Prob #1

Given: Spur gear

$\Phi = 20$

$N_p = 20$

$N_G = 80$

$P = 32$

Find Contact Ratio

$$CR = \frac{\sqrt{r_{ap}^2 - r_{bp}^2} + \sqrt{r_{ag}^2 - r_{bg}^2} - C \sin\phi}{p_b}$$

For Excel input

$$P = \frac{N_p}{d_p} \Rightarrow d_p = \frac{20}{32} = 0.625''$$

$$d_g = m\, d_p \Rightarrow d_g = 4(0.625) = 2.5''$$

$\Rightarrow$ From Excel $\boxed{CR = 1.69}$

Prob #2

Given: $N_p = 20$

$N_g = 80$

$P = 32$

$P = 32$

$\phi = 20^\circ$

$n_p = 1500$ rpm

$h_p = 0.5$

$$N_p = \frac{2K}{(1+2m)\sin^2\phi}\left(m + \sqrt{m^2 + (1+2m)\sin^2\phi}\right)$$

$$= \frac{2(1)}{(1+2(4))\sin^2 20}\left(4 + \sqrt{4^2 + (1+2(4))\sin^2 20}\right)$$

where $m = \frac{N_g}{N_p} = \frac{80}{20} = 4$

$N_{P,min} = 15.4$ or $\boxed{N_{P,min} = 16}$

Prob #3

Given $\phi = 20$ $\quad P = 10$

$h_p = 30$ $\quad F = 1.25''$

$n_p = 1000$ rpm

$m = 4$

$N_p = 24$

Find Radial force F_r

33000 hp = 33000 (30) = 1575.6 lbs

$$F_t = \frac{33000\ hp}{V} = \frac{33000(30)}{628.3} = 1575.6 \text{ lbs}$$

where $$V = \frac{\pi n d}{12} = \frac{\pi(1000)(2.4)}{12} = 628.3 \text{ ft/min}$$

where $$d_p = \frac{N_p}{P} = \frac{24}{10} = 2.4''$$

$$F_r = F_t \tan \phi$$

$$= 1575.6 \tan 20$$

$$\boxed{F_r = 573.4 \text{ lbs}}$$

Problem #4

Given n_A = Given output n_2

$n_6 = 0$

$N_2 = 24$

$N_3 = 36$

$N_5 = 18$

Find gear ratio $m = \dfrac{n_A}{n_2}$

Find gear ratio $m = \frac{\cdot\cdot}{n_2}$

<u>Solution</u>

Assume $n_A = 100$ (Any other value is ok)

From geometry

$$N_2 + N_3 = N_6 + N_5$$

$$(r_2 + r_3 = r_6 + r_5)$$

$$\Rightarrow 24 + 36 = 18 + N_6$$

$$\Rightarrow N_6 = 42 \text{ teeth}$$

inputs n_A, n_6

output n_2

$$\frac{n_{2/A}}{n_{6/A}} = \frac{n_2 - n_A}{n_6 - n_A} = \frac{n_2 - 100}{0 - 100}$$

Since Arm is stationary, we can find the ratio between n_2 and n_6 using a regular gear train relationship

$$\frac{n_{2/A}}{n_{6/A}} = \frac{n_{2/A}}{n_{3/A}} \cdot \frac{n_{3/A}}{n_{5/A}} \cdot \frac{n_{5/A}}{n_{6/A}}$$

$$= \left(-\frac{N_3}{\cdot\cdot}\right)\left(1\right)\left(-\frac{N_6}{N_5}\right) = + \frac{36\,(42)}{(24)(18)} = 3.5$$

$$= \left(-\frac{N_3}{N_2}\right)(1)\left(-\frac{N_6}{N_5}\right) = + \frac{36\,(42)}{(24)(18)} = 3.5$$

$$\frac{n_2 - 100}{-100} = 3.5 \implies n_2 = -350 + 100$$

$$\implies n_2 = -250 \text{ rpm}$$

$$\boxed{m = \frac{n_A}{n_2} = \frac{100}{-250} = -0.4} \leftarrow$$

Prob#5

Given: $\phi = 20$ uniform — Mod. shock

$hp = 2$

$n_p = 2000$ $Q_v = 8$

$m = 2$ Grade-II through hardened steel BHN=300

$P = 24$

$F = 0.25''$ Life $\equiv 10^7$ cycles (Pinion)

$N_p = 18$

$R = 99.9\%$ (for S_t)

Find

Factor of Safety against eventual tooth breakage

and $K_m = 1.2$

tooth ...

Assume $K_S = K_T = K_B = 1$ and $K_m = 1.2$

Solution

$$F_t = \frac{3000\,(hp)}{V} \quad \text{where } V = \frac{\pi n d}{12}$$

$$V = \frac{\pi\,(2000)(0.75)}{12} = 392 \quad ft/min$$

where

$$d_p = \frac{N_p}{P} = \frac{18}{24} = 0.75$$

$$W^t \equiv F_t = \frac{33000\,(2)}{392} = 168.3 \text{ lbs}$$

$$\sigma = W^t K_o K_v K_s \left(\frac{P}{F}\right) \frac{K_m K_B}{J}$$

where $K_o = 1.25$

$K_v = 1.17$ $(Q_v = 8 \;\&\; V \cong 400)$

$K_s = 1$

$F = 0.25$

$J = 0.33$

$K_m = 1.2$

$K_m = 1.2$

$K_B = 1$

$$\sigma = (168.3)(1.25)(1.17)(1)\left(\frac{24}{0.25}\right)\left(\frac{1.2(1)}{0.33}\right)$$

$\sigma = 85925$ psi

Strength

$$S_b = \frac{Y_N}{K_T K_R} S_t$$

where

$S_t = 48$ ksi (Fig 14-2)

$K_R = 1.25$ (Table 14-10)

$K_T = 1$

$Y_N = 1$ (10 million cycles)

$$S_b = \frac{48(1)}{(1)(1.25)} = 38.4 \text{ ksi}$$

$$\Rightarrow F_S = \frac{S_b}{\quad} \frac{\quad}{85.9} \Rightarrow \boxed{F_S = 0.45}$$

Prob#6)

$N_p = 15$

$N_G = 45$

$P = 6$

$F = 2''$

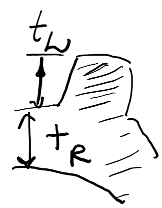
$n_p = 3000$ rpm

$Q_v = 8$

Uniform — Heavy shock

Enclosed Commercial quality

$t_R = t_h$



Saddle mounted in the middle
of Two bearings

Not Crowned

Not lapped

$h_p = 20$

$L = 100$ million

$R = 99.9\%$ for stren number

Grade-II through-hardened steel BHN=280

Find: Factor of Safety against tooth breakage

$$\sigma = W^t K_o K_s K_v \frac{K_m K_B}{J} \cdot \frac{P}{F}$$

$=$

where

$$W^t = \frac{33000\,H}{V} = \frac{33000\,(20)}{1963.5} = 336.1 \text{ lbs}$$

where

$$V = \frac{\pi n d}{12} = \frac{\pi(3000)(2.5)}{12} = 1963.5 \text{ ft/min}$$

where

$$d = \frac{N}{P} = \frac{15}{6} = 2.5$$

And $K_o = 1.75$

$K_s = 1$

$K_v = 1.35$ (Fig 14-9)

$P = 6$

$F = 2$

$$K_B = 1.6 \ln \frac{2.242}{m_B} = 1.6 \ln \frac{2.242}{1}$$

$K_B = 1.29$

where $m_B = \dfrac{t_R}{t_h} = 1$

Calculating K_m

$$K_m = 1 + C_{mc}\left(C_{pf}\, C_{pm} + C_{ma}\, C_e\right)$$

where $C_{mc} = 1$ (uncrowned)

$$C_{pf} = \frac{F}{10d} - 0.0375 + 0.0125\,F$$

$$= \frac{2}{10(2.5)} - 0.0375 + 0.0125(2)$$

$C_{pf} = 0.0675$

$C_{pm} = 1$ (Saddle mounted in the)

$$C_{ma} = 0.15 \quad (\text{Fig } 14\text{-}11)$$

$$C_e = 1 \quad (\text{No lapping})$$

$$K_m = 1 + 1\,(0.0675 * 1 + 0.15 * 1)$$

$$K_m = 1.2175$$

Also from (Fig 14-6)

$$J = 0.25$$

$$\Rightarrow \quad \sigma = (336.1)(1.75)(1)(1.35)\,\frac{(1.2175)(1.29)}{0.25} \cdot \frac{6}{2}$$

$$\sigma = 14965.1 \text{ Psi}$$

Strength

$$S_b = \frac{Y_N}{K_T K_R} S_t = \frac{0.9}{(1)(1.25)}(43) = 30.96 \text{ ksi}$$

where $Y_N \cong 0.9$ (Fig 14-14) lower Curve

$K_R = 1.25$ (Fig 14-10)

Also $S_t \cong 43$ ksi (Fig 14-2)

Factor of safety

$$\boxed{n = \frac{S_b}{\sigma} = \frac{30.96}{14.96} \cong 2.0}$$

Prob #7

Given: Series-II Deep groove ball bearing

$F_R = 3000$ N

$L_D = 50$ million

$K_a = 1.2$

$R = 99\%$

Find: Bore size of smallest adequate bearing

$$C_{10,min} = F_R K_a \left(\frac{L_D/x}{L_{10}} \right)^{0.333}$$

$$= (3000)(1.2)\left(\frac{\frac{50 \times 10^6}{0.2196}}{10^6} \right)^{0.333}$$

where from Excel program for reliability

$x = 0.2196$ for 99%

$$\boxed{\begin{array}{l} C_{10,min} = 21960^{N} \\ \text{Bore} = 35^{mm} \end{array}}$$

Prob # 8

Given $F_R = 370^{lbs}$

$K_a = 1.4$

$L = 30$ million

15mm bore deep groove (Table 11-2)

Find $R \equiv$ reliability

$C_{10,sel} = 7.8^{KN}$

$$C_{10,sel} = F_R K_a \left(\frac{L/x}{10^6}\right)^{0.333}$$

$$7800 = (370 * 4.45)(1.4)\left(\frac{30}{x}\right)^{1/3}$$

$$\left(\frac{30}{x}\right)^{1/3} = 3.384$$

$$\frac{30}{x} = (3.384)^3 = 38.74$$

$$\Rightarrow x = 0.774 \xRightarrow{\text{Excel Program}} \boxed{R \cong 93\%}$$

Prob #9

Given $F_R = 300$ lbs

$F_a = 100$ lbs

20^{mm} - bore Deep groove

Find : Equivalent load F_e

Solution

$$C_o = 6.2^{KN}$$

$$\frac{F_a}{C_o} = \frac{100\,(4.45)}{6200} = 0.072$$

$$\Rightarrow e \cong 0.27$$

$$\frac{F_a}{F_R} = \frac{100}{300} = 0.333$$

$\Rightarrow$ Axial load Cannot be ignored $\left(\frac{F_a}{F_R} > e\right)$

Combing the F_R and F_a into F_e

$$F_e = X_2 F_R + Y_2 F_a$$

$$= 0.56\,(300) + 1.63\,(100)$$

$$\Rightarrow \boxed{F_e = 331 \text{ lbs}}$$

Prob #10

$F_R = 1000$ lbs

$L = 30$ million

$R = 90\%$

if the radial load experienced is 2000 lbs (rather than 1000), how much the life would be reduced with the same reliability

Solution

$$C_{10,min} = (1000 * 4.45)\left(\frac{30}{x}\right)^{1/3}$$

where $K_a = 1$

and $x = 1$

$$C'_{10,min} = (2000 \cdot 4.45)(L)^{1/3}$$

equating the two capacities

$$(30)^{1/3} = 2(L)^{1/3}$$

million

$$30 = 8L \Rightarrow L = \frac{30}{8} = 3.75$$

Prob #11

Given: 4 idential bearings

$R = 98\%$ each bearing

R_{sys}

$$R_{sys} = (R)^4 = (0.98)^4$$

$$R_{sys} = 0.92 \text{ or } 92\%$$
