GEAR FUNDAMENTALS

Base Pitch Tables

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There is one dimension common to both members of a pair of properly mating spur gears - the base pitch (BP). This base pitch is equal to the circular pitch of the gear on the base circle (see Fig. 1). For a helical gear, the base pitch can be described in either the transverse or normal plane, and is called the transverse base pitch (TBP) or normal base pitch (NBP), respectively. For parallel axis helical gears, both the TBP and NBP must be the same on both mating gears. For skew axis helical gears, only the NBP must be common.

Gears are traditionally designed on the basis of diametral pitch and pressure angle rather than solely on base pitch. This is for purposes of standardization, interchangeability, minimal tooling use, and simplicity of specifications.

Two pieces of information, diametral pitch and pressure angle, are required to arrive at the base pitch.

For spurs: BP = CP*Cos(PA)
CP = PI/DP
where CP = Circular pitch
DP = Diametral pitch
PA = Pressure angle

For helicals:
NBP = NCP*Cos(NPA)
NCP = PI/NDP
where NCP = Normal circular pitch
NDP = Normal diametral pitch
NPA = Normal pressure angle

There are three different base pitch tables included here, one based on a metric module array (Table 1); another based on an inch circular pitch series (Table 2); and the last based on a diametral pitch sequence (Table 3). The base pitches in all cases are listed in inches.

While the tables can be used in span or block readings for gear tooth thickness measurements, the main use of these tables is usually to define the diametral pitch, circular pitch or module, and the pressure angle of an undefined or unknown gear.

Frequently a broken or worn gear is removed from a piece of machinery, and a replacement is wanted. If the original gear specifications are not available, the gear engineer may be handed this piece of broken gear or, perhaps, the mating gear and asked to define the original specifications so a replacement can be made. The base pitch tables offer a starting point to define an

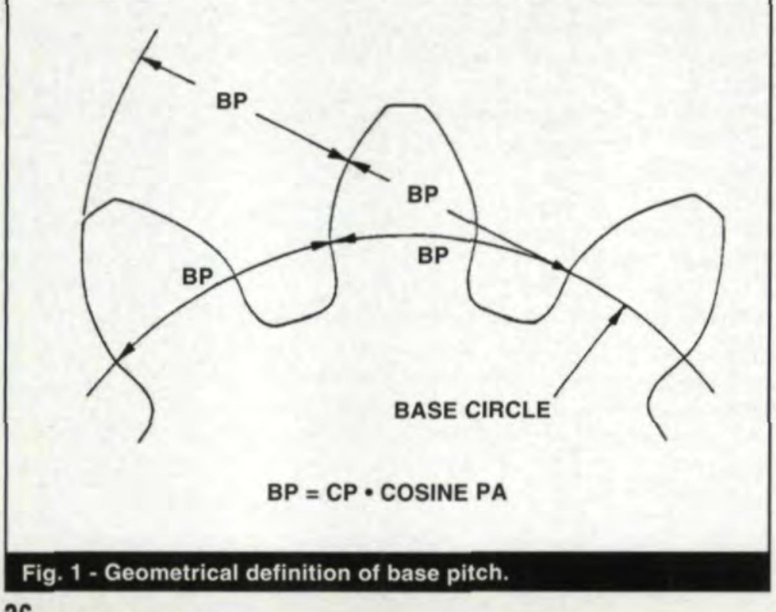

Fig. 1 - Geometrical definition of base pitch.

Table 1 - Metric Module Array								
MOD	14.5	15	17.5	20	22.5	25	28	30
26.00	3.11337	3.10623	3.06697	3.02187	2.97102	2.91451	2.83939	2.78497
25.00	2.99363	2.98676	2.94901	2.90564	2.85675	2.80241	2.73018	2.67785
24.00	2.87388	2.86729	2.83105	2.78942	2.74248	2.69032	2.62097	2.57074
23.00	2.75414	2.74782	2.71309	2.67319	2.62821	2.57822	2.51176	2.46363
22.00	2.63439	2.62835	2.59513	2.55696	2.51394	2.46612	2.40256	2.35651
21.00	2.51465	2.50888	2.47717	2.44074	2.39967	2.35403	2.29335	2.24940
20.00	2.39490	2.38941	2.35921	2.32451	2.28540	2.24193	2.18414	2.14228
19.00	2.27516	2.26994	2.24124	2.20829	2.17113	2.12983	2.07494	2.03517
18.00	2.15541	2.15047	2.12328	2.09206	2.05686	2.01774	1.96573	1.92805
17.00	2.03567	2.03100	2.00532	1.97584	1.94259	1.90564	1.85652	1.82094
16.00	1.91592	1.91152	1.88735	1.85961	1.82832	1.79354	1.74731	1.71383
15.00	1.79618	1.79205	1.76940	1.74338	1.71405	1.68145	1.63811	1.60671
14.00	1.67643	1.67258	1.65144	1.62716	1.59978	1.56935	1.52890	1.49960
13.00	1.55669	1.55311	1.53348	1.51903	1.48551	1.45725	1.41969	1.39248
12.00	1.43694	1.43364	1.41552	1.39471	1.37124	1.34516	1.31049	1.28537
11.00	1.31720	1.31417	1.29756	1.27848	1.25697	1.23306	1.20128	1.17826
10.00	1.19745	1.19470	1.17960	1.16226	1.14270	1.12096	1.09207	1.07114
9.00	1.07771	1.07523	1.06164	1.04603	1.02843	1.00887	0.98286	0.96403
8.00	0.95796	0.95576	0.94368	0.92981	0.91416	0.89677	0.87366	0.85691
7.00	0.83822	0.83629	0.82572	0.81358	0.79989	0.78468	0.76445	0.74980
6.00	0.71847	0.71682	0.70776	0.69735	0.68526	0.67258	0.65524	0.64268
5.00	0.59873	0.59735	0.58980	0.58113	0.57135	0.56048	0.54604	0.53557
4.00	0.47898	0.47788	0.47184	0.46490	0.45708	0.44839	0.43683	0.42846
3.50	0.41911	0.41815	0.41286	0.40679	0.39994	0.39234	0.38223	0.37490
3.00	0.35924	0.35841	0.35388	0.34868	0.34281	0.33629	0.32762	0.32134
2.75	0.32930	0.32854	0.32439	0.31962	0.31424	0.30826	0.30032	0.29456
2.50	0.29935	0.29868	0.29490	0.29056	0.28567	0.28024	0.27302	0.26779
2.25	0.26943	0.26881	0.26541	0.26151	0.25711	0.25222	0.24572	0.24101
2.00	0.23949	0.23894	0.23592	0.23245	0.22854	0.22419	0.21841	0.21423
1.75	0.20955	0.20907	0.20643	0.20339	0.19997	0.19617	0.19111	0.18745
1.50	0.17962	0.17921	0.17694	0.17434	0.17140	0.16814	0.16381	0.16067
1.25	0.14968	0.14934	0.14745	0.14528	0.14284	0.14012	0.13651	0.13389
1.00	0.11975	0.11947	0.11796	0.11623	0.11427	0.11210	0.10921	0.10711
0.90	0.10777	0.10752	0.10616	0.10460	0.10284	0.10089	0.09829	0.09640
0.80	0.09580	0.09558	0.09436	0.09298	0.09142	0.08968	0.08737	0.08569
0.75	0.08981	0.08960	0.08847	0.08717	0.08570	0.08407	0.08191	0.08034
0.60	0.07185	0.07168	0.07078	0.06974	0.06856	0.06726	0.06552	0.06427
0.50	0.05987	0.05974	0.05898	0.05811	0.05713	0.05605	0.05460	0.05356
0.40	0.04790	0.04779	0.04718	0.04649	0.04571	0.04484	0.04368	0.04285
0.30	0.03592	0.03584	0.03539	0.03487	0.03428	0.03363	0.03276	0.03213

unknown gear.

Fig. 2 shows how a flange micrometer can be used to measure over a span or block of teeth on a gear, in this case over three teeth. In Fig. 3 a digital caliper is shown for a similar measurement over four teeth. Fig. 4 shows the requirement that the anvil or face of the measuring tool contacts tangent to the involute profile, and not on the fillet or across the tooth corners.

The difference between any two adjacent span readings, for example, the difference between the reading over three

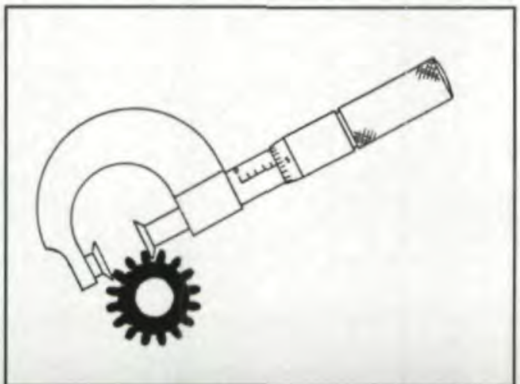

Fig. 2 - Flange micrometer measuring the span over 3 teeth on a 16-tooth spur gear.

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Table 2 - Inch Circular Pitch Series

CP	14.5	15	17.5	20	22.5	25	28	30
4.0000	3.87259	3.86370	3.81487	3.75877	3.69552	3.62523	3.53179	3.46410
3.7500	3.63055	3.62222	3.57644	3.52385	3.46455	3.39865	3.31105	3.24760
3.5000	3.38852	3.38074	3.33801	3.28892	3.23358	3.17208	3.09032	3.03109
3.2500	3.14648	3.13926	3.09958	3.05400	3.00261	2.94550	2.86958	2.81458
3.0000	2.90444	2.89778	2.86115	2.81908	2.77164	2.71892	2.64884	2.59808
2.7500	2.66241	2.65630	2.62272	2.58415	2.54067	2.49235	2.42811	2.38157
2.5000	2.42037	2.41481	2.38429	2.34923	2.30970	2.26577	2.20737	2.16506
2.2500	2.17833	2.17333	2.14586	2.11431	2.07873	2.03919	1.98663	1.94856
2.0000	1.93630	1.93185	1.90743	1.87939	1.84776	1.81262	1.76590	1.73205
1.7500	1.69426	1.69037	1.66900	1.64446	1.61679	1.58604	1.54516	1.51554
1.5000	1.45222	1.44889	1.43058	1.40954	1.38582	1.35946	1.32442	1.29904
1.2500	1.21018	1.20741	1.19215	1.17462	1.15485	1.13288	1.10368	1.08253
1.0000	0.96815	0.96593	0.95372	0.93969	0.92388	0.90631	0.88295	0.86603
0.8750	0.84713	0.84519	0.83450	0.82223	0.80839	0.79302	0.77258	0.75777
0.7500	0.72611	0.72444	0.71529	0.70477	0.69291	0.67973	0.66221	0.64952
0.6250	0.60509	0.60370	0.59607	0.58731	0.57742	0.56644	0.55184	0.54127
0.5000	0.48407	0.48296	0.47686	0.46985	0.46194	0.45315	0.44147	0.43301
0.3750	0.36306	0.36222	0.35764	0.35238	0.34645	0.33987	0.33111	0.32476
0.2500	0.24204	0.24148	0.23843	0.23492	0.23097	0.22658	0.22074	0.21651
0.1875	0.18153	0.18111	0.17882	0.17619	0.17323	0.16993	0.16555	0.16238
0.1250	0.12102	0.12074	0.11921	0.11746	0.11548	0.11329	0.11037	0.10825
0.0625	0.06051	0.06037	0.05961	0.05873	0.05774	0.05664	0.05518	0.05413

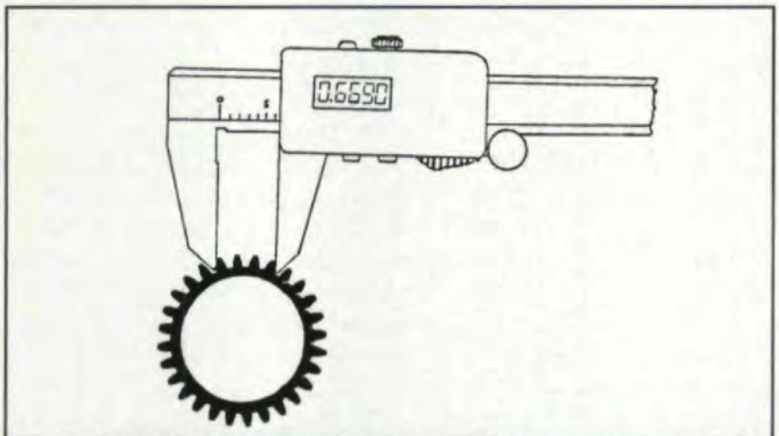

Fig. 3 - A digital caliper measuring the span over 4 teeth on a 28-tooth gear. Reads to nearest .0005 inches.

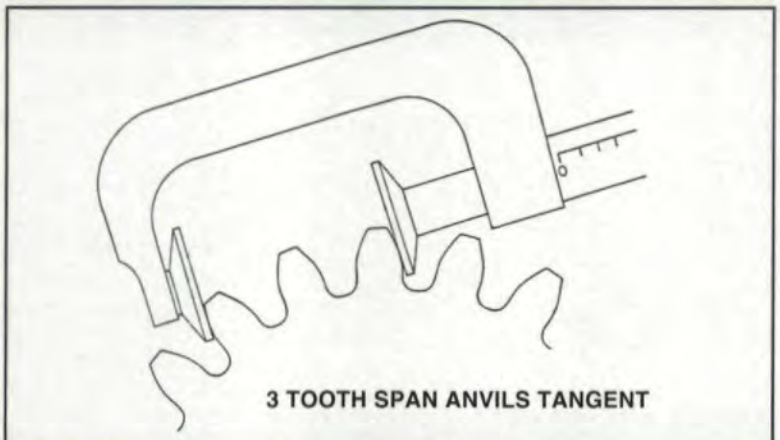

Fig. 4 - Contact on anvils must be tangent for a valid measurement.

teeth minus the reading over two teeth, yields the base pitch. This base pitch value can be compared to the tables to see if a match can be found.

EXAMPLE:

Using a flange micrometer.

Spur gear
20 teeth
Outer diameter 1.908
Root Diameter 1.528

4 tooth span = .9104
3 tooth span = .6642
Difference .2462 = Base pitch

The nearest match in the tables is a base pitch of .24601 for 12DP, 20°PA. A further check shows the pitch diameter falling on the tooth form, so there is a good probability that the gear is identified.

A dial or digital caliper can also be used, but does not have the accuracy of a micrometer. Good results can be had by averaging five or ten sets of readings.

These hand measuring tools are not very expensive compared to an involute checking instrument, although if such equipment is

Table 3 - Diametral Pitch Sequence								
DP	14.5	15	17.5	20	22.5	25	28	30
1.00	3.04153	3.03455	2.99619	2.95213	2.90245	2.84725	2.77386	2.72070
1.25	2.43322	2.42764	2.39695	2.36171	2.32196	2.27780	2.21909	2.17656
1.50	2.02768	2.02303	1.99746	1.96809	1.93497	1.89817	1.84924	1.81380
1.75	1.73801	1.73403	1.71211	1.68693	1.65854	1.62700	1.58506	1.55469
2.00	1.52076	1.51727	1.49810	1.47607	1.45123	1.42363	1.38693	1.36035
2.25	1.35179	1.34869	1.33164	1.31206	1.28998	1.26544	1.23283	1.20920
2.50	1.21661	1.21382	1.19848	1.18085	1.16098	1.13890	1.10954	1.08828
2.75	1.10601	1.10347	1.08952	1.07350	1.05544	1.03536	1.00868	0.98935
3.00	1.01384	1.01152	0.99873	0.98404	0.96748	0.94908	0.92462	0.90690
3.50	0.86901	0.86701	0.85605	0.84347	0.82927	0.81350	0.79253	0.77734
4.00	0.76038	0.75864	0.74905	0.73803	0.72561	0.71181	0.69347	0.68017
4.50	0.67589	0.67434	0.66582	0.65603	0.64499	0.63272	0.61641	0.60460
5.00	0.60831	0.60691	0.59924	0.59043	0.58049	0.56945	0.55477	0.54414
5.50	0.55300	0.55174	0.54476	0.53675	0.52772	0.51768	0.50434	0.49467
6.00	0.50692	0.50576	0.49937	0.49202	0.48374	0.47454	0.46231	0.45345
7.00	0.43450	0.43351	0.42803	0.42173	0.41464	0.40675	0.39627	0.38867
8.00	0.38019	0.37932	0.37452	0.36902	0.36281	0.35591	0.34673	0.34009
9.00	0.33795	0.33717	0.33291	0.32801	0.32249	0.31636	0.30821	0.30230
10.00	0.30415	0.30345	0.29962	0.29521	0.29025	0.28473	0.27739	0.27207
11.00	0.27650	0.27587	0.27238	0.26838	0.26386	0.25884	0.25217	0.24734
12.00	0.25346	0.25288	0.24968	0.24601	0.24187	0.23727	0.23116	0.22672
13.00	0.23396	0.23343	0.23048	0.22709	0.22327	0.21902	0.21337	0.20928
14.00	0.21725	0.21675	0.21402	0.21087	0.20732	0.20338	0.19813	0.19434
16.00	0.19010	0.18966	0.18726	0.18451	0.18140	0.17795	0.17337	0.17004
18.00	0.16897	0.16859	0.16646	0.16401	0.16125	0.15818	0.15410	0.15115
20.00	0.15208	0.15173	0.14981	0.14761	0.14512	0.14236	0.13869	0.13603
22.00	0.13825	0.13793	0.13619	0.13419	0.13193	0.12942	0.12608	0.12367
24.00	0.12673	0.12644	0.12484	0.12301	0.12094	0.11864	0.11558	0.11336
28.00	0.10863	0.10838	0.10701	0.10543	0.10366	0.10169	0.09907	0.09717
32.00	0.09505	0.09483	0.09363	0.09225	0.09070	0.08898	0.08668	0.08502
36.00	0.08449	0.08429	0.08323	0.08200	0.08062	0.07909	0.07705	0.07557
38.00	0.08004	0.07986	0.07885	0.07769	0.07638	0.07493	0.07300	0.07160
40.00	0.07604	0.07586	0.07490	0.07380	0.07256	0.07118	0.06935	0.06802
44.00	0.06913	0.06897	0.06810	0.06709	0.06596	0.06471	0.06304	0.06183
48.00	0.06337	0.06322	0.06242	0.06150	0.06047	0.05932	0.05779	0.05668
52.00	0.05849	0.05836	0.05762	0.05677	0.05582	0.05475	0.05334	0.05232
56.00	0.05431	0.05419	0.05350	0.05272	0.05183	0.05084	0.04953	0.04858
60.00	0.05069	0.05058	0.04994	0.04920	0.04837	0.04745	0.04623	0.04534
64.00	0.04752	0.04741	0.04682	0.04613	0.04535	0.04449	0.04334	0.04251
72.00	0.04224	0.04215	0.04161	0.04100	0.04031	0.03955	0.03853	0.03779

available, using it would be the next step for accurate profile definition.

On a helical gear, the result of these measurements yields the NBP and, from the tables, the normal diametral pitch and normal pressure angle. This is the usual plane, for basic tooling information and many times, the design basis. Some further determination of the gear lead, such as might be accomplished on a helical lead inspection machine, is necessary to fully define the basic gear geometry.

The table for metric module gears is included because metric gear applications are frequently found in machine tools, printing equipment, textile machinery, packaging machinery, and transmissions. Metric gears are quite widely used.

Consideration also should be given to the quality and condition of the gear being inspected as this will influence the accuracy of the values. ■

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