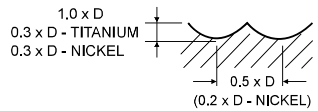
Cutting Conditions 170329, (4 Flute VX Ball Nose)

MATERIAL GROUP			Type of cut		Diameter (mm)									
					3.0	4.0	5.0	6.0	8.0	10.0	12.0	16.0	20.0	25.0
P	11, 12	Magnetic soft steels, structural steels, case carburizing steels		v_c (m/min)	162 (130-194)									
				n	17189	12892	10313	8594	6446	5157	4297	3223	2578	2063
				f_z	0.025	0.027	0.030	0.040	0.060	0.065	0.070	0.075	0.090	0.099
				f (mm/min)	1719	1392	1238	1375	1547	1341	1203	967	928	817
	13, 14	Plain carbon steels, alloy steels		v_c (m/min)	113 (90-136)									
				n	11990	8992	7194	5995	4496	3597	2997	2248	1798	1439
				f_z	0.025	0.027	0.030	0.040	0.060	0.065	0.070	0.074	0.090	0.099
				f (mm/min)	1199	921	863	959	1079	935	839	665	647	570
H	15	Alloy steels Hardened & Tempered steels		v_c (m/min)	68 (54-82)									
				n	7215	5411	4329	3608	2706	2165	1804	1353	1082	866
				f_z	0.017	0.019	0.021	0.028	0.042	0.045	0.049	0.052	0.063	0.070
				f (mm/min)	491	411	364	404	455	390	354	281	273	242
M	21	Free machining stainless steels		v_c (m/min)	85 (68-102)									
				n	9019	6764	5411	4509	3382	2706	2255	1691	1353	1082
				f_z	0.020	0.020	0.025	0.041	0.045	0.050	0.055	0.060	0.065	0.068
				f (mm/min)	722	541	541	740	609	541	496	406	352	294
	22	Ferritic, Ferritic & Austenitic, Martensitic stainless steels		v_c (m/min)	77 (62-92)									
				n	8170	6127	4902	4085	3064	2451	2042	1532	1225	980
				f_z	0.015	0.015	0.025	0.030	0.040	0.045	0.050	0.054	0.058	0.059
				f (mm/min)	490	368	490	490	490	441	408	332	284	231
	23	Austenitic stainless steels		v_c (m/min)	77 (62-92)									
				n	8170	6127	4902	4085	3064	2451	2042	1532	1225	980
				f_z	0.020	0.020	0.025	0.041	0.045	0.050	0.055	0.060	0.065	0.068
				f (mm/min)	654	490	490	670	551	490	449	368	319	267
K	31, 32, 33, 34	Grey cast irons		v_c (m/min)	119 (95-143)									
				n	12626	9470	7576	6313	4735	3788	3157	2367	1894	1515
				f_z	0.031	0.033	0.037	0.050	0.074	0.081	0.087	0.093	0.112	0.124
				f (mm/min)	1566	1250	1121	1263	1402	1227	1098	881	848	752
S	41, 42, 43	Titanium, Titanium alloys		v_c (m/min)	47 (38-56)									
				n	4987	3740	2992	2493	1870	1496	1247	935	748	598
				f_z	0.018	0.018	0.022	0.037	0.040	0.045	0.049	0.054	0.058	0.064
				f (mm/min)	359	269	263	369	299	269	244	202	174	146
	51, 52, 53	Nickel, Nickel alloys		v_c (m/min)	21 (17-25)									
				n	2228	1671	1337	1114	836	668	557	418	334	267
				f_z	0.014	0.014	0.017	0.028	0.031	0.035	0.038	0.042	0.045	0.048
				f (mm/min)	125	94	91	125	104	94	85	70	60	51



Recommended cutting depths are **maximum** depths, and **speeds and feeds are a starting point** based on these depths.
All recommendations are based on ideal machining conditions. Adjustments may need to be made according to your set-up.

v_c - cutting speed (m/min)
n - RPM (rev/min)
f_z - feed per tooth (mm)
f - feed rate (mm/min)
a_p - axial depth of cut
a_e - radial depth of cut

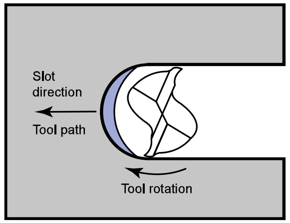
Trochoidal milling

Trochoidal milling should be used as the preferred method for producing slots using high efficiency machining. Multi-flute tools are normally used to allow higher radial feed rates, and high cutting speeds reduce the amount of time taken to produce the slot. Small radial depths of cut are taken, so the tool removes thin sections of material as it follows continuous spiral paths along it's radial direction, effectively turning slot milling into side cutting. Low cutting forces are generated as the tool engages, allowing large axial depths of cut. Generally, the tools maximum cutting length is used to ensure wear is uniform, which gives longer tool life than standard slotting techniques. Tool diameter should be no larger than 70% of the slot width, ideally around 50%. Full slot width and depth can be achieved with one pass, compared with several passes conventionally. Mastermill VX6 tool geometry has been optimised for use in trochoidal milling

To be able to increase feed rate it is necessary to reduce chip thickness, chip thinning as it is commonly known. For long tool life, feed per tooth should be equal to maximum chip thickness, which occurs when radial engagement (radial depth of cut) is equal to half the diameter of the tool. By reducing radial engagement, and therefore creating chip thinning, feed rate needs to be significantly increased to achieve maximum chip thickness. To facilitate higher feed rates, speed must also be increased. This process is known as high speed or high efficency machining. The trochoidal toolpath is a series of arcs or circles, but machining time can be reduced by altering the toolpath to form a 'D' shape. Dynamic trochoidal milling is the preferred programming method if CAD/CAM software is available, as the tool wears more evenly with constant tool engagement toolpaths.

Conventional slot milling

- Tool diameter generally close to slot size
- Several passes required to reach slot depth
- Inconsistent chip thickness, tool wear uneven
- Differing finish to each side of the slot
- Slow speed and feed rate to facilitate chip evacuation
- High power machine required for large slots



Trochoidal milling

- Tool size no larger than 0.7 x width of slot, one tool can produce several sizes
- Full flute length used, slot depth achieved in one pass
- Constant chip thickness, even tool wear along length of flute
- Slot can be finished and roughed in one pass
- High speed and feed rate due to thin chip width
- High metal removal rates, even with low power machines