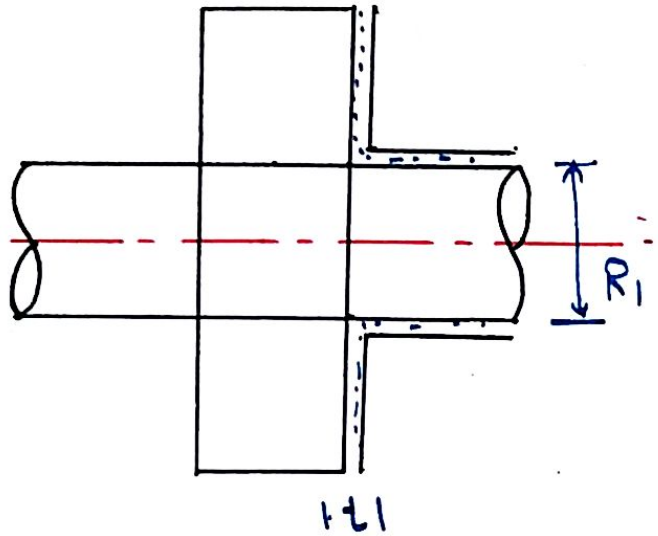
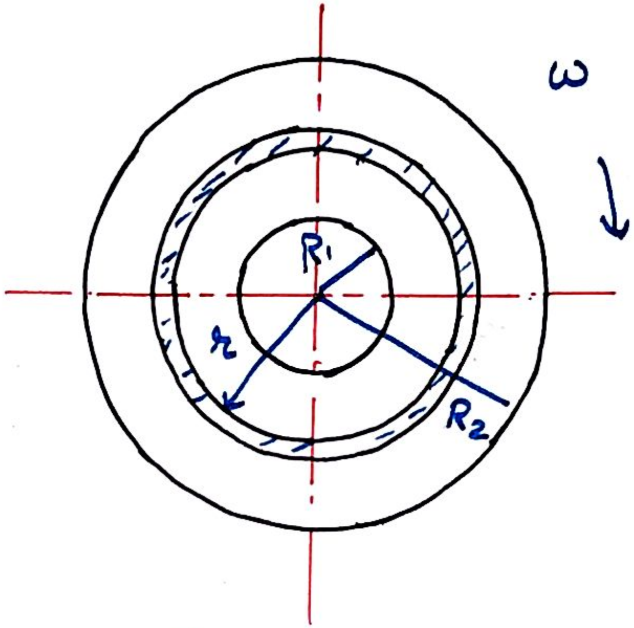
Power Absorbed in Viscous Flow - Collar Bearing





N = speed of shaft rpm

R_1 = internal Radius of collar

R_2 = external Radius of collar

for calⁿ of viscous force elementary ring radius of r thickness dr

area of elementary ring $dA = 2\pi r\,dr$

Shear stress

$$\tau = \mu \frac{\partial u}{\partial y}$$

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

V = Tangential velocity

$$V = r\omega$$

$$= r\,\frac{2\pi N}{60}$$

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

Shear force

$$dF = \tau \times dA$$

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

$$= \frac{\mu}{15}\,\frac{\pi^2 N r^2 dr}{t}$$

Torque on elementary Ring

$$dT = dF \times r$$

$$= \frac{\mu}{15}\cdot\frac{\pi^2 N r^2 dr}{t}\cdot r$$

$$dT = \frac{\mu}{15}\,\frac{\pi^2 N r^3 dr}{t}$$

Total Torque Required to overcome this viscous force on the whole collar

$$T = \int_{R_1}^{R_2} dT$$

$$= \int_{R_1}^{R_2} \frac{\mu}{15} \cdot \frac{\pi^2 N r^3 \, dr}{t}$$

$$= \frac{\mu}{15} \cdot \frac{\pi^2 N}{t} \int_{R_1}^{R_2} r^3 \, dr$$

$$= \frac{\mu}{15} \frac{\pi^2 N}{t} \left[\frac{R^4}{4} \right]_{R_1}^{R_2}$$

$$T = \frac{\mu}{15} \frac{\pi^2 N}{t} \left(\frac{R_2^4 - R_1^4}{4} \right)$$

$$T = \frac{\mu \pi^2 N (R_2^4 - R_1^4)}{60t}$$

Power Absorbed

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

$$P = \frac{2\pi N}{60} \times \frac{\mu}{60t} \cdot \pi^2 N (R_2^4 - R_1^4)$$

$$\boxed{P = \frac{\pi^3 N^2 \mu (R_2^4 - R_1^4)}{30t \times 60}}$$