Quiz 2

Soln - 1

For gear A

Shaft diameter d_A = 44.45 mm or r_A = 22.225 mm

from the given table we get $W \times H$ = 14 mm x 9 mm (+1)

~~Torque acting on gear A = $r_A \times F_A \cos 20°$~~

~~= 0.022225 x 1384.466 x 0.9397~~

Torque acting on gear A = $R_A \times F_A \cos 20°$

T_A = 0.254 x 1334.466 x 0.9397

= 318.52 Nm

(+1) T_A or F_{key}

Force acting on the key $F_{key} = T_A / r_A$

= 318.52 / 0.022225

= 14331.61 N

Average direct shear = F_{key} / A_{shear} = $F_{key} / L_s W$

= 14331.61 / $L_s \times 14$ = 1023.69 / L_s N/mm²

for shear failure $\tau_{max} = \frac{\sigma_{ys}}{FoS}$ ($\sigma_{ys} = \sigma_y/2$, $\sigma_{ys} = \sigma_y/\sqrt{3}$)

Using maximum shear stress theory $\sigma_y/2$	Using distortion energy theory $\sigma_y/\sqrt{3}$
$\frac{1023.69}{L_s} = \frac{372}{1.2 \times 2}$	$\frac{1023.69}{L_s} = \frac{372}{1.2 \times \sqrt{3}}$
(+1) L_s	
$\Rightarrow L_s$ = 6.6 mm	L_s = 5.72 mm

Average crushing stress $\sigma_c = F_{key} / A_{crush} = F_{key} / L_c H/2$

$$\Rightarrow \quad \sigma_c = \frac{2 \times 14331.61}{L_c \times 9} = \frac{3184.8}{L_c} \text{ N/mm}^2$$

& for crushing failure $\sigma_{c\,max} = \sigma_y / FOS$

$$\Rightarrow \quad \cancel{318.4} \quad \frac{3184.8}{L_c} = \frac{372}{1.2}$$

+1

or $L_c = 10.27$ mm

∴ length of key for gear A = max (L_s, L_c)

= 10.27 mm ~~= 10.27 mm~~

+1

for gear B

Shaft diameter = 25.4 mm

key's W×H = 8×7 mm^2. (+1)

Torque acting would be same & = 318.5 Nm

Forces acting on the key = T/r_{shaft}

F_B = 25078.7 N (+1) , [2]

Average direct shear for B ≐ τ_B = F_B/LW

= 3134.84 / L N/mm^2

∴ for shear failure $\tau_B = \sigma_y/\sqrt{3} \times FOS$

$$\Rightarrow \frac{3134.84}{L_s} = \frac{372}{\sqrt{3} \times 1.2}$$

(+1) , [3]

L_s = 17.51 mm

using $\left(\frac{\sigma_y}{2}\right)$ L_s = 20.22 mm

Average crushing stress = $\sigma_{B\,crush}$ = $2F_B/LH$

= 7165.34 / L N/mm^2

∴ for crushing failure $\sigma_{B\,crush} = \sigma_y/$ FOS

$$\Rightarrow \frac{7165.34}{L_c} = \frac{372}{1.2}$$

or $L_c = 23.11$ mm (+1)

$\therefore$ length of key for gear B = max (L_s , L_c)

= 23.11 mm. (+1)

ME 423 Quiz 2

2) Given :- Desired life = L_{10h} = 5000 hrs
Speed = N = 1500 rpm
Load Application factor = K_a = 1.2
F_A = 1334.466 N

To find :- C_{10} for bearing at 'O' and 'C'

Solution :- For given shaft system.

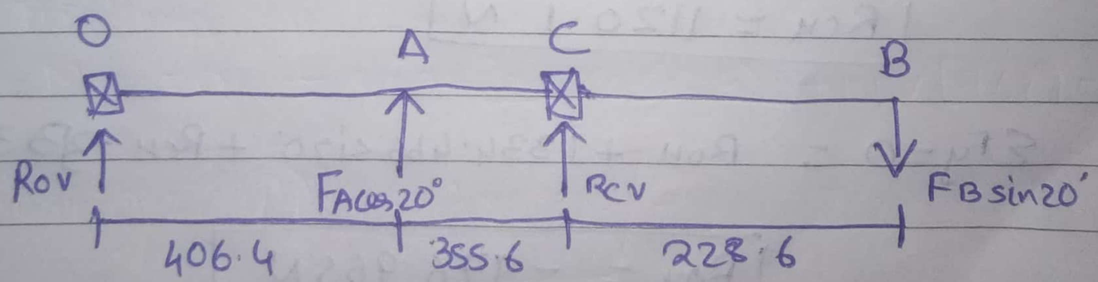
$$\text{Torque A} + \text{Torque B} = 0$$

$$F_A \cos 20^\circ \times \frac{508}{2} - F_B \times \cos 20^\circ \times \frac{203.2}{2} = 0$$

$$F_B = \frac{F_A \times 508}{203.2} = \frac{1334.466 \times 508}{203.2}$$

$$\boxed{F_B = 3336.165\ N}$$

Now vertical loading diagram.



$$\Sigma M_O = F_A \cos 20^\circ \times 406.4 + R_{cv}(762) - F_B \sin 20 (990.6) = 0$$

$$R_{cv} = \frac{3336.165 \times \sin 20 \times 990.6 - 13334.466 \times \cos 20^\circ \times 406.4}{762}$$

$$\boxed{R_{cv} = 3669.018\ N}$$

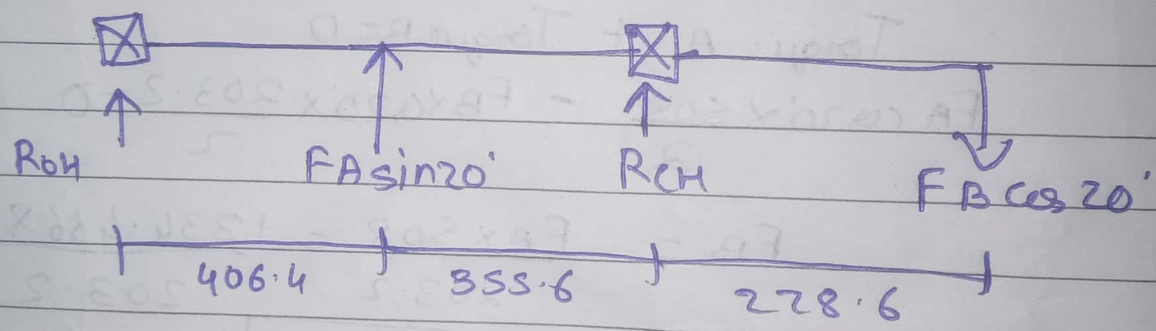
Date

$\Sigma F_y = 0 \qquad R_{OV} + F_A \cos 20^\circ + R_{CV} - F_B \sin 20^\circ = 0$

$R_{OV} = 3336.165 \sin 20^\circ - 1334.466 \cos 20^\circ$
$- 3669.08$

$\boxed{R_{OV} = -1167.85 \text{ N}}$

Horizontal loading diagram :-



$\Sigma M_O = 0 = 1334.466 \times \sin 20^\circ \times 406.4 + R_{CH} \times 762$
$- 3336.165 \times 990.6 = 0$
$\cos 20^\circ$

$\boxed{R_{CH} = 1120.1 \text{ N}}$

$\Sigma F_y = 0 = R_{OH} + 1334.466 \sin 20^\circ + R_{CH} - 3336.165 \cos 20^\circ = 0$

$\boxed{R_{OH} = -976.965 \text{ N}}$

CamScanner

$\therefore$ Radial load at 'O' $= \sqrt{R_{OH}^2 + R_{OV}^2}$

$= \sqrt{(-976.965)^2 + (-1167.85)^2}$

$$\boxed{R_O = 1522.61 \text{ N}}$$

Radial load at 'C' $= \sqrt{R_{CH}^2 + R_{CV}^2}$

$= \sqrt{(1120.1)^2 + (3669.018)^2}$

$$\boxed{R_C = 3836.185 \text{ N}}$$

$\therefore$ Equivalent ~~eq.~~ dynamic load on Bearing 'O', 'C'

$P_{eo} = K_a R_O = 1.2 \times 1522.61$
$= 1827.132 \text{ N}$

$P_{ec} = K_a R_C = 1.2 \times 3836.185$
$= 4603.422 \text{ N}$

Now for bearing $L_{10} = \dfrac{L_{10h} \times N \times 60}{10^6}$ million rev

$= \dfrac{5000 \times 1500 \times 60}{10^6}$

$= 450$

$L_{10} = \left(\dfrac{C}{P_e}\right)^3$ for ball bearing.

for Bearing 'O' $\quad 450 = \left[\dfrac{C}{1827.132}\right]^3 \quad C = 14.001 \text{ kN}$

for Bearing 'C' $\quad 450 = \left[\dfrac{C}{4603.422}\right]^3 \quad C = 35.276 \text{ kN}$

$a = 3$ (roller Bearing)

Q3 Bearing A →

$F_A = 2\,kN$

$L_A = 3000 \times 500 \times 60$ cycles

$= 9 \times 10^7$ cycles

Bearing B

$C_B = 7\,kN$

$L_B = 10^6$ cycles

To compare the both, they need to be rated in terms of the same Catalog rating system. (10^6 cycles)

$$C_A = F_A \times \left(\frac{L_A}{L_B}\right)^{1/a} = 2 \times \left(\frac{9 \times 10^7}{10^6}\right)^{1/3} = 8.96\,kN$$

Catalogue rating of Bearing A for 10^6 cycles is 8.96 kN

Catalogue rating of Bearing B for 10^6 cycles is 7.0 kN

$\boxed{C_A > C_B}$

∴ Bearing A can carry the larger load.

→ Calculation of number of cycles → 1 mark

→ using $L_{10} C_{10}^3 = $ Constant → 1 mark

→ Finding $(C_{10})_A$ or $L_{10} C_{10}^3 = \boxed{\text{Constant}}$ → 1 mark

(calculation of constant)

→ Final Comparision of Bearing A & B → 1 mark

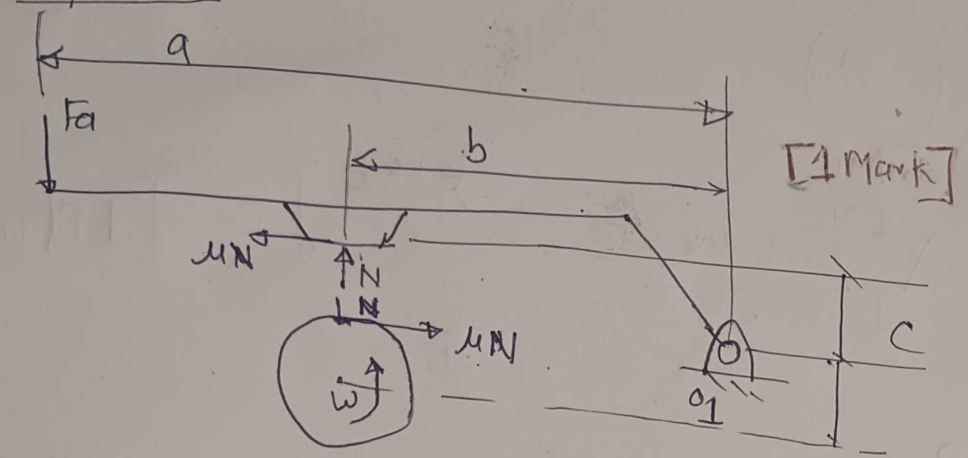
Quiz2

[Q.4]

Partial FBD

FBD

Top Shoe



given

$a = 90$

$b = 80$

$e = 30$

$r = 40$

$w = 60$

$\theta = 25^\circ$

$P_{max} = 1.5\ MPa$

$\mu = 0.25$

① Normal reaction $N = PA = (r\theta w) = 1570.796\,(N) \rightarrow$ [1 Mark]

② $T_f = \mu N r = 15.708\,(Nm)$ [1 Mark]

③ $c = r - e = 40 - 30 = 10$

$+\circlearrowleft \Sigma M_{O1} = 0$

$+(Fa \cdot a) - (Nb) + \mu N c = 0$; $Fa = \dfrac{N(b - \mu c)}{a} = 1352.63\,(N)$

[1 Mark]

④ Self lock

If $\mu c \geq b$

here

$\mu c = 0.25 \times 10 = 2.5$

$b = 80 \Rightarrow \quad \because \mu c \not\geq b \Rightarrow$ no self lock.

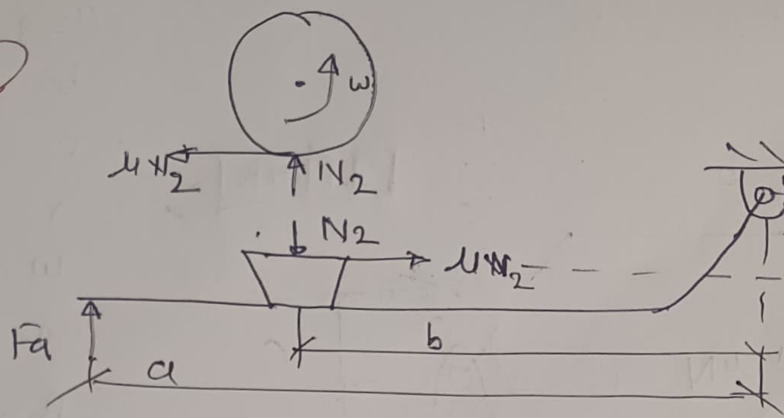
⑤ Value of c for self lock $= b/\mu = 80/0.25 = 320\,(mm)$

[1 Mark]

⑥ bottom Shoe :-

Partial FBD

FBD



[1 Mark]

$+\circlearrowleft \Sigma M_{O_2} = 0$

$-[Fa \cdot a] + [N_2 \cdot b] + [\mu N_2 c] = 0$;

$Fa = \frac{N_2(b+\mu c)}{a} \Rightarrow N_2 = Fa \cdot \left[\frac{a}{b+\mu c}\right]$

$N_2 = 1475.596$ (N) [1 Mark]

⑦ $T_2 = (\mu N_2 r) = 14.7559$ (N m) $\simeq 14.756$ (Nm) [1 Mark]

⑧ total torque Capacity $= T_1 + T_2 = 30.464$ (N m) [2 Mark]