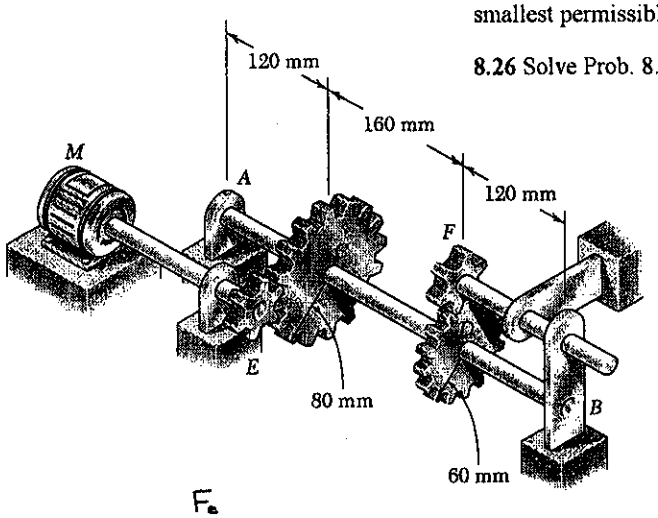
PROBLEM 8.26

8.25 The solid shaft *AB* rotates at 600 rpm and transmits 80 kW from the motor *M* to a machine tool connected to gear *F*. Knowing that τ_{all} = 60 MPa, determine the smallest permissible diameter of shaft *AB*.

8.26 Solve Prob. 8.25, assuming that shaft *AB* rotates at 720 rpm



SOLUTION

$$f = \frac{720 \text{ rpm}}{60 \text{ sec/min}} = 12 \text{ Hz}$$

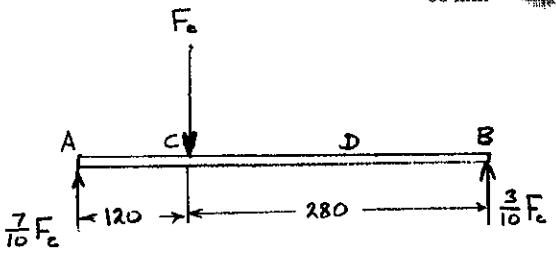
$$T = \frac{P}{2\pi f} = \frac{80 \times 10^3}{(2\pi)(12)} = 1061.0 \text{ N·m}$$

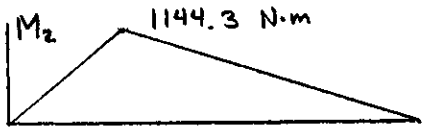
Gear C $\quad F_C = \frac{T}{r_C}$

$$F_C = \frac{1061.0}{80 \times 10^{-3}} = 13.262 \times 10^3 \text{ N}$$

Gear D $\quad F_D = \frac{T}{r_D}$

$$F_D = \frac{1061.0}{60 \times 10^{-3}} = 17.684 \times 10^3 \text{ N}$$

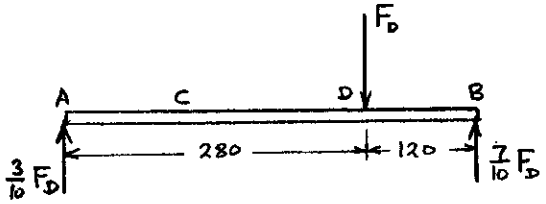


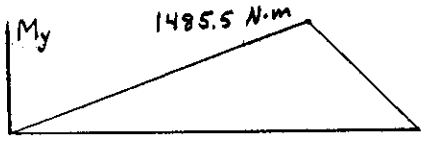


Forces in vertical plane

$$M_{Cz} = (120 \times 10^{-3})\left(\tfrac{7}{10} F_C\right) = 1114.0 \text{ N·m}$$

$$M_{Dz} = \frac{120}{280} M_{Cz} = 477.4 \text{ N·m}$$





Forces in horizontal plane

$$M_{Dy} = (120 \times 10^{-3})\left(\tfrac{7}{10} F_D\right) = 1485.5 \text{ N·m}$$

$$M_{Cy} = \frac{120}{280} M_{Dy} = 636.6 \text{ N·m}$$

At C: $\sqrt{M_y^2 + M_z^2 + T^2} = 1664.9 \text{ N·m}$

At D: $\sqrt{M_y^2 + M_z^2 + T^2} = 1886.9 \text{ N·m}$

$$\tau_{all} = \frac{c}{J}\left(\sqrt{M_y^2 + M_z^2 + T^2}\right)_{max}$$

$$\frac{J}{c} = \frac{\pi}{2} c^3 = \frac{\left(\sqrt{M_y^2 + M_z^2 + T^2}\right)_{max}}{\tau_{all}} = \frac{1886.9}{60 \times 10^6} = 31.448 \times 10^{-6} \text{ m}^3$$

$$c = 27.15 \times 10^{-3} \text{ m} \qquad d = 2c = 54.3 \times 10^{-3} \text{ m} = 54.3 \text{ mm}$$