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Design of Machine-Elements-Lab-~~10~~ 8:

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B22ME055

* **Calculations:**

Given: $P = 720N$ $W = 100KN$

$h_{max} = 0.5m = 500mm$

$S_b = 10 N/mm^2$ $\mu = 0.18$

Considering F.O.S. to be $\boxed{5}$.

Step 1: Calculate the core-diameter (d_c)

Steel → $S_{yt} = 400$ $E = 207000 N/mm^2$

$\sigma_c = \frac{S_{yt}}{FOS}$

$= \frac{400}{5} = 80$.

$W = \sigma_c \times \pi/4 \times d_c^2$

$\therefore d_c = \sqrt{\frac{4W}{\sigma_c \times \pi}}$

$\therefore d_c = \sqrt{\frac{4 \times 1000 \times 10^3}{80 \times \pi}} = 40mm$ (before-threading)

For Safe-Design:

$d = 60m$, $p = 8mm$
(after-threading)

Step 2. Checking for combined torsion, compression and bending.

$d_m = \frac{1}{2}[d + d_c] = d - 0.5p$

$\therefore d_m = 60 - 0.5 \times 8 = 60 - 4 = 56$

$$\boxed{\tan\alpha = \frac{l}{\pi d_m}}$$

Helix Angle: $\boxed{\alpha = \tan^{-1}\left(\frac{l}{\pi d_m}\right)}$

$\alpha = \tan^{-1}\left(\frac{8}{\pi \times 56}\right) \Rightarrow \boxed{\alpha = 2.60}$

Also, $\mu = \tan\phi \Rightarrow \phi = \tan^{-1}(\mu) = \tan^{-1}(0.18)$

$\therefore \boxed{\phi = 10.20}$

Torque required to rotate the screw

$M_t = \frac{W d_m}{2} \tan(\phi + \alpha)$

$\therefore M_t = \frac{100 \times 10^3 \times 56}{2} \tan[10.2 + 2.60]$

$M_t = 6.36 \times 10^5$ Nmm

$\boxed{d_c = d - p}$ $\quad d_c = 60 - 8 = 52$ mm.

$\Rightarrow \boxed{d_c = 52 \text{ mm}}$

Shear-stress $\Rightarrow \boxed{\tau = \frac{16 M_t}{\pi d_c^3}}$

$\tau = \frac{16 \times 6.36 \times 10^5}{\pi \times 52^3} = \boxed{23.03 \text{ N/mm}^2}$

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$\sigma_b = \frac{32 M_b}{\pi d_c^3}$ $M_b = P l_1$ $l_1 \to$ maxlift + H + clearance

Axial-length of nut $\boxed{H = 2p}$ (p = pitch)

No. of threads,

$$z = \frac{4W}{\pi S_b (d^2 - d_c^2)}$$

$$z = \frac{4 \times 100 \times 10^3}{\pi \times 16 \times (60^2 - 52^2)}$$

$H = 15 \times 8 = 120 mm$. $\boxed{H = 120 mm}$

max-lift $= h \times 1000$
$= 0.5 \times 1000 = 500 mm$

$M_b = 720 \times [500 + 120 + 120]$ $\boxed{c = 20 mm}$

$M_b = 460800$

$$\sigma_b = \frac{32 \times 4.6 \times 10^5}{\pi \times (52)^3}$$

$$\Rightarrow \boxed{\sigma_b = 33.38\ N/mm^2}$$

$\Rightarrow$ Max. shear stress $\tau_{max} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau^2}$

$$\tau_{max} = \sqrt{\left(\frac{33.38}{2}\right)^2 + (25.03)^2}$$

$$\Rightarrow \tau_{max} = \sqrt{808.937} \Rightarrow \boxed{\tau_{max} = 28.46 N/mm^2}$$

$$\therefore FOS_{combined} = \frac{0.5 \times S_{yt}}{\tau_{max}} = \boxed{7.02}.$$

$\therefore$ As (combined) fos > (normal) fos.

→ We can consider this design to be safe.

Step 3: Check for buckling.

$l \rightarrow$ length of coulmn $= h_{max} = 500mm$.

$$K = \sqrt{\frac{I}{A}} = \sqrt{\frac{\pi \times dc^4/64}{\pi \times \left(\frac{dc}{2}\right)^2}} = \sqrt{\frac{dc^2}{16}}$$

$= 13$

$$\lambda = \frac{l}{K} \qquad \lambda = \frac{500}{13} = 38.45.$$

critical slenderness ratio.

$$\boxed{n = 0.25} \qquad \boxed{\frac{S_{yt}}{2} = \frac{n\pi^2 E}{(l/K)^2}}$$

$$\frac{S_{yt}}{2} = \frac{n\pi^2 E}{(l/K)^2} \qquad \frac{l}{K} = \sqrt{\frac{2 \times n \times \pi^2 \times E}{S_{yt}}}$$

$$\frac{l}{K} = \sqrt{\frac{2 \times 0.25 \times \pi^2 \times 207000}{400}}$$

$$\boxed{\frac{l}{k} = 50.53}$$

λ < critical ratio

36.4 < 50.5

$\therefore$ Use Johson's equation:

$$P_{cr} = S_{yt} A \left[1 - \frac{S_{yt}}{4n \times \pi^2 \times E} \left(\frac{l}{k}\right)^2 \right]$$

$\left[\frac{l}{k} = d\right]$

$$P_{cr} = 400 \times \pi \times \left(\frac{56}{2}\right)^2$$

$$\left[1 - \frac{400}{4 \times 0.25 \times \pi^2 \times 207000} \times (50.53)^2 \right]$$

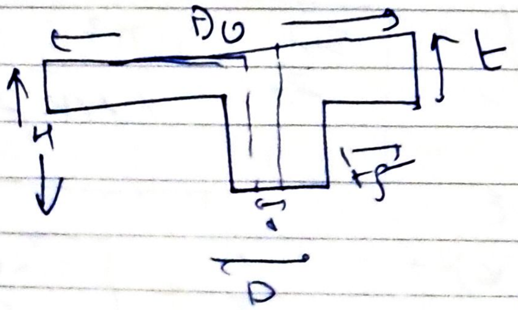
$$\boxed{P_{cr} = 699882.02}$$

$$\boxed{\Rightarrow (F.O.S.)_{Buckling} = \frac{P_{cr}}{W}}$$

$$(F.O.S.)_{buckling} = \frac{6.99 \times 10^5}{100 \times 10^5}$$

$= 0.03.$

Step 4: Design of Nut:



$$\boxed{\sigma_t = 190 \text{ N/mm}^2}$$

$$\boxed{H = 120 \text{ mm}}$$

$\Rightarrow \boxed{Z = 15}$

Outer nut diameter $W = \frac{\pi}{4}(D^2 - d^2)\sigma_t$.

$$D = \sqrt{\frac{4W + \pi \sigma_t \times d^2}{\pi \times \sigma_t}}$$

$$\boxed{D = 65.34mm}$$

height/thickness of the nut collar.

$W = \pi D t \tau$ $t = \frac{W}{\pi D \tau}$.

$$t = \frac{100 \times 10^3}{\pi \times 65.34 \times 95}$$

$\tau = 0.5\sigma_t$

$\tau = 0.5 \times 190$

$$\boxed{t = 5.12mm}$$

$\tau = 95 N/mm^2$

outer-diameter of the collar.

$W = \frac{\pi}{4}(D_o^2 - D^2)\sigma_c$.

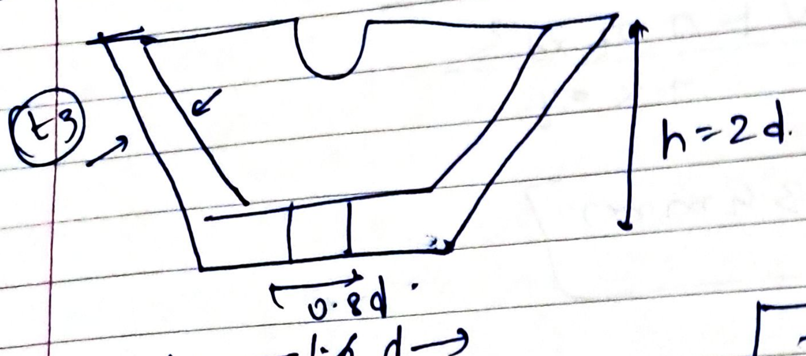
$$D_o = \sqrt{\frac{4W + \pi D^2 \sigma_c}{\pi \sigma_c}} \quad \{ \sigma_c = 2\sigma_t \}.$$

$$D_o = \sqrt{\frac{4 \times 100 \times 10^3 + \pi \times 65.34^2 \times 2 \times 190}{\pi \times 2 \times 190}}.$$

$$\boxed{D_o = 67.86}$$

→

(5) Design of Handle:



length of the handle

$pl_h = M_t +$
$\mu_c \frac{W}{4} [D_o + D_i]$.

$\boxed{\mu_c = 0.2}$

D_o = ~~outsi~~ outer dia $D_i \rightarrow$ inner dia.

$D_i = 0.8 \times d = 0.8 \times 60 = 48mm.$

$D_{outer} = 1.6 \times d = 1.6 \times 60 = 96mm.$

$l_h = \frac{M_t}{P} = \frac{6.36 \times 10^5}{720} = \underline{884.07mm}$

$\therefore d_{handle} = \frac{1}{3}\sqrt{\frac{32 \times 4.6 \times 10^7}{33.38}}$ $\sigma_b = \frac{32 M_b}{\pi d_h^3}$

$\boxed{d_h = 23mm}$

Cup-Design: $t_3 = 2 \times t$ [t = thickness of nut collar].

$t_3 = 2 \times 5.12$

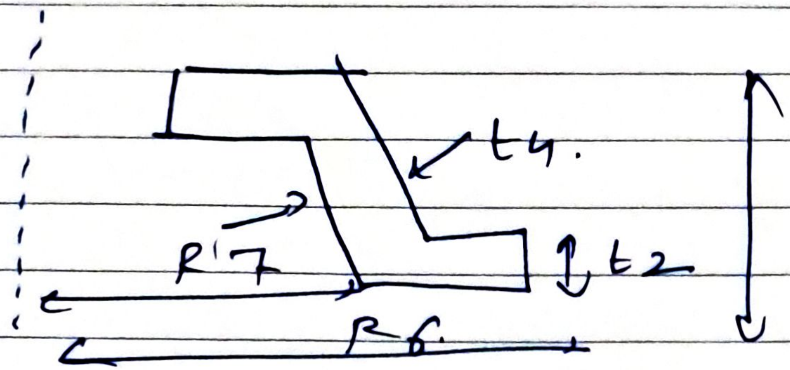
$\boxed{t_3 = 10.25}$

$h_{cup} = 2 \times d$ (height of cup):

$= 2 \times 60$

$= 120mm.$

(6) Design of base:



base out radius

$R_5 = 1.5 \times D_{outer} = 72mm$

Base-bottom radius $R_6 = 2.25 \times \frac{D_{outer}}{2}$

$= 108mm.$

$t_2 = 0.25 \times d = \boxed{15mm}$

$\boxed{t_4 = t}$ $\boxed{t_4 = 5.12mm}$

$H'_{prime} = H' = h_{max} + H + L = 500 + 120 + 20$

$h' = 640mm$ (including clearance):