

Ultra-Mill

Formulas, Legend, Milling Theory and Calculations

Note:

The equations and quick-reference charts below do not take into account the condition of the machine or spindle, fixture design or condition, part configuration, size/condition of taper or any other application specific data. Before relying on data gathered from any calculations, please make an assessment of your specific machining conditions and adjust feeds, speeds and depths of cut accordingly. Please do not adjust feed-per-tooth to a value greater than your wiper flat.

Milling Theory and Calculations

Metal Removal Rates:

$$Q = a_e \cdot a_p \cdot v_f$$

Cutting Speed and RPM-Inch:

$$V_c = \frac{n \cdot \pi \cdot D}{12} \quad V_c = n \div 3.82 \cdot D$$

$$n = \frac{V_c \cdot 12}{\pi \cdot D} \quad n = V_c \cdot 3.82 \div D$$

Cutting Speed and RPM-Metric:

$$V_c = \frac{n \cdot \pi \cdot D}{1000} \quad V_c = n \cdot .00314 \cdot D$$

$$n = \frac{V_c \cdot 1000}{\pi \cdot D} \quad n = V_c \cdot 318.057 \div D$$

Average Chip Thickness:

$$h_m = f_z \cdot \sqrt{\frac{a_e}{D}} \quad f_z = h_m \cdot \sqrt{\frac{D}{a_e}}$$

Axial chip thinning requires increase in feed rate to maintain proper chip thickness.

- If $a_p \leq 25\%$ of cartridge radius, increase feed by 4x
- If $a_p = 26-50\%$ of cartridge radius, increase feed by 2x
- If $a_p = 51-75\%$ of cartridge radius, increase feed by 25%
- If $a_p = 100\%$ or more of cartridge radius, do not increase feed

Formulas and Legend

D = Cutting Diameter

D_w = Working Diameter

R = Cutter Radius

z = Number of Teeth

z_c = Effective Number of Teeth

n = RPM

V_c = Surface Feet/Meters per Minute

v_f = Cutter Feed-Inches/mm per Minute

f = Feed per Revolution

f_z = Feed per Tooth

h_m = Average Chip Thickness

a_e = Width of Cut-Radial Depth of Cut

a_p = Depth of Cut-Axial Depth of Cut

Q = Metal Removal Rate-in³/min or mm³/min

K = Lead Angle

π = Pi (3.1415)

Note:

If using a two- or three- stage Ultramill, use the effective (z_c) number of teeth to calculate feed rate.

Feed Rates:

$$V_f = n \cdot z \cdot f_z \quad \text{or} \quad V_f = n \cdot z_c \cdot f_z$$

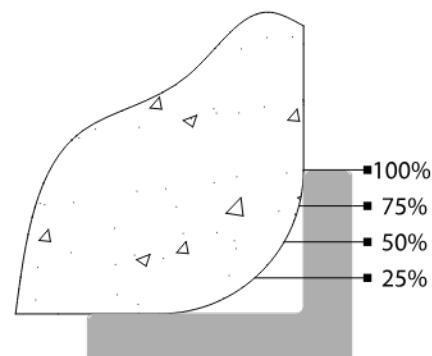
$$f = z \cdot f_z \quad \text{or} \quad f = z_c \cdot f_z$$

Note:

Use to calculate when width of cut (a_e) is less than 50% of D.

Quick Reference:

a_e =	increase feed by:
35%	1.20
25%	1.45
10%	2.05
5%	3.00



Ultra-Mill Cutting Data

Inch

Cutter Family	Low Silicon Aluminums			Medium Silicon Aluminums			High Silicon Aluminums		
	<8% Silicon			8-10% Silicon			>10% Silicon		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	2000	4000	10,000	2000	3000	6000	1000	1500	2000
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.001	0.004	0.008	0.001	0.004	0.008	0.001	0.004	0.008
Ultramill Intermediate	0.001	0.004	0.006	0.001	0.004	0.006	0.001	0.004	0.006
Ultramill Mini	0.001	0.003	0.004	0.001	0.003	0.004	0.001	0.003	0.004
Ultra Endmill	0.001	0.003	0.004	0.001	0.003	0.004	0.001	0.003	0.004
Cutter Family	Copper – Bronze – Zinc			Free Machining Alloys ie: Gold, Platinum, Lead			Carbide and Ceramic (Green)		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	1000	1500	2500	500	1000	1500	500	1000	1500
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.001	0.003	0.006	0.003	0.004	0.007	0.002	0.004	0.008
Ultramill Intermediate	0.001	0.003	0.005	0.003	0.004	0.006	0.002	0.004	0.006
Ultramill Mini	0.001	0.002	0.005	0.002	0.003	0.005	0.001	0.003	0.004
Ultra Endmill	0.001	0.002	0.005	0.002	0.003	0.005	0.001	0.003	0.004
Cutter Family	Unfilled Plastics			Reinforced Plastics ie: Carbon Fiber Composites			Manufactured Wood		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	1500	2500	5000	1500	2500	5000	3000	6000	8000
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.001	0.003	0.006	0.002	0.003	0.005	0.004	0.006	0.010
Ultramill Intermediate	0.001	0.003	0.005	0.002	0.003	0.004	0.004	0.006	0.008
Ultramill Mini	0.001	0.002	0.005	0.001	0.002	0.004	0.003	0.005	0.008
Ultra Endmill	0.001	0.002	0.005	0.001	0.002	0.004	0.003	0.005	0.008

Sample		
Cutting Speed Vc		
Low	Starting	High
Feed Rate per Tooth fz		
Low	Starting	High

Lowest
recommended
cutting data

Recommended
starting cutting data

Not recommended
to exceed without
calling **Decatur Diamond**

Note:

Do not exceed maximum RPM listed
on product pages.

Metric

Cutter Family	Low Silicon Aluminums			Medium Silicon Aluminums			High Silicon Aluminums		
	<8% Silicon			8-10% Silicon			>10% Silicon		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	610	1220	3050	610	915	1830	305	460	610
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.025	0.100	0.200	0.025	0.100	0.200	0.025	0.100	0.200
Ultramill Intermediate	0.025	0.100	0.150	0.025	0.100	0.150	0.025	0.100	0.150
Ultramill Mini	0.025	0.075	0.100	0.025	0.075	0.100	0.025	0.075	0.100
Ultra Endmill	0.025	0.075	0.100	0.025	0.075	0.100	0.025	0.075	0.100
Cutter Family	Copper – Bronze – Zinc			Free Machining Alloys ie: Gold, Platinum, Lead			Carbide and Ceramic (Green)		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	305	460	760	150	305	460	150	305	460
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.025	0.075	0.150	0.075	0.100	0.180	0.050	0.100	0.200
Ultramill Intermediate	0.025	0.075	0.120	0.075	0.100	0.150	0.050	0.100	0.150
Ultramill Mini	0.025	0.050	0.120	0.050	0.080	0.120	0.025	0.075	0.100
Ultra Endmill	0.025	0.050	0.120	0.050	0.080	0.120	0.025	0.075	0.100
Cutter Family	Unfilled Plastics			Reinforced Plastics ie: Carbon Fiber Composites			Manufactured Wood		
	Cutting Speed Vc			Cutting Speed Vc			Cutting Speed Vc		
	460	760	1525	460	760	1525	915	1830	2440
	Feed Rate per Tooth fz			Feed Rate per Tooth fz			Feed Rate per Tooth fz		
Ultramill	0.025	0.075	0.150	0.050	0.075	0.120	0.100	0.150	0.250
Ultramill Intermediate	0.025	0.075	0.150	0.050	0.075	0.100	0.100	0.150	0.200
Ultramill Mini	0.025	0.050	0.150	0.025	0.050	0.100	0.075	0.120	0.200
Ultra Endmill	0.025	0.050	0.120	0.025	0.050	0.100	0.075	0.120	0.200