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Problem 1

$$d_1 = 60 \text{ mm} \\ = 0,06 \text{ m}$$

$$d_2 = 110 \text{ mm} \\ = 0,11 \text{ m}$$

$$l_1 = 1,2 \text{ m}$$

$$l_2 = 0,9 \text{ m}$$

$$G_2 = 80 \text{ GPa} + E_3 G_1$$

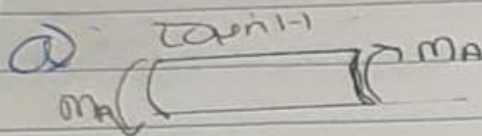
$$G_1 = 70 \text{ GPa} + E_2 G_2 = 756 \text{ GPa}$$

$$\tau_{\text{allow}} = 110 \text{ MPa}$$

$$\tau_{\text{allow}} = 70 \text{ MPa}$$

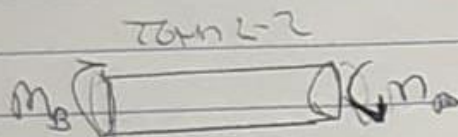
$$E_2 = 5$$

$$E_3 = 15$$



$$\tau_1 = \tau_{\text{allow}} \\ = 110 \text{ MPa}$$

$$\frac{\tau_1 \cdot 0,03}{\frac{1}{2} \pi (0,03)^4} = 110 \cdot 10^6$$



$$\tau_2 = 70 \text{ MPa} \\ \tau_1 = 4,66 \text{ kNm}$$

$$\frac{4,66 \cdot 1,2}{\frac{1}{2} \pi \cdot 0,03^4 \cdot 75 \cdot 10^9} = \tau_2$$

$$\tau_2 = 88,91 \text{ kNm}$$

$$\text{For } \tau_2 = \frac{88,91 \cdot 10^3 \cdot (0,055)^3}{\frac{1}{2} \pi \cdot (0,055)^4}$$

$$= 0,34 \text{ MPa}$$

$$0,34 \text{ MPa} < 110 \text{ MPa} \text{ (safe)}$$

$$\text{Maximum power } M = 4,66 + 0,34 = 5 \text{ kNm}$$

6)

$$\Phi_r = \frac{88,91 \cdot 10^3 \cdot 0,9}{\frac{1}{2} \pi (0,055^4) \cdot 95 \cdot 10^9}$$

$$= 0,058 \text{ rad}$$

$$= 3,32^\circ$$

Problema 2

$$d = 40 \text{ mm} + 15 \text{ mm} \\ = 55 \text{ mm}$$

$$\tau_{\text{ad}} = 80 \text{ MPa}$$

$$G = 38 \text{ GPa}$$

$$\tau_{\text{ad AB}} = 50 \text{ MPa}$$

$$G = 77 \text{ GPa}$$

$$J_p = \frac{1}{2} \pi \left(\frac{55}{2} \right)^4 \cdot 10^{-12} = 8,98 \cdot 10^{-7}$$

$$50 \cdot 10^6 = \frac{\tau_1 \cdot 40 \cdot 10^{-3}}{\frac{1}{2} \pi (80 \cdot 10^{-3})^4 - (74 \cdot 10^{-3})^4}$$

$$\Phi_1 + \Phi_{AB} = 0$$

$$\frac{0,2 \cdot 21,5 \cdot 10^3}{1,72 \cdot 10^{-5} \cdot 38 \cdot 10^9} = 0,2 \tau_{AB}$$

$$\tau_1 = 21,5 \text{ kN/m}$$

$$\tau_{AB} = 2,27 \text{ kN/m}$$

EXOS

$$\tau_{AB} = \frac{2,27 \cdot 10^3 \cdot 55 \cdot 10^{-3}}{8,98 \cdot 10^{-7}} = 69,5 \text{ MPa} < 80 \text{ MPa OK}$$

$$\text{for } T = \tau_1 + \tau_{AB}$$

$$= 21,5 + 2,27$$

$$= 23,77$$

$$\Phi = \Phi_{AB} + \Phi_1$$

$$= \frac{23,77 \cdot 10^3 \cdot 0,3}{8,98 \cdot 10^{-7} \cdot 77 \cdot 10^9} - \frac{21,5 \cdot 10^3 \cdot 0,2}{1,72 \cdot 10^{-5} \cdot 38 \cdot 10^9}$$

$$= 0,10 \text{ rad}$$

$$= 5,73^\circ$$