Spur Gear

Bending stress

σ_g, σ_p ← $\sigma = \dfrac{F_t P}{bJ} K_o K_m K_v$

K_o from Tables (P_2)

$K_m = C_{mc}(C_{pf} C_{pm} + C_{ma} C_e) + 1$
From Tables (P_3)-(P_2)

Combined Reability

$K_A K_B = R \rightarrow K_A = \sqrt{R}$

J : Figure 14-6

$V = \dfrac{\pi d n}{60}$ m/s

S.I $K_v = \left(\dfrac{A + \sqrt{200V}}{A}\right)^B$

Q_v → 8-12 acc
→ 7 or less commercial

$B = \dfrac{(12 - Q_v)^{2/3}}{4}$

$A = 50 + 56(1 - B)$

U.S $K_v = \left(\dfrac{A + \sqrt{V}}{A}\right)^B$ → $\dfrac{\pi d n}{12}$ ← V fpm

calculate once

Bending Strength

σ_g, σ_p ← $S_e = S_t \dfrac{K_L K_t}{K_r}$

S_t from Tables (P_3)-(P_4)

K_L " " (P_4)

K_R from Tables (P_5)

$K_t = \dfrac{460 + T}{620}$ ← $T > 250°F$

$\dfrac{L_p}{L_g} = \dfrac{\omega_p}{\omega_g} = \dfrac{N_g}{N_p} = V_R$

n_g, n_p ← $n = \dfrac{S_e}{\sigma}$

← لما يكون في Hidden line
معناها مش نفس السرعة

Contact Stress

σ_g, $\sigma_p = \sigma_c = C_p \sqrt{\dfrac{F_t C_o C_m C_v}{b I d_p}}$ = Psi, Mpa

$C_o = K_o$
$C_m = K_m$
$C_v = K_v$

given one hardness →

C_p from tables (P_5)

$I = \dfrac{\sin\phi \cos\phi}{2} \dfrac{R}{R+1}$, $R = \dfrac{N_g}{N_p} = \dfrac{\pm d_g}{d_p}$ (+) Ext, (−) if Int

Contact Strength

g, p ← $S_{fe} = S_c \dfrac{C_L C_t C_H}{C_R}$

S_c from tables (P_6)

C_L from tables (P_6)

C_R " " (P_6) or Book P 778

$C_t = K_t$

C_H " " (P_7)

Hardness
core → different ← surface
320 → S_c, 300 → S_t
مثلاً غير

Catalog rating = FR ②

Helical Geear

Bending Stress

σ_g, σ_p: $\sigma = \dfrac{F_t\ P\ K_o\ K_m\ K_v}{b\ J}$ ← All same as spur gear

$J \rightarrow$ Tables (P7) $N \neq 75$, $J = K_J\ J_{75}$

Contact Strength

$\sigma_g = \sigma_p = \sigma_c = C_p \sqrt{\dfrac{F_t\ C_o C_m C_v}{b\ I\ d_p}}$

$I = \dfrac{\sin\emptyset\ \cos\emptyset}{2\left(\dfrac{1}{0.95\,C.R}\right)} \dfrac{R}{R+1}$

- $C.R = \dfrac{L_{ab}}{P_{bn}}$, $P_{bn} = P_n \cos\emptyset_n = P\cos\psi$

$L_{ab} = \underbrace{\sqrt{r_{ap}^2 - r_{bp}^2} + \sqrt{r_{ag}^2 - r_{bg}^2}}_{P_n} - C\sin\emptyset$

- Interferenca of Int. gear

$\sqrt{(r_{ag})^2 - (r_{bg})^2} > (r_{bg} - r_{bp})\tan\emptyset$

$A = d + 2m$

$D = d - (1.25)(2m)$

$C = \left(\dfrac{N_p + N_g}{2}\right) m$

$P_b = P_c \cos\emptyset$

$P_c P = \pi$

$P_c = \pi \dfrac{d}{N}$

$t = \dfrac{P}{2}$

$P = \dfrac{N}{d}$

$c = b - a$

Interference:

External: $N_{p\,min} = \dfrac{2K}{(1+2V_R)(\sin\emptyset)^2}\left(V_R + \sqrt{V_R^2 + (1+2V_R)(\sin\emptyset)^2}\right)$

$K = 1$ full depth

$= 0.8$ stub

$N_{g\,max} = (N_p)^2 (\sin\emptyset)^2 - 4K^2 / 4K - 2N_p(\sin\emptyset)^2$

Backlass

$B = 2C'(Inv\emptyset - Inv\emptyset')$ $Inv\emptyset = \tan\emptyset - \emptyset$

$R_p' = \dfrac{N_p}{N_p+N_g} C'$ / $R_g' = C' - R_p'$ $\cos\emptyset' = \dfrac{C}{C'}\cos\emptyset$

$t = 2R'(t/2R - Inv\emptyset - Inv\emptyset')$

Bearings

$a = \begin{cases} 3 & \text{ball bearings} \\ \frac{10}{3} & \text{roller} \quad " \end{cases}$

Basic load Rating

- $C_{10} = K_a F_e \left(\dfrac{L}{K_r L_{10}}\right)^{1/a}$

$K_r = X_o + (\theta - X_o)(1-R)^{1/b}$ (P8)

K_a Tables (P8)

F_e → F_r and F_t (No axial load)

F_e → $= \max\begin{cases} VF_r \\ V_x F_r + YF_a \end{cases}$ (Axial load)

- C_o tables (P8 + P9)
- $e \rightarrow$ compare with $\dfrac{F_a}{F_r}$
- $\rightarrow$ choose $X, Y \rightarrow F_{eq}$
- $\rightarrow$ get C
- $C_{calc} < C_{table}$ Choose another

Tapered Bearings

$L = 3000$

$n = 500$

Timken:- $F_a = 0.4F_r$ / $K \begin{cases} 0.75 & \text{steep} \\ 1.5 & \text{shallow} \end{cases}$

Note

L Table 11-1

Direct ~~Direct connection~~ toward A (back faces facing each other of cone)

$$F_{eA} = 0.4\,F_{rA} + K_A\left(\frac{0.47\,F_{rB}}{K_B} + T_e\right)$$

$$F_{eB} = 0.4\,F_{rB} + K_B\left(\frac{0.47\,F_{rA}}{K_A} - T_e\right)$$

T_e

~~Toward B~~ ~~Direct connection~~ Indirect connection

$$F_{eA} = 0.4\,F_{rA} + K_A\left(\frac{0.47\,F_{rB}}{K_B} - T_e\right)$$

$$F_{eB} = 0.4\,F_{rB} + K_B\left(\frac{0.47\,F_{rA}}{K_A} + T_e\right)$$

F_{DA} and $F_{DB} \Rightarrow F_D = \max\{F_e, F_r\}$

$$C = K_a F_D\left(\frac{L_D n_D}{L_{10} n_{10}}\right)^{3/10}$$ ← Roller

$$C = K_a F_e\left(\frac{L_D n_D}{f_t f_v K_r L_R n_R}\right)^{3/10} \qquad K_r = 4.48(1-R)^{2/3}$$

Variable loadings

$$\frac{l_1}{L_1} + \frac{l_2}{L_2} + \dots = 1 \quad / \quad F_1^a l_1 + F_2^a l_2 + \dots = F_1^a L_1 = F_2^a L_2 = \dots = C^a \underbrace{L_{10}}_{\text{Table 11-2}}$$

$$F_{eq} = F_1^a \frac{l_1}{\sum l} + F_2^a \frac{l_2}{\sum l} + \frac{F_3^a}{\sum l} \quad / \quad F^a L_i = C^a L_{10}$$ ← 10^6

Power

$$H_p = \frac{F_t V}{33000} = \frac{T n}{63025} \quad \text{RPm} \qquad V = \frac{\pi d n}{12}$$

$$W = F_t V = T\omega \quad \text{rad/s} \qquad V = \frac{\pi d n}{60}$$

N.m

Helical gear

$d = \frac{N}{P} = N m$

$a = 1/P_n$

$b = 1.25/P_n$

$P_a = P/\tan\psi$

$P = P_n \cos\psi$

$N_e = N/\cos^3\psi$

H.G Force analysis

$F_r = F_t \tan\phi_t$

$F_t = F_b \cos\psi$

$F_a = F_t \tan\psi$

$\tan\phi_n = \tan\phi\cos\psi$

F_b : F_a, F_b [illegible]

F_n : F_b, F_r ~

Planetary Gears

$$\frac{\omega_L - \omega_{arm}}{\omega_F - \omega_{arm}} = \frac{\text{driven teeth}}{\text{drived teeth}}$$

F_L { Same Direction (+) / opposite Direc (−)

Note, if we don't know direction we assume

S.G Force analysis

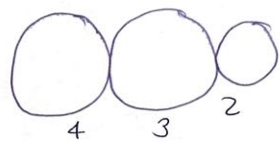
$$F_t = \frac{2T}{d}$$

$$F_r = F_t \tan\phi$$

- If Hardness is core and surface
  Solve Bending and ~~??~~ contact

- " " " only one number
  Solve only an contact

- If 3 has two hardness
  Solve bending and contact
  for 2, 4

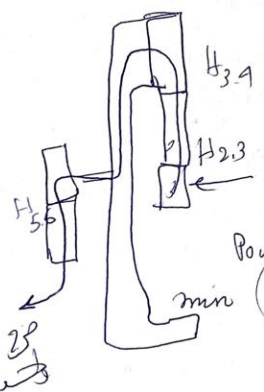


- If 2 " " "
  " " " "
  for 3 But for 4 only contacts

core used for Bending
Surface used for Contact

مجمع القوة

واحد

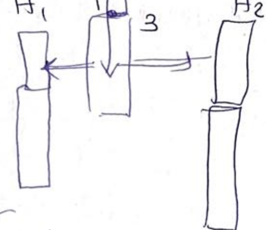


← motor

If H motor = 5 يبقى
كلهم نفس ال Power

$\min(H_{2,3}, H_{3,4}, H_{5,6})$

متفرع



$\min(H_1 + H_2$ و $H_{23})$

H

وازا