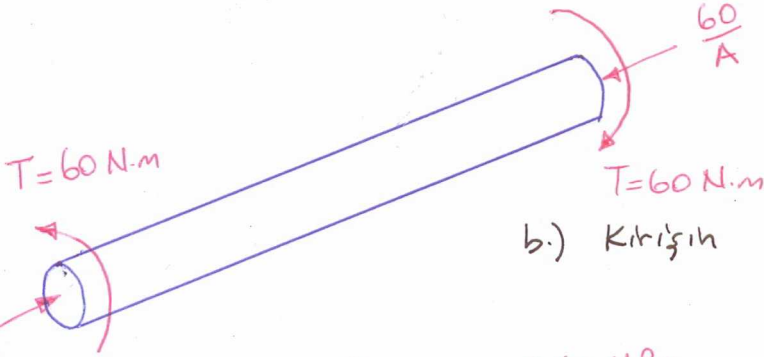


a.)

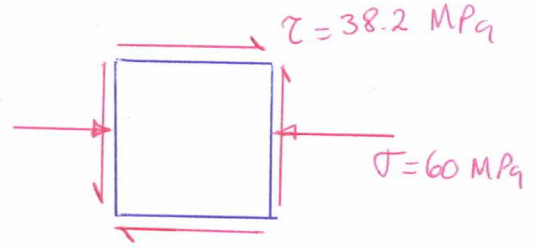
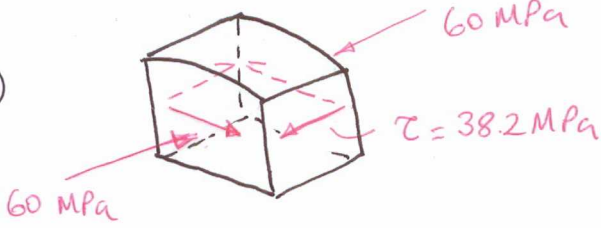
$$\tau = 60 \text{ MPa}$$

$$\tau = \frac{T \cdot c}{J} = \frac{60 \cdot (0.01)}{\frac{\pi \cdot (0.02)^4}{32}} = 38.2 \text{ MPa}$$



b.) Kirişin yüzeyindeki her nokta kritiktir.

c.)



d.)

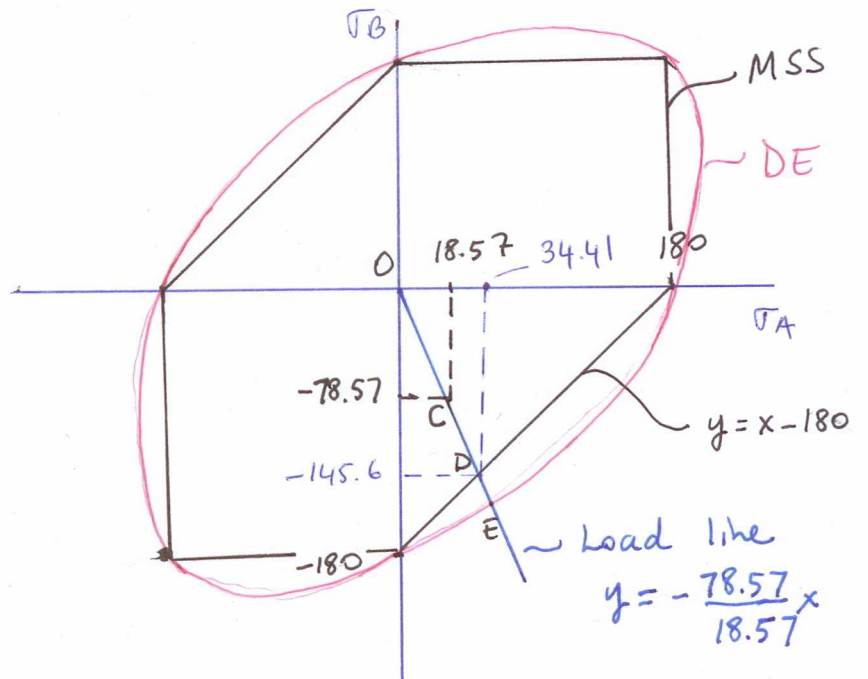
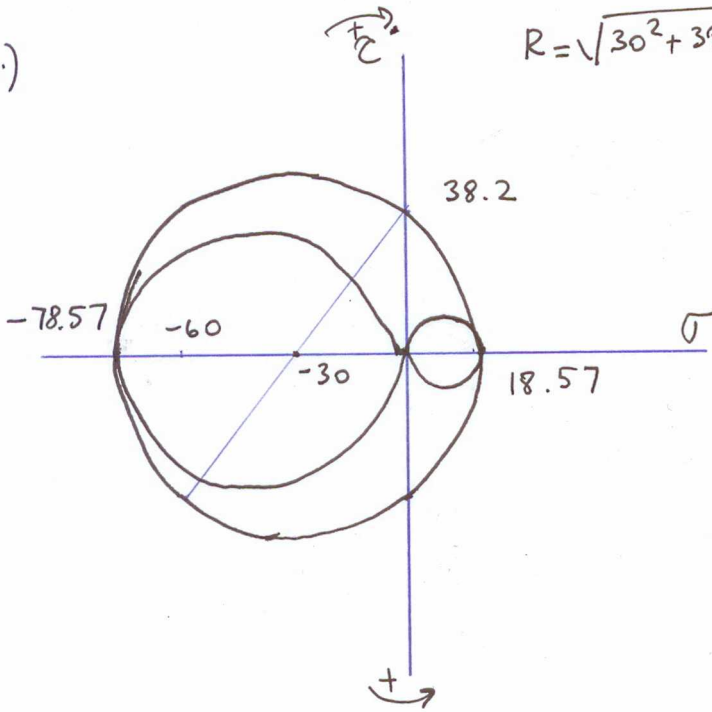
$$R = \sqrt{30^2 + 38.2^2} = 48.57$$

$$\sigma_A = 48.57 - 30 = 18.57 \text{ MPa}$$

$$\sigma_B = -30 - 48.57 = -78.57 \text{ MPa}$$

$$\sigma_A > 0 > \sigma_B$$

$$S_y = 180 \text{ MPa}$$



e.) Maksimum shear stress criterion (Ductile)

$$n_{MSS} = \frac{|\sigma_1|}{|\sigma_c|} = \frac{34.41}{18.57} = 1.853$$

yada

$$n_{MSS} = \frac{S_y}{\sigma_1 - \sigma_3} = \frac{180}{(18.57) - (-78.57)} = 1.853$$

Distortion Energy criterion. (Ductile)

$$\sigma' = \sqrt{\sigma_1^2 - \sigma_1\sigma_3 + \sigma_3^2} = \sqrt{(18.57)^2 - (18.57)(-78.57) + (-78.57)^2}$$

$$\sigma' = 89.31 \text{ MPa}$$

$$n_{DE} = \frac{S_y}{\sigma'} = \frac{180}{89.31} = 2.015$$

Coulomb Mohr (Brittle)

$$\frac{\sigma_A}{S_{ut}} - \frac{\sigma_B}{S_{uc}} = \frac{1}{n} \Rightarrow \frac{18.57}{320} - \frac{(-78.57)}{1000} = \frac{1}{n}$$

$$n = 7.32$$

f.) Emniyet katsayısı en küçük olana göre tasarım yapılır. Yani  $n_{MSS} = 1.853$ 'e göre tasarım yapılmalıdır. Fakat Distortion energy testlerinden elde edilen datalar birbirine daha yakın olduğundan  $n = 2.015$ 'e göre de tasarım yapılabilir. MSS theory daha emniyetli (conservative) dir. Daha hafif bir tasarım için D.E. kullanılabilir.

2.)  $S_y = 180 \text{ MPa}$

$S_{ut} = 320 \text{ MPa}$

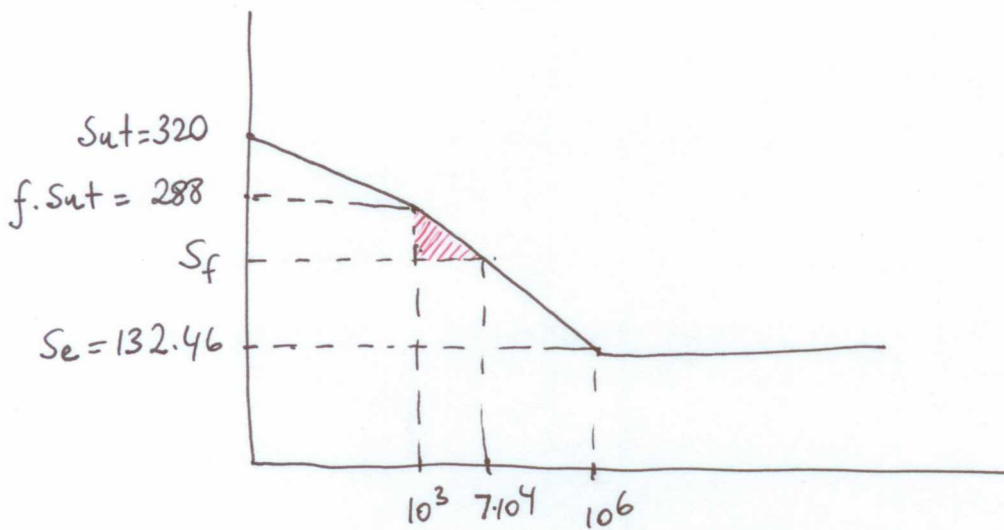
$N = 70000 \text{ cycles} \rightarrow \text{finite life}$

$S_e' = 0.5 S_{ut} = 0.5(320) = 160 \text{ MPa}$  ;  $k_b = 1.24(20)^{-0.107} = 0.8999$

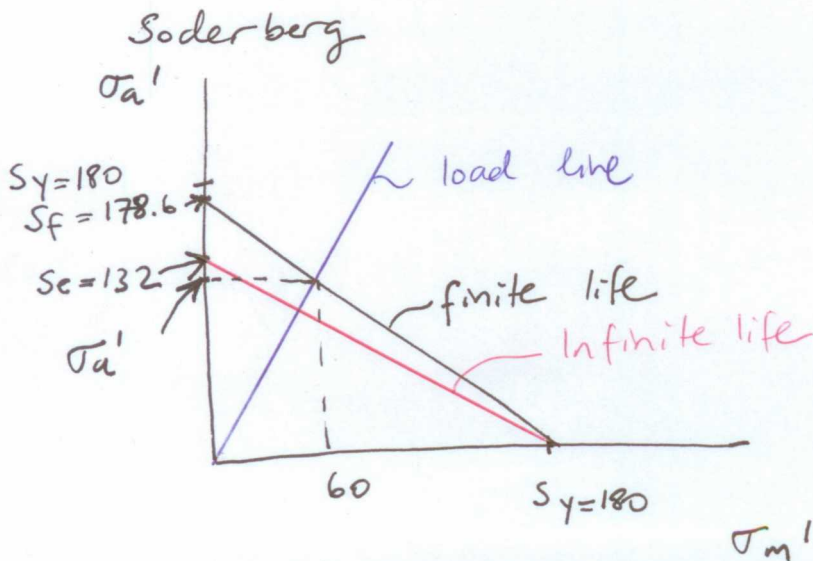
$k_a = 0.92$  ;  $k_b = 0.8999$  ;  $k_c = 1$  ;  $k_e = 1$

$S_e = k_a \cdot k_b \cdot S_e' = (0.92)(0.8999)(160) = 132.46 \text{ MPa}$

$f \cdot S_{ut} = 0.9(320.00) = 288 \text{ MPa}$



$$\frac{\log(7 \times 10^4) - \log 10^3}{\log 10^6 - \log 10^3} = \frac{\log 288 - \log S_f}{\log 288 - \log(132.46)} \Rightarrow S_f = 178.62$$



$$\frac{\sigma_a'}{S_f} + \frac{\sigma_m'}{S_y} = 1$$

$$\sigma_m' = \sqrt{\sigma_m^2 + 3\tau_m^2} = \sigma_m = 60 \text{ MPa}$$

$$\sigma_a' = \left(1 - \frac{\sigma_m'}{S_y}\right) S_f$$

$$\sigma_a' = \left(1 - \frac{60}{180}\right) 178.62$$

$$\sigma_a' = 119.08 \text{ MPa}$$

$$\sigma_a' = \sqrt{\cancel{\sigma_a^2} + 3\tau_a^2} = \sqrt{3} \tau_a$$

$$\tau_a = \frac{\sigma_a'}{\sqrt{3}} = 68.75$$

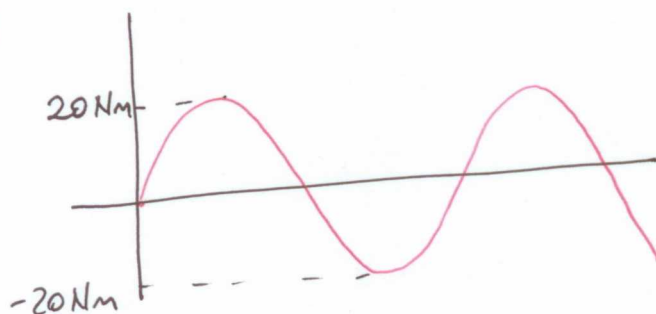
$$\tau_a = K_{fs} \cdot \frac{T \cdot c}{J} = [1 + q_s(K_{ts} - 1)] \cdot \frac{T \cdot (0.01)}{\frac{\pi (0.02)^4}{32}} = 68.75 \text{ MPa}$$

$\swarrow 0.97$        $\swarrow 1.6$

T = 68.3 N.m

 for 70000 cycles.

b.)



$$T_a = 20 \text{ N.m}$$

$$T_m = 0$$

$$\sigma_a = 0$$

$$\sigma_m = 60 \text{ MPa}$$

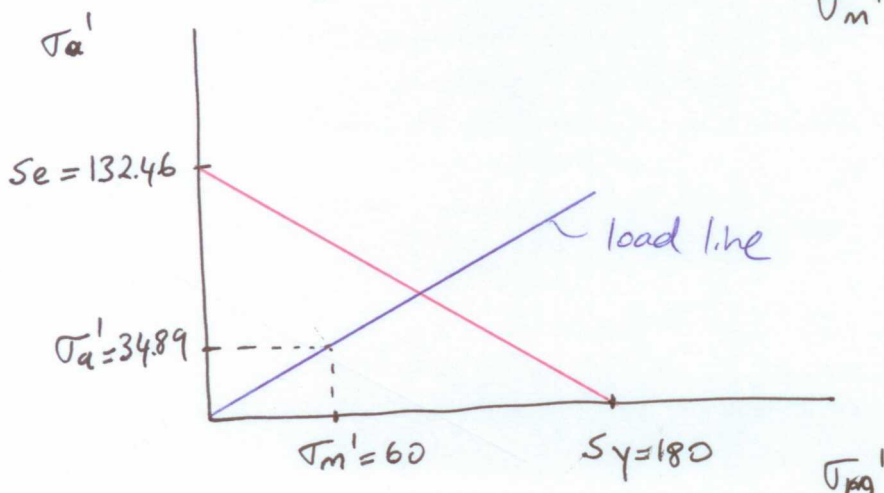
$$\tau_a = K_{fs} \cdot \frac{T \cdot c}{J} = \underbrace{[1 + 0.97(1.6 - 1)]}_{K_{fs} = 1.582} \cdot \frac{20 \cdot (0.01)}{\frac{\pi (0.02)^4}{32}} = 20.14 \text{ MPa}$$

$$\tau_m = 0$$

Soderberg

$$\sigma_a' = \sqrt{\cancel{\sigma_a^2} + 3\tau_a^2} = \sqrt{3} \tau_a = 34.89 \text{ MPa}$$

$$\sigma_m' = \sqrt{\cancel{\sigma_m^2} + 3\tau_m^2} = \sigma_m = 60 \text{ MPa}$$

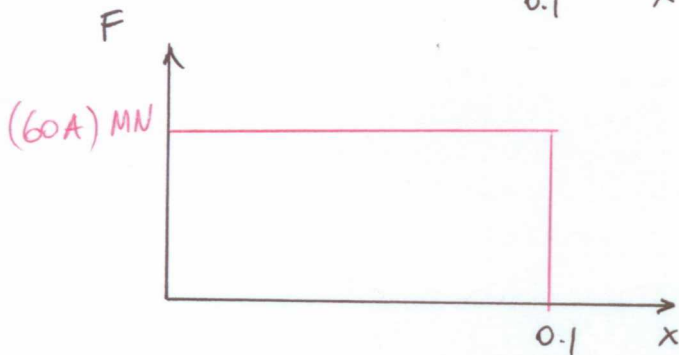
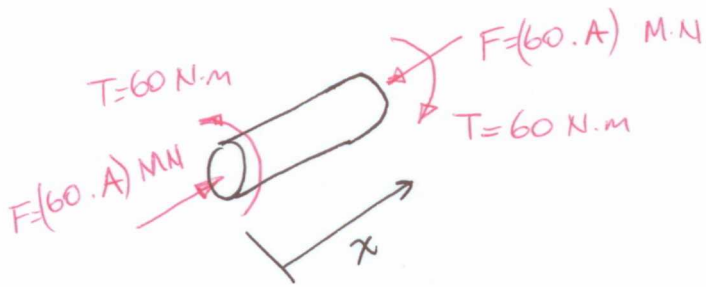


$$\frac{\sigma_a'}{S_e} + \frac{\sigma_m'}{S_y} = \frac{1}{n}$$

$$\frac{34.89}{132.46} + \frac{60}{180} = \frac{1}{n}$$

$$n = 1.676$$

$$3.) \quad U_T = \frac{T^2 L}{2GJ} + \frac{F^2 L}{2EA}$$



$$U_T = \int_0^{0.1} \frac{T^2 dx}{2GJ} + \int_0^{0.1} \frac{F^2 dx}{2EA}$$

$$\delta u_\phi = \frac{\partial U_T}{\partial T} = \int_0^{0.1} \frac{2T dx}{2GJ} = \frac{TL}{GJ}$$

$$\delta u_\phi = \frac{60 \cdot (0.1)}{79.3 \times 10^9 \frac{\pi (0.02)^4}{32}}$$

$$\delta u_\phi = 4.8168 \times 10^{-3} \text{ rad} = 0.276^\circ$$

$$\delta u_F = \frac{\partial U_T}{\partial F} = \int_0^{0.1} \frac{2F dx}{2EA} = \frac{FL}{EA}$$

$$= \frac{60 \cdot 10^6 \pi \cdot (0.01)^2 \cdot (0.1)}{207 \cdot 10^9 \cdot \pi (0.01)^2}$$

$$\delta u_F = 28.98 \times 10^{-6} \text{ m} = 0.0289 \text{ mm}$$

**4. Soru:** (16 puan) 20 mm nominal çap değerine sahip mil ve delik için H7/h6 geçmesi için:

- Delik ve mil için uluslararası tolerans numaralarını yazarak hangi yüzeyin daha kaliteli işlendiğini belirtiniz
- Şekil çizerek mil ve delik için toleransları nominal çap etrafında kutucuklarla gösteriniz.
- Toplam tolerans nedir?
- Geçmenin türü nedir?

$$\text{Tolerans} = i \cdot K \quad i = 0.45 \cdot \sqrt[3]{D} + 0.001D$$

$$K = 10(1.6)^{(IT_n-6)}$$

$$i = 0.45 \sqrt[3]{20} + 0.001(20) = 1.241 \mu\text{m}$$

Hole : H7

$$K = 10(1.6)^{(7-6)} = 16$$

$$T_h = i \cdot K = (1.241 \times 10^{-3})(16) = 19.86 \mu\text{m} = 0.01986 \text{ mm}$$

$$D_{\text{min}} = 20 \text{ mm}$$

$$D_{\text{max}} = 20 + 0.01986 = 20.01986 \text{ mm}$$

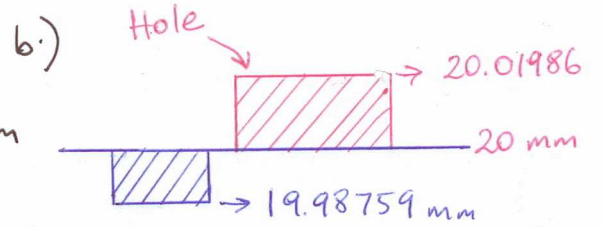
Shaft : h6

$$K = 10(1.6)^{(6-6)} = 10$$

$$T_s = i \cdot K = (1.241)(10) = 12.41 \mu\text{m} = 0.012 \text{ mm}$$

$$d_{\text{max}} = 20 \text{ mm}$$

$$d_{\text{min}} = 20 - 0.01241 \text{ mm} = 19.98759 \text{ mm}$$



a.) hole  $\rightarrow$  H7, shaft  $\rightarrow$  h6  
mil daha kaliteli işlenmiştir.

c.) Toplam tolerans =  $T_f = T_h + T_s = 19.86 + 12.41 = 32.27 \mu\text{m}$

d.) Geçme clearance fit (boşluklu geçme)