

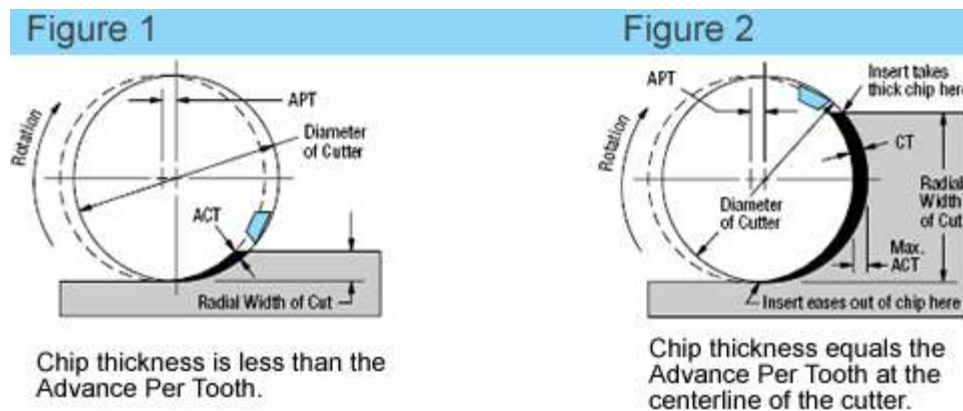
## Radial Chip Thickness

Limitations on a cutting tool's performance are generally established in terms of maximum chip load. Since commonly used speed and feed calculators show only Advance Per Tooth (APT), chip load and APT tend to be used interchangeably. This is an area of misunderstanding which can be significant. Chip load actually refers to chip thickness, not APT.

APT is defined as the increment of feed that takes place in the time necessary for the cutter to rotate the distance between cutting edges.

The chip thickness is the "bite" taken by each cutting edge as it performs its work. For a typical end mill in a radial Depth Of Cut (DOC) exceeding two-thirds the diameter of the cutter, the chip thickness increases until it equals the APT at the centerline of the cutter. The chip thickness then decreases to nothing as the cutting edge exits the cut (Figure 1).

Thus, APT is a constant for a given operation and the chip thickness is variable, changing cyclically.



## Peripheral cutting

When end mill cuts are shallow in relation to the cutter diameter, the Actual Chip Thickness (ACT) is less than the APT. This chip thinning effect allows much higher feed rates (Figure 2).

For example, assume the following parameters:

2.000" diameter end mill

Two-effective

500 Surface Feet per Minute (SFM)

.12" radial Width Of Cut (WOC)

.005" chip thickness

955 effective RPM

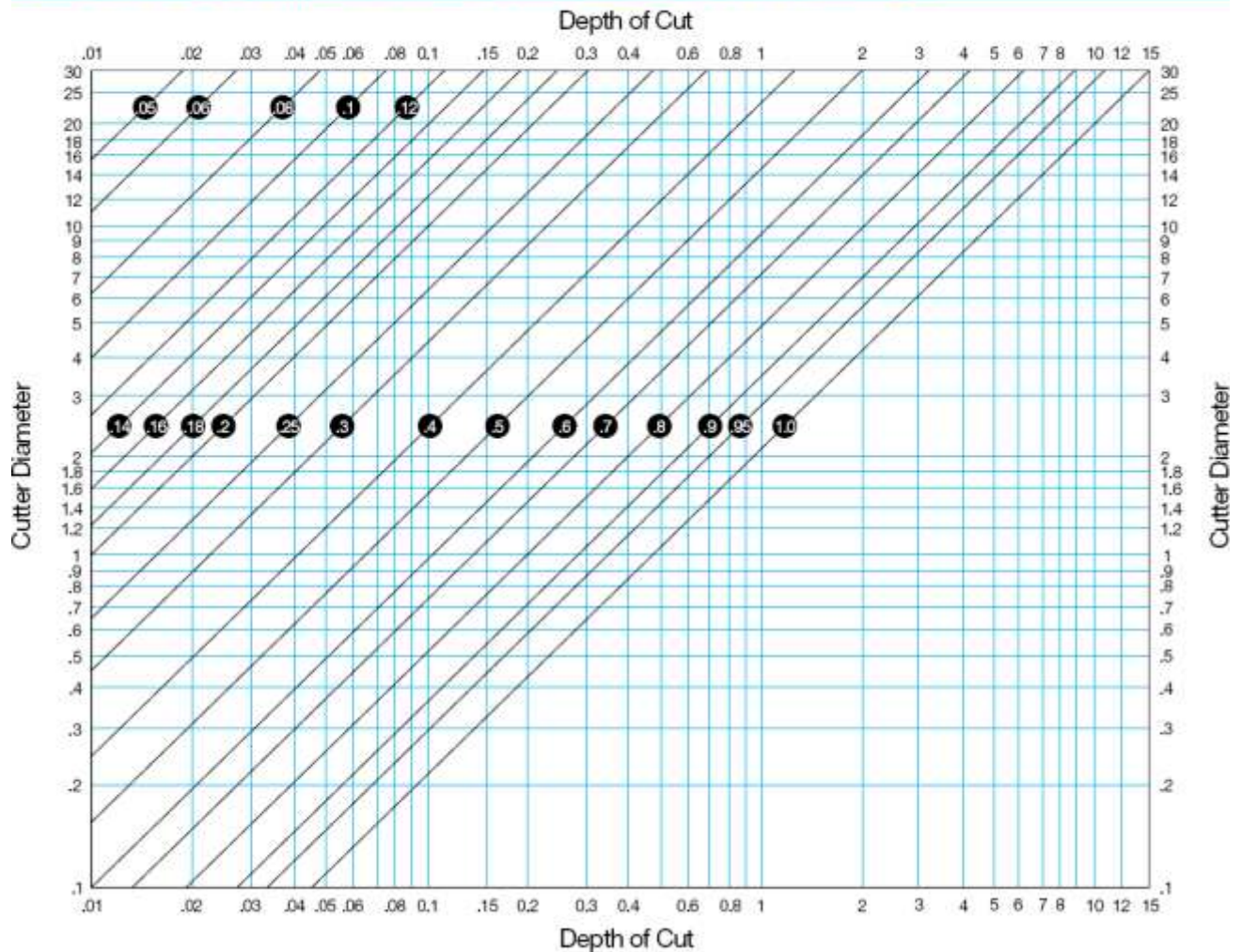
Even though the APT in this case is .0105", the ACT (or chip load) is only .005".

A two-effective, 2.000" diameter end mill had an APT of .0105" and a chip thickness of only

.005". The Radial Chip Thinning Factor (RCTF) is the ratio of chip thickness to APT or, in this example, .48.

Whenever the radial DOC is equal to or greater than the effective cutter radius, the RCTF is equal to 1.

**Fig. 3: Radial Chip Thinning factors for Peripheral Milling**



To find the Radial Chip Thinning Factor for a slabbing cut:

1. Find the Depth of Cut on the horizontal scale.
2. Locate the nominal diameter of the cutter on the vertical axis.
3. Cross-reference the two figures.
4. Locate the diagonal line closest to the intersection of the vertical and horizontal axes. The value of this diagonal is the Radial Chip Thinning Factor for your specific application.

The RCTF can also be found with the help of the graph in Figure 3.

A thorough understanding of the relationship between APT and chip thickness enables the tool engineer to establish optimum feed rates for a cutting tool. After determining the RCTF, the maximum permissible chip load is divided by the RCTF to arrive at the optimum APT.

Again, referring to the example, the chip load of .005" is divided by the RCTF of .48 to arrive at the optimum APT of .0105". This APT should be used in calculating the feed rate, in this case, 20.1 IPM.

In addition to increasing productivity, applying the RCTF can improve a cutter's performance. At the higher feed rate, the insert will be taking a true bite. At lower feed rates without applying the RCTF, the insert may rub instead of cut and produce chatter, building heat, work hardening, and compromising tool life.

## Calculations:

$R := 0.0625$  Radius of cutter.

$c_l := 0.0013$  Chip Thickness at Center.

See page two for  
reverse order.

$doc := 0.01$  Depth of Cut.

$SFM := 200$  Surface Feet per Minute.

$N_f := 3$  Number of Flutes.

$$\theta := \arccos\left(1 - \frac{doc}{R}\right)$$

$$\theta \cdot \frac{180}{\pi} = 32.86$$

$$x_1 := \sin(\theta)^2 \cdot \left(c_l + \frac{\sqrt{R^2 - c_l^2 \cdot \cos(\theta)^2}}{\sin(\theta)}\right)$$

$$x_1 = 0.03429$$

$$y_1 := \frac{x_1}{\tan(\theta)}$$

$$y_1 = 0.05308$$

$$x_0 := \sqrt{doc \cdot (2 \cdot R - doc)}$$

$$x_0 = 0.03391$$

$$y_0 := R - doc$$

$$y_0 = 0.0525$$

$$A_{cl} := \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2}$$

$$A_{cl} = 0.0007 \quad \text{Chip Thickness.}$$

$$\frac{A_{cl}}{c_l} = 0.535 \quad \text{Radial Chip Thinning Factor}$$

$$RPM := \frac{6 \cdot SFM}{\pi \cdot R}$$

$$RPM = 6112$$

$$IPM := RPM \cdot N_f \cdot c_l$$

$$IPM = 23.835 \quad \text{\_in/min}$$

## Page 2:

$A_{cl} := 0.0025$       Actual Chip Thickness.

$$C_{load}(x) := \left( \sin(\theta)^2 \cdot \left( x + \frac{\sqrt{R^2 - x^2 \cdot \cos(\theta)^2}}{\sin(\theta)} \right) - x_0 \right)^2 + \left( \frac{\sin(\theta)^2 \cdot \left( x + \frac{\sqrt{R^2 - x^2 \cdot \cos(\theta)^2}}{\sin(\theta)} \right)}{\tan(\theta)} - y_0 \right)^2 - A_{cl}^2$$

$x := 0$  Finding the first positive root near zero.

$C_l := \text{root}(C_{load}(x), x)$        $C_l = 0.00485$       Chip Thickness at Center.

$IPM := RPM \cdot N_f \cdot C_l$        $IPM = 88.975$       \_in/min

