Question (1)

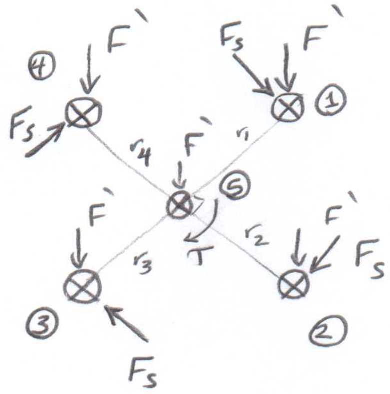
$F = 2000\ N$ ، $n = 5$ ، $\tau_{max} = 150\ MPa$ ، $L = 240\ mm$

d_{min} ؟

sol

$$T = F * L = 2000 * 240 = 480 * 10^3\ N.mm$$

$$T = 4 F_s r_1 \quad (\text{as } r_1 = r_2 = r_3 = r_4)$$



$$\boxed{r_1 = 20\sqrt{2}\ mm}$$

$$F_s = \frac{T}{4 r_1} = \frac{480 * 10^3}{4 * 20\sqrt{2}}$$

$$F_s = 4242.6\ N$$

$$\theta = 45^\circ$$

primary shear

max stress on ① or ②

$$F` = \frac{F}{n} = \frac{2000}{5}$$

$$F` = 400\ N$$

$$F_{total} = \sqrt{F`^2 + F_s^2 + 2 F` F_s \cos\theta}$$

$$F_{total} = \sqrt{(4242.6)^2 + (400)^2 + 2 * 4242.6 * 400 \cos 45}$$

$$F_{total} = 4534.3\ N$$

$$\therefore \tau_{max} = \frac{F_{total}}{A_{bolt}} = \frac{F_{total}}{\frac{\pi}{4} d_i^2} \Rightarrow 150 = \frac{4534.3}{\frac{\pi}{4} d_i^2}$$

$d_i = 6.2\ mm \Rightarrow d_i = 0.85\ d_o \Rightarrow d_o = 7.3\ mm$ $\quad d_o = 8\ mm$

if $L\downarrow$ $T\downarrow$ $F_s\downarrow$ $F_{total}\downarrow$ $\therefore A_{bolt}\downarrow$ $d_o\downarrow$

Question (2)

$n = 1$ ، $d_m = 50 \text{ mm}$ ، $P = 12.5 \text{ mm} = L$ ، $W = 10 * 10^3 N$

$d_{m_c} = 60 \text{ mm}$ ، $\mu = 0.15$ ، $\mu_c = 0.18$ ، $f_{handle} = 100 N$

Req: D_{wheel} ? ، η ? ، check ?

sol

for square threads $\alpha = \text{Zero}$ $\sec\alpha = 1$

$$T = W * \frac{d_m}{2}\left[\frac{\pi \mu d_m + L}{\pi d_m - \mu L}\right] + \frac{\mu_c W d_{m_c}}{2}$$

$$T = 10*10^3 * \frac{50}{2}\left[\frac{\pi * 0.15 * 50 + 12.5}{\pi * 50 - 0.15 * 12.5}\right] + \frac{0.18 * 10 * 10^3 * 60}{2}$$

$$T = 58087.7 + 54000$$

$$\boxed{T = 112.1 * 10^3 \text{ N.mm}}$$

$$T_o = \frac{WL}{2\pi} = \frac{10*10^3 * 12.5}{2\pi} \Rightarrow \boxed{T_o = 19.9 * 10^3 \text{ N.mm}}$$

$$\eta = \frac{T_o}{T} = \frac{19.9*10^3}{112.1*10^3} \Rightarrow \boxed{\eta = 17.8\ \%}$$

$$\because T = f_{handle} * L_{handle} \Rightarrow L_{hand} = \frac{112.1 * 10^3}{100} = 1121 \text{ mm}$$

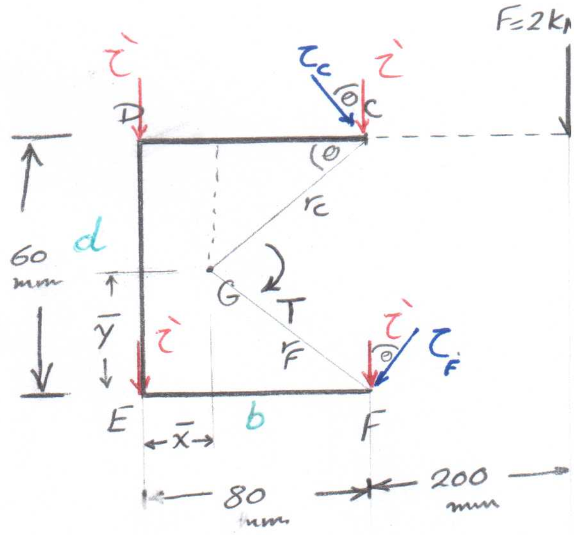
$$\boxed{L_{hand} = 1.12 \text{ m}}$$

check

$$\pi d_m \mu = \pi * 50 * 0.15 = 23.6 \text{ mm}$$

$\because L < \pi d_m \mu$ (self locking)(overhauling)

Question (3) $\quad \tau_{max} = 120\ MPa \quad , h = 6\ mm$



Max stress on C or F as r_{max} & θ_{min}

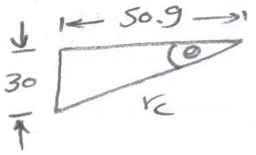
from table $\quad b = 80\ mm \quad , d = 60\ mm$

$$\bar{x} = \frac{b^2}{2b+d} = \frac{(80)^2}{(2*80)+60} = 29.1\ mm$$

$$A = 0.707\,h*(2b+d) = 0.707*6(220)$$

$$A = 933.24\ mm^2$$

$$J_u = \frac{8(80)^3 + (6*80*3600) + (60)^3}{12} - \frac{(80)^4}{160+60} = 317.15*10^3\ mm^3$$



$$\because\ \tau' = \frac{F}{A} = \frac{2000}{933.24}$$

$$\boxed{\tau' = 2.14\ MPa}$$

$$\because\ \tau_c = \frac{Tr}{J} = \frac{T r_c}{0.707\,h J_u} \qquad r_c = \sqrt{(50.9)^2 + (30)^2} = 59.1\ mm$$

$$T = F*(200+80-\bar{x}) = 2000*(280-29.1)$$

$$T = 501.8*10^3\ N.mm$$

$$\tau_c = \frac{501.8*10^3*59.1}{0.707*6*317.15*10^3} = 22.04\ MPa \Rightarrow \boxed{\tau_c = 22.04\ MPa}$$

$$\tan\theta = \frac{30}{50.9} = 0.59 \Rightarrow \theta = 30.5^\circ$$

$$\tau_{max} = \sqrt{\tau'^2 + \tau_c^2 + 2\tau'\tau_c \cos\theta}$$

$$\tau_{max} = \sqrt{(2.14)^2 + (22.04)^2 + 2*2.14*22.04*\cos 30.5}$$

$$\boxed{\tau_{max} = 24\ MPa}$$

There is no need to add another weld on CF side

as $\tau_{stress} < \tau_{max}$ available

Question (4) Plain , $F_{max} = 620\ N$, $\delta = 30\ mm$, $C = 6 = \frac{D}{d}$

$\tau_{all} = 570\ MPa$, $G = 70 * 10^3\ MPa$

Req. d , $K_{stiffness}$, N , Solid , free length if $P = 8\ mm$

sol

The wahl factor $K = \frac{4*6-1}{4*6-4} + \frac{0.615}{6} = 1.25$

$\because \tau = K \frac{8FD}{\pi d^3} = K \frac{8FC}{\pi d^2}$

$570 = \frac{1.25 * 8 * 620 * 6}{\pi d^2} \Rightarrow \boxed{d = 4.6\ mm}$ $C = \frac{D}{d} = 6 \Rightarrow D = 27.6\ mm$

$\because K_{stiff} = \frac{F}{\delta} = \frac{620}{30} \Rightarrow \boxed{K_{stiff} = 20.7\ N/mm}$

$\because \delta = \frac{8FD^3N}{Gd^4} \Rightarrow$

$N = \frac{30 * 70 * 10^3 * (4.6)^4}{8 * 620 * (27.6)^3} \Rightarrow N = 9.02 \Rightarrow \boxed{N = 10\ turns}$

Solid length $= (n+1)d = 11 * 4.6 \Rightarrow \boxed{\text{Solid length} = 50.6\ mm}$

Free length $= (P*n) + d = (8*10) + 4.6 \Rightarrow \boxed{\text{free length} = 84.6\ mm}$