

ANEXOS

A1. Estudio de la línea de engrane en engranajes con dientes de perfil de evolvente

La línea de engrane es el lugar geométrico que describen los puntos de contacto de los flancos durante el engrane de un par de dientes desde su inicio hasta su fin. Suponiendo que en un instante determinado los dientes de dos ruedas están en contacto en el punto 0 (Ver figura A1-1). Al girar la rueda 1, también gira la rueda 2. Los dientes de ambas ruedas se mueven y su contacto se produce en nuevos puntos 1, 2, 3, etc. Al unir estos puntos por una curva suave se obtiene la "línea de engrane".

Cuando se trata de engranajes de perfil evolvente (Ver figura A1-2) la línea de engrane es una línea recta. Esta línea pasa por el punto primitivo P y forma con la perpendicular a la línea de centros el ángulo " α " llamado ángulo de presión. La trayectoria del contacto es la recta AB, la cual será normal a los perfiles en todos los puntos de contacto y además ocupará siempre la misma posición en virtud de que es tangente a los dos círculos base.

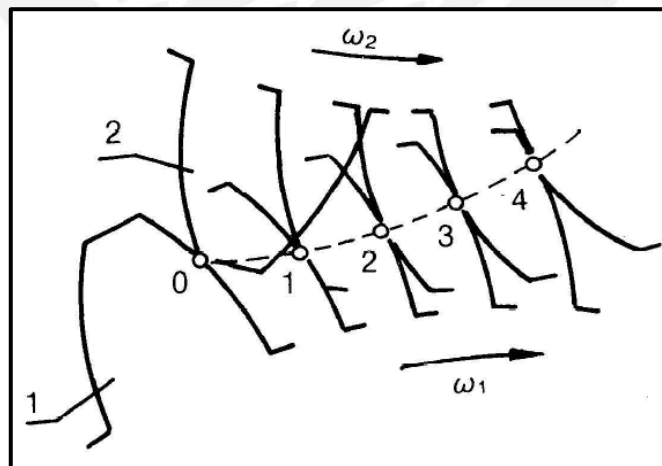


Figura A1-1. Representación de la línea de engrane. (Fuente: "Las Fallas en los Engranajes".

Luis Eduardo Benítez Hernández.)

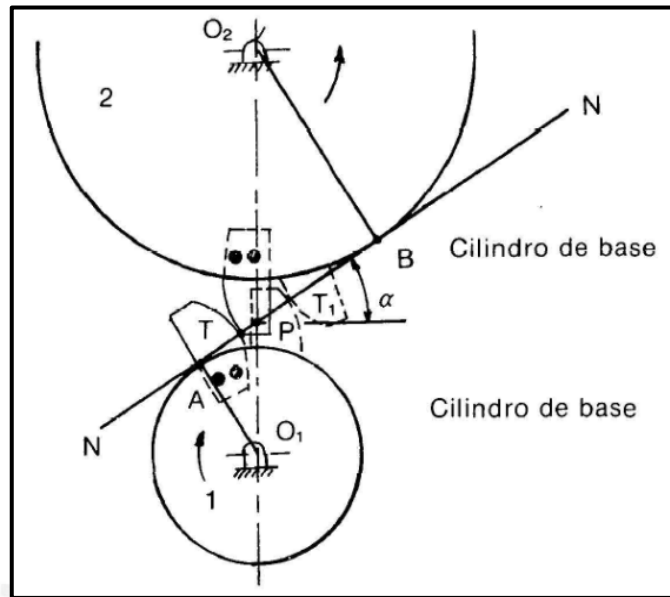
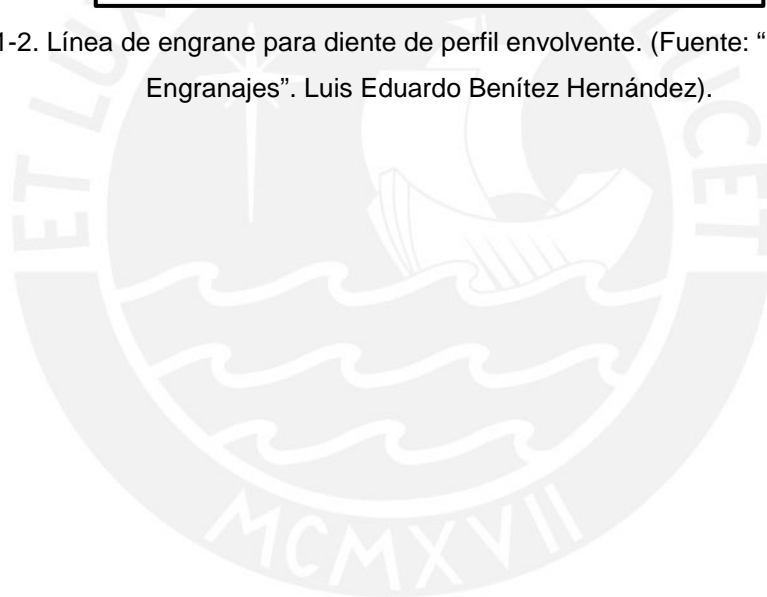


Figura A1-2. Línea de engrane para diente de perfil envolvente. (Fuente: "Las Fallas en los Engranajes". Luis Eduardo Benítez Hernández).



A2. Gráficas para seleccionar los factores influyentes en la resistencia a la fatiga por flexión en la raíz del diente

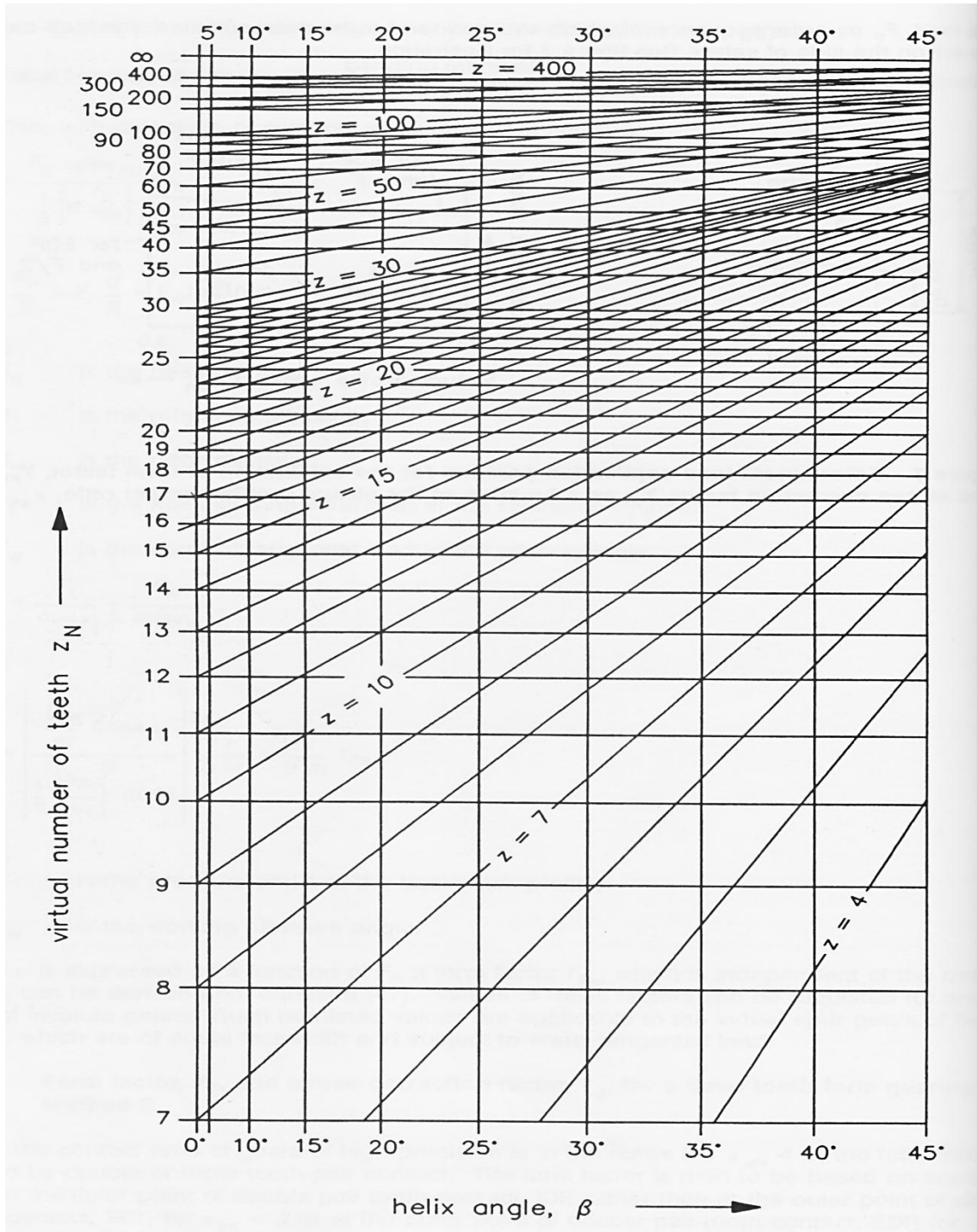


Gráfico A2-1. Número virtual de dientes Z

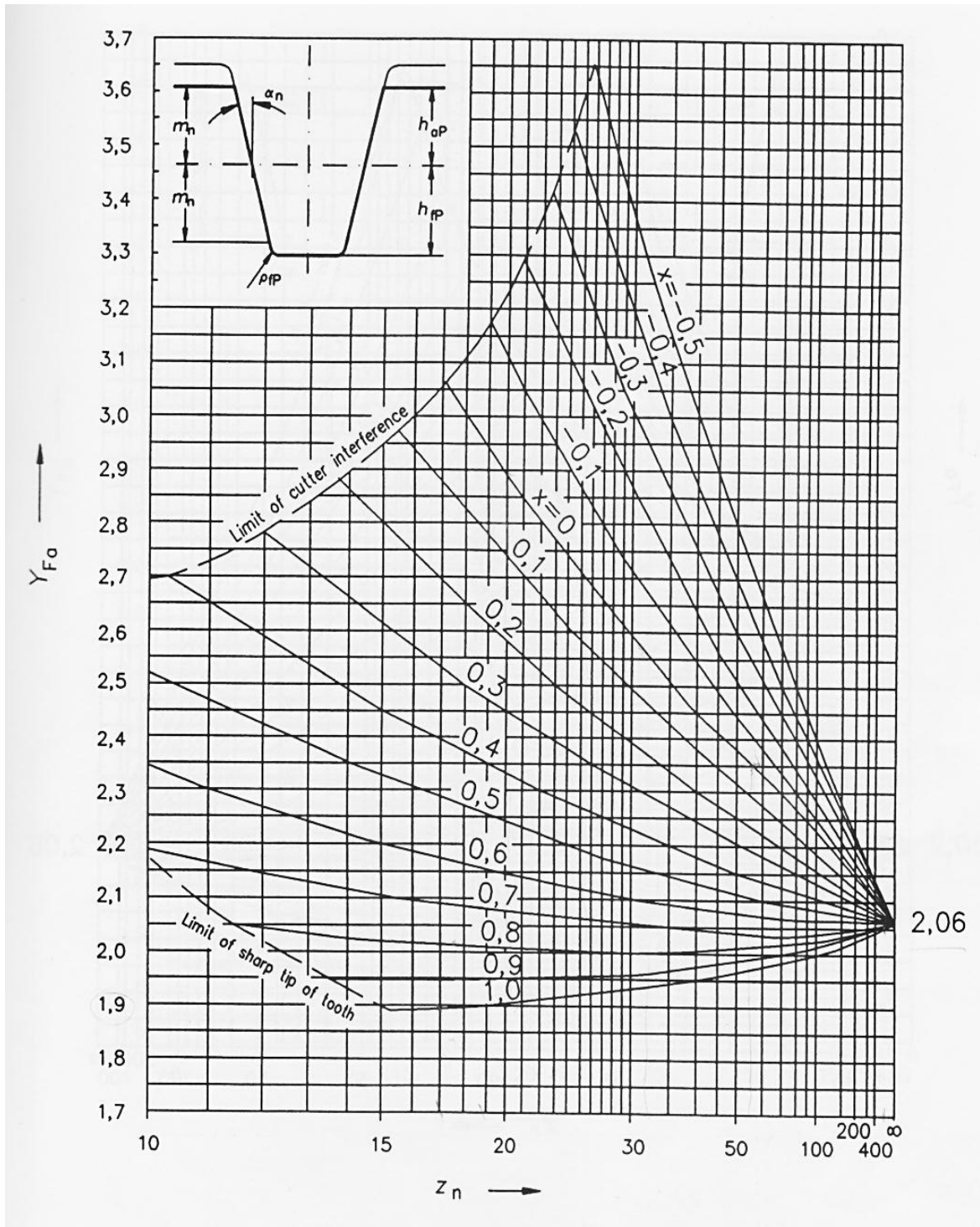


Gráfico A2-2. Factor de forma Y_{Fa}

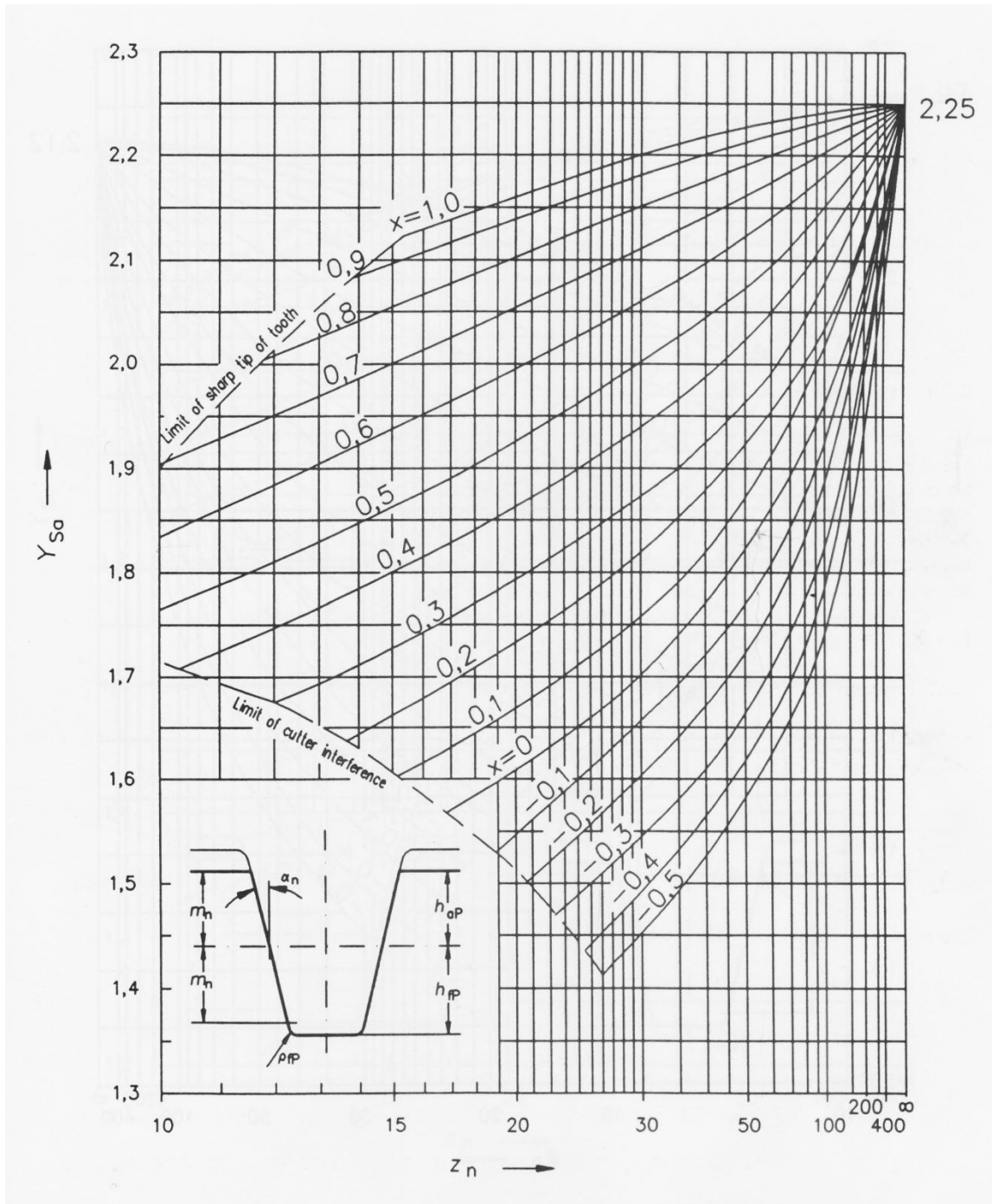


Gráfico A2-3. Factor de concentración de tensión Y_{Sa}

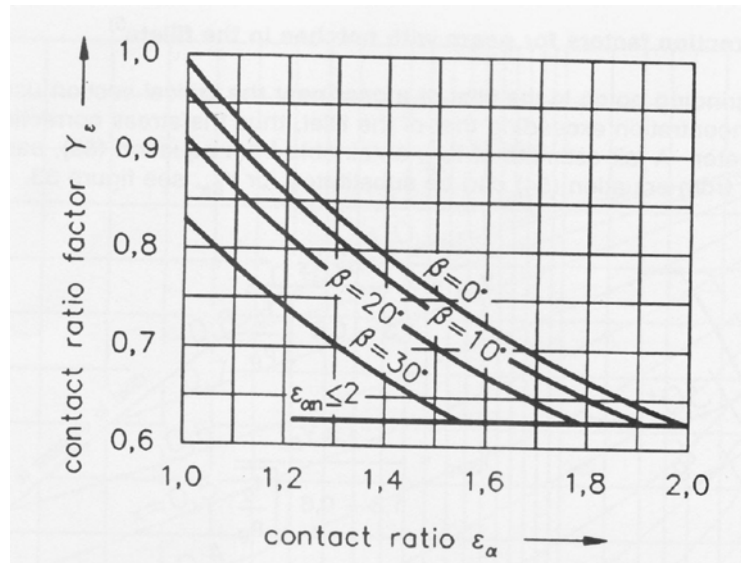


Gráfico A2-4. Factor de engrane Y_ϵ

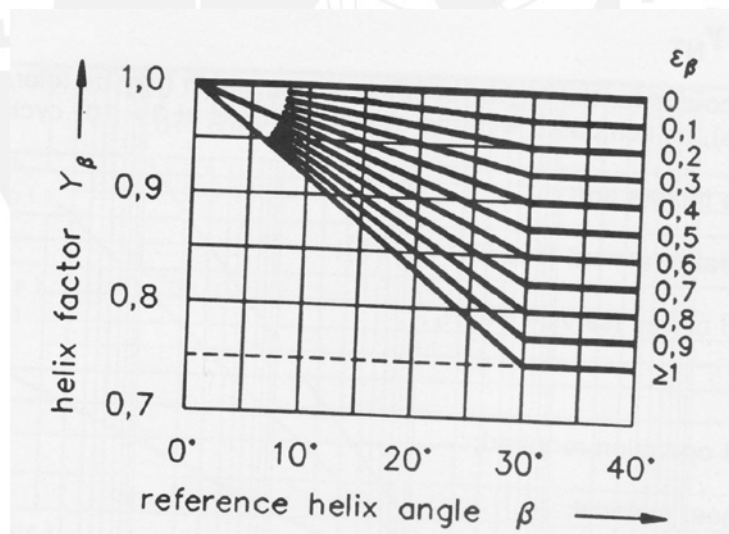


Gráfico A2-5. Factor de inclinación de la hélice Y_β

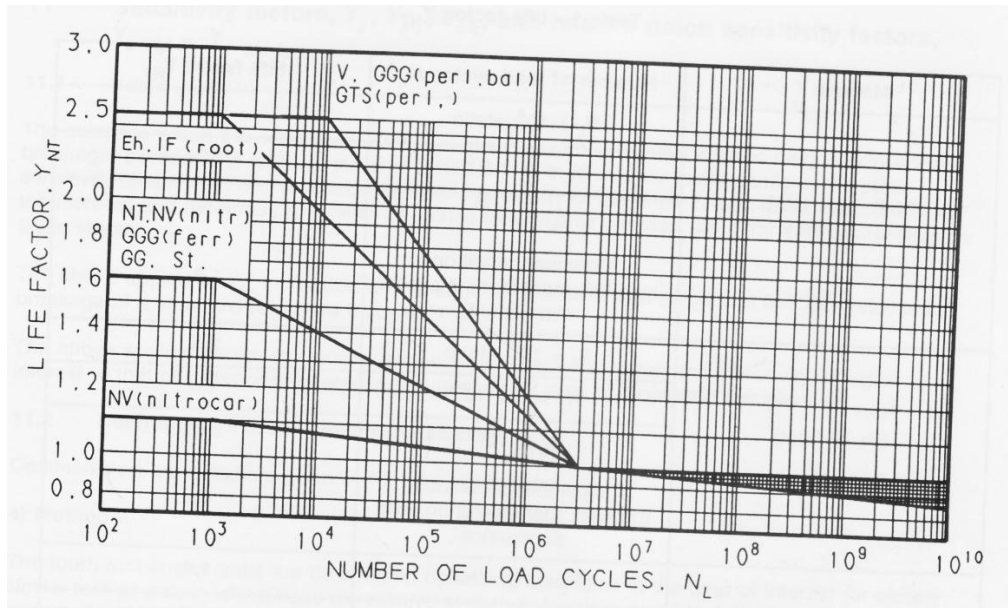


Gráfico A2-6. Factor de duración Y_{NT}

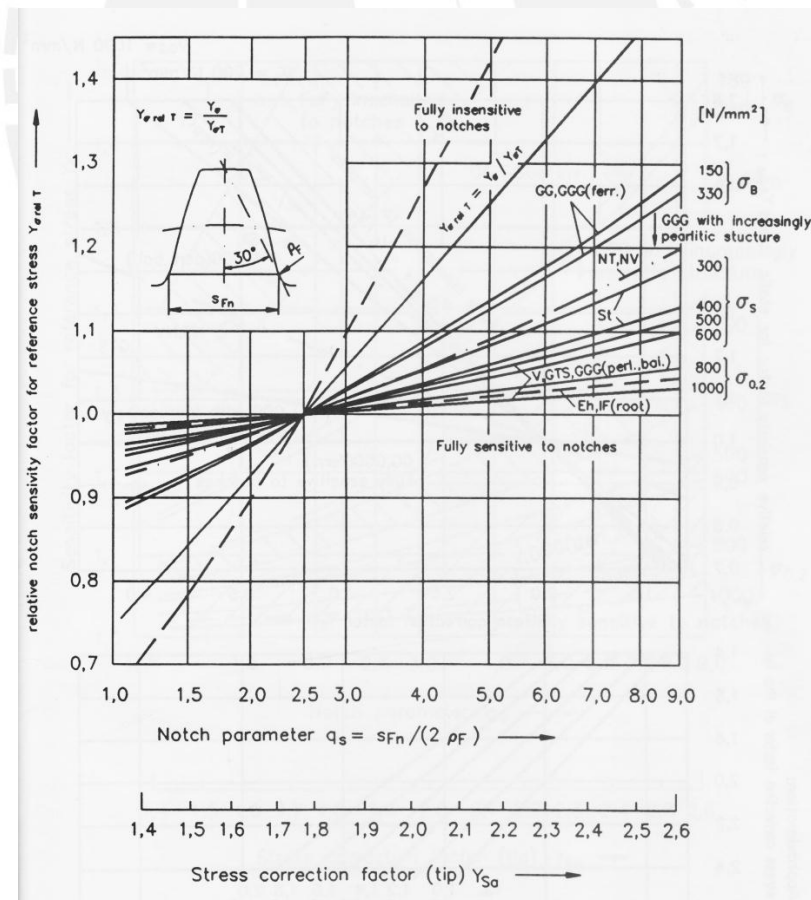


Gráfico A2-7. Cifra relativa de apoyo, considerando la sensibilidad a la entalla del material $Y_{\delta \text{ rel } T}$

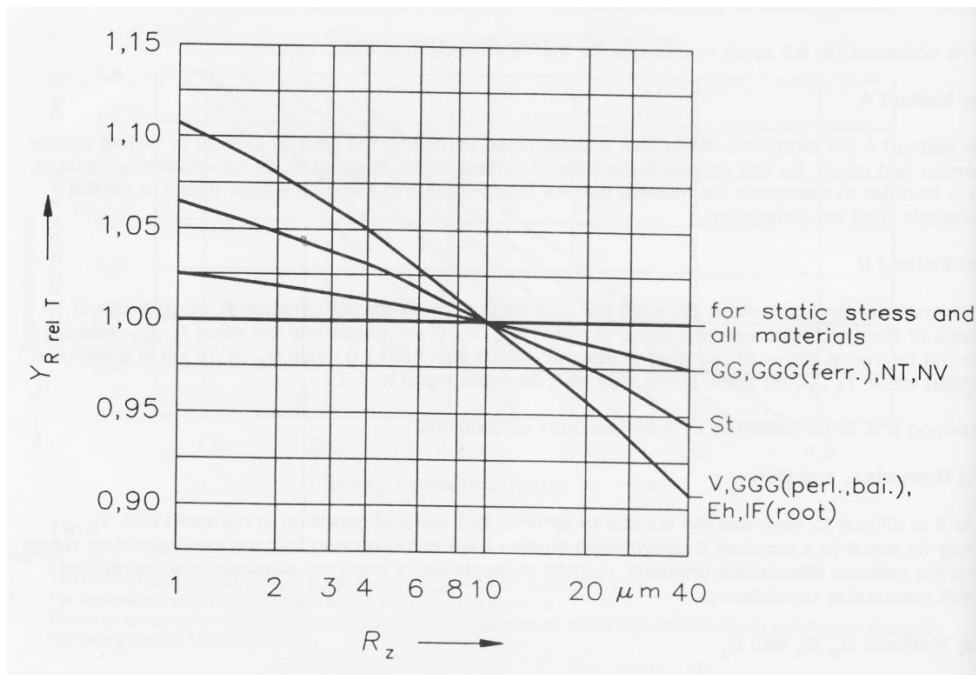


Gráfico A2-8. Factor de acabado superficial en el redondeo de la raíz $Y_{R \text{ rel } T}$

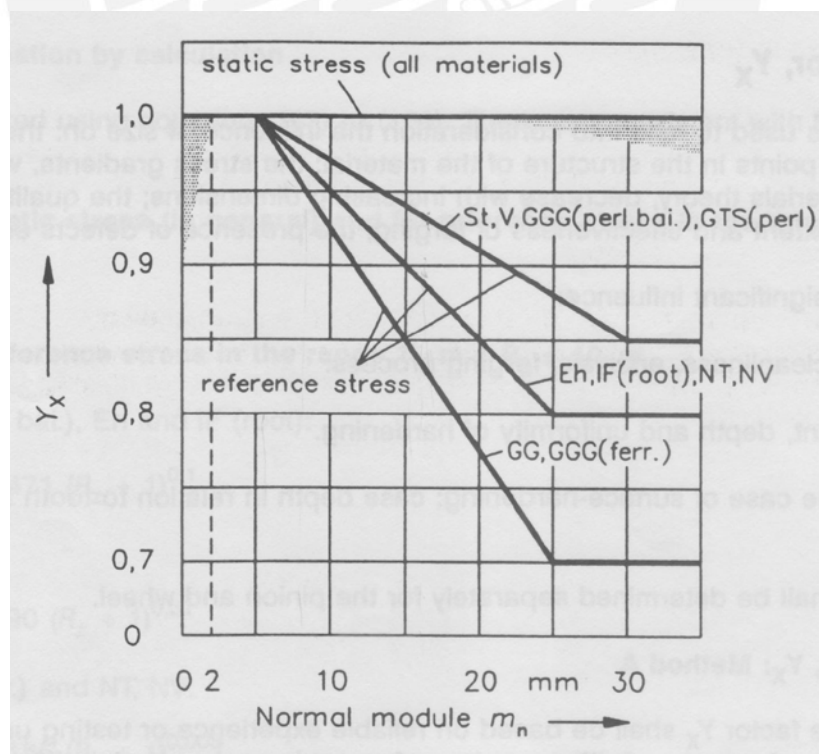


Gráfico A2-9. Factor de tamaño Y_x

A3. Tablas para validación de resultados obtenidos por el método de los elementos finitos en especímenes de geometría sencilla

A3-1. Resultados para K_I mediante método analítico y mediante simulación numérica

Factor de Intensidad de Tensiones K_I (MPa * $\sqrt{\text{mm}}$)			
Tamaño de grieta (mm)	Método Analítico	Simulación Numérica	Variación (%)
1	71.749	71.242	0.786
2	101.491	102.85	1.321
3	124.273	126.624	1.857
4	173.644	177.287	2.05
5	222.103	226.916	2.121
6	251.836	258.025	2.398
7	284.479	291.968	2.565
8	320.985	329.555	2.601
9	358.342	368.772	2.828
10	387.403	399.287	2.976
11	432.824	446.735	3.114
12	473.294	489.562	3.322

A3-2. Resultados para K_I mediante método analítico y mediante simulación numérica para grieta pasante

Factor de Intensidad de Tensiones K_I (MPa * $\sqrt{\text{mm}}$)			
Tamaño de grieta (mm)	Método Analítico	Simulación Numérica	Variación (%)
1	100.798	109.09	7.601
2	144.507	154.921	6.721
3	179.287	193.23	7.216
4	212.159	228.356	7.093
5	246.229	265.775	7.354
6	277.008	298.174	7.098
7	306.647	328.438	6.635
8	339.803	368.743	7.848
9	376.046	408.778	8.007
10	416.371	451.462	7.773
11	461.855	502.396	8.069
12	509.512	550.754	7.488

A3-3. Resultados para K_{II} mediante método analítico y mediante simulación numérica para grieta pasante

Factor de Intensidad de Tensiones K_{II} (MPa * $\sqrt{\text{mm}}$)			
Tamaño de grieta (mm)	Método Analítico	Simulación Numérica	Variación (%)
1	101.296	106.34	4.824
2	135.355	143.5	5.676
3	158.738	169.99	6.619
4	182.682	195.142	6.385
5	200.954	215.027	6.545
6	221.606	238.79	7.196
7	240.937	261.152	7.741
8	259.231	282.364	8.193
9	280.573	301.578	6.965
10	302.031	326.615	7.527
11	319.014	346.75	7.999
12	335.482	365.448	8.197

A3-4. Resultados para K_{III} mediante método analítico y mediante simulación numérica para grieta pasante

Factor de Intensidad de Tensiones K_{III} (MPa * $\sqrt{\text{mm}}$)			
Tamaño de grieta (mm)	Método Analítico	Simulación Numérica	Variación (%)
1	46.832	51.833	9.337
2	66.231	72.45	8.584
3	81.316	90.02	9.669
4	93.664	103.284	9.314
5	104.72	116.16	9.848
6	114.715	129.245	11.242
7	123.907	142.262	12.902
8	132.462	151.278	12.438
9	140.497	161.378	12.939
10	148.097	171.33	13.56

A4. Tablas para validación de resultados obtenidos por el método de los elementos finitos en casos de engranajes cilíndricos fisurados

A4-1. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 1 de engranaje cilíndrico recto fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica (MPa * \sqrt{m})	Factor de Intensidad de Tensiones K_I por método analítico (MPa * \sqrt{m})	Variación (%)
a=1 mm	11.055	9.788	11.46
a=1.5 mm	12.412	12.098	2.53
a=2 mm	13.965	14.279	2.19
a=2.5 mm	14.623	16.126	9.32
a=3 mm	15.798	18.032	12.39
a=3.5 mm	16.374	19.162	14.549
a=4 mm	17.308	19.974	13.347
a=4.5 mm	17.856	20.94	14.728
a=5 mm	18.514	21.321	13.165
a=5.5 mm	18.98	21.806	12.959
a=6 mm	19.521	22.122	11.758
a=6.5 mm	19.995	22.723	12.005
a=7 mm	20.464	23.048	11.211
a=7.5 mm	21.248	23.425	9.293
a=8 mm	22.021	23.964	8.108
a=8.5 mm	22.533	24.689	8.733
a=9 mm	23.255	25.178	7.638
a=9.5 mm	23.758	25.665	8.058
a=10 mm	24.582	26.58	7.517

A4-2. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 2 de engranaje cilíndrico recto fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica (MPa * \sqrt{m})	Factor de Intensidad de Tensiones K_I por método analítico (MPa * \sqrt{m})	Variación (%)
a=1 mm	10.28	9.239	10.126
a=1.5 mm	12.089	11.261	6.849
a=2 mm	13.63	12.983	4.747
a=2.5 mm	14.676	14.536	0.755
a=3 mm	15.735	15.971	1.678
a=3.5 mm	16.432	17.035	3.539
a=4 mm	17.224	18.269	5.72
a=4.5 mm	17.975	19.355	7.129
a=5 mm	18.791	19.995	6.022
a=5.5 mm	19.296	20.742	6.972
a=6 mm	20.022	21.955	8.803
a=6.5 mm	20.634	22.926	9.997
a=7 mm	21.377	24.022	11.011
a=7.5 mm	21.786	24.635	11.565
a=8 mm	22.233	25.157	11.623
a=8.5 mm	22.766	25.542	10.868
a=9 mm	23.262	25.984	9.476
a=9.5 mm	23.874	26.483	9.852
a=10 mm	24.532	27.535	10.906

A4-3. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 3 de engranaje cilíndrico recto fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica ($\text{MPa} * \sqrt{\text{m}}$)	Factor de Intensidad de Tensiones K_I por método analítico ($\text{MPa} * \sqrt{\text{m}}$)	Variación (%)
a=1 mm	9.734	8.644	11.197
a=1.5 mm	11.489	10.672	7.111
a=2 mm	13.247	12.804	3.344
a=2.5 mm	15.055	15.65	3.802
a=3 mm	16.697	18.552	9.998
a=3.5 mm	17.836	19.467	8.378
a=4 mm	19.214	21.335	9.941
a=4.5 mm	20.479	22.856	10.399
a=5 mm	21.324	24.036	11.283
a=5.5 mm	22.156	24.458	9.412
a=6 mm	23.368	24.892	6.122
a=6.5 mm	24.123	25.993	7.194
a=7 mm	25.412	26.878	5.454
a=7.5 mm	26.652	28.426	6.241
a=8 mm	27.976	30.032	6.846

A4-4. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 1 de engranaje cilíndrico helicoidal fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica ($\text{MPa} * \sqrt{\text{m}}$)	Factor de Intensidad de Tensiones K_I por método analítico ($\text{MPa} * \sqrt{\text{m}}$)	Variación (%)
a=1 mm	12.287	11.147	9.278
a=1.5 mm	14.95	13.681	8.488
a=2 mm	15.752	16.339	3.593
a=2.5 mm	17.333	18.264	5.097

a=3 mm	18.055	19.948	9.489
a=3.5 mm	18.967	20.341	6.755
a=4 mm	19.743	21.522	8.266
a=4.5 mm	20.546	22.648	9.281
a=5 mm	21.389	23.895	10.487
a=5.5 mm	22.124	25.736	13.509
a=6 mm	22.776	26.012	12.44
a=6.5 mm	23.484	26.426	11.133
a=7 mm	24.236	26.988	10.197
a=7.5 mm	24.907	27.468	9.323
a=8 mm	25.633	27.852	7.967
a=8.5 mm	25.948	28.226	8.071
a=9 mm	26.714	28.734	7.03
a=9.5 mm	27.368	29.188	6.235
a=10 mm	28.169	30.575	7.869
a=10.5 mm	29.004	31.772	12.714
a=11 mm	29.635	32.216	8.012
a=11.5 mm	30.357	33.495	9.368
a=12	31.111	34.863	10.762

A4-5. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 2 de engranaje cilíndrico helicoidal fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica ($\text{MPa} \cdot \sqrt{\text{m}}$)	Factor de Intensidad de Tensiones K_I por método analítico ($\text{MPa} \cdot \sqrt{\text{m}}$)	Variación (%)
a=1 mm	9.857	8.723	11.504
a=1.5 mm	11.418	10.465	8.346
a=2 mm	12.783	12.092	5.421

a=2.5 mm	13.8	14.266	3.267
a=3 mm	14.872	16.42	9.428
a=3.5 mm	15.633	17.053	8.327
a=4 mm	16.512	18.256	9.553
a=4.5 mm	17.224	19.552	11.907
a=5 mm	17.885	20.438	12.491
a=5.5 mm	18.586	21.166	12.175
a=6 mm	18.947	21.658	12.517
a=6.5 mm	19.534	21.832	10.525
a=7 mm	20.156	22.248	9.403
a=7.5 mm	20.646	22.879	9.76
a=8 mm	21.238	23.206	8.481
a=8.5 mm	21.745	23.915	9.074
a=9 mm	22.413	25.268	11.299
a=9.5 mm	22.934	26.954	14.914
a=10 mm	23.432	27.552	14.958
a=10.5 mm	23.971	27.973	14.307
a=11 mm	24.482	28.464	13.989
a=11.5 mm	25.055	29.136	14.007
a=12	25.531	29.814	14.366

A4-6. Resultados para K_I mediante método analítico y mediante simulación numérica para CASO 3 de engranaje cilíndrico helicoidal fisurado ($c/a = 1.5$)

Profundidad de grieta	Factor de Intensidad de Tensiones K_I por simulación numérica ($\text{MPa} * \sqrt{\text{m}}$)	Factor de Intensidad de Tensiones K_I por método analítico ($\text{MPa} * \sqrt{\text{m}}$)	Variación (%)
a=1 mm	9.983	8.655	13.303
a=1.5 mm	12.138	10.934	9.919

a=2 mm	13.442	13.114	2.441
a=2.5 mm	14.812	15.246	2.845
a=3 mm	16.035	17.308	7.355
a=3.5 mm	17.212	18.276	5.822
a=4 mm	18.344	19.185	4.384
a=4.5 mm	19.455	20.586	5.494
a=5 mm	20.562	21.883	6.037
a=5.5 mm	21.735	23.477	7.421
a=6 mm	22.974	24.758	7.206
a=6.5 mm	24.148	26.175	7.744
a=7 mm	25.429	27.735	8.314
a=7.5 mm	26.712	29.368	9.044
a=8 mm	28.051	31.19	10.064
a=8.5 mm	29.433	33.164	11.25
a=9 mm	30.874	34.863	11.442
a=9.5 mm	32.652	35.966	9.214
a=10 mm	33.826	37.464	9.711

A5. Tablas para la obtención del número de ciclos necesarios para la propagación de una grieta en un engranaje cilíndrico fisurado, partiendo del factor de intensidad de tensiones para cada longitud de grieta.

A5-1. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico recto $c/a = 1.5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.782	1.13062E-05	44223.6203	44223.62034
1	11.364	2.71584E-05	25997.9463	70221.56661
1.5	12.68	3.94188E-05	15020.1546	85241.72121
2	14.198	5.78989E-05	10275.6205	95517.34169
2.5	14.683	6.49035E-05	8143.15998	103660.5017
3	15.961	8.6199E-05	6618.02137	110278.523
3.5	16.7	0.000100539	5355.09907	115633.6221
4	17.691	0.000122308	4487.37891	120121.001
4.5	18	0.000129725	3967.7246	124088.7256
5	18.6	0.000145025	3639.6726	127728.3982
5.5	19.1	0.000158713	3292.31813	131020.7163
6	19.707	0.000176526	2982.95298	134003.6693
6.5	20.2	0.000191996	2713.54317	136717.2125
7	20.8	0.000212087	2474.73971	139191.9522
7.5	21.3	0.000229926	2262.37693	141454.3291
8	22.194	0.000264423	2022.8616	143477.1907
8.5	22.831	0.000291127	1800.0177	145277.2084
9	23.371	0.000315211	1649.24556	146926.454
9.5	24.068	0.000348333	1507.06096	148433.515
10	24.792	0.000385263	1363.14887	149796.6638
10.5	25.357	0.00041594	1248.12289	151044.7867
11	26.185	0.000463956	1136.4978	152181.2845
11.5	27.0525	0.000518326	1018.0373	153199.3218
12	27.92	0.000577046	912.931625	154112.2534
12.5	28.523	0.000620528	835.021114	154947.2746
13	29.197	0.000671812	773.78964	155721.0642
13.5	29.826	0.000722306	717.299303	156438.3635
14	30.487	0.000778194	666.444531	157104.808
14.5	31.212	0.00084293	616.855911	157721.6639
15	31.841	0.000902096	573.057348	158294.7213
15.5	32.604	0.00097773	531.964026	158826.6853
16	33.167	0.001036332	496.50888	159323.1942
16.5	33.952	0.001122123	463.294362	159786.4886
17	35.035	0.001248548	421.821584	160208.3101

17.5	36.459	0.001429665	373.383332	160581.6935
18	38.052	0.001653414	324.351153	160906.0446
18.5	39.268	0.001840051	286.248774	161192.2934
19	40.448	0.002034923	258.066225	161450.3596
19.5	42.184	0.002347472	228.185721	161678.5453
20	44.559	0.002827994	193.219307	161871.7647
20.5	46.245	0.00320862	165.655769	162037.4204
21	48.552	0.003786189	142.963162	162180.3836
21.5	50.886	0.004441527	121.540416	162301.924
22	52.928	0.005077252	105.055495	162406.9795
22.5	55.532	0.005977854	90.4559421	162497.4354
23	58.578	0.007167958	76.0698513	162573.5053

A5-2. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico recto $c/a = 3$.

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.445	1.44805E-05	34529.1027	34529.1027
1	11.495	2.82377E-05	23409.2321	57938.33485
1.5	12.555	3.81132E-05	15071.4076	73009.74242
2	13.365	4.71403E-05	11729.7276	84739.47002
2.5	14.14	5.70987E-05	9593.33894	94332.80896
3	14.908	6.83477E-05	7971.53322	102304.3422
3.5	15.437	7.69506E-05	6882.39348	109186.7357
4	16.186	9.04008E-05	5975.44967	115162.1853
4.5	16.981	0.000106408	5081.07987	120243.2652
5	17.795	0.00012477	4325.67081	124568.936
5.5	18.586	0.000144654	3711.6188	128280.5548
6	19.389	0.000167027	3208.41037	131488.9652
6.5	20.108	0.000189039	2808.46606	134297.4312
7	20.844	0.000213616	2483.51385	136780.9451
7.5	21.527	0.000238365	2212.48404	138993.4291
8	22.219	0.000265437	1984.90809	140978.3372
8.5	23.024	0.00029958	1769.85872	142748.1959
9	23.82	0.000336279	1572.67542	144320.8714
9.5	24.746	0.000382838	1390.59385	145711.4652
10	25.831	0.000442974	1210.9294	146922.3946
10.5	27.308	0.00053516	1022.35482	147944.7494
11	28.254	0.000600855	880.269862	148825.0193
11.5	30.277	0.000760119	734.767671	149559.787
12	32.451	0.000962218	580.606364	150140.3933

12.5	34.672	0.001205109	461.397848	150601.7912
13	36.866	0.001484658	371.779395	150973.5706
13.5	39.175	0.001825276	302.120759	151275.6913
14	41.464	0.002214013	247.568312	151523.2596
14.5	44.032	0.00271588	202.844155	151726.1038
15	46.884	0.003361877	164.534361	151890.6382
15.5	49.787	0.00412375	133.589342	152024.2275
16	52.761	0.00502299	109.328575	152133.5561
16.5	55.955	0.006134092	89.6291694	152223.1852
17	58.793	0.007257803	74.6720321	152297.8573

A5-3. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico recto $c/a = 5$.

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.929	1.71624E-05	29133.5379	29133.53794
1	11.712	3.00915E-05	21162.302	50295.83997
1.5	12.403	3.6567E-05	15001.8474	65297.68739
2	13.122	4.42892E-05	12367.6351	77665.32249
2.5	13.958	5.46383E-05	10108.413	87773.73549
3	14.676	6.47984E-05	8372.63888	96146.37437
3.5	15.268	7.41237E-05	7198.27681	103344.6512
4	15.975	8.64564E-05	6227.42119	109572.0724
4.5	16.663	9.97835E-05	5369.4185	114941.4909
5	17.472	0.000117237	4607.86881	119549.3597
5.5	18.512	0.000142705	3847.01797	123396.3777
6	19.872	0.000181601	3083.50223	126479.8799
6.5	21.332	0.000231103	2423.04183	128902.9217
7	23.017	0.00029927	1885.46465	130788.3864
7.5	24.941	0.000393192	1444.12091	132232.5073
8	27.063	0.000519011	1096.24715	133328.7544
8.5	29.318	0.000681326	833.099828	134161.8543
9	31.755	0.000893839	634.854282	134796.7085
9.5	34.344	0.001166785	485.289809	135281.9984
10	37.211	0.00153243	370.478039	135652.4764
10.5	40.431	0.002032017	280.54846	135933.0249
11	43.917	0.002691839	211.691471	136144.7163
11.5	47.781	0.003585633	159.299791	136304.0161
12	52.15	0.004827949	118.855436	136422.8716
12.5	57.116	0.006577707	87.675798	136510.5473

**A5-4. Con grieta pasante por todo el ancho del diente de engranaje recto.
CASO 1 de engranaje cilíndrico recto**

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	16.438	9.52762E-05	10495.7975	10495.79745
1	19.606	0.000173469	9572.382	20068.17945
2	22.974	0.000297374	4247.7077	24315.88715
3	26.561	0.000487	2549.80465	26865.69181
4	30.379	0.000768861	1592.53273	28458.22454
5	34.96	0.001239484	995.844882	29454.06942
6	39.882	0.001939722	629.087821	30083.15724
7	45.315	0.002994476	405.334351	30488.49159
8	51.28	0.004559543	264.759745	30753.25134
9	57.803	0.006850611	175.28247	30928.53381

**A5-5. Relación de radios de la grieta con forma semi-elíptica para CASO 2
de engranaje cilíndrico recto $c/a = 1.5$**

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.71	1.09941E-05	45478.9299	45478.92989
1	10.415	2.01902E-05	32067.4665	77546.39636
1.5	12.056	3.32039E-05	18728.6793	96275.07566
2	13.66	5.07727E-05	11908.077	108183.1527
2.5	14.545	6.28528E-05	8800.83906	116983.9917
3	15.895	8.49931E-05	6763.79721	123747.7889
3.5	16.65	9.95191E-05	5419.69473	129167.4837
4	17.486	0.000117556	4606.6957	133774.1793
4.5	18.158	0.000133638	3980.98651	137755.1659
5	18.941	0.000154265	3473.39244	141228.5583
5.5	19.575	0.000172538	3059.94833	144288.5066
6	20.244	0.000193422	2732.54219	147021.0488

6.5	20.861	0.000214209	2453.20069	149474.2495
7	21.499	0.000237312	2214.7359	151688.9854
7.5	21.998	0.000256567	2024.78622	153713.7716
8	22.494	0.000276774	1874.97393	155588.7456
8.5	22.967	0.000297066	1742.64781	157331.3934
9	23.465	0.000319542	1621.77663	158953.17
9.5	24.096	0.000349712	1494.20039	160447.3704
10	24.704	0.000380633	1369.21482	161816.5852
10.5	25.238	0.000409341	1265.8646	163082.4498
11	26.484	0.000482217	1121.63295	164204.0827
11.5	26.889	0.000507752	1010.13274	165214.2155
12	27.254	0.000531571	962.165001	166176.3805
12.5	27.711	0.000562491	914.025444	167090.4059
13	28.084	0.000588652	868.701973	167959.1079
13.5	28.477	0.000617133	829.335667	168788.4436
14	28.878	0.000647182	790.942619	169579.3862
14.5	29.27	0.000677541	754.875223	170334.2614
15	29.699	0.000711902	719.713062	171053.9745
15.5	30.278	0.000760205	679.298625	171733.2731
16	30.89	0.000813727	635.35149	172368.6246
16.5	31.483	0.000868074	594.600491	172963.2251
17	32.108	0.000928075	556.746625	173519.9717
17.5	32.735	0.000991151	521.043243	174041.0149
18	33.357	0.001056656	488.32707	174529.342
18.5	33.971	0.001124259	458.523062	174987.8651
19	34.531	0.001188527	432.378901	175420.244
19.5	35.119	0.001258755	408.616473	175828.8605
20	35.732	0.001335036	385.536041	176214.3965
20.5	36.343	0.001414258	363.729743	176578.1262
21	37	0.00149812	343.362049	176921.4883
21.5	37.588	0.001585862	324.256146	177245.7444
22	38.216	0.001677768	306.407319	177552.1518
22.5	38.828	0.001770888	289.968058	177842.1198
23	39.427	0.001865506	274.997672	178117.1175
23.3	40.01	0.001960971	156.802193	178273.9197
24	40.979	0.002127192	342.452137	178616.3718
24.5	41.886	0.002291565	226.307975	178842.6798
25	42.751	0.002456492	210.612441	179053.2922
25.5	43.523	0.00261061	197.351448	179250.6437
26	44.748	0.002868986	182.495208	179433.1389
26.5	45.933	0.003135613	166.539035	179599.6779

27	46.317	0.003225637	157.201821	179756.8797
27.5	47.112	0.003417789	150.524741	179907.4045
28	48.259	0.003709064	140.314381	180047.7189
28.5	49.466	0.004034049	129.14703	180176.8659
29	50.715	0.004390984	118.693895	180295.5598
29.5	51.964	0.004769653	109.162708	180404.7225
30	52.674	0.004994885	102.411403	180507.1339
30.5	54.392	0.005570794	94.64607	180601.78
31	55.791	0.00607318	85.8813306	180687.6613
31.5	56.695	0.006414314	80.0801195	180767.7414
32	58.117	0.006977966	74.6698812	180842.4113
32.5	59.818	0.007697088	68.1428468	180910.5541

A5-6. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico recto $c/a = 3$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.309	1.37838E-05	36274.5189	36274.51891
1	11.865	3.14491E-05	22107.8066	58382.32552
1.5	12.705	3.96837E-05	14058.2146	72440.54008
2	13.567	4.9607E-05	11199.3762	83639.91632
2.5	14.446	6.14101E-05	9007.61932	92647.53564
3	15.298	7.46201E-05	7351.30748	99998.84311
3.5	15.876	8.46482E-05	6278.71288	106277.556
4	16.249	9.16028E-05	5673.72749	111951.2835
4.5	17.006	0.000106941	5036.66529	116987.9488
5	17.701	0.000122544	4357.58566	121345.5344
5.5	18.443	0.000140905	3795.81198	125141.3464
6	19.269	0.000163538	3284.68848	128426.0349
6.5	20.1	0.000188784	2838.31291	131264.3478
7	20.786	0.000211602	2497.59311	133761.9409
7.5	21.539	0.000238817	2220.15745	135982.0984
8	22.285	0.000268127	1972.60416	137954.7025
8.5	23.033	0.000299978	1760.23633	139714.9388
9	23.808	0.000335704	1573.11407	141288.0529
9.5	24.58	0.000374176	1408.68881	142696.7417

10	25.374	0.000416889	1264.11796	143960.8597
10.5	26.137	0.000461071	1139.00443	145099.8641
11	27.046	0.000517903	1021.47792	146121.342
11.5	27.75	0.000565187	923.284309	147044.6264
12	28.445	0.000614778	847.482823	147892.1092
12.5	29.142	0.000667519	779.850412	148671.9596
13	29.83	0.000722635	719.344501	149391.3041
13.5	30.628	0.000790499	660.879854	150052.1839
14	31.237	0.000845228	611.349015	150663.533
14.5	31.911	0.000908857	570.097973	151233.6309
15	32.562	0.000973455	531.261743	151764.8927
15.5	33.172	0.001036864	497.433673	152262.3263
16	33.773	0.001102135	467.508452	152729.8348
16.5	34.385	0.001171528	439.818873	153169.6537
17	35.123	0.001259243	411.392102	153581.0458
17.5	35.983	0.001367191	380.744452	153961.7902
18	36.822	0.001478642	351.390971	154313.1812
18.5	37.754	0.001609801	323.78774	154636.9689
19	38.802	0.00176686	296.150605	154933.1195
19.5	39.938	0.001948998	269.11685	155202.2364
20	41.159	0.002159128	243.419957	155445.6564
20.5	42.457	0.002399527	219.362935	155665.0193
21	43.779	0.002663188	197.522454	155862.5417
21.5	45.236	0.002976763	177.306483	156039.8482
22	46.695	0.003316021	158.912157	156198.7604
22.5	48.243	0.003704885	142.43176	156341.1921
23	49.785	0.004123186	127.745391	156468.9375
23.5	51.443	0.004609008	114.518756	156583.4563
24	53.132	0.005144095	102.531474	156685.9878
24.5	54.892	0.005746836	91.8195106	156777.8073
25	56.758	0.00643858	82.06531	156859.8726
25.5	58.745	0.007237676	73.1194255	156932.992

A5-7. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico recto $c/a = 5$

Tamaño de grieta (mm)	Factor $K_{\text{equi.}}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.908	1.70392E-05	29344.0174	29344.01739
1	12.659	3.91973E-05	17782.0346	47126.05195
1.5	13.593	4.9931E-05	11219.7848	58345.83673
2	14.704	6.52197E-05	8684.27415	67030.11088
2.5	15.685	8.12354E-05	6828.03096	73858.14184
3	16.677	0.000100069	5515.58934	79373.73118
3.5	17.133	0.000109681	4767.58197	84141.31315
4	17.604	0.000120275	4348.65002	88489.96317
4.5	18.028	0.000130413	3989.02212	92478.98528
5	18.547	0.000143624	3649.14034	96128.12562
5.5	19.105	0.000158854	3306.0208	99434.14643
6	19.51	0.000170598	3035.34839	102469.4948
6.5	19.894	0.000182286	2833.79643	105303.2912
7	20.435	0.000199697	2617.91692	107921.2082
7.5	20.91	0.000215924	2406.03504	110327.2432
8	21.458	0.000235777	2213.85176	112541.095
8.5	21.966	0.0002553	2036.33913	114577.4341
9	22.887	0.000293562	1821.94971	116399.3838
9.5	23.699	0.000330507	1602.38737	118001.7712
10	24.479	0.000368975	1429.63093	119431.4021
10.5	25.348	0.000415438	1274.8386	120706.2407
11	26.334	0.000472994	1125.57857	121831.8193
11.5	27.41	0.000541987	985.240636	122817.0599
12	28.569	0.000623938	857.68848	123674.7484
12.5	29.832	0.0007228	742.535175	124417.2836
13	31.198	0.000841645	639.204305	125056.4879
13.5	32.671	0.000984578	547.578108	125604.066
14	34.257	0.001156767	466.996207	126071.0622
14.5	35.979	0.001366674	396.284333	126467.3465
15	37.81	0.001617934	335.052397	126802.3989
15.5	39.778	0.001922578	282.445014	127084.8439
16	41.832	0.002281536	237.862211	127322.7061
16.5	43.98	0.002704991	200.54037	127523.2465

17	46.245	0.00320862	169.101417	127692.3479
17.5	48.563	0.003789106	142.903561	127835.2515
18	51.028	0.004483809	120.876377	127956.1279
18.5	53.958	0.005421106	100.959977	128057.0878
19	57.192	0.006607513	83.1350644	128140.2229

A5-8. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico recto $c/a = 7$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	10.182	1.86952E-05	26744.8058	26744.80582
1	13.028	4.32198E-05	16151.1795	42895.98531
1.5	14.135	5.70301E-05	9975.0802	52871.06551
2	15.223	7.33836E-05	7667.90991	60538.97542
2.5	16.412	9.47648E-05	5947.12754	66486.10296
3	17.378	0.000115106	4764.83946	71250.94242
3.5	17.951	0.000128529	4104.5118	75355.45422
4	18.546	0.000143598	3674.75924	79030.21346
4.5	19.109	0.000158967	3305.07257	82335.28603
5	19.692	0.000176069	2984.75146	85320.03749
5.5	20.314	0.000195705	2689.80245	88009.83994
6	20.985	0.000218569	2413.85972	90423.69966
6.5	21.622	0.00024196	2171.4149	92595.11456
7	22.286	0.000268168	1960.29072	94555.40528
7.5	23.066	0.000301442	1755.58644	96310.99171
8	23.959	0.000342998	1551.73477	97862.72648
8.5	24.923	0.000392228	1360.12514	99222.85162
9	25.978	0.000451604	1185.06981	100407.9214
9.5	27.099	0.000521362	1027.78579	101435.7072
10	28.333	0.000606587	886.56551	102322.2727
10.5	29.681	0.000710436	759.28839	103081.5611
11	31.189	0.00084082	644.638922	103726.2
11.5	32.765	0.000994243	544.940398	104271.1404
12	34.448	0.001178842	460.175193	104731.3156
12.5	36.251	0.001402123	387.451997	105118.7676
13	38.198	0.001675082	324.970223	105443.7378

13.5	40.287	0.002007515	271.547472	105715.2853
14	42.499	0.002407607	226.494291	105941.7796
14.5	44.785	0.002877059	189.226696	106131.0063
15	47.181	0.003434838	158.430957	106289.4373
15.5	50.111	0.004215708	130.709624	106420.1469
16	53.478	0.005258884	105.545449	106525.6923
16.5	56.946	0.006511379	84.9598675	106610.6522

A5-9. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico recto $c/a = 1.5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.193	8.92903E-06	55997.1492	55997.14921
1	9.908	1.70392E-05	38508.5273	94505.67647
1.5	11.685	2.98563E-05	21323.9953	115829.6718
2	13.45	4.81675E-05	12816.6111	128646.2828
2.5	15.236	7.35969E-05	8212.58559	136858.8684
3	16.912	0.000104945	5600.93342	142459.8018
3.5	18.048	0.000130905	4239.98287	146699.7847
4	19.573	0.000172478	3296.1636	149995.9483
4.5	20.684	0.000208092	2627.63874	152623.587
5	21.532	0.000238553	2238.91439	154862.5014
5.5	22.338	0.000270302	1965.19788	156827.6993
6	23.195	0.000307213	1731.55938	158559.2587
6.5	24.181	0.000353924	1512.54596	160071.8047
7	25.287	0.000412049	1305.52831	161377.333
7.5	26.573	0.000487749	1111.36101	162488.694
8	28.008	0.000583253	933.705191	163422.3992
8.5	29.645	0.000707511	774.735015	164197.1342
9	31.514	0.000870984	633.51508	164830.6493
9.5	33.682	0.001092071	509.410193	165340.0595
10	36.169	0.001391368	402.667389	165742.7268
10.5	39.065	0.001807909	312.570542	166055.2974
11	42.372	0.002383233	238.598428	166293.8958
11.5	45.861	0.003118933	181.746613	166475.6424
12	49.644	0.004083617	138.839713	166614.4821

12.5	53.569	0.005289372	106.689553	166721.1717
13	57.806	0.00685182	82.364237	166803.5359

A5-10. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico recto $c/a = 3$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.554	1.03389E-05	48361.1398	48361.13982
1	10.232	1.90092E-05	34073.7794	82434.91925
1.5	12.033	3.2989E-05	19231.429	101666.3483
2	14.554	6.29851E-05	10419.4717	112085.82
2.5	16.745	0.000101463	6080.94565	118166.7656
3	19.101	0.000158741	3843.14066	122009.9063
3.5	21.735	0.000246287	2468.96809	124478.8744
4	24.621	0.000376303	1606.19512	126085.0695
4.5	27.624	0.000556509	1072.02742	127157.0969
5	30.741	0.000800459	736.936818	127894.0337
5.5	33.917	0.001118194	521.198824	128415.2326
6	37.503	0.001573702	371.485335	128786.7179
6.5	41.538	0.002227476	263.076352	129049.7943
7	45.744	0.003091962	187.989796	129237.7841
7.5	50.223	0.004247829	136.243661	129374.0277
8	55.517	0.005972366	97.8454897	129471.8732

A5-11. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico recto $c/a = 5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.908	1.18673E-05	42132.6966	42132.69659
1	10.538	2.10124E-05	30413.9217	72546.61826
1.5	11.791	3.07872E-05	19305.1635	91851.78175

2	14.364	6.0233E-05	10986.5738	102838.3556
2.5	18.179	0.000134164	5144.11264	107982.4682
3	22.213	0.000265193	2504.02322	110486.4914
3.5	26.628	0.00049119	1322.0818	111808.5732
4	31.391	0.00085948	740.373793	112548.947
4.5	36.639	0.001453806	432.28567	112981.2327
5	42.494	0.002406644	259.037162	113240.2698
5.5	49.072	0.003925842	157.915854	113398.1857
6	55.965	0.00613782	99.3674043	113497.5531

A5-12. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico helicoidal $c/a = 1.5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	10.908	2.36282E-05	21161.1139	21161.1139
1	12.637	3.89662E-05	15975.869	37136.9829
1.5	15.237	7.36133E-05	8882.6159	46019.5988
2	16.54	9.73013E-05	5850.87468	51870.47349
2.5	17.551	0.000119049	4622.14109	56492.61458
3	18.398	0.000139739	3864.17001	60356.78459
3.5	19.185	0.000161127	3323.73765	63680.52224
4	19.951	0.000184068	2896.91516	66577.43739
4.5	20.738	0.000209945	2537.98879	69115.42618
5	21.661	0.000243447	2205.59583	71321.02201
5.5	22.252	0.00026678	1959.91191	73280.93392
6	22.946	0.000296143	1776.44206	75057.37598
6.5	23.603	0.000325977	1607.40715	76664.78313
7	24.498	0.000369949	1436.93446	78101.71759
7.5	25.038	0.000398416	1301.46429	79403.18188
8	25.847	0.000443908	1187.19223	80590.37411
8.5	26.186	0.000464016	1101.41402	81691.78813
9	26.939	0.00051097	1025.65593	82717.44406
9.5	27.596	0.000554594	938.470817	83655.91488
10	28.367	0.000609065	859.358546	84515.27342
10.5	29.193	0.0006715	780.905602	85296.17903
11	29.849	0.000724201	716.485915	86012.66494

11.5	30.676	0.000794719	658.362284	86671.02722
12	31.225	0.000844124	610.186412	87281.21364
12.5	31.944	0.000912056	569.417544	87850.63118
13	32.532	0.000970409	531.218403	88381.84958
13.5	33.659	0.001089537	485.449614	88867.2992
14	34.868	0.001228429	431.412684	89298.71188
14.5	36.062	0.001377423	383.751659	89682.46354
15	37.244	0.001537055	343.114546	90025.57809
15.5	38.504	0.001721147	306.917718	90332.4958
16	39.886	0.001940384	273.10981	90605.60562
16.5	41.372	0.002197355	241.677891	90847.28351
17	43.006	0.002506668	212.584003	91059.86751
17.5	44.893	0.002900717	184.93227	91244.79978
18	46.88	0.003360902	159.703095	91404.50287
18.5	49.056	0.003921492	137.317482	91541.82036
19	51.424	0.004603222	117.305989	91659.12635
19.5	54.018	0.005441629	99.5534882	91758.67983
20	56.844	0.00647181	83.9388152	91842.61865

A5-13. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico helicoidal $c/a = 3$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	11.166	2.55829E-05	19544.2966	19544.29658
1	12.842	4.11575E-05	14983.4234	34527.71997
1.5	14.825	6.70625E-05	9240.43142	43768.15139
2	15.646	8.05507E-05	6774.45962	50542.611
2.5	16.588	9.82647E-05	5592.35792	56134.96893
3	17.255	0.000112359	4747.79664	60882.76557
3.5	18.328	0.00013794	3995.22205	64877.98762
4	19.224	0.000162243	3331.30097	68209.2886
4.5	20.515	0.000202368	2742.64883	70951.93743
5	21.662	0.000243486	2242.89064	73194.82806
5.5	22.694	0.00028523	1891.37538	75086.20344
6	23.821	0.000336327	1608.86167	76695.06511
6.5	24.733	0.000382155	1391.82358	78086.88869

7	25.912	0.000447715	1205.00916	79291.89785
7.5	26.866	0.000506277	1048.2272	80340.12505
8	28.089	0.000589008	913.004085	81253.12914
8.5	29.231	0.000674476	791.462148	82044.59128
9	30.416	0.00077205	691.311651	82735.90293
9.5	31.783	0.000896521	599.315239	83335.21817
10	33.321	0.001052784	513.003213	83848.22139
10.5	34.939	0.001236954	436.731115	84284.9525
11	36.677	0.001458938	370.934639	84655.88714
11.5	38.531	0.001725254	314.051386	84969.93853
12	40.494	0.002042802	265.388827	85235.32735
12.5	42.601	0.002427311	223.707998	85459.03535
13	44.79	0.002878152	188.484998	85647.52035
13.5	47.058	0.003404488	159.168767	85806.68912
14	49.394	0.00401412	134.796182	85941.4853
14.5	51.812	0.004722384	114.462272	86055.94757
15	54.352	0.005556878	97.2832558	86153.23083
15.5	57.039	0.006547606	82.6140179	86235.84484

A5-14. Relación de radios de la grieta con forma semi-elíptica para CASO 1 de engranaje cilíndrico helicoidal $c/a = 5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	11.449	2.78553E-05	17949.91	17949.91003
1	13.719	5.15222E-05	12598.0297	30547.93973
1.5	14.488	6.20193E-05	8807.35393	39355.29366
2	15.325	7.50688E-05	7294.57827	46649.87193
2.5	16.188	9.04388E-05	6042.01643	52691.88836
3	17.003	0.000106877	5068.01301	57759.90137
3.5	17.978	0.000129187	4236.13689	61996.03826
4	18.712	0.000148015	3607.47342	65603.51168
4.5	20.159	0.000190674	2952.55391	68556.06559
5	21.766	0.000247483	2282.28442	70838.35002
5.5	23.635	0.000327482	1739.23707	72577.58709
6	25.678	0.000434116	1313.02856	73890.61564
6.5	27.945	0.000578805	987.243842	74877.85949

7	30.464	0.0007762	738.004882	75615.86437
7.5	33.22	0.001041974	550.002468	76165.86684
8	36.206	0.001396214	410.140736	76576.00757
8.5	39.414	0.001863416	306.783328	76882.7909
9	42.89	0.002483754	230.034716	77112.82562
9.5	46.678	0.003311919	172.542525	77285.36814
10	50.867	0.004435891	129.068737	77414.43688
10.5	55.253	0.005876354	96.9720918	77511.40897
11	59.622	0.007611676	74.1398112	77585.54878

A5-15. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico helicoidal $c/a = 1.5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación da/dN	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	7.276	5.96394E-06	83837.21	83837.20998
1	9.767	1.62288E-05	45059.808	128897.018
1.5	11.427	2.76737E-05	22777.7398	151674.7578
2	12.785	4.05397E-05	14659.871	166334.6288
2.5	13.918	5.41077E-05	10565.5279	176900.1567
3	15.071	7.0922E-05	7998.09701	184898.2537
3.5	15.996	8.68434E-05	6338.52502	191236.7787
4	16.735	0.000101257	5316.30722	196553.0859
4.5	17.457	0.000116895	4583.96462	201137.0505
5	18.064	0.0001313	4029.09211	205166.1426
5.5	18.604	0.000145131	3617.5394	208783.682
6	19.125	0.00015942	3283.52397	212067.206
6.5	19.752	0.0001779	2964.54448	215031.7505
7	20.328	0.000196164	2673.33827	217705.0888
7.5	20.886	0.000215083	2431.62755	220136.7163
8	21.459	0.000235814	2217.79985	222354.5162
8.5	21.956	0.000254905	2037.82302	224392.3392
9	22.535	0.000278493	1874.77256	226267.1117
9.5	23.089	0.000302465	1721.29515	227988.4069
10	23.651	0.000328236	1585.53648	229573.9434
10.5	24.183	0.000354024	1465.71675	231039.6601
11	24.702	0.000380529	1361.3731	232401.0332

11.5	25.227	0.000408734	1267.00501	233668.0382
12	25.746	0.000438037	1180.95576	234848.994
12.5	26.268	0.000468975	1102.52047	235951.5145
13	26.81	0.000502698	1029.15255	236980.667
13.5	27.356	0.000538365	960.556556	237941.2236
14	27.908	0.000576203	897.208395	238838.432
14.5	28.456	0.000615587	839.074156	239677.5061
15	28.995	0.00065614	786.332449	240463.8386
15.5	29.549	0.000699751	737.522328	241201.3609
16	30.085	0.000743855	692.709949	241894.0708
16.5	30.632	0.00079085	651.591068	242545.6619
17	31.181	0.000840087	613.144451	243158.8064
17.5	31.736	0.000892022	577.330991	243736.1374
18	32.293	0.000946382	543.950065	244280.0874
18.5	32.855	0.001003559	512.835889	244792.9233
19	33.412	0.001062592	483.991714	245276.915
19.5	33.972	0.001124372	457.255049	245734.1701
20	34.52	0.001187241	432.598542	246166.7686
20.5	35.173	0.001265348	407.73245	246574.5011
21	35.739	0.001335925	384.427088	246958.9282
21.5	36.327	0.001412142	363.892065	247322.8202
22	36.924	0.001492615	344.262859	247667.0831
22.5	37.536	0.001578415	325.623661	247992.7067
23	38.157	0.001668977	307.939399	248300.6461
23.5	38.8	0.00176655	291.076153	248591.7223
24	39.475	0.00187324	274.74117	248866.4635
24.5	40.161	0.001986248	259.10178	249125.5652
25	40.856	0.002105561	244.390679	249369.9559
25.5	41.555	0.002230577	230.619946	249600.5759
26	42.269	0.002363593	217.667161	249818.243
26.5	42.993	0.002504093	205.436425	250023.6795
27	43.73	0.002653067	193.905176	250217.5846
27.5	44.486	0.002812273	182.971229	250400.5559
28	45.275	0.002985498	172.48008	250573.0359
28.5	46.13	0.003181572	162.151548	250735.1875
29	47.016	0.003394168	152.074132	250887.2616
29.5	47.927	0.003623021	142.507201	251029.7688
30	48.879	0.003873592	133.393566	251163.1624
30.5	49.993	0.004182051	124.136581	251287.299
31	51.223	0.004542334	114.621259	251401.9202
31.5	52.803	0.005036598	104.395773	251506.316

32	54.663	0.005665729	93.4376233	251599.7536
32.5	56.155	0.006208958	84.212746	251683.9664
33	57.858	0.006872799	76.4423309	251760.4087
33.5	59.232	0.007443716	69.8494004	251830.2581

A5-16. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico helicoidal $c/a = 3$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.729	1.10759E-05	45143.2359	45143.2359
1	11.183	2.57156E-05	27180.2371	72323.47304
1.5	12.126	3.3864E-05	16784.2847	89107.75771
2	12.984	4.27255E-05	13056.6299	102164.3876
2.5	13.85	5.32142E-05	10423.2194	112587.6069
3	14.476	6.18448E-05	8691.19565	121278.8026
3.5	15.238	7.36297E-05	7381.46194	128660.2645
4	15.773	8.27955E-05	6392.8316	135053.0961
4.5	16.252	9.16603E-05	5732.1118	140785.2079
5	16.804	0.000102684	5145.51794	145930.7258
5.5	17.502	0.000117922	4532.96896	150463.6948
6	18.219	0.00013517	3951.12125	154414.8161
6.5	18.944	0.000154348	3454.00918	157868.8252
7	19.561	0.000172119	3063.09862	160931.9239
7.5	20.146	0.000190257	2759.5702	163691.4941
8	20.755	0.000210531	2495.0884	166186.5825
8.5	21.31	0.000230294	2268.47797	168455.0604
9	21.905	0.000252898	2069.57332	170524.6338
9.5	22.517	0.000277737	1884.53493	172409.1687
10	23.141	0.000304788	1716.6656	174125.8343
10.5	23.762	0.000333503	1566.6837	175692.518
11	24.391	0.000364484	1432.6903	177125.2083
11.5	25.024	0.000397659	1312.08922	178437.2975
12	25.663	0.000433255	1203.49427	179640.7918
12.5	26.33	0.000472749	1103.7478	180744.5396
13	26.989	0.000514201	1013.2219	181757.7615
13.5	27.677	0.000560148	930.79612	182688.5576
14	28.373	0.000609503	854.955905	183543.5135

14.5	29.072	0.000662083	786.419139	184329.9327
15	29.784	0.000718853	724.146084	185054.0787
15.5	30.502	0.000779497	667.400743	185721.4795
16	31.225	0.000844124	615.907291	186337.3868
16.5	31.956	0.000913222	569.039918	186906.4267
17	32.394	0.000956484	534.843586	187441.2703
17.5	33.139	0.001033361	502.551807	187943.8221
18	33.928	0.001119428	464.513768	188408.3359
18.5	34.866	0.001228189	425.963848	188834.2997
19	35.819	0.00134612	388.453721	189222.7534
19.5	36.857	0.001483426	353.41354	189576.167
20	38.011	0.001647364	319.408139	189895.5751
20.5	39.238	0.001835276	287.138474	190182.7136
21	40.584	0.00205828	256.834606	190439.5482
21.5	42.052	0.002322591	228.265111	190667.8133
22	43.586	0.002623481	202.180663	190869.994
22.5	45.11	0.002948666	179.464029	191049.458
23	46.863	0.00335676	158.593546	191208.0515
23.5	48.685	0.003821568	139.308193	191347.3597
24	50.571	0.004348738	122.394426	191469.7542
24.5	52.403	0.00490805	108.028832	191577.783
25	54.486	0.005603596	95.1325856	191672.9156
25.5	56.231	0.006237575	84.4511093	191757.3667
26	58.438	0.007109879	74.920655	191832.2873
26.5	60.579	0.008035135	66.028331	191898.3157

A5-17. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico helicoidal $c/a = 5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.383	1.41599E-05	35311.0091	35311.0091
1	11.972	3.24239E-05	21466.7087	56777.71779
1.5	12.872	4.14853E-05	13530.1154	70307.8332
2	13.995	5.51323E-05	10350.0807	80657.9139
2.5	14.858	6.75715E-05	8149.71182	88807.62572
3	15.781	8.29384E-05	6644.08546	95451.71118

3.5	16.192	9.05148E-05	5765.24456	101216.9557
4	16.511	9.67225E-05	5340.81535	106557.7711
4.5	16.88	0.000104271	4975.28043	111533.0515
5	17.204	0.000111234	4640.25631	116173.3078
5.5	17.893	0.000127122	4195.40229	120368.7101
6	18.526	0.000143072	3701.03947	124069.7496
6.5	19.188	0.000161213	3286.39304	127356.1426
7	19.805	0.000179528	2934.78243	130290.9251
7.5	20.182	0.000191415	2695.82985	132986.7549
8	20.515	0.000202368	2539.47057	135526.2255
8.5	20.866	0.000214383	2399.51322	137925.7387
9	21.296	0.00022978	2251.42554	140177.1642
9.5	22.572	0.00028005	1961.43837	142138.6026
10	23.295	0.000311739	1689.79008	143828.3927
10.5	24.259	0.000357821	1493.51782	145321.9105
11	25.283	0.000411827	1299.29442	146621.2049
11.5	26.369	0.000475134	1127.44419	147748.6491
12	27.493	0.000547587	977.783189	148726.4323
12.5	28.657	0.000630496	848.836309	149575.2686
13	29.889	0.000727506	736.375657	150311.6443
13.5	31.168	0.000838897	638.405373	150950.0496
14	32.494	0.00096656	553.876504	151503.9261
14.5	33.872	0.001113158	480.834359	151984.7605
15	35.302	0.001281196	417.649085	152402.4096
15.5	37.268	0.001540426	354.406084	152756.8157
16	39.326	0.001849308	295.008422	153051.8241
16.5	41.45	0.002211472	246.258097	153298.0822
17	43.646	0.00263578	206.302453	153504.3846
17.5	45.881	0.00312356	173.631013	153678.0157
18	48.17	0.003685858	146.855428	153824.8711
18.5	50.504	0.00432918	124.765462	153949.6366
19	52.886	0.005063566	106.465132	154056.1017
19.5	55.312	0.005897716	91.2302014	154147.3319
20	57.991	0.006926663	77.9764826	154225.3084

A5-18. Relación de radios de la grieta con forma semi-elíptica para CASO 2 de engranaje cilíndrico helicoidal $c/a = 7$

Tamaño de grieta (mm)	Factor $K_{\text{equi.}}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.591	1.52558E-05	32774.3989	32774.39888
1	12.285	3.53976E-05	9572.382	42346.78088
1.5	13.522	4.90498E-05	11841.694	54188.47485
2	14.54	6.27794E-05	8942.2102	63130.68505
2.5	15.498	7.79893E-05	7103.85067	70234.53571
3	16.395	9.44315E-05	5799.76291	76034.29862
3.5	16.946	0.000105664	4997.61689	81031.91552
4	17.413	0.000115896	4513.45357	85545.36908
4.5	17.884	0.000126905	4118.60413	89663.97321
5	18.395	0.000139662	3751.40974	93415.38295
5.5	18.8	0.000150395	3447.59629	96862.97924
6	19.405	0.000167496	3145.72779	100008.707
6.5	19.931	0.000183441	2849.51247	102858.2195
7	20.493	0.000201631	2596.91676	105455.1363
7.5	21.082	0.000222023	2360.41722	107815.5535
8	21.694	0.000244711	2142.54926	109958.1027
8.5	22.309	0.00026911	1946.20322	111904.306
9	22.927	0.00029531	1771.72818	113676.0342
9.5	23.549	0.000323448	1616.13995	115292.1741
10	24.184	0.000354074	1475.96749	116768.1416
10.5	24.823	0.000386903	1349.56933	118117.7109
11	25.467	0.000422107	1236.0781	119353.789
11.5	26.415	0.000477958	1111.03037	120464.8194
12	27.868	0.0005734	951.15031	121415.9697
12.5	29.62	0.000705484	781.931629	122197.9013
13	31.314	0.000852333	641.92405	122839.8254
13.5	33.637	0.001087118	515.609922	123355.4353
14	35.923	0.001359455	408.734965	123764.1703
14.5	38.712	0.001752964	321.293442	124085.4637
15	41.768	0.00226969	248.592068	124334.0558
15.5	45.212	0.002971397	190.800112	124524.8559
16	48.964	0.003896543	145.604069	124670.46
16.5	53.431	0.005243186	109.412435	124779.8724

17	58.119	0.006978783	81.8198769	124861.6923
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A5-19. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico helicoidal $c/a = 1.5$

Tamaño de grieta (mm)	Factor $K_{equi.}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.293	9.30503E-06	53734.3874	53734.3874
1	10.122	1.83233E-05	36194.7408	89929.12815
1.5	12.335	3.58898E-05	18445.7244	108374.8526
2	13.657	5.07348E-05	11544.0613	119918.9139
2.5	15.057	7.06983E-05	8234.9881	128153.902
3	16.367	9.38843E-05	6075.97806	134229.88
3.5	17.557	0.000119187	4693.26367	138923.1437
4	18.587	0.00014468	3789.78171	142712.9254
4.5	19.667	0.00017531	3125.09015	145838.0156
5	20.787	0.000211636	2584.33519	148422.3508
5.5	21.937	0.000254156	2146.87877	150569.2295
6	23.117	0.000303714	1792.53127	152361.7608
6.5	24.357	0.00036276	1500.43409	153862.1949
7	25.637	0.000431764	1258.61565	155120.8105
7.5	26.933	0.000510583	1061.18041	156181.9909
8	28.348	0.000607679	894.244971	157076.2359
8.5	29.834	0.000722965	751.515937	157827.7519
9	31.407	0.00086097	631.339186	158459.091
9.5	33.096	0.001028809	529.162415	158988.2535
10	34.91	0.001233467	442.032713	159430.2862
10.5	36.803	0.00147605	369.069507	159799.3557
11	38.778	0.001763147	308.718551	160108.0742
11.5	40.9	0.002113281	257.969465	160366.0437
12	43.241	0.002553545	214.278389	160580.3221
12.5	45.808	0.003106695	176.670965	160756.993
13	48.597	0.003798133	144.826201	160901.8192
13.5	51.52	0.004632506	118.614973	161020.4342
14	54.564	0.005630917	97.4333859	161117.8676
14.5	57.782	0.006842153	80.1727249	161198.0403

A5-20. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico helicoidal $c/a = 3$

Tamaño de grieta (mm)	Factor $K_{\text{equi.}}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	8.764	1.12276E-05	44533.2007	44533.20071
1	10.842	2.31457E-05	29092.3801	73625.58085
1.5	12.533	3.78866E-05	16384.7819	90010.36276
2	15.354	7.55529E-05	8815.273	98825.63576
2.5	17.645	0.00012123	5081.73036	103907.3661
3	19.475	0.000169559	3438.91171	107346.2778
3.5	21.268	0.000228754	2510.58712	109856.865
4	23.436	0.000318201	1828.30316	111685.1681
4.5	26.029	0.000454625	1293.95158	112979.1197
5	28.343	0.000607315	941.672867	113920.7926
5.5	30.218	0.000755095	733.993692	114654.7862
6	32.256	0.000942701	588.999129	115243.7854
6.5	34.41	0.001174427	472.338151	115716.1235
7	36.678	0.001459074	379.722737	116095.8463
7.5	39.464	0.001871465	300.251695	116396.098
8	42.447	0.002397606	234.242973	116630.3409
8.5	45.716	0.003085532	182.377325	116812.7183
9	49.394	0.00401412	140.851989	116953.5702
9.5	53.341	0.005213219	108.373611	117061.9439
10	57.569	0.006756777	83.542219	117145.4861

A5-21. Relación de radios de la grieta con forma semi-elíptica para CASO 3 de engranaje cilíndrico helicoidal $c/a = 5$

Tamaño de grieta (mm)	Factor $K_{\text{equi.}}$	Relación d_a/d_N	# de ciclos cada 0.5 mm de grieta	# de ciclos necesarios totales desde $a=0$ mm
0.5	9.208	1.32819E-05	37645.226	37645.22595
1	11.348	2.70286E-05	24807.4267	62452.65263
1.5	13.538	4.92474E-05	13110.2803	75562.93289
2	15.783	8.29741E-05	7563.06629	83125.99918

2.5	17.563	0.000119326	4943.16116	88069.16035
3	19.794	0.000179189	3349.91612	91419.07647
3.5	22.383	0.000272157	2215.59122	93634.66769
4	25.252	0.000410113	1465.69409	95100.36178
4.5	28.521	0.000620381	970.408634	96070.77041
5	32.307	0.000947778	637.690646	96708.46106
5.5	36.683	0.00145975	415.363804	97123.82486
6	41.658	0.002249431	269.601296	97393.42616
6.5	47.226	0.00344599	175.579654	97569.00581
7	53.36	0.005219535	115.399816	97684.40563

