MD-1 ASSIGNMENT No.

Q.) Design rigid type flange coupling two connect two shafts. Input shaft transmits 37.5 kW of power at 180 RPM. Service factor is 1.5, ie. design torque is 1.5 times rated torque. Select suitable materials for various parts of coupling. Design coupling and specify dimensions of components.

Data: $P = 37.5\ kW$, $N = 180\ RPM$

$$P = \frac{2\pi N T}{60}$$

$$T = \frac{60 \times 37.5 \times 10^3}{2\pi \times 180\cancel{0}}$$

$$T_{\cancel{max}} = 1989436.78\ N\,mm$$

Shapes are subjected to torsional shear stress and hence strength becomes criteria for ~~&~~ selection of material on basis of strength. Plain Carbon Steel of grade 40C8 (C40) ($S_{yt} = 380\ N/mm^2$) is used for shaft (PSG 1.11)

Factor of safety is assumed to be 2.5

Key and bolts are subjected to compressive shear stresses, on basis of strength, material is 30C8.
F.o.S = 2.5. (PSG 1.11)

Flanges have complex shape and easiest method to make flanges is casting. Material selected is grey cast iron G.C.I = 20, $S_{ut} = 200\ N/mm^2$ (PSG 1.4.)

From manufacturing considerations point of view,

(A) For casting F.S = 6

∴ Permissible stresses:

(1) For shaft; $\tau = \frac{0.5 \times 380}{2.5} = 76 N/mm^2$

(2) Keys and bolts:

$\tau = \frac{0.5 \times 400}{2.5} = 80 N/mm^2$

$\sigma_c = 1.5\ \sigma_t = \frac{1.5 \times 400}{2.5} = 240 N/mm^2$

(3) Flanges:

$\tau = \frac{0.5 \times S_{yt}}{6} = \frac{0.5 \times 200}{6} = 16.67 N/mm^2$

(1) For Shaft design

$T_{max} = 1.5\ T_0$

↑ Service factor

$= 1.5 \times 1989436.78$

$\boxed{T_{max} = 2984155.17\ Nmm}$

~~(3) For Shaft~~ Design

$T_{max} = \frac{\pi}{16} \times \tau_{shaft} \times d^3$

$2984155.17 = \frac{\pi}{16} \times 76 \times d^3$

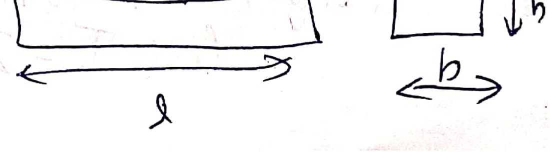
$d = 58.47 mm$

(Shaft diameter) → $\boxed{d = 60 mm}$

(2) Key Selection: [PSG 5.16]

For $d = 60mm$,

$b = W = 18mm$, $h = t = 11mm$, $L = 1.5 \times d = 90$



(a) Crushing of key:

$mm^3 \times N/mm$

$T_{max} = l \times \sigma_c \times \frac{d}{2} \times \frac{b}{2}$

N mm

$\sigma_c = \frac{\cancel{28}\ 2984155.17 \times 2 \times 2}{90 \times 60 \times 11} = \cancel{X004.76}$

$= 200.95\ N/mm^2$

$200.95 < 240 N/mm^2$

Safe!!

(b) Shearing of key:

$T_{max} = l \times w \times \tau \times \frac{d}{2}$

$2984155.17 = 90 \times 18 \times \tau \times \frac{60}{2}$

$\tau = 61.40 N/mm^2$

$61.40 < 80 N/mm^2$

Safe!!

(3) Hub Design/Flange $D = 2d = 2 \times 60 = 120$ (emphirical)

(a) Torsional shear:

$T_{max} = \frac{\pi}{16} \times \tau \times D^3 [1 - k^4]$ $\therefore k = 0.5$

$2984155.17 = \frac{\pi}{16} \times \tau \times 120^3 [1 - 0.5^4]$

$\tau = 9.381$

$9.381 < 16.67 N/mm^2$

Thickness of hub:

$t = 1.5 \times d$

$t = 1.5 \times 60$

$t_h = 90$

Flange:

thickness of ~~hub~~ flange $= 0.5 \times d = 0.5 \times 60 = 30\,mm$

$n = 4$ as d $40 < d < 100$ $(d = 60)$

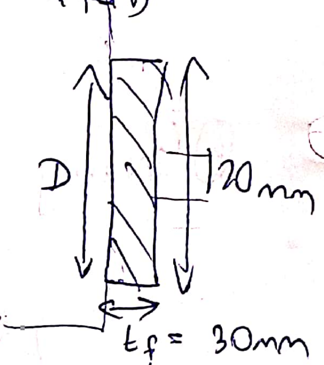
~~Outher~~ diameter of flange

(1) Shearing of flange at junction of hub

Diameter of hub

Area resisting $= \pi \times D \times t_f$

$T_{max} = \pi \times D \times t_f \times \tau \times \frac{D}{2}$



$\tau = \frac{2984155.17 \times 2}{\pi \times 120^2 \times 30}$

$\tau = \cancel{17.67} \; 4.39\,N/mm^2$

$= \cancel{88}$

$\cancel{17.67} < 4.39 < 16.67\,N/mm^2$

(4) Selection of Bolts:

$PCD = D_1 = 3 \times d = 3 \times 60 = 180\,mm$

(1) Shear failure of Bolts:

$T_{max} = \left(\frac{\pi}{4} \times d_b^2\right) \times \tau \times n \times \frac{D_1}{2}$

$2984155.17 = 4 \times \cancel{}\,80 \times \left(\frac{\cancel{60}\,\cancel{90} \times 3}{2}\right) \times \frac{\pi}{4} \times d_b^2$

$d_b = \sqrt{\frac{2984155.17 \times 8}{4 \times 80 \times \cancel{60}\,180 \times \pi}}$

$d_b = 11.486$

$\boxed{d_b = 12\,mm}$ M12 Bolt.

$\cancel{F \times r}$ $P \times A \times r$

$\cancel{\frac{P.F}{r}}$

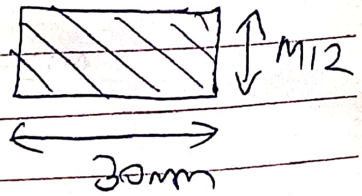
(2) Compressive stress in bolt.

Half of PCD

$\cancel{\sigma_c}$

$$T_{max} = \sigma_c \times A \times r \times n$$

$$= \cancel{\sigma_c \times \frac{\pi}{4} \times d_b^2 \times \frac{D_1}{2} \times n}$$



$$T_{max} = \sigma_c \times d_b \times t_f \times \frac{D_1}{2} \times n$$

$$T = \sigma_c \, N \left(\frac{D_1}{2}\right) A$$

$$A = d_1 \times t.$$

$$\sigma_c = \frac{2 T_{max}}{D_1 \times n \times d_b \times t}$$

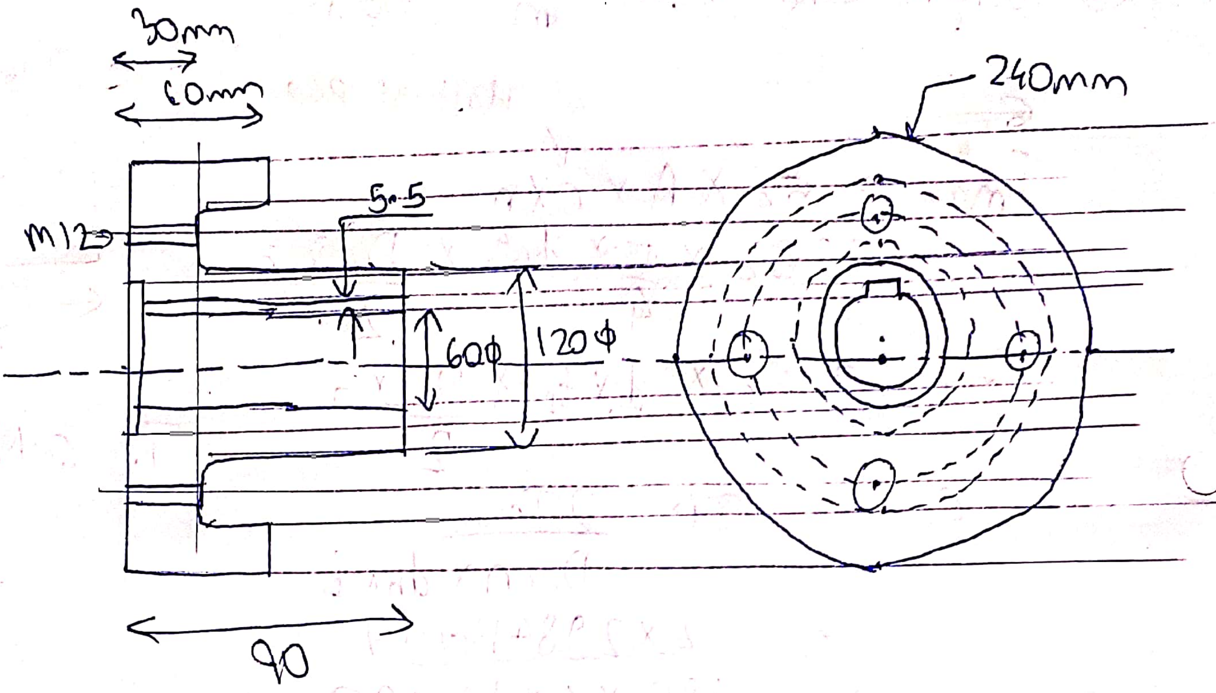
$$= \frac{2 \times 2984144.17}{180 \times 4 \times 12 \times 30}$$

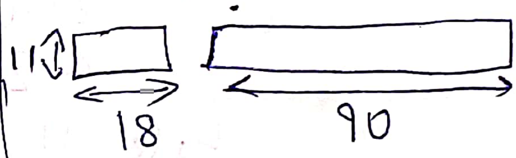
$$\sigma_c = 23.0258 \ N/mm^2$$

$$< 220 \ N/mm^2$$

Safe !!

Design of flange:





Shaft Dia. = $d = 60mm$

Hub Diameter = $d_h = 2d = 2X60 = 120mm$

PCD = $D = 3d = 3X60 = 180mm$

Thickness of flange = $t = 0.5d = 30mm$

Gap inbetween bolt and edge = $0.25d = 15mm$

$= d_r = 1.5d = 90mm$

Outer dia of Flange = $D_o = \cancel{(d+2d_h)}\ 4d = 240mm$