SECTION-2

Q2

Ans Given data:

Diameter ratio, $k = \frac{d}{D} = \frac{3}{4} = 0.75$

Power $P = 60\ kW = 60 \times 10^3\ W$

Speed $N = 200\ rpm$

$\tau_{max} = 70\ N/mm^2$

$l = 4\ m = 4000\ mm$

$\theta = 3.8^\circ = 3.8 \times \frac{\pi}{180} = 0.0631$ radian

$G = 80\ kN/mm^2 = 80 \times 10^3\ N/mm^2$

$D = ?$

$d = ?$

Calculation of Torque to be transmitted:

$$P = \frac{2\pi NT}{60}$$

$$60 \times 10^3 = \frac{2\pi \times 200 \times T}{60}$$

$$T = 2.864 \times 10^3\ N\text{-}m$$

$$T = 2.864 \times 10^6\ N - mm$$

First of all, let us find out the value of diameter of the shaft for its strength and stiffness

Diameter for Strength:

We know that torque transmitted by the shaft, T

$$T = \frac{\pi}{16} \times \tau \times \left[\frac{D^4 - d^4}{D}\right]$$

$$2.864 \times 10^6 = \frac{\pi}{16} \times 70 \; \frac{D^4\left[1 - \left(\frac{d}{D}\right)^4\right]}{D}$$

$$2.864 \times 10^6 = \frac{\pi}{16} \times 70 \times D^3 \left[1 - \left(\frac{3}{4}\right)^4\right]$$

$$D^3 = \frac{2.864 \times 10^6 \times 16}{\pi \times 70 \times 0.6836} = 304822.5$$

$$D = 67.3 \text{ say } 68 \text{ mm}$$

$$[D = 68 \text{ mm}]$$

Diameter for stiffness:

$$\frac{T}{J} = \frac{G\theta}{\ell}$$

$$\frac{2.864 \times 10^6}{\frac{\pi}{32} \times (D^4 - d^4)} = \frac{80 \times 10^3 \times 0.0663}{4000}$$

$$D^4 - d^4 = 22 \times 10^6$$

$$D^4\left[1-\left(\frac{d}{D}\right)^4\right] = 22\times10^6$$

$$D^4\left[1-\left(\frac{3}{4}\right)^4\right] = 22\times10^6$$

$$D^4 \times 0.68\% = 22\times10^6$$

$$D = 75.32\text{mm} \text{ Say } 76\text{mm}$$

$$[D = 76\text{ mm}].$$

The required external diameter, (Greater value of the two)

$$\boxed{D = 76\text{mm}}$$

And

$$d = 0.75 \times 76$$

$$\boxed{d = 57\text{mm}}$$ Ans