

Problem 2.89

[Difficulty: 2]

2.89 SAE 30 oil at 100°C flows through a 12-mm-diameter stainless-steel tube. What is the specific gravity and specific weight of the oil? If the oil discharged from the tube fills a 100-mL graduated cylinder in 9 seconds, is the flow laminar or turbulent?

Given: Type of oil, flow rate, and tube geometry

Find: Whether flow is laminar or turbulent

Solution:

Data on SAE 30 oil SG or density is limited in the Appendix. We can Google it or use the following $\nu = \frac{\mu}{\rho}$ so $\rho = \frac{\mu}{\nu}$

At 100°C, from Figs. A.2 and A.3 $\mu = 9 \times 10^{-3} \cdot \frac{\text{N} \cdot \text{s}}{\text{m}^2}$ $\nu = 1 \times 10^{-5} \cdot \frac{\text{m}^2}{\text{s}}$

$$\rho = 9 \times 10^{-3} \cdot \frac{\text{N} \cdot \text{s}}{\text{m}^2} \times \frac{1}{1 \times 10^{-5}} \cdot \frac{\text{s}}{\text{m}^2} \times \frac{\text{kg} \cdot \text{m}}{\text{s}^2 \cdot \text{N}} \quad \rho = 900 \frac{\text{kg}}{\text{m}^3}$$

Hence $\text{SG} = \frac{\rho}{\rho_{\text{water}}} \quad \rho_{\text{water}} = 1000 \cdot \frac{\text{kg}}{\text{m}^3} \quad \text{SG} = 0.9$

The specific weight is $\gamma = \rho \cdot g \quad \gamma = 900 \cdot \frac{\text{kg}}{\text{m}^3} \times 9.81 \cdot \frac{\text{m}}{\text{s}^2} \times \frac{\text{N} \cdot \text{s}^2}{\text{kg} \cdot \text{m}} \quad \gamma = 8.829 \times 10^3 \cdot \frac{\text{N}}{\text{m}^3}$

For pipe flow (Section 2-6) $Q = \frac{\pi \cdot D^2}{4} \cdot V \quad \text{so} \quad V = \frac{4 \cdot Q}{\pi \cdot D^2}$

$$Q = 100 \cdot \text{mL} \times \frac{10^{-6} \cdot \text{m}^3}{1 \cdot \text{mL}} \times \frac{1}{9} \cdot \frac{1}{\text{s}} \quad Q = 1.111 \times 10^{-5} \frac{\text{m}^3}{\text{s}}$$

Then $V = \frac{4}{\pi} \times 1.11 \times 10^{-5} \cdot \frac{\text{m}^3}{\text{s}} \times \left(\frac{1}{12} \cdot \frac{1}{\text{mm}} \times \frac{1000 \cdot \text{mm}}{1 \cdot \text{m}} \right)^2 \quad V = 0.0981 \frac{\text{m}}{\text{s}}$

Hence $\text{Re} = \frac{\rho \cdot V \cdot D}{\mu}$

$$\text{Re} = 900 \cdot \frac{\text{kg}}{\text{m}^3} \times 0.0981 \cdot \frac{\text{m}}{\text{s}} \times 0.012 \cdot \text{m} \times \frac{1}{9 \times 10^{-3}} \cdot \frac{\text{m}^2}{\text{N} \cdot \text{s}} \times \frac{\text{N} \cdot \text{s}^2}{\text{kg} \cdot \text{m}} \quad \text{Re} = 118$$

Flow is laminar