Tutorial # 3 - Solution

1- A steel spur pinion has 15 teeth cut on the 20° full-depth system with a module of 5 mm and a face width of 60 mm. The pinion rotates at 200 rev/min and transmits 5 kW to the mating gear. Determine the resulting bending stress assuming accurate mounting and uniform power source.

Solution:

$N_p = 15$ T
$\phi = 20°$
$m = 5$ mm
$b = 60$ mm
$n_p = 200$ rpm
$H = 5$ kW

From fig. $J = 0.25$

$v^t = \omega r$

$= \frac{2\pi \times 200}{60} \cdot \frac{15 \times 5 \times 10^{-3}}{2} = 0.785$ m/s

Take $Q_v = 6$

$B = 0.8255$

$A = 59.77$

$K_v = 1.17$

Assume uniform power source and driven machinery

$K_o = 1$

$k_b = 0.91$ (from table)

$K_s = \frac{1}{0.91} = 1.099$

Assuming accurate mounting, using table

$K_H = 1.4$

No rim thickness given

$\therefore K_B = 1$

$H = T\omega$ $\quad T = \frac{5 \times 10^3}{\frac{2\pi \times 200}{60}} = 238.7$ N.m

$W^t = \frac{T}{r} = \frac{238.7}{37.5 \times 10^{-3}} = 6365$ N

$\sigma = 152.78$ MPa

2- A 20° spur pinion with 20 teeth and a module of 2.5 mm transmits 120 W to a 36 tooth gear. The pinion speed is 100 rev/min, and the gears are grade 1, 18 mm face width, through-hardened steel at 200 Brinell, uncrowned, manufactured to a No.6 quality standard, and considered to be of open gearing quality installation (low accuracy).
Find the AGMA bending and contact stresses and the corresponding factors of safety for a pinion life of 10^8 cycles and a reliability of 0.95.

Solution:

$\phi = 20°$ $N_P = 20\,T$ $m = 2.5$ mm

$H = 120$ W $N_G = 36\,T$ $n_p = 100$ rpm

$b = 18$ mm Grade 1, Through hard. St. $H_B = 200$ Brinel

uncrowned $Q_v = 6$ Open gearing

$L_p = 10^8$ Cycles $R = 0.95$

Pinion	Gear
$J_p = 0.325$ (from fig)	$J_G = 0.375$
$V_t = \omega_p r_p = 0.2618$ m/s	
$B = 0.825$	
$A = 59.77$	
$K_v = 1.098$	$K_v = 1.098$ (same)
Assuming uniform power source and driven M/C:	
$K_O = 1$	$K_O = 1$ (same)
$K_b = 0.974$	
$K_S = 1.0267$	$K_S = 1.0267$ (same)
for open gearing	
$K_H = 2.2$ (or greater)	$K_H = 2.2$ (same)
$K_B = 1$	$K_B = 1$ (same)

$$W_p^t = W_G^t = \frac{H}{r_p \omega_p} = 458\ N$$

Bending Stresses:

$\sigma_{p)_{bend}} = 77.6$ MPa $\sigma_{G)_{bend}} = 67.3$ MPa

Pinion	Gear
$\sigma'_{FP} = 0.703 \times 200 + 113$	
$= 253.6$ MPa	$\sigma'_{FP} = 253.6$ MPa (same)
$Y_N = 0.95$ (fig)	$L_G = \frac{L_P}{36/20} = 5.5 \times 10^7$ Cycles
	$Y_N = 0.98$ (fig)
$Y_Z = 0.885$	$Y_Z = 0.885$ (same)
$Y_\theta = 1$ (Temp. below 120°C)	$Y_\theta = 1$ (same)
$\sigma_{FP})_P = 272$ MPa	$\sigma_{FP})_G = 281$ MPa
$n_P = \frac{272}{77.6} = 3.5$	$n_G = \frac{281}{67.3} = 4.17$
Contact Stresses:	
$C_P = 191$ (table)	$C_P = 191$ (same)
$m_G = 1.8$	
$I = 0.103$	$I = 0.103$ (same)
Take $C_f = 1$	$C_f = 1$ (same)
$\sigma_{P})_{Cont.} = 668.95$ MPa	$\sigma_{G})_{cont} = 668.95$ MPa (same)
$\sigma'_{HP} = 644$ MPa	$\sigma'_{HP} = 644$ MPa (same)
$Z_N = 1.4488\, N^{-0.023}$	
$Z_{N_P} = 0.948$	$Z_{N_G} = 0.96$
$C_H = 1$	$C_H = 1$ (Same)
$\sigma_{HP})_P = 690$ MPa	$\sigma_{HP})_G = 698.5$
$n'_{C_P} = 1.03$	$n'_{C_G} = 1.04$
$n_{C_P} = 1.06$	$n_{C_G} = 1.09$