4.3 Measurement method with Gear tooth vernier

Measurement method based on Tip circle, measure Chordal tooth thickness upon Pitch cylinder. Refer to Fig. 9 for measurement method based upon Gear tooth vernier calipers. Fix gear tooth vernier calipers at theoretical value of Tooth depth *h* and measure deviation between actual Chordal tooth thickness *s* and its theoretical value. This is a time-honored measurement method with low accuracy due to influence from inconsistent measurement and Jaw conditions.

For Spur gear, calculation is by following formula :

$$\overline{h} = \frac{mz}{2} \left\{ 1 - \cos\left(\frac{\pi}{2z} + \frac{2x\tan\alpha}{z}\right) \right\} + \frac{da-d}{2}$$
$$\overline{s} = mz\sin\left(\frac{\pi}{2z} + \frac{2x\tan\alpha}{z}\right)$$

Hereby

\overline{h}	: Chordal addendum		<u>-</u>	: Chordal tooth thickness
т	: Module	i.	z	: Number of teeth
α	: Reference pressure angle	2	x	: Rack shift coefficient
da	: Tip (outside) diameter		d	: Reference diameter

Refer to Table 2. Below chart shows \overline{h} : Chordal addendum and \overline{s} : Chordal tooth thickness for gear with module 1.0 and Rack shift coefficient x=0.

For Helical gear, use Normal surface to measure module, Pressure angle and Rack shift coefficient using value of Normal. Number of teeth *z* uses ⁽¹⁾Virtual number of teeth for Spur gear.



13	1.0474	1.5670	40	1.0154	1.5704
14	1.0440	1.5675	45	1.0137	1.5705
15	1.0411	1.5679	50	1.0123	1.5705
16	1.0385	1.5683	60	1.0103	1.5706
17	1.0363	1.5686	70	1.0088	1.5706
18	1.0342	1.5688	80	1.0077	1.5707
19	1.0324	1.5690	90	1.0069	1.5707
20	1.0308	1.5692	100	1.0062	1.5707
22	1.0280	1.5695	120	1.0051	1.5708
24	1.0257	1.5697	150	1.0041	1.5708
26	1.0237	1.5698	200	1.0031	1.5708
28	1.0219	1.5700	×	1.0000	1.5708
30	1.0206	1.5701			
					-

Table 2. Chordal tooth thickness for standard gear

Z

35

 \overline{h} mm

1.0176

 \bar{s} mm

1.5703

s mm

1.5663

 \overline{h} mm

1.0513

 \overline{z}

12

Fig. 9 Measurement with gear tooth vernier calipers

Values of \overline{h} and \overline{s} . (m=1, x=0)

< Reference > Gear analysis method

How to obtain module, Pressure angle and Rack shift coefficient for Involute spur gear,

There are various methods on how to obtain module and Pressure angle for Involute spur gear. Method introduced here is by Base pitch measurement. There is a method of using Sector span to measure the Base pitch.

For Sector span, assuming *n* of Number of teeth is E_n . Reduce one tooth from *n* is E_{n-1} . Therefore Base pitch P_b is by following formula.

$$p_b = E_n - E_{n-1} \quad (1)$$

$$=\pi m \cos \alpha$$

α_0	14.5°	20°	22.5°	25°				
1	3.042	2.952	2.902	2.847				
1.25	3.802	3.690	3.628	3.559				
1.5	4.562	4.428	4.354	4.271				
1.75	5.323	5.166	5.079	4.983				
2	6.083	5.904	5.805	5.695				
2.25	6.843	6.642	6.531	6.406				
2.5	7.604	7.380	7.256	7.118				
2.75	8.364	8.118	7.982	7.830				
3	9.125	8.856	8.707	8.542				
3.25	9.885	9.594	9.433	9.254				
3.5	10.645	10.332	10.159	9.965				
3.75	11.406	11.070	10.884	10.677				
4	12.166	11.809	11.610	11.389				
4.5	13.687	13.285	13.061	12.813				
5	15.208	14.761	14.512	14.236				
5.5	16.728	16.237	15.963	15.6.60				
6	18.249	17.713	17.415	17.0.84				
6.5	19.770	19.189	18.866	18.507				
7	21.291	20.665	20.317	19.931				
8	24.332	23.617	23.220	22.778				
9	27.374	26.569	26.122	25.625				
10	30.415	29.521	29.025	28.473				

Table 3. Base pitch

Compare Base pitch calculation result by formula (1) with Base pitch in Table 3.

Example for Spur gear: Calculate module, Pressure

angle and Rack shift coefficient for Number of teeth = 12 and Tip (outside) diameter =29.9mm.

Result of measurement for Sector span (Z_m) was as follows

 Z_m = Two (2) teeth of Sector span E_2 = 9.855 mm

 Z_m = Three (3) teeth of Sector span E_3 = 15.758 mm Therefore calculate P_b by following formula (1)

 $p_b = E_3 - E_2$

= 15.758 - 9.855

With reference to Base pitch chart in Table 3, module is 2.0 mm and Pressure angle is 20°.

Calculation formula for Rack shift coefficient

Calculation for Sector span W is by following formula $W = m\cos\alpha \{\pi(Zm - 0.5) + zinv\alpha\} + 2xm\sin\alpha$ Calculating Sector span W'' for Standard spur gear with pressure angle 20° is by following formula:

 $W' = m\cos\alpha \{\pi (Zm - 0.5) + zinv\alpha\}$

= m(0.01400554z + 2.95213zm - 1.47606)

Calculating Sector span W''' for Rack shifted spur gear with pressure angle 20° is by following formula:

 $W'' = W'[\text{standard}] + 2 \ xm \sin \alpha$

W'' = W'[standard] + 0.68404 xm (2)

[Standard] is abbreviation of Standard spur gear.

From above formula (2), calculation for Rack shift coefficient *x* is as follows:

$$x = \frac{W'' - W'}{0.68404m}$$
(3)

Therefore, results are W''=9.855, W''=9.193. Rack shift coefficient *x* is 0-.484.

$$x = \frac{9.855 - 9.193}{2 \times 0.68404}$$