Endmills for milling built-up of welding parts

ADDITIVE MANUFACTURING

AM-EBT · AM-CRE · AM-HFC · PXHF-AM

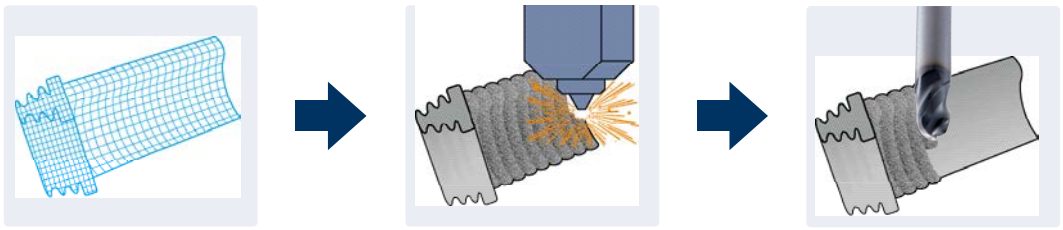
Volume 3

High Feed Radius Type:
9 new items - Ø4~ Ø20

INDEX

What is Additive Manufacturing?

In contrast to subtractive manufacturing processes such as cutting, where an object is formed by removing excessive materials, "additive manufacturing" deposits materials layer upon layer by metal 3D printing to create an object. By utilizing 3D data, short delivery and low production cost are made possible.



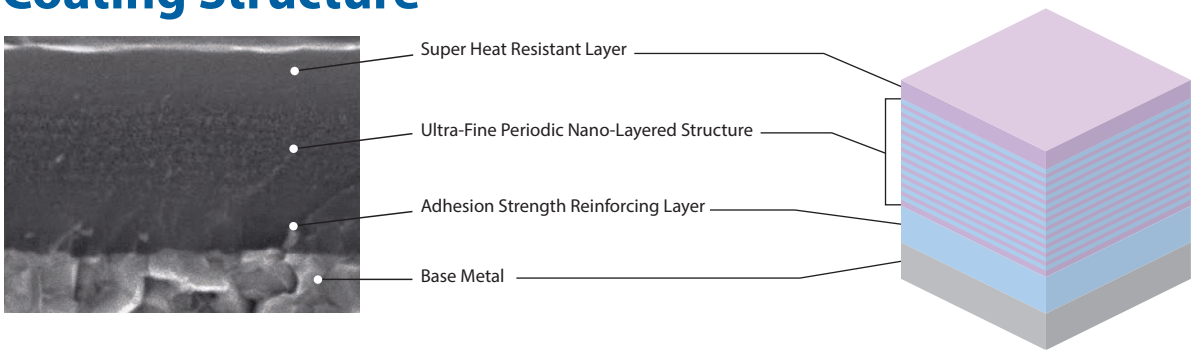
① 3D Data
② Laser additive manufacturing
③ Milling process

The name Additive Manufacturing was established in 2009 by the American Society for Testing and Materials (ASTM).

DUROREY coating enables superior heat resistance and high toughness optimized for high-hardness steel milling

Super heat resistant layer and ultra-fine periodic nano-layered structure provide superior toughness while maintaining high heat resistance and abrasion resistance. Also suppresses chipping even in high-hardness milling and achieves long tool life.

Coating Structure



Super Heat Resistant Layer

Smoothening of surface, high toughness and adhesion resistance due to the SiC containing ultra-heat-resistance material and crystal miniaturization

Ultra-Fine Periodic Nano-Layered Structure

Crystal miniaturization and improvement of mechanical properties due to the laminated structure of periodic nano-layer and wear-resistant layer

Coating Color	Coating Structure	(GPa) Hardness	Oxidation Temperature (C°)	Heat Resistance	Adhesion Strength	Surface roughness	Wear Resistance	Welding Resistance	Toughness
Black Grey	Ultra-Fine Periodic Nano-Layered	41	1.300	☆	◎	○	☆	◎	○

(Good) ○ → ◎ → ☆ (Best)

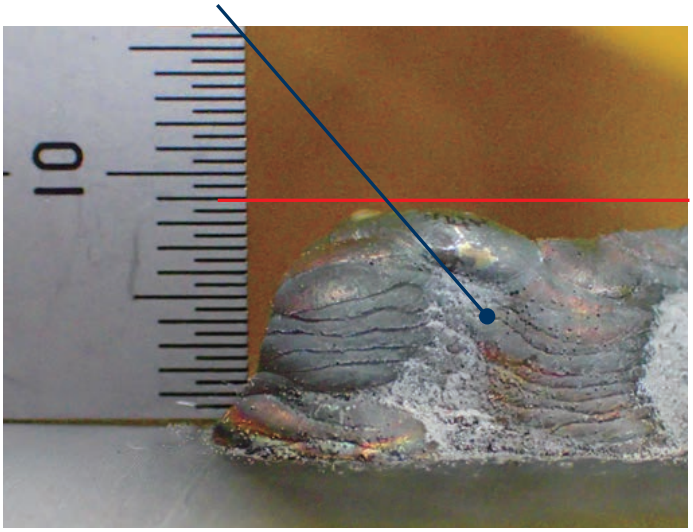
Characteristics of Additive Manufacturing Part

- The surface is very hard
- Large fluctuations in the part to be removed by cutting (cutting allowance)

Required Tool Specifications

- Ability to withstand the hardness of the surface
- Ability to respond to fluctuations in cutting allowance

Additive Manufacturing Part

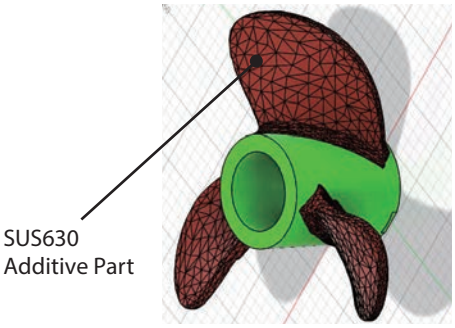


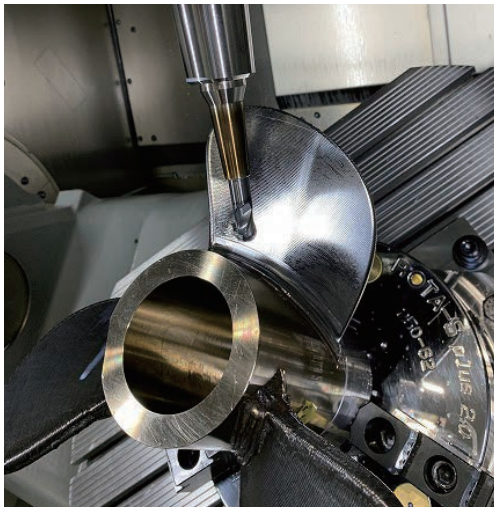
High efficiency milling by the AM-EBT in additive manufacturing part with high-hardness and unequal cutting allowance

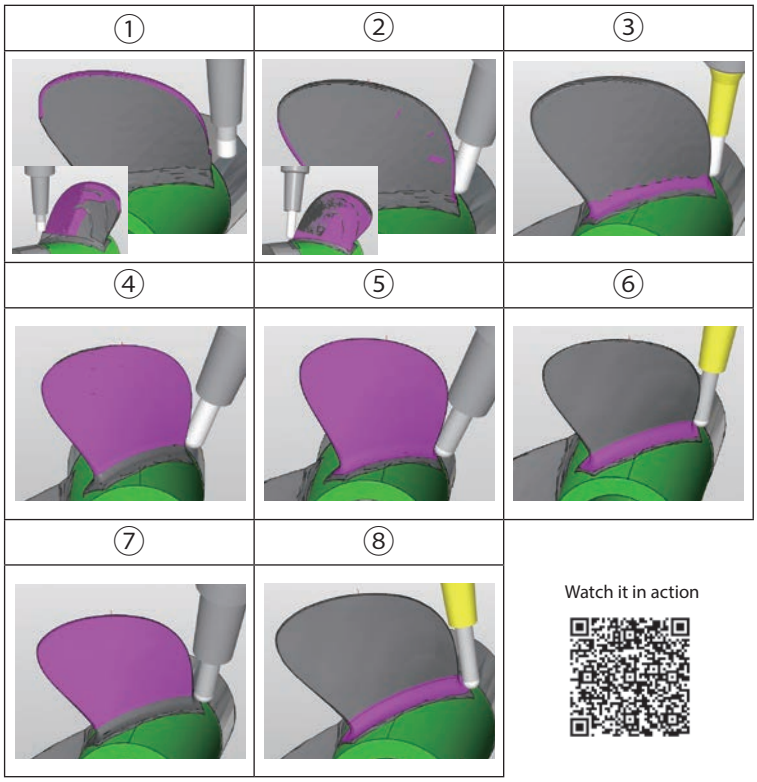
Machining of propeller wing additive part

Work Material: SUS630 (34HRC)
Machine: Five-axis Machining Center
Main Spindle: HSK-A63
Maximum RPM: 20.000min $^{-1}$
Holder: Shrink Fit
Coolant: MQL*

*MQL is used for filming purposes







Watch it in action

Total machining time: approximately 12 hours / wing(ATC tool change time not included)

Process	Milling Part	Milling Process	Tool	Cutting Speed (m/min)	Feed (mm/min)	ap (mm)	ae (mm)	Machining Time(hr)
①	Overall	Roughing	NEO-CR-PHS Ø16×R2	60 (1.194min^{-1})	239 (0,05mm/t)	1	3	1:40
②	Wing Surface	Roughing	AM-EBT R8×16	60 (1.194min^{-1})	179 (0,05mm/t)	1	3,5	2:30
③	Wing Surface	Semi-roughing	AM-EBT R8×16	60 (1.194min^{-1})	179 (0,05mm/t)	1	1	2:30
④	Base of Wing	Roughing	AM-EBT R6×12	60 (1.592min^{-1})	239 (0,05mm/t)	0,5	2	0:20
⑤	Wing Surface	Semi-finishing	WXL-EBD R8×30	70 (1.393min^{-1})	334 (0,12mm/t)	0,5	1	2:20
⑥	Base of Wing	Semi-finishing	WXL-EBD R6×18	60 (1.592min^{-1})	382 (0,12mm/t)	0,5	0,5	0:10
⑦	Wing Surface	Finishing	WXL-EBD R8×30	70 (1.393min^{-1})	334 (0,12mm/t)	0,5	0,5	2:20
⑧	Base of Wing	Finishing	WXL-EBD R6×18	70 (1.857min^{-1})	446 (0,12mm/t)	0,5	0,5	0:10

AM-HFC enables highly efficient milling of Inconel additive material with unequal cutting allowance

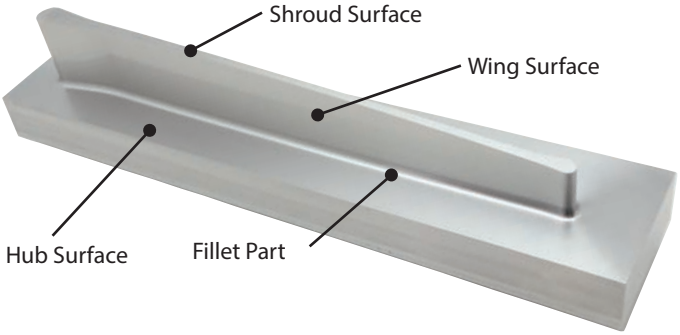
Milling of blade wing additive part

Work Material: Inconel 718 Additive Material
Machine: Five-axis Machining Center
Main Spindle: BT50
Maximum RPM: 12.000min $^{-1}$
Holder: Shrink Fit
Coolant: Water-Soluble

Shape of Work Material

Before Machining

After Machining



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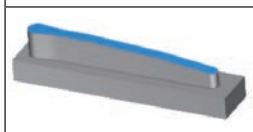
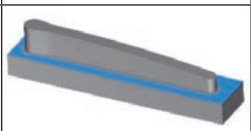
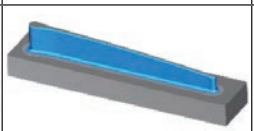
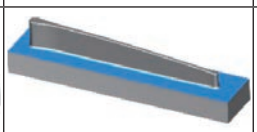
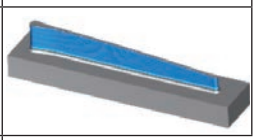
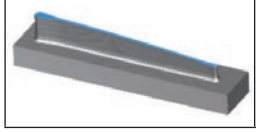
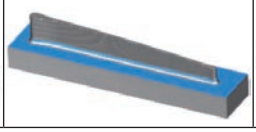
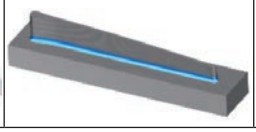
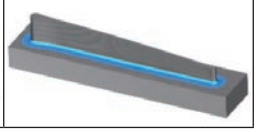
				
⑥	⑦	⑧	⑨	Watch it in action
				

Total machining time: approximately 6 hours (ATC tool change time not included)

Process	Milling Part	Milling Process	Tool	Cutting Speed (m/min)	Feed (mm/min)	ap (mm)	ae (mm)	Machining Time(hr)
①	Shroud Surface	Roughing	AM-HFC 12×R1.5	60 (1,591min^{-1})	1,146 (0.12mm/t)	0.3	4.5	0:46
②	Hub Surface	Roughing						0:24
③	Wing Surface	Roughing						0:54
④	Hub Surface	Semi-roughing	AM-HFC 12×R1.5	60 (1,591min^{-1})	1,146 (0.12mm/t)	0.3	4.5	0:04
⑤	Wing Surface	Finishing	AM-EBT R5×10	45 (1,432min^{-1})	430 (0.1mm/t)	0.1	0.45	1:37
⑥	Shroud Surface	Finishing						1:16
⑦	Hub Surface	Finishing	AM-EBT R3×6	40 (2,068min^{-1})	620 (0.1mm/t)	0.1	0.45	0:15
⑧	Fillet Part	Finishing						0:12
⑨	Fillet Part	Finishing						0:25

KEY FEATURES: AM-EBT

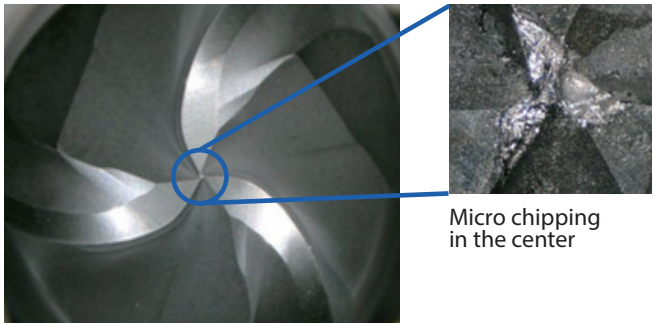
Ball end mill that can accommodate large fluctuations in cutting allowance

1. Three-dimensional negative geometry that achieves both rigidity and sharpness
   - Compatible with hard additive manufacturing parts
   - Corresponds to fluctuations in cutting allowance
2. Large chip pocket
   - Corresponds to fluctuation in chip volume
   - Good chip evacuation
3. Flute specification that allows regrinding
4. DUROREY coating optimized for high-hardness steel machining

Long tool life even in milling of built-up welding parts with large depth of cut

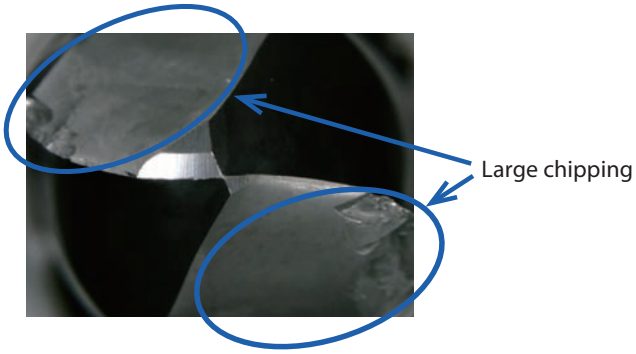
Tool	AM-EBT R6X12	Conventional 2-flute ball end mill
Work Material	BK-660R	
Milling Method	Linear Machining	
Cutting Speed	37 m/min (1.000 min^{-1})	
Feed	1.000 mm/min (0,33 mm/t)	666 mm/min (0,33 mm/t)
Depth of Cut	ap=3 mm Pf=0,5 mm	
Coolant	Air Blow	
Machine	Vertical Machining Center	

AM-EBT After milling 25m

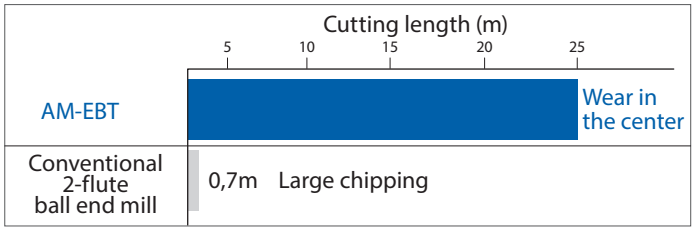


Micro chipping in the center

Conventional - 2 flutes ball end mill
After milling 0,7m



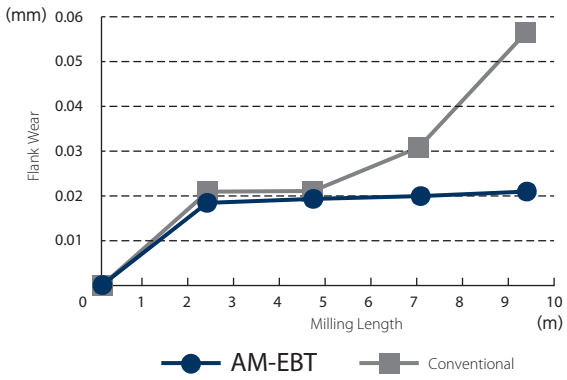
Large chipping



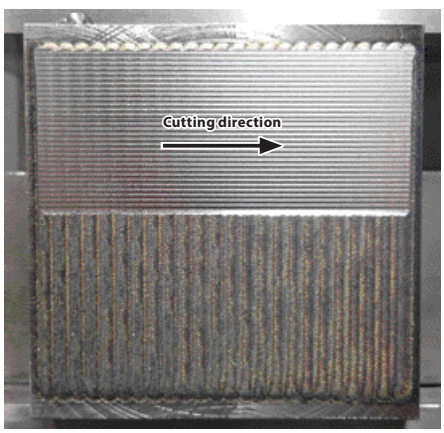
Machining example with high-hardness additive material

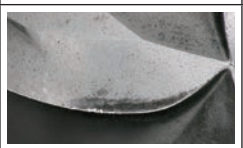
Stable wear transition and good machined surface without peeling

Tool	AM-EBT R3X6
Work Material	Additive High-speed Steel DAP540MOD (66 HRC)
Milling Method	Pick milling (direction perpendicular to the deposited direction)
Cutting Speed	90 m/min (4.800 min^{-1})
Feed	1.340 mm/min (0,093 mm/t)
Depth of Cut	ap=0,3 mm Pf=0,9 mm
Coolant	Air Blow
Machine	Horizontal Machining Center (HSK63)



Condition after milling 9,38 m

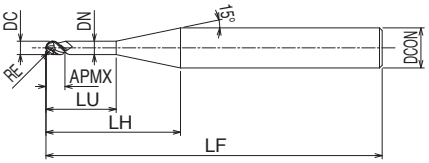


	Wear condition of ball section		Machined Surface
	Flank	Rake Face	
AM-EBT			
Conventional			

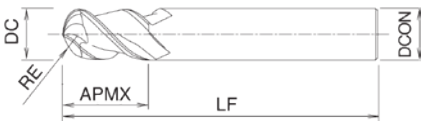
AM-EBT

Milling | Additive manufacturing

Type 1

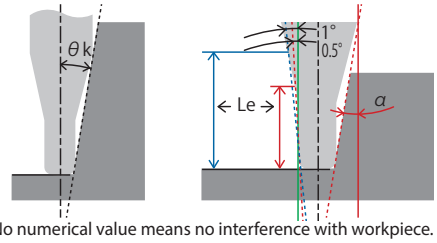


Type 2



- Carbide end mill with Durorey coating
- For challenging applications, removing welding seams
- 3 flutes, ball type

Effective Neck length (Le) depending on Inclined Angle (α) of workpiece



No numerical value means no interference with workpiece.

EDP	ZEFP	DC	RE	LU	DN	APMX	LH	DCON	LF	ØK	Effective length by inclined angles (Le)					Type	Price
											0,5°	1°	1,5°	2°	3°		
3187240	3	2	1	4	1,95	2	11,9	6	60	10,32°	4,22	4,44	4,65	4,86	5,26	1	
3187280	3	2	1	8	1,95	2	15,9	6	60	7,62°	8,47	8,87	9,22	9,54	10,24	1	
3187360	3	3	1,5	6	2,85	3	11,8	6	60	8,18°	6,25	6,49	6,72	6,94	7,4	1	
3187392	3	3	1,5	12	2,85	3	17,8	6	60	5,23°	12,53	12,98	13,4	13,85	14,85	1	
3187408	3	4	2	8	3,85	4	12	6	60	5,68°	8,32	8,62	8,91	9,17	9,76	1	
3187416	3	4	2	16	3,85	4	20	6	60	3,18°	16,68	17,23	17,78	18,37	19,71	1	
3187510	3	5	2,5	10	4,85	5	12,1	6	60	2,97°	10,4	10,75	11,08	11,4	-	1	
3187520	3	5	2,5	20	4,85	5	22,1	6	60	1,46°	20,82	21,47	-	-	-	1	
3188060	3	6	3	-	-	9	-	6	60	-	-	-	-	-	-	2	
3188080	3	8	4	-	-	12	-	8	70	-	-	-	-	-	-	2	
3188100	3	10	5	-	-	15	-	10	80	-	-	-	-	-	-	2	
3188120	3	12	6	-	-	18	-	12	90	-	-	-	-	-	-	2	
3188160	3	16	8	-	-	24	-	16	105	-	-	-	-	-	-	2	
3188200	3	20	10	-	-	30	-	20	110	-	-	-	-	-	-	2	

CUTTING CONDITIONS

Milling | Cutting conditions

AM-EBT

Ball type

		Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~65HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc		50~70m/min		40~60m/min		20~40m/min		60~80m/min		50~70m/min		40~60m/min		20~40m/min	
R	Lu (mm)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
1	4	9.500	940	8.000	790	4.800	480	11.100	1.100	9.500	940	8.000	790	4.800	480
1	8	4.800	430	4.300	390	2.600	230	5.600	500	4.800	430	4.300	390	2.600	230
1,5	6	6.400	960	5.300	800	3.200	480	7.400	1.110	6.400	960	5.300	800	3.200	480
1,5	12	3.800	510	3.300	450	2.000	270	4.400	590	3.800	510	3.300	450	2.000	270
2	8	4.800	930	4.000	770	2.400	470	5.600	1.080	4.800	930	4.000	770	2.400	470
2	16	2.900	490	2.500	420	1.500	250	3.400	570	2.900	490	2.500	420	1.500	250
2,5	10	3.800	910	3.200	770	1.900	460	4.500	1.080	3.800	910	3.200	770	1.900	460
2,5	20	2.400	550	2.000	430	1.200	280	2.800	600	2.400	520	2.000	430	1.200	280
3	-	3.200	960	2.700	800	1.600	480	3.700	1.120	3.200	960	2.700	800	1.600	480
4	-	2.400	860	2.000	720	1.200	430	2.800	1.000	2.400	860	2.000	720	1.200	430
5	-	1.900	860	1.600	720	960	430	2.200	1.000	1.900	860	1.600	720	960	430
6	-	1.600	960	1.300	800	800	480	1.900	1.120	1.600	960	1.300	800	800	480
8	-	1.200	790	1.000	660	600	390	1.400	920	1.200	790	1.000	660	600	390
10	-	1.000	720	800	600	480	360	1.100	840	1.000	720	800	600	480	360

Depth of cut

	ap	pf
R≤6	Max:0,15D	0,05D
8≤R	Max:3mm	

1. This tool is recommended for the roughing of additive manufacturing and mold overlay surfaces.
2. Please use machines and holders that are rigid and highly accurate.
3. The values listed above are for reference. Please set the cutting condition in accordance with the actual machining environment.
4. Please reduce the feed rate when the depth of cut is greater than specified.
5. Please adjust the speed, feed and depth of cut accordingly when the overhang length is longer than specified.
6. Please use a suitable fluid with high smoke retardant properties.
7. During dry (no fluid) milling, please use air blow to remove disposable chips from the milling area and to eliminate chip packing.
8. Please use water-soluble coolant when machining stainless steel, cobalt-chromium based alloy, titanium alloy, and Ni-based alloy.
9. Tool runout should be kept to a minimum for maximum accuracy.
10. When the cutting load fluctuates in areas such as the corners, please reduce the rotational speed.

KEY FEATURES: AM-CRE

Stable performance and enhanced efficiency with multi-flute configuration

1. Three-dimensional negative geometry that achieves both rigidity and sharpness
   - Corner configuration that enables milling of hard additive manufacturing parts
   - Corresponds to fluctuations in cutting allowance
2. Flute specification that allows regrinding
3. Multi-flute specification that achieves long tool life and high efficiency

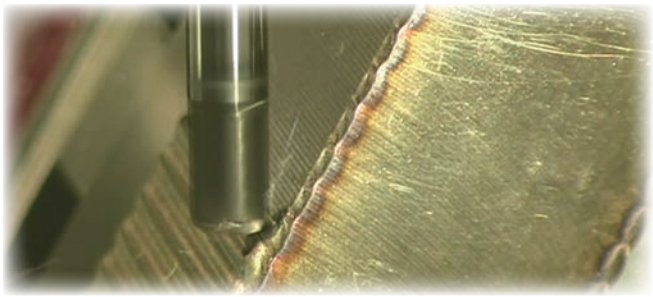
Outer diameter under Ø10
6-flute specification

Outer diameter Ø12 or above
8-flute specification

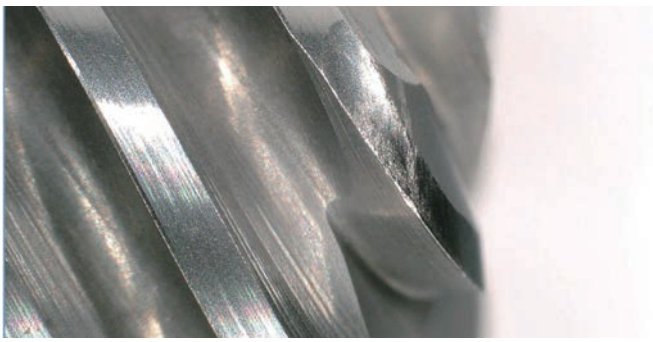
4. DUROREY coating optimized for high-hardness steel machining

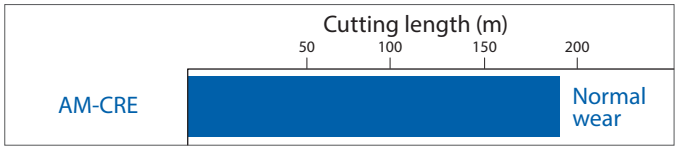
Milling example in Stellite Alloys

Tool	AM-CRE Ø8XR2 (6FL)
Work Material	Stellite (48HRC)
Milling Method	Contour Line Operation
Cutting Speed	50 m/min (2.000 min^{-1})
Feed	600 mm/min (0,05 mm/t)
Depth of Cut	ap=0,5 mm ae=0,5 mm
Coolant	Air Blow
Machine	Vertical Machining Center



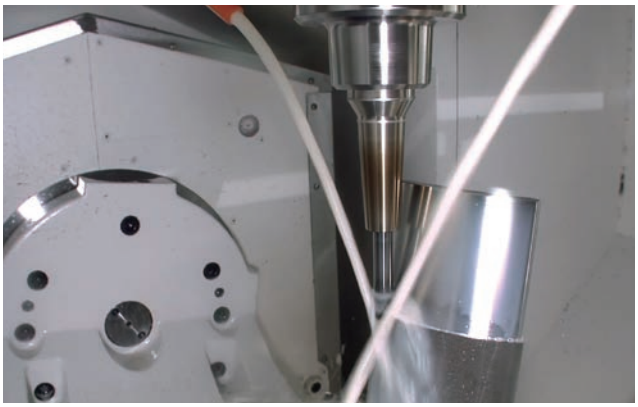
AM-CRE • After milling 190 m

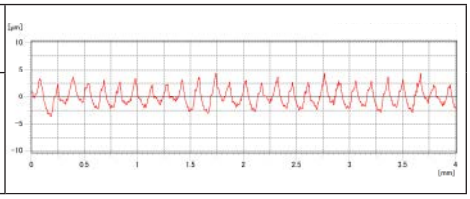




Machining example with precipitation hardening stainless steel additive material

Tool	AM-CRE Ø8XR2 (6FL)
Work Material	SUS630 (45 HRC)
Milling Method	Contour Line Operation
Cutting Speed	63 m/min (2.500 min^{-1})
Feed	869 mm/min (0,058 mm/t)
Depth of Cut	ap=0,1 mm ae=1,0 mm
Coolant	Water Soluble
Machine	Five-axis Machining Center (BT50)



Surface roughness	
Ra1.3627μ m Rz6.9465μ m	

End mills for additive manufacturing are also suitable for milling built-up welding parts of molds

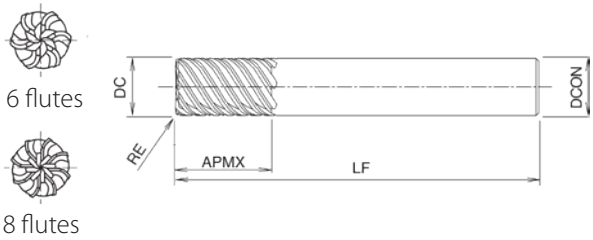
Overlay welding is a method for partially modifying a mold.

Built-up weld has high-hardness and high fluctuation in cutting allowance, making machining extremely difficult.

End mills for additive manufacturing can also be used for built-up welding parts due to their tough cutting edge geometry.

AM-CRE

Milling | Additive manufacturing



- Carbide end mill with Durorey coating
- For challenging applications, removing welding seams
- 6-8 flutes, radius type

EDP	ZEFP	DC	RE	APMX	LF	DCON	Price
3183010	6	6	1	9	60	6	
3183015	6	6	1,5	9	60	6	
3183018	6	8	1	12	70	8	
3183020	6	8	2	12	70	8	
3183110	6	10	1	15	80	10	
3183120	6	10	2	15	80	10	
3183210	8	12	1	18	90	12	
3183220	8	12	2	18	90	12	
3183226	8	16	1	24	105	16	
3183230	8	16	3	24	105	16	
3183310	8	20	1	30	110	20	
3183330	8	20	3	30	110	20	

AM-CRE

Radius type

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~60HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	50~70m/min		40~60m/min		20~40m/min		60~80m/min		50~70m/min		40~60m/min		20~40m/min	
DC x RE	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
6×R1	3.700	1.330	3.200	1.150	1.910	690	4.240	1.530	3.700	1.330	3.200	1.150	1.910	690
6×R1.5	3.200	960	2.700	800	1.600	480	3.700	1.120	3.200	960	2.700	800	1.600	480
8×R1	2.780	1.250	2.400	1.080	1.430	640	3.180	1.430	2.780	1.250	2.400	1.080	1.430	640
8×R2	2.400	720	2.000	600	1.200	360	2.800	840	2.400	720	2.000	600	1.200	360
10×R1	2.220	1.600	1.900	1.370	1.150	830	2.540	1.830	2.220	1.600	1.900	1.370	1.150	830
10×R2	1.900	920	1.600	760	960	460	2.200	1.070	1.900	920	1.600	760	960	460
12×R1	1.850	2.220	1.600	1.920	960	1.150	2.120	2.540	1.850	2.220	1.600	1.920	960	1.150
12×R2	1.600	1.270	1.300	1.060	800	640	1.900	1.490	1.600	1.270	1.300	1.060	800	640
16×R1	1.380	2.430	1.200	2.110	720	1.270	1.590	2.800	1.380	2.430	1.200	2.110	720	1.270
16×R3	1.200	1.430	1.000	1.190	600	720	1.400	1.670	1.200	1.430	1.000	1.190	600	720
20×R1	1.110	2.490	1.000	2.240	570	1.280	1.270	2.840	1.110	2.490	1.000	2.240	570	1.280
20×R3	1.000	1.530	800	1.270	480	760	1.100	1.780	1.000	1.530	800	1.270	480	760

Depth of cut	ae	ap
	Max:0,5xD	Max:0,2xR

1. This tool is recommended for the roughing of additive manufacturing and mold overlay surfaces.
2. Please use machines and holders that are rigid and highly accurate.
3. The values listed above are for reference. Please set the cutting condition in accordance with the actual machining environment.
4. Please reduce the feed rate when the depth of cut is greater than specified.
5. Please adjust the speed, feed and depth of cut accordingly when the overhang length is longer than specified.
6. Please use a suitable fluid with high smoke retardant properties.
7. During dry (no fluid) milling, please use air blow to remove disposable chips from the milling area and to eliminate chip packing.
8. Please use water-soluble coolant when machining stainless steel, cobalt-chromium based alloy, titanium alloy, and Ni-based alloy.
9. Tool runout should be kept to a minimum for maximum accuracy.
10. When the cutting load fluctuates in areas such as the corners, please reduce the rotational speed.

KEY FEATURES: AM-HFC / PXHF-AM

High Feed Radius Type enables high feed milling of high-hardness additive manufacturing parts.

1 Composite radius cutting edge optimized for flat surface milling

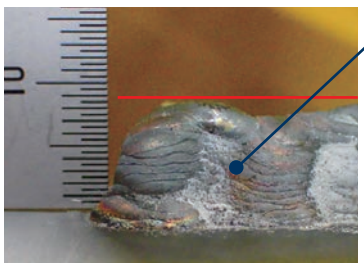
- A robust cutting edge that can withstand shapes with unstable depth of cut

2 Flat cutting edge

- Suppresses chipping of the end cutting edge
- Achieves good machined surface quality

3 Specification with coolant hole

Mold surface by additive manufacturing



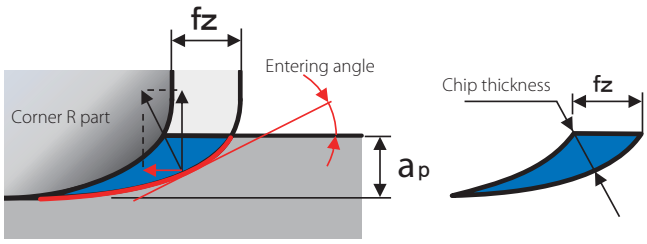
Deposited additive material
Large fluctuations in the part to be removed by cutting (cutting allowance)

- Cutting edge specification that minimizes chipping even if the amount of cut suddenly increases
- Reduction of machining time

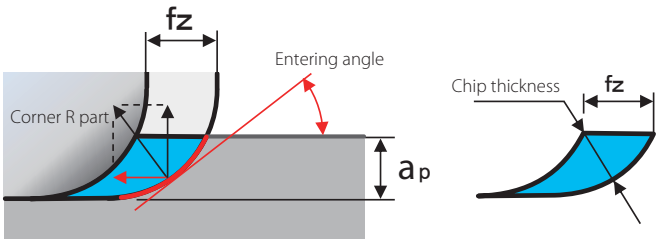
Composite radius cutting edge

Since the depth of cut is small, cutting resistance in the feed direction is reduced, suppressing tool vibration and deflection.

By reducing the chip thickness, cutting heat is easily transferred to the chip, making it more difficult for heat to remain on the tool cutting edge and work material.



Composite radius shape

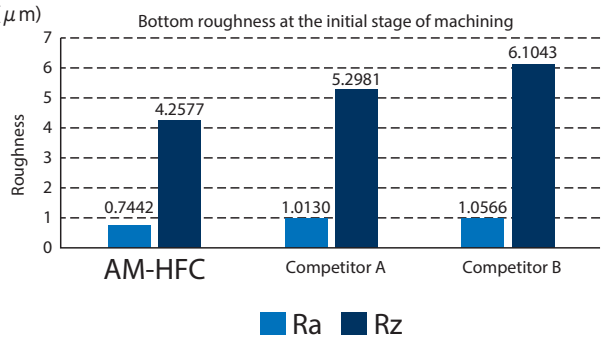


Conventional radius shape

Good machined surface

Wiper edge enables good machined surface

Tool	AM-HFC Ø4XR0,5	Competitor 6FL	Competitor 4FL
Work Material	SKD61 (50HRC) Additive Material		
Milling Method	Frontal Milling		
Cutting Speed	60 m/min (4.775 min^{-1})		
Feed	4.300 mm/min		
	0,15 mm/t	0,225 mm/t	
Depth of Cut	ap= 0,16 mm ae= 2 mm		
Coolant	Air Blow		
Machine	Vertical Machining Center (BT40)		



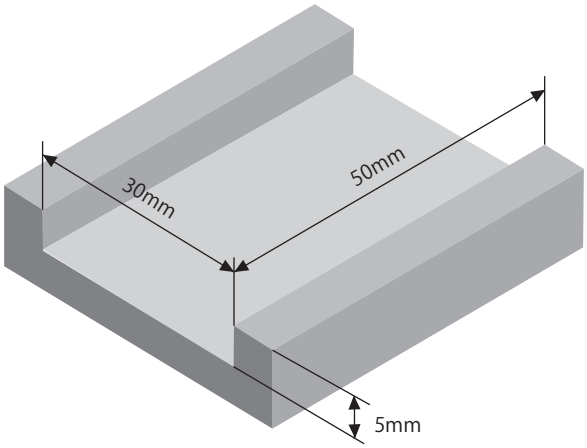
Good chip evacuation

Specification with coolant hole improves chip evacuation and prevents chips from getting tangled

DUROREY coating optimized for high-hardness steel machining

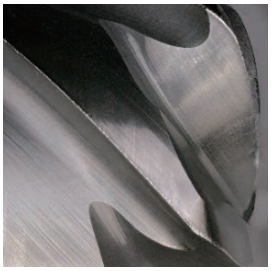
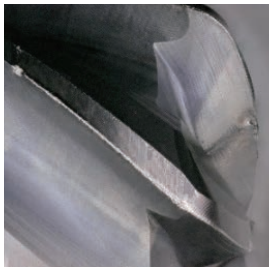
Stable machining with no chipping on both the end cutting edge and outer peripheral cutting edge

Tool	AM-HFC Ø10XR1,2	
Work Material	S600 (SKH51) 65HRC	
Milling Method	Frontal Milling	Trochoidal Milling
Cutting Speed	100 m/min (3.200 min^{-1})	
Feed	1.536 mm/min (0,08 mm/t)	900 mm/min (0,046 mm/t)
Depth of Cut	ap= 0,1 mm ae= 4 mm	ap= 5 mm ae= 0,2 mm
Coolant	Air Blow	
Machine	Vertical Machining Center (BT40)	



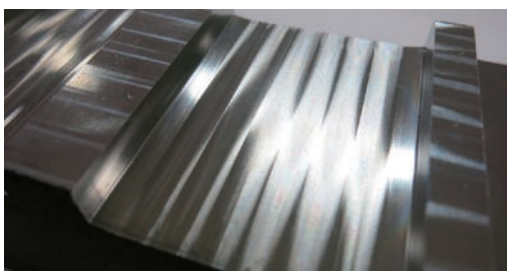
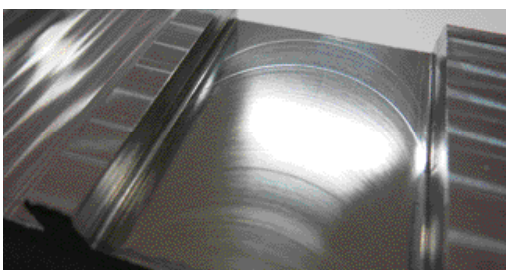
Shape of work material

Worn state after frontal milling 3 slots and trochoidal milling 2 slots

End cutting edge		Peripheral cutting edge	
AM-HFC	Competitor	AM-HFC	Competitor
			

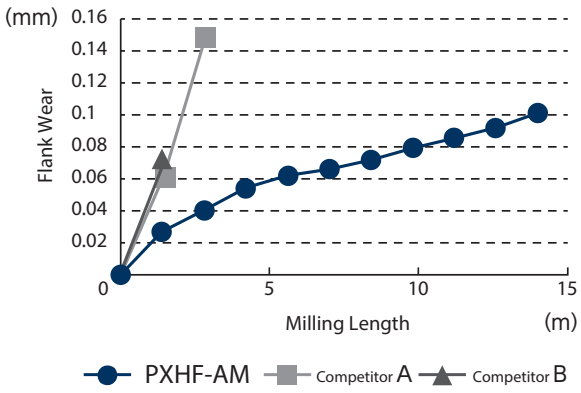
The AM-HFC exhibits no chipping on the end cutting edge and outer peripheral cutting edge, and can continued to be used.

Condition of the bottom surface machined by AM-HFC

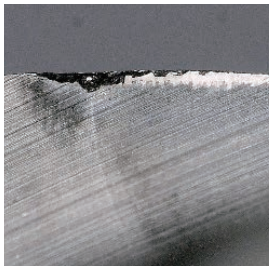
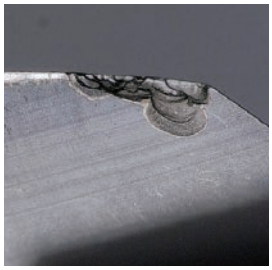
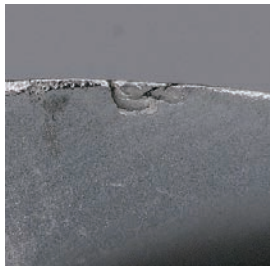
Frontal milling	Trochoidal milling
	

Machining example in SKH51 (65 HRC)

Tool	Head: PXHF-AM160C16-06R200-O Holder: PXMZ-C16SS16-S100-O	A,B Competitor
Size	Ø16 6FL	φ16 4FL
Work Material	SKH51 (65HRC)	
Milling Method	Frontal Milling	
Cutting Speed	60 m/min (1.200 min^{-1})	
Feed	1.440 mm/min (0,2 mm/t)	1.440 mm/min (0,3 mm/t)
Depth of Cut	ap= 0,3 mm ae= 8 mm	
Coolant	Air Blow	
Machine	Vertical Machining Center (BT40)	



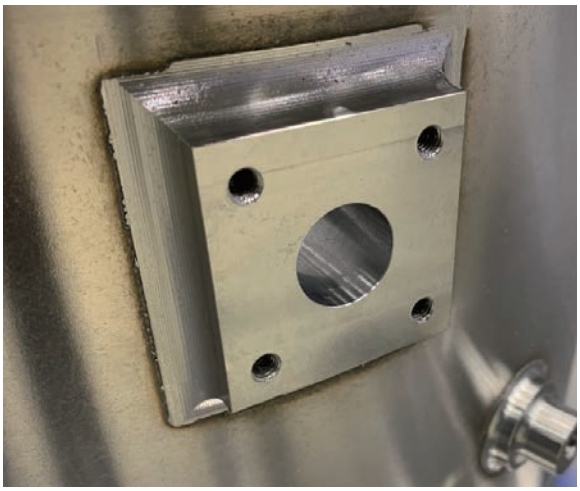
Worn state of corner R

PXHF-AM 13,9m	Competitor A 2m	Competitor B 1,4m
		

Four times the durability was achieved versus the competitor products in the machining of SKH51 (65 HRC).

Machining example in Inconel 718 (additive material)

Tool	AM-HFC Ø10XR1,2
Work Material	Inconel 718 (Additive Material)
Milling Method	Frontal Milling
Cutting Speed	50 m/min (1.592 min^{-1})
Feed	478 mm/min (0,05 mm/t)
Depth of Cut	ap= 0,5 mm ae= 2 mm
Coolant	Air Blow
Machine	Five-axis Maching Center



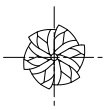
The machining of up to 8 workpieces (total cutting amount: 188,8 cm3 and more) in Inconel 718 (additive material) was made possible.

AM-HFC NEW

Milling | Additive manufacturing

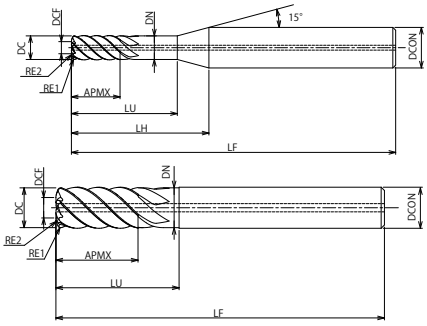
- Carbide end mill with Durorey coating
- End Mills for Additive Manufacturing
- 6 flutes, High Feed Radius Type
- With oil hole

Type 1

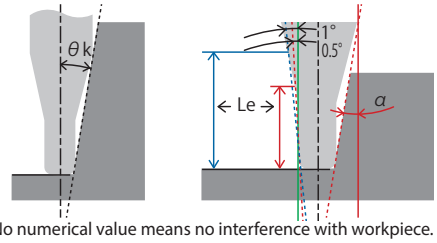


6 flutes

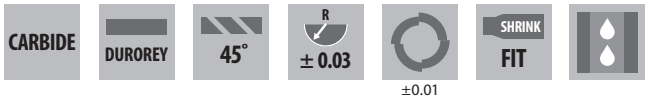
Type 2

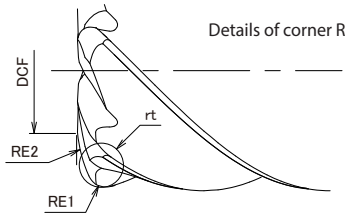


Effective Neck length (Le) depending on Inclined Angle (α) of workpiece



No numerical value means no interference with workpiece.



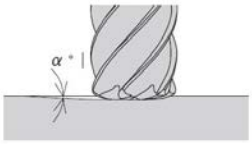


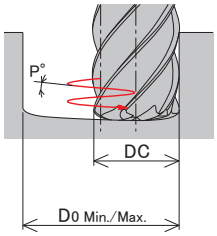
EDP	DC	rt	DCF	RE1	RE2	ZEFP	DCON	APMX	LH	DN	LF	LU	ØK	Effective length by inclined angles (Le)					Type	Price
														0,5°	1°	1,5°	2°	3°		
3188204	4	0,5	2	0,4	2,5	6	6	8	15,9	3,8	50	12	3,73°	12,53	12,98	13,43	13,91	15	1	
3188205	5	0,6	2,5	0,5	3	6	6	10	17	4,8	60	15	1,76°	15,64	16,18	16,74	-	-	1	
3188206	6	0,8	3	0,6	3,5	6	6	12	-	5,8	60	18	-	-	-	-	-	-	2	
3188208	8	1	4	0,8	5	6	8	16	-	7,7	70	24	-	-	-	-	-	-	2	
3188210	10	1,2	5	1	6	6	10	20	-	9,7	80	30	-	-	-	-	-	-	2	
3188212	12	1,5	6	1,2	7	6	12	24	-	11,7	90	36	-	-	-	-	-	-	2	

AM-HFC

High Feed Radius type **Maximum Ramping Angle (E°)**

DC x rt	Ramping Angle E°	Helical Milling (mm) D0 Min.	Helical Milling (mm) D0 Max.	Helical Angle P°
4×R0,5	3°	6	7	1,5°
5×R0,6	3°	7,5	9	1,5°
6×R0,8	3°	9	11	1,5°
8×R1	3°	12	15	1,5°
10×R1,2	3°	15	19	1,5°
12×R1,5	3°	18	23	1,5°

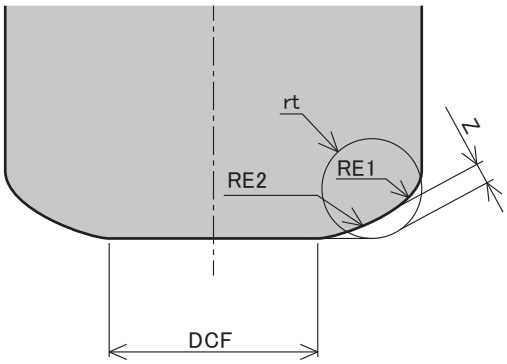




Edge shape definitions for the purpose of creating a program

DC	rt	Remainder Z
4	R0,5	0,11
5	R0,6	0,15
6	R0,8	0,17
8	R1	0,22
10	R1,2	0,31
12	R1,5	0,36

During machining, please program the milling paths according to the recommended simulated R (rt) respective to the individual end mill diameter.



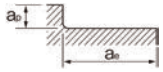
AM-HFC

High Feed Radius type

Frontal Milling

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	90~110m/min		70~90m/min		50~70m/min		100~120m/min		90~110m/min		70~90m/min		30~50m/min	
DC x rt	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
4 × R0,5	7.960	5.730	6.370	4.590	4.780	1.720	8.760	6.310	7.960	5.730	6.370	4.590	3.180	760
5 × R0,6	6.370	5.730	5.100	4.590	3.820	1.720	7.010	6.310	6.370	5.730	5.100	4.590	2.550	770
6 × R0,8	5.310	5.730	4.250	4.590	3.180	1.720	5.840	6.310	5.310	5.730	4.250	4.590	2.120	760
8 × R1	3.980	5.730	3.180	4.580	2.390	1.720	4.380	6.310	3.980	5.730	3.180	4.580	1.590	760
10 × R1,2	3.180	5.720	2.550	4.590	1.910	1.720	3.500	6.300	3.180	5.720	2.550	4.590	1.270	760
12 × R1,5	2.650	5.720	2.120	4.580	1.590	1.720	2.920	6.310	2.650	5.720	2.120	4.580	1.060	760

Depth of cut



ae	ap
Max: 0,5D	Max: 0,04D

If the pick amount is 0.5 x D or more, cusp may occur on the machined surface.

During machining, please program the milling paths according to the recommended simulated R (rt) respective to the individual end mill diameter.

AM-HFC

High Feed Radius type

Side Milling

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	80~100m/min		50~70m/min		30~50m/min		90~110m/min		80~100m/min		50~70m/min		20~40m/min	
DC x rt	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
4 × R0,5	7.170	1.200	4.780	570	3.180	230	7.960	1.340	7.170	1.200	4.780	570	2.390	230
5 × R0,6	5.730	1.200	3.820	570	2.550	230	6.370	1.340	5.730	1.200	3.820	570	1.910	230
6 × R0,8	4.780	1.200	3.180	570	2.120	230	5.310	1.340	4.780	1.200	3.180	570	1.590	230
8 × R1	3.580	1.720	2.390	800	1.590	380	3.980	1.910	3.580	1.720	2.390	800	1.190	230
10 × R1,2	2.870	1.720	1.910	800	1.270	380	3.180	1.910	2.870	1.720	1.910	800	960	230
12 × R1,5	2.390	1.720	1.590	800	1.060	380	2.650	1.910	2.390	1.720	1.590	800	800	230

Depth of cut

ae	ap
Max: 0,05D	Max: 1,5D

ae	ap
Max: 0,02D	Max: 1,5D

ae	ap
Max: 0,02D	Max: 1D

ae	ap
Max: 0,05D	Max: 1,5D

ae	ap
Max: 0,02D	Max: 1,5D

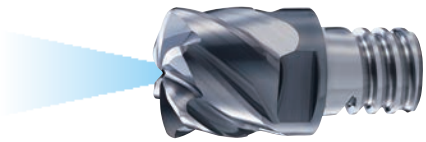
1. This tool is recommended for the roughing of additive manufacturing and mold overlay surfaces.
2.Please use machines and holders that are rigid and highly accurate.
3. The values listed above are for reference. Please set the cutting condition in accordance with the actual machining environment.
4.Please reduce the feed rate when the depth of cut is greater than specified.
5. The above table is a guide when the amount of protrusion of the tool is 4 x D or less. If the amount of protrusion is large, chattering is likely to occur, so adjust the rotation speed, feed rate and depth of cut with reference to the coefficients.
6. Please use a suitable fluid with high smoke retardant properties.
7. During dry (no fluid) milling, please use air blow to remove disposable chips from the milling area and to eliminate chip packing.
8. Please use water-soluble coolant when machining stainless steel, cobalt-chromium alloy, titanium alloy, and Ni-based alloy.
9.Tool runout should be kept to a minimum for maximum accuracy.
10. When the cutting load fluctuates in areas such as the corners, please reduce the rotational speed.

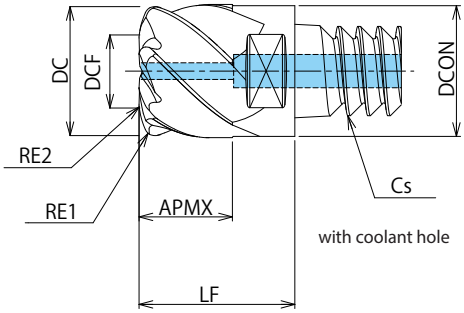
Tool extension coefficients

Overhang Length	Cutting Speed	ap	fz
L/D ≤ 4	100%	100%	100%
4 < L/D ≤ 5	90%	75%	80%
5 < L/D ≤ 6	80%	50%	60%

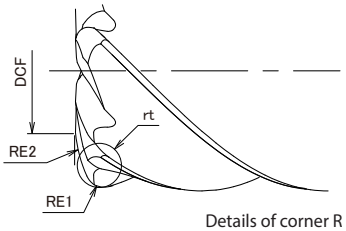
PXHF-AM NEW

Milling | Additive manufacturing





- Exchangeable Head End Mill PXM for Additive Manufacturing
- Coolant hole
- 6 flutes, high feed radius type

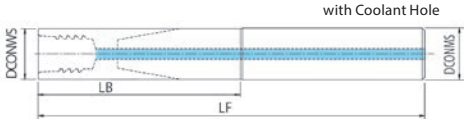


EDP	Designation	DC	rt	DCF	ZEFP	RE1	RE2	DCON	APMX	LF	FHA	Cs	Grades	Price
7830377	PXHF-AM120C12-06R150-0	12	1,5	6	6	1,2	7	11,7	8,4	14,4	45°	C12	XP6703	
7830378	PXHF-AM160C16-06R200-0	16	2	8	6	1,6	9,5	15,7	11,2	18,7	45°	C16	XP6703	
7830379	PXHF-AM200C20-06R250-0	20	2,5	10	6	2	12	19,6	14	21,5	45°	C20	XP6703	

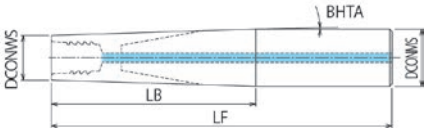
PXMZ

Milling | Indexables

Type 1

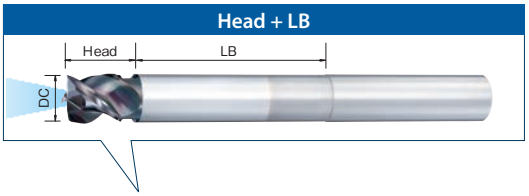


Type 2



with Coolant Hole

- Straight Shank Holder for PXM
- Carbide shank with coolant hole
- Shank & matching spanner sold as set



EDP	Designation	DCONWS	DCONMS	BHTA	LF	LB	Head + LB	CS	Type	Price
48309005	PXMZ-C12SS12-S075CS-O	11,7	12	0°	75	25	39,4	C12	1	
48309006	PXMZ-C12SS12-L100CS-O	11,7	12	0°	100	46,3	60,7	C12	1	
48309007	PXMZ-C12SS12-L115CS-O	11,7	12	0°	115	65	79,4	C12	1	
48309008	PXMZ-C12TP16-LL135CS-O	11,7	16	1.3°	135	85	99,4	C12	2	
48309009	PXMZ-C12TP16-LL150CS-O	11,7	16	1°	150	85,6	100	C12	2	
48309010	PXMZ-C16SS16-S090CS-O	15,7	16	0°	90	40	58,7	C16	1	
48309011	PXMZ-C16SS16-L130CS-O	15,7	16	0°	130	62	80,7	C16	1	
48309012	PXMZ-C16SS16-L135CS-O	15,7	16	0°	135	85	103,7	C16	1	
48309013	PXMZ-C16TP20-LL165CS-O	15,7	20	1°	165	115	133,7	C16	2	
48309014	PXMZ-C16TP20-LL180CS-O	15,7	20	1°	180	116,6	135,3	C16	2	
48309015	PXMZ-C20SS20-S090CS-O	19,6	20	0°	90	40	61,5	C20	1	
48309016	PXMZ-C20SS20-L150CS-O	19,6	20	0°	150	79,3	100,8	C20	1	
48309017	PXMZ-C20SS20-L180CS-O	19,6	20	0°	180	110	131,5	C20	1	
48309018	PXMZ-C20TP25-LL200CS-O	19,6	25	1°	200	140	161,5	C20	2	
48309019	PXMZ-C20TP25-LL210CS-O	19,6	25	1°	210	145	166,5	C20	2	

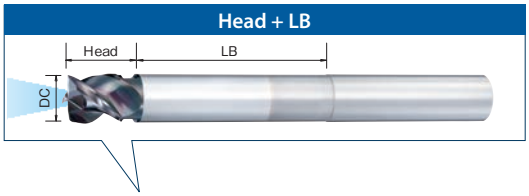
1. For the use of internal coolant, please use the appropriate head and shank holders with oil hole.
2. Adjust the position of the coolant nozzles accoringly so that the chips do not get tangled.

PXMZ

Milling | Indexables

with Coolant Hole

- Straight Shank Holder for PXM
- Steel Shank with coolant hole
- Shank & matching spanner sold as set



EDP	Designation	DCONWS	DCONMS	BHTA	LF	LB	Head + LB	CS	Price
48309001	PXMZ-C12SS12-S100-O	11,7	12	0°	100	18	32,4	C12	
48309002	PXMZ-C16SS16-S100-O	15,7	16	0°	100	23	41,7	C16	
48309003	PXMZ-C20SS20-S120-O	19,6	20	0°	120	28	49,5	C20	

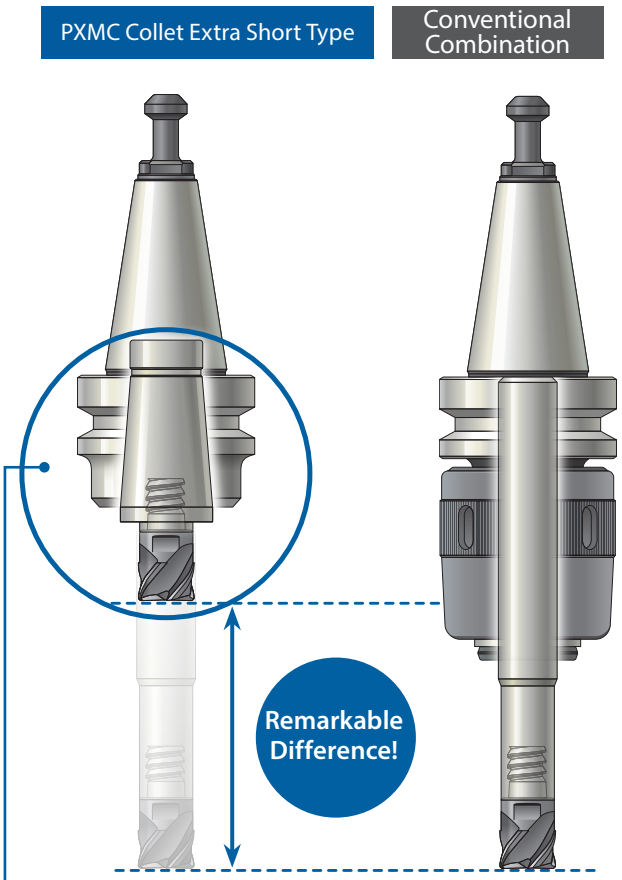
Adjust the position of the coolant nozzles accordingly so that the chips do not get tangled.

Accessories

Tool	EDP	Designation	Applicable Head Dia.	Cs	Recommended Tightening Torque	Price
Spanner	7801890	PXMP8-10	Ø12	C12	12N•m	
	7801891	PXMP13-16	Ø16	C16	30N•m	
	7801891	PXMP13-16	Ø20	C20	50N•m	

KEY FEATURES: PXMC COLLET

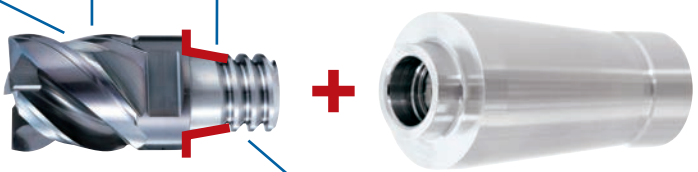
1. Powerful chip evacuation even on small machining center
2. The reduction of overhang length improves rigidity and rotational balance
3. A wide variety of exchangeable heads
   · Suitable for steel, stainless steel and aluminum
   · Wide processing range from roughing to finishing
4. Greater cost performance compared to monoblock type holders, only need to change the collet in case of trouble.



KEY FEATURES: PXM EXCHANGEABLE HEAD

All the knowledge and know-how acquired by designing solid carbide end mills are found in these exchangeable heads.
·Various types are available to meet variety of machining methods.

End Face + Taper = Double Face Clamping
·High rigidity and accuracy of tightening
·High precision of run out≤0,015mm
·High head replacing accuracy = ±0.03mm



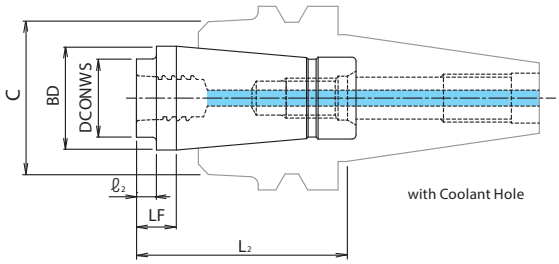
Applying buttress screw makes easy and reduces time to desorb heads

PXMC COLLET

Milling | Collets

Short

Extra Short

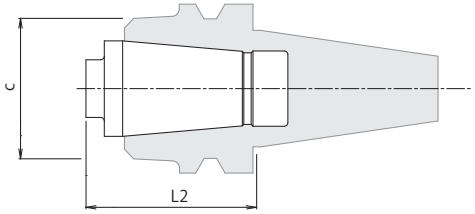


- PXMC collet for PHOENIX PXM series.
- With coolant hole
- Reducing overhang length allows high rigidity

EDP	Designation	DCONWS	BD	LF	l2	HEAD + l2	Cs	Type	Price
7834001	PXMC-C1205	11,7	26	10,5	5	19,4	C12	Extra Short	
7834002	PXMC-C1605	15,7	26	10,5	5	23,7	C16	Extra Short	
7834003	PXMC-C2005	19,6	26	10,5	5	26,5	C20	Extra Short	
7834011	PXMC-C1230	11,7	26	35,5	30	44,4	C12	Short	
7834012	PXMC-C1630	15,7	26	35,5	30	48,7	C16	Short	
7834013	PXMC-C2030	19,6	26	35,5	30	51,5	C20	Short	

HY-PRO HOLDER

Milling | Holders



- HY-PRO holder for PXMC collet

EDP	Designation	C	L2		Price
			Extra short	Short	
8910000	BT30-SLK12-35 P30T-1(MAS1)	38	45,5	70,5	
8910001	BT30-SLK12-35 P30T-2(MAS2)	38	45,5	70,5	
8910002	BT40-SLK12-45	38	55,5	80,5	
8910003	BT40-SLK12-75	38	85,5	110,5	
8910005	A63-SLK12-75	38	85,5	110,5	
8910006	A63-SLK12-135	38	145,5	170,5	

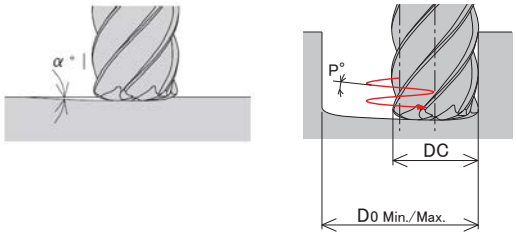
CUTTING CONDITIONS

PXHF-AM

For both PXMZ straight shank holder / PXMC collet

Maximum Ramping Angle (E°)

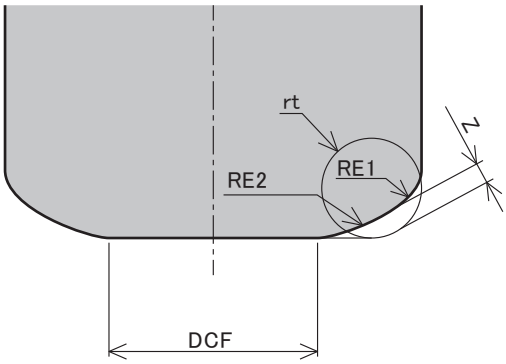
Designation	Ramping Angle E°	Helical Milling (mm)		Helical Angle P°
		D0 Min.	D0 Max.	
PXHF-AM120C12-06R150-O	3°	18	23	1,5°
PXHF-AM160C16-06R200-O	3°	24	31	1,5°
PXHF-AM200C20-06R250-O	3°	30	39	1,5°



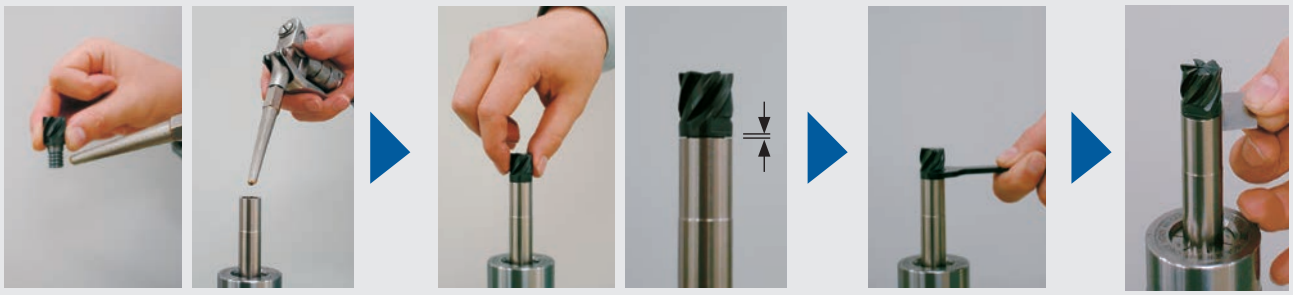
Edge shape definitions for the purpose of creating a program

Designation	R rt	Remainder Z
PXHF-AM120C12-06R150-O	R1,5	0,36
PXHF-AM160C16-06R200-O	R2	0,47
PXHF-AM200C20-06R250-O	R2,5	0,59

During machining, please program the milling paths according to the recommended simulated R (rt) respective to the individual end mill diameter.



TIGHTENING PROCEDURE



1. Cleaning

Remove dirt and chips from the connecting thread and shank.

2. Initial Tightening

Tighten by hand

3. Final Tightening

Tighten with a spanner wrench

4. Confirmation

Confirm that there is no gap

Cautions during use

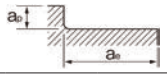
· Only use the spanner wrenches that are designed specifically for the PXM (P. 13). Please do not use alternative spanner wrenches sold on the market as a replacement.
· Please tighten until the head and the shank holder faces meet. Confirm that there is no gap.
· Degreasing the connecting thread may result in over tightening or a possible separation of the faces. Please do not degrease.
· Please make sure that the spanner wrench is inserted properly and turn it slowly during use.

CUTTING CONDITIONS

PXHF-AM

For both PXMZ straight shank holder / PXMC collet

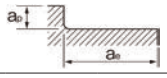
Frontal Milling L/D ≤ 4

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	110~130m/min		90~110m/min		65~85m/min		125~145m/min		110~130m/min		90~110m/min		30~50m/min	
DC	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
12	3.180	5.270	2.650	4.390	1.990	1.580	3.580	5.930	3.180	5.270	2.650	4.390	1.060	760
16	2.390	5.280	1.990	4.390	1.490	1.570	2.690	5.940	2.390	5.280	1.990	4.390	800	770
20	1.910	5.270	1.590	4.390	1.190	1.570	2.150	5.930	1.910	5.270	1.590	4.390	640	770
Depth of cut														

ae	ap
Max: 0,5D	Max: 0,04D

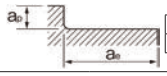
During machining, please program the milling paths according to the recommended simulated R (rt) respective to the individual end mill diameter.

Frontal Milling 4<L/D ≤ 5

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	100~120m/min		80~100m/min		60~80m/min		115~135m/min		100~120m/min		80~100m/min		25~45m/min	
DC	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
12	2.920	3.780	2.390	3.100	1.860	1.210	3.320	4.300	2.920	3.780	2.390	3.100	930	540
16	2.190	3.780	1.790	3.090	1.390	1.200	2.490	4.300	2.190	3.780	1.790	3.090	700	540
20	1.750	3.780	1.430	3.090	1.110	1.200	1.990	4.300	1.750	3.780	1.430	3.090	560	540
Depth of cut														

ae	ap
Max: 0,5D	Max: 0,03D

Frontal Milling 5<L/D ≤ 6

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	90~110m/min		70~90m/min		50~70m/min		100~120m/min		90~110m/min		70~90m/min		20~40m/min	
DC	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
12	2.650	2.670	2.120	2.140	1.590	800	2.920	2.940	2.650	2.670	2.120	2.140	800	350
16	1.990	2.670	1.590	2.140	1.190	800	2.190	2.940	1.990	2.670	1.590	2.140	600	350
20	1.590	2.670	1.270	2.130	960	810	1.750	2.940	1.590	2.670	1.270	2.130	480	350
Depth of cut														

ae	ap
Max: 0,5D	Max: 0,02D

PXHF-AM

Side Milling

	Prehardened Steel • Hardened Steel ~45HRC		Hardened Steel ~62HRC		Hardened Steel ~70HRC		Stainless Steel ≤200HB		Cobalt Chromium Based Alloy (Stellite)		Titanium Alloy		Ni based Alloy (Inconel 718)	
Vc	80~100m/min		50~70m/min		50~70m/min		100~120m/min		90~110m/min		70~90m/min		30~50m/min	
DC	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)	S (min^{-1})	F (mm/min)
12	2.390	1.200	1.590	570	1.060	230	2.650	1.340	2.390	1.200	1.590	570	800	230
16	1.790	1.200	1.190	570	800	230	1.990	1.340	1.790	1.200	1.190	570	600	230
20	1.430	1.200	960	580	640	230	1.590	1.340	1.430	1.200	960	580	480	230
Depth of cut	ae: Max: 0,05D / ap: Max: 0,5D		ae: Max: 0,02D / ap: Max: 0,5D				ae: Max: 0,05D / ap: Max: 0,5D				ae: Max: 0,02D / ap: Max: 0,5D			

1. This tool is recommended for the roughing of additive manufacturing and mold overlay surfaces.
2.Please use machines and holders that are rigid and highly accurate.
3. The values listed above are for reference. Please set the cutting condition in accordance with the actual machining environment.
4.Please reduce the feed rate when the depth of cut is greater than specified.
5. Please adjust the cutting condition when the overhang length is longer.
6. Please use a suitable fluid with high smoke retardant properties.
7. During dry (no fluid) milling, please use air blow to remove disposable chips from the milling area and to eliminate chip packing.
8. Please use water-soluble coolant when machining stainless steel, cobalt-chromiumalloy, titanium alloy, and Ni-based alloy.
9.Tool runout should be kept to a minimum for maximum accuracy.
10. When the cutting load fluctuates in areas such as the corners, please reduce the rotational speed.
11. If the pick amount is 0.5 x D or more, cusp may occur on the machined surface.

During machining, please program the milling paths according to the recommended simulated R (rt) respective to the individual end mill diameter.

MOUNTING PROCEDURE

1. Initial Tightening (BT30)

Make sure the fastening portion of the collet is clean then insert it into the holder. Turn the pull stud to tighten.

*For models other than BT30 please refer to the instructions below.

2. Final Tightening

Tighten with a spanner wrench

3. Cleaning

Remove dirt and chips from the connecting thread and collet

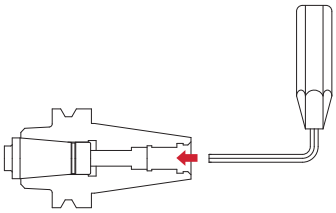
4. Mounting the Head

After screwing the head in by hand, use the PXM spanner wrench to tighten.

Mounting procedure for holders other than BT30

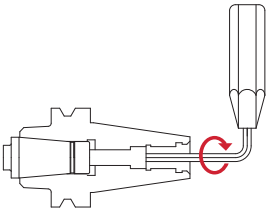
①

Insert the hexagon socket wrench into the pull screw hexagonal section.
*For pull studs with holes (φ6 or above), it is operational with the stud being attached.



②

To prevent the collet from rotating, support the tip of the collet by hand, tighten with the wrench by turning to the right, then fastening to the required torque.
*Recommended tightening torque: 18N·m



Cautions during use

- Only use the spanner wrenches that are designed specifically for the PXM (p.24) for attaching PXM heads . Please do not use alternative spanner wrenches sold on the market as a replacement.
- Please refer to p.24 for tightening torque.
- Please tighten until the head and the collet faces meet. Confirm that there is no gap.
- Degreasing the connecting thread may result in over tightening or a possible separation of the faces. Please do not degrease.
- Please make sure that the spanner wrench is inserted properly and turn it slowly during use.

Abundant exchangeable milling heads! Exchangeable head end mill PXM

The PXM is an exchangeable head end mill series with the same high performance of a solid tool and the cost efficiency of an indexable tool. A single exchangeable head body is able to accommodate a wide range of exchangeable heads to meet various application needs.

Available shapes

- Square Type
- Roughing Type
- Corner Radius Type
- Ball Type

Please see OSG PHOENIX Catalog for details.

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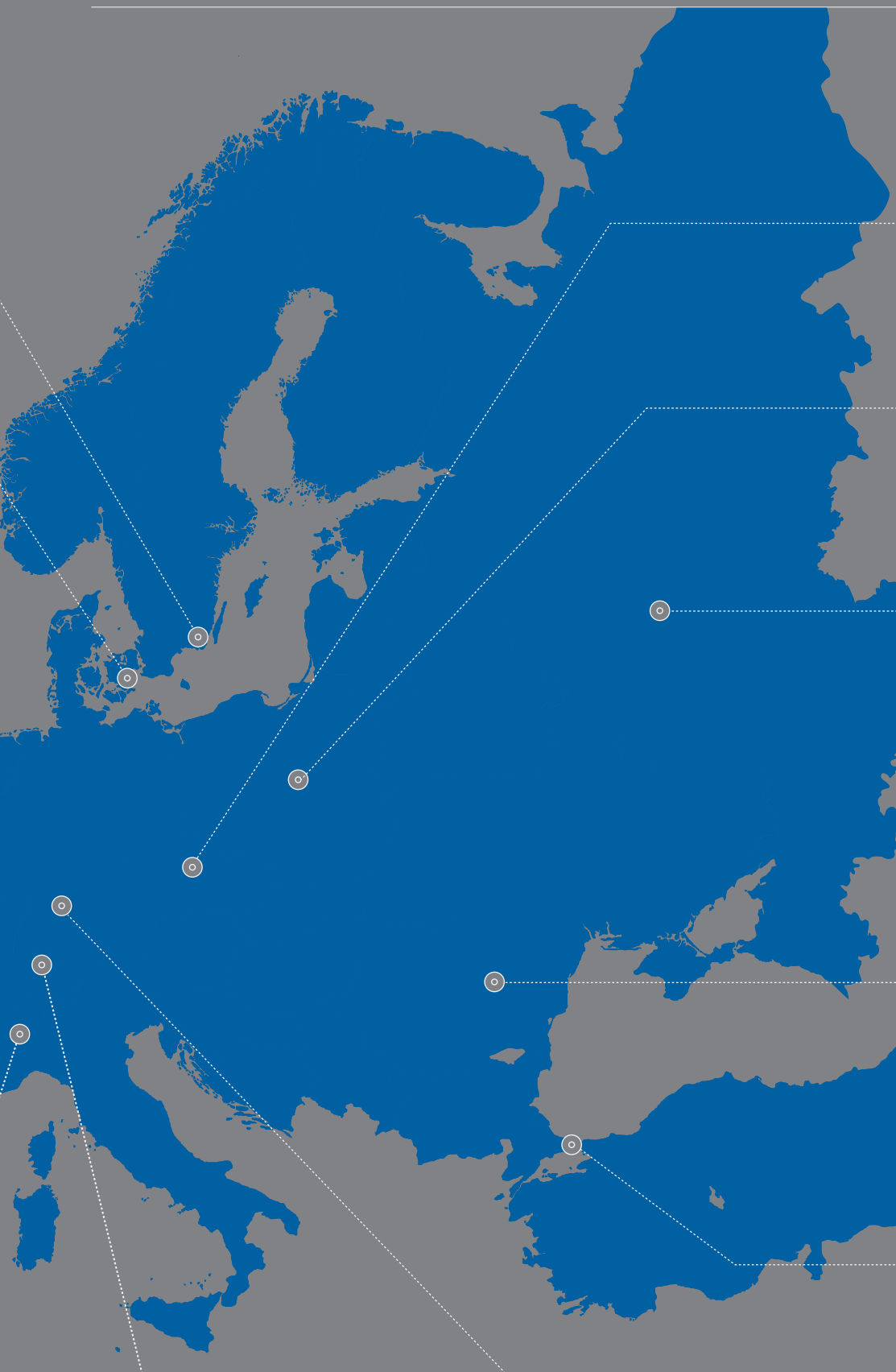

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