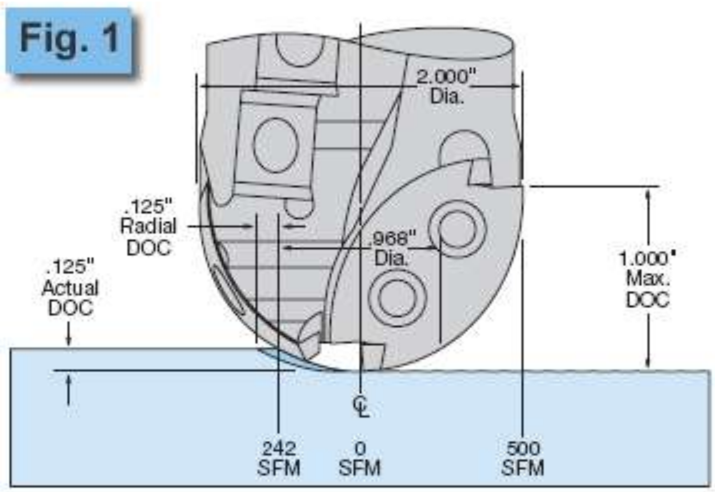
# Axial Chip Thickness




In this example, the SFM is 500 at a 2.000" diameter. The effective cutting diameter is .968", at which point, the SFM is 242. The RPM must be increased to 1973 in order to achieve 500 SFM at the .968" effective cutting diameter.

***Effective Diameter:*** When applying ball nose end mills, quite often the full diameter of the cutter is not engaged in the work. Since ball nose end mills cut to center, the speed in SFM is reduced to 0 as the centerline of the cutter is reached (see Fig.1).

To determine the Axial Chip Thinning Factor (ACTF), first determine the effective cutting diameter.

As the DOC varies, so does the effective cutting diameter. Since SFM calculations are based on the diameter of the cutter engaged in the cut, they must be made at the effective cutting diameter, not the nominal diameter of the tool.

The effective cutting diameter can be found in Chart A on pages M466-M467 by using the nominal tool diameter at the top and the DOC on the side. The SFM is calculated using the resulting effective cutting diameter at DOC.

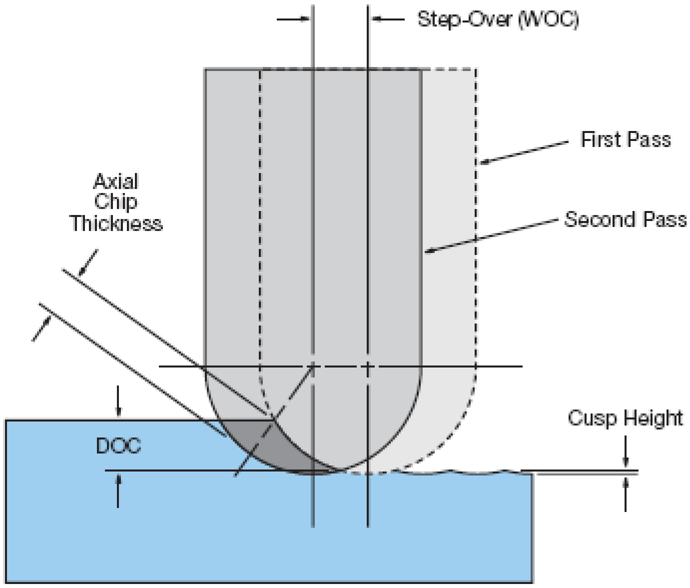
In order to achieve the best productivity possible, be sure to consider the effective cutting diameter when setting RPM for a profiling ball nose application.

# Chip Thickness

Due to the spherical form presented to the workpiece, axial chip thinning can affect chip thickness the same way as a lead angle on a face mill. This can have an adverse effect on the performance of a ball nose end mill. The ACTF must be applied when calculating the desired chip thickness and resulting feed rate.

The ACTF is determined by the radius of the ball nose at a given DOC. Figure 2 illustrates the concept of axial chip thinning. Notice as the axial DOC increases, so does the axial chip thickness.

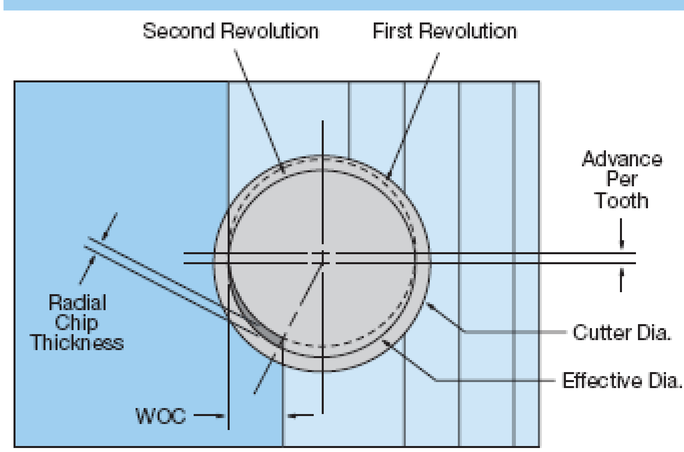
**Fig. 2: Axial Chip Thinning**




Whenever the axial DOC is equal to or greater than the radius of the ball nose, the ACTF is equal to 1.

Next, determine the RCTF by the chart on pages M466-M467 or the formula. As Figure 3 shows, the RCTF is determined by the radius of the cutter at a given radial DOC. When determining the RCTF, use the effective diameter of the ball nose rather than the cutter diameter. Radial DOC is the same as the radial “step over.” The formula used to calculate axial chip thinning is the same as that used for radial chip thinning.

**Fig. 3: Radial chip Thinning at Effective Diameter**




Ultimately, the purpose of determining the chip thinning factor is to optimize the feed rate. To calculate the proper feed rate, first multiply the ACTF by the RCTF.

This result is the Feed Correction Factor (FCF):
FCF = RCTF x ACTF

Divide the desired chip thickness by the FCF. This result is the desired APT to maintain proper chip thickness:
APT = CT/FCF

Finally, to arrive at the feed rate in Inches Per Minute (IPM), multiply the APT by the number of effective flutes and the RPM:
IPM = RPM x (No. of Flutes)

Overall performance would also improve since the cutter would be taking a true “bite” at the new feed rate. At the lower feed rate, the carbide may rub rather than cut.

## Example

Figure 1 shows a 2.000″ diameter ball nose end mill running at .125″ DOC and a .125″ radial DOC (step over). the effective diameter at this DOC is .968″. If the desired SFM is 500, the RPM would normally be set at 955 RPM for a 2.000″ diameter cutter. However, since the effective diameter is .968″, the RPM should be set at 1973 to achieve 500 SFM. This is an increase of more than 100 percent.

The DOC also affects the feed rate due to axial chip thinning. At .125″ DOC, a 2.000″ diameter has a chip thinning factor of .48. If the desired chip thickness is .010″, the feed rate will need to be increased more than 100 percent. Without chip thinning, the feed rate would be set at 19.7 IPM (1973 x .010″). However, at this DOC, the ACT would be only .0048″ (.010 x .48). To achieve the proper chip thickness (APT or ACT), divide the desired chip thickness by the chip thinning factor.
.010″/.48 = .021″ APT
The feed rate would be:
1973 RPM x .021 = 41.4 IPM

In the same manner, the radial DOC (step over) has the same effect on feed rate. The radial DOC on a ball nose end mill is the same as the radial WOC on an end mill or face mill. In this example, the radial DOC of .125″ has an RCTF of .67.

To achieve the desired chip thickness of .010″, multiply the ACTF by the RCTF resulting in the FCF.
.48 ACTF x .67 RCTF = .32 FCF
The APT is:
.010″/.32 = .021″ APT

Productivity in this example is three times greater by using the correct chip thinning factors. On a single flute, one effective tool using this example, the feed rate should be set at:
1973 RPM x .031″ APT = 61.3 IPM

At this feed rate, productivity is increased over 200 percent by using the proper chip thinning factors.

Ingersoll Cutting Tool Company provides speed and feed selectors which are designed to help obtain optimum speed, feed, and ACT multipliers. Ask your Ingersoll sales engineer for a complimentary selector.

# Effective Diameter and Axial Chip Thinning Factor

Axial DOC will affect the effective cutting diameter and, consequently, the ACTF. Note that as the axial DOC increases, the effective diameter and ACTF also increase. A lower DOC results in a smaller effective diameter and, therefore, a lower ACTF; i.e., the spindle RPM and feed rate need to be increased to maintain a proper surface speed and chip load.

# Cusp Height

Step over, or radial DOC, affects the cusp height. Cusp height is the theoretical surface finish produced by successive tool paths made by a radius tool. Larger step over or a smaller cutter diameter produces a larger cusp height; i.e. a rougher finish.

For the best surface finish, use the largest diameter tool possible at the lowest practical radial DOC.