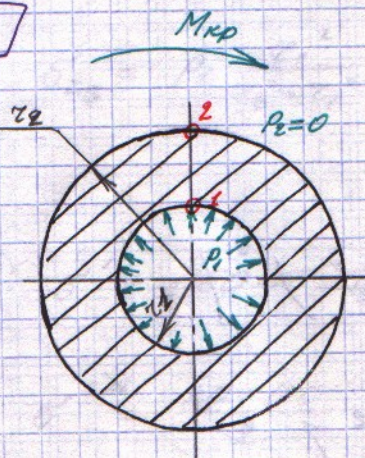


2



Дано:  $p_1 = 60 \text{ МПа}$

$$p_2 = 0$$

$$r_1 = 100 \text{ мм}$$

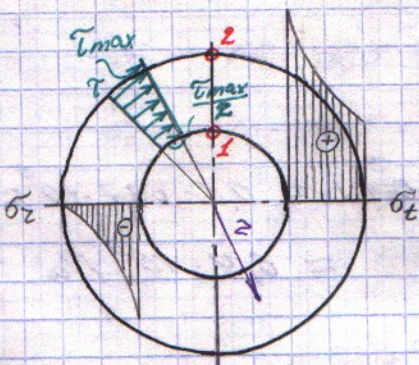
$$r_2 = 200 \text{ мм}$$

$$M_{кр} = 150 \text{ кН}\cdot\text{м}$$

$$\sigma_{\tau p} = \sigma_{\tau c} = \sigma_{\tau} = 200 \text{ МПа}$$

Найти:  $\eta_{\tau}$

Решение



$$\eta_p = \frac{\pi D^4}{32} \left[ 1 - \left( \frac{d}{D} \right)^4 \right] =$$

$$= \frac{\pi D^4}{32} \left[ 1 - \left( \frac{r_1}{r_2} \right)^4 \right] =$$

$$= \frac{\pi D^4}{32} \left[ 1 - c^4 \right]$$

$$\tau_{\text{max}}^{(r)} = \frac{\tau \cdot M_{кр}}{J_p} = \frac{32 \cdot M_{кр} \cdot r}{\pi D^4 (1 - c^4)} = \frac{r \cdot 32 \cdot 150 \cdot 10^3}{\pi \cdot 0,4^4 \cdot (1 - 0,5^4)} =$$

$$= 2 \cdot 63,7 \cdot 10^6$$

$$\sigma_{z_1} = \frac{\rho_1 \cdot z_1^2}{z_2^2 - z_1^2} \left[ 1 \mp \left( \frac{z_2}{z_1} \right)^2 \right] =$$

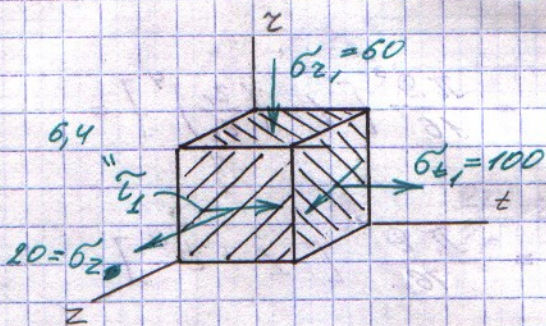
$$= \frac{6 \cdot 10^7 \cdot 0,1^2}{0,2^2 - 0,1^2} \left[ 1 \mp \left( \frac{0,2}{z_1} \right)^2 \right] =$$

$$= 20 \cdot 10^6 \cdot \left[ 1 \mp \left( \frac{0,2}{z_1} \right)^2 \right]$$

\* < - - - - -

Опасные точки: 1 и 2.

Т. 1



$$\sigma_{z_1} = \sigma_z \left( \frac{z_1}{z} \right) = 0,1 \cdot 63,7 \cdot 10^6 =$$

$$= 6,4 \cdot 10^6 \text{ Па}$$

$$\sigma_{z_1} = \sigma_z \left( \frac{z_1}{z} \right) = 20 \cdot 10^6 \left[ 1 - \left( \frac{0,2}{0,1} \right)^2 \right] =$$

$$= -60 \cdot 10^6 \text{ Па}$$

$$\sigma_{x_1} = \sigma_x \left( \frac{z_1}{z} \right) = 20 \cdot 10^6 \left[ 1 + \left( \frac{0,2}{0,1} \right)^2 \right] = 100 \cdot 10^6 \text{ Па}$$

$$-\sigma_{z_1} = p_1 \frac{z_1^2}{z_2^2 - z_1^2} = \frac{p_1 z_1^2}{4z_1^2 - z_1^2} = \frac{p_1}{3} = 20 \cdot 10^6 \text{ Па.}$$

$$\sigma' = -60 \cdot 10^6 \text{ Па}$$

$$\sigma_{1,3}^{II,III} = \frac{20+100}{2} \pm \sqrt{\left(\frac{20-100}{2}\right)^2 + 6,4^2} =$$
$$= 60 \pm 40,5$$

$$\sigma_1 > \sigma_2 > \sigma_3$$

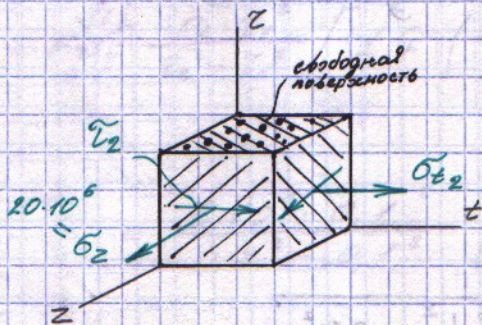
$$\sigma_1 = 60 + 40,5 = 100,5 \text{ МПа}$$

$$\sigma_2 = 60 - 40,5 = 19,5 \text{ МПа.}$$

$$\sigma_3 = -60 \text{ МПа.}$$

$$\sigma_{\text{экв},1} = \sigma_1 - \sqrt{\sigma_3^2} = 100,5 + 60 = 160,5 \text{ МПа.}$$

Т. 2



$$\sigma_z = 20 \cdot 10^6 \text{ Па}$$

$$\sigma_x = \sigma_x(z_x) =$$

$$= 20 \cdot 10^6 \cdot \left[ 1 + \left( \frac{0,2}{0,2} \right)^2 \right] =$$

$$= 40 \cdot 10^6 \text{ Па}$$

$$\tau_{xy} = \tau(z_x) = 12,8 \cdot 10^6 \text{ Па}$$

$$\sigma_x' = 0$$

$$\sigma_{I,III} = \frac{20 + 40}{2} \pm \sqrt{\left( \frac{20 - 40}{2} \right)^2 + 12,8^2} =$$

$$= 30 \pm \sqrt{100 + 163,84} = 30 \pm 16,24$$

$$\sigma_1 > \sigma_2 > \sigma_3$$

$$\sigma_1 = 30 + 16,24 = 46,24 \text{ МПа}$$

$$\sigma_2 = 30 - 16,24 = 14,84 \text{ МПа}$$

$$\sigma_3 = 0$$

$$\sigma_{\text{экв}} = 46,24 - 0 = 46,24 \text{ МПа}$$

Умак:

$$\sigma_{\text{элв}} = \max(\sigma_{\text{элв}_1}, \sigma_{\text{элв}_e}) = 160,5 \text{ МПа}$$

$$\eta_T = \frac{\sigma_T}{\sigma_{\text{элв}}} = \frac{200 \cdot 10^6}{160,5 \cdot 10^6} = 1,25$$