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LAB - 8 (Screw Jack)

Step 1 : Calculate the core diameter

$$W = \sigma_c \frac{\pi}{4} d_c^2$$

Material for screw : [Steel 30C8]

$S_{yt} = 400 \ N/mm^2$

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

W = 100 KN

Assume FOS = 2

$\sigma_c = 200 \ N/mm^2$

$$100 \times 1000 = 200 \times \frac{\pi}{4} (d_c)^2$$

$$d_c = \sqrt{\frac{4 \times \cancel{100}^{2} \times 1000}{\cancel{200} \times \pi}}$$

$$d_c = 25.23772326 \ mm$$

$$\Rightarrow \boxed{d_c \simeq 25.24 \ mm}$$

(pitch = 5mm)

$\therefore \boxed{d = 30.24 \ mm}$ $\boxed{d_m = 27.74m}$

Step 2 : Check for combined torsion, compression, & bending.

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

$$M_t = \frac{100 \times 1000 \times 27.74}{2} \times \tan(10.2 + 3.285)$$

$\mu = 0.18$

$\tan(\phi) = 0.18$

$\boxed{\phi = 10.2^\circ}$

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

$\tan\alpha = \frac{5}{3.14 \times 27.74}$

$\tan\alpha = 0.0574$

$\alpha = \tan^{-1}(0.0574)$

$\boxed{\alpha = 3.285^\circ}$

$$M_t = 50 \times 1000 \times 27.74 \times \tan(13.485)$$

$$M_t = 332,605.218 \text{ N·mm}$$

$$\boxed{M_t = 332.6 \text{ KN·mm}}$$

(shear stress) $\tau = \dfrac{16 M_t}{\pi d_c^3} = \dfrac{16 \times (332,605.218)}{3.14 \times (25.24)^3}$

$$\boxed{\tau = 105 \text{ N/mm}^2}$$

(bending stress) $\sigma_b = \dfrac{32 M_b}{\pi d_c^3}$

$$M_b = P l_1$$

$P = \cancel{\ } \; 720 \text{ N}$

$M_b = 720 \times 750 =$

$M_b = 540 \text{ KN·mm}$

$$\sigma_b = \frac{32 \times 540 \times 1000}{3.14 \times (25.24)^3}$$

$$\boxed{\sigma_b = 342.25 \text{ N/mm}^2}$$

20 mm

$l_1 =$ Max lift + H + clearance

$l_1 = \cancel{\ } \; 500 +$

$H = zp$

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

$$z = \frac{\cancel{4 \times 100 \times 1000} \; 400 \times 1000}{3.14 \times 10 \times (55.48)(5)}$$

$z = 45.92$

$z \approx 46$

$H = 46 \times 5 = 230 \text{ mm}$

$l_1 = 500 + 230 + 20 = 750 \text{ mm}$

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$$\frac{\tau}{k} = \frac{M_t \, d_c/2}{\frac{\pi}{32} d_c^4}$$

$$T_{max} = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + \tau^2}$$

$$= \sqrt{\left(\frac{342.25}{2}\right)^2 + (105)^2}$$

$$= \sqrt{40,309.11377}$$

$$T_{max} = 200.77 \ N/mm^2$$

$$\Rightarrow \boxed{FOS = \frac{400}{200.77} \approx 2}$$

Step 3 : Check for buckling

l/K

$$\cancel{K = \sqrt{\frac{I}{A}} = \sqrt{\frac{\pi d_c^2/8}{\pi d_c^2/4}} = \sqrt{\frac{1}{2}}}$$

$$\cancel{K = 0.7071}$$

$$\cancel{l/K = \frac{750}{0.7071} = 1060.66}$$

$$K = \sqrt{\frac{I}{A}} \qquad I = \frac{\pi}{64} \times d_c^4$$

$$K = \sqrt{\frac{\pi/64 \times d_c^4}{\pi/4 \times d_c^2}} = \sqrt{\frac{d_c^2}{16}} = \sqrt{\frac{27.74^2}{16}}$$

$$K = \frac{27.74}{4} = 6.935$$

$$l/k = \frac{750}{6.936} = 108.147$$

$$n = 0.25$$

$$\frac{S_{yt}}{2} = \frac{n \pi^2 E}{(l/k)^2}$$

$$\frac{400}{2} = \frac{0.25 \times 3.14^2 \times 207{,}000}{\cancel{(108.147)^2}\ (l/k)^2}$$

$$(l/k)^{*} = 50.50$$

$$\frac{l}{k} > \left(l/k\right)_{critical}$$

Use [Euler's Formula]

$$A = \pi d_m^2/4$$

$$P_{cr} = \frac{\pi^2 E A}{(l/k)^2} = \frac{(3.14)^2 \times 207{,}000 \times (3.14) \times (27.74)^2}{(50.50)^2\ \cancel{(108.147)^2} \times 4}$$

$$P_{cr} = 483{,}425.38$$

$$W = 100{,}000 \text{ N}$$

$$FOS = \frac{483.42838}{100} = 4.834$$

Assumed FOS = 2

$$\Rightarrow \boxed{\begin{array}{l} FOS > \text{Assumed FOS} \\ 4.834 > 2 \end{array}}$$

Step 4 Design of Nut

$Z = 45.92 \approx 46$

$H = 46 \times 5 = 230$ mm

$W = \frac{\pi}{4} (D^2 - d_c^2) \sigma_t$

$W = \frac{\pi}{4} (D^2 - 30.24^2) \times 82.74$

$D^2 - 30.24^2 = \frac{100,000 \times 4}{82.74 \times \pi}$

$\rightarrow \boxed{D = 49.53 \text{ mm}}$

$W = \pi D t \tau$

$W = 3.14 \times 49.53 \times t \times 105$

$t = \frac{100,000}{3.14 \times 49.53 \times 105}$

$\boxed{t = 6.123 \text{ mm}}$

$W = \frac{\pi}{4} (D_0^2 - D_i^2) \sigma_c$

$100,000 = \frac{\pi}{4} (D_0^2 - 49.53^2) \times 82.74$

$D_0^2 = \frac{100,000 \times 4}{\pi \times 82.74} + (49.53)^2$

$\boxed{D_0 = 63.18 \text{ mm}}$

Step 5 : design of handle

$$P l_h = M_t + \frac{\mu_c W}{4}(D_o + D_i)$$

$D_o = 1.6 d = 1.6 \times 30.24 = 48.384$

$D_i = 0.8 d = 0.8 \times 30.24 = 24.192$

$\boxed{\mu_c = 0.2}$

$$720 \times (l_n) = 332.6 \times 10^3 + \frac{0.2 \times 100 \times 10^3}{4} \times \cancel{2.4}^{0.6} \times 30.24$$

$$720 \times (l_n) = 10^3 (332.6 + 362.88)$$

$$l_n = \frac{695.48}{720} \times 10^3$$

$$\boxed{l_n = 965.9 \text{ mm}}$$

$$d_n = \left(\frac{32 M_b}{\pi \sigma_b}\right)^{1/3} = 32$$

Step 6 : Design of cup.

$t_h = 2 \times$ thickness of nut collar.

$h = 2d = 2 \times 30.24 = 60.48$ mm

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Step 6 : Design of base

$R_5 = 1.5 \times D_0 = 72.576$ mm

$R_6 = 2.25 \times$ ~~outer radius of the~~ $D_0 = 108.864$ mm

$t_2 = 0.25 \times d = 7.56$ mm

t_n = thickness of nut collar =

H' = Max lift + H + clearance. = 780 mm