Cálculo de tensões:

1 - Cálculo da tensão de flexão:

$$\sigma_b = \frac{W_t\, p_d}{FJ}\,\frac{K_a K_m}{K_v}\,K_s K_B K_I$$

$$\sigma_b = \frac{W_t}{FmJ}\,\frac{K_a K_m}{K_v}\,K_s K_B K_I$$

a) Valor de J:

Table 11-8 AGMA Bending Geometry Factor J for 20°, Full-Depth Teeth with Tip Loading

Gear teeth	Pinion teeth: 12 P	12 G	14 P	14 G	17 P	17 G	21 P	21 G	26 P	26 G	35 P	35 G	55 P	55 G	135 P	135 G
12	U	U														
14	U	U	U	U												
17	U	U	U	U	U	U										
21	U	U	U	U	U	U	0.24	0.24								
26	U	U	U	U	U	U	0.24	0.25	0.25	0.25						
35	U	U	U	U	U	U	0.24	0.26	0.25	0.26	0.26	0.26				
55	U	U	U	U	U	U	0.24	0.28	0.25	0.28	0.26	0.28	0.28	0.28		
135	U	U	U	U	U	U	0.24	0.29	0.25	0.29	0.26	0.29	0.28	0.29	0.29	0.29

Table 11-9 AGMA Bending Geometry Factor J for 20°, Full-Depth Teeth with HPSTC Loading

Gear teeth	Pinion teeth: 12 P	12 G	14 P	14 G	17 P	17 G	21 P	21 G	26 P	26 G	35 P	35 G	55 P	55 G	135 P	135 G
12	U	U														
14	U	U	U	U												
17	U	U	U	U	U	U										
21	U	U	U	U	U	U	0.33	0.33								
26	U	U	U	U	U	U	0.33	0.35	0.35	0.35						
35	U	U	U	U	U	U	0.34	0.37	0.36	0.38	0.39	0.39				
55	U	U	U	U	U	U	0.34	0.40	0.37	0.41	0.40	0.42	0.43	0.43		
135	U	U	U	U	U	U	0.35	0.43	0.38	0.44	0.41	0.45	0.45	0.47	0.49	0.49

Table 11-10 AGMA Bending Geometry Factor J for 20°, 25%-Long-Addendum Teeth with Tip Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	U	U														
14	U	U	U	U												
17	U	U	U	U	0.27	0.19										
21	U	U	U	U	0.27	0.21	0.27	0.21								
26	U	U	U	U	0.27	0.22	0.27	0.22	0.28	0.22						
35	U	U	U	U	0.27	0.24	0.27	0.24	0.28	0.24	0.28	0.24				
55	U	U	U	U	0.27	0.26	0.27	0.26	0.28	0.26	0.28	0.26	0.29	0.26		
135	U	U	U	U	0.27	0.28	0.27	0.28	0.28	0.28	0.28	0.28	0.29	0.28	0.30	0.28

Table 11-11 AGMA Bending Geometry Factor J for 20°, 25%-Long-Addendum Teeth with HPSTC Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	U	U														
14	U	U	U	U												
17	U	U	U	U	0.36	0.24										
21	U	U	U	U	0.37	0.26	0.39	0.27								
26	U	U	U	U	0.37	0.29	0.39	0.29	0.41	0.30						
35	U	U	U	U	0.37	0.32	0.40	0.32	0.41	0.33	0.43	0.34				
55	U	U	U	U	0.38	0.35	0.40	0.36	0.42	0.36	0.44	0.37	0.47	0.39		
135	U	U	U	U	0.39	0.39	0.41	0.40	0.43	0.41	0.45	0.42	0.48	0.44	0.51	0.46

Table 11-12 AGMA Bending Geometry Factor J for 25°, Full-Depth Teeth with Tip Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	U	U														
14	U	U	0.28	0.28												
17	U	U	0.28	0.30	0.30	0.30										
21	U	U	0.28	0.31	0.30	0.31	0.31	0.31								
26	U	U	0.28	0.33	0.30	0.33	0.31	0.33	0.33	0.33						
35	U	U	0.28	0.34	0.30	0.34	0.31	0.34	0.33	0.34	0.34	0.34				
55	U	U	0.28	0.36	0.30	0.36	0.31	0.36	0.33	0.36	0.34	0.36	0.36	0.36		
135	U	U	0.28	0.38	0.30	0.38	0.31	0.38	0.33	0.38	0.34	0.38	0.36	0.38	0.38	0.38

Table 11-13 AGMA Bending Geometry Factor J for 25°, Full-Depth Teeth with HPSTC Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	U	U														
14	U	U	0.33	0.33												
17	U	U	0.33	0.36	0.36	0.36										
21	U	U	0.33	0.39	0.36	0.39	0.39	0.39								
26	U	U	0.33	0.41	0.37	0.42	0.40	0.42	0.43	0.43						
35	U	U	0.34	0.44	0.37	0.45	0.40	0.45	0.43	0.46	0.46	0.46				
55	U	U	0.34	0.47	0.38	0.48	0.41	0.49	0.44	0.49	0.47	0.50	0.51	0.51		
135	U	U	0.35	0.51	0.38	0.52	0.42	0.53	0.45	0.53	0.48	0.54	0.53	0.56	0.57	0.57

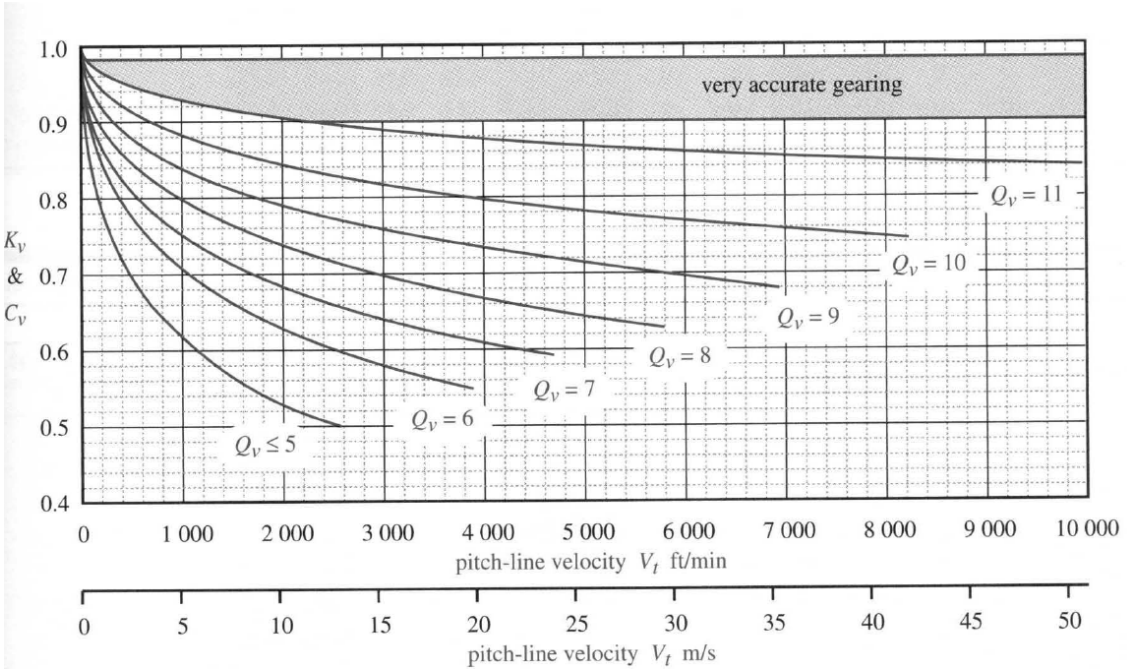
Table 11-14 AGMA Bending Geometry Factor J for 25°, 25%-Long-Addendum Teeth with Tip Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	0.32	0.20														
14	0.32	0.22	0.33	0.22												
17	0.32	0.25	0.33	0.25	0.34	0.25										
21	0.32	0.27	0.33	0.27	0.34	0.27	0.36	0.27								
26	0.32	0.29	0.33	0.29	0.34	0.29	0.36	0.29	0.36	0.29						
35	0.32	0.31	0.33	0.31	0.34	0.31	0.36	0.31	0.36	0.31	0.37	0.31				
55	0.32	0.34	0.33	0.34	0.34	0.34	0.36	0.34	0.36	0.34	0.37	0.34	0.38	0.34		
135	0.32	0.37	0.33	0.37	0.34	0.37	0.36	0.37	0.36	0.37	0.37	0.37	0.38	0.37	0.39	0.37

Table 11-15 AGMA Bending Geometry Factor J for 25°, 25%-Long-Addendum Teeth with HPSTC Loading

Gear teeth	Pinion teeth: 12		14		17		21		26		35		55		135	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
12	0.38	0.22														
14	0.38	0.25	0.40	0.25												
17	0.38	0.29	0.40	0.29	0.43	0.29										
21	0.38	0.32	0.41	0.32	0.43	0.33	0.46	0.33								
26	0.39	0.35	0.41	0.35	0.44	0.36	0.46	0.36	0.48	0.37						
35	0.39	0.38	0.41	0.39	0.44	0.39	0.47	0.40	0.49	0.41	0.51	0.41				
55	0.39	0.42	0.42	0.43	0.44	0.44	0.47	0.44	0.49	0.45	0.52	0.46	0.55	0.47		
135	0.40	0.47	0.42	0.48	0.45	0.49	0.48	0.49	0.50	0.50	0.53	0.51	0.56	0.53	0.59	0.55

b) Valores de K_v e C_v:



c) Valores de Q_v:

Recommended Gear Quality Numbers versus Pitch Line Velocity

Pitch Velocity	Q_v
0–800 fpm	6–8
800–2000 fpm	8–10
2000–4000 fpm	10–12
Over 4000 fpm	12–14

Recommended AGMA Gear Quality Numbers for Various Applications

Application	Q_v
Cement mixer drum drive	3–5
Cement kiln	5–6
Steel mill drives	5–6
Corn picker	5–7
Cranes	5–7
Punch press	5–7
Mining conveyor	5–7
Paper-box making machine	6–8
Gas meter mechanism	7–9
Small power drill	7–9
Clothes washing machine	8–10
Printing press	9–11
Computing mechanism	10–11
Automotive transmission	10–11
Radar antenna drive	10–12
Marine propulsion drive	10–12
Aircraft engine drive	10–13
Gyroscope	12–14

d) Valores de Km

Table 11-16
Load Distribution Factors K_m

Face Width in	(mm)	K_m
<2	(50)	1.6
6	(150)	1.7
9	(250)	1.8
≥20	(500)	2.0

e) Valores de Ka

Table 11-17 Application Factors K_a

Driving Machine	Driven Machine: Uniform	Driven Machine: Moderate Shock	Driven Machine: Heavy Shock
Uniform (Electric motor, turbine)	1.00	1.25	1.75 or higher
Light Shock (Multicylinder engine)	1.25	1.50	2.00 or higher
Medium Shock (Single-cylinder engine)	1.50	1.75	2.25 or higher

2 - Cálculo da tensão de contato

$$\sigma_c = C_p \sqrt{\frac{W_t}{FId} \frac{C_a C_m}{C_v} C_s C_f}$$

a) Valores de I:

$$I = \frac{\cos\phi}{\left(\frac{1}{\rho_p} \pm \frac{1}{\rho_g}\right) d_p}$$

$$\rho_p = \sqrt{\left(r_p + \frac{1+x_p}{p_d}\right)^2 - \left(r_p \cos\phi\right)^2} - \frac{\pi}{p_d}\cos\phi$$

$$\rho_g = C\sin\phi \mp \rho_p$$

b) Valores de Cp:

$$C_p = \sqrt{\frac{1}{\pi\left[\left(\frac{1-\nu_p^2}{E_p}\right) + \left(\frac{1-\nu_g^2}{E_g}\right)\right]}}$$

Propriedades mecânicas dos Aços

Número UNS	*Estado*	*Limite de Escoamento* S_e (kpsi)[2]	*Tensão Máxima de Tração* S_{ut} (kpsi)[2]	*Alongamento em 2 pol ou 50,8 mm* (%)	*Estricção* (%)	*Dureza Brinell* H_B
G10100	LQ	26	47	28	50	95
	EF	44	53	20	40	105
G10150	LQ	27	50	28	50	101
	EF	47	56	18	40	111
G10180	LQ	32	58	25	50	116
	EF	54	64	15	40	126
G10350	LQ	39	72	18	40	143
	EF	67	80	12	35	163
	Estirado a 427°C	81	110	18	51	220
	Estirado a 538°C	72	103	23	59	201
	Estirado a 649°C	62	91	27	66	180
G10400	LQ	42	76	18	40	149
	EF	71	85	12	35	170
	Estirado a 538°C	86	113	23	62	235
G10500	LQ	49	90	15	35	179
	EF	84	100	10	30	197
	Estirado a 316°C	180	220	10	30	450
	Estirado a 482°C	130	155	18	55	310
	Estirado a 649°C	80	105	28	65	210
G15216[3]	LQ[4]	81	100	25	57	192
G41300	LQ[4]	60	90	30	45	183
	EF[4]	87	98	21	52	201
	Estirado a 538°C	133	146	17	60	293
G41400	LQ[4]	63	90	27	58	187
	EF[4]	90	102	18	50	223
	Estirado a 538°C	131	153	16	45	302
G43400	LQ[4]	69	101	21	45	207
	EF[4]	99	111	16	42	223
	Estirado a 316°C	234	260	12	43	498
	Estirado a 538°C	162	182	15	40	363
G46200	Núcleo[5]	89	120	22	55	248
	Estirado a 427°C	94	130	23	66	256
G61500	LQ[4]	58	91	22	53	183
	Estirado a 538°C	132	155	15	44	302
G87400	LQ[4]	64	95	25	55	190
	EF[4]	96	107	17	48	223
	Estirado a 538°C	129	152	15	44	302
G92550	LQ[4]	78	115	22	45	223
	Estirado a 538°C	160	180	15	32	352

[1] De acordo com a "Unified Numbering System for Metals and Alloys" (UNS), Society of Automotive Engineers, Warrendale, Pa., 1975. Esta referência contém as classificações correspondentes para as especificações da AISI, ASTM, FED, MIL SPEC e SAE.

Os valores indicados para os laminados a quente (LQ) e estirados a frio (EF) são *valores mínimos estimados*, normalmente encontrados na faixa de 19 mm a 32 mm (3/4 pol a 1 1/4 pol). Um valor mínimo é, a grosso modo, vários desvios-padrão abaixo da média aritmética. Os valores indicados para aços tratados termicamente são *valores típicos*. Tais valores não são nem médios nem mínimos. Podem ser obtidos por um controle cuidadoso das especificações de compra e do tratamento térmico, além de inspeções e testes constantes. As propriedades mostradas nesta tabela são oriundas de grande variedade de fontes de consulta e, por isso, são bastante representativas. Entretanto, existem tantas variáveis que afetam essas propriedades, que os valores indicados devem ser considerados como aproximações.

[2] Multiplicar por 6,89 para ter em MPa.

[3] O mesmo que AISI 52100.

[4] Recozido.

[5] Cementado, propriedades do núcleo.