COLLEGE OF ENGINEERING & TECHNOLOGY

Department : MECHANICAL & MARINE ENG. DEP.
Lecturers : Teaching Staff
Course : Machine Design I
Course No. : ME 356 **Marks: 40**
Date : 14/1/2016 **Time : 2:00- 4:00**

1- The cutter of a broaching machine is pulled by square threaded screw of 55mm external diameter and 10mm pitch. The operating nut is 70mm in height. The collar takes the axial load of 50kN on a flat surface of 60mm and 90mm internal and external diameters respectively. If the coefficient of friction is 0.15 for all contact surfaces on the nut and the collar, determine the power required to rotate the power screw when the cutting speed is 6m/min. Also, find the efficiency of the screw and the bearing stress on the threads. **(10 marks)** $d_{mc} = (\frac{d_{oc} + d_{ic}}{2})$

$v = N(rpm) * p$, $\sigma_{br} = -\frac{2F}{\pi d_m n_t p}$ and $T = W\left[r_m\left(\frac{L + \pi\ \mu\ d_m \sec\alpha}{\pi d_m - \mu\ L \sec\alpha}\right) + \mu_c r_{mc}\right]$

square thread $P = d_o - d_i$ $\sec\alpha = 1$ $L = P$

$d_o = 55\ mm$ $P = 10\ mm$ $d_i = 45\ mm$

$H = 70\ mm$ $W = 50KN = 5 * 10^4\ N$

$d_{ic} = 60\ mm$ $d_{oc} = 90\ mm$ $d_{mc} = \frac{60+90}{2} = 75\ mm$

$\mu = \mu_c = 0.15$ power = ?? $V = 6\ \frac{m}{min} * \frac{1min}{60sec} = 0.1\ m/s$

$\eta = ??$ $\sigma_{br} = ??$ $d_m = \frac{d_i + d_o}{2} = \frac{45+55}{2} = 50\ mm$

soln $T = W\left[r_m\left(\frac{L + \pi\mu\, d_m \sec\alpha}{\pi d_m - \mu L \sec\alpha}\right) + \mu_c r_{mc}\right]$

$T = 5*10^4\left[\frac{50}{2}\left(\frac{10 + \pi * 0.15 * 50 * 1}{\pi * 50 - 0.15 * 10 * 1}\right) + 0.15 * \frac{75}{2}\right]$

$= 550902.46\ N.mm$

$= 550.9\ N.m$

power $= T\omega$

$V = N\ P$

$$6\ \frac{m}{min} = N\ \frac{rev.}{min} * 10*10^{-3}\ m \quad \therefore N = 600\ rpm$$

$$\omega = \frac{2\pi N}{60} = \frac{2\pi * 600}{60} = 62.83\ rad/sec$$

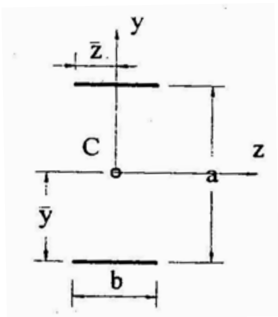
$$power = 550.9 * 62.83 = 34614.19\ watt = 34.6\ KW$$

$$T_o = \frac{WL}{2\pi} = \frac{5*10^4 * 10}{2\pi} = 79545.46\ N.mm$$

$$\eta = \frac{T_o}{T} = \frac{79545.46}{550902.46} = 0.144$$

$$\sigma_{br} = \frac{-2W}{\pi d_m H} = \frac{-2*5*10^4}{\pi * 50 * 70} = 9.09\ MPa$$

1- A bracket as shown in figure 1 carries a load of 10 KN. Find the size of the weld if the allowable shear stress is not to exceed 80MPa. **(10 marks)**



$\bar{z} = b/2$

$\bar{y} = a/2$

$I_u = ba^2/2$

$J_u = b(3a^2 + b^2)/6$

$A_w = 1.414hb$

h = weld thickness

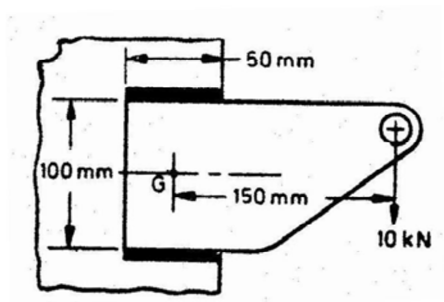
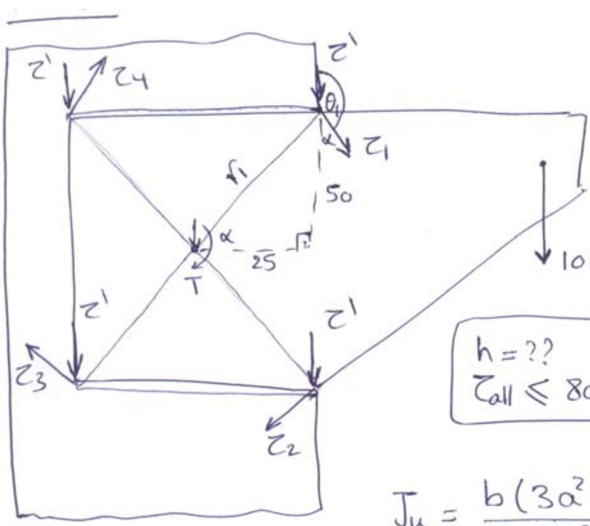


Figure 1.



$h = ??$
$\tau_{all} \leq 80MPa$

بسم الله

$b = 50\ mm$

$a = 100\ mm$

$\bar{y} = \frac{a}{2} = 50\ mm$

$\bar{z} = \frac{b}{2} = 25\ mm$

$A_w = 1.414\ hb$

$= 1.414 * 50\ h$

$= 70.7h\ mm^2$

$$J_u = \frac{b(3a^2+b^2)}{6} = \frac{50(3*100^2+50^2)}{6}$$

$$= 270833.33\ mm^3$$

$$T = F * l = 10 * 10^3 * 150 = 1.5 * 10^6 \ \text{N.mm}$$

$$\tau' = \frac{F}{A} = \frac{10 * 10^3}{70.7h} = \frac{141.44}{h}$$

$$r_1 = r_2 = r_3 = r_4 = \sqrt{25^2 + 50^2} = 55.9 \ \text{mm}$$

max. stress point ①

$$\alpha = \tan^{-1}\frac{50}{25} = 63.43^\circ \qquad \theta_1 = 180 - \alpha = 116.57^\circ$$

$$\tau_1 = \frac{Tr}{J} = \frac{Tr_1}{J_u * 0.707h} = \frac{1.5 * 10^6 * 55.9}{270833.33 * 0.707h} = \frac{437.9}{h}$$

$$\tau_s = \sqrt{\tau'^2 + \tau_1^2 - 2\tau'\tau_1\cos\theta_1}$$

$$= \sqrt{\left(\frac{141.44}{h}\right)^2 + \left(\frac{437.9}{h}\right)^2 - 2\left(\frac{141.44}{h}\right)\left(\frac{437.9}{h}\right)\cos 116.57^\circ}$$

$$= \frac{516.76}{h} \leq 80$$

$$\therefore h \geq 6.45 \ \text{mm}$$

1- Two steel compression coil springs are to be nested. The outer spring has an inside diameter of 38mm, a wire diameter of 3mm and 10 active coils. The inner spring has an outside diameter of 32mm, a wire diameter of 2.5mm and 13 active coils. The two springs of the assembly have the same free length. If the assembly is loaded by an axial force of 50N and the modulus of rigidity (shear modulus) is 80GPa., calculate:

a- The spring rate of each spring.

b- The deflection of the assembly.

c- The shear stress on each spring. **(10 marks)**

$$C = \frac{D}{d}, \quad K_B = \frac{4C+2}{4C-3}, \quad \tau = K_B\frac{8FD}{\pi d^3}, \quad y = \delta = \frac{8FD^3N}{d^4G}$$

OR $\tau = K_w\frac{8FD}{\pi d^3}, \quad K_w = \frac{4C-1}{4C-4} + \frac{0.615}{C}$

2 Comp. springs in parallel $F = F_1 + F_2$, $\delta = \delta_1 = \delta_2$

$F = 50\ N$

$G = 80\ GPa = 80 * 10^3\ MPa$

outer spring

$D_1 = 38 + 3 = 41$

$d_1 = 3\ mm$

$N_1 = 10$ Coils

inner spring

$D_2 = 32 - 2.5 = 29.5\ mm$

$d_2 = 2.5\ mm$

$N_2 = 13$ Coils

b) $\delta = ??$ of the assembly $\delta = \dfrac{8FD^3N}{d^4G}$ $\therefore F = \dfrac{\delta d^4 G}{8D^3N}$

$$F = F_1 + F_2$$

$$50 = \frac{\delta d_1^4 G}{8D_1^3 N_1} + \frac{\delta d_2^4 G}{8D_2^3 N_2}$$

$$50 = \frac{\delta (3)^4\ 8*10^4}{8(41)^3 * 10} + \frac{\delta\ (2.5)^4 * 8*10^4}{8(29.5)^3\ (13)} = 1.18\delta + 1.17\delta$$

$$50 = 2.35\ \delta \qquad \therefore \delta = 21.28 \text{ mm}$$

$$F_1 = \frac{\delta d_1^4 G}{8D_1^3 N_1} = \frac{21.28 * (3)^4 * 8*10^4}{8(41)^3 * 10} = 25.1 \text{ Newton}$$

$$F_2 = \frac{\delta d_2^4 G}{8D_2^3 N_2} = \frac{21.28 * (2.5)^4 * 8*10^4}{8(29.5)^3 * 13} = 24.9 \text{ Newton}$$

a) spring rate $K = ??$

$$F = K\delta \qquad \therefore K = \frac{F}{\delta}$$

$$K_1 = \frac{F_1}{\delta} = \frac{25.1}{21.28} = 1.1755 \quad N/mm$$

$$K_2 = \frac{F_2}{\delta} = \frac{24.9}{21.28} = 1.17 \quad N/mm$$

c) $\tau = ??$ on each spring

$$C_1 = C_{outer} = \frac{D}{d} = \frac{41}{3} = 13.67$$

$$C_2 = C_{inner} = \frac{D}{d} = \frac{29.5}{2.5} = 11.8$$

$$K_{B1} = \frac{4C_1 + 2}{4C_1 - 3} = \frac{4 * 13.67 + 2}{4 * 13.67 - 3} = 1.097$$

$$K_{B2} = \frac{4C_2 + 2}{4C_2 - 3} = \frac{4 * 11.8 + 2}{4 * 11.8 - 3} = 1.11$$

$$\tau_1 = K_{B1}\frac{8F_1 D_1}{\pi d_1^3} = 1.097 * \frac{8*25.1*41}{\pi\ (3)^3} = 106.5\ MPa$$

$$\tau_2 = K_{B2}\frac{8F_2 D_2}{\pi d_2^3} = 1.11 * \frac{8*24.9*29.5}{\pi\ (2.5)^3} = 132.88\ MPa$$

c) $\tau = ??$ for each spring using K_w

$$K_{w1} = \frac{4C_1-1}{4C_1-4} + \frac{0.615}{C_1}$$

$$= \frac{4(13.67)-1}{4(13.67)-4} + \frac{0.615}{13.67} = 1.1$$

$$K_{w2} = \frac{4*11.8-1}{4*11.8-4} + \frac{0.615}{11.8} = 1.12$$

$$\tau_1 = K_{w1}\frac{8F_1 D_1}{\pi d_1^3} = \frac{1.1*8*25.1*41}{\pi*(3)^3} = 106.45\ MPa$$

$$\tau_2 = K_{w2}\frac{8F_2 D_2}{\pi d_2^3} = \frac{1.12*8*24.9*29.5}{\pi\ (2.5)^3} = 134.52\ MPa$$

2- Determine the size of the foundation bolts for a 50KN pillar crane of figure 2, assuming that the base is of a square shape and there are 3 bolts in each row. The dimensions are in meters and the allowable tensile stress of bolts material is 120MPa. **(10 marks)**

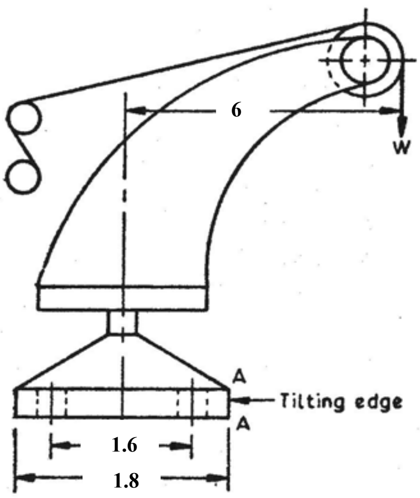


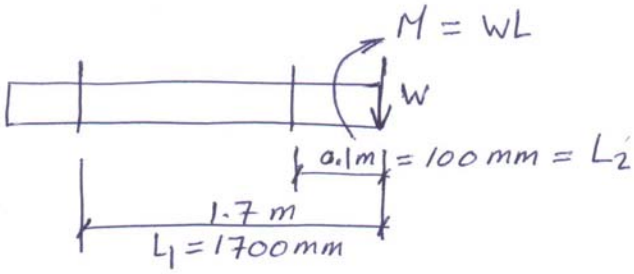
Figure 2.

$W = 50\ KN = 5 * 10^4$ Newton $\qquad d = ??$

square shape base & 3 bolts in each row

$\sigma_{all} = 120\ MPa$

<u>soln</u>



$M = 3F_1 L_1 + 3F_2 L_2$

$5*10^4 * (6000 - 900) =$

$3F_1 * 1700 + 3F_2 * 100$

$17F_1 + F_2 = 0.85 * 10^6 \longrightarrow ①$

$\frac{F_1}{L_1} = \frac{F_2}{L_2} \quad \therefore \quad \frac{F_1}{1700} = \frac{F_2}{100} \quad \therefore F_1 = 17F_2 \longrightarrow ②$

$17 * 17 F_2 + F_2 = 0.85 * 10^6 \quad \therefore F_2 = 2931.03$ Newton

$F_1 = 17 F_2 = 49827.59$ Newton

$\sigma_t = \frac{F_1}{A} = \frac{49827.59}{\frac{\pi}{4}(0.85d)^2} \leqslant \sigma_{all}$

$\frac{49827.59}{0.567 d^2} \leqslant 120$

$d \geqslant 27.05\ mm \qquad \therefore d = 28\ mm$