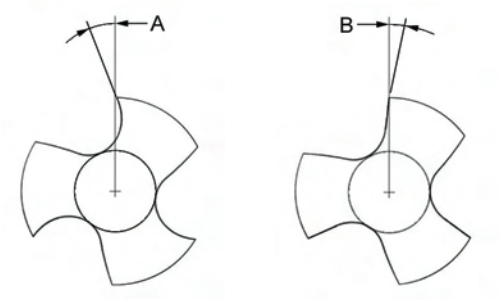
General Geometry



A. Positive rake angle
B. Negative rake angle

Rake Angle	Benefits / range of application	Disadvantages
Low or negative (-5° – 5°)	Strong geometry, strong edge. Works well in cast iron and hardened steel.	Doesn't work in soft or tensile material. High cutting forces.
Medium (8° – 14°)	Cuts well. Works well in most materials for example steel and stainless steel	
High (20° – 30°)	Low cutting force. Works best in aluminium and other soft materials.	Chipping often occurs because of the sharp edge.

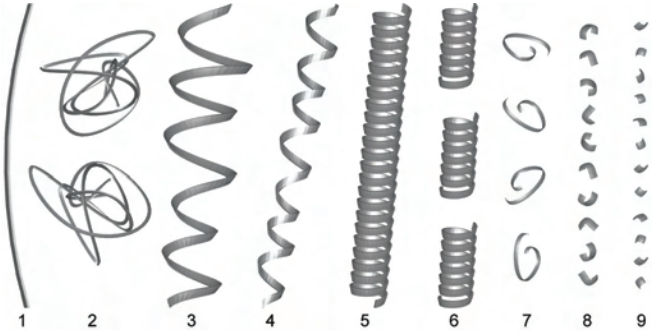
Types Of Chips

Chip formation is mostly caused by plastic deformation. This process, due to the friction generated during machining, generates heat. Heat has the positive effect of increasing the plasticity of the workpiece material, but the negative effect of increasing the wear on the tool. When workpiece material reaches its breakage point, then the chip is generated. Its form and development depend on different factors, such as:

- Chemical-physical compatibility between tool and workpiece materials
- Cutting operation
- Cutting conditions (speed, feed, material removal rate)
- Tool geometry
- Friction coefficient (with or without coating)
- Lubrication

General Information

Depending on different combinations of the above mentioned factors, the chips can turn out in many different ways (see figure below).

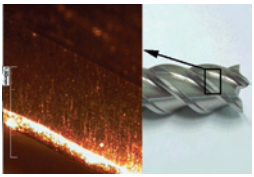
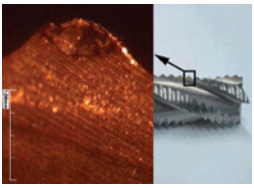


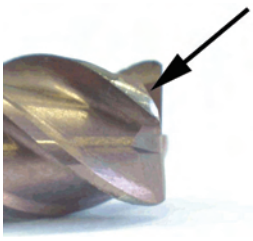
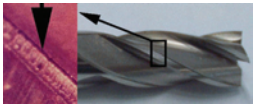
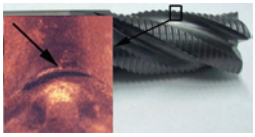
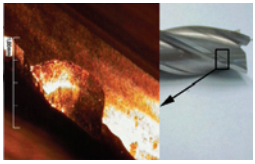
1 Ribbon chips
2-3 Snarled chips
4-6 Washer-type chips
7 Arc chips
8-9 Element chips

Types Of Wear

Wear is generated by mechanical abrasion, adhesion, chemical diffusion and oxidation. The most important factors to influence the different types of wear are the mechanical and chemical properties of the materials in contact, the working conditions, but mainly cutting speed and temperature. At low speeds, abrasion and adhesion wear are most important, whereas at high speeds, it is diffusion and plastic deformation. It is not easy to set up a mechanical model to foresee wear development on cutting tools.

Types of wear can be briefly summarised in nine different types (see table below).

TYPE	ORIGIN	CONSEQUENCE	REMEDY
Flank Wear 	Cutting speed too high.	High surface roughness, inconsistent tolerance, high friction.	Reduce cutting speed. Use a coated tool. Use more wear resistant tool material.
Crater Wear 	Generated by chemical diffusion due to high temperature on the cutting edge.	Cutting edge weakness, high surface roughness.	Choose a tool with positive geometry. Reduce cutting speed and then feed. Use coated tool.

TYPE	ORIGIN	CONSEQUENCE	REMEDY
Plastic Deformation 	High temperature and high pressure.	Bad chip control, high surface roughness, high flank wear.	Use a tool with bigger cross section. Reduce cutting speed and then feed.
Notch Wear 	Oxidation, friction.	High surface roughness, cutting edge breakage.	Reduce cutting speed. Use coated tool.
Thermal Micro-flaws 	Due to thermal variation, caused by interrupted cutting or low cooling.	Cracks through cutting edge, high surface roughness.	Increase cooling flow. Use cutting tool with high tensile strength.
Cracks 	Due to mechanical fatigue.	Tool breakage.	Reduce feed rate, Improve tool holder stability.
Chipping 	Due to weak tool geometry or built up edge.	High roughness, flank wear.	Choose a tool with stronger and positive geometry. Increase cutting speed to reduce BUE. Reduce feed rate at first removal pass. Improve machine stability.
Tool Breakage 	Too high load.	Tool breakage, work-piece breakage.	Reduce feed and/or speed. Choose a tool with stronger geometry. Improve machine stability.
Built up edge (BUE) 	Negative geometry. Low cutting speed. Work-piece material with welding tendency (as stainless steel or aluminium).	Workpiece material slides on tool edge and welds on it. High surface roughness, chipping.	Increase cutting speed. Choose a tool with positive geometry. Increase lubrication amount.

General Information

Hardness and Tensile Strength

			Tensile Strength					Tensile Strength	
HV Vickers Hardness No.	HRC Rockwell C. Scale Hardness No.	HB Brinell Hardness No.	Newton per sq. mm	Tons per sq. in.	HV Vickers Hardness No.	HRC Rockwell C. Scale Hardness No.	HB Brinell Hardness No.	Newton per sq. mm	Tons per sq. in.
940	68				434	44	413	1400	91
900	67				423	43	402	1360	88
864	66				413	42	393	1330	86
829	65				403	41	383	1300	84
800	64				392	40	372	1260	82
773	63				382	39	363	1230	80
745	62				373	38	354	1200	78
720	61				364	37	346	1170	76
698	60				355	36	337	1140	74
675	59				350		333	1125	73
655	58		2200	142	345	35	328	1110	72
650		618	2180	141	340		323	1095	71
640		608	2145	139	336	34	319	1080	70
639	57	607	2140	138	330		314	1060	69
630		599	2105	136	327	33	311	1050	68
620		589	2070	134	320		304	1030	67
615	56	584	2050	133	317	32	301	1020	66
610		580	2030	131	310	31	295	995	64
600		570	1995	129	302	30	287	970	63
596	55	567	1980	128	300		285	965	62
590		561	1955	126	295		280	950	61
580		551	1920	124	293	29	278	940	61
578	54	549	1910	124	290		276	930	60
570		542	1880	122	287	28	273	920	60
560	53	532	1845	119	285		271	915	59
550		523	1810	117	280	27	266	900	58
544	52	517	1790	116	275		261	880	57
540		513	1775	115	272	26	258	870	56
530		504	1740	113	270		257	865	56
527	51	501	1730	112	268	25	255	860	56
520		494	1700	110	265		252	850	55
514	50	488	1680	109	260	24	247	835	54
510		485	1665	108	255	23	242	820	53
500		475	1630	105	250	22	238	800	52
497	49	472	1620	105	245		233	785	51
490		466	1595	103	243	21	231	780	50
484	48	460	1570	102	240		228	770	50
480		456	1555	101	235		223	755	49
473	47	449	1530	99	230		219	740	48
470		447	1520	98	225		214	720	47
460		437	1485	96	220		209	705	46
458	46	435	1480	96	215		204	690	45
450		428	1455	94	210		199	675	44
446	45	424	1440	93	205		195	660	43
440		418	1420	92	200		190	640	41

Useful Tolerances

Tolerance values in μm 1 μm = 0.001 mm / 0.000039 inches

Tolerance	Diameter (mm)							
	> 1 ≤ 3	> 3 ≤ 6	> 6 ≤ 10	> 10 ≤ 18	> 18 ≤ 30	> 30 ≤ 50	> 50 ≤ 80	> 80 ≤ 120
	Diameter (inch)							
	> 0.039 ≤ 0.118	> 0.118 ≤ 0.236	> 0.236 ≤ 0.394	> 0.394 ≤ 0.709	> 0.709 ≤ 1.181	> 1.181 ≤1.968	>1.968 ≤ 3.149	> 3.149 ≤ 4.724
	Tolerance values (μm)							
e8	-14 / -28	-20 / -38	-25 / -47	-32 / -59	-40 / -73	-50 / -89	-60 / -106	-72 / -126
f6	-6 / -12	-10 / -18	-13 / -22	-16 / -27	-20 / -33	-25 / -41	-30 / -49	-36 / -58
f7	-6 / -16	-10 / -22	-13 / -28	-16 / -34	-20 / -41	-25 / -50	-30 / -60	-36 / -71
h6	0 / -6	0 / -8	0 / -9	0 / -11	0 / -13	0 / -16	0 / -19	0 / -22
h7	0 / -10	0 / -12	0 / -15	0 / -18	0 / -21	0 / -25	0 / -30	0 / -35
h8	0 / -14	0 / -18	0 / -22	0 / -27	0 / -33	0 / -39	0 / -46	0 / -54
h9	0 / -25	0 / -30	0 / -36	0 / -43	0 / -52	0 / -62	0 / -74	0 / -87
h10	0 / -40	0 / -48	0 / -58	0 / -70	0 / -84	0 / -100	0 / -120	0 / -140
h11	0 / -60	0 / -75	0 / -90	0 / -110	0 / -130	0 / -160	0 / -190	0 / -220
h12	0 / -100	0 / -120	0 / -150	0 / -180	0 / -210	0 / -250	0 / -300	0 / -350
k10	+40 / 0	+48 / 0	+58 / 0	+70 / 0	+84 / 0	+100 / 0	+120 / 0	+140 / 0
k12	+100 / 0	+120 / 0	+150 / 0	+180 / 0	+210 / 0	+250 / 0	+300 / 0	+350 / 0
m7	+2 / +12	+4 / +16	+6 / +21	+7 / +25	+8 / +29	+9 / +34	+11 / +41	+13 / +48
js14	+/- 125	+/- 150	+/- 180	+/- 215	+/- 260	+/- 310	+/- 370	+/- 435
js16	+/- 300	+/- 375	+/- 450	+/- 550	+/- 650	+/- 800	+/- 950	+/- 1100
H7	+10 / 0	+12 / 0	+15 / 0	+18 / 0	+21 / 0	+25 / 0	+30 / 0	+35 / 0
H8	+14 / 0	+18 / 0	+22 / 0	+27 / 0	+ 33 / 0	+39 / 0	+46 / 0	+54 / 0
H9	+25 / 0	+30 / 0	+36 / 0	+43 / 0	+52 / 0	+62 / 0	+74 / 0	+87 / 0
H12	+100 / 0	+120 / 0	+150 / 0	+180 / 0	+210 / 0	+250 / 0	+300 / 0	+350 / 0
P9	-6 / -31	-12 / -42	-15 / -51	-18 / -61	-22 / -74	-26 / -86	-32 / -106	-37 / -124
S7	-13 / -22	-15 / -27	-17 / -32	-21 / -39	-27 / -48	-34 / -59	-42 / -72	-58 / -93