ADJUSTMENTS FOR BALL NOSE END MILLS

The speeds and feeds of ball nose end mills must be adjusted to ensure proper tool life. Adjustments are based on the amount of tool engagement.

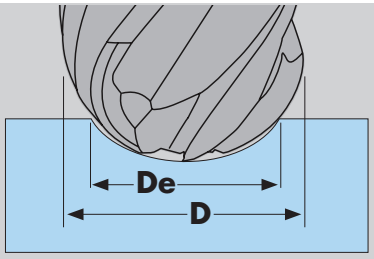
If the depth of cut (ADOC) is <50% of the tool diameter:

Adjustments must be made to determine the effective cutting diameter and to adjust for axial chip thinning. Follow these steps:

STEP 1: Use speed and feed values for slot cuts from the speed and feed charts for the appropriate material and tool diameter.
Note: Make an additional adjustment using the chart to the right if the tool projection exceeds 2.5 x the tool diameter.

Projection	Speed Adj	Feed Adj
> 2.5 to 3 x D	SFM or MMPM x .95	IPT or MMPT x .95
> 3 to 4 x D	SFM or MMPM x .90	IPT or MMPT x .90
> 4 to 5 x D	SFM or MMPM x .80	IPT or MMPT x .80
> 5 to 6 x D	SFM or MMPM x .70	IPT or MMPT x .70

STEP 2: Determine the effective cutting diameter (De) of the end mill based on the axial depth of cut. The effective cutting diameter will be used to make both speed and feed adjustments.



Use D when making shallow cuts with full radius

Ball Nose "Effective Diameter"

$$D = 2x \sqrt{R^2 - (R - ADOC)^2}$$

For easy reference, use the charts below.

Fractional:

Depth of Cut (ADOC)	1/8		1/4		3/8		1/2		3/4		1	
	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De
10% of tool diameter	.013	.075	.025	.150	.038	.225	.050	.300	.075	.450	.100	.600
20% of tool diameter	.025	.100	.050	.200	.075	.300	.100	.400	.150	.600	.200	.800
30% of tool diameter	.038	.115	.075	.229	.113	.344	.150	.458	.225	.687	.300	.917
40% of tool diameter	.050	.123	.100	.245	.150	.367	.200	.490	.300	.73	.400	.980
50% of tool diameter	.063	.125	.125	.250	.186	.375	.250	.500	.375	.7500	.500	1.000

Metric:

Depth of Cut (ADOC)	3.0		6.0		10.0		12.0		20.0		25.0	
	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De	Depth	De
10% of tool diameter	.300	1.800	.600	3.600	1.000	6.000	1.200	7.200	2.000	12.000	2.500	15.000
20% of tool diameter	.600	2.400	1.200	4.800	2.000	8.000	2.400	9.600	4.000	16.000	5.00	20.000
30% of tool diameter	.900	2.750	1.800	5.500	3.000	9.165	3.600	10.998	6.000	18.330	7.500	22.913
40% of tool diameter	1.200	2.940	2.400	5.880	4.000	9.800	4.800	11.760	8.000	19.600	10.000	24.500
50% of tool diameter	1.500	3.000	3.000	6.000	5.000	10.000	6.000	12.000	10.000	20.000	12.500	25.000

STEP 3: Calculate speed based on using the effective cutting diameter. Use the standard SFM or M/min to RPM conversion formula. Substitute the effective cutting diameter (De) for the actual tool diameter (D).

Fractional: ***RPM = (SFM x 3.82) / De***
Metric: ***RPM = (M/min x 318.3) / De***

D = Actual tool diameter
IPT = Feed rate from chart for slot milling
De = Effective cutting diameter
MMPT = Feed rate from chart for slot milling

STEP 4: Calculate the adjusted feed rate based on the effective cutting diameter and the axial chip thinning formula.

Fractional: ***IPTadj = (D x IPT) / De***
Metric: ***MMPTadj = (D x MMPT) / De***

The new feed rate is calculated:

Fractional: ***IPM = RPM x (Z x IPT adj)***
Metric: ***MMPM = RPM x (Z x MMPTadj)***

IPM = Inches per minute
Z = # of flutes
IPT adj = Adjusted chip load per tooth fractional
MMPT adj = Adjusted chip load per tooth metric
MMPM = Millimeters per minute

If the axial depth of cut (ADOC) is ≥50% of the tool diameter:

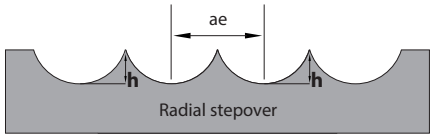
- Use the speed and feed values shown for the slotting operation in the speed and feed charts for the series of end mill being used.
- If the tool projection exceeds 2.5 x the tool diameter, adjust the slotting speeds and feeds by the chart for long reach tool adjustments. This can be found on page 133.

SURFACE FINISH

Radial depth of cut (RDOC), or step-over, is based on the desired finish. The lighter the step-over, the lower the scallop height (material left uncut by the radius of the tool), and the better the finish. These charts calculate approximate scallop height using the following formula:

h ~ (ae²) / (8R)

h = Scallop height
ae = Radial step-over
R = Radius of end mill
(tool diameter x .5)



Fractional

Tool Diameter	Step-over % of OD	Step-over Actual	Approx Scallop Height
1/8	10%	.013	.0003
	20%	.025	.0013
	30%	.038	.0028
1/4	10%	.025	.0006
	20%	.050	.0025
	30%	.075	.0056
3/8	10%	.038	.0009
	20%	.075	.0038
	.30%	.113	.0084
1/2	10%	.050	.0013
	20%	.100	.0050
	30%	.150	.0113
3/4	10%	.075	.0019
	20%	.150	.0075
	30%	.225	.0169
1	10%	.100	.0025
	20%	.200	.0100
	30%	.300	.0225

Metric

Tool Diameter	Step-over % of OD	Step-over Actual	Approx Scallop Height
3.0 mm	10%	.300	.0075
	20%	.600	.0300
	30%	.900	.0675
6.0 mm	10%	.600	.0150
	20%	1.200	.0600
	30%	1.800	.1350
10.0 mm	10%	1.000	.0250
	20%	2.000	.1000
	.30%	3.000	.2250
12.0 mm	10%	1.200	.0300
	20%	2.400	.1200
	30%	3.600	.2700
20.0 mm	10%	2.000	.0500
	20%	4.000	.2000
	30%	6.000	.4500
25.0 mm	10%	2.500	.0625
	20%	5.000	.2500
	30%	7.500	.5625