

Chapter 4 Measurement for Tooth thickness

4.1 Method of measurement for Sector span

Put designated Number of teeth at parallel flat face of Tooth thickness of Micrometer and measure its distance. Nipped Number of teeth at flat face is commonly called **Sector span of teeth** z_m . Unlike other methods, reference surface is not needed.

For large Sector span of teeth, deviation in measurement occurs because of influence by Pressure angle deviation and different pressure angle on either sides of tooth. Furthermore, it is common practice to measure a few positions along the whole circumference of the gear to obtain the mean in order to take into consideration Pitch and Profile deviations.

It is the most common measurement method for hobbing process as it is able to measure Sector span of teeth during machining and convert measurement into cutter tool machining adjusting amount easily.

Sector span for Spur gear

(1) Sector span for Standard spur gear W

$$W = m \cos \alpha \{ \pi (z_m - 0.5) + z \operatorname{inv} \alpha \}$$

(2) Sector span for Profile shifted spur gear W

$$W = m \cos \alpha \{ \pi (z_m - 0.5) + z \operatorname{inv} \alpha \} + 2x m \sin \alpha$$

(3) Sector span of teeth

$$z_m = \frac{\alpha z}{180} + 0.5$$

Calculation for Sector span of teeth using nearest integer by above calculated formula.

Hereby

α : Reference pressure angle

m : module

z : Number of teeth

x : Rack shift coefficient

Table 1 shows the values of Sector span and Sector span of teeth with module 1.0 and Reference pressure angle 20° (Rack shift coefficient=0).

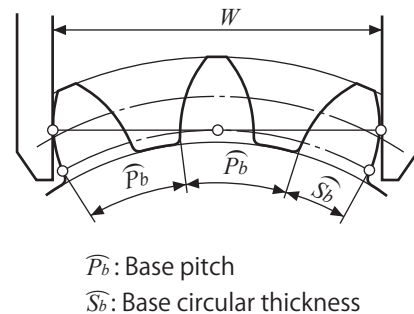


Fig. 1 Sector span

Table 1. Sector span for Standard spur gear
Adopted for module 1.0 with Pressure angle 20° (Rack shift coefficient $x = 0$).

Unit: mm

z	z_m	W	z	z_m	W	z	z_m	W	z	z_m	W	z	z_m	W
4	2	4.4842	41	5	13.8588	81	10	29.1797	121	14	41.5484	161	18	53.9172
			42	5	13.8728	82	10	29.1937	122	14	41.5624	162	19	56.8833
5	2	4.4982	43	5	13.8868	83	10	29.2077	123	14	41.5765	163	19	26.8973
			44	5	13.9008	84	10	29.2217	124	14	41.5905	164	19	26.9113
6	2	4.5122	45	6	16.8670	85	10	29.2357	125	14	41.6045	165	19	56.9253
			46	6	16.8810	86	10	29.2497	126	15	44.5706	166	19	56.9394
7	2	4.5262	47	6	16.8950	87	10	29.2637	127	15	44.5846	167	19	56.9534
8	2	4.5402	48	6	16.9090	88	10	29.2777	128	15	44.5986	168	19	56.9674
9	2	4.5543	49	6	16.9230	89	10	29.2917	129	15	44.6126	169	19	56.9814
10	2	4.5683	50	6	16.9370	90	11	32.2579	130	15	44.6266	170	19	56.9954
11	2	4.5823	51	6	16.9510	91	11	32.2719	131	15	44.6406	171	20	59.9615
12	2	4.5963	52	6	16.9650	92	11	32.2859	132	15	44.6546	172	20	59.9755
13	2	4.6103	53	6	16.9790	93	11	32.2999	133	15	44.6686	173	20	59.9895
14	2	4.6243	54	7	19.9452	94	11	32.3139	134	15	44.6826	174	20	60.0035
15	2	4.6383	55	7	19.9592	95	11	32.3279	135	16	47.6488	175	20	60.0175
16	2	4.6523	56	7	19.9732	96	11	32.3419	136	16	47.6628	176	20	60.0315
17	2	4.6663	57	7	19.9872	97	11	32.3559	137	16	47.6768	177	20	60.0455
18	3	7.6324	58	7	20.0012	98	11	32.3699	138	16	47.6908	178	20	60.0595
19	3	7.6464	59	7	20.0152	99	12	35.3361	139	16	47.7048	179	20	60.0736
20	3	7.6604	60	7	20.0292	100	12	35.3501	140	16	47.7188	180	21	63.0397
21	3	7.6744	61	7	20.0432	101	12	35.3641	141	16	47.7328	181	21	63.0537
22	3	7.6885	62	7	20.0572	102	12	35.3781	142	16	47.7468	182	21	63.0677
23	3	7.7025	63	8	23.0233	103	12	35.3921	143	16	47.7608	183	21	63.0817
24	3	7.7165	64	8	23.0373	104	12	35.4061	144	17	50.7270	184	21	63.0957
25	3	7.7305	65	8	23.0513	105	12	35.4201	145	17	50.7410	185	21	63.1097
26	3	7.7445	66	8	23.0653	106	12	35.4341	146	17	50.7550	186	21	63.1237
27	4	10.7106	67	8	23.0794	107	12	35.4481	147	17	50.7690	187	21	63.1377
28	4	10.7246	68	8	23.0934	108	13	38.4142	148	17	50.7830	188	21	63.1517
29	4	10.7386	69	8	23.1074	109	13	38.4282	149	17	50.7970	189	22	66.1179
30	4	10.7526	70	8	23.1214	110	13	38.4423	150	17	50.8110	190	22	66.1319
31	4	10.7666	71	8	23.1354	111	13	38.4563	151	17	50.8250	191	22	66.1459
32	4	10.7806	72	9	26.1015	112	13	38.4703	152	17	50.8390	192	22	66.1599
33	4	10.7946	73	9	26.1155	113	13	38.4843	153	18	53.8051	193	22	66.1739
34	4	10.8086	74	9	26.1295	114	13	38.4983	154	18	53.8192	194	22	66.1879
35	4	10.8227	75	9	26.1435	115	13	38.5123	155	18	53.8332	195	22	66.2019
36	5	13.7888	76	9	26.1575	116	13	38.5263	156	18	53.8472	196	22	66.2159
37	5	13.8028	77	9	26.1715	117	14	41.4924	157	18	53.8612	197	22	66.2299
38	5	13.8168	78	9	26.1856	118	14	41.5064	158	18	53.8752	198	23	69.1961
39	5	13.8308	79	9	26.1996	119	14	41.5204	159	18	53.8892	199	23	69.2101
40	5	13.8448	80	9	26.2136	120	14	41.5344	160	18	53.9032	200	23	69.2241

Note: Calculation for Sector span (W) increases proportionately with module.

Sector span for Helical gear

(1) Sector span for Normal type of Standard helical gear

$$W = m_n \cos \alpha_n \{ \pi (z_m - 0.5) + z \operatorname{inv} \alpha_t \}$$

(2) Sector span for Normal type of Rack shifted helical gear

$$W = m_n \cos \alpha_n \{ \pi (z_m - 0.5) + z \operatorname{inv} \alpha_t \} + 2 x_n m_n \sin \alpha_n$$

Sector span of gear z_m

$$z_m = \frac{\alpha_n z_v}{180} + 0.5$$

Calculation for Sector span of teeth uses nearest integer by above calculated formula.

Hereby

α_n : Normal pressure angle

α_t : Transverse pressure angle

m_n : Normal module

x_n : Normal rack shift coefficient

z_v : Virtual number of teeth of Spur gear⁽¹⁾

$$(z_v = z / \cos^3 \beta)$$

When measuring the Sector span for Helical gear, put the micrometer perpendicularly to the teeth. Minimum Facewidth is $W \sin \beta$ to prevent contact to flank from coming off.

Example,

When Normal module $m_n=4.0$, Number of teeth $z=19$, Normal pressure angle $\alpha_n = 20^\circ$, Reference cylinder helix angle $\beta=26^\circ 42'$, Normal rack shift coefficient $x_n=0.4$.

Note: (1) Adopted the old Standard term.

① ⁽¹⁾Virtual Number of teeth of Spur gear z_v

$$z_v = z / \cos^3 \beta = 19 / \cos^3 26^\circ 42' = 26.65$$

② Sector span of teeth z_m

$$z_m = \frac{\alpha_n z_v}{180} + 0.5$$

$$= \frac{20 \cdot 26.65}{180} + 0.5 = 3.46 \approx 4 \text{ (Expressed as integer)}$$

③ Transverse pressure angle α_t

$$\alpha_t = \tan^{-1}(\tan \alpha_n / \cos \beta)$$

$$= \tan^{-1}(\tan 20^\circ / \cos 26^\circ 42') = 22.16666^\circ$$

④ $\operatorname{inv} \alpha_t$ (Involute function for α_t)

$$\operatorname{inv} \alpha_t = \tan \alpha_t - \alpha_t = \tan 22.16666^\circ - 22.16666^\circ \cdot \pi / 180^\circ = 0.020532565$$

⑤ Sector span W

$$\begin{aligned} W &= m_n \cos \alpha_n \{ \pi (z_m - 0.5) + z \operatorname{inv} \alpha_t \} + 2 x_n m_n \sin \alpha_n \\ &= 4 \cdot \cos 20^\circ \{ \pi (4 - 0.5) + 19 \cdot 0.020532565 \} \\ &\quad + 2 \cdot 0.4 \cdot 4 \cdot \sin 20^\circ = 43.891 \text{ (mm)} \end{aligned}$$

⑥ Minimum Facewidth required for measurement of Sector span b

$$b = W \sin \beta = 43.891 \cdot \sin 26^\circ 42' = 19.72 \approx 20 \text{ (mm)}$$

Therefore, Facewidth above 20mm is needed. If Facewidth is below 20mm, use method of Over balls or Rollers to measure the Tooth thickness.