

A generator shaft turns at 200 rpm and delivers 50 hp. What is the minimum required shaft diameter, if the shearing stress in the shaft is not to exceed 5000 psi.

First convert angular velocity, ω , to proper units.

$$\omega = 200 \text{ rpm} \left(2\pi \frac{\text{rad}}{\text{rev}} \right) \left(\frac{1}{60 \text{ sec/min}} \right) \quad (1)$$

$$\omega = 20.94 \frac{\text{rad}}{\text{s}} \quad (2)$$

Convert horsepower to proper units

$$P = 50 \text{ hp} \left(\frac{550 \text{ ft-lb}}{\text{s hp}} \right) \left(\frac{12 \text{ in/ft}}{1} \right) \quad (3)$$

$$P = 330,000 \frac{\text{in-lb}}{\text{s}} \quad (4)$$

Calculate Torque in shaft

$$P = T \omega \quad (5)$$
$$T = \frac{P}{\omega} = \frac{330,000 \frac{\text{in-lb}}{\text{s}}}{20.94 \frac{\text{rad}}{\text{s}}} = 15,759 \text{ in-lb} \quad (6)$$

Calculate required diameter of shaft
based on maximum allowable stress

$$\tau_{max} = \frac{T r}{I_p} \quad (7)$$

$$5000 \frac{lb}{in^2} = \frac{(15,759 in-lb)(r)}{\frac{\pi}{2} r^4} \quad (8)$$

$$r^3 = \frac{(15,759)(2)}{\pi (5000)} \quad (9)$$

$$r^3 = 2.007 \quad (10)$$

$$r = 1.26 \text{ in} \quad (11)$$

$$d = 2r \quad (12)$$

$$d = 2(1.26 \text{ in}) \quad (13)$$

$$d = 2.52 \text{ in} \quad (14)$$

Minimum Req Diameter