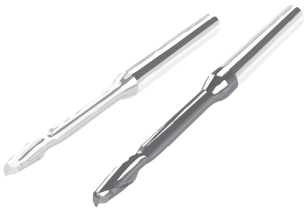
Hard Milling Guidelines for Miniature End Mills



Machining centers with rigid workholding (minimizing vibration) and balanced toolholders (providing T.I.R.) will optimize tool performance along with air/coolant for materials over 45 Rc.

To avoid chipping and/or breakage, slow the feedrate into the workpiece by ramping or helical interpolation. By utilizing the "Climb Milling" method, extended tool life and improved surface finish can be expected.

Machine RPM formula: RPM = 3.82 x SFM ÷ Cutter Diameter

Material Hardness: 44-55 Rc / Reach: 1.5x to 5x

Cutter Diameter	SFM	IPT	RDOC	ADOC
.010	110	.00010	.0050	.0003
.015	110	.00010	.0050	.0003
.020	110	.00010	.0050	.0003
.025	190	.00025	.0110	.0006
.030	190	.00025	.0110	.0006
.031	190	.00025	.0110	.0006
.035	190	.00025	.0110	.0006
.040	290	.00040	.0160	.0009
.045	290	.00040	.0160	.0009
.047	290	.00040	.0160	.0009
.050	290	.00040	.0160	.0009
.060	360	.00050	.0220	.0012
.062	360	.00050	.0220	.0012
.075	430	.00065	.0270	.0016
.078	430	.00065	.0270	.0016
.090	470	.00075	.0330	.0019
.093	470	.00075	.0330	.0019
.125	580	.00090	.0440	.0025
.187	580	.00130	.0650	.0037
.250	580	.00160	.0880	.0050

Material Hardness: 55-68 Rc / Reach: 1.5x to 5x

Cutter Diameter	SFM	IPT	RDOC	ADOC
.010	80	.00010	.0050	.0003
.015	80	.00010	.0050	.0003
.020	80	.00010	.0050	.0003
.025	140	.00020	.0080	.0006
.030	140	.00020	.0080	.0006
.031	140	.00020	.0080	.0006
.035	140	.00020	.0080	.0006
.040	210	.00030	.0120	.0009
.045	210	.00030	.0120	.0009
.047	210	.00030	.0120	.0009
.050	210	.00030	.0120	.0009
.060	270	.00040	.0160	.0012
.062	270	.00040	.0160	.0012
.075	320	.00050	.0200	.0016
.078	320	.00050	.0200	.0016
.090	350	.00055	.0230	.0019
.093	350	.00055	.0230	.0019
.125	420	.00070	.0310	.0025
.187	420	.00110	.0470	.0037
.250	420	.00150	.0630	.0050

Material Hardness: 44-55 Rc / Reach: 8x to 12x

Cutter Diameter	SFM	IPT	RDOC	ADOC
.010	90	.00010	.0050	.0002
.015	90	.00010	0050	.0002
.020	90	.00010	0050	.0002
.025	170	.00020	.0110	.0003
.030	170	.00020	.0110	.0003
.031	170	.00020	.0110	.0003
.035	170	.00020	.0110	.0003
.040	250	.00025	.0160	.0005
.045	250	.00025	.0160	.0005
.047	250	.00025	.0160	.0005
.050	250	.00025	.0160	.0005
.060	320	.00030	.0220	.0006
.062	320	.00030	.0220	.0006
.075	390	.00045	.0270	.0008
.078	390	.00045	.0270	.0008
.090	390	.00045	.0270	.0009
.093	430	.00055	.0330	.0009
.125	520	.00070	.0440	.0013
.187	520	.00100	.0650	.0019
.250	520	.00120	.0880	.0025

Material Hardness: 55-68Rc / Reach: 8x to 12x

Cutter Diameter	SFM	IPT	RDOC	ADOC
.010	70	.00010	.0040	.0002
.015	70	.00010	.0040	.0002
.020	70	.00010	.0040	.0002
.025	130	.00015	.0080	.0003
.030	130	.00015	.0080	.0003
.031	130	.00015	.0080	.0003
.035	130	.00015	.0080	.0003
.040	190	.00020	.0120	.0005
.045	190	.00020	.0120	.0005
.047	190	.00020	.0120	.0005
.050	190	.00020	.0120	.0005
.060	240	.00025	.0160	.0006
.062	240	.00025	.0160	.0006
.075	290	.00035	.0200	.0008
.078	290	.00035	.0200	.0008
.090	320	.00040	.0230	.0009
.093	320	.00040	.0230	.0009
.125	350	.00055	.0310	.0013
.187	350	.00090	.0470	.0019
.250	350	.00130	.0630	.0025

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Machining centers with rigid workholding (minimizing vibration) and balanced toolholders (providing T.I.R.) will optimize tool performance along with air/coolant for materials over 45 Rc.

To avoid chipping and/or breakage, slow the feedrate into the workpiece by ramping or helical interpolation. By utilizing the "Climb Milling" method, extended tool life and improved surface finish can be expected.

Machine RPM formula: M/Min = RPM x .00312 x Cutter Diameter

Material Hardness: 44-55 Rc / Reach: 1.5x to 5x			
Cutter Diameter	M/Min	MMPT	ADOC
0.10	15	.0013	.0038
0.15	15	.0013	.0038
0.20	15	.0013	.0038
0.30	33	.0025	.0076
0.40	33	.0025	.0076
0.50	33	.0025	.0076
0.60	57	0064	.0152
0.80	57	.0064	.0152
1.0	88	.0102	.0229
1.2	88	.0102	.0229
1.5	109	.0127	.0305
2.0	130	.0165	.0406
2.5	143	.0191	.0483
3.0	143	.0229	.0635
4.0	176	.0330	.0940
5.0	176	.0406	.1270

Material Hardness: 44-55 Rc / Reach: 8x to 12x			
Cutter Diameter	M/Min	MMPT	ADOC
0.10	15	.0013	.0038
0.15	15	.0013	.0038
0.20	15	.0013	.0038
0.30	27	.0025	.0051
0.40	27	.0025	.0051
0.50	27	.0025	.0051
0.60	51	.0051	.0076
0.80	51	.0051	.0076
1.0	76	.0064	.0127
1.2	76	.0064	.0127
1.5	109	.0076	.0152
2.0	118	.0114	.0203
2.5	130	.0140	.0229
3.0	157	.0178	.0330
4.0	157	.0254	.0483
5.0	157	.0305	.0635

Material Hardness: 55-68 Rc / Reach: 1.5x to 5x			
Cutter Diameter	M/MIN	MMPT	ADOC
0.10	12	.0013	.0038
0.15	12	.0013	.0038
0.20	12	0013	.0038
0.30	24	.0025	.0076
0.40	24	.0025	.0076
0.60	24	.0025	.0076
0.80	42	.0051	.0152
1.0	42	.0051	.0152
1.2	64	.0076	.0229
1.5	64	.0076	.0229
2.0	82	.0102	.0229
2.5	82	.0127	.0406
3.0	106	.0140	.0482
4.0	127	.0178	.0635
5.0	127	.0279	.0940

Material Hardness: 55-68Rc / Reach: 8x to 12x			
Cutter Diameter	M/Min	MMPT	ADOC
0.10	10	.0013	.0025
0.15	10	.0013	.0025
0.20	10	.0013	.0025
0.30	21	.0025	.0051
0.40	21	.0025	.0051
0.60	39	.0038	.0076
0.80	39	.0038	.0076
1.0	57	.0051	.0127
1.2	57	.0051	.0127
1.5	73	.0064	.0152
2.0	88	.0089	.0203
2.5	97	.0102	.0229
3.0	106	.0140	.0330
4.0	106	.0229	.0483
5.0	106	.0330	.0635

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