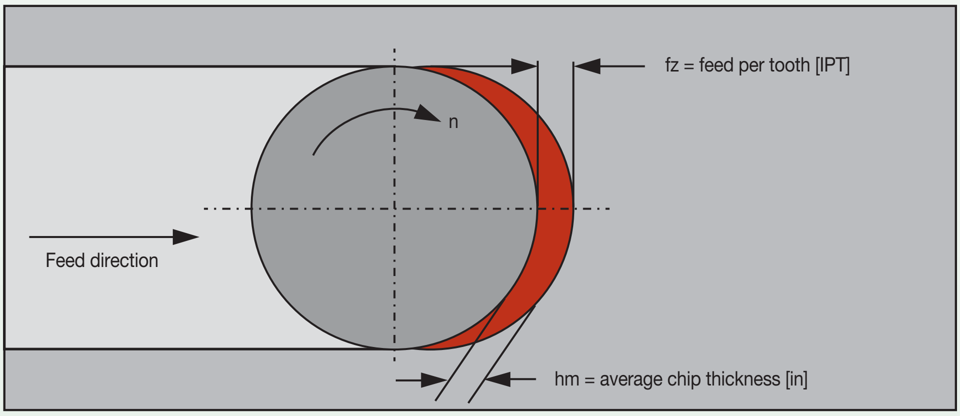
WIDIA™ 2017 Master Catalog
Inch

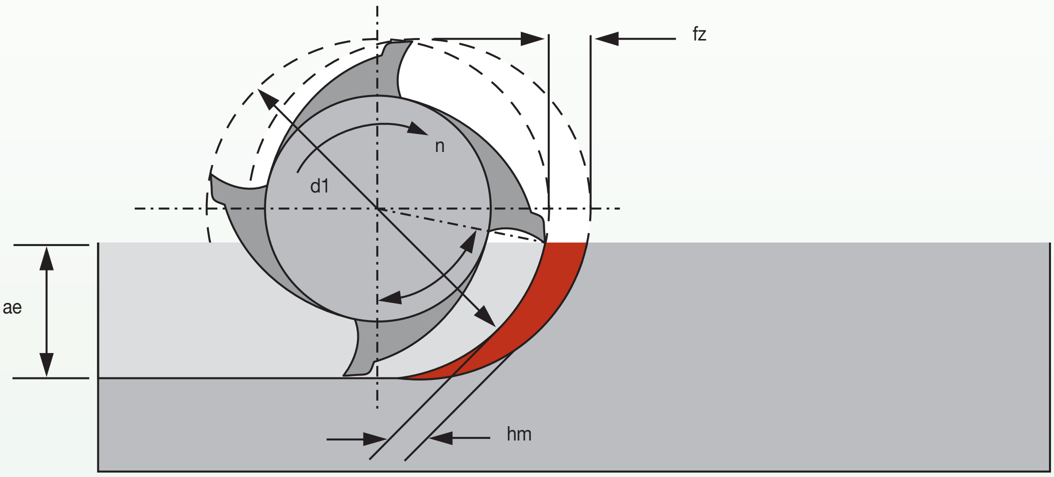
WIDIA™

Conventional Slotting

- Full slotting limitations:
  - Usually not more then ap = 1 x D.
  - Conventional and climb milling at the same time.
  - High heat development on the tool and on the workpiece.
  - Difficult chip evacuation.
  - High radial forces.
- This Means:
  - No constant chip thickness.
  - Low MRR.
  - Surface quality from the left to right side are different.
  - Limited tool life.
  - High power and torque requirements for the machine.



ae and Chip Thickness



To calculate average chip thickness:

$$hm = fz \bullet \left(\sqrt{\frac{ae}{d1}}\right)$$

Simplified formula for shown application and 90° angles on the tool.
The chip thickness defines the load on the cutting edge.

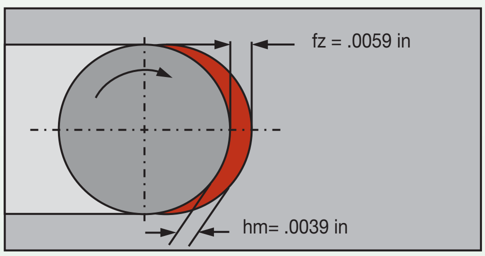
ae and Chip Thickness

chip thinning effect

a_e	programmed feed (f_z)	chip thickness (h_m)
100%	.0059 in	.0039 in
50%	.0059 in	.0039 in
40%	.0059 in	.0035 in
20%	.0059 in	.0028 in
10%	.0059 in	.0018 in

The chip thickness needs to be compensated by feed

100%



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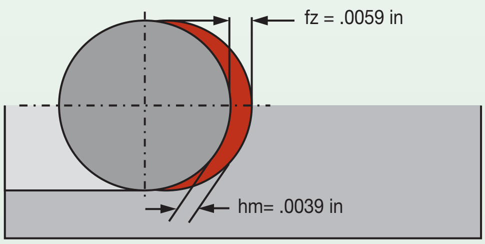

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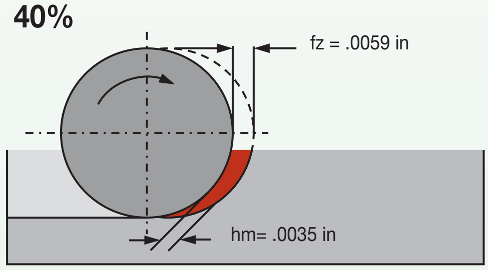

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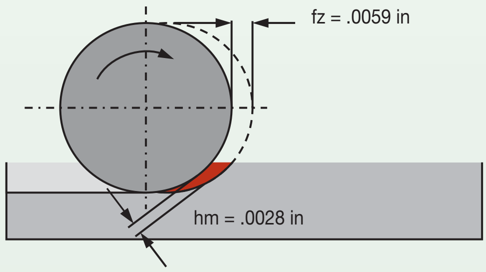

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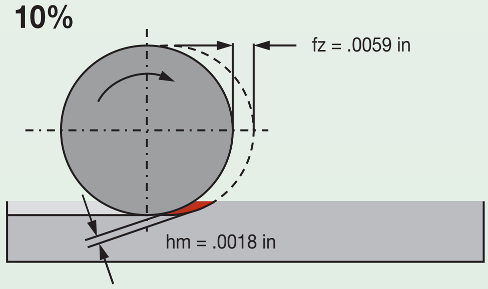
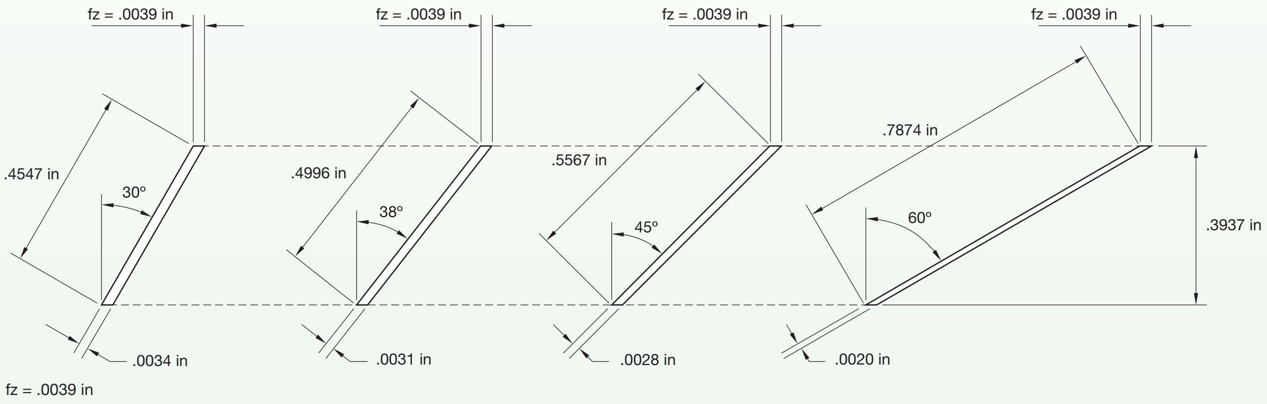


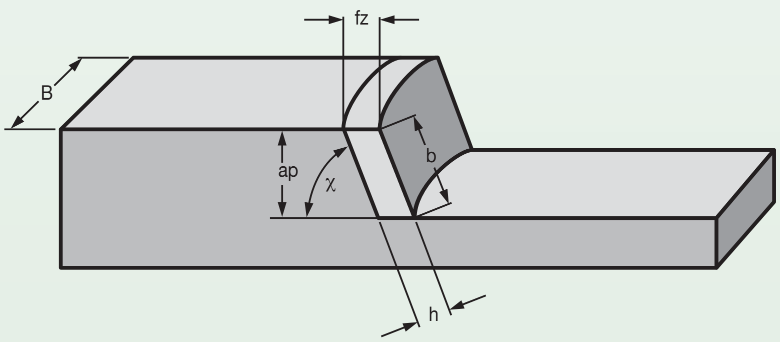
Helix Angle and Chip Thickness

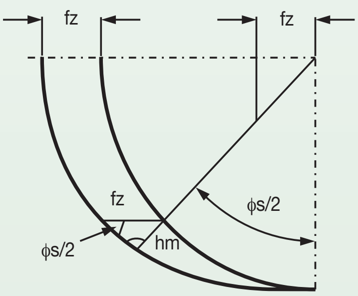
The chip thickness (h) depends on the helix angle of the cutting edge. If the feed fz is constant, the chip thickness gets thinner as helix angle rises. That means with more helix angle, the chip gets thinner — or you can rise feed rate to increase productivity and load to the cutting edge.



Calculation of Chip Thickness

The chip thickness (h) is not constant, but defines the load of the cutting edge. By reducing the load on the cutting edge, machining at higher speeds is possible through the machining parameters. For easier calculation, use an average chip thickness hm. When calculating machining data this way cutting data may be compromised because the workpiece is often a different shape.





$$hm = \frac{360^\circ}{\pi \bullet \phi s} \bullet \frac{ae}{D} \bullet fz \bullet \sin \chi$$

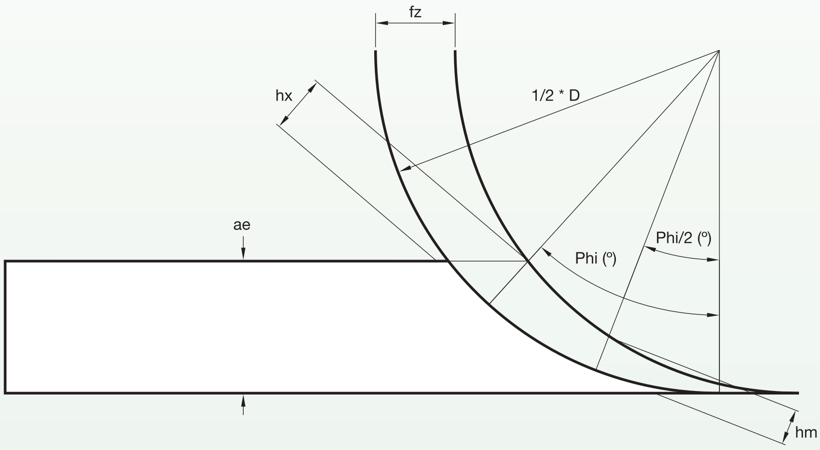
hm [in]	=	average chip thickness
ϕs [°]	=	engagement angle
ae [in]	=	width of engagement
D1 [in]	=	outer diameter tool
fz [IPT]	=	feed per tooth
χ [°]	=	lead angle
λ [°]	=	helix angle *

* Solid End Mills: $\chi = 90° - \lambda$

NOTE: It makes no difference if the tool is solid or an indexable milling tool.

Differences between hm and hx

In conventional milling, it makes sense to calculate the load to the cutting edge through hm. With reducing the ae to very low values, you can calculate with the maximum chip thickness hx to make sure that the feed per tooth is set up correctly.



Conventional

$hm = 360°/\pi \cdot \phi s \cdot ae/D \cdot fz \cdot \sin x$

hm [in]	=	average chip thickness
fs [°]	=	engagement angle
ae [in]	=	width of engagement
D1 [in]	=	outer diameter tool
fz [IPT]	=	feed per tooth
χ [°]	=	lead angle
λ [°]	=	helix angle *

Smart Machining

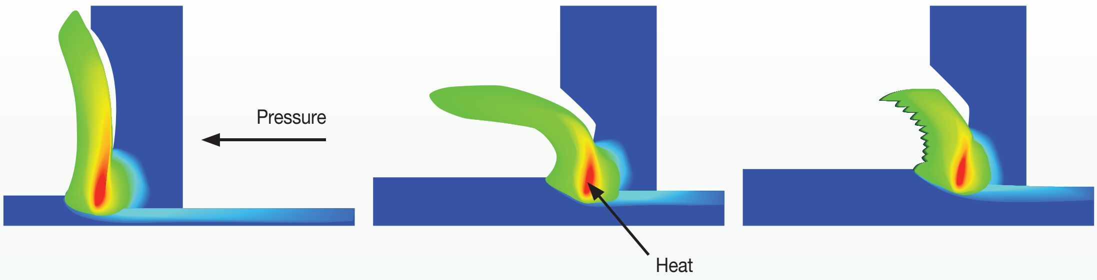
$hx = 360°/\pi \cdot \phi s \cdot 2 \cdot ae/D \cdot fz \cdot \sin x$

hx [in]	=	maximum chip thickness
fs [°]	=	engagement angle
ae [in]	=	width of engagement
D1 [in]	=	outer diameter tool
fz [IPT]	=	feed per tooth
χ [°]	=	lead angle
λ [°]	=	helix angle *

* Solid End Mills: $\chi = 90° - \lambda$

Trochoidal Milling can be performed with solid or indexable milling tools.

Cutting Speed

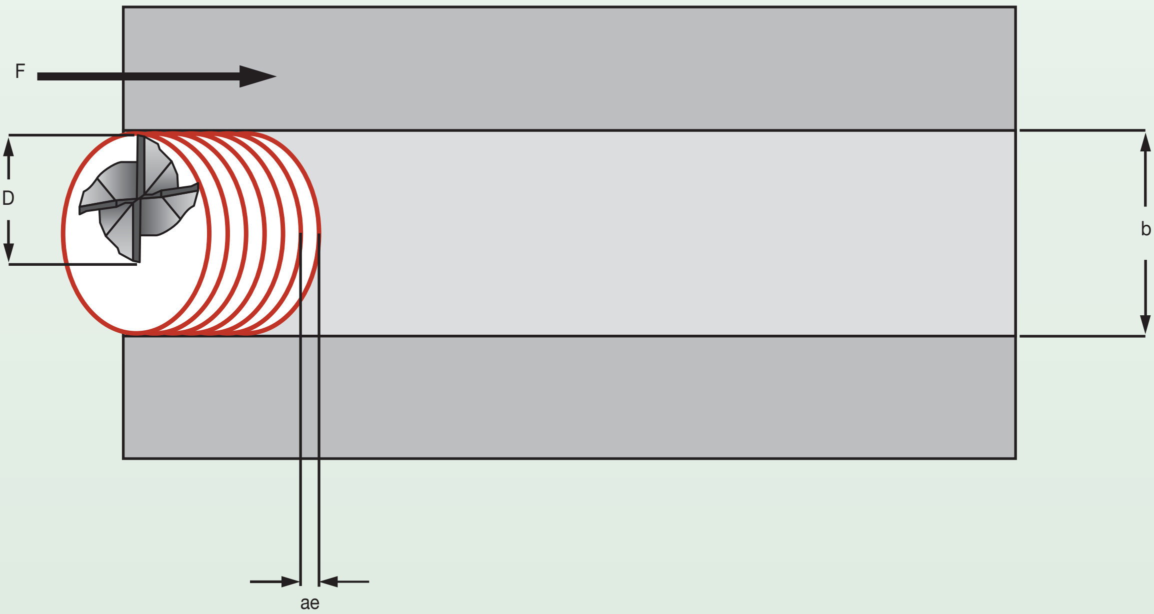


Reduced radial engagement influences the cutting speed, because the heat produced through the cutting process limits the cutting speed.

ae/D	full slot	50% ae	40% ae	30% ae	20% ae	10 % ae	5% ae	4% ae
speed factors	0.9	1	1.1	1.2	1.3	1.4	2.5	3
phi [°]	180	90	78.46	66.42	53.13	36.87	25.84	23.07

Static Trochoidal Milling for a Full Slot

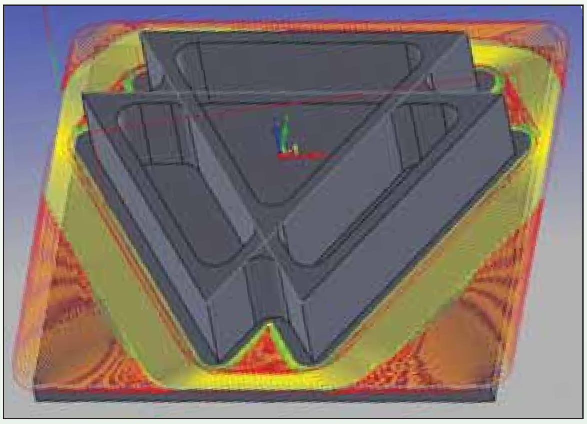
- Use a tool which D < b.
- Program circles in the CNC program (as a cycle).
- After one circle, repeat the same with an offset.
- Optimize by shortening the lane “in the air” to a form like a “D”.

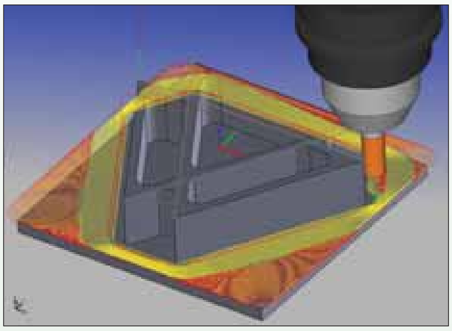


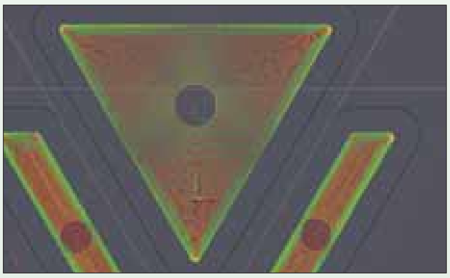
Trochoidal Milling can be performed with solid or indexable milling tools.

Dynamic Trochoidal Milling

- Transfer the basic idea control of chip thickness to dynamic processes.
- Dynamic adaption of feed in relation to ae and wrap angle through an intelligent CAM Software.
- Using helix interpolation, D-lanes, and morphing cycles.







Requirements

Static trochoidal milling
- Dynamic machine.
- CNC Program.
- Modern tool.
- Cutting data for trochoidal machining.

Dynamic trochoidal milling
- Dynamic CNC machine.
- CAD/CAM optimization software.
- Modern tool.
- Cutting data for trochoidal machining.

Benefits

- Constant chip thickness.
- Reduced arc/angle engagement (wrap angle).
- Tremendously reduced load on the cutting edge.
- Reduced temperature during the machining process.
- Higher cutting speed and feed per tooth possible.
- Reduced cycle time and increased tool life.
- Better chip evacuation.
- Better usage of the tool length.
- Less torque and power requirements for the machine.
- Less risk of spindle damages through torque fluctuation and reduced torque peaks caused by conventional milling processes.