Fluid Mechanics Wi n Engineering Applications (10th Edition)

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.

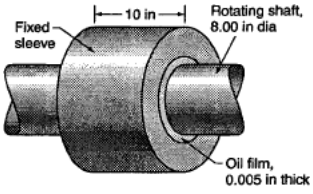


Figure P2.23

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 $T = 100°\text{F}$

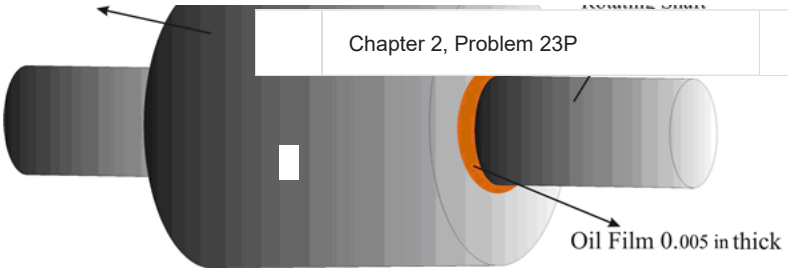
The rotating speed of a shaft $N = 100\,\text{rpm}$

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

Comment

Step 2 of 5

The given diagram



Comment

Step 3 of 5

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

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

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

Comment

Step 4 of 5

The shear stress of journal bearing

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

Comments (2)

Step 5 of 5

The frictional force

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

$$T\omega = Fu$$
$$= 30.69 \times 3.49$$
$$= 107.10\,\text{ft} \cdot \text{lb/sec}$$
$$= 107.10 \times \frac{3600}{778}$$
$$= 496\,\text{Btu/hr}$$

The rate of heat generation $\boxed{496\,\text{Btu/hr}}$

Comment

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See solution

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