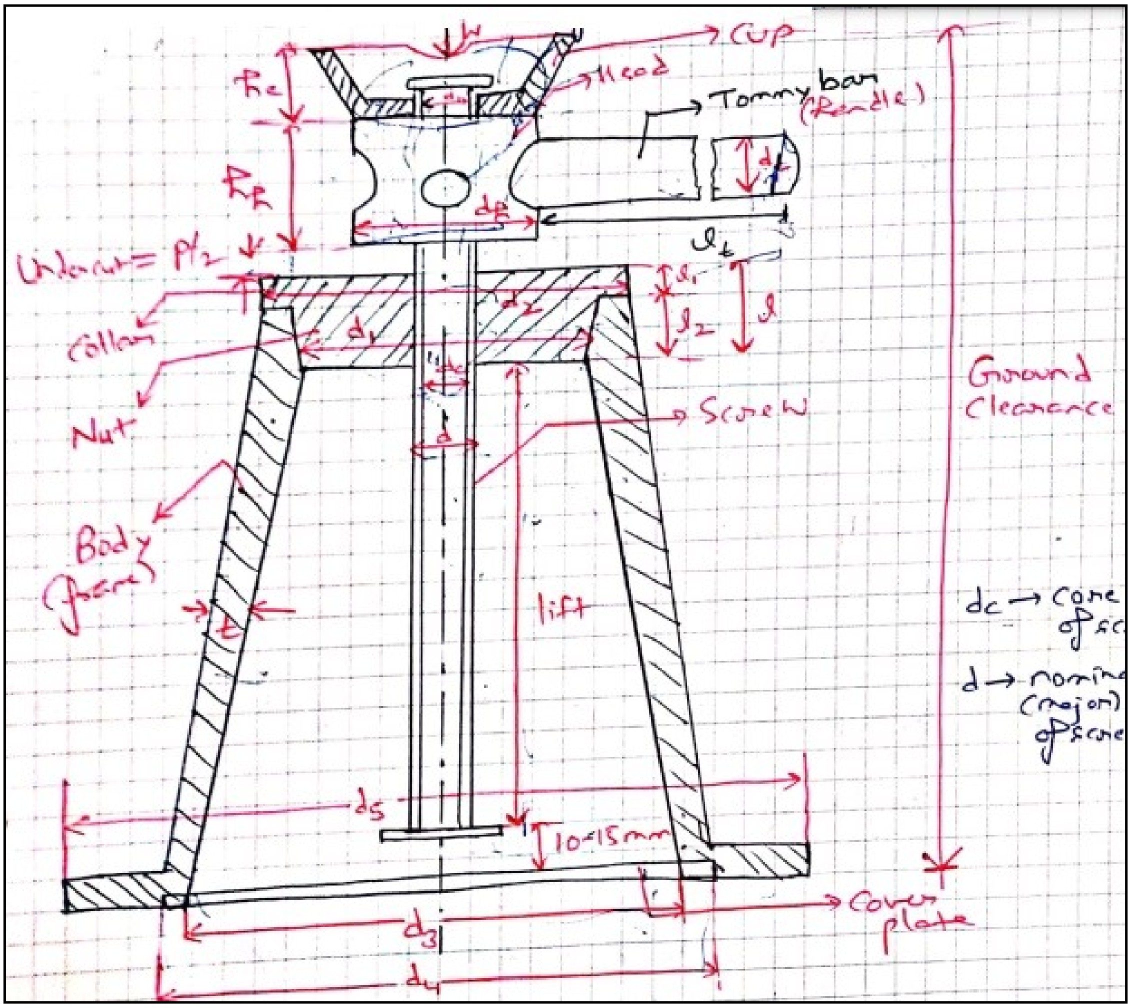
<u>Standard size of Rod/Shaft/Tube/Bolts</u>

Range of Size	Increment steps
0-10	1mm
10-24	2mm
24-45	3 mm
45-100	5 mm
>100	10 mm

Design of Screw Jack

Design 7: Design a screw jack to lift a load of W = 25/35/40/50 kN with load eccentricity of 2 mm. The ultimate compressive strength in 35C8 material of the screw is 760 MPa. The allowable bearing pressure between screw and nut is 15 MPa. The coefficient of friction between nut and screw is 0.14 and for collar friction is 0.18. The ground clearance is 300 mm. the Tommy bar is made up of 25C6 steel with UTS = 430 MPa. Nut is made up of gun metal having UTS = 210 MPa.



Design Steps:

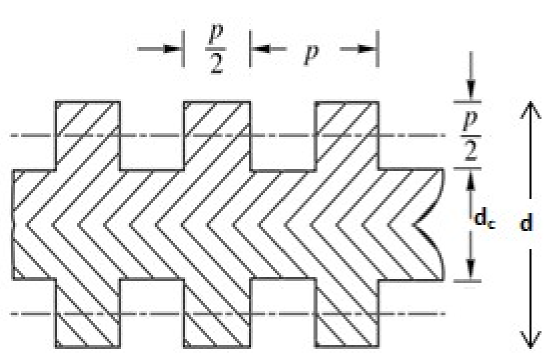
1. Assume an initial FOS = 6-10 to find allowable compressive stress in the screw core section.

$$\sigma_c = \frac{UCS}{FOS}$$

2. Core diameter (d_c) will be calculated as

$$W = \sigma_c . \frac{\pi}{4} . d_c^2 \Rightarrow d_c \text{ ?},$$

Select suitable pitch, p = 5-12mm, to find nominal diameter (d)



$$d = d_c + \frac{p}{2} + \frac{p}{2} = d_c + p \Rightarrow d? \text{ (std size)}$$

Mean diameter,

$$d_m = \frac{d + d_c}{2}$$

3. Helix angle,

$$\alpha = \tan^{-1}\left(\frac{p}{\pi d_m}\right)$$

Check that $\alpha = 4° \; to \; 7°$. If not, change p and find d_m again.

4. Friction angle

$$\phi = \tan^{-1}\mu_t$$

For irreversibility,

$$\alpha < \phi$$

For self locking,

$$\eta < 50\%$$

$$where, \eta = \frac{\tan\alpha}{\tan(\alpha + \phi)}$$

Otherwise change p and reiterate.

5. Torque required to lift the load in N-mm,

$$T_1 = W.\frac{d_m}{2}\tan(\alpha + \phi)$$

6. For nut, from bearing considerations

$$W = p_b.n.\frac{\pi}{4}.(d^2 - d_c^2) \Rightarrow no.of\ threads, n?$$

Length of nut, $l = np$

Check that $d \leq l \leq 2d$ or revise n

7. **Stresses in the screw**
   a. Compressive stress due to load W

$$\sigma_{c_1} = \frac{W}{\frac{\pi}{4}.d_c^2}$$

   b. Bending stress due to load eccentricity

$$\sigma_{c_2} = \frac{W.e}{\frac{\pi}{32}.d_c^3}$$

   Total compressive stress, $\sigma_c = \sigma_{c_1} + \sigma_{c_2}$

   c. Torsional shear stress due to torque T_1

$$\tau_1 = \frac{16T_1}{\pi d_c^3}$$

   d. Direct shear stress due to load W

$$\tau_2 = \frac{W}{\pi d_c . \frac{p}{2} . n}$$

Total compressive stress, $\tau = \tau_1 + \tau_2$

8. Principal stress induced in the screw

$$\sigma_p = \frac{1}{2}\left[\sigma_c + \sqrt{\sigma_c^2 + 4\tau^2}\right]$$

$$Final\ FOS = \frac{(UCS)_{screw}}{\sigma_p}$$

Check that

$$3.8 \leq FOS \leq 4.2$$

Else go to step 1and choose another initial FOS and reiterate steps from 1-7.

9. <u>Nut Dimension</u>

Length of collar of nut, l_1 = 10-12 mm

Length of nut, $l = l_1 + l_2$

Outside diameter of nut, $d_1 = 1.75d\ to\ 2.0d = 2d$

Diameter of collar of nut, $d_2 = 1.5d_1 to\ 2.0\ d_1$

Take FOS = 2.5-3.0

$$\sigma_{ta} = \frac{UTS\ of\ nut\ material}{FOS}$$

$$\sigma_{ca} = 1.6\sigma_t$$

$$\text{and, } \tau_a = 0.8\ \sigma_t$$

Initial stresses in nut,

Tensile stress,

$$\sigma_t = \frac{W}{\frac{\pi}{4}(d_1^2 - d^2)} < (\sigma_{ta})_{nut}$$

Compressive stress,

$$\sigma_c = \frac{W}{\frac{\pi}{4}(d_2^2 - d_1^2)} < (\sigma_{ca})_{nut}$$

Shear stress,

$$\tau = \frac{W}{\pi d_1 l_1} < (\tau_a)_{nut}$$

10. Tommy Bar

Take FOS ≤ 2.5, say 2.0

$$\sigma_{ta} = \frac{UTS\ of\ Tommy\ Bar\ material}{FOS}$$

Inner diameter of screw collar, $d_i \geq 20$
Outer diameter of screw collar, $d_h = 2d$
Collar friction torque will be,

$$T_2 = \mu_c W \frac{1}{3}\left[\frac{d_h^3 - d_i^3}{d_h^2 - d_i^2}\right]$$

Total torque will be,

$$T = T_1 + T_2 \qquad Nmm$$

Assuming that one person can apply a force of 300 N to 400 N,

$$T = N(350)l_{tb} \quad Nmm$$

Let, N be the number of persons, = 1,2,3………
Check that $\qquad l_{tb} < 1000\,mm$
Actual length of Tommy bar, $L_{tb} = l_{tb} + 100\ \ mm$
Bending stress in Tommy Bar,

$$\sigma_b = \frac{M}{z} = \frac{N.350.(l_{tb} - d)}{\frac{\pi}{32}d_{tb}^3} \leq \sigma_{ta} \Rightarrow diameter\ of\ tommy\ bar, d_{tb}?\,(std\ size)$$

Height of the head, $h_h = 2d_{tb}$
Height of cup, $h_c \geq 30\ mm$

11. Ground Clearance (G.C.)

$$\text{G.C.} = h_c + h_h + \frac{p}{2} + l + lift + (10\ to\ 15)mm$$

From above, lift will be calculated as,

$$\text{lift} = G.C. - \left[h_c + h_h + \frac{p}{2} + l + (10\ to\ 15)mm\right]$$

12. Buckling check of screw

Length of screw above nut, $l' = lift + \frac{p}{2} + h_c + h_h$= Buckling Length
Effective length (for one end fixed and other end free) will be, $l_{eff} = 2l'$
Radius of gyration,

$$k = \sqrt{\frac{I}{A}} = \frac{d_c}{4}$$

Where, $I = \frac{\pi}{64}d_c^4$ and $A = \frac{\pi}{4}d_c^2$

By Rankine-Gordon formula,

$$P_{cr} = \frac{\sigma_c . A}{1 + a\left(\frac{l_{eff}}{k}\right)^2}$$

$$where, a = \frac{1}{12500} and\ \sigma_c = 410\ MPa$$

Check that for safety in buckling,

$$P_{cr} \geq (2W\ to\ 3W)$$

Other dimensions,

$$d_3 = (1.5\ to\ 2.0)d_2$$

$$d_4 = 1.25\ d_3$$

$$d_5 = 1.5\ d_3$$

$$Cover\ Plate\ thickness = 2 - 3\ mm$$

VIVA QUESTIONS

1. Name all the stresses induced in the screw of a screw jack?
2. Why is the lever of a screw jack designed as the weakest part?
3. Why is the lead angle of screw jack restricted between 4° - 7°?
4. Why is nut made up of softer material and why is it made separate from body of screw jack?