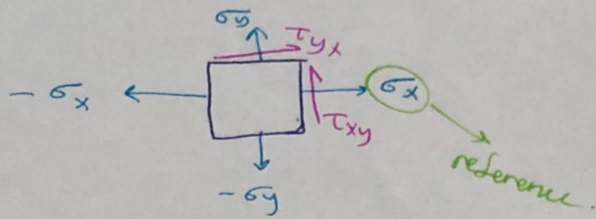
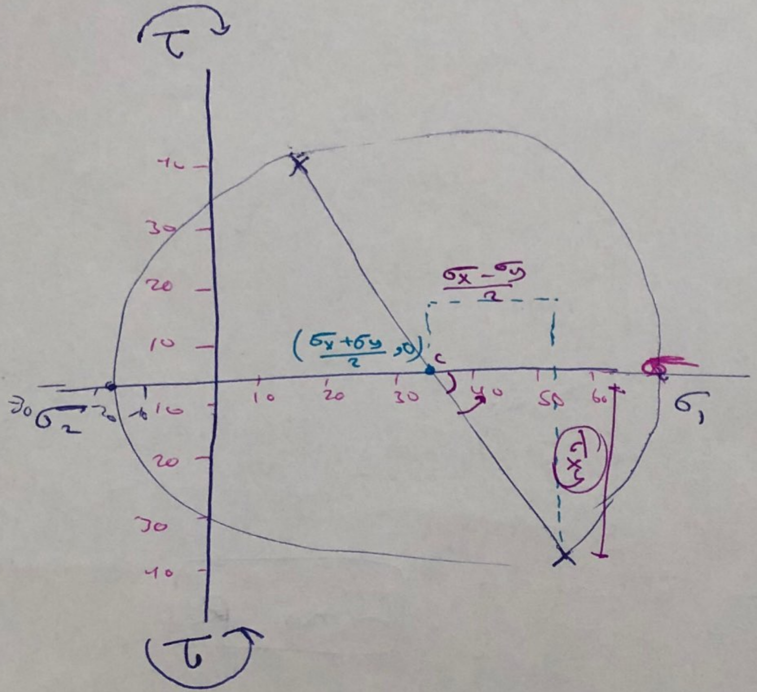
* Mohr circle



$\sigma_y < \sigma_x$

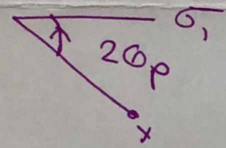


$$C = \frac{\sigma_x + \sigma_y}{2}, 0$$

$$R = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

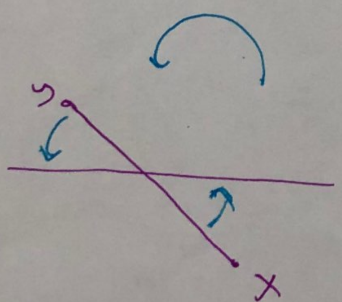
$$\sigma_1 = (C + R)$$

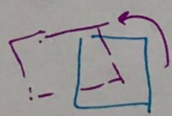
$$\sigma_2 = C - R$$

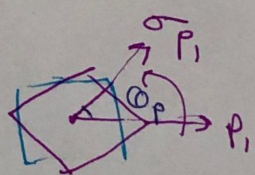


Principle plate oriented

$$\tan 2\theta_p = \frac{\tau_{xy}}{\frac{\sigma_x - \sigma_y}{2}}$$

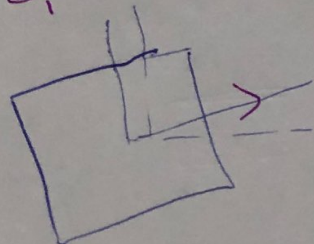






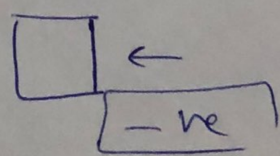
$$\sigma_{ave} = \frac{\sigma_x + \sigma_y}{2}$$

σ_1 or σ_2



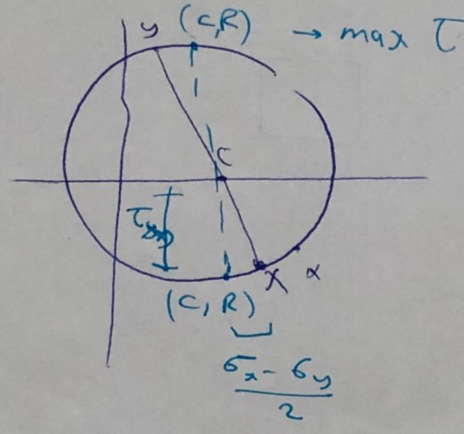
σ_1 or σ_2

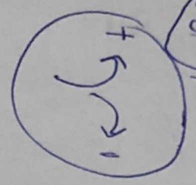
حسب معطيات ، سؤال



تعويض

Scanned with CamScanner

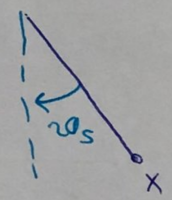


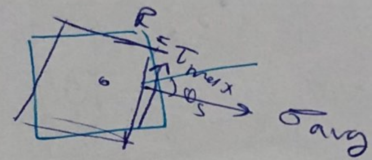


حذرًا اوقع

$$\tan 2\theta_s = \frac{\frac{\sigma_x - \sigma_y}{2}}{-(\tau_{xy})}$$

$$\tau_{max} = R$$





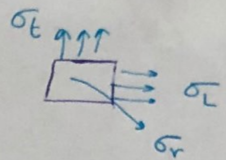
$$\sigma_{avg} = \frac{\sigma_x + \sigma_y}{2}$$

$$\boxed{\tau_{max} = R}$$

اتجاه التشير حسب المعطى بالسؤال اما مش

يضل نفسه.

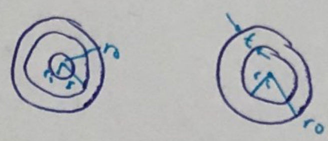
② Presurized Stresses



$\frac{r_i}{t} \geq 10$ thin $\quad r \{ ^{o}_{i}$

$\frac{r_i}{t} < 10$ thick

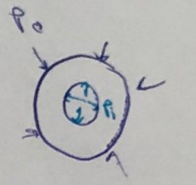
Thick Thin



highest $\sigma = \sigma_{tang}$

$\sigma_t \rightarrow$ thin walls $\rightarrow$ hoop stress

Thick walled pressure vessels



$$\sigma_3 = \sigma_r = \frac{P_i r_i^2 - P_o r_o^2 + r_i^2 r_o^2 (P_o - P_i)/r^2}{r_o^2 - r_i^2}$$

$$\sigma_1 = \sigma_t = \frac{P_i r_i^2 - P_o r_o^2 - r_i^2 r_o^2 (P_o - P_i)/r^2}{r_o^2 - r_i^2}$$

$P_o = 0$

$$\sigma_t = \frac{r_i^2 P_i \left(1 + \frac{r_o^2}{r^2}\right)}{r_o^2 - r_i^2}$$

$$\tau_{max} = \frac{1}{2}(\sigma_t - \sigma_r)$$

$$\sigma_r = \frac{r_i^2 P_i}{r_o^2 + r_i^2} \left(1 - \frac{r_o^2}{r^2}\right)$$

if cylinder is closed

$$\sigma_2 = \sigma_L = \frac{P_i r_i^2 - P_o r_o^2}{r_o^2 - r_i^2}$$

$\downarrow$

cylinder is capped (closed) σ_{tang}

Thin walled pressure vessels $r_i/t > 20$

$\sigma_1 = \sigma_t = \cancel{\frac{P(d_i+t)}{2t}} \rightarrow$ hoop stress

$\rightarrow \frac{P * r_i}{t} = \sigma_t$

$D_i = D_o - 2t$

$\frac{D_i}{2} = r_i$

$\sigma_2 = \sigma_L = \frac{P r_i}{2t}$

$\frac{P(d_i + t)}{2t} = \sigma_{t\,max}$

$\sigma_3 = \sigma_r = 0$

$\tau_{max} = \frac{\sigma_1}{2} = \frac{\sigma_t}{2}$

$\sigma_r = 0$

σ_r max r_o

σ_r min r_i

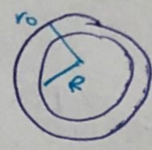
σ_t max r_i

σ_t min r_o

$\boxed{P = Mn/m^2 = MPa}$

③ Press & shrink fits

$$\sigma = P = \frac{\delta E}{R}\left[\frac{(r_o^2 - R^2)(R^2 - r_i^2)}{2R^2(r_o^2 - r_i^2)}\right]$$



stress ↑ pressure ↑ R ↓ inner hub outer shaft

$r_i \to$ shaft Dmax → hole

$r_o \to$ hub Dmin → shaft

$\delta \to$ interference

$\delta_{min} = d_{min} - D_{max} \to P_{min}$ → $(d_{inner} + t_{min}) - (D_{outer} + t_{tolerance\ max})$ shaft r_i, hole r_o

~~δ = tolerance & tolerance~~

$\delta_{max} = d_{max} - D_{min} \to P_{max} \to \dfrac{d_{outer} + t_{max} - (D_{inner} + t)_{min}}{R} = t_{max\ shaft} - t_{min\ hole}$

↑ shaft ↑ hole.

$$\delta_{inner} = -\frac{PR}{E_i}\left[\frac{R^2 + r_i^2}{R^2 - r_i^2} - v_i\right] \to \text{deformation}$$

Change in radians

$$\delta_{outer} = \frac{PR}{E_o}\left[\frac{R^2 + r_o^2}{r_o^2 - R^2} + v_o\right]$$

$\delta = |\delta_{inner}| + |\delta_{outer}| \to$ total radial interference → + total deformation

$F = \mu P \times A = \mu P(2\pi R f t) = (2\pi R P f L)$

friction force

$f_{friction} = \mu P$

stress

$$\sigma_{i\,tang} = \frac{-P(R^2 + r_i^2)}{R^2 - r_i^2} \to \text{tangential @ inner}$$

$$\sigma_{o\,tang} = P\left(\frac{r_o^2 + R^2}{r_o^2 - R^2}\right)$$

$$\varepsilon_{ot} = \frac{\delta_o}{R} = \frac{\sigma_{ot}}{E_o} - \frac{v_o \sigma_{or}}{E_o}$$

(4) Stress concentration

1. I تختلف عن I_{hole}
2. اذا تم وضع F غير عن رسمة الكتاب ← بقلب ال dimentions
3. σ ال بطلعها من الرسمات تكون σ_1, σ_2 ....
   مادام ماخ shear
4. المساحة ← بتقص O

$$k_t = \frac{\sigma_{max}}{\sigma_{avg}}$$

table $\boxed{A-15}$

K_t

$$A = (w - \underset{\text{hole}}{d}) * t$$

$$\sigma_{max_1} = \frac{f}{A} \times K$$

$$\sigma_{max_1} = \frac{Mc}{I_{hole}} \times K \qquad C = \frac{y}{2} \rightarrow \max \sigma$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} \times k$$

$$n = \frac{\sigma_{yield}}{\sigma_{max}} > 1$$

no yield

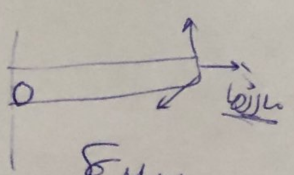
$\boxed{\text{shafts}}$ → $k_t \times$ Previous Answer → M

$k_{ts} \times$ Previous Answer → τ

العصاة k

$$\sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} + \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \cancel{(\tau_{xy})}^2}$$

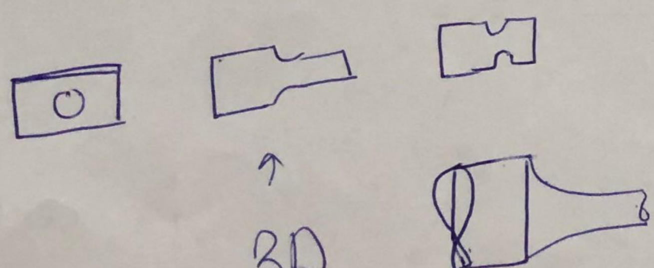
something → zero



$\sigma_M \times k_t$

$\sigma_t \times k_{ts}$

$\sigma_{axial} \times 1$

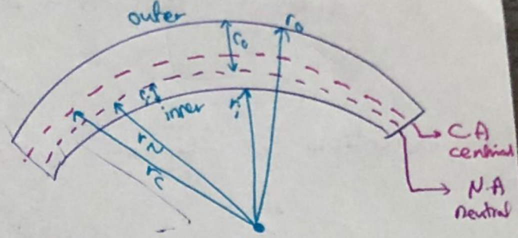


2D

shaft
3D

(4) Curved beams

مش صغيرة.



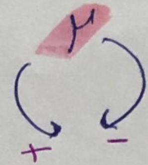
$R = r_c$

$R - r_n = r_c - r_n = e$ (eccentricity)

σ_i = inner

σ_o = outer

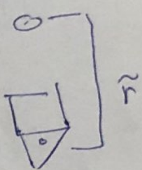
$\sigma = \dfrac{M y}{A_\perp e (r_n - y)}$ → on neutral



بالمتر

(3) $\sigma_i = \pm\dfrac{F}{A_\perp} \mp \dfrac{M c_i}{A_\perp e\, r_i}$ → $y = c_i = r_n - r_i$
$A_\perp \to \Sigma$, r_i → original

(4) $\sigma_o = \mp\dfrac{F}{A_\perp} \mp \dfrac{M c_o}{A_\perp e\, r_o}$ → $y = -c_o = r_n - r_o$
$A_\perp \to \Sigma$, r_o → original



(1) $r_c = \dfrac{\Sigma \tilde{r} A_\perp}{\Sigma A_\perp}$ $\tilde{r} \to$ O & shape centroid.

(2) $r_n = \dfrac{\Sigma A}{\Sigma \int \frac{dA}{r}}$ → Page 135

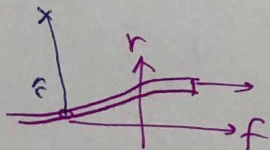
$\boxed{M = F \times (\text{center of the shape and } \cancel{F})}$

* بيشوف القوة عن أي سطح

$\sigma_{outer} + \sigma_{inner} = \dfrac{F}{A}$

صغيرة

estimation:

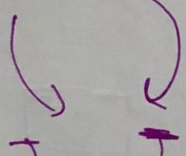


$e = \dfrac{I}{r_c A}$

$\sigma = \pm\dfrac{M y}{I} \dfrac{r_c}{r}$

$M = r \times f$

منه بعرف المسافة



$\sigma_i = \pm\dfrac{M c_i r_c}{I r_i} \pm \dfrac{f}{A}$

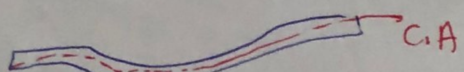
$\sigma_o = \pm\dfrac{M c_o r_c}{I r_o} \pm \dfrac{f}{A}$

صغيرة من الركبة

r = center + f

المسافة

Table A-18



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(1)

Sec 1

$$FOS = \mu_{\text{member}\,(S)} / \mu_{\text{applied}\,\sigma}$$
$$= \sigma_{\text{member}\,(S)} / \sigma_{\text{applied}\,\sigma}$$

deterministic > 1
یعني أكبر

* Table A-10 Z chart *

Table A-25 (μ, σ)

$$\mu_Q = \mu_{(S)} - \mu_\sigma$$

$\boxed{Q = S - \sigma}$

$$\sigma_Q = \sqrt{\sigma_S^2 + \sigma_\sigma^2}$$

$$P(Q=0)\left(z = \frac{Q - \mu_Q}{\sigma_Q}\right)$$ → Prob of failure $P(z)\uparrow$

$1 - P(Q=0)$ → reliability (survival)

$$\begin{bmatrix} \pm\sigma_{xx} & \pm\tau_{xy} & \pm\tau_{xz} \\ \pm\tau_{yx} & \pm\sigma_{yy} & \pm\tau_{yz} \\ \pm\tau_{zx} & \pm\tau_{zy} & \pm\sigma_{zz} \end{bmatrix}$$

$$\sigma_{1,2,3} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$\sigma_{1,2,3} =$ ..

$\sigma_{1,2,3} =$ ..

$\sigma_1 \quad \sigma_2 \quad \sigma_3$

$$\tau_{max} = \pm\left(\frac{\sigma_1 - \sigma_2}{2}\right)$$

2D

$$\sigma^3 - I_1\sigma^2 + I_2\sigma - I_3 = 0$$

$$I_1 = \sigma_x + \sigma_y + \sigma_z$$

$$I_2 = \sigma_x\sigma_y + \sigma_x\sigma_z + \sigma_y\sigma_z - \tau_{xy}^2 - \tau_{xz}^2 - \tau_{yz}^2$$

$$I_3 = \sigma_x\sigma_y\sigma_z + 2\tau_{xy}\tau_{xz}\tau_{yz} - \sigma_x\tau_{yz}^2 - \sigma_y\tau_{xz}^2 - \sigma_z\tau_{xy}^2$$

$\sigma_1 \quad \sigma_2 \quad \sigma_3 \quad \tau_{max} = \dfrac{(\sigma_1 - \sigma_2)}{2}$

3D

Von missesses

$$\tau_{oct} = \frac{1}{3}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$$

$$S_y = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2}$$

$\tau_{oct} > \frac{\sqrt{2}}{3} S_y \quad n < 1$

$\tau_{oct} < \frac{\sqrt{2}}{3} S_y \quad n > 1$

$$\boxed{n = \frac{\sqrt{2}\,S_y}{3\,\tau_{oct}}}$$ Safety factor

$$\sigma_{oct} = \frac{\sigma_1 + \sigma_2 + \sigma_3}{3}$$

* $\boxed{n = \dfrac{S_{y\,\text{given}}}{S_{y\,\text{measured}}}}$ → table A-20

Scanned with CamScanner

Tresca

$$\tau_{max} = \sqrt{\quad} = \frac{1}{2}(\sigma_{max} - \sigma_{min})$$

$$n = \frac{S_y}{2\tau_{max}}$$

Shafts

2

$\sigma_{M\,x,y}$	$\sigma_B = \frac{Mc}{I}$, $c = \frac{d}{2}$	$\sigma = \frac{32M}{\pi d^3} \rightarrow I = \frac{\pi d^4}{64}$, $\frac{Mc}{}$
$\sigma_{A\,x,y}$	$\sigma_A = \frac{F}{Bh}$ $+ -$	$- +$ $\sigma_A = \frac{F}{\frac{\pi}{4}d^2}$
τ_{xy} $_{xz}$	$\frac{Tc}{J}$	$\frac{16T}{\pi d^3} = \frac{T\left(\frac{d}{2}\right)}{\frac{\pi d^4}{32}}$

Table A-18

$F \rightarrow N$, $L = mm$ $\rightarrow$ MPa

$F \rightarrow kN$, $L = m$

ال بتكون ع امتداد الشافت $\leftarrow T$

$T = \frac{P}{\omega} \rightarrow rad$

$\omega = n \times \frac{2\pi}{60}$

$P = 1000\,W$

N.m

Principle stresses

3

$$\sigma_1, \sigma_2 = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xz})^2}$$

$\sigma_y \rightarrow 0$

$$\tau_{max} = \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + (\tau_{xy})^2}$$

$\sigma_y \rightarrow 0$

1

$$M = \vec{r} \times \vec{F}$$

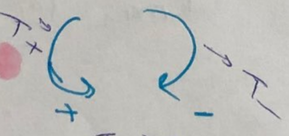
$$\begin{array}{c|ccc|} & \hat{i} & \hat{j} & \hat{k} \\ \text{مسافة} & & & \\ \text{قوة} & \pm & \pm & \pm \end{array}$$

$\hat{i} \rightarrow$ مسافة كل X axis

$\hat{j}$ = " " ل محور y axis

$\hat{k}$ = " " Z axis

لحد القوة عن (0,0,0)



$T \pm ?$

Tresca

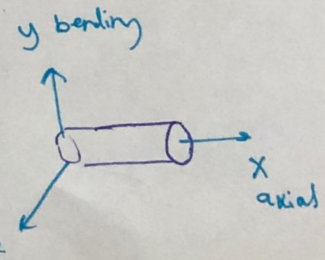
$$n = \frac{\sigma_y}{2\tau_{max}} \rightarrow \text{Table A-20}$$

(المسافة بين النقطة والفورس)

von misses

$$\sigma_e = \frac{1}{\sqrt{2}}\sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}$$

$$n = \frac{S_y}{\sigma_e} \rightarrow \text{Table A-20}$$



$\sigma_x = \sigma_M + \sigma_{axial}$

① Bearings.

Ⓐ Ball bearing ~~[illegible]~~ = 90%. (SKF)

ⓐ $R_{desired} = R_{rated}$

$$F_{desired} \times L_{desired}^{(\frac{1}{a})} = C_{10} \times L_{10}^{1/a}$$

$F_{desired}$ ↓ lb

C_{10} ↓ rated load

L_{10} ↓ rated life $= 10^6$ (SKF)

$a = 3$ → ball bearings

$a = \frac{10}{3}$ → tappered / cylindrical

L10 in hrs → $L_R^h \times n_{rated} \times 60$ → التحويل ال rev

L_R^h ↓ hrs

n_{rated} ↓ rev / min.

$L_{desired} \times n_{desired} \times 60$ → min → rev.

(mm)

C_{10} → table (11-2) page 573 Deep grove

lb x .4448 = mm

فاصلتين حركي.

ⓑ $R_{desired} \neq R_{rated}$

$$C_{10} = af \; F_D \left[\frac{x_D}{x_0 + (\theta - x_0)\left(\ln \frac{1}{R_D}\right)^{1/b}} \right]^{1/a}$$

R_D ↓ rate

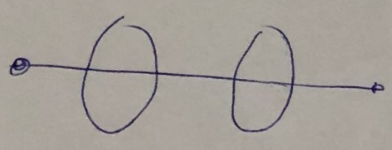
$a = 3$
$b = 1.483$
$L_D = 10^6$
$x_0 = .02$
$\theta - x_0 = 4.439$

Deep grove.

$$x_D = \frac{L_D}{L_R}$$

$(x_0) / (\theta - x_0) / b$ → wiebull dis

table 11-6 page 601



① $T = F \times$ radius

② R biggest

③ Select bearings from the table

Radial forces

outer ring rotating → $V = 1.2$

inner ring rotating → $V = 1$

not mentioned $V = 1$

Solu:

$C_{10} \to C_0$ not given

① $i = 2$ $X_2 = .56$ $Y = 1.63$ 11-1 P 572

② $F_e = X_2 V F_r + Y_2 \times F_a$
(reaction)e radial (N) (given) thrust (N)

2b → choose the reaction which the force is on it

case SJ
$R = .9$
$R \neq .9$

③ $C_{10} = a_f F_e \left[\dfrac{X_D}{x_0 + (\theta - x_0)(\ln(\frac{1}{R}))^{1/b}} \right]^{1/a}$

→ $C \times L^{1/a} = F \times L$

$a = 3$
$b = 1.483$
$x_0 = .02$
$\theta - x_0 = 4.439$
$L_D = 10^6$

④ angular contact (11-2) P 573

⑤ $X_2 =$ ___ $Y_2 =$ ___

diff

biggest reaction	the one who Fa is on it
groove	anguler

F_x → on bearing nothing
→ on beam → moment around Z
M_z

→ قيمة متساوية
الها.

(B) Tappered bearing. — Timken / direct in direct mount

(1) $f_i \Rightarrow$ induced force

$$f_{iA} = \frac{.47\, f_{rA} \rightarrow \text{reaction}}{k_A} \qquad f_{rA} \rightarrow \sqrt{A_y^2 + A_z^2}$$

$$k_A = k_B = 1.5$$

$$f_{iB} = \frac{.47\, f_{rB} \rightarrow \text{reaction}}{k_B}$$

(2) $f_{iA} \leq (f_{iB} + \underbrace{f_{ae}}_{\text{thrust }(x)})$ (الاشارة معها)

$$f_{eA} = .4\, \underbrace{f_{rA}}_{\text{reaction}} + k_A \left(\frac{.47\, f_{rB}}{k_B} + f_{ae} \right)$$

$$f_{eB} = \underbrace{f_{rB}}_{\text{reaction}}$$

الأكبر باخذه

$f_{iA} \geq (f_{iB} + \underbrace{f_{ae}}_{\text{thrust }(x)})$ (الاشارة معها)

$$f_{eB} = .4 f_{rB} + k_B \left(\frac{.47\, f_{rA}}{k_A} - f_{ae} \right)$$

$$f_{eA} = f_{rA}$$

الأكبر باخذه

(3) $$C_{10} \cong f_D \left(\frac{x_D}{x_o + (\theta - x_o)(1 - \underbrace{R_D}_{\text{In}})^{1/b}} \right)^{1/a}$$

$a = 10/3$
$L = 90 \times 10^6$
$x_o = 0$
$\theta = 4.48$
$b = 1.5$

(4) table. 11-15 586 page

11-16 587

اذا كان الفرق 100 واقل عن رقم بالجدول بوقف حل

1. $R = ?$
2. cos / sin
3. $\boxed{r} \times F \rightarrow r$?
4. [illegible]
5. Fe
6. groove / angular
7. F_a / co

ACME threads

$$T_R = \left(\frac{f\,d_m}{2} \left(\frac{l + \pi f d_m \sec\alpha}{\pi d_m - f L \sec\alpha} \right) \right) \qquad \alpha = \frac{29}{2}$$

page 414

$$T_L = \left(\frac{f\,d_m}{2} \left(\frac{\pi f d_m - l}{\pi d_m + f_L} \right) + \frac{f f_c d_c}{2} \right)$$

$d_m = d_{major} - \frac{P}{2}$

+ collar friction $\qquad d_m = d_{major} - \frac{P}{2}$

$$T_c = \frac{f f_c d_c}{2}$$

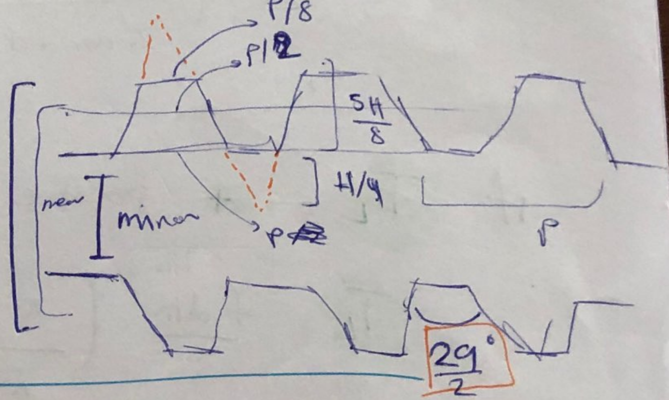
414

$$T_R = \frac{f\,d_m}{2} \left(\frac{L + \pi f d_m \sec\alpha\left(\frac{29}{2}\right)}{\pi d_m - f l \sec\alpha\left(\frac{29}{2}\right)} \right) + \frac{f f_c d_c}{2}$$

$V_{head} = N_{screws} \times P$

$d_r = d_{major} - \frac{P}{4}$

$d_m = d_{major} - \frac{P}{2}$



$\frac{5}{8}$ - 18 UNF → fine / coarse

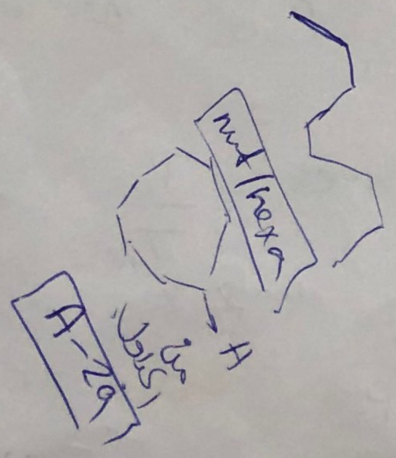
$\frac{5}{8} \to d_{major}$, $18 \to N$, $P = \frac{1}{N}$

$$T = \frac{Power}{2\pi \times n}$$

$n \to$ rev/sec

M10 X 12

M10 → d_{major}, 12 → pitch



$H = \frac{\sqrt{3}}{2} P$

Squre threads

width $=\frac{\text{Pitch}}{2}=\frac{P}{2}=$ depth

$d_{mean}=\frac{d_{major}+d_{minor}}{2}$ $\qquad d_{minor}=d_{major}-P$

$$P_R=\frac{F\left(\frac{L}{\pi d_m}+f\right)}{1-(fL/\pi d_m)}$$

$L=P=$ Pitch

$\tan\lambda=\frac{L}{\pi d_m}$

$$P_L=\frac{F\left(f-\left(\frac{L}{\pi d_m}\right)\right)}{1+(fL/\pi d_m)}$$

$L=NP$

$$T_R=\frac{F\,d_m}{2}\left(\frac{L+\pi f d_m}{\pi d_m-fL}\right)+\boxed{\frac{F f_c d_c}{2}}$$

$L=NP$

$$T_L=\frac{F\,d_m}{2}\left(\frac{\pi f d_m-L}{\pi d_m+fL}\right)+\boxed{\frac{F f_c d_c}{2}}$$

if $T_L\rightarrow +$ positive. $\quad \pi f d_m > L$

$$T_L=\frac{f\,d_m}{2}\left(\frac{\pi f d_m-L}{\pi d_m+fL}\right)$$

$L=NP$

$L=NP$

$$T_o=\frac{FL}{2\pi}\qquad f=0\quad\text{no friction losses}$$

$L=NP$

$$\text{effeciency}=e=\frac{T_o}{T_R}=\frac{FL}{2\pi T_R}$$

$m\times sec^2$

Power $=\frac{T*n}{63025}$ $\qquad n=\frac{V}{L}\times 60\rightarrow$ rev/min $\qquad$ rev/sec $\rightarrow\times 2\pi$

$d_r=d_{major}-P$ $\qquad d_m=d_{major}-\frac{P}{2}$

Stresses in body of Power screws

① $\tau = \frac{Tc}{J} = \frac{16 T_R}{\pi d_r^3}$ Torsion

② $\sigma = \frac{P}{A}$ Axial stress normal compressive

$A = \frac{\pi d_r^2}{4}$

$\sigma = \frac{4F}{\pi d_r^2}$

③ $\sigma_B = \frac{-2F}{\pi d_m n_t P}$ Bearing (~~Bending~~) stress @ the interface of the nut & the bolt.

→ $N = \frac{\text{tickness}}{\text{Pitch}}$ num of threads in contact

④ Area contact btw nuts & bolts $= \frac{\pi d_m P n_t}{2}$

⑤ Bending stress @ root of the thread. σ_x

$\sigma_b = \frac{Mc}{I} = \frac{6F}{\pi d_r n_t P}$ max * .38

$$\boxed{n = \frac{S_y}{\sigma'_{\text{von misses}}}}$$

⑥ σ_x / root Bending $= \frac{6 F_{\text{dam}}}{\pi d_r n_t P}$ $\tau_{xy} = 0$ → Bending in root of thread.

↳ given / also

$\sigma_y = \frac{-4 F_{\text{dam}}}{\pi d_r^2}$ $\tau_{yz} = \frac{16T}{\pi d_r^3}$

axial normal   shear

$\sigma_z = 0$ $\tau_{zx} = 0$

stresses in screw threads

$d_r = d_{maj} - P$

⑦ von misses $d_r = d_{maj} - \frac{P}{4}$ $d_m = d_{maj} - \frac{P}{2}$

$$\sigma' = \frac{1}{\sqrt{2}}\left((\sigma_x - \sigma_y)^2 + (\sigma_y - \sigma_z)^2 + (\sigma_z - \sigma_x)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)\right)^{1/2}$$

max shear stress = $\tau_{max} = \left(\frac{\sigma_1 - \sigma_2}{2}\right)$ $\sigma_1 = \sigma_x$ $\sigma_2 =$

$\sigma_2, \sigma_1 = \frac{\cancel{\sigma_x} + \sigma_y}{2} \pm \sqrt{\left(\frac{\cancel{\sigma_x} - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$ max

~~Joint Stiffness~~

$F_{bolt} = P_b + F_i$ → tension

$F_{m_{member}} = P_m - F_i$

~~F_{bolt}~~ $C = \frac{P_b}{P \text{ (external load)}}$ → fraction of external load by bolt

$(1-C)$ → fraction of external load by member

fraction

$C = \frac{P_b}{P} = \frac{k_b}{k_m + k_b}$ $k_m + k_b$ → joint stiffness

$F_b = \cancel{CP} + F_i$ resultant load

$F_m = (1-C)P - F_i$

F_i = Preload $\begin{cases} .75\,F_p & \text{nonpermanent connection} \\ .9\,F_p & \text{permanent conection} \end{cases}$

$P = P_m + P_b$ → Portion

A_t → table 8-1 / 8-2

$A_d = \frac{\pi \times d_{major}^2}{4}$

$F_p = S_p A_t$

l = given → 2x plates

$l_d = L - L_{two}$

bolt stiffness

$k_b = \frac{A_d A_t E}{A_d L_t + A_t l_d}$

~~l_d~~

bolt length $L = l + H + 2P$

$E = 207$ ↳ table A-31

member stiffness

$k_m = \frac{.5774 \pi E\, d_{major}}{2 \ln\left(5 \times \frac{.5774\, l + .5\, d_{major}}{.5774\, l + 2.5\, d_{major}}\right)}$

UNF-30

$L_T =$ UNF $\begin{cases} 2d + \frac{1}{4} \text{ in} & L \leq 6 \\ 2d + \frac{1}{2} \text{ in} & L > 6 \end{cases}$

$\sigma_{b(i)} = \frac{F_i}{A_t}$ → (A-2) Preload stress

$\sigma_{b(i)} = \frac{F_b}{A_t} = \frac{CP + F_i}{A_t}$ → service load stress

$L_T =$ Metric $\begin{cases} 2d + 6 & L \leq 125 \\ 2d + 12 & 125 < L \leq 200 \\ 2d + 25 & L > 200 \end{cases}$

Shear joints loaded by other forces & moments

$\bar{x} = \bar{y} = \frac{A_A X_A + A_B X_B -}{\Sigma A}$

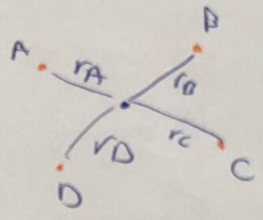
① G $(\bar{x}, \bar{y})$

② $F \longrightarrow \longrightarrow \longrightarrow G$

$\mu = \bar{R} \times \vec{F}$

③ $F_n' = \frac{V}{n}$ → # of bolts

④ $F_n'' = \frac{\mu\, r_n}{r^2_A + r^2_B + r^2_C}$ → $\boxed{F_n'' \perp r_n}$



$+ r_n = C_x$

⑤ $F_{Resultant} = \left\| \vec{F_n'} + \vec{F_n''} \right\|$

⑥ ⓐ $F_R = \sqrt{(F_n')^2 + (F_n'')^2 + 2F_n' F_n'' \cos\theta}$

ⓑ $F_R = F_n' \pm F_n''$

⑦ highest F_R

⑧ $\tau_{max} = \frac{F_R}{Area}$

area $= \frac{\pi d_{root}^2}{4}$ if the thread portion passes through shear interface

area $= \frac{\pi d_{major}^2}{4}$ assume bolt threads do not extend in joints

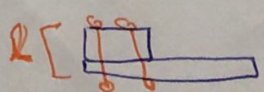
$d_{root} = d_{major} - P$

$l_d = L - L_t < \frac{l}{2}$

$L = H + l + 2P$

b

A - 31.



FOS

(n) shear of bolts

$$\tau_{max} = \frac{f}{\frac{\pi}{4} d^2 \times n}$$

— UN

UN $\boxed{8-9}$ Mehid $\boxed{8-11}$ $\leftarrow \frac{Sy \times .577}{\tau_{max}}$

(n) bearing on bolt.

$A_{bearing} = d_{major} \times$ thickness smaller $\times n$

↑ bolts

$$\sigma_{bearing} = -\frac{F_{max}/n}{A_{bearing}}$$

$$n = \frac{Sy}{\sigma_{bearing}} \longrightarrow \begin{matrix} 8-9 \\ 8-11 \end{matrix}$$

(n) bearing on member

$A_{bearing} = d_{major} \times$ thickness smallest

$$\sigma_{bearing} = \frac{-f_{max}}{A_{bearing}}$$

$$n = \frac{Sy}{\sigma_{bearing}} \rightarrow \text{table A-20}$$

(n) bending safety factor (strength of member)

d — kN

$$\sigma = \frac{Mc}{I} \quad c = \frac{h}{2}$$

critical bending

$$I = I_{bar} - 2(I_{holes} + d^2 A)$$

$$I_{bar} = \frac{bh^3}{12}$$

h

b

$$n = \frac{Sy}{\sigma} \rightarrow \text{table A-20}$$

$$I_{hole} = \frac{b \times d^3_{major}}{12}$$

$\sqrt{x^2+y^2}$ Distance d = y between G and bolt

$$A = b \times d_{major}$$

Tension member

$At = (b - d_{major}) \times$ thickness

b

$$\sigma = \frac{f}{A}$$

$$n = \frac{Sy}{\sigma} \rightarrow A\text{-}20$$

Fatigue

Kpsi × 6895 = MPa

① Find UTS S_{ut} table A-20

② S_e' =
$$\begin{cases} .5\, S_{ut} & S_{ut} \le 200 \text{ kpsi} \\ & \le 1400 \text{ MPa} \\ \hline 100 \text{ kpsi} & S_{ut} > 200 \text{ kpsi} \\ 700 \text{ MPa} & S_{ut} > 1400 \text{ MPa} \end{cases}$$

experemental endurance limit

③ $S_e = k_a k_b k_c k_e k_D k_f \times S_e'$ (endurance limit)

* k_a : surface condition modification factor

$k_a: a\, S_{ut}^{b}$ a/b → table $\boxed{6-2}$ Page 296

* k_b = size modification factor

لو السؤال ما أعطى الحالة [illegible]

→ ① circular cross sec ⊥
→ ② Rotating part (shaft)

] → ✓ $d = d_{actual}$

③ axial $k_b = 1$ k_b → table page 296

$k_c = 1$

if ① Circular ⊥ ✗ ② Rotating ✗

↪ $d = d_{effective}$ $\boxed{\text{table 6-3} \quad p\ 298}$

$.37\, d$

* k_c = load modification factor

$$k_c = \begin{cases} 1 & \text{bending} \\ .85 & \text{axial} \\ .59 & \text{torsion} \\ 1 & \text{combined loading} \end{cases}$$

* k_d = temperature modification factor

$$k_d = .9887 + .6507 \times 10^{-3} \times T_{\boxed{C}} - .3414 \times 10^{-5}\, T_{\boxed{C}}^{2} + .5621 \times 10^{-8} \times T_{\boxed{C}}^{3} - 6.426 \times 10^{-12}\, T_{\boxed{C}}^{4}$$

$\boxed{T_c = S_e T}$

$37 \le T_c \le 540$

* k_e = Releability mf $\boxed{\text{table 6-5} \quad \text{page } 301}$

* k_f → miscellaneous effect modification factor

given in the Q

④ if failure occurs

S_F = failure strength $\Rightarrow aN^b$
endurace strength

N ↓ ** num of cycles (life cycles)

AD

6-10
P 293

$$a = \frac{(f\,S_{ut})^2}{Se}$$

P 293

$$b = -\frac{1}{3}\log\left(\frac{f\,S_{ut}}{Se}\right)$$

6.89 KPSI = Mpa

$S_{ut} > 200$
$f = .77$

$$N = \left(\frac{\sigma_{rev}}{a}\right)^{1/b}$$

$\sigma_{max} = \sigma_{rev} = \boxed{S_f = S_{amp}}$ → completely totaly reversal

$k_f \times \sigma_{nom}$ reversal max

⑤ Notch (discontinuity)

normal σ → $K_f = 1 + q\,(k_t - 1)$ → A-15 أخر الكتاب

q ↓ fig 6-20 P 303

shear σ $k_{fs} = 1 + q_s(k_{ts} - 1)$ → A-15

q_s ↓ fig 6-21 P 304

q: notch sensitivity factor

k_f → fatigue stress factor

⑥ $\sigma_{max_{rev}} = k_f\,\sigma_{nom_{rev}} = k_f \times \frac{F_{max}}{(w-t)h}$

σ_{nom} → A-15

$S_{ut} = 3.4\,H_B$

⑦ $n = \frac{Se_{calc}}{\sigma_{max_{rev}}}$

* Fatigue Factor of Safety *

(7) $\sigma_{mean} = \dfrac{\sigma_{max} + \sigma_{min}}{2} = 0$ if completly reversal sinsoudid

a xial

$$\boxed{\sigma_{mo} = \sigma_{ao} = \frac{4F_m}{\pi d^2}}$$

$\sigma_{max} = \sigma_{mo} \times k_f$

$\sigma_{amp} = \dfrac{\sigma_{max} - \sigma_{min}}{2}$

$\sigma_{max} = k_f \dfrac{F_{max}}{(w-d)t}$ $\quad \sigma_{min} = k_f \dfrac{F_{min}}{(w-d)t}$.

(8) Check for yeilding

$\sigma_a + \sigma_m \geq S_y$ $\quad$ if yes $\rightarrow$ failure stop solving.

$\tau_a + \tau_m \geq .577\ S_y$

(9) Use Criteria.

$\dfrac{\sigma_{amp}}{S_e} + \dfrac{\sigma_{mean}}{S_y} = \dfrac{1}{n_f}$ Soderburg

$\dfrac{\sigma_{amp}}{S_e} + \dfrac{\sigma_{mean}}{S_{ut}} = \dfrac{1}{n_f}$ mod-goodman

$\dfrac{n_f \sigma_{amp}}{S_e} + \left(\dfrac{n_f \sigma_{mean}}{S_{ut}}\right)^2 = 1$ Gerbor

$\left(\dfrac{\sigma_{am}}{S_e}\right)^2 + \left(\dfrac{\sigma_{mean}}{S_y}\right)^2 = \dfrac{1}{n_f^2}$ ASME -elliptic

$n_f > 1$ safe تعاكة

$n_f = 1$ ساكة

$n_f < 1$ failure موقت اركم.

$\dfrac{\pi d^2}{4} \Rightarrow$ مساحة (1)

(10) if not safe

use S_e if $\sigma_m = 0$
use S_f if $\sigma_m \neq 0$

$$S_f = a N^b$$

$$a = \frac{(f\ S_{ut})^2}{S_e \text{ or } S_f} \quad A\text{-}20 \qquad b = -\frac{1}{3} \log\left(\frac{f\ S_{ut}}{S_e \text{ or } S_f}\right)$$

page 293

* stress range $= \Delta\sigma = \sigma_{max} - \sigma_{min}$

* load ratio $\Rightarrow R = \frac{\sigma_{min}}{\sigma_{max}}$

let $S_a = S_f$

$n_f = 1$

(9) تعويض غير رقم

$$\tau_{max} = k_{f_s} \frac{16\ T_{max}}{\pi d^3}$$

ch 7 designing shafts

1. reactions

2. moment $\sqrt{x^2+y^2}$

3. @ which point M is the max $\Rightarrow T = F * R$ cos sin

↳ shoulder / keyseat ?

4. S_{ut} S_y ⇒ A-20

5. S_e'

6. $S_e = k_a k_b k_c S_e'$

$k_a = a S_{ut}^b$ → page 296

⇒ *0

$k_b = .9$

$k_c = 1$

7. $k_f = k_t$] → table 7-1 page 365

$k_{fs} = k_{ts}$

8. $$d = \left(\frac{16n}{\pi} \left(\frac{1}{S_e \times 10^6} \left[4 (k_f M_a)^2 \right]^{\frac{1}{2}} + \frac{1}{S_{ut} \times 10^6} \left[3 (k_{fs} * T_m)^2 \right]^{\frac{1}{2}} \right) \right)^{1/3}$$

N.m N.m

$$n = \left(\frac{16}{\pi d^3} \left(\frac{1}{S_e \times 10^6} \left[4 (k_f M_a)^2 \right]^{1/2} + \left(\frac{1}{S_{ut} \times 10^6} \left[3 (k_{fs} * T_m)^2 \right]^{1/2} \right) \right) \right)^{-1}$$

9. $d = ? \times 10^3$

↳ $k_b = ?$ → 296

↳ $S_e = ?$

↳ $\frac{r}{d} = ?$ → table 7-1

↳ $r = d * ?$ → page 303

↳ $q = ?$ $q_s = ?$ → $\boxed{d \text{ new}}$ → $\boxed{\text{Se same stop !!!}}$

↳ k_f k_{fs} $k_f = q(k_t - 1) + 1$ k_t → Table 7-1