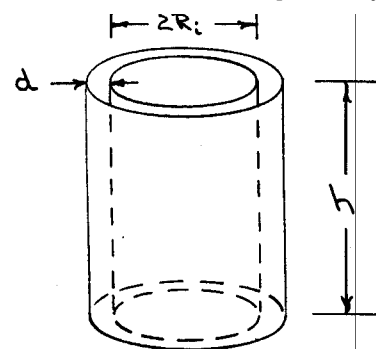


Problem 2.59

[Difficulty: 2]

2.59 A concentric cylinder viscometer may be formed by rotating the inner member of a pair of closely fitting cylinders. For small clearances, a linear velocity profile may be assumed in the liquid filling the annular clearance gap. A viscometer has an inner cylinder of 75 mm diameter and 150 mm height, with a clearance gap width of 0.02 mm. A torque of 0.021 N·m is required to turn the inner cylinder at 100 rpm. Determine the viscosity of the liquid in the clearance gap of the viscometer.



Solution

The imposed torque must balance the resisting torque of the shear force.

The shear force is given by $F = \tau A$ where $A = 2\pi R_i h$

For a Newtonian fluid $\tau = \mu \frac{dv}{dy}$

Since the velocity profile is assumed to be linear, $\tau = \mu \frac{v}{d}$
where v is the tangential velocity of the inner cylinder, $v = R_i \omega$

Thus,

$$F = \tau A = \mu \frac{v}{d} 2\pi R_i h = \frac{2\pi \mu R_i^2 \omega h}{d}$$

$$\text{and the torque } T = R_i F = \frac{2\pi \mu R_i^3 \omega h}{d}$$

Solving for μ ,

$$\mu = \frac{T d}{2\pi R_i^3 \omega h} = 0.021 \text{ N}\cdot\text{m} \times 0.02 \text{ mm} \times \frac{1}{2\pi} \times \frac{1}{(37.5)^3} \text{ mm}^3 \times \frac{\text{min}}{100 \text{ rev}} \times \frac{1}{150 \text{ mm}} \\ \times \frac{\text{rev}}{2\pi \text{ rad}} \times \frac{60 \text{ s}}{\text{min}} \times (1000)^3 \frac{\text{mm}^3}{\text{m}^3}$$

$$\mu = 8.07 \times 10^{-4} \text{ N}\cdot\text{s}/\text{m}^2$$