Design procedure of spur gearbox

The data provided by the user should be:

a. The input speed and the output speed (n_p and n_G)
b. The power required to be transmitted (P)
c. Calculate the transmission ratio i=Input speed/Output speed

Design steps:

1. Dimensions (Pinion)
   a. Select a suitable module *m in mm (3-10 mm* medium load*)*
   b. *Select the number of teeth (N_p=20)*
   c. *Calculate the pitch circle diameter ($d_p=mxN_p$)*
   d. *Calculate the diametral pitch p_d*
2. *Dimensions (Gear)*
   a. Calculate the number of teeth of the gear ($N_G=N_pxi$)
   b. Calculate the pitch circle diameter ($d_G=mxN_G$)

3. *Force Analysis and torque estimation*
   a. From the input speed or the outputs speed and the given power calculate the torque ($P=Tx\omega$)
   b. Calculate the tangential force $F_t=2xT_p/d_p$
   c. Calculate the radial force $F_r=F_t$ tan(α), (α=20^o)

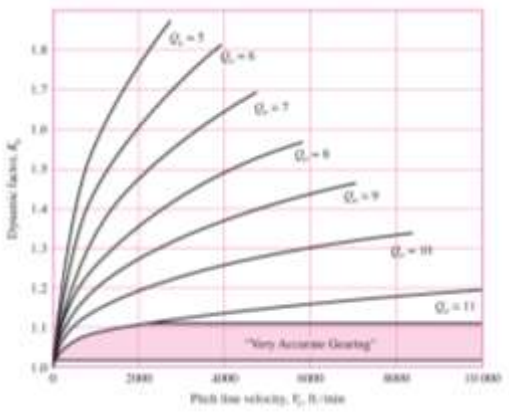
4. Check on Bending Stress
   a. Use the AGMA equation as follows:

$$\sigma = (F_t p/b)\, K_b$$

Where $K_b=K_oK_vK_sK_mK_B/J$
b: the teeth width in mm
K_o

Table of Overload Factors, K_o

Power source	Driven Machine: Uniform	Moderate shock	Heavy shock
Uniform	1.00	1.25	1.75
Light shock	1.25	1.50	2.00
Medium shock	1.50	1.75	2.25



K_v

K_s : size factor can be taken as 1
K_m: **Load-Distribution Factor (1-1.2)**

K_B: Rim thickness factor (1-1.8)

J: Bending strength geometry factor (0.3-0.35)

5. Calculate the bending factor of safety

$$S_F = \frac{S_t Y_N / (K_T K_R)}{\sigma}$$

Where

S_t: allowable fatigue bending stress

Y_N is the stress cycle factor for bending stress (1.5:3 depends on the surface hardness)

K_T=1 for normal operating temperature

K_R: Reliability factor use the side table

Reliability	K_R (Y_Z)
0.9999	1.50
0.999	1.25
0.99	1.00
0.90	0.85
0.50	0.70

6. Calculate the contact stress

$$\sigma_c = C_p (F_t / pb\, K_c)^{0.5}$$

Where $K_c = K_o K_v K_s K_m K_B\, C_f / I$

$$C_p = \left[\frac{1}{\pi \left(\frac{1 - \nu_P^2}{E_P} + \frac{1 - \nu_G^2}{E_G} \right)} \right]^{1/2}$$

For steel pinion and steel gear $E_p = E_G$210 GPa and $\nu_p = \nu_G$=0.3

C_f: is the surface condition factor=1

I : is the geometry factor for pitting resistance=0.1-0.2

7. Calculate the contact stress factor of safety

$$S_H = \frac{S_c Z_N C_H / (K_T K_R)}{\sigma_c}$$

S_c: Allawable contact stress

Z_N: 1.1

C_H: 1-1.14

Table 14–4

Repeatedly Applied Bending Strength S_t for Iron and Bronze Gears at 10^7 Cycles and 0.99 Reliability

Source: ANSI/AGMA 2001-D04.

Material	Material Designation[1]	Heat Treatment	Typical Minimum Surface Hardness[2]	Allowable Bending Stress Number, S_t,[3] psi
ASTM A48 gray cast iron	Class 20	As cast	—	5000
	Class 30	As cast	174 HB	8500
	Class 40	As cast	201 HB	13 000
ASTM A536 ductile (nodular) iron	Grade 60–40–18	Annealed	140 HB	22 000–33 000
	Grade 80–55–06	Quenched and tempered	179 HB	22 000–33 000
	Grade 100–70–03	Quenched and tempered	229 HB	27 000–40 000
	Grade 120–90–02	Quenched and tempered	269 HB	31 000–44 000
Bronze		Sand cast	Minimum tensile strength 40 000 psi	5700
	ASTM B–148 Alloy 954	Heat treated	Minimum tensile strength 90 000 psi	23 600

Repeatedly Applied Contact Strength S_c 10^7 Cycles and 0.99 Reliability for Iron and Bronze Gears

Source: ANSI/AGMA 2001-D04.

Material	Material Designation[1]	Heat Treatment	Typical Minimum Surface Hardness[2]	Allowable Contact Stress Number,[3] S_c, psi
ASTM A48 gray cast iron	Class 20	As cast	—	50 000–60 000
	Class 30	As cast	174 HB	65 000–75 000
	Class 40	As cast	201 HB	75 000–85 000
ASTM A536 ductile (nodular) iron	Grade 60–40–18	Annealed	140 HB	77 000–92 000
	Grade 80–55–06	Quenched and tempered	179 HB	77 000–92 000
	Grade 100–70–03	Quenched and tempered	229 HB	92 000–112 000
	Grade 120–90–02	Quenched and tempered	269 HB	103 000–126 000
Bronze	—	Sand cast	Minimum tensile strength 40 000 psi	30 000
	ASTM B-148 Alloy 954	Heat treated	Minimum tensile strength 90 000 psi	65 000