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Fluid Mechanics With Engineering Applications (10th Edition)

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Problem

A journal bearing consists of a 8.00-in shaft in a 8.01-in sleeve 10 in long, the clearance space (assumed to be uniform) being filled with SAE 30 Eastern lubricating oil at 100°F. Calculate the rate at which heat is generated at the bearing when the shaft turns at 100 rpm. Refer to Appendix A. Express the answer in Btu/hr.

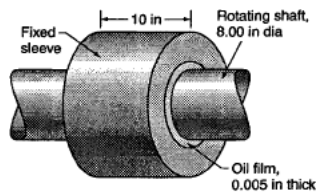


Figure P2.23

Step-by-step solution

Step 1 of 5

Given data:-

The diameter of a rotating shaft $d_{shaft} = 8 \text{ in}$

The diameter of a sleeve $d_{sleeve} = 8.01 \text{ in}$

The length of a sleeve $L_{sleeve} = 10 \text{ in}$

The temperature of SAE 30 Eastern lubricating oil $T = 100^\circ\text{F}$

The rotating speed of a shaft $N = 100 \text{ rpm}$

The Oil film thickness $t = 0.005 \text{ in}$

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Step 2 of 5

The given diagram

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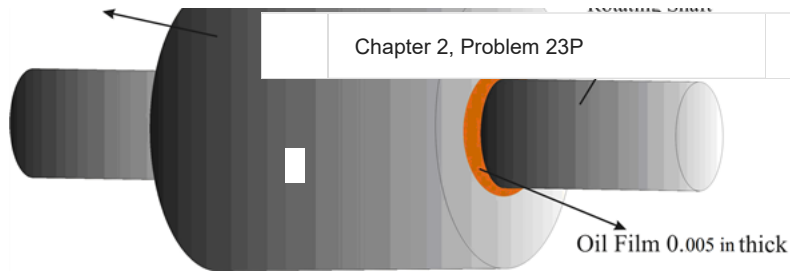


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[Comment](#)**Step 3 of 5**

From the absolute viscosity of fluid chart at temperature $T = 100^\circ\text{F}$

The SAE-30 Eastern lubricating oil given absolute viscosity $\mu = 0.0021 \text{ lb}\cdot\text{s}/\text{ft}^2$

The velocity of a shaft $v = r\omega$

The velocity of a shaft

$$\begin{aligned} u &= \frac{\pi d N}{60} \\ &= \frac{\pi \times d_{\text{shaft}} N}{60} \\ &= \frac{\pi \times 8 \times 100}{60 \times 12} \\ &= 3.49 \text{ fps} \end{aligned}$$

[Comment](#)**Step 4 of 5**

The shear stress of journal bearing

$$\begin{aligned} \tau &= \mu \frac{du}{dy} \\ &= \mu \frac{du}{\frac{\Delta d}{2}} \\ &= \mu \left(\frac{du}{\left(\frac{d_{\text{sleeve}} - d_{\text{shaft}}}{2} \right)} \right) \\ &= 0.0021 \times \frac{3.49}{\left(\frac{8.01 - 8}{2 \times 12} \right)} \\ &= 17.58 \text{ lb}/\text{ft}^2 \end{aligned}$$

[Comments \(2\)](#)**Step 5 of 5**

The frictional force

$$\begin{aligned} F &= \tau A \\ &= \tau \times \pi \times d_{\text{shaft}} \times L_{\text{sleeve}} \\ &= 17.58 \times \pi \times \frac{10}{12} \times \frac{8}{12} \\ &= 30.69 \text{ lb} \end{aligned}$$



$$T\omega = Fu$$

$$= 30.69 \times 3.49$$

$$= 107.10 \text{ ft} \cdot \text{lb}/\text{sec}$$

$$= 107.10 \times \frac{3600}{778}$$

$$= 496 \text{ Btu}/\text{hr}$$

The rate of heat generation

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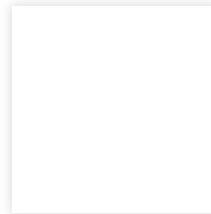
Find the change in volume of 10 m³ of water for the following situations: (a) a temperature increase from 60°C to 70°C with...

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Chapter 2, Problem 7P

Water at 68°F is in a long rigid cylinder of inside diameter 0.600 in. A plunger applies pressure to the water. If, with zero...

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