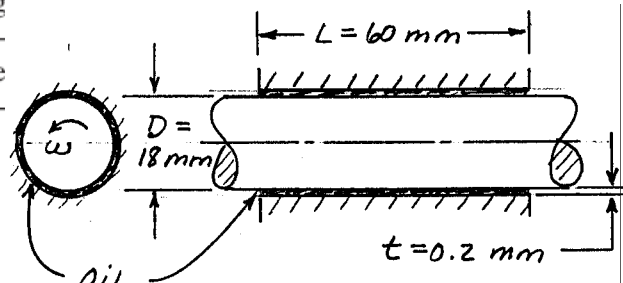


Problem 2.62

Difficulty: [2]

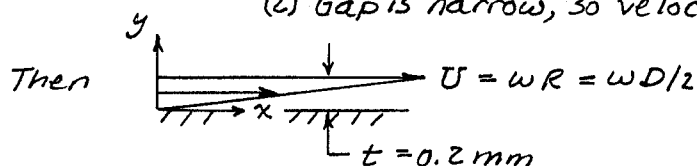
2.62 A shaft with outside diameter of 18 mm turns at 20 revolutions per second inside a stationary journal bearing 60 mm long. A thin film of oil 0.2 mm thick fills the concentric annulus between the shaft and journal. The torque needed to turn the shaft is 0.0036 N·m. Estimate the viscosity of the oil that fills the gap.



Solution: Basic equation $\tau_{yx} = \mu \frac{du}{dy}$

Assumptions: (1) Newtonian fluid

(2) Gap is narrow, so velocity profile is linear, $\frac{du}{dy} \approx \frac{\Delta u}{\Delta y}$



Shear stress is

$$\tau_{yx} \approx \mu \frac{\Delta u}{\Delta y} = \mu \frac{U}{t} = \frac{\mu \omega D}{2t}$$

Neglecting end effects, torque is

$$T = FR = \tau_{yx} A R = \tau_{yx} (\pi D L) \frac{D}{2} = \frac{\mu \pi \omega D^3 L}{4t}$$

Solving for viscosity

$$\mu = \frac{4tT}{\pi \omega D^3 L}$$

$$= \frac{4}{\pi} \times 0.2 \text{ mm} \times 0.0036 \text{ N}\cdot\text{m} \times \frac{1}{20 \text{ rev}} \times \frac{1}{(18)^3 \text{ mm}^3} \times \frac{1}{60 \text{ mm}} \times \frac{\text{rev}}{2\pi \text{ rad}} \times \frac{(1000)^3 \text{ mm}^3}{\text{m}^3}$$

$$\mu = 0.0208 \text{ N}\cdot\text{s} / \text{m}^2$$

{ From Fig. A.2, this oil appears somewhat less viscous than SAE 10W, }
assuming the oil is at room temperature.