

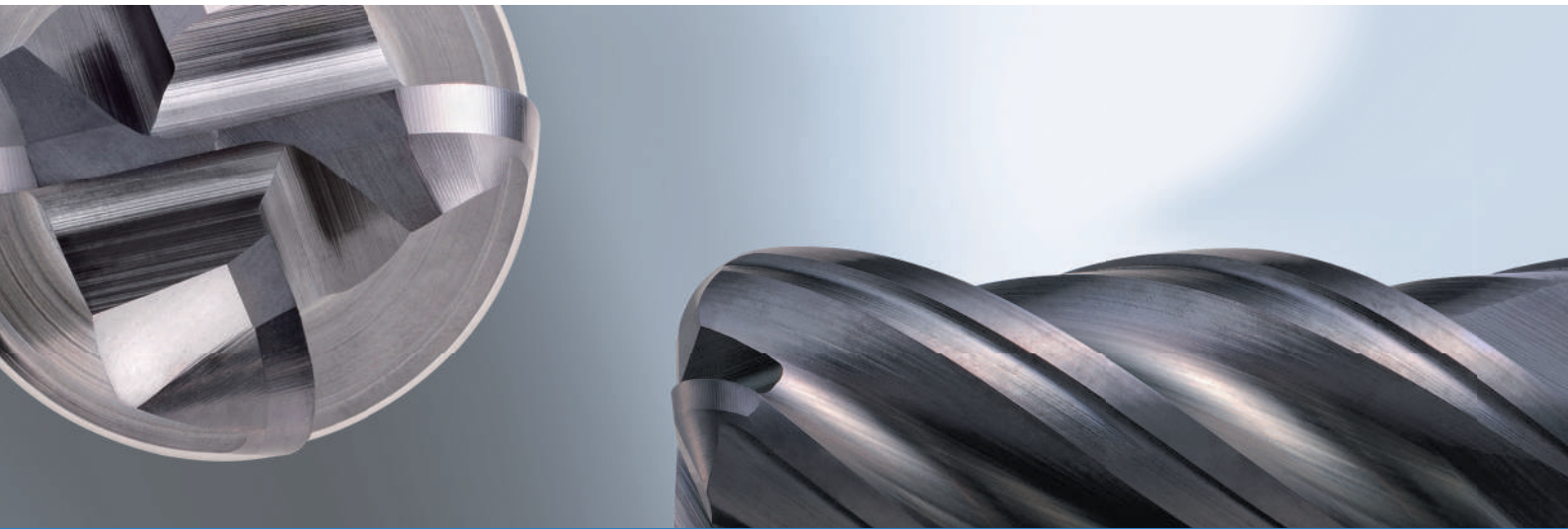
THE NEW VALUE FRONTIER



Solid End Mill | **Z Series**

Surpressing Vibration

# Z Series



Chatter-resistant Machining for Steel and Difficult-to-Cut Material

## 4 Different Types of Design

For Various Machining Applications from Steel to Super Alloy

Radius	Z1MPCR / Z1MPLC
Roughing	Z5MCR
Square / Ball-nose	Z1M / Z1MB
For Super Alloy Machining	ZH1MCR



## Suppressing Vibration

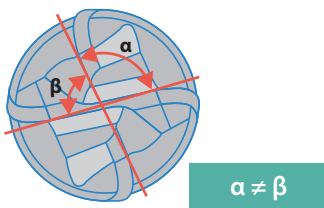
# Z Series

Resistance to Chattering with Special Variable Design, 4 Different Types of End Mill  
For Various Machining Applications such as Steel, Stainless Steel, Titanium Alloy and Super Alloy

## Variable Pitch and Variable Helix Angle

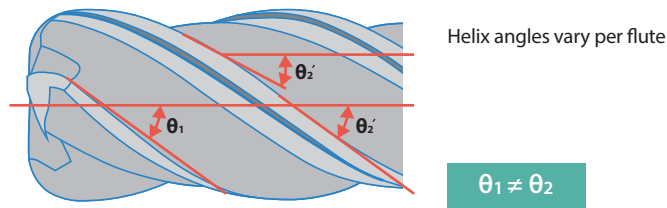
### Superior Anti Vibration Performance

#### Variable Pitch



Prevents periodic vibration during machining

#### Variable Helix Angle



Anti vibration effect  
Reduce chattering and excellent surface finish

## Lineup for Various Machining Applications

### Radius Z1MPCR / Z1MPLC

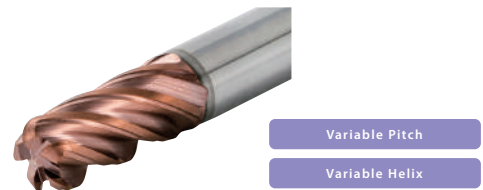
Superior Anti-Vibration Performance with Special Variable Rake Angle



Cutting Dia.  $\phi 1 \sim \phi 20$   
Multi-element Coating

### Roughing Z5MCR

Radius type end mill with 5 flutes  
High Efficiency Ramping



Cutting Dia.  $\phi 6 \sim \phi 25$   
Multi-element Coating

### Square / Ball-nose Z1M / Z1MB

First choice in Z series  
Ball-nose Type Available



Cutting Dia.  $\phi 3 \sim \phi 25$   
New AlTiN Coating (Z1M)  
Multi-element Coating (Z1MB)

### For Super Alloy Machining ZH1MCR

For Super Alloy Machining such as Inconel®  
High rigidity, Low Cutting Force



Cutting Dia.  $\phi 6 \sim \phi 20$   
New AlTiN Coating

Suppressing Vibration

# Z1MPCR / Z1MPLC

Special Variable Helix and Rake Angle

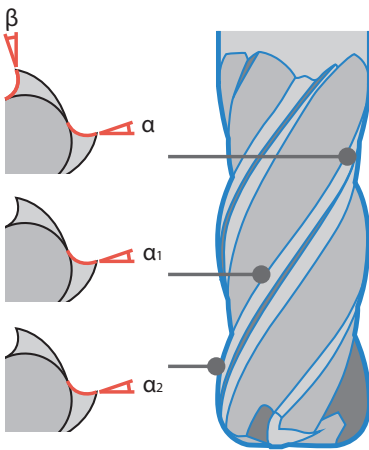
Suppressing Chattering and High Efficiency Machining for Steel, Stainless and Titanium Alloy

## 1

### Anti-chattering Performance with Special Variable Rake Angle

Suppressing chattering by changing the timing of periodical vibration

Special Variable Rake Angle



Rake angle varies from one flute to other

$$\alpha \neq \beta$$

Also gradually changes on each cutting position

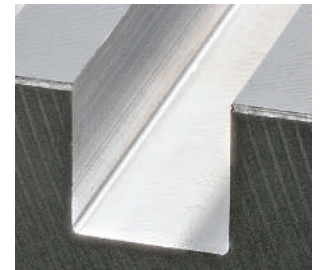
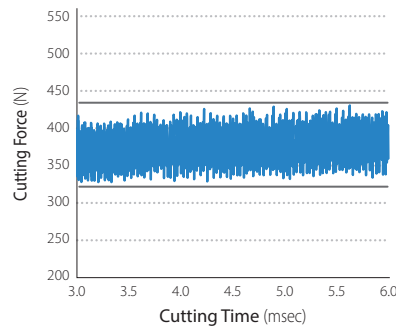
$$\alpha \neq \alpha_1 \neq \alpha_2$$

Stable machining for low rigid material with superior anti vibration performance

Thrust Cutting Force / Surface Finish Comparison (In-house Evaluation)

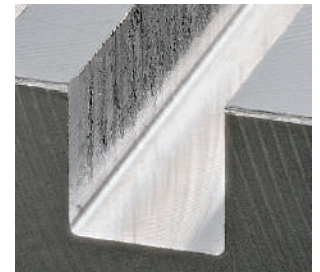
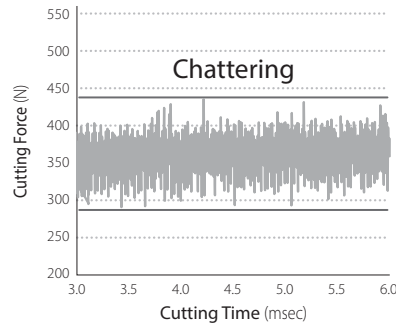
Z1MPCR

Cutting Conditions : n = 4,780 min<sup>-1</sup>, Vf = 840 mm/min, ap = 4 mm  
Cutting Dia.ø8, Slotting, Wet, Workpiece : S50C (36HS)



Surface Finish of Side Wall : 0.32μmRa

Competitor A  
(Varied Interval Pitch / Variable Helix)



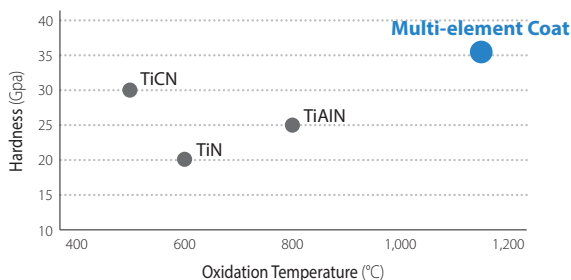
Surface Finish of Side Wall : 1.76μmRa

## 2

### Long Tool Life

Long Tool Life with Multi-element Coat

Coating Properties (In-house Evaluation)



Cutting Edge Comparison (In-house Evaluation)

Z1MPCR



After Machining 50 minutes

Competitor B



After Machining 10 minutes

Cutting Conditions : n = 3,300 min<sup>-1</sup>, Vf = 400 mm/min  
ap x ae = 15 x 1 mm, Cutting Dia.ø10, Shouldering, Wet, Workpiece : SUS316L

Surpressing Vibration (Roughing)

# Z5MCR

Radius End Mill with 5 flutes for Roughing

High Efficiency Machining for Various Workpiece from Steel to Super Alloy

## 1 Anti-chattering Performance

Great chatter resistance with odd-number of flutes and Varied Pitch



Open Center Design

## 2 A Wide Variety of Machining Operations

High efficiency machining for steel and super alloy such as Inconel®

Applicable to ramping up to 5° without decreasing feed rate

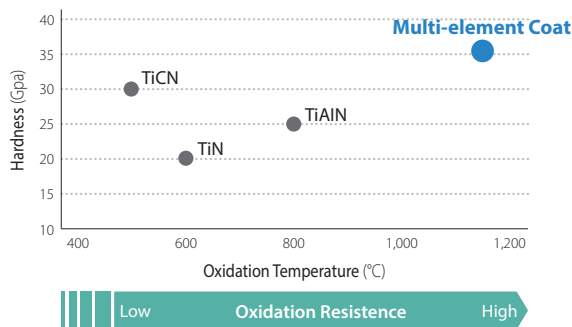
Open center design delivers efficiency during entry movements into the workpiece

Smooth chip evacuation

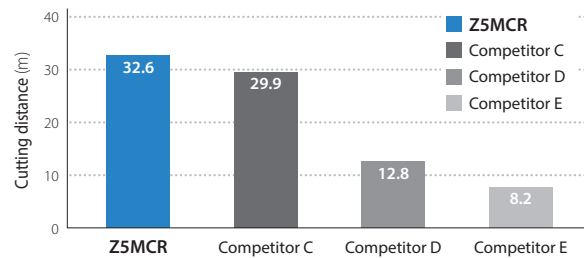


## 3 Long Tool Life with Multi-element Coat

Coating Properties (In-house Evaluation)



Tool Life Comparison (In-house Evaluation)



Cutting Conditions : n = 1,643 min<sup>-1</sup>, Vf = 416 mm/min  
ap x ae = 19 x 6.3 mm, Cutting Dia.φ12.7, Workpiece : Ti-6Al-4V

Square / Ball-nose

# Z1M / Z1MB

First choice in Z Series

Square and Ball-nose Type are Available



Square (Z1M)



Ball-nose (Z1MB)

For Super Alloy Machining (Radius)

# ZH1MCR

Designated for Super Alloy Machining such as Inconel®

High Rigidity with Large Core Diameter  
Lead Angle : 38°/41°, Low Cutting Force

New AlTiN Coating

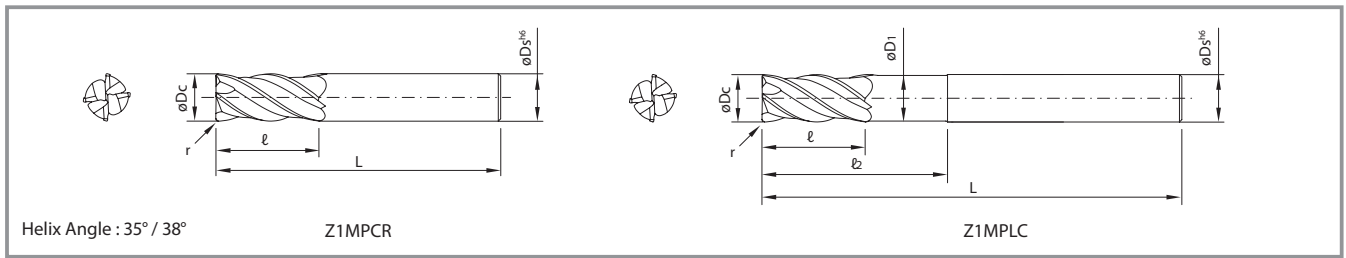
Hardness : 36.3GPa

Oxidation Temperature : 1.100°C



Radius

# Z1MPCR / Z1MPLC Lineup (Radius)



## Z1MPCR (Medium)

(Unit : mm)

Description	*Code	Stock	Outside Dia. øDc	Mill Dia. Tolerance	Corner Radius r	Length of Cut ℓ	Shank Dia. øDs	Overall Length L	No. of Inserts Z
Z1MPCR010-030-R01	46873	●	1	+0.012 -0.012	0.1	3	6	57	4
Z1MPCR015-045-R01	46849	●	1.5	+0.012 -0.012	0.1	4.5	6	57	4
Z1MPCR020-060-R02	46850	●	2	+0.012 -0.012	0.2	6	6	57	4
Z1MPCR025-070-R02	46874	●	2.5	+0.012 -0.012	0.2	7	6	57	4
Z1MPCR030-080-R03	46851	●	3	0	0.3	8	6	57	4
Z1MPCR030-080-R05	46880	●		-0.030	0.5				
Z1MPCR040-110-R03	46852	●	4	0	0.3	11	6	57	4
Z1MPCR040-110-R05	46881	●		-0.030	0.5				
Z1MPCR060-130-R05	46854	●	6	0 -0.030	0.5	13	6	57	4
Z1MPCR060-130-R10	46855	●			1.0				
Z1MPCR060-130-R15	46884	●			1.5				
Z1MPCR080-190-R05	46856	●	8	0 -0.040	0.5	19	8	63	4
Z1MPCR080-190-R10	46857	●			1.0				
Z1MPCR080-190-R15	46886	●			1.5				
Z1MPCR080-190-R20	46887	●			2.0				
Z1MPCR100-220-R05	46858	●	10	0 -0.040	0.5	22	10	72	4
Z1MPCR100-220-R10	46859	●			1.0				
Z1MPCR100-220-R15	46889	●			1.5				
Z1MPCR100-220-R20	46890	●			2.0				
Z1MPCR120-260-R05	46860	●	12	0 -0.050	0.5	26	12	83	4
Z1MPCR120-260-R10	46893	●			1.0				
Z1MPCR120-260-R15	46894	●			1.5				
Z1MPCR120-260-R20	46895	●			2.0				
Z1MPCR120-260-R30	42718	●			3.0				
Z1MPCR160-320-R10	46863	●	16	0 -0.050	1.0	32	16	92	4
Z1MPCR160-320-R15	46898	●			1.5				
Z1MPCR160-320-R20	46899	●			2.0				
Z1MPCR160-320-R30	46864	●			3.0				
Z1MPCR200-380-R10	46865	●	20	0 -0.050	1.0	38	20	104	4
Z1MPCR200-380-R20	46904	●			2.0				
Z1MPCR200-380-R30	42722	●			3.0				

\*The code is a reference number that is listed on the product.  
When ordering, please refer to "Description" in the table.

● : Standard Stock

## Z1MPLC (Long shank, Short length of cut type)

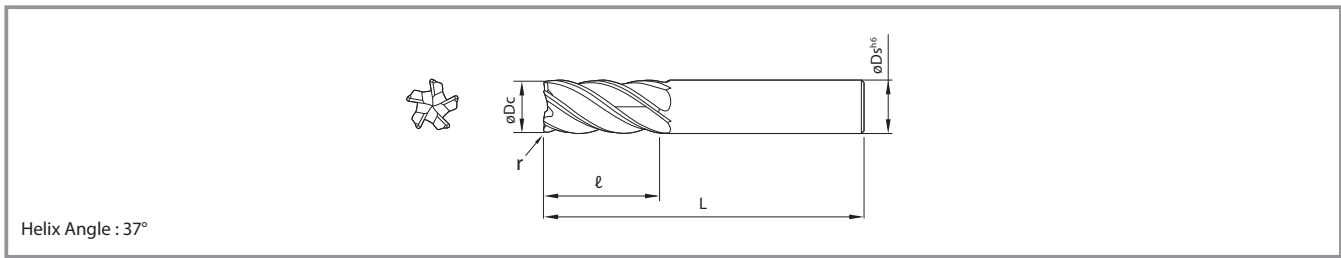
(Unit : mm)

Description	*Code	Stock	Outside Dia. øDc	Mill Dia. Tolerance	Corner Radius r	Length of Cut ℓ	Length of Cut øD1	Under Neck Length ℓ2	Shank Dia. øDs	Overall Length L	No. of Inserts Z
Z1MPLC060-080-R05	46821	●	6	0 -0.030	0.5	8	5.5	24	6	75	4
Z1MPLC080-100-R10	46822	●	8	0 -0.040	1.0	10	7.5	32	8	75	4
Z1MPLC080-100-R20	46823	●			2.0						
Z1MPLC100-120-R10	46824	●	10	0 -0.040	1.0	12	9.5	40	10	100	4
Z1MPLC100-120-R20	46825	●			2.0						
Z1MPLC120-150-R10	46826	●	12	0 -0.050	1.0	15	11.5	48	12	100	4
Z1MPLC120-150-R15	46827	●			1.5						
Z1MPLC120-150-R20	46828	●			2.0						
Z1MPLC120-150-R30	46829	●			3.0						
Z1MPLC160-200-R10	46830	●	16	0 -0.050	1.0	20	15.5	65	16	115	4
Z1MPLC160-200-R15	46831	●			1.5						
Z1MPLC160-200-R20	46832	●			2.0						
Z1MPLC160-200-R30	46833	●		3.0							
Z1MPLC200-240-R10	46836	●	20	0 -0.050	1.0	24	19.5	80	20	140	4
Z1MPLC200-240-R15	46837	●			1.5						
Z1MPLC200-240-R20	46838	●			2.0						
Z1MPLC200-240-R30	46839	●		3.0							

\*The code is a reference number that is listed on the product.  
When ordering, please refer to "Description" in the table.

● : Standard Stock

## Z5MCR Lineup (Radius)



### Z5MCR (Radius)

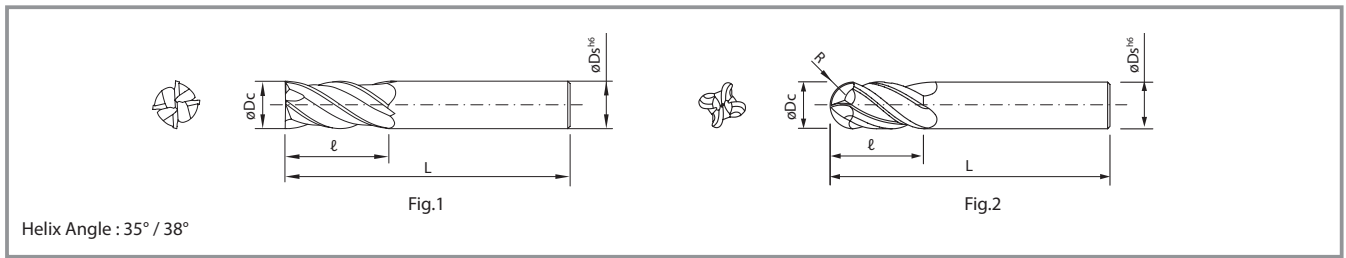
(Unit : mm)

Description	*Code	Stock	Outside Dia.	Mill Dia. Tolerance	Corner Radius	Length of Cut	Shank Dia.	Overall Length	No. of Inserts
			øDc		r	ℓ	øDs	L	Z
Z5MCR060-130-R03	47001	●	6	0 -0.030	0.3	13	6	57	5
Z5MCR060-130-R05	47002	●			0.5				
Z5MCR060-130-R10	47003	●			1.0				
Z5MCR060-130-R15	47004	●			1.5				
Z5MCR080-180-R05	47006	●	8	0 -0.040	0.5	18	8	63	5
Z5MCR080-180-R10	47007	●			1.0				
Z5MCR080-180-R15	47008	●			1.5				
Z5MCR080-180-R20	47009	●			2.0				
Z5MCR100-220-R05	47011	●	10	0 -0.040	0.5	22	10	72	5
Z5MCR100-220-R10	47012	●			1.0				
Z5MCR100-220-R15	47013	●			1.5				
Z5MCR100-220-R20	47014	●			2.0				
Z5MCR120-260-R05	47017	●	12	0 -0.050	0.5	26	12	83	5
Z5MCR120-260-R10	47019	●			1.0				
Z5MCR120-260-R15	47020	●			1.5				
Z5MCR120-260-R20	47021	●			2.0				
Z5MCR120-260-R30	47023	●			3.0				
Z5MCR160-350-R10	47033	●	16	0 -0.050	1.0	35	16	92	5
Z5MCR160-350-R15	47034	●			1.5				
Z5MCR160-350-R20	47035	●			2.0				
Z5MCR160-350-R30	47037	●			3.0				
Z5MCR200-430-R10	47054	●	20	0 -0.050	1.0	43	20	104	5
Z5MCR200-430-R20	47056	●			2.0				
Z5MCR200-430-R30	47058	●			3.0				
Z5MCR250-530-R10	47078	●	25	0 -0.050	1.0	53	25	121	5
Z5MCR250-530-R20	47079	●			2.0				
Z5MCR250-530-R30	47081	●			3.0				

\*The code is a reference number that is listed on the product. When ordering, please refer to "Description" in the table.

● : Standard Stock

## Z1M / Z1MB Lineup (Square / Ball-nose)



### Z1M (Square)

(Unit : mm)

Description	*Code	Stock	Outside Dia.	Mill Dia. Tolerance	Length of Cut	Shank Dia.	Overall Length	No. of Inserts	Fig.
			øDc		ℓ	øDs	L	Z	
Z1M030-080	46357	●	3	0 -0.030	8	6	57	4	1
Z1M040-110	46358	●	4	0 -0.030	11	6	57	4	1
Z1M050-130	46359	●	5	0 -0.030	13	6	57	4	1
Z1M060-130	46360	●	6	0 -0.030	13	6	57	4	1
Z1M080-190	46362	●	8	0 -0.040	19	8	63	4	1
Z1M100-220	46364	●	10	0 -0.040	22	10	72	4	1
Z1M120-260	46366	●	12	0 -0.050	26	12	83	4	1
Z1M140-260	46368	●	14	0 -0.050	26	14	83	4	1
Z1M160-320	46370	●	16	0 -0.050	32	16	92	4	1
Z1M180-320	46372	●	18	0 -0.050	32	18	92	4	1
Z1M200-380	46374	●	20	0 -0.050	38	20	104	4	1
Z1M250-380	46376	●	25	0 -0.050	38	25	104	4	1

\*The code is a reference number that is listed on the product. When ordering, please refer to "Description" in the table.

● : Standard Stock

### Z1MB (Ball-nose)

(Unit : mm)

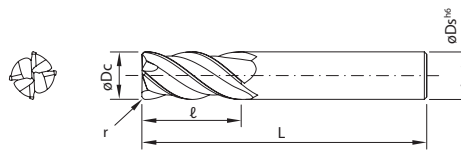
Description	*Code	Stock	Radius of Ball-nose	Radius of Ball-nose	Outside Dia.	Length of Cut	Shank Dia.	Overall Length	No. of Inserts	Fig.
			R	Tolerance	øDc	ℓ	øDs	L	Z	
Z1MB030-080	46354	●	1.5	±0.013	3	8	6	57	4	2
Z1MB040-110	46355	●	2	±0.013	4	11	6	57	4	2
Z1MB050-130	46356	●	2.5	±0.013	5	13	6	57	4	2
Z1MB060-130	46343	●	3	±0.013	6	13	6	57	4	2
Z1MB080-190	46344	●	4	±0.013	8	19	8	63	4	2
Z1MB100-220	46345	●	5	±0.013	10	22	10	72	4	2
Z1MB120-260	46346	●	6	±0.013	12	26	12	83	4	2
Z1MB140-260	46347	●	7	±0.013	14	26	14	83	4	2
Z1MB160-320	46348	●	8	±0.013	16	32	16	92	4	2
Z1MB180-320	46349	●	9	±0.013	18	32	18	92	4	2
Z1MB200-380	46350	●	10	±0.013	20	38	20	104	4	2
Z1MB250-380	46351	●	12.5	±0.013	25	38	25	104	4	2

\*The code is a reference number that is listed on the product. When ordering, please refer to "Description" in the table.

● : Standard Stock



## ZH1MCR Lineup (Radius)



Helix Angle : 38° / 41°

### ZH1MCR (Radius)

(Unit : mm)

Description	*Code	Stock	Outside Dia.	Mill Dia. Tolerance	Corner Radius	Length of Cut ℓ	Shank Dia. øDs	Overall Length L	No. of Inserts Z
			øDc		r				
ZH1MCR060-130-R05	46450	●	6	0 -0.030	0.5	13	6	57	4
ZH1MCR060-130-R10	46451	●			1.0				
ZH1MCR060-130-R15	46452	●			1.5				
ZH1MCR080-190-R05	46453	●	8	0 -0.040	0.5	19	8	63	4
ZH1MCR080-190-R10	46454	●			1.0				
ZH1MCR080-190-R15	46455	●			1.5				
ZH1MCR100-220-R05	46456	●	10	0 -0.040	0.5	22	10	72	4
ZH1MCR100-220-R10	46457	●			1.0				
ZH1MCR100-220-R15	46458	●			1.5				
ZH1MCR100-220-R20	46459	●			2.0				
ZH1MCR120-260-R05	46460	●	12	0 -0.050	0.5	26	12	83	4
ZH1MCR120-260-R10	46461	●			1.0				
ZH1MCR120-260-R15	46462	●			1.5				
ZH1MCR120-260-R20	46463	●			2.0				
ZH1MCR120-260-R30	46464	●			3.0				
ZH1MCR160-320-R15	46465	●	16	0 -0.050	1.5	32	16	92	4
ZH1MCR160-320-R20	46466	●			2.0				
ZH1MCR160-320-R30	46467	●			3.0				
ZH1MCR200-380-R30	46468	●	20	0 -0.050	3.0	38	20	104	4

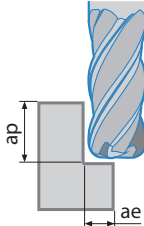
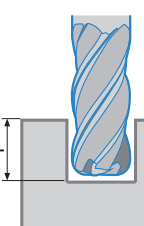
\*The code is a reference number that is listed on the product. When ordering, please refer to "Description" in the table.

● : Standard Stock



# Cutting Conditions

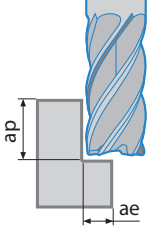
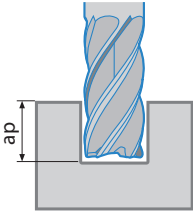
## Z1MPCR / Z1MPLC

Applications	Workpiece	Application	Depth of Cut( $a_p \times a_e$ )(mm)	Outside Dia. $D_c$ (mm)	$\phi 1$	$\phi 3$	$\phi 6$	$\phi 8$	$\phi 10$	$\phi 12$	$\phi 16$	$\phi 20$
 <p>Shouldering</p>  <p>Slotting</p>	Carbon Steel S45C	Shouldering	(Z1MPCR) Shoulderings : $1.5D_c \times 0.25D_c$ ( $D_c < \phi 3$ ) $1.5D_c \times 0.5D_c$ ( $D_c \geq \phi 3$ )  Slotting : $0.25D_c$ ( $D_c < \phi 3$ ) $0.5D_c$ ( $D_c \geq \phi 3$ )  (Z1MPLC) Shoulderings : $1.5D_c \times 0.25D_c$  Slotting : $0.25D_c$	Spindle Revolution ( $\text{min}^{-1}$ )	53,800	17,900	9,000	6,700	5,400	4,500	3,400	2,700
		Feed Rate (mm/min)		650	780	1,040	1,320	1,310	1,330	1,170	1,070	
	Alloy Steel SCM, SNCM	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	42,700	14,200	7,100	5,300	4,300	3,600	2,700	2,100
		Feed Rate (mm/min)		510	620	830	1,050	1,040	1,050	930	850	
	Pre-hardened Steel $\leq 40\text{HRC}$	Shouldering		Spindle Revolution ( $\text{min}^{-1}$ )	30,500	10,200	5,100	3,800	3,100	2,500	1,900	1,500
		Feed Rate (mm/min)		280	330	450	550	550	560	510	460	
	Stainless Steel SUS303, SUS416	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	24,200	8,100	4,000	3,000	2,400	2,000	1,500	1,200
		Feed Rate (mm/min)		220	260	360	440	440	440	410	360	
	Stainless Steel SUS304, SUS316	Shouldering		Spindle Revolution ( $\text{min}^{-1}$ )	17,900	6,000	3,000	2,200	1,800	1,500	1,100	900
		Feed Rate (mm/min)		130	160	200	270	270	260	230	210	
	Stainless Steel SUS303, SUS416	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	14,100	4,700	2,300	1,800	1,400	1,200	900	700
		Feed Rate (mm/min)		100	120	160	210	210	200	180	170	
	Stainless Steel SUS304, SUS316	Shouldering		Spindle Revolution ( $\text{min}^{-1}$ )	47,500	15,800	7,900	5,900	4,800	4,000	3,000	2,400
		Feed Rate (mm/min)		440	510	700	860	860	870	800	710	
	Stainless Steel 13-8PH, 15-5PH	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	37,800	12,600	6,300	4,700	3,800	3,200	2,400	1,900
		Feed Rate (mm/min)		350	410	560	680	680	690	630	570	
	Titanium Alloy Ti-6Al-4V	Shouldering		Spindle Revolution ( $\text{min}^{-1}$ )	33,000	11,000	5,500	4,100	3,300	2,700	2,100	1,600
		Feed Rate (mm/min)		240	280	370	490	490	470	420	390	
	Titanium Alloy Ti-10Al-2-Fe-3Al	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	26,200	8,700	4,400	3,300	2,600	2,200	1,600	1,300
		Feed Rate (mm/min)		190	220	300	390	390	380	330	310	
	Super Alloy Inconel®625	Shouldering		Spindle Revolution ( $\text{min}^{-1}$ )	30,100	10,000	5,000	3,800	3,000	2,500	1,900	1,500
		Feed Rate (mm/min)		220	260	340	450	450	430	380	360	
	Super Alloy Inconel®718	Slotting		Spindle Revolution ( $\text{min}^{-1}$ )	24,200	8,100	4,000	3,000	2,400	2,000	1,500	1,200
		Feed Rate (mm/min)		170	210	280	360	360	350	310	290	
Cast Iron FC, FCD $\leq 19\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	20,800	6,900	3,500	2,600	2,100	1,700	1,300	1,000		
	Feed Rate (mm/min)	170	200	260	330	330	330	290	270			
Cast Iron FC, FCD $\leq 26\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	16,500	5,500	2,700	2,100	1,600	1,400	1,000	800		
	Feed Rate (mm/min)	130	160	210	260	260	260	230	210			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	7,300	2,400	1,200	900	700	600	500	400		
	Feed Rate (mm/min)	60	70	90	120	120	120	100	90			
Cast Iron FC, FCD $\leq 26\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	5,800	1,900	1,000	700	600	500	400	300		
	Feed Rate (mm/min)	50	60	70	90	90	90	80	70			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	7,800	2,600	1,300	1,000	800	600	500	400		
	Feed Rate (mm/min)	60	60	80	110	110	110	90	80			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	6,300	2,100	1,100	800	600	500	400	300		
	Feed Rate (mm/min)	50	50	70	90	90	90	80	70			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	6,000	2,000	1,000	800	600	500	400	300		
	Feed Rate (mm/min)	30	30	40	60	60	60	50	40			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	4,800	1,600	800	600	500	400	300	200		
	Feed Rate (mm/min)	30	30	40	50	50	50	40	40			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	43,100	14,400	7,200	5,400	4,300	3,600	2,700	2,200		
	Feed Rate (mm/min)	480	570	750	970	970	960	850	790			
Cast Iron FC, FCD $\leq 19\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	34,400	11,500	5,700	4,300	3,400	2,900	2,200	1,700		
	Feed Rate (mm/min)	390	450	600	770	770	770	680	630			
Cast Iron FC, FCD $\leq 26\text{HRC}$	Shouldering	Spindle Revolution ( $\text{min}^{-1}$ )	33,000	11,000	5,500	4,100	3,300	2,700	2,100	1,600		
	Feed Rate (mm/min)	260	330	440	560	570	550	490	440			
Cast Iron FC, FCD $\leq 26\text{HRC}$	Slotting	Spindle Revolution ( $\text{min}^{-1}$ )	26,200	8,700	4,400	3,300	2,600	2,200	1,600	1,300		
	Feed Rate (mm/min)	210	260	350	450	450	440	390	350			

Water soluble coolant is recommended for stainless steel, titanium alloy, and super alloy.

# Cutting Conditions

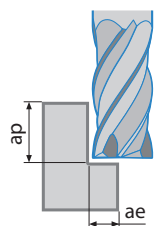
Z5MCR

Applications	Workpiece	Application	Depth of Cut( $ap \times ae$ )(mm)	Outside Dia. Dc (mm)	$\phi 6$	$\phi 8$	$\phi 10$	$\phi 12$	$\phi 16$	$\phi 20$	$\phi 25$
 <p>Shouldering</p>  <p>Slotting</p>	Carbon Steel S45C	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	9,000	6,700	5,400	4,500	3,400	2,700	2,200
				Feed Rate (mm/min)	1,290	1,650	1,650	1,670	1,460	1,330	1,160
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	7,100	5,300	4,300	3,600	2,700	2,100	1,700
				Feed Rate (mm/min)	1,020	1,310	1,310	1,320	1,160	1,050	920
	Alloy Steel SCM, SNCM	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	5,100	3,800	3,100	2,500	1,900	1,500	1,200
				Feed Rate (mm/min)	550	690	690	700	640	570	490
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	4,000	3,000	2,400	2,000	1,500	1,200	1,000
				Feed Rate (mm/min)	440	550	550	560	500	450	390
	Pre-hardened Steel ≤40HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	3,000	2,200	1,800	1,500	1,100	900	700
				Feed Rate (mm/min)	250	340	340	320	290	260	230
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	2,300	1,800	1,400	1,200	900	700	600
				Feed Rate (mm/min)	200	260	260	250	230	210	180
	Stainless Steel SUS303, SUS416	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	7,900	5,900	4,800	4,000	3,000	2,400	1,900
				Feed Rate (mm/min)	860	1,080	1,080	1,090	990	890	760
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	6,300	4,700	3,800	3,200	2,400	1,900	1,500
				Feed Rate (mm/min)	680	860	860	870	790	710	610
	Stainless Steel SUS304, SUS316	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	5,500	4,100	3,300	2,700	2,100	1,600	1,300
				Feed Rate (mm/min)	460	620	620	590	530	480	410
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	4,400	3,300	2,600	2,200	1,600	1,300	1,000
				Feed Rate (mm/min)	370	490	490	470	420	380	330
	Stainless Steel 13-8PH, 15-5PH	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	5,000	3,800	3,000	2,500	1,900	1,500	1,200
				Feed Rate (mm/min)	420	560	560	540	480	440	380
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	4,000	3,000	2,400	2,000	1,500	1,200	1,000
				Feed Rate (mm/min)	340	450	450	440	390	360	300
Titanium Alloy Ti-6Al-4V	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	3,500	2,600	2,100	1,700	1,300	1,000	800	
			Feed Rate (mm/min)	330	420	420	420	370	330	290	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	2,700	2,100	1,600	1,400	1,000	800	700	
			Feed Rate (mm/min)	260	330	330	330	290	260	230	
Titanium Alloy Ti-10Al2-Fe-3Al	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,200	900	700	600	500	400	300	
			Feed Rate (mm/min)	120	150	150	150	130	120	100	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,000	700	600	500	400	300	200	
			Feed Rate (mm/min)	90	120	120	120	100	90	80	
Super Alloy Inconel®625	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,300	1,000	800	600	500	400	300	
			Feed Rate (mm/min)	100	130	130	130	120	100	90	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,100	800	600	500	400	300	300	
			Feed Rate (mm/min)	80	110	110	110	90	80	80	
Super Alloy Inconel®718	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,000	800	600	500	400	300	200	
			Feed Rate (mm/min)	60	70	70	70	60	60	50	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	800	600	500	400	300	200	200	
			Feed Rate (mm/min)	50	60	60	60	50	50	40	
Cast Iron FC, FCD ≤19HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	7,200	5,400	4,300	3,600	2,700	2,200	1,700	
			Feed Rate (mm/min)	950	1,210	1,210	1,210	1,070	980	840	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	5,700	4,300	3,400	2,900	2,200	1,700	1,400	
			Feed Rate (mm/min)	760	960	960	960	850	780	670	
Cast Iron FC, FCD ≤26HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	5,500	4,100	3,300	2,700	2,100	1,600	1,300	
			Feed Rate (mm/min)	550	700	700	690	610	550	480	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	4,400	3,300	2,600	2,200	1,600	1,300	1,000	
			Feed Rate (mm/min)	440	560	560	550	480	440	380	

Water soluble coolant is recommended for stainless steel, titanium alloy, and super alloy. Decrease feed when ramping angle is 5° or more

# Cutting Conditions

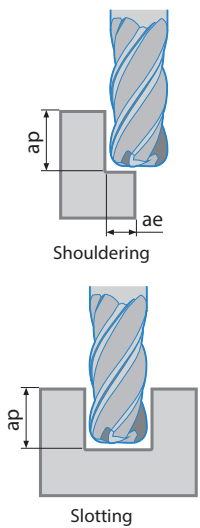
## Z1M / Z1MB

Applications	Workpiece	Application	Depth of Cut( $a_p \times a_e$ )(mm)	Outside Dia. Dc (mm)	$\phi 3$	$\phi 6$	$\phi 8$	$\phi 10$	$\phi 12$	$\phi 16$	$\phi 20$	$\phi 25$	
 <p>Shouldering</p>	Carbon Steel S45C	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	17,900	9,000	6,700	5,400	4,500	3,400	2,700	2,200	
				Feed Rate (mm/min)	650	860	1,090	1,090	1,080	1,070	930	750	
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	14,200	7,100	5,300	4,300	3,600	2,700	2,100	1,700	
				Feed Rate (mm/min)	520	680	870	860	850	850	740	600	
		Alloy Steel SCM, SNCM	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	10,200	5,100	3,800	3,100	2,500	1,900	1,500	1,200
					Feed Rate (mm/min)	270	390	460	460	460	470	410	330
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	8,100	4,000	3,000	2,400	2,000	1,500	1,200	1,000	
				Feed Rate (mm/min)	220	310	360	360	370	370	320	260	
		Pre-hardened Steel $\leq 40$ HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	6,000	3,000	2,200	1,800	1,500	1,100	900	700
					Feed Rate (mm/min)	120	140	190	190	190	180	160	130
		Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	4,700	2,300	1,800	1,400	1,200	900	700	600	
				Feed Rate (mm/min)	90	110	150	150	150	140	130	100	
	Stainless Steel SUS303, SUS416	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	15,800	7,900	5,900	4,800	4,000	3,000	2,400	1,900	
				Feed Rate (mm/min)	460	530	710	710	680	700	610	480	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	12,600	6,300	4,700	3,800	3,200	2,400	1,900	1,500		
			Feed Rate (mm/min)	360	420	570	570	540	560	480	380		
	Stainless Steel SUS304, SUS316	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	11,000	5,500	4,100	3,300	2,700	2,100	1,600	1,300	
				Feed Rate (mm/min)	210	320	390	390	370	380	330	260	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	8,700	4,400	3,300	2,600	2,200	1,600	1,300	1,000		
			Feed Rate (mm/min)	170	250	310	310	290	300	270	210		
	Stainless Steel 13-8PH, 15-5PH	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	10,000	5,000	3,800	3,000	2,500	1,900	1,500	1,200	
				Feed Rate (mm/min)	190	290	350	350	340	350	310	240	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	8,100	4,000	3,000	2,400	2,000	1,500	1,200	1,000		
			Feed Rate (mm/min)	160	230	280	280	270	280	250	190		
	Titanium Alloy Ti-6Al-4V	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	6,900	3,500	2,600	2,100	1,700	1,300	1,000	800	
				Feed Rate (mm/min)	130	170	220	220	220	210	190	150	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	5,500	2,700	2,100	1,600	1,400	1,000	800	700		
			Feed Rate (mm/min)	110	130	180	180	170	170	150	120		
	Titanium Alloy Ti-10Al-2-Fe-3Al	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	2,400	1,200	900	700	600	500	400	300	
				Feed Rate (mm/min)	50	60	80	80	80	70	70	50	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,900	1,000	700	600	500	400	300	200		
			Feed Rate (mm/min)	40	50	60	60	60	60	50	40		
	Super Alloy Inconel®625	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	2,600	1,300	1,000	800	600	500	400	300	
				Feed Rate (mm/min)	60	50	70	50	60	70	60	50	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	2,100	1,100	800	600	500	400	300	300		
			Feed Rate (mm/min)	40	40	50	50	50	50	50	40		
	Super Alloy Inconel®718	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	2,000	1,000	800	600	500	400	300	200	
				Feed Rate (mm/min)	20	30	30	30	30	30	30	20	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,600	800	600	500	400	300	200	200		
			Feed Rate (mm/min)	20	20	30	30	30	20	20	20		
	Cast Iron FC, FCD $\leq 19$ HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	14,400	7,200	5,400	4,300	3,600	2,700	2,200	1,700	
				Feed Rate (mm/min)	480	690	830	830	830	830	710	590	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	11,500	5,700	4,300	3,400	2,900	2,200	1,700	1,400		
			Feed Rate (mm/min)	390	550	660	660	660	660	570	470		
	Cast Iron FC, FCD $\leq 26$ HRC	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	11,000	5,500	4,100	3,300	2,700	2,100	1,600	1,300	
				Feed Rate (mm/min)	320	370	490	490	480	490	420	330	
	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	8,700	4,400	3,300	2,600	2,200	1,600	1,300	1,000		
			Feed Rate (mm/min)	250	290	390	390	380	390	340	260		

Water soluble coolant is recommended for stainless steel, titanium alloy, and super alloy.

# Cutting Conditions

## ZH1MCR

Applications	Workpiece	Application	Depth of Cut( $a_p \times a_e$ )(mm)	Outside Dia.Dc (mm)	ø6	ø10	ø12	ø20	
 <p>Shouldering</p> <p>Slotting</p>	Titanium Alloy Ti-6Al-4V	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	3,500	2,100	1,700	1,000	
				Feed Rate (mm/min)	260	340	340	240	
		Titanium Alloy Ti-10Al2-Fe-3Al	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	2,700	1,600	1,400	800
			Feed Rate (mm/min)		210	270	270	190	
		Titanium Alloy Ti-10Al2-Fe-3Al	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,200	700	600	400
			Feed Rate (mm/min)		90	120	120	80	
		Titanium Alloy Ti-10Al2-Fe-3Al	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,000	600	500	300
			Feed Rate (mm/min)		70	100	100	70	
		Super Alloy Inconel®625	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,400	800	700	400
			Feed Rate (mm/min)		90	110	110	90	
	Super Alloy Inconel®625	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	1,100	700	600	300	
		Feed Rate (mm/min)		80	90	90	70		
	Super Alloy Inconel®718	Shouldering	1.5Dc×0.5Dc	Spindle Revolution (min <sup>-1</sup> )	1,100	700	600	300	
		Feed Rate (mm/min)		50	70	70	50		
	Super Alloy Inconel®718	Slotting	1Dc	Spindle Revolution (min <sup>-1</sup> )	900	500	400	300	
		Feed Rate (mm/min)		40	50	50	40		

Water soluble coolant is recommended for stainless steel, titanium alloy, and super alloy.