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Tolerances associated with gears

Selecting the proper tolerance for the bore and keyway can eliminate assembly headaches.

Have you ever purchased something that cautioned, "Some assembly required" on the packaging, only to learn later that even with a master's degree in mechanical engineering the parts don't seem to assemble in the same fashion as the instructions describe? This is typically an issue with the tolerances of the components in the assembly. When working with gears, the clearances between the bore and shaft and the key and keyway and the location of the set screws can all contribute to an easy assembly or a nightmare.

When working with metric gearing, the tolerance for the bore is detailed as an alphanumeric callout. Typically, the callout selected is either H6, H7, or H8. These bore tolerance bands reflect a tight oversized hole with H6, a moderately oversized hole with H7 and a looser fit oversized hole with H8. The accompanying table details the band range for each tolerance, which is dependent on the bore size.

The corresponding shaft tolerance needs to be determined based on whether the fit between the gear and shaft is to be an interference fit, a transition fit, or a clearance fit.

When selecting a keyway tolerance, there are two common selections in the metric system. The first is Js9. This is a ± band clearance where the value of the tolerance is equally oversized or undersized. The second is a P9 tolerance. This is an undersized clearance. The advantage of the Js9 tolerance is that the key can be inserted and the gear manipulated without much difficulty, whereas the P9 tolerance is a press fit tolerance. Once the key is inserted into the keyway, it is not going to move.

The final consideration with sizing is the thread size and location of the set screw. For many applications, just one set screw, positioned at 90 degrees to the keyway, is sufficient. For other applications, a second set screw is considered for just above the keyway. Although not as common, a more effective position for two set screws is to have each one offset 120 degrees from the keyway in a triangle-type pattern. This positioning helps to balance the gear during high speed rotation but is more difficult to set up.

Set screws and keys are not the only methods for attaching gears to shafts. In future columns, I will detail some of the other methods. Just remember — when designing your gear train, take into account the clearances needed to assemble all of the components.

STANDARD DIMENSIONS AND TOLERANCES (BORES)

COMMON DEVIATIONS OF HOLE DIMENSIONS (JIS B 0401-2: 1998)

Unit: μm

Bore size (mm)		B	C		D			E			F			G		H					
Over	To incl.	B10	C9	C10	D8	D9	D10	E7	E8	E9	F6	F7	F8	G6	G7	H5	H6	H7	H8	H9	H10
—	3	+180 +140	+85 +60	+100 +60	+34 +20	+45 +20	+60 +20	+24 +14	+28 +14	+39 +14	+12 +6	+16 +6	+20 +6	+8 +20	+12 +20	+4	+6	+10	+14 0	+25	+40
3	6	+188 +140	+100 +70	+118 +70	+48 +30	+60 +30	+78 +30	+32 +20	+38 +20	+50 +20	+18 +10	+22 +10	+28 +10	+12 +4	+16 +4	+5	+8	+12	+18 0	+30	+48
6	10	+208 +150	+116 +80	+138 +80	+62 +40	+76 +40	+98 +40	+40 +25	+47 +25	+61 +25	+22 +13	+28 +13	+35 +13	+14 +5	+20 +5	+6	+9	+15	+22 0	+36	+58
10	14	+220 +150	+138 +95	+165 +95	+77 +50	+93 +50	+120 +50	+50 +32	+59 +32	+75 +32	+27 +16	+34 +16	+43 +16	+17 +6	+24 +6	+8	+11	+18	+27 0	+43	+70
14	18																				
18	24	+244 +160	+162 +110	+194 +110	+98 +65	+117 +65	+149 +65	+61 +40	+73 +40	+92 +40	+33 +20	+41 +20	+53 +20	+20 +7	+28 +7	+9	+13	+21	+33 0	+52	+84
24	30																				
30	40	+270 +170	+182 +120	+220 +120	+119 +80	+142 +80	+180 +80	+75 +50	+89 +50	+112 +50	+41 +25	+50 +25	+64 +25	+25 +9	+34 +9	+11	+16	+25	+39 0	+62	+100
40	50	+280 +180	+192 +130	+230 +130																	
50	65	+310 +190	+214 +140	+260 +140	+146 +100	+174 +100	+220 +100	+90 +60	+106 +60	+134 +60	+49 +30	+60 +30	+76 +30	+29 +10	+40 +10	+13	+19	+30	+46 0	+74	+120
65	80	+320 +200	+224 +150	+270 +150																	
80	100	+360 +220	+257 +170	+310 +170	+174 +120	+207 +120	+260 +120	+107 +72	+125 +72	+159 +72	+58 +36	+71 +36	+90 +36	+37 +12	+47 +12	+15	+22	+35	+54 0	+87	+140
100	120	+380 +240	+267 +180	+320 +180																	
120	140	+420 +260	+300 +200	+360 +200	+208 +145	+245 +145	+305 +145	+125 +85	+148 +85	+185 +85	+68 +43	+83 +43	+106 +43	+39 +14	+54 +14	+18	+25	+40	+63 0	+100	+160
140	160	+440 +280	+310 +210	+370 +210																	
160	180	+470 +310	+330 +230	+390 +230																	
180	200	+525 +340	+355 +240	+425 +240	+242 +170	+285 +170	+355 +170	+146 +100	+172 +100	+215 +100	+79 +50	+96 +50	+122 +50	+44 +15	+61 +15	+20	+29	+46	+72 0	+115	+185
200	225	+565 +380	+375 +260	+445 +260																	
225	250	+605 +420	+395 +280	+465 +280																	
250	280	+690 +480	+430 +300	+510 +300	+271 +190	+320 +190	+400 +190	+162 +110	+191 +110	+240 +110	+88 +56	+108 +56	+137 +56	+49 +17	+69 +17	+23	+32	+52	+81 0	+130	+210
280	315	+750 +540	+460 +330	+540 +330																	
315	355	+830 +600	+500 +360	+590 +360	+299 +210	+350 +210	+440 +210	+182 +125	+241 +125	+265 +125	+98 +62	+119 +62	+151 +62	+54 +18	+75 +18	+25	+36	+57	+89 0	+140	+230
355	400	+910 +680	+540 +400	+630 +400																	
400	450	+1010 +760	+595 +440	+690 +440	+327 +230	+385 +230	+480 +230	+198 +135	+232 +135	+290 +135	+108 +68	+131 +68	+165 +68	+60 +20	+83 +20	+27	+40	+63	+97 0	+155	+250
450	500	+1090 +840	+635 +480	+730 +480																	

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