



PFB Ball End Mill
PH Machining Guide



Roughing & Finishing (LDR 4xD)

For LDR Greater See LDR Notes

RPM/Spindle Speed

Material		Carbon/Alloy Steel (30-40 HRC)		Tool Steel (40-50 HRC)		Tool Steel (50-60 HRC)	
Diameter		Rough	Finish	Rough	Finish	Rough	Finish
Inch	mm						
-	6	14715 - 17950	29100 - 35580	13100 - 16330	17950 - 35740	9865 - 13100	16330 - 24420
0.250	-	13900 - 16960	27500 - 33615	12375 - 15430	16960 - 33770	9320 - 12380	15430 - 23070
-	8	11035 - 13465	21830 - 26685	9825 - 12250	13465 - 26800	7400 - 9825	12250 - 18315
0.375	-	9270 - 11300	18335 - 22410	8250 - 10290	11310 - 22515	6215 - 8250	10290 - 15385
-	10	8830 - 10770	17465 - 21345	7860 - 9800	10770 - 21445	5920 - 7860	9800 - 14650
-	12	7360 - 8975	14555 - 17790	6550 - 8165	8975 - 17870	4930 - 6550	8165 - 12210
0.500	-	6950 - 8480	13750 - 16810	6190 - 7715	8480 - 16885	4660 - 6190	7715 - 11535
0.625	-	5560 - 6785	11000 - 13445	4950 - 6175	6785 - 13510	3730 - 4950	6175 - 9230
-	16	5520 - 6730	10915 - 13340	4910 - 6125	6730 - 13400	3700 - 4910	6125 - 9160
0.750	-	4635 - 5655	9170 - 11200	4125 - 5145	5655 - 11255	3110 - 4125	5145 - 7690
-	20	4415 - 5385	8735 - 10675	3930 - 4900	5385 - 10725	2960 - 3930	4900 - 7325
-	25	3530 - 4310	6985 - 8540	3145 - 3920	4310 - 8575	2365 - 3145	3920 - 5860
1.000	-	3475 - 4240	6875 - 8400	3095 - 3860	4240 - 8445	2330 - 3095	3860 - 5770
-	30	2945 - 3590	5825 - 7115	2620 - 3265	3590 - 7150	1975 - 2620	3265 - 4885
1.250	-	2780 - 3390	5500 - 6720	2475 - 3090	3390 - 6750	1865 - 2475	3090 - 4615
-	32	2760 - 3360	5460 - 6670	2455 - 3060	3360 - 6700	1850 - 2455	3060 - 4580

Chip Load/Inch Per Tooth

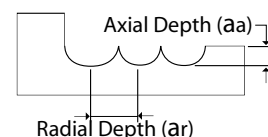
Material		Carbon/Alloy Steel (30-40 HRC)		Tool Steel (40-50 HRC)		Tool Steel (50-60 HRC)	
Diameter		Rough	Finish	Rough	Finish	Rough	Finish
Inch	mm						
-	6	0.0045 - 0.0055	0.0040 - 0.0050	0.0040 - 0.0050	0.0040 - 0.0045	0.0040 - 0.0045	0.0035 - 0.0040
0.250	-	0.0045 - 0.0055	0.0040 - 0.0050	0.0040 - 0.0050	0.0040 - 0.0045	0.0040 - 0.0045	0.0035 - 0.0040
-	8	0.0063 - 0.0070	0.0052 - 0.0067	0.0052 - 0.0067	0.0052 - 0.0063	0.0052 - 0.0063	0.0047 - 0.0055
0.375	-	0.0070 - 0.0080	0.0063 - 0.0079	0.0062 - 0.0077	0.0054 - 0.0065	0.0060 - 0.0072	0.0050 - 0.0060
-	10	0.0070 - 0.0080	0.0063 - 0.0079	0.0062 - 0.0077	0.0054 - 0.0065	0.0060 - 0.0072	0.0050 - 0.0060
-	12	0.0087 - 0.0100	0.0080 - 0.0094	0.0080 - 0.0092	0.0070 - 0.0090	0.0078 - 0.0090	0.0062 - 0.0081
0.500	-	0.0087 - 0.0100	0.0080 - 0.0094	0.0080 - 0.0092	0.0070 - 0.0090	0.0078 - 0.0090	0.0062 - 0.0081
0.625	-	0.0097 - 0.0110	0.0090 - 0.0106	0.0096 - 0.0105	0.0092 - 0.0101	0.0094 - 0.0102	0.0090 - 0.0098
-	16	0.0097 - 0.0110	0.0090 - 0.0106	0.0096 - 0.0105	0.0092 - 0.0101	0.0094 - 0.0102	0.0090 - 0.0098
0.750	-	0.0108 - 0.0120	0.0100 - 0.0116	0.0100 - 0.0112	0.0103 - 0.0108	0.0099 - 0.0109	0.0095 - 0.0105
-	20	0.0108 - 0.0120	0.0100 - 0.0116	0.0100 - 0.0112	0.0103 - 0.0108	0.0099 - 0.0109	0.0095 - 0.0105
-	25	0.0118 - 0.0130	0.0110 - 0.0126	0.0110 - 0.0120	0.0106 - 0.0116	0.0100 - 0.0110	0.0096 - 0.0106
1.000	-	0.0118 - 0.0130	0.0110 - 0.0126	0.0110 - 0.0120	0.0106 - 0.0116	0.0100 - 0.0110	0.0096 - 0.0106
-	30	0.0125 - 0.0138	0.0118 - 0.0134	0.0118 - 0.0130	0.0114 - 0.0122	0.0110 - 0.0118	0.0106 - 0.0114
1.250	-	0.0130 - 0.0145	0.0125 - 0.0145	0.0125 - 0.0135	0.0120 - 0.0130	0.0115 - 0.0125	0.0110 - 0.0120
-	32	0.0130 - 0.0145	0.0125 - 0.0145	0.0125 - 0.0135	0.0120 - 0.0130	0.0115 - 0.0125	0.0110 - 0.0120

Axial and Radial Depths

Material Hardness	Carbon/Alloy Steel (30-40 HRC)	Tool Steel (40-50 HRC)	Tool Steel (50-60 HRC)	Tool Steel (Over 60 HRC)
Axial Depth (Aa)	10% of tool Dia. Max.	7% of tool Dia. Max.	5% of tool Dia. Max.	4% of tool Dia. Max.
Radial Depth (Ar)	40% of tool Dia. Max.	35% of tool Dia. Max.	30% of tool Dia. Max.	25% of tool Dia. Max.

Length-to-Diameter Compensations

Overhang Length	Cutting Speed	Aa	Ar
LDR Under 4xD	100%	100%	100%
LDR 4xD to 6xD	60% - 80%	60% - 80%	60% - 80%
LDR 6xD to 10xD	40% - 60%	40% - 60%	40% - 60%

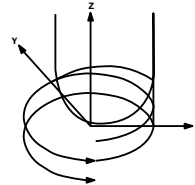


Carbide shank recommended for LDR 6xD and above.

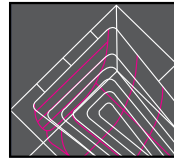
High Speed Machining Guide

Machining Tips

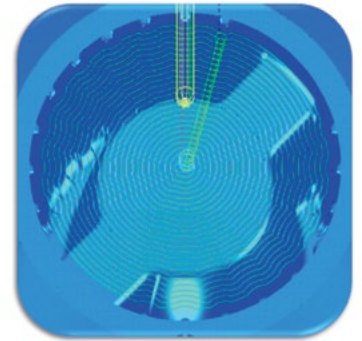
- Use Z-Level climb cutting for roughing operations.
- Use Helical for material engagement whenever possible. Use 3° ramp angle and 0.8xDiameter of cutter for the tool path arc.
- Add radiuses larger than cutter to corner of tool path for smooth operation.
- LDR should always be as short as possible.
- LDR of 4xD or less use chart on reverse side with high speed steel body.
- LDR of 6xD to 10xD use chart on reverse side with carbide body.
- **Machining is very difficult over 10xD.**
- Leave extra stock for semi-finishing to prevent gouging of surface when using long reach tools.
- Use air or oil mist for all applications except those involving gummy or sticky materials such as stainless, which machines well with water based coolant.



Helical Interpolation



Corner Rounding on Tool Path



Z-Level Machining with Climb Cutting is Highly Recommended

Diagnosing Problems

Insert Chipping - early during use means chip load too high, please reduce feed rate in increments of 20% until problem is resolved or shorten the length of the tool.

Insert Burning - of coating or glowing at the tip means RPM is too high. Reduce RPM by 20% increments until problem is resolved along with feed rate until excessive heat is subdued.

Chatter - excessive tool length is a primary cause. After reducing tool length if possible, lower RPM and feed rate until chatter is minimized.

Formulas

$$\text{RPM} = (3.82 \times \text{SFM}) / \text{Tool Diameter}$$

$$\text{SFM} = 0.262 \times \text{RPM} \times \text{Tool Diameter}$$

$$\text{IPM} = \text{RPM} \times \# \text{ Flutes} \times \text{Chip Load}$$

$$\text{Chip Load} = \text{IPM} / (\text{RPM} \times \# \text{ Flutes})$$

Stock Left for Semi-Finishing

Medium parts 6" square to 24"

- No heat treat: leave 0.010" to 0.015" stock.
- Heat treat: leave 0.015" to 0.030" stock, depending on geometry.

Finishing Tips for Surface Finishes

$Ar = CL$ (Radial DOC = Chip Load)

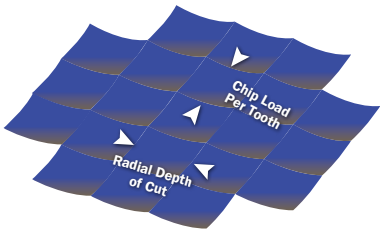
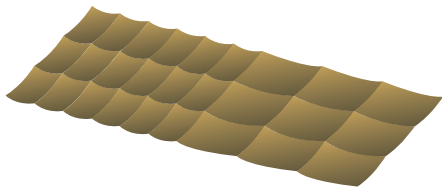


Fig. 1 (Above): Chip load and radial depth of cut must be equal to achieve best surface finish as shown.

Fig. 2 (Below): Shows non-symmetrical finish resulting from not using $Ar = CL$.



Radial DOC (Step Over) Calculation

h = Cusp Height
 r = Cutter Radius

$$Ar = \sqrt{hx8xr}$$

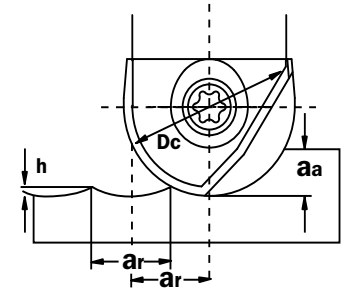
Radial DOC (Step Over) Example

50 RMS finish with 3/8" Dia. BEM

$h = 0.000050$ (Cusp Height)

$r = 0.1875$ "

$$Ar = \sqrt{0.000050 \times 8 \times 0.1875} = 0.0087$$



Tool Dia.		Radial Depth or Step Over		Surface Finish (h)	
Inch	mm	Inch	mm	Inch	mm
0.250	6	0.0071	0.180	0.000050	0.00127
0.275	7	0.0074	0.188	0.000050	0.00127
0.312	8	0.0079	0.201	0.000050	0.00127
0.375	10	0.0087	0.225	0.000050	0.00127
0.500	12	0.0100	0.247	0.000050	0.00127
0.625	16	0.0112	0.285	0.000050	0.00127
0.750	20	0.0122	0.319	0.000050	0.00127
1.000	25	0.0141	0.356	0.000050	0.00127
1.187	30	0.0154	0.390	0.000050	0.00127
1.250	32	0.0158	0.402	0.000050	0.00127

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