

21/9/19

MODULE - 3

from
Pg. 127 Database

• THREADED COMPONENTS :

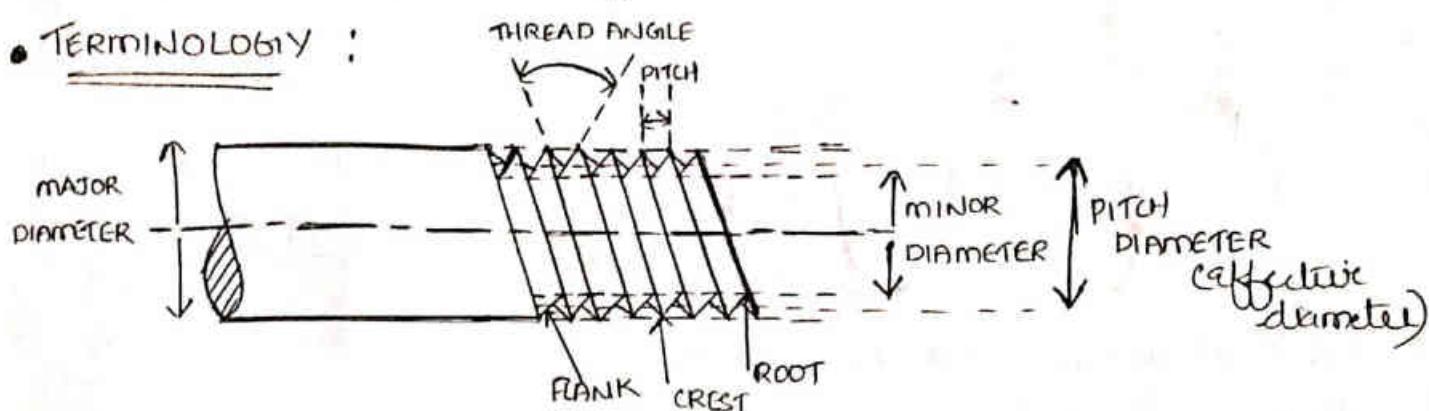
A thread is a continuous helical groove cut on a cylindrical surface. Threaded components are generally used for two applications

① To make temporary joints (screws, nuts & bolts)

② To transmit motion (lead screw, screw jack etc).

→ In case of a threaded component, the threaded portion engages with a corresponding threaded hole in a nut or a machine part so the two elements form a screw pair.

• TERMINOLOGY :



→ Pitch is the distance b/w adjacent thread forms measured \parallel to the thread axis.

→ Major diameter is the largest dia. of the screw thread.

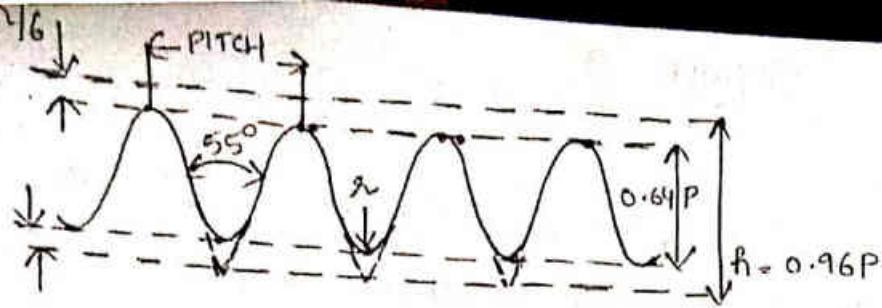
→ Minor diameter is the smallest dia. of the screw thread.

→ Pitch diameter is the dia. of an imaginary cylinder, the surface of which would pass through the thread at such points as to make equal the width of the threads to the space b/w them.

→ Lead is the distance the nut moves \parallel to the screw axis when the nut is given 1-turn. For a single thread, lead is same as pitch. In case of multi-threaded screw, lead is n times pitch ($L = nP$) \rightarrow no. of threads \times pitch.

• FORMS OF SCREW THREADS

① British Standard Whitworth;
→ (BSW) Thread



It's a symmetrical V-thread, angle b/w flanks $\rightarrow 55^\circ$.

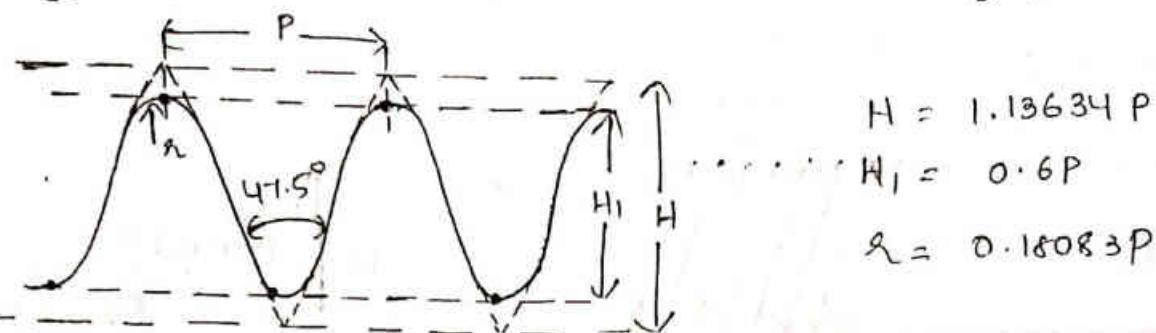
App.

\rightarrow bolts, steel and iron pipe, screwed fasteners.

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• (2) BRITISH ASSOCIATION THREAD

Thread w/ fine pitches. Used on screws for precision works

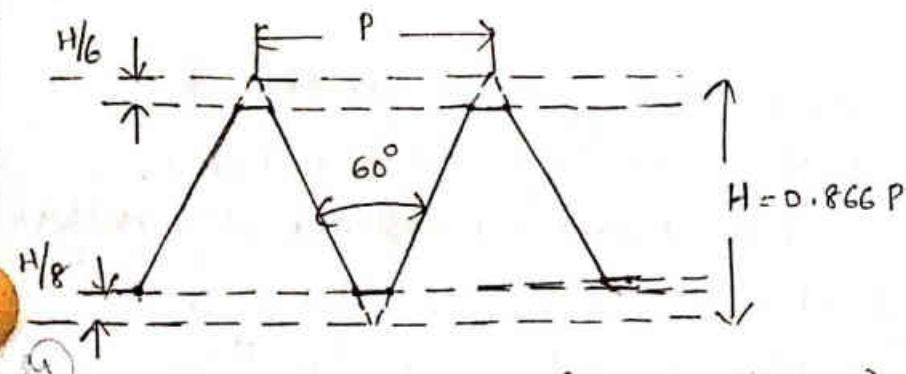


$$H = 1.13634 P$$

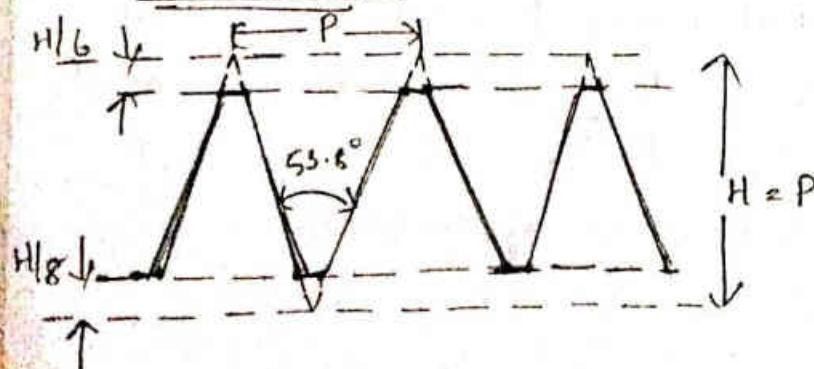
$$H_1 = 0.6 P$$

$$\alpha = 0.18083 P$$

• (3) AMERICAN NATIONAL STANDARD THREAD

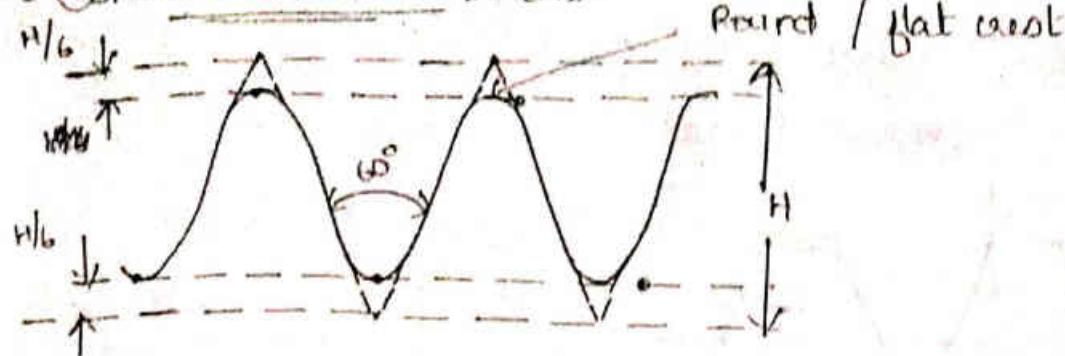


• (4) HAUDEHERZ THREAD: (German Standard)



These are used in Germany for measuring precision

• UNIFIED NATIONAL THREAD:



It is used in US, Canada etc. The offer interchangeability between threads. It's a combination of BSW & ANST.

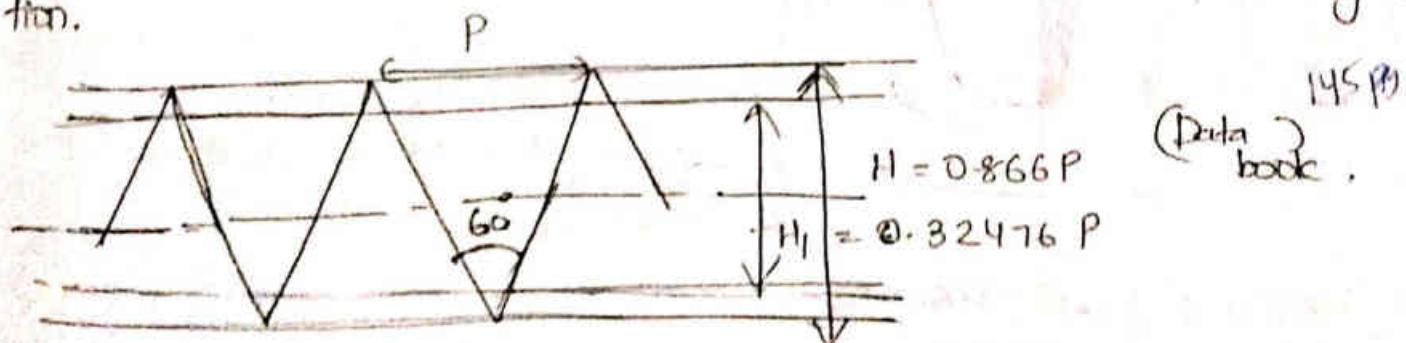
Coarse pitch is more common. fine threads are more resistant to loosening from vibration & is used in automobiles and aircraft. Extra fine pitch is used where wall thickness is limited.

3 Standard families are defined in UN Thread

- Coarse Pitch (UNC)
- Fine Pitch (UNF)
- Extra fine Pitch (UNEF)

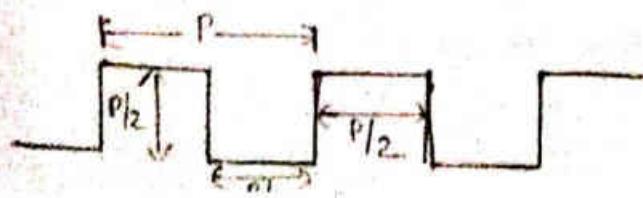
• INTERNATIONAL ORGANIZATION FOR STANDARDS METRIC THREAD:

Iso Metric Thread is an internationally used standard. Metric threads are specified by writing the dia. & pitch in 'mm' in that order. M12×1.75 is a thread having nominal dia → 12 & pitch → 1.75 mm. 'M' is due to metric designation.



It has coarse and fine series of thread.

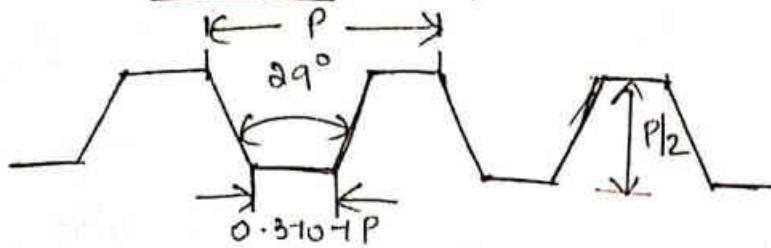
SQUARE THREAD



USES

→ Valves, spindles, screw jack, lead screws

- ACME THREAD (Trapezoidal thread)

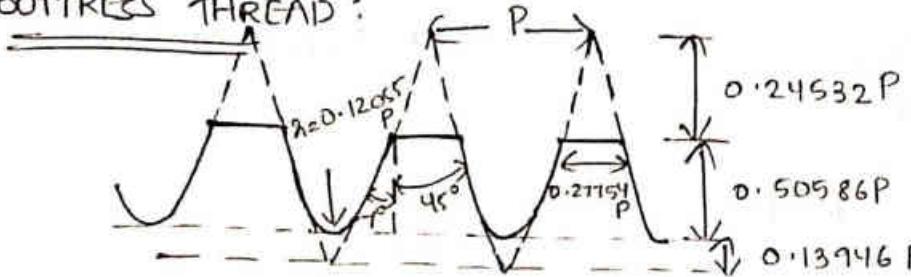


It is a modification of square thread which is stronger & easy to produce compared to it but it is less efficient.

USE

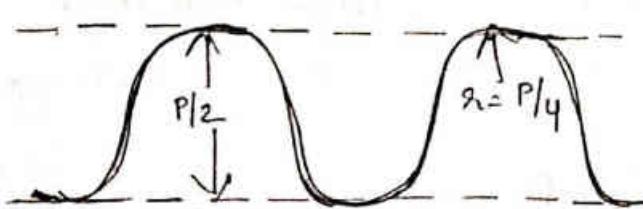
→ Screw cutting lathes, bench vice, brass valves

- BUTTRESS THREAD:



It is used to transmit transverse power in the direction. Adv. of both square & trapezoidal thread.

- KNUCKLE THREAD:



Used for rough & ready cocks (quick)

Use
→ railway carriage
→ big & mated insulators
→ neck of glass bottles

- STRESSES IN THREADS:

Stresses acting in a threaded joint can be broadly classified into 2:-

- ① Stresses due to initial tightening
- ② Stresses due to external load or force.

STRESSES IN THREADS DUE TO INITIAL TIGHTENING:

When a nut is tightened over a screw, following stresses are induced.

a) Tensile stress due to stretching of the bolt :-

In order to make a joint leak proof, the initial tensile force is estimated by an empirical relation.

$$F_t = 2805d \quad \text{in SI unit (N)} \quad \left\{ \begin{array}{l} \text{Pg. 127} \\ \text{Eq. 9.1c} \end{array} \right.$$

$d \rightarrow$ major diameter (mm)

If leak proof is not required, half of the estimated load may be used.

b) Stress due to initial tension

$$\sigma_t = \frac{F_t}{\text{Stress Area}} \quad \left\{ \begin{array}{l} \text{Pg. 140} \\ \text{Table 9.8} \\ (\alpha) \end{array} \right.$$

$$\rightarrow \text{Stress Area} = \frac{\pi}{4} \left(\frac{d_p + d_c}{2} \right)^2 \quad \begin{aligned} d_c &\rightarrow \text{core or internal dia} \\ d_p &\rightarrow \text{pitch dia.} \end{aligned}$$

b) Torsional shear stress :-

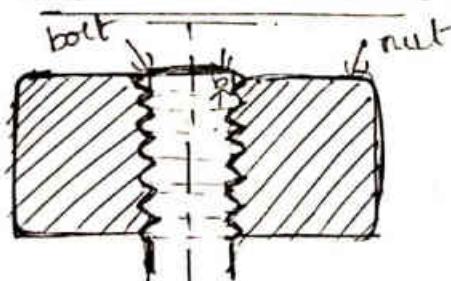
$$\tau = \frac{16T}{\pi d_c^3}$$

$T \rightarrow$ Torque (to tighten the bolt)

$d_c \rightarrow$ core dia

$$\left\{ \begin{array}{l} T = \frac{T_R}{J} \end{array} \right.$$

c) Shear stress across the threads :-



$$\tau_c = \frac{F_t}{\pi d_c b n}$$

$b \rightarrow$ base width of thread
 $n \rightarrow$ no. of threads in engagement

d) Cutting stress :-

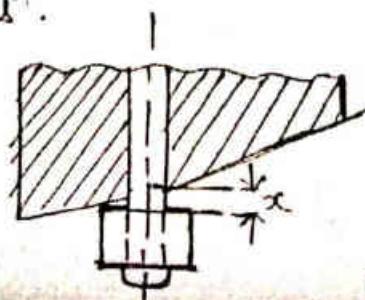
$$\sigma_c = \frac{F_t}{\frac{\pi}{4}(d^2 - d_c^2)n}$$

$d \rightarrow$ outer diameter

e) Bending stress :-

If the surface under the head or nut are not perfectly perp to the bolt axis.

$l \rightarrow$ length of bolt shank



$$\sigma_b = \frac{\alpha E}{2l}$$

$\alpha \rightarrow$ diff. in height b/w extreme corners of nut and/or head

$E \rightarrow$ Young's modulus.

STRESSES IN THREAD DUE TO EXTERNAL FORCE

a) Tensile stress:

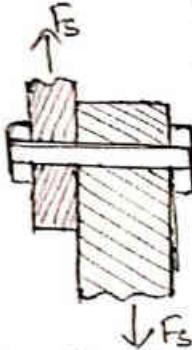
When a bolt is subjected to an axial tensile load the greatest action will be at the root of the thread & the tensile stress

$$\sigma_t = \frac{F_t}{\frac{\pi d_c^2}{4}}$$

$F_t \rightarrow$ external tensile load
 $d_c \rightarrow$ minor dia. of bolt

b) Shear stress:

Sometimes the bolts are used to prevent relative motion of two or more parts and then shear stress is induced in the bolt.



c) Combination of tensile & shear stress:

In this case max. shear stress τ_{max} :

$$\tau_{max} = \frac{1}{2} \sqrt{\sigma_t^2 + 4 \tau_s^2}$$

$$\sigma_{max} = \frac{\sigma_t}{2} + \frac{1}{2} \sqrt{\sigma_t^2 + 4 \tau_s^2}$$

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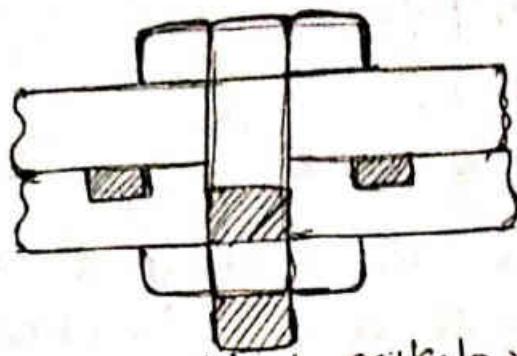
GASKETED JOINT

Gaskets are used to make bolted joints tight and leak proof. The main objectives of gaskets are:

- 1) To make ~~joints~~ leak proof
- 2) To reduce fluctuations of joints.

They are of two types:-

- ① Confined gasket
- ② Unconfined gasket

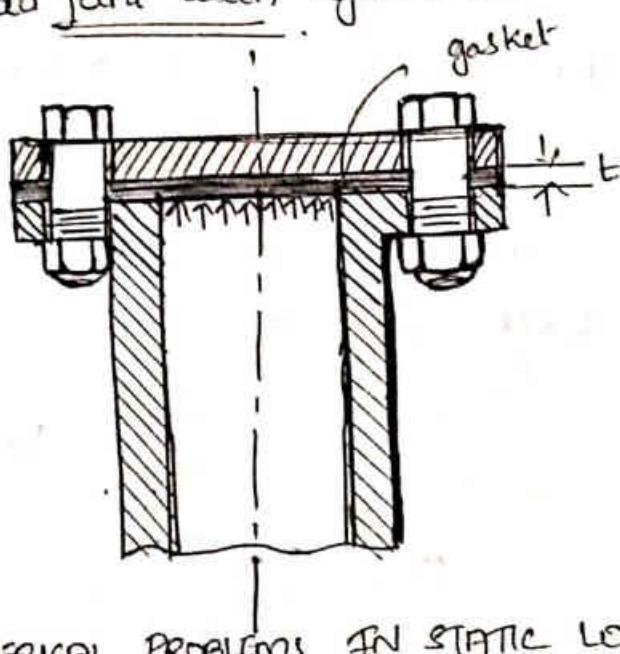


stiffness of confined gasket is same as that of unconfined joint

$$\frac{1}{K} = \frac{1}{K_b} + \frac{1}{K_m}$$

$K_b \rightarrow$ stiffness of bolt
 $K_m \rightarrow$ stiffness of metallic plate

Bolted joint with gasket



• NUMERICAL PROBLEMS IN STATIC LOADING OF BOLTED JOINTS

a) Determine the safe tensile load for M12, M20, & M30 coarse grade, assuming a safe tensile stress of 43 MPa.

\Rightarrow Given:

$$\text{safe tensile stress} = 43 \text{ MPa} = \frac{\text{Safe load}}{\text{stress area}}$$

M12

$$\sigma = \frac{F}{A} \quad A = 84.3 \text{ mm}^2 \quad (\text{at } 1.15 \text{ pitch}) \quad (141 \text{ Pg.})$$

$$9.8$$

$$\therefore \text{safe load} = 43 \times 84.3 \text{ N/mm}^2$$

$$= 3624.9 \text{ N}$$

M20

$$A = 245 \text{ mm}^2 \quad (\text{at } 0.5 \text{ coarse grade pitch})$$

$$\therefore \text{safe load} = 245 \times 43$$

$$= 10535 \text{ N}$$

M30

$$A = 561 \text{ mm}^2 \text{ at } (3.5 \text{ pitch})$$

$$\therefore \text{safe load} = 43 \times 561 \\ = 24123 \text{ N}$$

561
1143
1683
22440
24123

Q/ Two plates bolted to form an assembly is initially tightened by a spanner so as to induce a pre-load of 3kN in the bolt. Then it's subjected to an external load of 8kN. The bolt with coarse thread made of plain carbon steel of tensile yield strength of 400 MPa. The effective stiffness of the parts held together by the bolts is 3 times the stiffness of the bolt. Determine the size of the bolt assuming FOS = 3.

$$\Rightarrow \text{Initial pre-load} = 3 \text{ kN} \quad \text{FOS} = 3 \\ \text{external load} = 8 \text{ kN} \quad K_m = 3 K_b \\ \sigma_y = 400 \text{ MPa}$$

$$F = K F_a + F_i$$

$$K = \frac{(E_b A_b)}{L}$$

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$$\left(\frac{E_b A_b}{L} + \frac{E_g A_g}{t} \right)$$

$$K = \frac{K_b}{K_b + K_m} = \frac{K_b}{K_b + 3K_b} = \frac{K_b}{4K_b}$$

$\frac{25}{200000}$

$$K = 0.25$$

$$F = 0.25 (8000) + 3000$$

$$F = \underline{5000 \text{ N}}$$

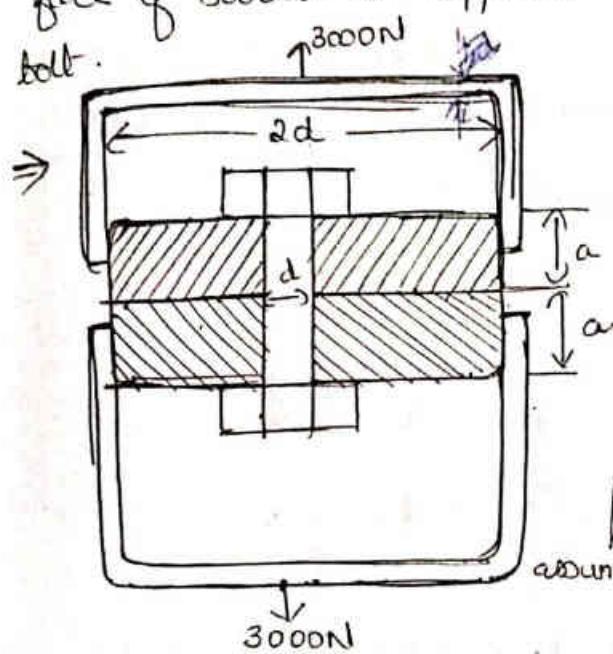
$$\text{Permissible stress} = \frac{\sigma_y}{\text{FOS}} = \frac{400}{3} = 133.33 = \frac{F}{A}$$

$$133.33 = \frac{5000}{\frac{\pi d^2}{4}}$$

$$133.33 \times \frac{\pi d^2}{4} = \frac{5000}{5000}$$

$$A = \frac{5000}{133.33} = \underline{37 \text{ mm}^2}$$

worse grade pitch for 81 mm²
M10 of 96 mm² is taken
 All Two plates made of Al with modulus of elasticity 70,000
 MPa having internal dia 'd' and external dia '2d' by
 using a steel bolt whose modulus of elasticity is 200,000
 MPa. The initial tightening load is 3000N to an external
 force of 3000N is applied to it. Determine the size of the
 bolt.



$$\text{External dia} = 2d$$

$$\text{Internal dia} = d$$

$$E_{Al} = 70000 \text{ MPa}$$

$$E_{Steel} = 200000 \text{ MPa}$$

$$F_t = 3000 \text{ N}$$

$$F_a = 3000 \text{ N}$$

$$\text{Material of bolt} = \text{C30 Steel}$$

$$\text{assume } F_{as} = 4$$

$$\sigma_y = 294 \text{ MPa}$$

$$\text{Permissible tensile stress} = \frac{\sigma_y}{F_{as}} = \frac{294}{4} = \underline{\underline{73.5 \text{ MPa}}}$$

$$\text{From databook } F_t = K F_a + F_t$$

$$K = \frac{\text{Stiffness of bolt}}{\text{Stiffness of bolt} + \text{Stiffness of material}} = \frac{K_b}{K_b + K_m}$$

$$K_b = \frac{E_b A_b}{l_b}, \quad K_m = \frac{E_m A_m}{l_m}$$

$$K = \frac{\frac{200000 \times \pi d^3 / 4}{2a}}{\frac{200000 \pi d^3 / 4}{2a} + \frac{70000 \times 3 \pi d^3 / 4}{2a}} = \frac{20}{20 + (1 \times 3)}$$

$$K = \frac{20}{41} = \underline{\underline{0.4818}}$$

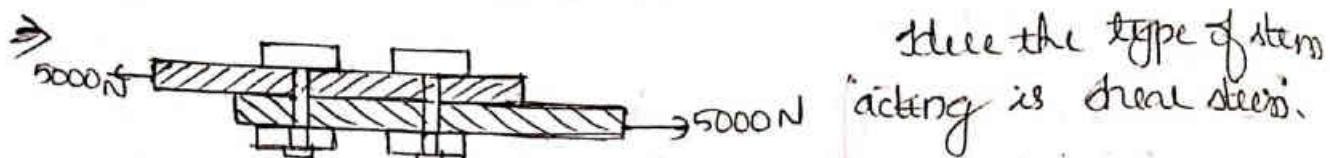
$$F_t = F_t + K F_a$$

$$= 3000 + 0.4818 \times 3000 = \underline{\underline{6463.4 \text{ N}}}$$

$$\sigma_F = \frac{F}{A} \Rightarrow 73.5 = 6463.4 / A \therefore A = \underline{\underline{87.94 \text{ mm}^2}}$$

databook (pg. 141) $M_{14} \times 2 \therefore \text{area} = \underline{\underline{115 \text{ mm}^2}}$

Q/ Two plates are connected using two bolts as shown in fig. The plates are loaded with 5000N force as shown in fig. Determine the size of the bolt if yield strength of the material is 400 MPa & FOS = 5.



$$\sigma_{yt} = 400 \text{ MPa}, \tau_y = \frac{\sigma_{yt}}{2} = \underline{\underline{200 \text{ MPa}}}$$

$$\text{Permissible shear stress, } \tau = \frac{\tau_y}{\text{FOS}} = \frac{200}{5} = \underline{\underline{40 \text{ MPa}}}$$

$$\text{Shear stress area of two bolts} = \frac{2\pi d^2}{4} = \frac{\pi d^2}{2}$$

Shear area of two bolts

$$\tau = \frac{F}{A} \Rightarrow 40 = \frac{5000}{\pi d^2 / 2} \Rightarrow d = \underline{\underline{8.3 \text{ mm}}}$$

databook

M₁₀ bolt with 1.5 pitch (M₁₀ x 1.5)

10/10/19

Q/ A cylinder head of a steam engine is subjected to steady pressure of 0.5 MPa. It is held in position by means of 12 bolts. A soft copper gasket is used to make it joint leak proof. The effective dia. of the cylinder is 300mm. Max. stress on the bolt is not to exceed 100 MPa. Determine the size of the bolt.

GIVEN

$$P = 0.5 \text{ MPa}$$

$$\text{No. of bolts} = 12$$

$$\sigma = \text{Max stress} = 100 \text{ MPa} \quad (\text{Permissible})$$

$$D = 300 \text{ mm}$$

$$F = \text{Total Area} \times \text{Pressure} \quad (\text{on cover})$$

$$F = \frac{\cancel{12 \times 1100}(300)^2}{4} \times 0.5 = \underline{\underline{35342.91 \text{ N}}}$$

Tensile force acting on bolt = $\frac{F}{12}$

$$F_a = \underline{\underline{29452 \text{ KN}}}$$

effective

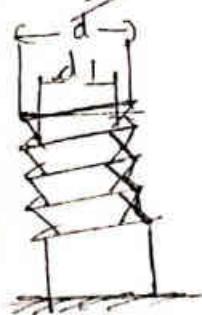
$$F = F_i + K F_a$$

{data - 127 Pg

$$F_i = 2805d \quad (\text{for leak proof joint})$$

Pg. 136
for K

$$K = 0.5 \quad (\text{for soft copper gasket})$$



$$\therefore F = 2805d + 0.5(2945.2)$$

$$F = 6 \times \frac{\pi d c^2}{4} = 2805d + 0.5(2945.2)$$

$$100 \times \frac{\pi d c^2}{4} = 2805d + 0.5(2945.2)$$

$$d_c = 0.84d \quad \text{empirical relation}$$

$$100 \times \pi \frac{(0.84d)^2}{4} = 2805d + 0.5(2945.2)$$

$$55.4176 d^2 - 2805d - 1472.6 = 0$$

$$d = \underline{\underline{51.135 \text{ mm}}}$$

$$\therefore \text{size of bolt} = \underline{\underline{52 \text{ mm (dia)}}} \quad (\text{Pg: 143})$$

pitch = 5 mm

Q) A cylinder head is held on a cylinder by 8 bolts. The inner dia of cylinder is 350mm. P. inside cylinder varies from 0 to a max. P. of 2.5 MPa.

$\sigma_{ut} = 630 \text{ MPa}$, $\sigma_{yt} = 380 \text{ MPa}$. The bolts are tightened w/ initial pre-load of 1.5 times steam load. A copper asbestos gasket is used to make the joint leak proof. Take FOS = 2.5. Neglect stress concentration factor.

Find the size of the bolt? Ans.

$$\Rightarrow \sigma_{ut} = 630 \text{ MPa} \quad F_i = 1.5(F_a)_{max} \text{ (given)}$$
$$\sigma_{yE} = 380 \text{ MPa} \quad \text{inner dia} = 350 \text{ mm}$$
$$\text{No. of bolts} = 8 \quad P_{max} = 2.5 \text{ MPa}$$

$$\text{Max. force on cylinder cover } F = \frac{\pi d^2}{4} \times P_{max}$$

$$= \frac{\pi \times (350)^2}{4} \times 2.5$$

~~F_a~~

$$\cancel{F_a} = \underline{240528.18 \text{ N}}$$

$$F_a = \frac{240528.18}{8} = \underline{30066.02 \text{ N}}$$

$$\text{initial force } F_i = \underline{1.5(30066.02)} \\ = 45099.03 \text{ N}$$

dome; for ~~copper~~ ^{asbestos} gasket - $K = \underline{0.6}$

$$F_{max} = F_i + K(F_a)_{max} = \underline{63138.64 \text{ N}}$$

$$F_{min} = F_i + K(0) = \underline{45099.03 \text{ N}}$$

$$F_a = \frac{F_{max} - F_{min}}{2} = \underline{9019.806 \text{ N}}$$

$$\sigma_a = \frac{F_a}{A} = \frac{9019.806}{\pi (380)^2} \times 4 = \frac{9019.806}{A}$$

$$\cancel{\sigma_a} = \underline{0.0937 \text{ MPa}}$$

Mean force,

$$F_m = \frac{F_{max} + F_{min}}{2} = \underline{54118.835 \text{ N}}$$

Mean stress,

$$\sigma_m = \frac{F_m}{A} = \underline{\frac{54118.835}{A}}$$

$$\sigma_{en} = 0.5 \sigma_u = \underline{315 \text{ MPa}}$$

$$k_t = 1$$

$$A = 0.8 \quad (\text{for eccentric loadings})$$

(cold drawn)

$$B = \frac{1}{t}, \quad C = 0.86, \quad n = 0.5$$

Soderberg's eqn

$$\frac{K_{sp} \cdot 6a}{ABC \cdot 6cn} + \frac{6m}{6\gamma_p} = \frac{1}{n}$$

$$\Rightarrow \frac{9019 \cdot 806}{A \times 0.8 \times 0.86 \times 315} + \frac{54118 \cdot 835}{A \times 380} = \frac{1}{2.5}$$

$$\frac{1}{A} [184.0376] = \frac{1}{2.5}$$

~~steels area~~ $A = 460.094 \rightarrow \frac{\pi d^2}{4}$

\rightarrow Pg. 142 $A = 561$, coarse pitch

major, $d = 30 \text{ mm}$, pitch = 3.5

14/10/19

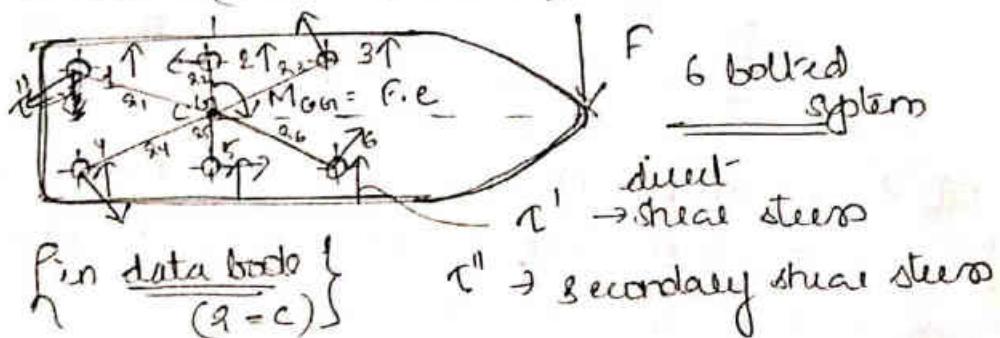
SCREWED JOINT WITH ECCENTRIC LOAD

① Eccentric load in the plane of joint

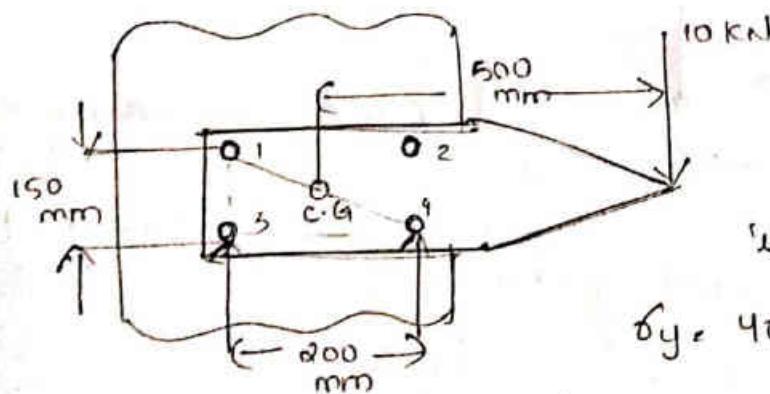
(Pg. 132)

$$\tau'' = c \cdot \tau_1$$

constant.



Q1.



Calculate the size
of the bolt. Material
is carbon steel 40

$\sigma_y = 400 \text{ N/mm}^2$, FOS = 2.5

$$\Rightarrow \tau_y = \frac{1}{2} \sigma_y = 200 \text{ N/mm}^2$$

$$\text{Permissible shear stress} = \frac{\tau_y}{FOS} = \frac{200}{2.5} = 80 \text{ N/mm}^2$$

$$\text{Primary shear force, } F = \frac{F}{N} = \frac{10 \times 1000}{42} = 2500 \text{ N}$$

$$\text{Secondary shear force, } F'' = \frac{F_e \cdot cn}{Z \cdot c^2} =$$

$$C_1 = C_2 = C_3, C_4 = \sqrt{100^2 + 15^2} = \underline{125 \text{ mm}}$$

$$F'' = \frac{10 \times 1000 \times 500 \times 125}{(4 \times 125)^2}$$

$$F_1'' = F_2'' = F_3'' = F_4'' \Rightarrow F'' \rightarrow \underline{\underline{2500 \text{ N}}} \quad \text{Octant } \left(\frac{75}{100}\right)$$

$$\begin{aligned} F_3 &= F_3' + F_3'' \cos \theta \\ &= 2500 + 10,000 \cos(66.87^\circ) \\ &= \underline{\underline{10500 \text{ N}}} \end{aligned}$$

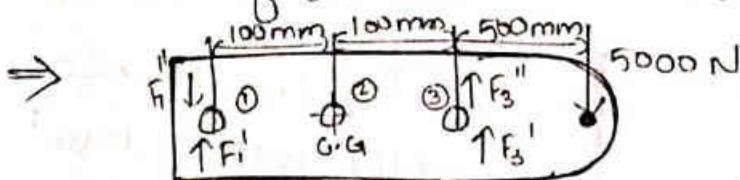
$$\begin{aligned} F_R &= \sqrt{(F')^2 + (F'')^2 + 2F'F'' \cos 36.87^\circ} \\ &= \sqrt{(2500)^2 + (10,000)^2 + (2 \times 2500 \times 10,000) \cos 36.87^\circ} \end{aligned}$$

$$T = \frac{F_R}{\frac{\pi d^2}{4}} = \frac{12093.8 \text{ N}}{\frac{\pi 80^2}{4}} = \underline{\underline{A = \frac{151.1725}{60.469} \text{ mm}^2}}$$

Pg. 141 M12

M18

All A scoured joint is loaded as shown in fig. Determine the size of the bolt of the permissible shear stress of the material of the bolt is 50 MPa.



$F_1', F_2', F_3' \rightarrow$ Primary shear force

$$\frac{F}{N} = \frac{5000}{3}$$

$$= \underline{\underline{1666.67 \text{ N}}}$$

$F_1'', F_2'', F_3'' \rightarrow$ Secondary shear force

$$F_1'' = \frac{F_e c_1}{\Sigma c^2}$$

$$F_1'' = \frac{5000 \times 600 \times 100}{(c_1^2 + c_2^2 + c_3^2)} = \frac{30 \times 10^7}{100^2 + 100^2} = \underline{\underline{15000 \text{ N}}}$$

$$F_2'' = F_3'' = \underline{\underline{0}}$$

Mass. force at bolt 3

$$\begin{aligned} F_{\max} &< F_3' + F_3'' = 15000 + 1666.67 \\ &= \underline{\underline{16666.67 \text{ N}}} \end{aligned}$$

$$T_c = \frac{\text{tensile}}{\pi d^2/4} \quad \pi d^2/4 = 16666.67 \quad \text{Pg. 142}$$

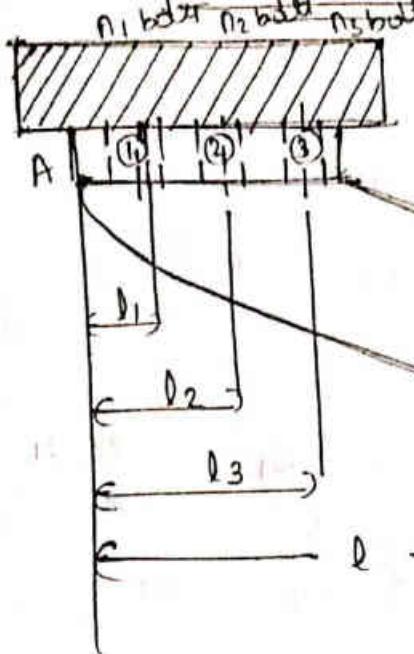
$$d_1 = 20.6 \text{ mm}$$

M25

(21. 3193 taken)

External thread

② Eccentric joint w/ load || to axis of bolt



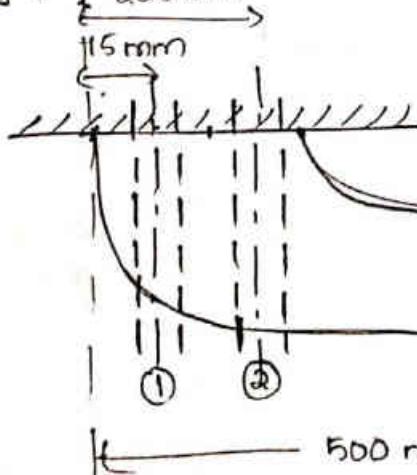
There are two types of force acting → direct tensile force (load of bolt), another force is tensile force which tend to tilt bolt the joint about edge A

$$\begin{aligned} F_l &= n_1 F_1'' l_1 + n_2 F_2'' l_2 + \\ &\quad n_3 F_3'' l_3 \\ &= n_1 C l_1^2 + n_2 C l_2^2 + n_3 C l_3^2 \\ C &= \frac{F l}{n_1 l_1^2 + n_2 l_2^2 + n_3 l_3^2} \end{aligned}$$

15/10/19

Q) A bracket is connected by 4-bolts as shown in fig. Specify size of the bolts.

Assume C40 steel



Max. secondary tensile force at ② (two bolts)

$$F_1' + F_2' = \frac{25000}{4} = \text{primarily shear force} = \underline{\underline{6250 \text{ N}}}$$

$$\begin{aligned} \text{Pg. 130} \\ 9.7(b) \quad F_{\max} \approx F_{2\max}'' &= \frac{F_e l_d}{2(l_1^2 + l_d^2)} = \frac{25000 \times 500 \times 225}{2(75^2 + 225^2)} \\ &= \underline{\underline{25,000 \text{ N}}} \end{aligned}$$

$$\begin{aligned} \text{Max. tensile force} &= F_1' + F_2'' = 25,000 + \frac{6250}{25,000} \\ F_{\max} &= \underline{\underline{31250 \text{ N}}} \end{aligned}$$

Yield strength of C40 $\sigma_y = 324 \text{ N/mm}^2$ (Pg. 464)

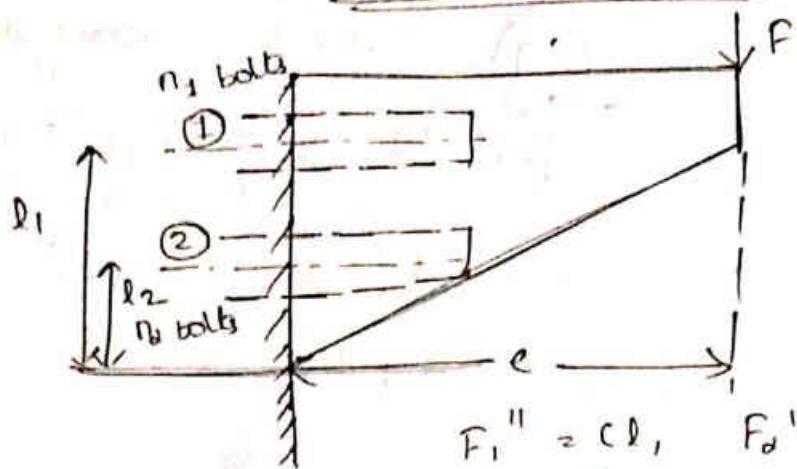
Assume, $FOS = 5$

$$\sigma_t = \frac{\sigma_y FOS}{5} = \frac{324}{5} = \underline{\underline{64.8 \text{ N/mm}^2}}$$

$$\sigma_t = \frac{F_{max}}{N} \quad \therefore \quad A = \frac{91250}{64.8} = \underline{\underline{482.25 \text{ mm}^2}}$$

Pg. 142 M30 selected (coarse pitch.)

(3) Eccentric load \perp to axis of bolt



max secondary tensile force

$$F_{\text{el}}'' = \frac{F_e l_1}{n_1 l_1^2 + n_2 l_2^2}$$

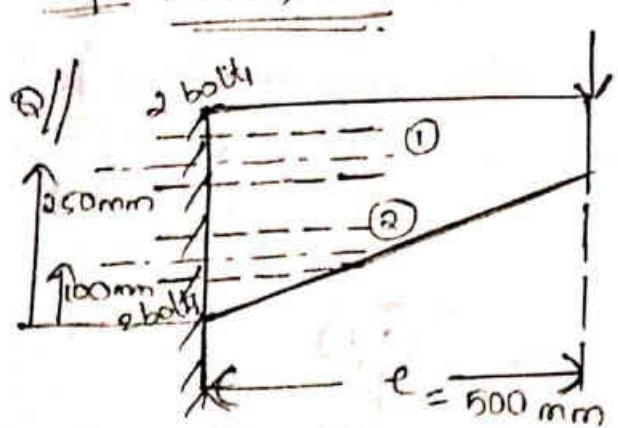
1° shear force, $F_1' = F_2' = \frac{F}{n_1 + n_2}$

2° tensile force $F_e = n_1 F_1'' l_1 + n_2 F_2'' l_2$

$$F_e = n_1 c l_1^2 + n_2 c l_2^2$$

$$c = \frac{F_e}{n_1 l_1^2 + n_2 l_2^2}$$

Eqn 9.1(c), 9.1(d)



$$F_e = 10,000 \text{ N}$$

$$l_1 = 250 \text{ mm}$$

$$l_2 = 100 \text{ mm}$$

$$F = 10,000 \text{ N}$$

$$e = 500 \text{ mm}$$

$$N = 4$$

$$F_1' = F_2' = \frac{F}{4} = \frac{10,000}{4} = \underline{\underline{2500 \text{ N}}}$$

max tensile force

$$F_1'' = \frac{F \times e \times l_1}{n_1 l_1^2 + n_2 l_2^2} = \frac{10,000 \times 500 \times 250}{2 \times (250)^2 + 2 \times (100)^2}$$

9.1(c) $F_1'' = \underline{\underline{8620.689 \text{ N}}}$

$$F_{\text{max}} = F_{\text{te}} = \frac{1}{2} \left[F_1 + \sqrt{F_1'^2 + F_1''^2} \right] = \frac{1}{2} \left[F_1'' + \sqrt{F_1''^2 + 4(F_1')^2} \right]$$

$$= \frac{1}{2} \left[2500 + \sqrt{2500^2 + 4(8620.689)^2} \right]$$

$$= \frac{1}{2} \left[8620.68 + \sqrt{(8620.68)^2 + 4 \times (2500)^2} \right]$$

$$F_{max} = 9293.213$$

$$\sigma_t = \sigma_{permissible} = 80 \text{ N/mm}^2$$

$$\therefore A = \frac{9293.213}{80} = \underline{\underline{116.165 \text{ mm}^2}}$$

M16 (P. 141)

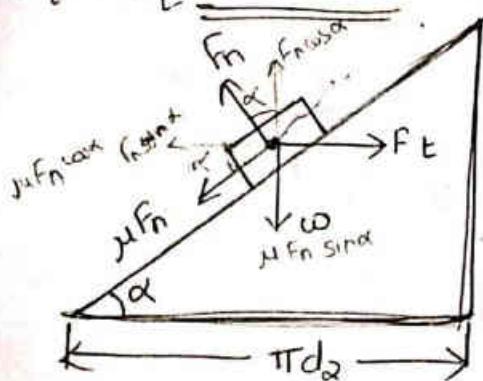
(P. 138)

16/10/19 To select from 1st & 2nd choice based on durability

• POWER SCREWS:

Used to convert rotary motion into linear motion. Lead screw, screw press, screw clamp vice etc. Essential elements are screw & a nut threaded to engage the screw. Commonly used forms of threads are :- ACME, square, trapezoidal thread etc.

→ Toque required to raise the load



$d_2 \rightarrow$ pitch circle dia. of screw

$F_t \rightarrow$ tangential force for square thread

$W \rightarrow$ axial force (load)

$F_n \rightarrow$ normal force

$\mu F_n \rightarrow$ Frictional force

$\alpha \rightarrow$ Helix angle of thread

Eqn. of equilibrium in Y-axis;

$$F_n \cos \alpha - \mu F_n \sin \alpha = W$$

Eqn. of equilibrium in X-axis;

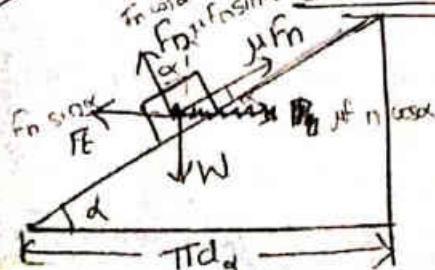
$$F_t = F_n \sin \alpha + \mu F_n \cos \alpha$$

$$\begin{cases} \mu = \tan \phi \\ \phi = \text{friction angle} \end{cases}$$

$$\frac{F_t}{W} = \frac{F_n [\sin \alpha + \mu \cos \alpha]}{F_n [\cos \alpha - \mu \sin \alpha]}$$

$$\frac{F_t}{W} = \left[\frac{\tan \alpha + \mu}{1 - \mu \tan \alpha} \right] = \frac{\tan \alpha + \tan \phi}{1 - \tan \alpha \tan \phi} \quad \frac{F_t}{W} = W \tan(\alpha + \phi)$$

→ Toque required to lower the load



$$W = F_n \cos \alpha + \mu F_n \sin \alpha$$

$$+ F_t = -F_n \sin \alpha + \mu F_n \cos \alpha$$

$$\frac{F_t}{W} = \left[\frac{\sin \alpha + \mu \cos \alpha}{\cos \alpha + \mu \sin \alpha} \right] = \left[\frac{\tan \alpha + \mu}{1 + \mu \tan \alpha} \right]$$

$$\frac{F_t}{W} = -\frac{\tan \alpha + \tan \phi}{1 + \mu \tan \phi} = \tan(\phi - \alpha) \tan(\phi - \alpha)$$

$$F_t = W \tan(\phi - \alpha)$$

$$\text{Friction torque} = F_t \cdot d/2 = \frac{W d \alpha}{2} \tan(\phi - \alpha)$$

If $\alpha > \phi$, the torque required to move the load upwards itself will turn the screw. No force is required to move the load. If the load is under a restraining torque is applied.

If $\phi \geq \alpha$, a positive torque is required to move the load, i.e., self-locking of the screw.

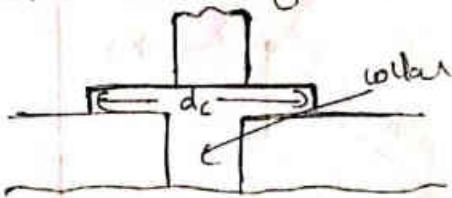
Efficiency of Power Screw:

$\eta = \frac{\text{torque required to move without friction}}{\text{torque required to move with friction}}$

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

If the screw with collar of mean dia d_c & $\mu = f_c$ then the torque required to overcome collar friction is

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



22/10/19

A lead screw of a lathe has 50x8 threads. The screw must exert an axial force of 4KN in order to drive the tool carriage. The thrust is carried on a collar 120mm outside dia & 60mm inside dia. The screw rotates at 40 rpm. Coefficient of friction for screw & collar is 0.15 & 0.12 respectively. Determine the force required to drive the screw & efficiency of the lead screw.

\Rightarrow Outside diameter = 50 mm
Pitch = 8 mm

(not specified)
(square thread)

databook
134 pg

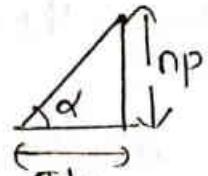
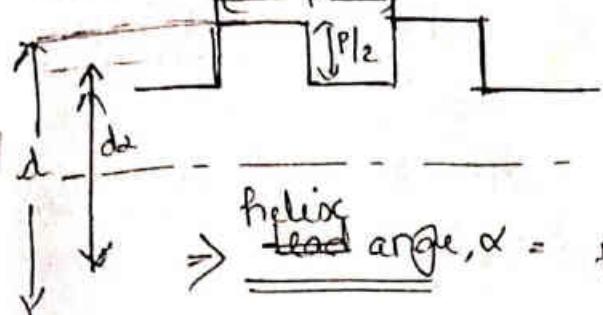
Axial force = 4000 N
O.D of collar = 120 mm, I.D of collar = 60 mm.

$$f_s = 0.15, f_c = 0.12$$

Speed of screw = 40 rpm

$$\text{Pitch diameter } d_2 = d - \frac{P}{2}$$

$$d_2 = 50 - \frac{8}{2} = 46 \text{ mm}$$



$$\Rightarrow \text{lead angle, } \alpha = \tan^{-1} \left[\frac{n_p}{\pi d_2} \right]$$

$$\alpha = \tan^{-1} \left[\frac{8}{\pi \times 46} \right] = 3.168^\circ$$

$$\alpha = \tan^{-1} \left[\frac{n_p}{\pi d_2} \right]$$

$$\text{Friction angle of screw, } \phi = \tan^{-1} [f_s]$$

$$\phi = \tan^{-1} [0.15] = 8.5301$$

$$\text{Pg. 135 Eq. 9.12(a)}$$

$$T = \frac{Wl}{2} [d_2 \tan(\phi + \alpha) + f_c d_2]$$

$$d_2 - \text{mean dia. of collar} = \frac{I.D + O.D}{2} = \frac{60 + 120}{2} = 90 \text{ mm}$$

$$T = \frac{4000}{2} [46 \tan(8.5301 + 3.168) + 0.12 \times 90]$$

$$T = 40650.107 \text{ Nmm}$$

$$P = T \times \omega = \frac{2\pi NT}{60}$$

$$= \frac{2\pi \times 40 \times 40650.107 \times 10}{60}$$

$$\text{also, Pg. 50 } 3.3(a)$$

$$T = \frac{9.55 \times 10^6 (P)}{n}$$

$$P =$$

$$\text{Pg. 135 Eqn: 9.12(b)}$$

$$\text{efficiency : } \eta =$$

$$\frac{1}{\pi [d_2 \tan(\alpha + \phi) + f_c d_2]} \rightarrow \begin{cases} \text{instead use} \\ \frac{d_2 \tan \alpha}{d_2 \tan(\alpha + \phi) + f_c d_2} \end{cases}$$

$$= \frac{1}{\pi [46 \tan(8.5301 + 3.168) + 0.12 \times 90]}$$

$$\eta = \frac{46 \tan(3.168)}{46 \tan(3.168 + 8.5301) + 0.12 \times 90} = 12.52\%$$

Q1) A square threaded power screw has nominal dia. 30 mm
pitch = 6 mm of double thread, load = 6 kN to turn dia.
of thread collar = 40 mm. $f_s = 0.1$, $f_c = 0.09$. Qlumini

- a) T required to raise the screw c) overall efficiency
b) T required to lower the screw d) if the screw self locking

$$\Rightarrow d = 30 \text{ mm}, W = 6000 \text{ N} \quad \left. \begin{array}{l} h_n = 2 \text{ (double start)} \\ \text{Given} \end{array} \right\}$$

$$P = 6 \text{ mm}, d_c = 40 \text{ mm}$$

$$f_s = 0.1, f_c = 0.09$$

$$\text{helix angle } \alpha = \tan^{-1}\left(\frac{\pi n P}{\pi d_2}\right) = \tan^{-1}\left(\frac{2 \times 6}{\pi \times 27}\right) = \underline{8.052^\circ}$$

$$d_2 = \underline{d - P/2} = 30 - \frac{6}{2} = \underline{27 \text{ mm}}$$

$$\text{friction angle } \phi = \tan^{-1}(0.1) = \underline{5.7105^\circ}$$

a) Torque required to raise screw, $T = \frac{W}{2} [d_2 \tan(\phi + \alpha) + f_c d_c]$

$$T = 3000 [27 \tan(8.052 + 5.7105) + 0.09 \times 40]$$

$$T = \underline{30639.304 \text{ Nmm}}$$

b) T required to lower the screw, $T = \frac{W}{2} [d_2 \tan(\phi - \alpha) + f_c d_c]$

$$T = 3000 [27 \tan(5.7105 - 8.052) + 0.09 \times 40]$$

$$T = \underline{7487.938 \text{ Nmm}}$$

c) efficiency, $\eta = \frac{d_2 \tan \alpha}{d_2 \tan(\alpha + \phi) + f_c d_c}$

$$= \frac{27 \times \tan(8.052)}{27 \tan(8.052 + 5.7105) + (0.09 \times 40)}$$

$$\eta = \underline{37.39 \%} \quad (\text{if } \eta < 50\%)$$

\checkmark hence self locking