Answer on Question #84695- Physics - Mechanics | Relativity

A hydraulic circular rod having a 100mm diameter and 2m long is pulled by a force of 200 N. It moves with a constant velocity within a circular hollow tube of 101mm internal diameter. The clearance of 0.5mm between the rod and the tube is filled with oil of specific gravity 0.8 and kinematic viscosity 400 mm2/s as shown in the figure below. Determine the velocity of the rod in units of m/s.

Solution.

According to the Newton's second law of motion:

$$F - F_{\text{viscosity}} = 0, \qquad (1)$$

where

$$F_{\text{viscosity}} = \mu S \frac{d\vartheta}{dh} \qquad (2)$$

$$\mu = \nu\rho \qquad (3)$$

ν is kinematic viscosity, μ is dynamic viscosity, ρ is density of oil.

Substituting (2) and (3) into (1), we receive:

$$F dh = \nu\rho S d\vartheta \qquad (4)$$

Taking into account, that velocity of oil layers is changing from 0 near the tube to ϑ near the rod, let's integrate (4):

$$\int_0^h F dh = \int_0^\vartheta \nu\rho S d\vartheta$$

After integration we receive:

$$Fh = \nu\rho S\vartheta$$

Thus:

$$\vartheta = \frac{Fh}{\nu\rho S} \qquad (5)$$

Specific gravity:

$$SG = \frac{\rho}{\rho_{H_2O}}$$

$$\rho = SG\rho_{H_2O} \qquad (6)$$

Cylinder's lateral area:

$$S = 2\pi Rl = \pi D_{rod} l \qquad (7)$$

Let's substitute (6) and (7) into (5):

$$\vartheta = \frac{Fh}{\nu SG\rho_{H_2O}\pi D_{rod} l}$$

Finally:

$$\vartheta = \frac{200 \cdot 0.5 \cdot 10^{-3}}{400 \cdot 10^{-6} \cdot 0.8 \cdot 1000 \cdot 3.14 \cdot 100 \cdot 10^{-3} \cdot 2} = 0.5\ (m/s)$$

Answer: $\vartheta = 0.5\ (m/s)$.

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