Pooja Singh
1807012 5060

Assignment - 9

MB-1

$P = 12.5\ KW$ | $BHN = 450$ | $\varphi = 23°$

$n_p = 1440\ rpm$ | $C_s = 1.5$ | $\alpha = 20°$

$z_1 = 20$ | Grade $= 6$

$z_2 = 60$ | $b = 10m$

$z_3 = 25$ | $b = 10m_n$

$z_4 = 50$ | $C = 11400\ N/mm^2$

$S_{ut} = 750\ N/mm^2$ | I_v of spur $= 5\ m/s$

$FOS = 1.55$ | I_v of Helical $= 10\ m/s$

For stage 1 $\sigma_b = \frac{750}{3} = 250\ N/mm^2$

$i = \frac{z_g}{z_p} = \frac{\cancel{60}^{3}}{\cancel{20}}$

$v = 5m/s$; $C_v = \frac{3}{3+5} = \frac{3}{8} = 0.375$

Based on Beam Strength

$$m = \left[\frac{60 \times 10^6}{\pi} \left\{ \frac{12.5 \times 1.5 \times 1.55}{20 \times 1440 \times 0.375 \times \frac{10m}{m} \times 250 \times 0.320} \right\} \right]^{1/3}$$

$\boxed{m = 4.00}$

Based on Wear Strength

$$Q = \frac{2z_g}{z_p + z_g} = \frac{2 \times 60}{20 + 60} = \frac{120}{80} = 1.5$$

$$K = 0.16 \left(\frac{450}{100} \right)^2 = 3.24$$

$$m = \left[\frac{60 \times 10^6}{\pi} \left\{ \frac{12.5 \times 1.5 \times 1.55}{(20)^2 \times 1440 \times 0.375 \times \frac{10m}{m} \times 1.5 \times 3.24} \right\} \right]^{1/3}$$

$\boxed{m = 3.75 \approx 4}$

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$m_b > m_w$ (~~so~~ $m = 5$)

Dimensions are

$d_p = 5 \times 20 = 100$ mm

$d_g = 5 \times 60 = 300$ mm

$b = 5 \times 10 = 50$ mm

$S_b = m \times b \times \sigma_b \times y$

$= 5 \times 50 \times 250 \times 0.320$

$= 20,000$

$S_w = b\, Q\, d_p\, k$

$= 50 \times 1.5 \times 100 \times 3.24$

$= 24300$

$S_w > S_b$

so for FOS cal^n we use S_b

~~Peff~~ $M_t = \dfrac{60 \times 10^6 \times 12.5}{2 \times \pi \times 1440} = 82893.19953$

$P_t = \dfrac{2M_t}{d_p} = 1657.864$

$P_d = \dfrac{21v\,(Ceb + P_t)}{21v\,(\sqrt{(Ceb + P_t)})}$

for Grade 6.

$e_p = 8.00 + 0.63\,\phi$

$\phi = m + 0.25\sqrt{d}$

$\phi_p = 5 + 0.25\sqrt{100} = 7.5$

$e_p = 8 + 0.63 \times 7.5 = 12.725$

$e_g = 8.00 + 0.63\,\phi$

$\phi = 5 + 0.25\sqrt{300} = 9.33$

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$e_g = 8 + 0.63 \times 9.33 = 13.87798$ $V = \frac{\pi d_p n_p}{60 \times 10^3}$

Total $e = 26.803 \times 10^{-3}$ mm $V = 7.54$ m/s

$$P_d = \frac{21 \times 7.54 \left(11400 \times 26.603 \times 10^{-3} \times 50 + 1657.864\right)}{21 \times 7.54 \left(\sqrt{11400 \times 26.603 \times 10^{-3} \times 50 + 1657.864}\right)}$$

$$\frac{158.34 \times (16821.574)}{158.34 + 129.698} = \frac{2663528.027}{288.038} = 9247.14$$

$P_{eff} = C_s P_t + P_d$
$= 1.5 \times 1657.864 + 9247.14$
$= 11733.9371$

So, $FOS = \frac{S_b}{P_{eff}} = \frac{20,000}{11733.94} = 1.7$

Calculated fos > Given fos so Design is safe

For Stage 2 $i = \frac{z_g}{z_p} = \frac{n_1}{n_2} \Rightarrow 3 = \frac{1440}{n_2} \Rightarrow n_2 = \frac{1440}{3} = 480$ rpm

$M_t = \frac{60 \times 10^6 \times 12.5}{2 \times \pi \times 480} = 248679.5986$ N-mm

$d_p = \frac{z_p \times m_n}{\cos\psi} = \frac{25 m_n}{\cos 23^\circ} = 25.16 m_n$ mm

~~$P_t = \frac{2M_t}{d_p} = \frac{249296.586}{25.16 m_n} = \left(\frac{379542.7896}{m_n}\right)$ N~~

$C_v = \frac{5.6}{5.6 + \sqrt{V}} = \frac{5.6}{5.6 + \sqrt{10}} = 0.6391$

Based on Beam Strength

$$m_n = \left[\frac{60\times10^6}{\pi}\left\{\frac{Kw \times Cs \times fos \times \cos\psi}{z_p \times n_p \times C_v \times \frac{S_{ut}}{3} \times \frac{b}{m_n} \times Y}\right\}\right]^{1/3}$$

$$m_n = \left[\frac{60\times10^6}{\pi}\left\{\frac{12.5\times1.5\times1.55\times\cos 23^\circ}{25\times480\times0.6391\times250\times\frac{10 m_n}{m_n}\times Y}\right\}\right]^{1/3}$$

$$z'_p = \frac{z_p}{\cos^3\psi} = \frac{25}{\cos^3 23} = 32.05$$

$$Y = 0.364 + \frac{(0.367-0.364)(32.05-32)}{(33-32)}$$

$$\boxed{Y = 0.36415}$$

$$\boxed{m_n = 4.183 \simeq 5}$$

Based on Wear Strength

$$m_n = \left[\frac{60\times10^6}{\pi}\left\{\frac{Kw\times Cs\times fos\times\cos^4\psi}{z_p^2\times n_p\times C_v\times\frac{b}{m_n}\times Q\times K}\right\}\right]^{1/3}$$

$$m_n = \left[\frac{60\times10^6}{\pi}\left\{\frac{12.5\times1.5\times1.55\times\cos^4(23^\circ)}{(25)^2\times480\times0.6391\times\frac{10 m_n}{m_n}\times1.333\times3.24}\right\}\right]^{1/3}$$

$$Q = \frac{2z_g}{z_g+z_p} = \frac{2\times50}{50+25} = \frac{100}{75} = 1.333$$

$$K = 0.16\left(\frac{BHN}{100}\right)^2 = 0.16\left(\frac{450}{100}\right)^2 = 3.24$$

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$\boxed{m_n = 3.627 \simeq 5}$

So $m_n = 5$

$b = 10 m_n = 10 \times 5 = 50$

$d_p = \frac{z_p m_n}{\cos 23} = \frac{25 \times 5}{\cos 23^\circ} = 135.79$

$d_g = \frac{z_g m_n}{\cos 23} = \frac{50 \times 5}{\cos 23} = 271.59$

$S_b = m_n \times b \times \sigma_b \times Y$

$= 5 \times 50 \times 250 \times 0.36415$

$\boxed{S_b = 22759.375}$

$S_w = \frac{b Q d_p K}{\cos^2 \psi} = \frac{50 \times 1.33 \times 135.79 \times 3.24}{\cos^2 23^\circ}$

$\boxed{S_w = 34528.8631}$

$P_t = \frac{2 M_t}{d_p} = 3662.708574$

$P_d = \frac{21 v (C e b \cos^2 \psi + P_t) \cos \psi}{21 v + \sqrt{C e b \cos^2 \psi + P_t}}$

For Grade 6

$e_p = 8 + 0.63 \phi$

$\phi = 5 + 0.25 \sqrt{135.79}$

$\boxed{e_p = 12.985}$

$e_g = 8 + 0.63 \phi$

$\phi = 5 + 0.25 \sqrt{271.59}$

$\boxed{e_g = 13.746}$

$\boxed{\text{Total } e = 26.73 \times 10^{-3} \text{mm}}$

$$V = \frac{\pi d_p n_p}{60 \times 10^3} = 3.4$$

$$P_d = \frac{71.67\,(16572.70077)\cos 23^\circ}{71.67 + \sqrt{16572.70077}}$$

$$= \frac{71.67 \times 15255.25749}{71.67 + 128.735021} = 1089224.457$$

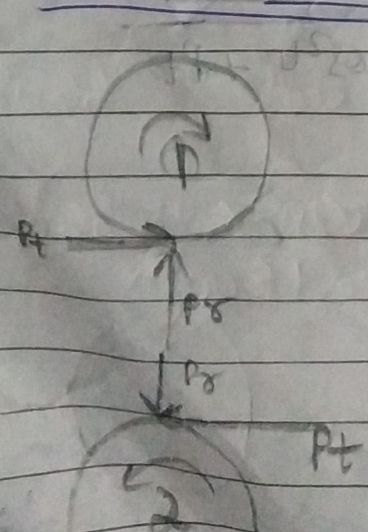
$$P_d = 5442.45$$

$$P_{eff} = C_s P_t + P_d$$
$$= 10,936.514$$

$$\text{So } FOS = \frac{S_b}{P_{eff}} = \frac{22759.375}{10936.514} = 2.08$$

Cal FOS > given FOS
Design is safe.

<u>Reaction at Bearing B_1 & B_2.</u>



$P_{t_{12}} = 1657.864$

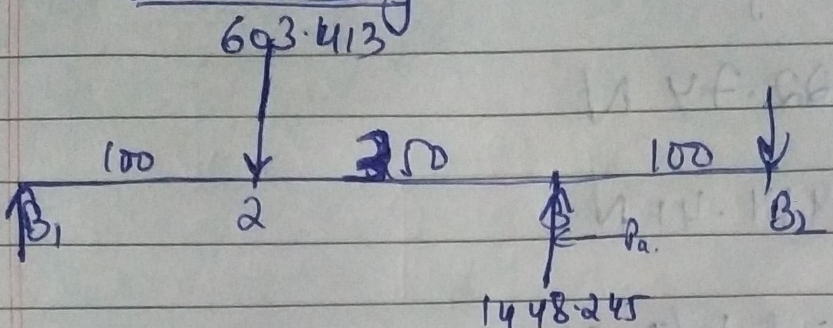
$P_{r_{12}} = P_{t_{12}} \times \tan 20 = 603.413$

$P_a = 1554.28$

$P_r = 1448.245$

$P_{t_{34}} = 3662.708574$

Vertical Loading



At B_1

$603.413 \times 100 - (1448.24 \times 450) + (1554.73 \times 67.9) + B_2 \times 550$

$60341.3 - 651708 + 105566.167 = -B_2\,550$

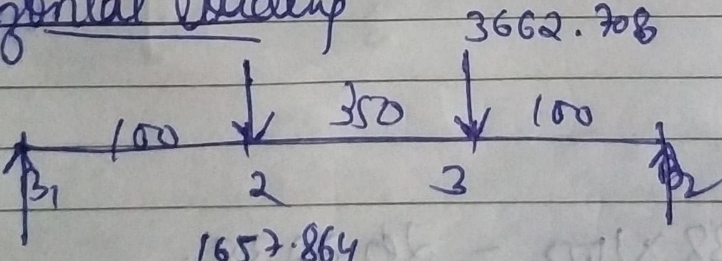
$-485800.533 = -B_2\,550$

$\boxed{B_2 = 883.274N}$

At eqm $B_1 - 603.413 + 1448.245 - 883.274 = 0$

$\boxed{B_1 = 38.442}$

Horizontal loading



At B_1

$1657.864 \times 100 + 3662.708574 \times 450 - B_2 \times 550 = 0$

$165786.4 + 1648218.858 = B_2 \times 550$

$\boxed{B_2 = 3298.19N}$

At eqm $B_1 - 1657.864 - 3662.708574 + 3298.19 = 0$

$\boxed{B_1 = 2022.38N}$

Resultant forces

$B_1 = 2022.74\ N$

$B_2 = 3414.41\ N$

(4) Let Material be 40C8

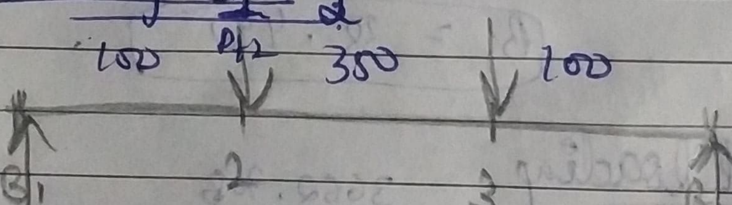
$S_{yt} = 380\ N/mm^2$

$$\tau = \frac{0.5 \times S_{yt}}{FOS} = \frac{0.5 \times 380}{1.55} = 122.58$$

$$M_t = \frac{60 \times 10^6 \times 12.5}{2\pi \times 480} = 248679.5986$$ (This is Maxm)

For Bearing B_1 & B_2

Horizontal



BM At $B_1 = 0$

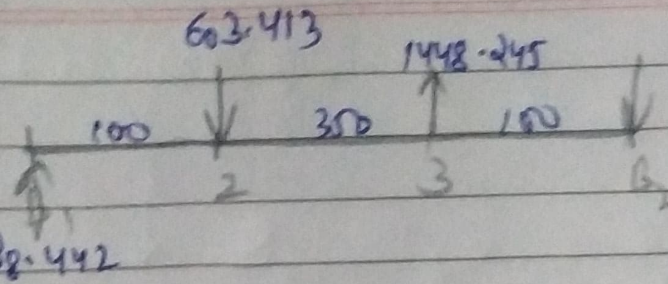
At 2 $= 2022.38 \times 100 = 202238.$

At 3 $= 2022.38 \times 450 - 1657.864 \times 350 = 0$

$910071 - 580252.4 = 329818.6$

At $B_2 = 0$

Vertical



At B_1 = 0

At 2 = 38.442 × 100 = 3844.2

At 3 = 38.442 × 450 − 603.413 × 350

= 17298.9 − 211194.55

= −193895.65

At B_2 = 0.

Resultant At 2 = 202274.53 N

At 3 = 382590.946 N Nmm

So M_b = 382590.946

$$\tau = \frac{16}{\pi d^3} \sqrt{M_b^2 + M_t^2}$$

$$122.58 = \frac{16}{\pi d^3} \sqrt{(382590.946)^2 + (248679.5986)^2}$$

d^3 = 18958.71841

$\boxed{d = 26.7}$

d ≃ 27mm