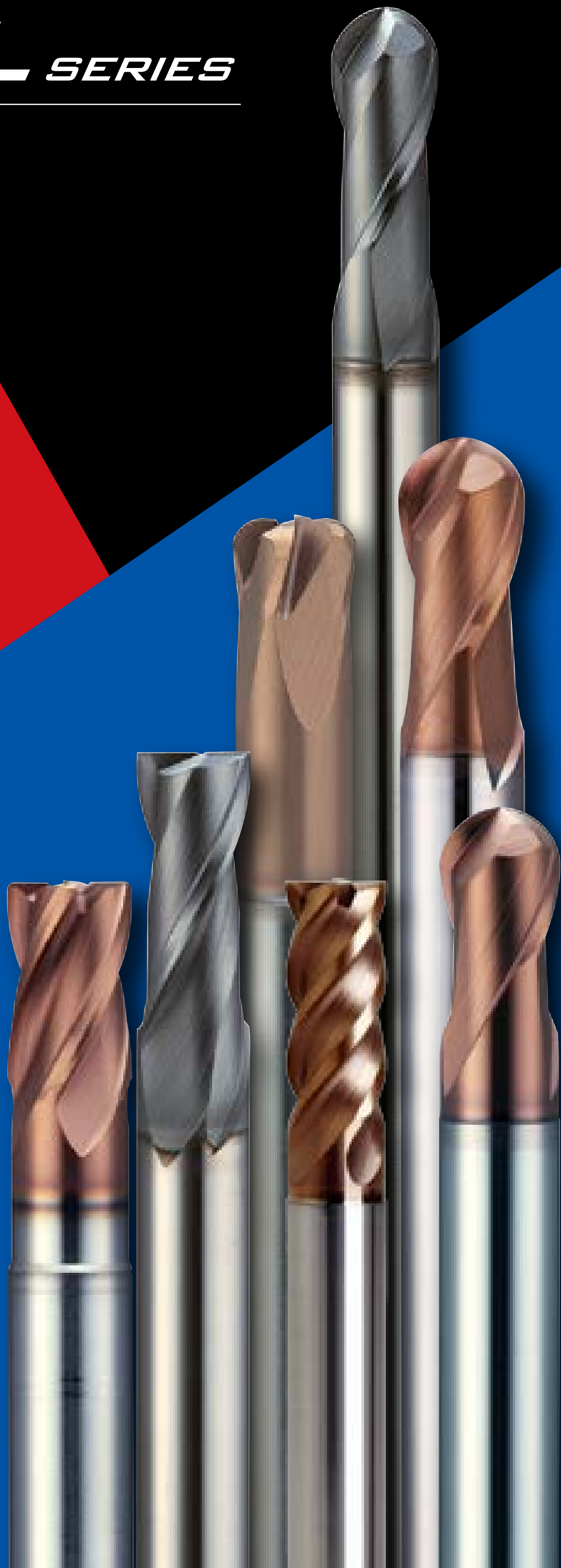
NEW

MOLDINO
The Edge To Innovation

EPOCH GLOBAL SERIES

Epoch G End Mill series



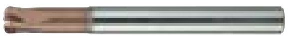
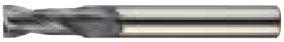
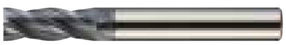
MOLDINO Tool Engineering, Ltd.

New Product News | No. H2205A-1 | 2022-08

Abundant lineup with a total of 118 items covers a broad machining range

Epoch G End Mill series

Line-up

Shape	Item code	Size(mm)	No. of items	Coating	Photo
Ball	Epoch G Ball Panacea **HGOB2-PN**	ϕ0.3～ϕ20	19 items	PN	
	Epoch G Ball -TH **HGOB2-TH**	ϕ0.5～ϕ20	13 items	TH	
	Global Forging Ball **HGFB2-TH**	ϕ2～ϕ12	7 items	TH	
Radius	Epoch G Turbo 2NT -TH **HGOF2-TH**	ϕ2～ϕ12	8 items	TH	
	Epoch G Turbo 4NT -TH **HGOF4-TH**	ϕ2～ϕ12	8 items	TH	
	Epoch G Radius 4NT -TH **HGOR4-TH**	ϕ6～ϕ20	15 items	TH	
Square	Epoch G Square 2NT Panacea **HGOS2-PN**	ϕ0.2～ϕ20	26 items	PN	
	Epoch G Square 4NT Panacea **HGOS4-PN**	ϕ1～ϕ20	13 items	PN	
	Epoch G Square 4NT -TH **HGOSH4-TH**	ϕ1～ϕ12	9 items	TH	

Coating

New PaNacea Coating

- A heat-resistant coating material with excellent adhesion to the tool substrate was achieved by optimizing the Al content.
- Exhibits with good wear resistance due to doping of the AlCr coating layer with Si.
- Exhibits excellent cutting life for cutting materials such as plastic molds, etc. where tool seizure often occurs. Provides the long life in cutting processing of materials such as prehardened steel, carbon steel, alloy steel, S420 type, H13, D2, etc.
- By improving heat resistance, long life are possible for both wet cutting and dry cutting.

Note) This product obtains less electric conductivity. Therefore, Please caution of using electri

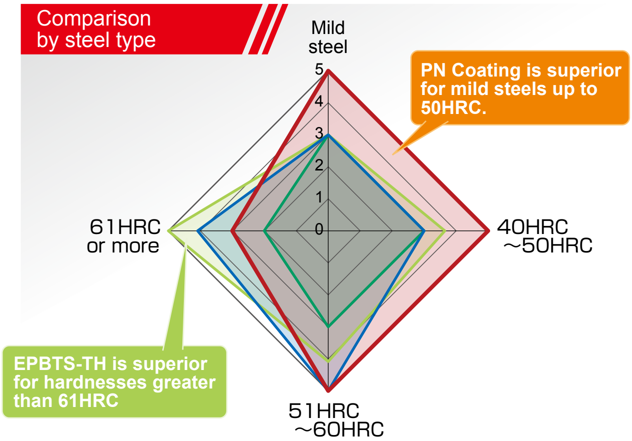
Advanced TH Coating

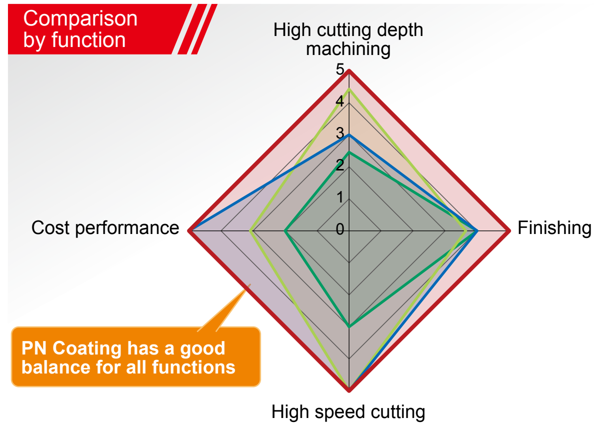
- Hardness and oxidation resistance of TH Coating is further improved. Enables longer life and higher efficient when cutting high-hardness materials with 55HRC or higher .(Si nano composite coating with finer crystal particles)
- Long life for both dry cutting and wet cutting

Concept

●Ball End Mill

HGOB-PN High-efficiency machining at high cutting depths. Stable even for finishing.
HGOB-TH Ideal for high-efficiency machining of high-hardness materials.

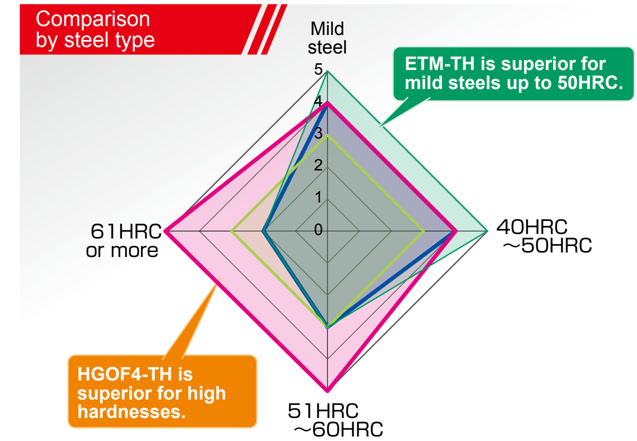


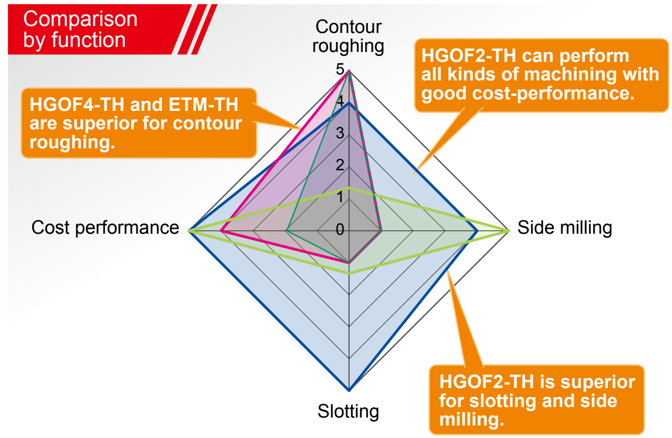


HGOB-TH | HGOB-PN | EPBTS-TH | Conventional general end mill

●Radius End Mill

HGOF-TH Ultra-high-efficiency contour machining can be performed. (HGOF2-TH can also perform slotting or side milling.)
HGOR-TH For general-purpose machining region with focus on side milling.





HGOF2-TH | HGOF4-TH | HGOR4-TH | ETM-TH

Cutting area

Newly developed PN Coating and the TH Coating with its excellent results enable high-efficiency machining for wide-ranging applications from roughing to finishing on a broad range of cutting materials.

■ Table of suitability of each coating for various cutting materials

Coating	Low-carbon steel	Alloy steels	Pre-hardened steels	Hardened steels		Stainless steels	Cast iron, Ductile cast iron	Non-ferric Aluminum alloy; Copper
				~50HRC	51~60HRC			
PN	◎	◎	◎	◎	○	◎	◎	◎
TH		◎	◎	◎	◎			

Can handle machining of plastic molds, diecast molds, press dies, or various parts.

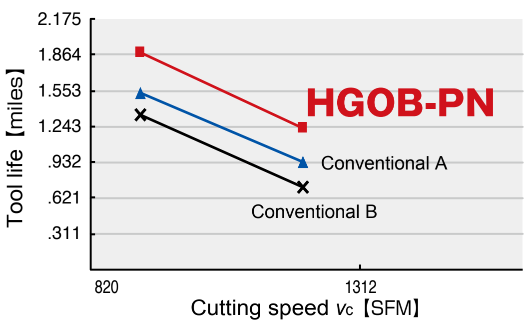
Field data

Performance of HGOB-PN and HGOS-PN

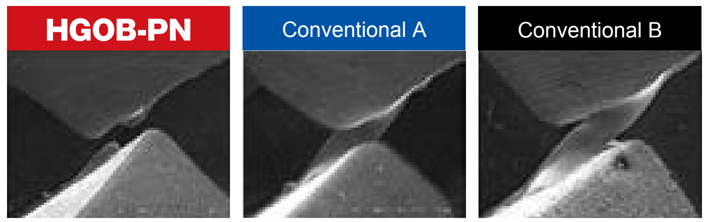
01 Life comparison when cutting high-performance plastic mold material

Tool: Ball End Mill (R3mm×2NT)

Cutting conditions n=15,000、20,000min^{-1}、v_f=236、315 IPM、 a_p×a_e= .016 x .008 inch、 Dry, Air-blow
Work material = Prehardened Steel（40HRC）



Cutting condition n=20,000min^{-1}、v_f=315 IPM
a_p×a_e=.016 x .008 inch Cutting distance L=2.5 miles

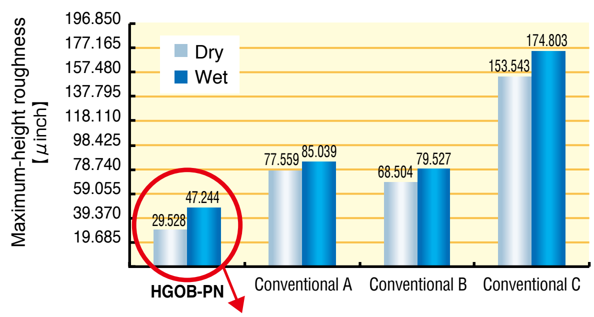


Provides stable machining in all rotation regions.

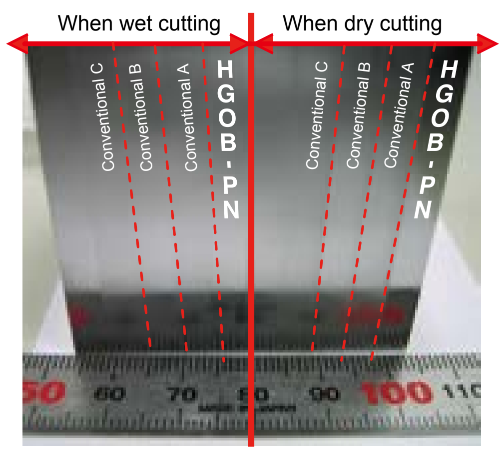
02 Comparison of machined surface grade when cutting carbon steel 1050

Tool: Ball End Mill (R1mm×2NT)

Cutting conditions n=24,000min^{-1} v_f=125 IPM
a_p×a_e=.004 x .004 inch
Work material =1050（200HB）
Coolant：Dry、Wet



HGOB-PN is good for both dry and wet cutting

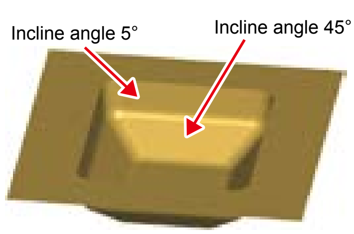


Comparison of machined surface gloss condition

03 Comparison of chipping damage when cutting hardened steel AISI 420

Tool: Ball End Mill (R3mm×2NT)

Cutting conditions n=19,200min^{-1} v_f=145 IPM a_p×a_e=.028 x .085 inch Work material =AISI 420
Coolant：Wet Cutting distance：1 pocketing（Cutting distance 32.81 feet）



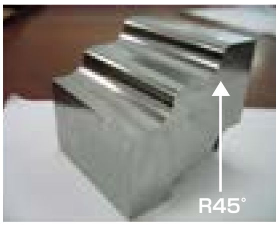
Upper ：1.378 x 1.575 inch
Bottom ：.866 x .669 inch
Depth ：Incline 5°（0～.315 inch）
Incline 45°（.315~.551 inch）

HGOB-PN is the best for high-performance cutting.

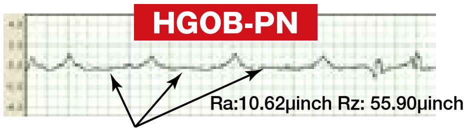
04 Comparison of machined surface when cutting general-purpose plastic mold material 4140

Tool: Ball End Mill (R3mm×2NT)　　Work material：4140 (30HRC)

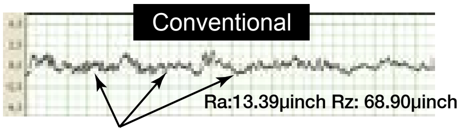
Process	Tool	Radius(mm)	Revolution (min-1)	Feed rate (IPM)	Depth of cut $a_p \times a_e$ (inch)	Coolant
Contour roughing	HGOB2060-PN	R3	8,000	76	.020 x .047	Air-blow
Contour finishing	HGOB2060-PN	R3	12,200	110	.008 x .008	Water base
Contour finishing (high-grade)	HGOB2060-PN	R3	12,200	110	.006 x .006	Water base
	Conventional					



Comparison of machined surface roughness of R45° section in pick direction



Good machined surface without vibrations

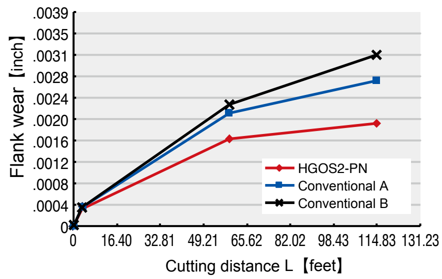


Vibrations occur within pitch

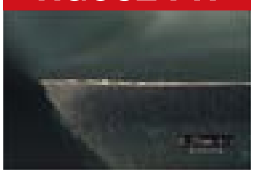
05 Side cutting surface comparison data on carbon steel 1050

Tool: Square End Mill (φ6mm×2NT)

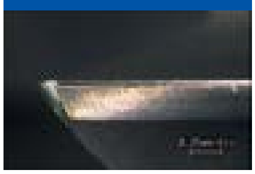
Cutting conditions
Work material =1050 (200HB)　Cutting distance：114.83 feet
n=4,700min^{-1}　v_f=11 IPM　$a_p \times a_e$=.354 x .024 inch　Coolant：Wet



HGOS2-PN



Conventional A

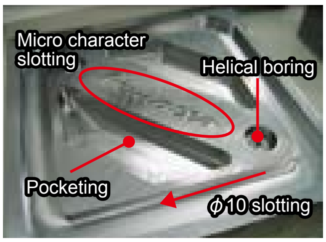


Conventional B

With HGOS2-PN, wear progress was the slowest and most stable.

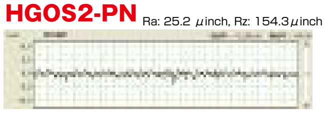
06 Part machining data on carbon steel 1050

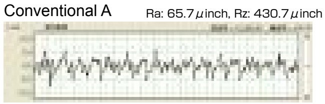
Process	Machined shape	Tool	Tool dia. (mm)	Revolution (min-1)	Feed rate (IPM)	Depth of cut $a_p \times a_e$ (inch)	Coolant	Cutting distance (inch)
Contour roughing	Helical boring	HGOS2060-PN	φ6	10,000	11.8	.256 x .079	Air-blow	28.5
Contour roughing	Pocketing	HGOS2060-PN	φ6	11,000	25.6	.256 x .024	Air-blow	111.7
Edge cutting	Character slotting	HGOS2010-PN	φ1	22,300	8.8	.020 x .039	Air-blow	12.8
Edge cutting	Slotting	HGOS2100-PN	φ10	1,250	6.9	.157 x .394	Air-blow	25.7



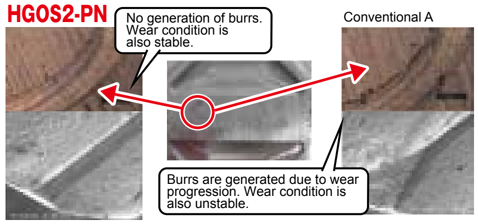
In addition to side surface and grooving, it can also be used in a variety of other ways.

Comparison of bottom surface roughness for slotting





Character slotting



Field data

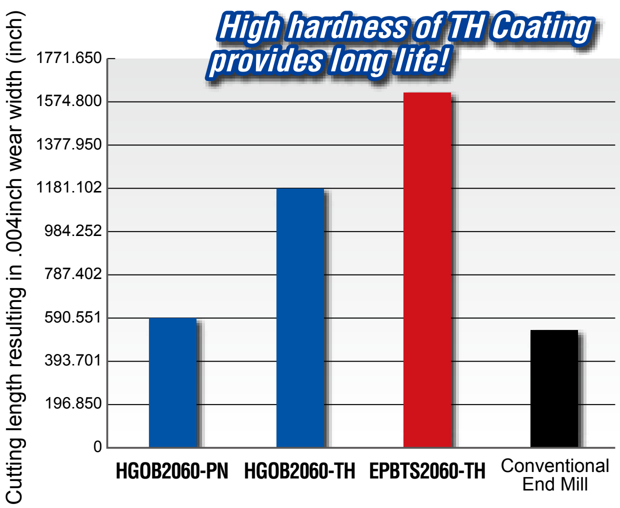
Performance of HGOB-TH

01 Direct-carving machining of cold-forged die material

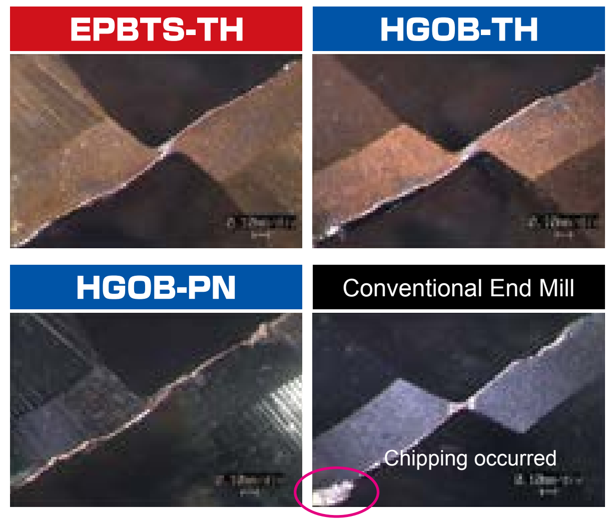
Work material : D2 (60HRC), Tool : R3mm×2NT

Cutting conditions n=10,000min^{-1} (v_c=617 SFM) v_f=118.1 IPM (f_z=.006 IPT) a_p×a_e= .014 x .043 inch
Air-blow

Comparison of tool life



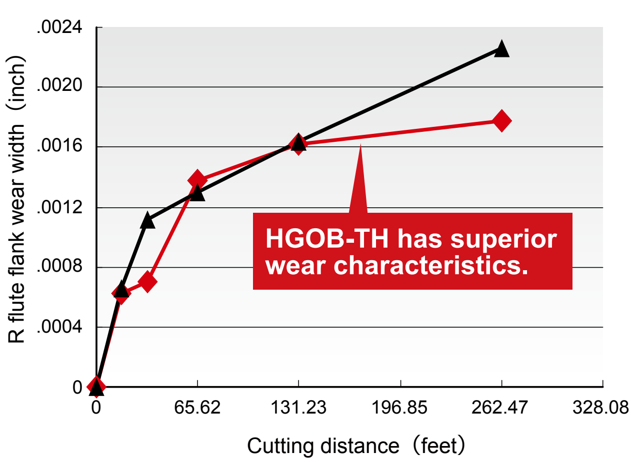
Photograph of wear after cutting 65.62 feet



02 Direct-carving machining of hot-forged die material

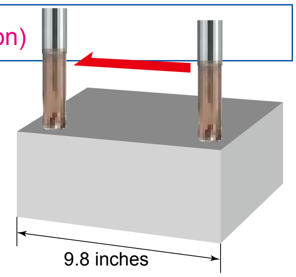
Work material : H13 (45HRC), Tool : R1mm×2NT

Cutting conditions n=30,000min^{-1} (v_c=617 SFM) v_f=66.9 IPM (f_z=.001 IPT) a_p×a_e= .008 x .024 inch
Air-blow、Cutting distance 262 feet



Performance of HGOF4-TH

01 Bottom machining of high-hardness materials (Feed limit evaluation)



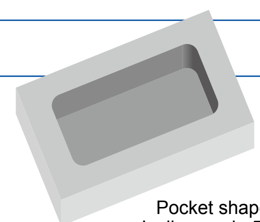
Work material : D2 (60HRC), Tool : ϕ10mm×R2mm HGOF4100-20-TH

Cutting conditions
n=1,600min^{-1} (v_c=164 SFM)、v_f = below table
a_p×a_e= .012 x .012 inch Air-blow

V_f (IPM)	39.4	47.2	55.1	63.0	70.9
f_z (IPT)	f_z=.006	f_z=.007	f_z=.009	f_z=.010	f_z=.011
HGOF4-TH	○	○	○	○	○
Conventional radius end mill	×				

Epoch G Turbo with low cutting resistance is particularly superior for high-efficiency machining of high-hardness materials.

02 High-efficiency pocket machining (Life evaluation)



Pocket shape
Incline angle 5°
1.7(W) x 3.5(L) x 1.0(D) inch

Work material : H13 (50HRC), Tool : ϕ6mm×R1.5mm HGOF4060-15-TH

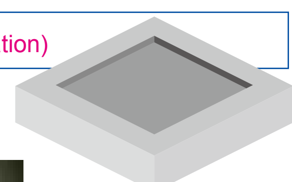
Cutting conditions
n=4,200min^{-1} (v_c=259 SFM) v_f=198.4 IPM (f_z=.012 IPT)
a_p×a_e= .012 x .118 inch Air-blow Cutting time：30min.

HGOF4-TH

Conventional end mill

Wear is small even for high-efficiency machining.

03 High-efficiency roughing of powder metallurgy HSS (Life evaluation)

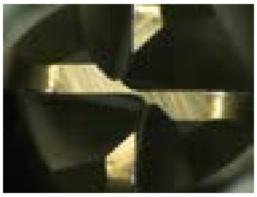


Pocket shape
3.15 x 3.15 x .024 inch

Work material : Powdered High-speed Tool Steel (67HRC), Tool : ϕ4mm×R1mm, HGOF4040-10-TH

Cutting conditions
n=4,800min^{-1} (v_c=197 SFM) v_f=198.4 IPM (f_z=.002 IPT)
a_p×a_e= .006 x .067 inch Mist-blow、

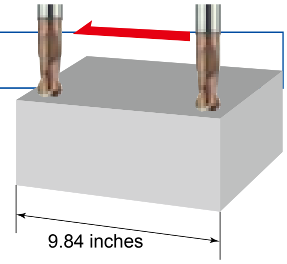
High-efficiency roughing of powder metallurgy HSS. Machining time: Approx. 18 min.



Wear width: .002 inch
Cutting length: 65.6 feet

Performance of HGOF2-TH

01 Bottom cutting (Feed limit evaluation)



Work material : Equivalent to AISI 420 (52HRC), Tool : ϕ6mm×R1.5mm HGOF2060-15-TH

Cutting conditions n=2,700min^{-1} (v_c=164 SFM) v_f=below table
OH=.945 inches (4D)、a_p×a_e=.012 x .059 inch Air-blow

V_f (IPM) / f_z (IPT)	19.7	39.4	59.1	78.7	98.4	118.1	137.8
	f_z=.004	f_z=.007	f_z=.011	f_z=.014	f_z=.018	f_z=.022	f_z=.026
HGOF2060-15-TH	○	○	○	○	○	○	○
Conventional general 2flutes radius end mill	○	Chipping					

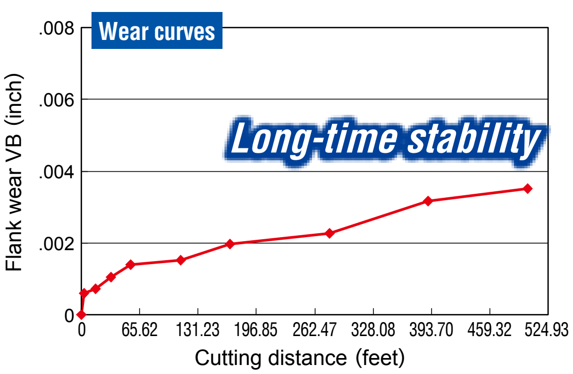
More than 7 times the machining efficiency.

Epoch G Turbo enables machining at far higher feed rates.

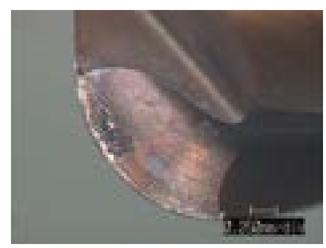
02 Bottom cutting (Life evaluation)

Work material : Equivalent to AISI 420 (52HRC), Tool : HGOF2060-15-TH

Cutting conditions n=2,700min^{-1} (v_c=164 SFM) v_f=63.8 IPM (f_z=.012 IPT) OH=.945 inches (4D)
a_p×a_e=.012 x .059 inch Cutting time：94min. Air-blow

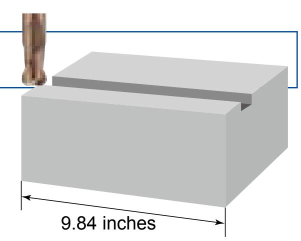


After cutting distance of 508.53 feet



Interrupted cutting possible

03 Slotting (High-efficiency slotting)



Work material : Equivalent to AISI 420 (52HRC), Tool : ϕ6mm×R1.5mm HGOF2060-15-TH

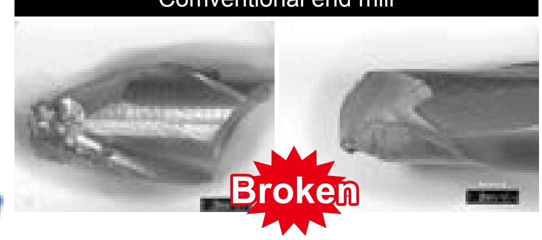
Cutting conditions n=3,200min^{-1} (v_c=197 SFM) v_f=9.8 IPM (f_z=.002 IPT)、
OH=.945 inches (4D) a_p×a_e=.236 x.236 inch Air-blow

After 1 slotting

HGOF2-TH

Ultra-high-efficiency slotting

Comventional end mill

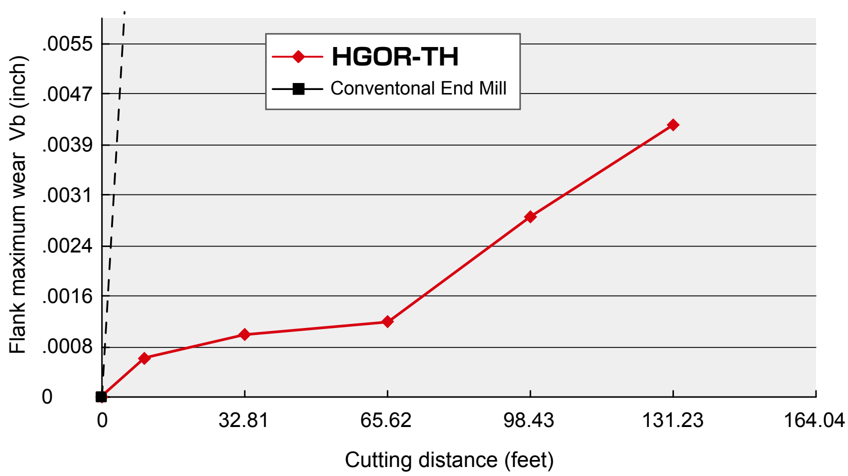


Performance of HGOR-TH

01 Comparison data for side milling of pre-hardened steel material for plastic mold

Work material : Pre-hardened steel (40HRC), Tool : ϕ6mm×4NT

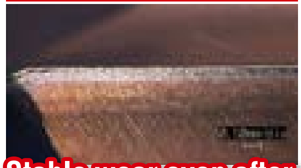
Cutting conditions n=4,250min^{-1} (v_c=262 SFM) v_f=20.1 IPM (f_z=.001 IPT)
a_p×a_e=.236 x .024 inch Air-blow



Conventonal End Mill

Chipping at 9.8 inches

HGOR-TH

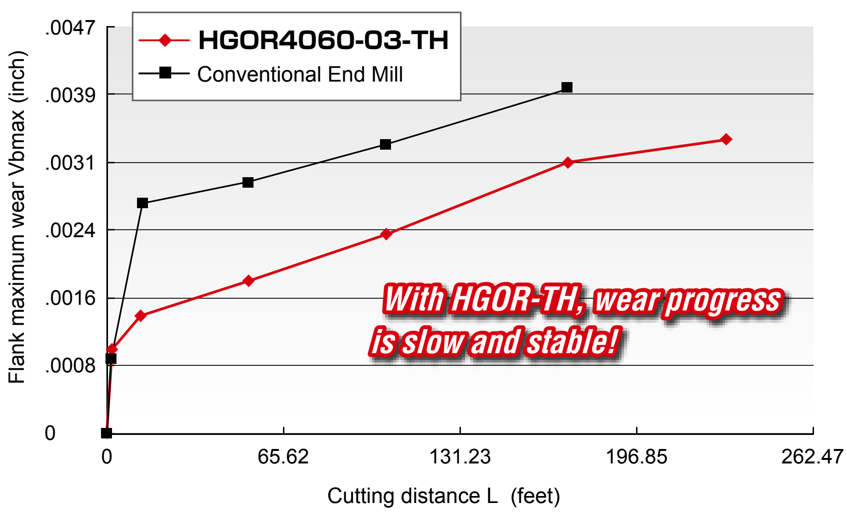


Stable wear even after cutting 65.62 feet

02 Comparison data for side milling of NO.35 B cast-iron material

Work material : NO.35 B, Tool : ϕ6mm×4NT

Cutting conditions n=9,550min^{-1} (v_c=614 SFM) v_f=90.2 IPM (f_z=.002 IPT)
a_p×a_e=.118 x .197 inch Air-blow



Photograph of wear after cutting 98.43 feet

Conventional End Mill

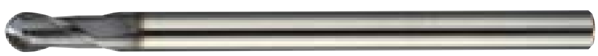
HGOR-TH

Line Up

Epoch G Ball

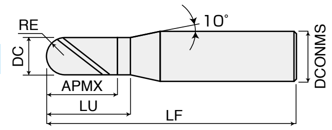
HGOB-PN Panacea

RE accuracy : Right table

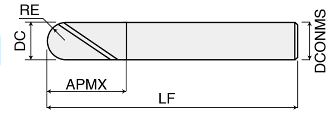


Tolerance on shank : h5

A type



B type



(mm)

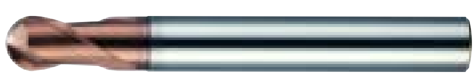
RE	RE accuracy
0.15~6	±0.005
8~10	±0.01

HGOB2○○○(-○)-PN

Item code	Stock	Size (mm)							No. of flutes	Type	Coating
		Ball radius RE	Tool dia. DC	Flute length APMX	Under neck length LU	Neck dia. DN	Overall length LF	Shank dia. DCONMS			
HGOB2003-PN	●	0.15	0.3	0.6	0.9	—	50	4	2	A	PN
HGOB2004-PN	●	0.2	0.4	0.8	1.1	—	50	4	2	A	PN
HGOB2005-PN	●	0.25	0.5	1	1.3	—	50	4	2	A	PN
HGOB2006-PN	●	0.3	0.6	1.2	1.5	—	50	4	2	A	PN
HGOB2008-PN	●	0.4	0.8	1.6	1.9	—	50	4	2	A	PN
HGOB2010-PN	●	0.5	1	2.5	3.5	—	50	4	2	A	PN
HGOB2015-PN	●	0.75	1.5	4	5	—	50	4	2	A	PN
HGOB2020-PN	●	1	2	5	6	—	50	6	2	A	PN
HGOB2025-PN	●	1.25	2.5	7	8	—	50	6	2	A	PN
HGOB2030-PN	●	1.5	3	8	9	—	70	6	2	A	PN
HGOB2040-4-PN	●	2	4	8	—	—	70	4	2	B	PN
HGOB2040-PN	●	2	4	8	9	—	70	6	2	A	PN
HGOB2050-PN	●	2.5	5	10	11	—	80	6	2	A	PN
HGOB2060-PN	●	3	6	12	—	—	90	6	2	B	PN
HGOB2080-PN	●	4	8	14	—	—	100	8	2	B	PN
HGOB2100-PN	●	5	10	18	—	—	100	10	2	B	PN
HGOB2120-PN	●	6	12	22	—	—	110	12	2	B	PN
HGOB2160-PN	●	8	16	30	—	—	140	16	2	B	PN
HGOB2200-PN	●	10	20	38	—	—	160	20	2	B	PN

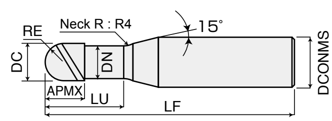
HGOB-TH

RE accuracy : Right table

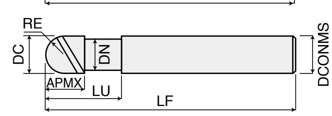


Tolerance on shank :h5

A type



B type



R8 and R10 don't have LU and DN

(mm)

RE	RE accuracy
0.15~6	±0.005
8~10	±0.01

HGOB2○○○-TH

Item code	Stock	Size (mm)							No. of flutes	Type	Coating
		Ball radius RE	Tool dia. DC	Flute length APMX	Under neck length LU	Neck dia. DN	Overall length LF	Shank dia. DCONMS			
HGOB2005-TH	●	0.25	0.5	0.5	1.25	0.47	40	4	2	A	TH
HGOB2010-TH	●	0.5	1	1	2.5	0.95	40	4	2	A	TH
HGOB2015-TH	●	0.75	1.5	1.5	3.75	1.45	40	4	2	A	TH
HGOB2020-TH	●	1	2	2	5	1.95	40	6	2	A	TH
HGOB2030-TH	●	1.5	3	3	7.5	2.9	45	6	2	A	TH
HGOB2040-TH	●	2	4	4	10	3.9	45	6	2	A	TH
HGOB2050-TH	●	2.5	5	5	12.5	4.9	50	6	2	A	TH
HGOB2060-TH	●	3	6	6	15	5.9	50	6	2	B	TH
HGOB2080-TH	●	4	8	8	20	7.9	60	8	2	B	TH
HGOB2100-TH	●	5	10	10	25	9.9	65	10	2	B	TH
HGOB2120-TH	●	6	12	12	30	11.9	75	12	2	B	TH
HGOB2160-TH	●	8	16	16	—	—	140	16	2	B	TH
HGOB2200-TH	●	10	20	20	—	—	160	20	2	B	TH

●：Inventory maintained in US

Special strong geometry provides both rigidity and good cutting performance.

Features of HGFB-TH

Enables high-efficient machining with increased cutting depth and feed rate.
Ideal for high-efficient machining from roughing to finishing of 35HRC or higher materials.

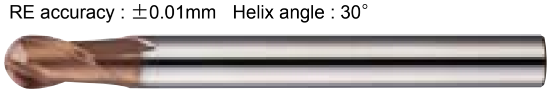
TH Coating

- Exhibits amazing performance when cutting high-hardness materials (35HRC or higher). Double the tool life and more than double the machining efficiency. Cold-worked die steel, HSS, tool steel, composite materials, carbide alloys, etc.
- Long life for both dry cutting and wet cutting.

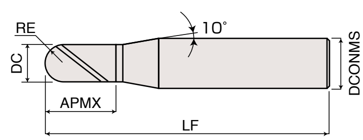
Global Forging Ball

HGFB-TH

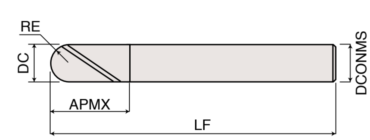
RE accuracy : ±0.01mm Helix angle : 30°



Tolerance on shank :h5



A type



B type

HGFB2○○○-TH

Item Code	Stock	Size (mm)					No. of flutes	Type	Coating
		Ball radius	Tool dia.	Flute length	Overall length	Shank dia.			
		RE	DC	APMX	LF	DCONMS			
HGFB2020-TH	●	**1**	**2**	**3**	50	6	2	A	TH
HGFB2030-TH	●	**1.5**	**3**	**4.5**	70	6	2	A	TH
HGFB2040-TH	●	**2**	**4**	**6**	70	6	2	A	TH
HGFB2060-TH	●	**3**	**6**	**9**	90	6	2	B	TH
HGFB2080-TH	●	**4**	**8**	**12**	100	8	2	B	TH
HGFB2100-TH	●	**5**	**10**	**15**	100	10	2	B	TH
HGFB2120-TH	●	**6**	**12**	**18**	110	12	2	B	TH

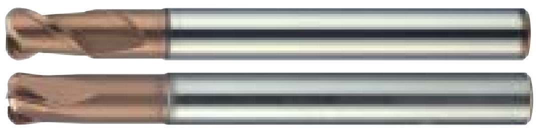
Line Up

Epoch G Turbo

HGOF-TH

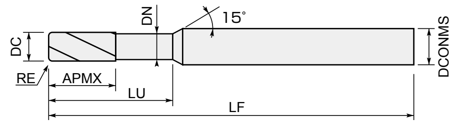
2 flutes

4 flutes

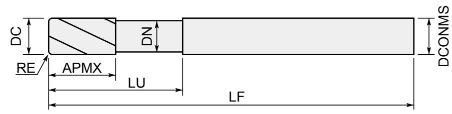


Tolerance on dia. : 0 / −0.03mm

A type



B type



HGOF2○○○-○○-TH

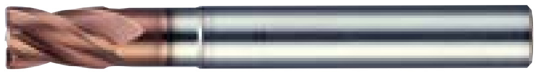
Item code	Stock	Size (mm)							No. of flutes	Type	Coating
		Tool dia.	Corner radius	Flute length	Under neck length	Neck dia.	Overall length	Shank dia.			
		DC	RE	APMX	LU	DN	LF	DCONMS			
HGOF2020-05-TH	★	2	0.5	3	6	1.9	60	6	2	A	TH
HGOF2030-08-TH	★	3	0.8	4.5	9	2.9	60	6	2	A	TH
HGOF2040-10-TH	★	4	1	6	12	3.8	60	6	2	A	TH
HGOF2050-12-TH	★	5	1.2	7.5	15	4.7	60	6	2	A	TH
HGOF2060-15-TH	★	6	1.5	9	18	5.7	60	6	2	B	TH
HGOF2080-20-TH	★	8	2	12	24	7.6	75	8	2	B	TH
HGOF2100-20-TH	★	10	2	15	30	9.5	80	10	2	B	TH
HGOF2120-20-TH	★	12	2	18	36	11.5	100	12	2	B	TH

HGOF4○○○-○○-TH

Item code	Stock	Size (mm)							No. of flutes	Type	Coating
		Tool dia.	Corner radius	Flute length	Under neck length	Neck dia.	Overall length	Shank dia.			
		DC	RE	APMX	LU	DN	LF	DCONMS			
HGOF4020-05-TH	●	2	0.5	1	6	1.9	60	6	4	A	TH
HGOF4030-08-TH	●	3	0.8	1.5	9	2.9	60	6	4	A	TH
HGOF4040-10-TH	●	4	1	2	12	3.8	60	6	4	A	TH
HGOF4050-12-TH	●	5	1.2	2.5	15	4.7	60	6	4	A	TH
HGOF4060-15-TH	●	6	1.5	3	18	5.7	60	6	4	B	TH
HGOF4080-20-TH	●	8	2	4	24	7.6	75	8	4	B	TH
HGOF4100-20-TH	●	10	2	5	30	9.5	80	10	4	B	TH
HGOF4120-20-TH	●	12	2	6	36	11.5	100	12	4	B	TH

Epoch G Radius

HGOR-TH



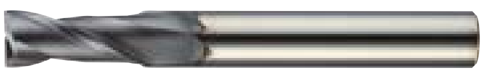
Tolerance on dia. : 0 / −0.03mm

HGOR4○○○-○○-TH

Item code	Stock	Size (mm)							No. of flutes	Coating
		Tool dia.	Corner radius	Flute length	Under neck length	Neck dia.	Overall length	Shank dia.		
HGOR4060-03-TH	●	6	0.3	9	18	5.7	50	6	4	TH
HGOR4060-05-TH	●	6	0.5	9	18	5.7	50	6	4	TH
HGOR4060-10-TH	●	6	1	9	18	5.7	50	6	4	TH
HGOR4080-03-TH	●	8	0.3	12	24	7.6	55	8	4	TH
HGOR4080-05-TH	●	8	0.5	12	24	7.6	55	8	4	TH
HGOR4080-10-TH	●	8	1	12	24	7.6	55	8	4	TH
HGOR4100-03-TH	●	10	0.3	15	30	9.5	70	10	4	TH
HGOR4100-05-TH	●	10	0.5	15	30	9.5	70	10	4	TH
HGOR4100-10-TH	●	10	1	15	30	9.5	70	10	4	TH
HGOR4120-03-TH	●	12	0.3	18	36	11.5	75	12	4	TH
HGOR4120-10-TH	●	12	1	18	36	11.5	75	12	4	TH
HGOR4160-05-TH	●	16	0.5	24	48	15	90	16	4	TH
HGOR4160-20-TH	●	16	2	24	48	15	90	16	4	TH
HGOR4200-05-TH	●	20	0.5	30	60	19	100	20	4	TH
HGOR4200-20-TH	●	20	2	30	60	19	100	20	4	TH

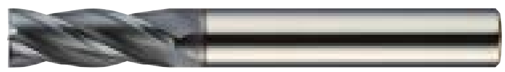
Epoch G Square

HGOS2-PN Panacea

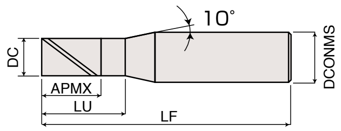


Tolerance on dia. : Below table　　Tolerance on shank : h5

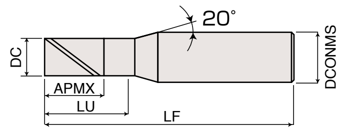
HGOS4-PN Panacea



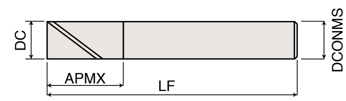
Tolerance on dia. : Below table　　Tolerance on shank : h5



A type



B type



C type

HGOS2○○○-PN

(mm)

Tool dia.	Dia. tolerance
0.2~0.9	0~−0.015
1~20	0~−0.02

Item code	Stock	Size (mm)					No. of flutes	Type	Coating
		Tool dia.	Flute length	Under neck length	Overall length	Shank dia.			
		DC	APMX	LU	LF	DCONMS			
HGOS2002-PN	★	0.2	0.4	0.6	40	4	2	A	PN
HGOS2003-PN	★	0.3	0.6	0.9	40	4	2	A	PN
HGOS2004-PN	★	0.4	0.8	1.1	40	4	2	A	PN
HGOS2005-PN	★	0.5	1	1.3	40	4	2	A	PN
HGOS2006-PN	★	0.6	1.2	1.5	40	4	2	A	PN
HGOS2007-PN	★	0.7	1.4	1.7	40	4	2	A	PN
HGOS2008-PN	★	0.8	1.6	1.9	40	4	2	A	PN
HGOS2009-PN	★	0.9	1.8	2.1	40	4	2	A	PN
HGOS2010-PN	★	1	2	2.5	40	4	2	A	PN
HGOS2015-PN	★	1.5	3	3.5	40	4	2	A	PN
HGOS2020-PN	★	2	6	7	40	4	2	A	PN
HGOS2025-PN	★	2.5	8	9	40	4	2	A	PN
HGOS2030-PN	★	3	8	9	45	6	2	A	PN
HGOS2035-PN	★	3.5	10	11	45	6	2	A	PN
HGOS2040-PN	★	4	11	12	45	6	2	B	PN
HGOS2045-PN	★	4.5	11	12	45	6	2	B	PN
HGOS2050-PN	★	5	13	14	60	6	2	B	PN
HGOS2055-PN	★	5.5	13	14	60	6	2	B	PN
HGOS2060-PN	★	6	13	—	60	6	2	C	PN
HGOS2070-PN	★	7	16	17	70	8	2	B	PN
HGOS2080-PN	★	8	19	—	75	8	2	C	PN
HGOS2090-PN	★	9	19	20	80	10	2	B	PN
HGOS2100-PN	★	10	22	—	80	10	2	C	PN
HGOS2120-PN	★	12	26	—	100	12	2	C	PN
HGOS2160-PN	★	16	35	—	110	16	2	C	PN
HGOS2200-PN	★	20	40	—	125	20	2	C	PN

HGOS4○○○-PN

(mm)

Tool dia.	Dia. tolerance
1~20	0~−0.02

Item code	Stock	Size (mm)					No. of flutes	Type	Coating
		Tool dia.	Flute length	Under neck length	Overall length	Shank dia.			
		DC	APMX	LU	LF	DCONMS			
HGOS4010-PN	★	1	2.5	3	40	4	4	A	PN
HGOS4015-PN	★	1.5	4	4.5	40	4	4	A	PN
HGOS4020-PN	★	2	6	7	40	4	4	A	PN
HGOS4025-PN	★	2.5	8	9	40	4	4	A	PN
HGOS4030-PN	★	3	10	11	45	6	4	A	PN
HGOS4040-PN	★	4	12	13	45	6	4	B	PN
HGOS4050-PN	★	5	15	16	60	6	4	B	PN
HGOS4060-PN	★	6	15	—	60	6	4	C	PN
HGOS4080-PN	★	8	20	—	75	8	4	C	PN
HGOS4100-PN	★	10	25	—	80	10	4	C	PN
HGOS4120-PN	★	12	30	—	100	12	4	C	PN
HGOS4160-PN	★	16	35	—	110	16	4	C	PN
HGOS4200-PN	★	20	40	—	125	20	4	C	PN

●：Inventory maintained in US　★：Inventory maintained in Japan

High-rigidity flute shape and TH Coating enables high-speed finishing of high-hardness steels.

Flute shape designed with consideration given to chip removal enables high-accuracy finishing of pre-hardened steel and hardened steel.

Features of HGOSH-TH

01 Enables high-speed finishing of pre-hardened steel and hardened steel with hardnesses of 35 to 55 HRC.

02 Use of TH Coating with excellent layer hardness and heat-resistance offers long tool life when cutting high-hardness steels.

03 Under neck specifications enable processing depths of up to 3D.

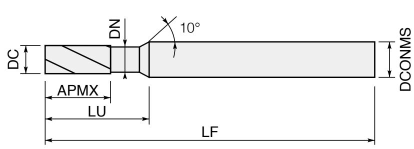
Epoch G Square

HGOSH-TH

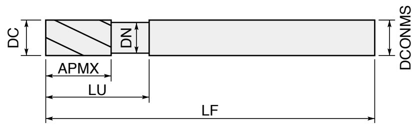
Tolerance on dia. : Right table

Tolerance on shank : h5

A type



B type



(mm)

Tool dia.	Tolerance on dia.
1~6	0 −0.015
8~12	0 −0.02

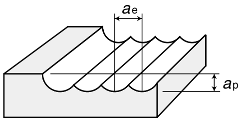
HGOSH4○○○-TH

Item Code	Stock	Size (mm)						No. of flutes	Type	Coating
		Tool dia.	Flute length	Under neck length	Neck dia.	Overall length	Shank dia.			
		DC	APMX	LU	DN	LF	DCONMS			
HGOSH4010-TH	●	1	2	3	0.96	50	6	4	A	TH
HGOSH4015-TH	●	1.5	3	4.5	1.44	50	6	4	A	TH
HGOSH4020-TH	●	2	4	6	1.92	50	6	4	A	TH
HGOSH4030-TH	●	3	6	9	2.88	60	6	4	A	TH
HGOSH4040-TH	●	4	8	12	3.85	60	6	4	A	TH
HGOSH4060-TH	●	6	12	18	5.85	60	6	4	B	TH
HGOSH4080-TH	●	8	16	24	7.8	75	8	4	B	TH
HGOSH4100-TH	●	10	20	30	9.8	80	10	4	B	TH
HGOSH4120-TH	●	12	24	36	11.8	100	12	4	B	TH

● : Inventory maintained in US

Recommended Cutting Conditions (Inch)

HGOB-PN

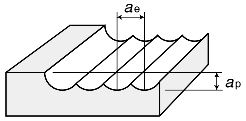


Types of finishing	Ball radius RE (mm)	Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy				Cast iron, Carbon steel (150～200HB) No.35B, 1050, 1060				Stainless steel (25～35HRC) AISI 304, AISI 316			
				Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch	Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch	Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch
Roughing	0.15	0.3	0.6	35,032	82.8	.002	.005	31,847	75.2	.002	.005	28,662	67.7	.001	.004
	0.2	0.4	0.8	35,032	82.8	.002	.006	31,847	75.2	.002	.006	28,662	67.7	.002	.006
	0.25	0.5	1	35,032	82.8	.003	.008	31,847	75.2	.003	.008	28,662	67.7	.002	.007
	0.3	0.6	1.2	29,193	91.9	.003	.009	26,539	83.6	.003	.009	23,885	75.2	.003	.009
	0.4	0.8	1.6	26,274	82.8	.004	.012	23,885	75.2	.004	.012	21,497	67.7	.004	.012
	0.5	1	2.5	28,025	110.4	.005	.015	25,478	100.3	.005	.015	22,930	90.3	.005	.015
	0.75	1.5	4	25,690	121.4	.008	.023	23,355	110.4	.008	.023	21,019	99.3	.007	.022
	1	2	5	24,522	135.2	.010	.031	22,293	122.9	.010	.031	20,064	110.6	.010	.030
	1.25	2.5	7	22,420	141.2	.013	.038	20,382	128.4	.013	.038	18,344	115.6	.012	.037
	1.5	3	8	21,019	148.9	.015	.046	19,108	135.4	.015	.046	17,197	121.9	.015	.044
	2	4	8	20,143	158.6	.020	.061	18,312	144.2	.020	.061	16,481	129.8	.020	.059
			8	20,143	190.3	.020	.061	18,312	173.0	.020	.061	16,481	155.7	.020	.059
	2.5	5	10	18,217	200.8	.026	.077	16,561	182.6	.026	.077	14,904	164.3	.025	.074
	3	6	12	15,764	198.6	.031	.092	14,331	180.6	.031	.092	12,898	162.5	.030	.089
	4	8	14	12,699	180.0	.041	.123	11,545	163.6	.041	.123	10,390	147.2	.039	.118
	5	10	18	10,860	171.0	.051	.154	9,873	155.5	.051	.154	8,885	139.9	.049	.148
	6	12	22	9,634	166.9	.061	.184	8,758	151.7	.061	.184	7,882	136.5	.059	.177
	8	16	30	7,444	140.7	.082	.246	6,768	127.9	.082	.246	6,091	115.1	.079	.236
	10	20	38	5,955	121.9	.102	.307	5,414	110.8	.102	.307	4,873	99.8	.098	.295
Finishing	0.15	0.3	0.6	44,586	70.2	.001	.001	37,155	58.5	.001	.001	33,439	47.4	.001	.001
	0.2	0.4	0.8	42,994	67.7	.001	.001	35,828	56.4	.001	.001	32,245	45.7	.001	.001
	0.25	0.5	1	42,038	66.2	.001	.001	35,032	55.2	.001	.001	31,529	44.7	.001	.001
	0.3	0.6	1.2	35,032	82.8	.001	.001	29,193	69.0	.001	.001	26,274	55.9	.001	.001
	0.4	0.8	1.6	31,051	73.3	.002	.002	25,876	61.1	.002	.002	23,288	49.5	.002	.002
	0.5	1	2.5	30,573	72.2	.002	.002	25,478	60.2	.002	.002	22,930	48.7	.002	.002
	0.75	1.5	4	29,299	69.2	.003	.003	24,416	57.7	.003	.003	21,975	46.7	.003	.003
	1	2	5	29,618	93.3	.004	.004	24,682	77.8	.004	.004	22,213	63.0	.004	.004
	1.25	2.5	7	28,280	89.1	.005	.005	23,567	74.2	.005	.005	21,210	60.1	.005	.005
	1.5	3	8	26,115	82.2	.006	.006	21,762	68.5	.006	.006	19,586	55.5	.006	.006
	2	4	8	24,363	76.7	.008	.008	20,303	63.9	.008	.008	18,272	51.8	.008	.008
			8	24,363	95.9	.008	.008	20,303	79.9	.008	.008	18,272	64.8	.008	.008
	2.5	5	10	22,548	88.8	.010	.010	18,790	74.0	.010	.010	16,911	59.9	.010	.010
	3	6	12	19,427	91.8	.012	.012	16,189	76.5	.012	.012	14,570	62.0	.012	.012
	4	8	14	16,003	75.6	.016	.016	13,336	63.0	.016	.016	12,002	51.0	.016	.016
	5	10	18	14,713	81.1	.020	.020	12,261	67.6	.020	.020	11,035	54.7	.020	.020
	6	12	22	13,535	95.9	.024	.024	11,279	79.9	.024	.024	10,151	64.8	.024	.024
	8	16	30	10,868	85.6	.031	.031	9,057	71.3	.031	.031	8,151	57.8	.031	.031
	10	20	38	7,739	60.9	.039	.039	6,449	50.8	.039	.039	5,804	41.1	.039	.039

【Note】

① PN Coating is less electro conductive. Therefore, electric transmitted measuring systems may not work.
② Use the appropriate coolant for the work material and machining shape.
③ Use a highly rigid and accurate machine as possible.
④ The pick feed in the table is a general condition; please select the *ae* according to the cusp height requested.
⑤ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
⑥ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

Recommended Cutting Conditions (Inch)



HGOB-PN

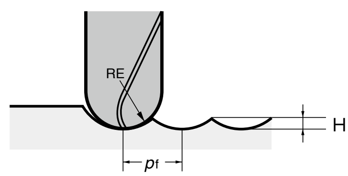
Types of finishing	Ball radius RE (mm)	Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25～35HRC) HPM7, H13, L6				Pre-hardened steel (35～45HRC) HPM-MAGIC, CENA1, NAK80				Hardened steel (45～52HRC) H13, HPM38, DAC-MAGIC			
				Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch	Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch	Revolution *n* min^{-1}	Feed rate *vf* IPM	*ap* inch	*ae* inch
Roughing	0.15	0.3	0.6	28,662	64.3	.001	.004	25,796	54.8	.001	.004	22,930	46.3	.001	.004
	0.2	0.4	0.8	28,662	64.3	.002	.006	25,796	54.8	.002	.005	22,930	46.3	.002	.005
	0.25	0.5	1	28,662	64.3	.002	.007	25,796	54.8	.002	.007	22,930	46.3	.002	.006
	0.3	0.6	1.2	23,885	71.5	.003	.009	21,497	60.9	.003	.008	19,108	51.5	.003	.008
	0.4	0.8	1.6	21,497	64.3	.004	.011	19,347	54.8	.004	.011	17,197	46.3	.003	.010
	0.5	1	2.5	22,930	85.7	.005	.014	20,637	73.1	.005	.014	18,344	61.7	.004	.013
	0.75	1.5	4	21,019	94.3	.007	.021	18,917	80.4	.007	.020	16,815	67.9	.006	.019
	1	2	5	20,064	105.0	.009	.028	18,057	89.6	.009	.027	16,051	75.6	.009	.026
	1.25	2.5	7	18,344	109.8	.012	.035	16,510	93.6	.011	.034	14,675	79.1	.011	.032
	1.5	3	8	17,197	115.8	.014	.043	15,478	98.7	.014	.041	13,758	83.3	.013	.039
	2	4	8	16,481	123.3	.019	.057	14,833	105.1	.018	.054	13,185	88.8	.017	.052
			8	16,481	148.0	.019	.057	14,833	126.1	.018	.054	13,185	106.5	.017	.052
	2.5	5	10	14,904	156.1	.024	.071	13,414	133.1	.023	.068	11,924	112.4	.022	.065
	3	6	12	12,898	154.4	.028	.085	11,608	131.6	.027	.081	10,318	111.1	.026	.078
	4	8	14	10,390	139.9	.038	.113	9,351	119.3	.036	.109	8,312	100.7	.035	.104
	5	10	18	8,885	132.9	.047	.142	7,997	113.3	.045	.136	7,108	95.7	.043	.130
	6	12	22	7,882	129.7	.057	.170	7,094	110.6	.054	.163	6,306	93.4	.052	.156
	8	16	30	6,091	109.3	.076	.227	5,482	93.2	.072	.217	4,873	78.7	.069	.208
	10	20	38	4,873	94.8	.094	.283	4,385	80.8	.091	.272	3,898	68.2	.087	.260
Finishing	0.15	0.3	0.6	33,439	47.4	.0005	.0005	30,096	38.4	.0004	.0004	26,752	30.3	.0004	.0004
	0.2	0.4	0.8	32,245	45.7	.001	.001	29,021	37.0	.001	.001	25,796	29.3	.001	.001
	0.25	0.5	1	31,529	44.7	.001	.001	28,376	36.2	.001	.001	25,223	28.6	.001	.001
	0.3	0.6	1.2	26,274	55.9	.001	.001	23,646	45.2	.001	.001	21,019	35.7	.001	.001
	0.4	0.8	1.6	23,288	49.5	.001	.001	20,959	40.1	.001	.001	18,631	31.7	.001	.001
	0.5	1	2.5	22,930	48.7	.002	.002	20,637	39.5	.001	.001	18,344	31.2	.001	.001
	0.75	1.5	4	21,975	46.7	.002	.002	19,777	37.8	.002	.002	17,580	29.9	.002	.002
	1	2	5	22,213	63.0	.003	.003	19,992	51.0	.002	.002	17,771	40.3	.002	.002
	1.25	2.5	7	21,210	60.1	.004	.004	19,089	48.7	.003	.003	16,968	38.5	.003	.003
	1.5	3	8	19,586	55.5	.005	.005	17,627	45.0	.004	.004	15,669	35.6	.004	.004
	2	4	8	18,272	51.8	.006	.006	16,445	42.0	.005	.005	14,618	33.1	.005	.005
			8	18,272	64.8	.006	.006	16,445	52.4	.005	.005	14,618	41.4	.005	.005
	2.5	5	10	16,911	59.9	.008	.008	15,220	48.5	.006	.006	13,529	38.3	.006	.006
	3	6	12	14,570	62.0	.009	.009	13,113	50.2	.007	.007	11,656	39.6	.007	.007
	4	8	14	12,002	51.0	.013	.013	10,802	41.3	.009	.009	9,602	32.7	.009	.009
	5	10	18	11,035	54.7	.016	.016	9,932	44.3	.012	.012	8,828	35.0	.012	.012
	6	12	22	10,151	64.8	.019	.019	9,136	52.4	.014	.014	8,121	41.4	.014	.014
	8	16	30	8,151	57.8	.025	.025	7,336	46.8	.019	.019	6,521	37.0	.019	.019
	10	20	38	5,804	41.1	.031	.031	5,224	33.3	.024	.024	4,643	26.3	.024	.024

Ball end mill pick feed and theoretical cusp height table (μinch)

Ball Radius RE		Pick Feed : *pf* (inch)										
mm	inch	.0008	.0012	.0016	.0020	.0030	.0039	.0059	.0079	.0118	.0157	.0197
0.1	0.004	19.685	44.488	79.527	125.197	–	–	–	–	–	–	–
0.3	0.012	6.693	14.961	26.378	40.945	92.520	165.354	375.196	–	–	–	–
0.5	0.020	3.937	9.055	15.748	24.803	55.512	98.819	222.834	397.637	906.691	1643.304	2637.396
1	0.039	1.969	4.331	7.874	12.205	27.559	49.213	111.023	197.244	445.275	795.274	1249.998
1.5	0.059	1.181	3.150	5.118	8.268	18.504	32.677	74.016	131.496	296.062	527.164	825.983
2	0.079	1.181	2.362	3.937	6.299	13.780	24.803	55.512	98.425	221.653	394.881	617.715
2.5	0.098	.787	1.969	3.150	5.118	11.024	19.685	44.488	78.740	177.165	315.354	493.306
3	0.118	.669	1.575	2.756	3.937	9.055	16.535	37.008	65.748	147.638	262.598	410.629
4	0.157	.512	1.181	1.969	3.150	7.087	12.205	27.559	49.213	110.630	196.850	307.873
5	0.197	.394	.787	1.575	2.362	5.512	9.843	22.047	39.370	88.583	157.480	246.063
6	0.236	.315	.787	1.181	1.969	4.724	8.268	18.504	32.677	74.016	131.102	205.118

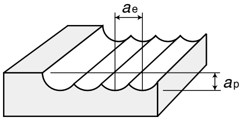
Pick feed and Cusp height

$$H = RE - \sqrt{RE^2 - pf^2/4} \fallingdotseq pf^2/8RE$$



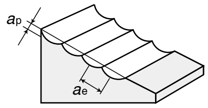
HGOB-TH

Roughing



Work material (Hardness)	Condition range	Depth of cut (mm)	Cutting condition	RE0.5×1	RE1×2	RE1.5×3	RE2×4	RE3×6	RE4×8	RE5×10	RE6×12	RE8×16	RE10×20
				Ball radius RE × Tool dia. DC (mm)									
Tool steel (25～35HRC) Alloy tool steels	High Speed	a_p=0.1DC	Revolution n (min^{-1})	50,000	48,000	32,000	24,000	16,000	12,000	10,000	8,000	6,000	4,800
		a_e=0.3DC	Feed rate v_f (IPM)	70.9	124.8	128.3	132.3	132.3	141.7	141.7	122.0	101.6	81.1
	General	a_p=0.1DC	Revolution n (min^{-1})	20,000	20,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		a_e=0.3DC	Feed rate v_f (IPM)	28.3	52.0	64.2	66.1	66.1	70.9	68.1	61.0	50.8	40.6
Pre-hardened steel (35～45HRC) P21	High Speed	a_p=0.1DC	Revolution n (min^{-1})	50,000	48,000	32,000	24,000	16,000	12,000	10,000	8,000	6,000	4,800
		a_e=0.3DC	Feed rate v_f (IPM)	63.0	109.4	113.4	115.4	115.7	118.9	122.8	105.9	87.4	70.1
	General	a_p=0.1DC	Revolution n (min^{-1})	20,000	20,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		a_e=0.3DC	Feed rate v_f (IPM)	25.2	45.7	56.7	57.5	57.9	59.4	59.1	52.8	43.7	35.0
Hardened steel (45～55HRC) H13, L6	High Speed	a_p=0.08DC	Revolution n (min^{-1})	50,000	38,000	25,000	19,000	13,000	10,000	7,600	6,400	4,800	3,800
		a_e=0.24DC	Feed rate v_f (IPM)	59.1	78.0	82.7	85.4	88.2	91.3	85.4	77.6	64.2	50.8
	General	a_p=0.1DC	Revolution n (min^{-1})	20,000	16,000	11,000	8,000	5,300	4,000	3,200	2,700	2,000	1,600
		a_e=0.3DC	Feed rate v_f (IPM)	21.3	29.5	32.7	32.3	32.3	33.1	32.3	29.5	24.0	19.3
Hardened steel (55～65HRC) D2, M2	High Speed	a_p=0.05DC	Revolution n (min^{-1})	50,000	29,000	19,000	14,000	9,600	7,200	5,700	4,800	3,600	2,900
		a_e=0.15DC	Feed rate v_f (IPM)	51.2	54.7	56.7	57.5	59.1	59.4	58.3	52.8	43.7	35.0
	General	a_p=0.07DC	Revolution n (min^{-1})	20,000	13,000	8,500	6,400	4,200	3,200	2,500	2,100	1,600	1,300
		a_e=0.21DC	Feed rate v_f (IPM)	18.5	22.0	22.8	23.6	23.2	23.6	23.2	20.9	17.3	14.2
Hardened steel (65～70HRC) High speed tool steel	High Speed	a_p=0.05DC	Revolution n (min^{-1})	38,000	19,000	13,000	10,000	6,400	4,800	3,800	3,200	2,400	1,900
		a_e=0.15DC	Feed rate v_f (IPM)	39.0	35.8	39.0	40.9	39.4	39.8	39.0	35.4	29.1	23.2
	General	a_p=0.07DC	Revolution n (min^{-1})	16,000	8,000	5,300	4,000	2,700	2,000	1,600	1,300	1,000	800
		a_e=0.21DC	Feed rate v_f (IPM)	14.6	13.8	14.2	14.6	15.0	15.0	14.6	13.0	11.0	8.7

Finishing



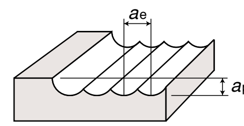
Work material (Hardness)	Condition range	a_p:Finishing cut amount a_e : Pick feed (mm)	Cutting condition	RE0.5×1	RE1×2	RE1.5×3	RE2×4	RE3×6	RE4×8	RE5×10	RE6×12	RE8×16	RE10×20
				Ball radius RE × Tool dia. DC (mm)									
Tool steel (25～35HRC) Alloy tool steel	High Speed	a_p=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	25,000	22,000	16,000	12,000	10,000	8,000	6,000	4,800
		a_e=0.02DC	Feed rate v_f (IPM)	196.9	151.2	137.8	147.2	138.6	113.4	102.4	85.0	66.1	52.8
	General	a_p=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	17,000	13,000	8,500	6,400	5,100	4,200	3,200	2,500
		a_e=0.02DC	Feed rate v_f (IPM)	78.7	94.5	93.7	87.0	73.6	60.6	52.4	44.5	35.4	27.6
Pre-hardened steel (35～45HRC) P21	High Speed	a_p=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	25,000	22,000	16,000	12,000	10,000	8,000	6,000	4,800
		a_e=0.02DC	Feed rate v_f (IPM)	196.9	151.2	137.8	147.2	138.6	113.4	102.4	85.0	66.1	52.8
	General	a_p=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	17,000	13,000	8,500	6,400	5,100	4,200	3,200	2,500
		a_e=0.02DC	Feed rate v_f (IPM)	78.7	94.5	93.7	87.0	73.6	60.6	52.4	44.5	35.4	27.6
Hardened steel (45～55HRC) H13, L6	High Speed	a_p=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	24,000	20,000	13,000	10,000	8,000	6,600	5,000	4,000
		a_e=0.02DC	Feed rate v_f (IPM)	157.5	126.0	113.4	126.0	107.5	90.6	78.7	67.7	53.1	42.5
	General	a_p=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	14,000	10,000	6,900	5,200	4,100	3,500	2,600	2,100
		a_e=0.02DC	Feed rate v_f (IPM)	63.0	78.7	66.1	63.0	57.1	47.2	40.6	35.8	27.6	22.4
Hardened steel (55～65HRC) D2, M2	High Speed	a_p=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	21,000	16,000	11,000	8,000	6,400	5,300	4,000	3,200
		a_e=0.02DC	Feed rate v_f (IPM)	98.4	113.4	99.2	94.5	86.6	69.3	60.6	52.4	40.9	32.7
	General	a_p=0.05～0.1	Revolution n (min^{-1})	15,000	15,000	13,000	9,600	6,400	4,800	3,800	3,200	2,400	1,900
		a_e=0.02DC	Feed rate v_f (IPM)	29.5	53.1	61.4	56.7	50.4	41.7	35.8	31.5	24.4	19.3
Hardened steel (65～70HRC) High speed tool steel	High Speed	a_p=0.05～0.1	Revolution n (min^{-1})	48,000	24,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		a_e=0.02DC	Feed rate v_f (IPM)	94.5	85.0	75.6	70.9	63.0	52.0	45.3	39.4	30.7	24.4
	General	a_p=0.05～0.1	Revolution n (min^{-1})	15,000	14,000	10,000	7,200	4,800	3,600	2,900	2,400	1,800	1,400
		a_e=0.02DC	Feed rate v_f (IPM)	29.5	49.6	47.2	42.5	37.8	31.1	27.6	23.6	18.5	14.2

【Note】
① Use a highly rigid and accurate machine as possible.
② The pick feed in the table is a general condition; please select the *ae* according to the cusp height requested.
③ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
④ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

Recommended Cutting Conditions (Inch)

HGFB-TH

**Applied for from heavy roughing to finishing of over 35HRC up to 70HRC.
Recommended for Forging die and die casting die cutting.**

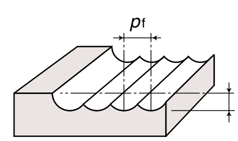


Roughing

Work material (Hardness)	Cutting range	Depth of cut (mm)	Cutting conditions	Ball radius RE × Tool dia. DC (mm)						
				RE1.5×3	RE2×4	RE2.5×5	RE3×6	RE4×8	RE5×10	RE6×12
Pre-hardened steel (35～45HRC) P21	High Speed	a_p=0.12DC a_e=0.36DC	Revolution n (min^{-1})	37,700	28,300	22,800	19,200	14,700	11,800	9,800
			Feed rate v_f (IPM)	142.5	142.5	143.7	145.3	148.0	148.8	143.7
	General	a_p=0.12DC a_e=0.36DC	Revolution n (min^{-1})	17,300	13,000	10,500	8,800	6,800	5,400	4,500
			Feed rate v_f (IPM)	61.4	61.4	62.2	62.2	64.2	63.8	61.8
Hardened steel (45～55HRC) H13, L6	High Speed	a_p=0.1DC a_e=0.3DC	Revolution n (min^{-1})	27,500	20,600	16,700	14,000	10,700	8,600	7,200
			Feed rate v_f (IPM)	110.6	110.2	111.8	112.6	114.6	115.0	112.2
	General	a_p=0.1DC a_e=0.3DC	Revolution n (min^{-1})	14,300	10,700	8,600	7,300	5,600	4,500	3,700
			Feed rate v_f (IPM)	40.6	40.6	40.6	41.3	42.5	42.5	40.6
Hardened steel (55～65HRC) D2, M2	High Speed	a_p=0.06DC a_e=0.18DC	Revolution n (min^{-1})	22,400	16,800	13,600	11,400	8,800	7,000	5,800
			Feed rate v_f (IPM)	89.8	89.8	90.9	91.7	94.1	93.7	90.6
	General	a_p=0.08DC a_e=0.24DC	Revolution n (min^{-1})	12,200	9,200	7,400	6,200	4,800	3,800	3,200
			Feed rate v_f (IPM)	28.7	29.1	29.1	29.1	30.3	29.9	29.1
Hardened steel (65～72HRC) High speed tool steel	High Speed	a_p=0.05DC a_e=0.15DC	Revolution n (min^{-1})	13,200	9,900	8,000	6,800	5,200	4,100	3,400
			Feed rate v_f (IPM)	43.7	43.7	44.1	44.9	45.7	45.3	43.7
	General	a_p=0.07DC a_e=0.21DC	Revolution n (min^{-1})	7,100	5,300	4,300	3,600	2,800	2,200	1,900
			Feed rate v_f (IPM)	13.4	13.4	13.4	13.8	14.2	13.8	13.8

Finishing

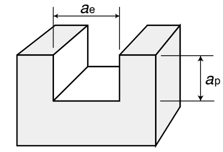
t: Finishing cut amount
p_f: Pick feed



Work material (Hardness)	Cutting range	Depth of cut (mm)	Cutting conditions	Ball radius RE × Tool dia. DC (mm)						
				RE1.5×3	RE2×4	RE2.5×5	RE3×6	RE4×8	RE5×10	RE6×12
Pre-hardened steel (35～45HRC) P21	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	27,500	24,200	20,900	17,600	13,200	11,000	8,800
			Feed rate v_f (IPM)	153.1	163.4	158.3	153.9	126.0	113.8	94.5
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	17,000	13,000	10,500	8,500	6,400	5,100	4,200
			Feed rate v_f (IPM)	103.1	95.7	89.0	81.1	66.5	57.5	48.8
Hardened steel (45～55HRC) H13, L6	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	26,400	22,000	18,150	14,300	11,000	8,800	7,260
			Feed rate v_f (IPM)	126.0	139.8	130.3	119.3	100.4	87.4	75.2
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	15,400	11,000	9,130	7,590	5,720	4,510	3,850
			Feed rate v_f (IPM)	72.8	69.3	65.7	63.0	52.0	44.5	39.4
Hardened steel (55～65HRC) D2, M2	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	23,100	17,600	14,850	12,100	8,800	7,040	5,830
			Feed rate v_f (IPM)	110.2	104.7	100.4	96.1	66.1	64.6	58.7
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	14,300	10,560	7,040	5,280	4,180	3,520	2,640
			Feed rate v_f (IPM)	67.7	62.2	56.7	55.5	46.1	39.4	34.6
Hardened steel (65～72HRC) High speed tool steel	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	17,600	13,200	11,000	8,800	6,600	5,280	4,400
			Feed rate v_f (IPM)	83.9	78.7	75.2	70.1	57.9	50.4	43.7
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	11,000	7,920	6,490	5,280	3,960	3,190	2,640
			Feed rate v_f (IPM)	52.0	46.9	43.3	41.7	34.3	30.3	26.0

HGOF2-TH

Slotting



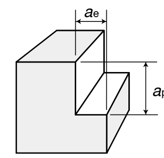
Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. DC (mm)							
			φ2	φ3	φ4	φ5	φ6	φ8	φ10	φ12
Cast iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1DC	Revolution n (min^{-1})	9,550	6,400	4,800	3,800	3,200	2,400	1,900	1,600
	a_e=1DC	Feed rate v_f (IPM)	6.6	7.7	8.7	9.1	9.6	10.2	9.1	8.5
Alloy steel (25～35HRC)	a_p≦0.5DC	Revolution n (min^{-1})	9,550	6,400	4,800	3,800	3,200	2,400	1,900	1,600
	a_e=1DC	Feed rate v_f (IPM)	5.4	6.9	7.9	8.3	8.7	9.3	8.2	7.6
Stainless steel (25～35HRC) 304	a_p≦0.5DC	Revolution n (min^{-1})	6,685	4,480	3,360	2,660	2,240	1,680	1,330	1,120
	a_e=1DC	Feed rate v_f (IPM)	3.5	4.5	5.1	5.4	5.7	6.1	5.3	4.9
Pre-hardened steel (35～45HRC) P21	a_p≦0.5DC	Revolution n (min^{-1})	8,750	5,800	4,400	3,500	2,900	2,200	1,800	1,500
	a_e=1DC	Feed rate v_f (IPM)	4.4	5.7	6.5	6.8	7.1	7.6	6.9	6.3
Hardened steel (45～55HRC) H13, L6	a_p≦0.2DC	Revolution n (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	a_e=1DC	Feed rate v_f (IPM)	3.0	3.8	4.4	4.6	4.9	5.2	4.6	4.1

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

HGOF2-TH

Side cutting



Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. DC (mm)							
			φ2	φ3	φ4	φ5	φ6	φ8	φ10	φ12
Cast iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1.5DC	Revolution n (min^{-1})	14,300	9,600	7,200	5,700	4,800	3,600	2,900	2,400
	a_e=0.15DC	Feed rate v_f (IPM)	15.2	16.9	18.1	19.7	21.3	22.6	21.1	19.7
Alloy steel (25～35HRC)	a_p≦1.5DC	Revolution n (min^{-1})	14,300	9,600	7,200	5,700	4,800	3,600	2,900	2,400
	a_e=0.1DC	Feed rate v_f (IPM)	13.6	15.2	16.3	17.7	19.1	20.5	18.9	17.7
Stainless steel (25～35HRC) 304	a_p≦1.5DC	Revolution n (min^{-1})	10,000	6,720	5,040	4,000	3,360	2,520	2,030	1,680
	a_e=0.1DC	Feed rate v_f (IPM)	8.9	9.8	10.6	11.6	12.4	13.4	12.4	11.6
Pre-hardened steel (35～45HRC) P21	a_p≦1.5DC	Revolution n (min^{-1})	12,700	8,500	6,400	5,100	4,200	3,200	2,500	2,100
	a_e=0.07DC	Feed rate v_f (IPM)	11.0	12.0	13.0	14.2	14.8	16.1	14.6	13.8
Hardened steel (45～55HRC) H13, L6	a_p≦1.5DC	Revolution n (min^{-1})	11,100	7,400	5,600	4,500	3,700	2,800	2,200	1,900
	a_e=0.05DC	Feed rate v_f (IPM)	7.9	9.1	9.8	10.8	11.4	12.4	11.2	10.8

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

HGOF4-TH HGOF2-TH

When using the 2-flute model, set feed rate only to 50% of the value below as a general criteria. Further, it is not recommended to use the 2-flute model for cutting materials with hardness of 55HRC.

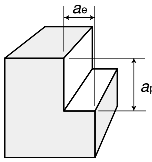
Contouring

Work material (Hardness)	Cutting condition	Tool dia. DC x Corner radius RE (mm) φ2×RE0.5	φ3×RE0.8	φ4×RE1	φ5×RE1.2	φ6×RE1.5	φ8×RE2	φ10×RE2	φ12×RE2
Cast Iron, Carbon steel, Alloy steel (150～250HB) Cast Iron, 1050	Revolution n (min^{-1})	12,000	8,000	6,000	4,800	4,000	3,000	2,400	2,000
	Feed rate v_f (IPM)	211.8	238.2	251.2	251.2	264.6	264.6	264.6	251.2
	a_p (inch)	.005	.007	.009	.011	.014	.019	.019	.019
	a_e (inch)	.020	.028	.039	.051	.059	.079	.118	.157
Tool steel (25～35HRC) 304	Revolution n (min^{-1})	11,000	7,400	5,600	4,500	3,700	2,800	2,200	1,900
	Feed rate v_f (IPM)	177.6	201.2	214.6	215.4	223.6	225.6	221.7	218.1
	a_p (inch)	.005	.007	.009	.011	.014	.019	.019	.019
	a_e (inch)	.020	.028	.039	.051	.059	.079	.118	.157
Pre-hardened steel (35～45HRC) P21	Revolution n (min^{-1})	10,000	6,900	5,200	4,100	3,400	2,600	2,100	1,700
	Feed rate v_f (IPM)	126.0	146.9	155.5	153.5	160.6	163.8	165.4	152.8
	a_p (inch)	.005	.007	.009	.011	.014	.019	.019	.019
	a_e (inch)	.020	.028	.039	.051	.059	.079	.118	.157
Hardened steel (45～55HRC) H13, L6	Revolution n (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	Feed rate v_f (IPM)	100.8	112.6	119.7	119.7	127.6	126.0	126.0	116.5
	a_p (inch)	.003	.005	.007	.008	.010	.013	.013	.013
	a_e (inch)	.020	.028	.039	.051	.059	.079	.118	.157
Hardened steel (55～60HRC) D2, M2	Revolution n (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	Feed rate v_f (IPM)	50.2	56.1	60.0	60.0	64.0	63.0	63.0	58.6
	a_p (inch)	.002	.004	.005	.006	.007	.009	.009	.009
	a_e (inch)	.020	.028	.039	.051	.059	.079	.118	.157

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

HGOR-TH



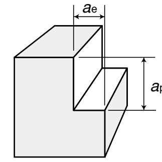
Side cutting

Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. DC (mm) φ6	φ8	φ10	φ12	φ16	φ20
Cast Iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1.5DC	Revolution n (min^{-1})	5,836	4,377	3,501	2,918	2,188	1,751
	a_e=0.1DC	Feed rate v_f (IPM)	36.8	34.4	33.1	32.2	31	30.3
Alloy steel (25～35HRC)	a_p≦1.5DC	Revolution n (min^{-1})	4,775	3,581	2,865	2,387	1,790	1,432
	a_e=0.1DC	Feed rate v_f (IPM)	26.3	25.4	24.8	24.4	24	22.6
Pre-hardened steel (35～45HRC) P21	a_p≦1DC	Revolution n (min^{-1})	4,244	3,183	2,546	2,122	1,592	1,273
	a_e=0.07DC	Feed rate v_f (IPM)	20	20	20	20	20	18
Hardened steel (45～55HRC) H13, L6	a_p≦1DC	Revolution n (min^{-1})	3,714	2,785	2,228	1,857	1,393	1,114
	a_e=0.05DC	Feed rate v_f (IPM)	8.8	8.8	8.8	8.8	8.8	7.9

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

HGOS2-PN HGOS4-PN



Side cutting

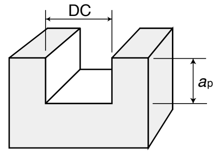
Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy				Cast iron, Carbon steel (150～200HB) No.35 B, 1050, 1055				Stainless steel (25～35HRC) 304, 316			
		Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)	Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)	Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)
0.2	0.4	66,879	26.3	.012	.0004	55,732	21.9	.012	.0004	33,439	11.9	.012	.0003
0.3	0.6	44,586	17.6	.018	.001	37,155	14.6	.018	.001	22,293	7.9	.018	.0005
0.4	0.8	38,217	15.0	.024	.001	27,866	11.0	.024	.001	16,720	5.9	.024	.001
0.5	1	38,217	15.0	.030	.001	25,478	10.0	.030	.001	15,287	5.4	.030	.001
0.6	1.2	41,401	26.1	.035	.001	26,539	16.7	.035	.001	15,924	9.0	.035	.001
0.7	1.4	35,487	22.4	.041	.001	29,572	18.6	.041	.001	17,743	10.1	.041	.001
0.8	1.6	33,439	21.1	.047	.002	25,876	16.3	.047	.002	15,525	8.8	.047	.001
0.9	1.8	33,970	21.4	.053	.002	24,770	15.6	.053	.002	14,862	8.4	.053	.001
1	2	38,217	30.1	.059	.002	25,478	20.1	.059	.002	15,287	10.8	.059	.002
1.5	3	28,025	22.1	.089	.006	21,231	16.7	.089	.006	12,739	9.0	.089	.005
2	6	21,019	24.8	.118	.008	19,108	22.6	.118	.008	11,465	12.2	.118	.007
2.5	8	16,815	19.8	.148	.010	17,834	21.1	.148	.010	10,701	11.4	.148	.009
3	8	15,287	24.1	.177	.012	15,924	25.1	.177	.012	9,554	13.5	.177	.011
3.5	10	13,103	20.6	.207	.014	14,559	22.9	.207	.014	8,735	12.4	.207	.012
4	11	11,465	22.6	.236	.016	13,535	26.7	.236	.016	8,121	14.4	.236	.014
4.5	11	10,191	20.1	.266	.018	12,739	25.1	.266	.018	7,643	13.5	.266	.016
5	13	9,172	21.7	.295	.020	12,102	28.6	.295	.020	7,261	15.4	.295	.018
5.5	13	8,338	19.7	.325	.022	11,581	27.4	.325	.022	6,948	14.8	.325	.019
6	13	7,643	18.1	.354	.024	10,616	25.1	.354	.024	6,369	13.5	.354	.021
7	16	6,551	18.1	.413	.028	9,099	25.1	.413	.028	5,460	13.5	.413	.025
8	19	5,732	15.8	.472	.031	7,962	21.9	.472	.031	4,777	11.9	.472	.028
9	19	5,096	16.1	.531	.035	7,077	22.3	.531	.035	4,246	12.0	.531	.032
10	22	4,586	18.1	.591	.039	6,369	25.1	.591	.039	3,822	13.5	.591	.035
12	26	3,822	18.1	.709	.047	5,308	25.1	.709	.047	3,185	13.5	.709	.043
16	35	2,866	15.8	.945	.063	3,981	21.9	.945	.063	2,389	11.9	.945	.057
20	40	2,293	14.4	1.181	.079	3,185	20.1	1.181	.079	1,911	10.8	1.181	.071

Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25～35HRC) P20, H13, L6				Pre-hardened steel (35～45HRC) P21				Hardened steel (45～52HRC) H13			
		Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)	Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)	Revolution n (min^{-1})	Feed rate vf (IPM)	ap (inch)	ae (inch)
0.2	0.4	33,439	11.9	.012	.0003	26,752	8.5	.012	.0002	16,720	4.1	.012	.0002
0.3	0.6	22,293	7.9	.018	.0005	17,834	5.7	.018	.0004	11,146	2.8	.018	.0004
0.4	0.8	16,720	5.9	.024	.001	13,376	4.3	.024	.0005	8,360	2.1	.024	.0005
0.5	1	15,287	5.4	.030	.001	12,229	3.9	.030	.001	7,643	1.9	.030	.001
0.6	1.2	15,924	9.0	.035	.001	12,739	6.5	.035	.001	7,962	3.1	.035	.001
0.7	1.4	17,743	10.1	.041	.001	14,195	7.2	.041	.001	8,872	3.5	.041	.001
0.8	1.6	15,525	8.8	.047	.001	12,420	6.3	.047	.001	7,763	3.1	.047	.001
0.9	1.8	14,862	8.4	.053	.001	11,890	6.1	.053	.001	7,431	3.0	.053	.001
1	2	15,287	10.8	.059	.002	12,229	7.8	.059	.001	7,643	3.8	.059	.001
1.5	3	12,739	9.0	.089	.005	10,191	6.5	.089	.005	6,369	3.1	.089	.002
2	6	11,465	12.2	.118	.007	6,115	5.9	.118	.006	5,732	4.3	.118	.002
2.5	8	10,701	11.4	.148	.009	5,707	5.5	.148	.008	5,350	4.0	.148	.003
3	8	9,554	13.5	.177	.011	5,096	6.5	.177	.009	4,777	4.7	.177	.004
3.5	10	8,735	12.4	.207	.012	4,659	5.9	.207	.011	4,368	4.3	.207	.004
4	11	8,121	14.4	.236	.014	4,331	6.9	.236	.013	4,061	5.0	.236	.005
4.5	11	7,643	13.5	.266	.016	4,076	6.5	.266	.014	3,822	4.7	.266	.005
5	13	7,261	15.4	.295	.018	3,873	7.4	.295	.016	3,631	5.4	.295	.006
5.5	13	6,948	14.8	.325	.019	3,706	7.1	.325	.017	3,474	5.2	.325	.006
6	13	6,369	13.5	.354	.021	3,397	6.5	.354	.019	3,185	4.7	.354	.007
7	16	5,460	13.5	.413	.025	2,912	6.5	.413	.022	2,730	4.7	.413	.008
8	19	4,777	11.9	.472	.028	2,548	5.7	.472	.025	2,389	4.1	.472	.009
9	19	4,246	12.0	.531	.032	2,265	5.8	.531	.028	2,123	4.2	.531	.011
10	22	3,822	13.5	.591	.035	2,038	6.5	.591	.031	1,911	4.7	.591	.012
12	26	3,185	13.5	.709	.043	1,699	6.5	.709	.038	1,592	4.7	.709	.014
16	35	2,389	11.9	.945	.057	1,274	5.7	.945	.050	1,194	4.1	.945	.019
20	40	1,911	10.8	1.181	.071	1,019	5.2	1.181	.063	955	3.8	1.181	.024

【Note】
① PN Coating is less electro conductive. Therefore, electric transmitted measuring systems may not work.
② The cutting conditions given above is applied to 2 flutes type end mills. As for 4 flutes type, increase the feed rate by 1.5 times.
③ Use a highly rigid and accurate machine as possible.
④ Use the appropriate coolant for the work material and machining shape.
⑤ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
⑥ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

Recommended Cutting Conditions (Inch)

HGOS2-PN



Slotting

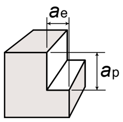
Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy			Cast iron, Carbon steel (150～200HB) No.35 B, 1050, 1055			Stainless steel (25～35HRC) 304, 316		
		Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)	Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)	Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)
0.2	0.4	58,678	9.3	.0004	53,344	8.4	.0004	37,341	6.2	.0004
0.3	0.6	39,119	6.1	.001	35,563	5.6	.001	24,894	5.5	.001
0.4	0.8	35,032	5.5	.001	26,672	4.2	.001	22,293	6.1	.001
0.5	1	31,529	5.0	.001	25,478	4.0	.001	20,064	5.5	.001
0.6	1.2	32,113	10.1	.001	23,885	7.5	.001	20,435	5.6	.001
0.7	1.4	30,027	9.4	.002	25,023	7.9	.002	19,108	6.3	.002
0.8	1.6	28,463	9.0	.002	23,885	7.5	.002	18,113	6.0	.002
0.9	1.8	27,247	8.6	.002	23,001	7.2	.002	17,339	6.7	.002
1	2	28,025	11.0	.002	22,293	8.8	.002	17,834	6.9	.002
1.5	3	21,019	8.3	.003	16,985	6.7	.003	14,862	5.7	.003
2	6	15,764	7.4	.005	14,331	6.8	.005	11,146	6.1	.005
2.5	8	12,611	5.9	.007	11,465	5.4	.007	8,917	4.9	.007
3	8	11,677	6.4	.012	9,554	5.3	.012	7,431	4.1	.012
3.5	10	10,009	5.5	.014	9,099	5.0	.014	6,369	5.3	.014
4	11	8,758	5.5	.024	7,962	5.0	.024	5,573	4.6	.024
4.5	11	7,785	4.9	.035	7,077	4.4	.035	4,954	5.5	.035
5	13	7,006	5.5	.049	6,369	5.0	.049	4,459	4.9	.049
5.5	13	6,369	5.0	.054	5,790	4.6	.054	4,053	4.4	.054
6	13	5,839	9.2	.071	5,308	8.3	.071	3,715	6.1	.071
7	16	5,005	7.9	.096	4,550	7.2	.096	3,185	6.1	.096
8	19	4,379	6.9	.126	3,981	6.3	.126	1,672	3.7	.126
9	19	3,892	9.2	.159	3,539	8.3	.159	1,486	5.7	.159
10	22	3,503	8.3	.197	3,185	7.5	.197	1,338	5.9	.197
12	26	2,919	9.2	.236	2,654	8.3	.236	1,115	5.5	.236
16	35	2,189	8.6	.315	1,990	7.8	.315	975	5.4	.315
20	40	1,752	8.3	.394	1,592	7.5	.394	836	5.5	.394

Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25～35HRC) P20, H13, L6			Pre-hardened steel (35～45HRC) P21			Hardened steel (45～52HRC) H13		
		Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)	Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)	Revolution *n* (min^{-1})	Feed rate *vf* (IPM)	*ap* (inch)
0.2	0.4	24,005	4.8	.0004	14,936	2.2	.0004	8,402	1.3	.0004
0.3	0.6	16,003	4.3	.001	9,958	2.0	.0004	5,601	1.2	.0004
0.4	0.8	14,331	4.8	.001	8,917	2.2	.001	5,016	1.3	.001
0.5	1	12,898	4.3	.001	8,025	2.0	.001	4,514	1.2	.001
0.6	1.2	13,137	4.4	.001	8,174	2.0	.001	4,598	1.2	.001
0.7	1.4	12,284	4.9	.002	7,643	2.3	.001	4,299	1.4	.001
0.8	1.6	11,644	4.7	.002	7,245	2.2	.002	4,075	1.3	.001
0.9	1.8	11,146	5.2	.002	6,936	2.4	.002	3,901	1.5	.002
1	2	11,465	5.4	.002	7,134	2.5	.002	4,013	1.5	.002
1.5	3	9,554	4.5	.003	5,945	2.0	.003	3,344	1.3	.002
2	6	7,166	4.8	.005	4,459	2.2	.004	2,508	1.3	.004
2.5	8	5,732	3.8	.007	3,567	1.8	.006	2,006	1.1	.006
3	8	4,777	3.2	.012	2,972	1.5	.011	1,672	0.9	.009
3.5	10	4,095	4.1	.014	2,548	1.9	.013	1,433	1.1	.011
4	11	3,583	3.6	.024	2,229	1.7	.021	1,254	1.0	.019
4.5	11	3,185	4.3	.035	1,982	2.0	.032	1,115	1.2	.029
5	13	2,866	3.8	.049	1,783	1.8	.044	1,003	1.1	.040
5.5	13	2,606	3.5	.054	1,621	1.6	.049	912	1.0	.044
6	13	2,389	4.8	.071	1,486	2.2	.064	836	1.3	.057
7	16	2,047	4.8	.096	1,274	2.2	.087	717	1.3	.078
8	19	1,075	2.9	.126	669	1.3	.113	376	0.8	.102
9	19	955	4.5	.159	594	2.0	.144	334	1.3	.129
10	22	860	4.6	.197	535	2.1	.177	301	1.3	.159
12	26	717	4.3	.236	446	2.0	.213	251	1.2	.191
16	35	627	4.2	.315	390	1.9	.283	219	1.2	.255
20	40	537	4.3	.394	334	2.0	.354	188	1.2	.319

【Note】 The 4 flutes not suitable for slotting.

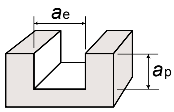
HGOSH4-TH

Side milling



Work Material (Hardness)	Cutting range	Depth of cut mm	Cutting conditions	Tool dia. DC (mm)								
				φ1	**φ1.5**	**φ2**	**φ3**	**φ4**	**φ6**	**φ8**	**φ10**	**φ12**
Carbon steel Alloy Steel (200～250HB) 1050	High speed	a_p=1.5DC	Revolution n (min^{-1})	47,800	31,800	23,800	16,000	12,000	8,000	6,000	4,800	4,000
		a_e=0.1DC	Feed rate v_f (IPM)	59.1	63.0	66.9	70.9	74.8	86.6	94.5	86.6	82.7
	General	a_p=1.5DC	Revolution n (min^{-1})	28,600	19,100	14,300	9,600	7,200	4,800	3,600	2,900	2,400
		a_e=0.15DC	Feed rate v_f (IPM)	27.2	29.9	32.7	33.9	36.2	42.5	45.3	42.1	39.4
Alloy steel P20	High speed	a_p=1.5DC	Revolution n (min^{-1})	41,400	27,600	20,700	14,000	10,000	6,900	5,200	4,100	3,500
		a_e=0.05DC	Feed rate v_f (IPM)	45.7	52.4	52.4	55.1	55.1	66.9	74.8	66.9	63.0
	General	a_p=1.5DC	Revolution n (min^{-1})	28,600	19,100	14,300	9,600	7,200	4,800	3,600	2,900	2,400
		a_e=0.1DC	Feed rate v_f (IPM)	22.8	27.2	29.1	30.3	32.7	38.2	40.9	37.8	35.4
Pre-hardened steel (35～45HRC) P21	High speed	a_p=1.5DC	Revolution n (min^{-1})	35,000	23,300	17,500	12,000	8,800	5,800	4,400	3,500	2,900
		a_e=0.05DC	Feed rate v_f (IPM)	27.6	36.6	38.6	43.3	43.3	51.2	55.1	51.2	47.2
	General	a_p=1.5DC	Revolution n (min^{-1})	25,500	17,000	12,700	8,500	6,400	4,200	3,200	2,500	2,100
		a_e=0.07DC	Feed rate v_f (IPM)	18.1	20.1	22.0	24.0	26.0	29.5	32.3	29.1	27.6
Hardened steel (45～55HRC) H13	High speed	a_p=1.5DC	Revolution n (min^{-1})	31,800	21,200	15,900	11,000	8,000	5,300	4,000	3,200	2,700
		a_e=0.02DC	Feed rate v_f (IPM)	25.2	29.9	32.7	33.9	35.4	40.9	44.1	40.6	38.6
	General	a_p=1.5DC	Revolution n (min^{-1})	22,300	14,800	11,100	7,400	5,600	3,700	2,800	2,200	1,900
		a_e=0.05DC	Feed rate v_f (IPM)	14.2	16.1	17.3	18.1	19.7	22.8	24.8	22.4	21.7

Slotting

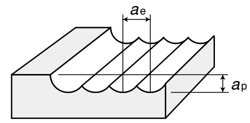


Work Material (Hardness)	Cutting range	Depth of cut mm	Cutting conditions	Tool dia. DC (mm)								
				φ1	**φ1.5**	**φ2**	**φ3**	**φ4**	**φ6**	**φ8**	**φ10**	**φ12**
Carbon steel Alloy Steel (200～250HB) 1050	High speed	a_p≦0.5DC	Revolution n (min^{-1})	25,500	17,000	12,700	8,500	6,400	4,200	3,200	2,500	2,100
		a_e=1DC	Feed rate v_f (IPM)	28.3	29.5	31.9	32.3	36.2	39.8	42.9	37.4	34.6
	General	a_p≦1DC	Revolution n (min^{-1})	19,100	12,700	9,500	6,400	4,800	3,200	2,400	1,900	1,600
		a_e=1DC	Feed rate v_f (IPM)	15.0	16.9	17.7	19.3	21.7	24.0	25.6	22.8	21.3
Alloy steel P20	High speed		Revolution n (min^{-1})									
			Feed rate v_f (IPM)									
	General	a_p≦0.5DC	Revolution n (min^{-1})	19,100	12,700	9,500	6,400	4,800	3,200	2,400	1,900	1,600
		a_e=0.1DC	Feed rate v_f (IPM)	13.4	15.0	15.7	17.3	19.7	21.7	23.2	20.5	18.9
Pre-hardened steel (35～45HRC) P21	High speed		Revolution n (min^{-1})									
			Feed rate v_f (IPM)									
	General	a_p≦0.5DC	Revolution n (min^{-1})	17,500	11,700	8,800	5,800	4,400	2,900	2,200	1,800	1,500
		a_e=1DC	Feed rate v_f (IPM)	11.0	11.8	13.0	14.2	16.1	17.7	18.9	17.3	15.7
Hardened steel (45～55HRC) H13	High speed		Revolution n (min^{-1})									
			Feed rate v_f (IPM)									
	General	a_p≦0.2DC	Revolution n (min^{-1})	16,000	10,600	8,000	5,300	4,000	2,700	2,000	1,600	1,300
		a_e=1DC	Feed rate v_f (IPM)	7.5	8.3	9.4	9.4	11.0	12.2	13.0	11.4	10.2

【Note】

①Use the high-rigidity and high accuracy machine as possible
②These Recommended Cutting Conditions indicate only the rule of a thumb for the cutting conditions. In actual machining, the condition should be adjusted according to the machining shape, purpose and the machine type.
③If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

Recommended Cutting Conditions (Metric)

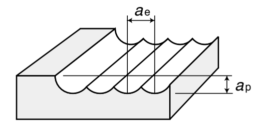


HGOB-PN

Types of finishing	Ball radius RE (mm)	Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy				Cast iron, Carbon steel (150～200HB) No.35B, 1050, 1060				Stainless steel (25～35HRC) AISI 304, AISI 316			
				Revolution *n* min⁻¹	Feed rate *vf* IPM	*ap* mm	*ae* mm	Revolution *n* min⁻¹	Feed rate *vf* IPM	*ap* mm	*ae* mm	Revolution *n* min⁻¹	Feed rate *vf* IPM	*ap* mm	*ae* mm
Roughing	0.15	0.3	0.6	35,032	2,102	0.039	0.117	31,847	1,911	0.039	0.117	28,662	1,720	0.038	0.112
	0.2	0.4	0.8	35,032	2,102	0.052	0.156	31,847	1,911	0.052	0.156	28,662	1,720	0.050	0.150
	0.25	0.5	1	35,032	2,102	0.065	0.195	31,847	1,911	0.065	0.195	28,662	1,720	0.063	0.187
	0.3	0.6	1.2	29,193	2,335	0.078	0.234	26,539	2,123	0.078	0.234	23,885	1,911	0.075	0.225
	0.4	0.8	1.6	26,274	2,102	0.104	0.312	23,885	1,911	0.104	0.312	21,497	1,720	0.100	0.300
	0.5	1	2.5	28,025	2,803	0.130	0.390	25,478	2,548	0.130	0.390	22,930	2,293	0.125	0.375
	0.75	1.5	4	25,690	3,083	0.195	0.585	23,355	2,803	0.195	0.585	21,019	2,522	0.188	0.562
	1	2	5	24,522	3,433	0.260	0.780	22,293	3,121	0.260	0.780	20,064	2,809	0.250	0.750
	1.25	2.5	7	22,420	3,587	0.325	0.975	20,382	3,261	0.325	0.975	18,344	2,935	0.313	0.937
	1.5	3	8	21,019	3,783	0.390	1.170	19,108	3,439	0.390	1.170	17,197	3,096	0.375	1.125
	2	4	8	20,143	4,029	0.520	1.560	18,312	3,662	0.520	1.560	16,481	3,296	0.500	1.500
			8	20,143	4,834	0.520	1.560	18,312	4,395	0.520	1.560	16,481	3,955	0.500	1.500
	2.5	5	10	18,217	5,101	0.650	1.950	16,561	4,637	0.650	1.950	14,904	4,173	0.625	1.875
	3	6	12	15,764	5,045	0.780	2.340	14,331	4,586	0.780	2.340	12,898	4,127	0.750	2.250
	4	8	14	12,699	4,572	1.040	3.120	11,545	4,156	1.040	3.120	10,390	3,740	1.000	3.000
	5	10	18	10,860	4,344	1.300	3.900	9,873	3,949	1.300	3.900	8,885	3,554	1.250	3.750
	6	12	22	9,634	4,239	1.560	4.680	8,758	3,854	1.560	4.680	7,882	3,468	1.500	4.500
	8	16	30	7,444	3,573	2.080	6.240	6,768	3,248	2.080	6.240	6,091	2,924	2.000	6.000
	10	20	38	5,955	3,097	2.600	7.800	5,414	2,815	2.600	7.800	4,873	2,534	2.500	7.500
Finishing	0.15	0.3	0.6	44,586	1,783	0.015	0.015	37,155	1,486	0.015	0.015	33,439	1,204	0.015	0.015
	0.2	0.4	0.8	42,994	1,720	0.020	0.020	35,828	1,433	0.020	0.020	32,245	1,161	0.020	0.020
	0.25	0.5	1	42,038	1,682	0.025	0.025	35,032	1,401	0.025	0.025	31,529	1,135	0.025	0.025
	0.3	0.6	1.2	35,032	2,102	0.030	0.030	29,193	1,752	0.030	0.030	26,274	1,419	0.030	0.030
	0.4	0.8	1.6	31,051	1,863	0.040	0.040	25,876	1,553	0.040	0.040	23,288	1,258	0.040	0.040
	0.5	1	2.5	30,573	1,834	0.050	0.050	25,478	1,529	0.050	0.050	22,930	1,238	0.050	0.050
	0.75	1.5	4	29,299	1,758	0.075	0.075	24,416	1,465	0.075	0.075	21,975	1,187	0.075	0.075
	1	2	5	29,618	2,369	0.100	0.100	24,682	1,975	0.100	0.100	22,213	1,599	0.100	0.100
	1.25	2.5	7	28,280	2,262	0.125	0.125	23,567	1,885	0.125	0.125	21,210	1,527	0.125	0.125
	1.5	3	8	26,115	2,089	0.150	0.150	21,762	1,741	0.150	0.150	19,586	1,410	0.150	0.150
	2	4	8	24,363	1,949	0.200	0.200	20,303	1,624	0.200	0.200	18,272	1,316	0.200	0.200
			8	24,363	2,436	0.200	0.200	20,303	2,030	0.200	0.200	18,272	1,645	0.200	0.200
	2.5	5	10	22,548	2,255	0.250	0.250	18,790	1,879	0.250	0.250	16,911	1,522	0.250	0.250
	3	6	12	19,427	2,331	0.300	0.300	16,189	1,943	0.300	0.300	14,570	1,574	0.300	0.300
	4	8	14	16,003	1,920	0.400	0.400	13,336	1,600	0.400	0.400	12,002	1,296	0.400	0.400
	5	10	18	14,713	2,060	0.500	0.500	12,261	1,717	0.500	0.500	11,035	1,390	0.500	0.500
	6	12	22	13,535	2,436	0.600	0.600	11,279	2,030	0.600	0.600	10,151	1,645	0.600	0.600
	8	16	30	10,868	2,174	0.800	0.800	9,057	1,811	0.800	0.800	8,151	1,467	0.800	0.800
	10	20	38	7,739	1,548	1.000	1.000	6,449	1,290	1.000	1.000	5,804	1,045	1.000	1.000

【Note】

① PN Coating is less electro conductive. Therefore, electric transmitted measuring systems may not work.
② Use the appropriate coolant for the work material and machining shape.
③ Use a highly rigid and accurate machine as possible.
④ The pick feed in the table is a general condition; please select the *ae* according to the cusp height requested.
⑤ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
⑥ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.



HGOB-PN

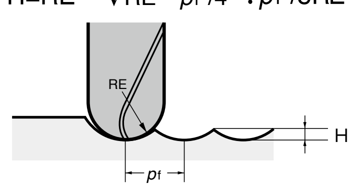
Types of finishing	Ball radius RE (mm)	Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25～35HRC) H13, L6				Pre-hardened steel (35～45HRC)				Hardened steel (45～52HRC) H13			
				Revolution n min^{-1}	Feed rate v_f IPM	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f IPM	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f IPM	a_p mm	a_e mm
Roughing	0.15	0.3	0.6	28,662	1,634	0.036	0.108	25,796	1,393	0.035	0.103	22,930	1,176	0.033	0.099
	0.2	0.4	0.8	28,662	1,634	0.048	0.144	25,796	1,393	0.046	0.138	22,930	1,176	0.044	0.132
	0.25	0.5	1	28,662	1,634	0.060	0.180	25,796	1,393	0.058	0.172	22,930	1,176	0.055	0.165
	0.3	0.6	1.2	23,885	1,815	0.072	0.216	21,497	1,548	0.069	0.207	19,108	1,307	0.066	0.198
	0.4	0.8	1.6	21,497	1,634	0.096	0.288	19,347	1,393	0.092	0.276	17,197	1,176	0.088	0.264
	0.5	1	2.5	22,930	2,178	0.120	0.360	20,637	1,857	0.115	0.345	18,344	1,568	0.110	0.330
	0.75	1.5	4	21,019	2,396	0.180	0.540	18,917	2,043	0.173	0.517	16,815	1,725	0.165	0.495
	1	2	5	20,064	2,668	0.240	0.720	18,057	2,275	0.230	0.690	16,051	1,921	0.220	0.660
	1.25	2.5	7	18,344	2,788	0.300	0.900	16,510	2,377	0.288	0.862	14,675	2,008	0.275	0.825
	1.5	3	8	17,197	2,941	0.360	1.080	15,478	2,507	0.345	1.035	13,758	2,117	0.330	0.990
	2	4	8	16,481	3,131	0.480	1.440	14,833	2,670	0.460	1.380	13,185	2,255	0.440	1.320
			8	16,481	3,758	0.480	1.440	14,833	3,204	0.460	1.380	13,185	2,706	0.440	1.320
	2.5	5	10	14,904	3,965	0.600	1.800	13,414	3,380	0.575	1.725	11,924	2,855	0.550	1.650
	3	6	12	12,898	3,921	0.720	2.160	11,608	3,343	0.690	2.070	10,318	2,823	0.660	1.980
	4	8	14	10,390	3,553	0.960	2.880	9,351	3,030	0.920	2.760	8,312	2,558	0.880	2.640
	5	10	18	8,885	3,376	1.200	3.600	7,997	2,879	1.150	3.450	7,108	2,431	1.100	3.300
	6	12	22	7,882	3,295	1.440	4.320	7,094	2,809	1.380	4.140	6,306	2,372	1.320	3.960
	8	16	30	6,091	2,777	1.920	5.760	5,482	2,368	1.840	5.520	4,873	2,000	1.760	5.280
	10	20	38	4,873	2,407	2.400	7.200	4,385	2,052	2.300	6.900	3,898	1,733	2.200	6.600
Finishing	0.15	0.3	0.6	33,439	1,204	0.012	0.012	30,096	975	0.009	0.009	26,752	770	0.009	0.009
	0.2	0.4	0.8	32,245	1,161	0.016	0.016	29,021	940	0.012	0.012	25,796	743	0.012	0.012
	0.25	0.5	1	31,529	1,135	0.020	0.020	28,376	919	0.015	0.015	25,223	726	0.015	0.015
	0.3	0.6	1.2	26,274	1,419	0.024	0.024	23,646	1,149	0.018	0.018	21,019	908	0.018	0.018
	0.4	0.8	1.6	23,288	1,258	0.032	0.032	20,959	1,019	0.024	0.024	18,631	805	0.024	0.024
	0.5	1	2.5	22,930	1,238	0.040	0.040	20,637	1,003	0.030	0.030	18,344	792	0.030	0.030
	0.75	1.5	4	21,975	1,187	0.060	0.060	19,777	961	0.045	0.045	17,580	759	0.045	0.045
	1	2	5	22,213	1,599	0.080	0.080	19,992	1,295	0.060	0.060	17,771	1,024	0.060	0.060
	1.25	2.5	7	21,210	1,527	0.100	0.100	19,089	1,237	0.075	0.075	16,968	977	0.075	0.075
	1.5	3	8	19,586	1,410	0.120	0.120	17,627	1,142	0.090	0.090	15,669	903	0.090	0.090
	2	4	8	18,272	1,316	0.160	0.160	16,445	1,066	0.120	0.120	14,618	842	0.120	0.120
			8	18,272	1,645	0.160	0.160	16,445	1,332	0.120	0.120	14,618	1,052	0.120	0.120
	2.5	5	10	16,911	1,522	0.200	0.200	15,220	1,233	0.150	0.150	13,529	974	0.150	0.150
	3	6	12	14,570	1,574	0.240	0.240	13,113	1,275	0.180	0.180	11,656	1,007	0.180	0.180
	4	8	14	12,002	1,296	0.320	0.320	10,802	1,050	0.240	0.240	9,602	830	0.240	0.240
	5	10	18	11,035	1,390	0.400	0.400	9,932	1,126	0.300	0.300	8,828	890	0.300	0.300
	6	12	22	10,151	1,645	0.480	0.480	9,136	1,332	0.360	0.360	8,121	1,052	0.360	0.360
	8	16	30	8,151	1,467	0.640	0.640	7,336	1,188	0.480	0.480	6,521	939	0.480	0.480
	10	20	38	5,804	1,045	0.800	0.800	5,224	846	0.600	0.600	4,643	669	0.600	0.600

Ball end mill pick feed and theoretical cusp height table (μm)

Ball Radius RE (mm)	Pick Feed：p_f (mm) 0.02	0.03	0.04	0.05	0.075	0.1	0.15	0.2	0.3	0.4	0.5
0.1	0.50	1.13	2.02	3.18	—	—	—	—	—	—	—
0.3	0.17	0.38	0.67	1.04	2.35	4.20	9.53	—	—	—	—
0.5	0.10	0.23	0.40	0.63	1.41	2.51	5.66	10.10	23.03	41.74	66.99
1	0.05	0.11	0.20	0.31	0.70	1.25	2.82	5.01	11.31	20.20	31.75
1.5	0.03	0.08	0.13	0.21	0.47	0.83	1.88	3.34	7.52	13.39	20.98
2	0.03	0.06	0.10	0.16	0.35	0.63	1.41	2.50	5.63	10.03	15.69
2.5	0.02	0.05	0.08	0.13	0.28	0.50	1.13	2.00	4.50	8.01	12.53
3	0.017	0.04	0.07	0.10	0.23	0.42	0.94	1.67	3.75	6.67	10.43
4	0.013	0.03	0.05	0.08	0.18	0.31	0.70	1.25	2.81	5.00	7.82
5	0.010	0.02	0.04	0.06	0.14	0.25	0.56	1.00	2.25	4.00	6.25
6	0.008	0.02	0.03	0.05	0.12	0.21	0.47	0.83	1.88	3.33	5.21

Pick feed and Cusp height

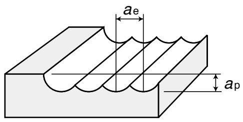
$$H = RE - \sqrt{RE^2 - p_f^2/4} \fallingdotseq p_f^2/8RE$$



Recommended Cutting Conditions (Metric)

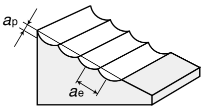
HGOB-TH

Roughing



Work material (Hardness)	Condition range	Depth of cut (mm)	Cutting condition	RE0.5×1	RE1×2	RE1.5×3	RE2×4	RE3×6	RE4×8	RE5×10	RE6×12	RE8×16	RE10×20
				Ball radius RE × Tool dia. DC (mm)									
Tool steel (25～35HRC) Alloy tool steel	High Speed	ap=0.1DC	Revolution n (min^{-1})	50,000	48,000	32,000	24,000	16,000	12,000	10,000	8,000	6,000	4,800
		ae=0.3DC	Feed rate vf (mm/min)	1,800	3,170	3,260	3,360	3,360	3,600	3,600	3,100	2,580	2,060
	General	ap=0.1DC	Revolution n (min^{-1})	20,000	20,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		ae=0.3DC	Feed rate vf (mm/min)	720	1,320	1,630	1,680	1,680	1,800	1,730	1,550	1,290	1,030
Pre-hardened steel (35～45HRC) P21	High Speed	ap=0.1DC	Revolution n (min^{-1})	50,000	48,000	32,000	24,000	16,000	12,000	10,000	8,000	6,000	4,800
		ae=0.3DC	Feed rate vf (mm/min)	1,600	2,780	2,880	2,930	2,940	3,020	3,120	2,690	2,220	1,780
	General	ap=0.1DC	Revolution n (min^{-1})	20,000	20,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		ae=0.3DC	Feed rate vf (mm/min)	640	1,160	1,440	1,460	1,470	1,510	1,500	1,340	1,110	890
Hardened steel (45～55HRC) H13, L6	High Speed	ap=0.08DC	Revolution n (min^{-1})	50,000	38,000	25,000	19,000	13,000	10,000	7,600	6,400	4,800	3,800
		ae=0.24DC	Feed rate vf (mm/min)	1,500	1,980	2,100	2,170	2,240	2,320	2,170	1,970	1,630	1,290
	General	ap=0.1DC	Revolution n (min^{-1})	20,000	16,000	11,000	8,000	5,300	4,000	3,200	2,700	2,000	1,600
		ae=0.3DC	Feed rate vf (mm/min)	540	750	830	820	820	840	820	750	610	490
Hardened steel (55～65HRC) D2, M2	High Speed	ap=0.05DC	Revolution n (min^{-1})	50,000	29,000	19,000	14,000	9,600	7,200	5,700	4,800	3,600	2,900
		ae=0.15DC	Feed rate vf (mm/min)	1,300	1,390	1,440	1,460	1,500	1,510	1,480	1,340	1,110	890
	General	ap=0.07DC	Revolution n (min^{-1})	20,000	13,000	8,500	6,400	4,200	3,200	2,500	2,100	1,600	1,300
		ae=0.21DC	Feed rate vf (mm/min)	470	560	580	600	590	600	590	530	440	360
Hardened steel (65～70HRC) High speed tool steel	High Speed	ap=0.05DC	Revolution n (min^{-1})	38,000	19,000	13,000	10,000	6,400	4,800	3,800	3,200	2,400	1,900
		ae=0.15DC	Feed rate vf (mm/min)	990	910	990	1,040	1,000	1,010	990	900	740	590
	General	ap=0.07DC	Revolution n (min^{-1})	16,000	8,000	5,300	4,000	2,700	2,000	1,600	1,300	1,000	800
		ae=0.21DC	Feed rate vf (mm/min)	370	350	360	370	380	380	370	330	280	220

Finishing

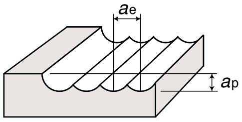


Work material (Hardness)	Condition range	ap:Finishing cut amount ae : Pick feed (mm)	Cutting condition	RE0.5×1	RE1×2	RE1.5×3	RE2×4	RE3×6	RE4×8	RE5×10	RE6×12	RE8×16	RE10×20
				Ball radius RE × Tool dia. DC (mm)									
Tool steel (25～35HRC) Alloy tool steel	High Speed	ap=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	25,000	22,000	16,000	12,000	10,000	8,000	6,000	4,800
		ae=0.02DC	Feed rate vf (mm/min)	5,000	3,840	3,500	3,740	3,520	2,880	2,600	2,160	1,680	1,340
	General	ap=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	17,000	13,000	8,500	6,400	5,100	4,200	3,200	2,500
		ae=0.02DC	Feed rate vf (mm/min)	2,000	2,400	2,380	2,210	1,870	1,540	1,330	1,130	900	700
Pre-hardened steel (35～45HRC) P21	High Speed	ap=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	25,000	22,000	16,000	12,000	10,000	8,000	6,000	4,800
		ae=0.02DC	Feed rate vf (mm/min)	5,000	3,840	3,500	3,740	3,520	2,880	2,600	2,160	1,680	1,340
	General	ap=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	17,000	13,000	8,500	6,400	5,100	4,200	3,200	2,500
		ae=0.02DC	Feed rate vf (mm/min)	2,000	2,400	2,380	2,210	1,870	1,540	1,330	1,130	900	700
Hardened steel (45～55HRC) H13, L6	High Speed	ap=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	24,000	20,000	13,000	10,000	8,000	6,600	5,000	4,000
		ae=0.02DC	Feed rate vf (mm/min)	4,000	3,200	2,880	3,200	2,730	2,300	2,000	1,720	1,350	1,080
	General	ap=0.05～0.1	Revolution n (min^{-1})	20,000	20,000	14,000	10,000	6,900	5,200	4,100	3,500	2,600	2,100
		ae=0.02DC	Feed rate vf (mm/min)	1,600	2,000	1,680	1,600	1,450	1,200	1,030	910	700	570
Hardened steel (55～65HRC) D2, M2	High Speed	ap=0.05～0.1	Revolution n (min^{-1})	50,000	32,000	21,000	16,000	11,000	8,000	6,400	5,300	4,000	3,200
		ae=0.02DC	Feed rate vf (mm/min)	2,500	2,880	2,520	2,400	2,200	1,760	1,540	1,330	1,040	830
	General	ap=0.05～0.1	Revolution n (min^{-1})	15,000	15,000	13,000	9,600	6,400	4,800	3,800	3,200	2,400	1,900
		ae=0.02DC	Feed rate vf (mm/min)	750	1,350	1,560	1,440	1,280	1,060	910	800	620	490
Hardened steel (65～70HRC) High speed tool steel	High Speed	ap=0.05～0.1	Revolution n (min^{-1})	48,000	24,000	16,000	12,000	8,000	6,000	4,800	4,000	3,000	2,400
		ae=0.02DC	Feed rate vf (mm/min)	2,400	2,160	1,920	1,800	1,600	1,320	1,150	1,000	780	620
	General	ap=0.05～0.1	Revolution n (min^{-1})	15,000	14,000	10,000	7,200	4,800	3,600	2,900	2,400	1,800	1,400
		ae=0.02DC	Feed rate vf (mm/min)	750	1,260	1,200	1,080	960	790	700	600	470	360

【Note】
① Use a highly rigid and accurate machine as possible.
② The pick feed in the table is a general condition; please select the *ae* according to the cusp height requested.
③ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
④ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

HGFB-TH

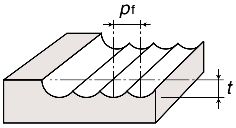
Applied for from heavy roughing to finishing of over 35HRC up to 70HRC.
Recommended for Forging die and die casting die cutting.



Roughing

Work material (Hardness)	Cutting range	Depth of cut (mm)	Cutting conditions	Ball radius RE × Tool dia. DC (mm)						
				RE1.5×3	RE2×4	RE2.5×5	RE3×6	RE4×8	RE5×10	RE6×12
Pre-hardened steel (35～45HRC) P21	High Speed	a_p=0.12DC a_e=0.36DC	Revolution n (min^{-1})	37,700	28,300	22,800	19,200	14,700	11,800	9,800
			Feed rate v_f (mm/min)	3,620	3,620	3,650	3,690	3,760	3,780	3,650
	General	a_p=0.12DC a_e=0.36DC	Revolution n (min^{-1})	17,300	13,000	10,500	8,800	6,800	5,400	4,500
			Feed rate v_f (mm/min)	1,560	1,560	1,580	1,580	1,630	1,620	1,570
Hardened steel (45～55HRC) H13, L6	High Speed	a_p=0.1DC a_e=0.3DC	Revolution n (min^{-1})	27,500	20,600	16,700	14,000	10,700	8,600	7,200
			Feed rate v_f (mm/min)	2,810	2,800	2,840	2,860	2,910	2,920	2,850
	General	a_p=0.1DC a_e=0.3DC	Revolution n (min^{-1})	14,300	10,700	8,600	7,300	5,600	4,500	3,700
			Feed rate v_f (mm/min)	1,030	1,030	1,030	1,050	1,080	1,080	1,030
Hardened steel (55～65HRC) D2, M2	High Speed	a_p=0.06DC a_e=0.18DC	Revolution n (min^{-1})	22,400	16,800	13,600	11,400	8,800	7,000	5,800
			Feed rate v_f (mm/min)	2,280	2,280	2,310	2,330	2,390	2,380	2,300
	General	a_p=0.08DC a_e=0.24DC	Revolution n (min^{-1})	12,200	9,200	7,400	6,200	4,800	3,800	3,200
			Feed rate v_f (mm/min)	730	740	740	740	770	760	740
Hardened steel (65～72HRC) High speed tool steel	High Speed	a_p=0.05DC a_e=0.15DC	Revolution n (min^{-1})	13,200	9,900	8,000	6,800	5,200	4,100	3,400
			Feed rate v_f (mm/min)	1,110	1,110	1,120	1,140	1,160	1,150	1,110
	General	a_p=0.07DC a_e=0.21DC	Revolution n (min^{-1})	7,100	5,300	4,300	3,600	2,800	2,200	1,900
			Feed rate v_f (mm/min)	340	340	340	350	360	350	350

t : Finishing cut amount
p_f : Pick feed

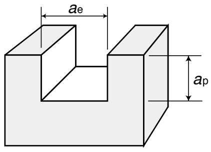


Finishing

Work material (Hardness)	Cutting range	Depth of cut (mm)	Cutting conditions	Ball radius RE × Tool dia. DC (mm)						
				RE1.5×3	RE2×4	RE2.5×5	RE3×6	RE4×8	R5E×10	RE6×12
Pre-hardened steel (35～45HRC) P21	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	27,500	24,200	20,900	17,600	13,200	11,000	8,800
			Feed rate v_f (mm/min)	3,890	4,150	4,020	3,910	3,200	2,890	2,400
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	17,000	13,000	10,500	8,500	6,400	5,100	4,200
			Feed rate v_f (mm/min)	2,620	2,430	2,260	2,060	1,690	1,460	1,240
Hardened steel (45～55HRC) H13, L6	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	26,400	22,000	18,150	14,300	11,000	8,800	7,260
			Feed rate v_f (mm/min)	3,200	3,550	3,310	3,030	2,550	2,220	1,910
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	15,400	11,000	9,130	7,590	5,720	4,510	3,850
			Feed rate v_f (mm/min)	1,850	1,760	1,670	1,600	1,320	1,130	1,000
Hardened steel (55～65HRC) D2, M2	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	23,100	17,600	14,850	12,100	8,800	7,040	5,830
			Feed rate v_f (mm/min)	2,800	2,660	2,550	2,440	1,680	1,640	1,490
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	14,300	10,560	7,040	5,280	4,180	3,520	2,640
			Feed rate v_f (mm/min)	1,720	1,580	1,440	1,410	1,170	1,000	880
Hardened steel (65～72HRC) High speed tool steel	High Speed	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	17,600	13,200	11,000	8,800	6,600	5,280	4,400
			Feed rate v_f (mm/min)	2,130	2,000	1,910	1,780	1,470	1,280	1,110
	General	t=0.05～0.1 p_f=0.02DC	Revolution n (min^{-1})	11,000	7,920	6,490	5,280	3,960	3,190	2,640
			Feed rate v_f (mm/min)	1,320	1,190	1,100	1,060	870	770	660

HGOF2-TH

Slotting



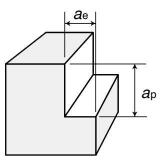
Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. (mm) ϕ2	ϕ3	ϕ4	ϕ5	ϕ6	ϕ8	ϕ10	ϕ12
Cast iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1DC	Revolution n (min^{-1})	9,550	6,400	4,800	3,800	3,200	2,400	1,900	1,600
	a_e=1DC	Feed rate v_f (mm/min)	168	196	220	232	244	260	232	216
Alloy steel (25～35HRC)	a_p≦0.5DC	Revolution n (min^{-1})	9,550	6,400	4,800	3,800	3,200	2,400	1,900	1,600
	a_e=1DC	Feed rate v_f (mm/min)	136	176	200	212	220	236	208	192
Stainless steel (25～35HRC) 304	a_p≦0.5DC	Revolution n (min^{-1})	6,685	4,480	3,360	2,660	2,240	1,680	1,330	1,120
	a_e=1DC	Feed rate v_f (mm/min)	90	115	130	138	145	155	135	125
Pre-hardened steel (35～45HRC) P21	a_p≦0.5DC	Revolution n (min^{-1})	8,750	5,800	4,400	3,500	2,900	2,200	1,800	1,500
	a_e=1DC	Feed rate v_f (mm/min)	112	144	164	172	180	192	176	160
Hardened steel (45～55HRC) H13, L6	a_p≦0.2DC	Revolution n (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	a_e=1DC	Feed rate v_f (mm/min)	76	96	112	116	124	132	116	104

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

HGOF2-TH

Side cutting



Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. (mm) ϕ2	ϕ3	ϕ4	ϕ5	ϕ6	ϕ8	ϕ10	ϕ12
Cast iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1.5DC	Revolution n (min^{-1})	14,300	9,600	7,200	5,700	4,800	3,600	2,900	2,400
	a_e=0.15DC	Feed rate v_f (mm/min)	385	430	460	500	540	575	535	500
Alloy steel (25～35HRC)	a_p≦1.5DC	Revolution n (min^{-1})	14,300	9,600	7,200	5,700	4,800	3,600	2,900	2,400
	a_e=0.1DC	Feed rate v_f (mm/min)	345	385	415	450	485	520	480	450
Stainless steel (25～35HRC) 304	a_p≦1.5DC	Revolution n (min^{-1})	10,000	6,720	5,040	4,000	3,360	2,520	2,030	1,680
	a_e=0.1DC	Feed rate v_f (mm/min)	225	250	270	295	315	340	315	295
Pre-hardened steel (35～45HRC) P21	a_p≦1.5DC	Revolution n (min^{-1})	12,700	8,500	6,400	5,100	4,200	3,200	2,500	2,100
	a_e=0.07DC	Feed rate v_f (mm/min)	280	305	330	360	375	410	370	350
Hardened steel (45～55HRC) H13, L6	a_p≦1.5DC	Revolution n (min^{-1})	11,100	7,400	5,600	4,500	3,700	2,800	2,200	1,900
	a_e=0.05DC	Feed rate v_f (mm/min)	200	230	250	275	290	315	285	275

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

HGOF4-TH HGOF2-TH

When using the 2-flute model, set feed rate only to 50% of the value below as a general criteria. Further, it is not recommended to use the 2-flute model for cutting materials with hardness of 55HRC.

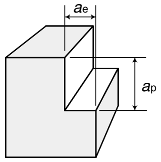
Contouring

Work material (Hardness)	Cutting condition	Tool dia DC× Corner radius RE (mm)							
		φ2×RE0.5	φ3×RE0.8	φ4×RE1	φ5×RE1.2	φ6×RE1.5	φ8×RE2	φ10×RE2	φ12×RE2
Cast Iron, Carbon steel, Alloy steel (150～250HB) Cast Iron, 1050	Revolution *n* (min^{-1})	12,000	8,000	6,000	4,800	4,000	3,000	2,400	2,000
	Feed rate v_f (mm/min)	5,380	6,050	6,380	6,380	6,720	6,720	6,720	6,380
	a_p (mm)	0.12	0.19	0.24	0.29	0.36	0.48	0.48	0.48
	a_e (mm)	0.5	0.7	1	1.3	1.5	2	3	4
Tool steel (25～35HRC) 304	Revolution *n* (min^{-1})	11,000	7,400	5,600	4,500	3,700	2,800	2,200	1,900
	Feed rate v_f (mm/min)	4,510	5,110	5,450	5,470	5,680	5,730	5,630	5,540
	a_p (mm)	0.12	0.19	0.24	0.29	0.36	0.48	0.48	0.48
	a_e (mm)	0.5	0.7	1	1.3	1.5	2	3	4
Pre-hardened steel (35～45HRC) P21	Revolution *n* (min^{-1})	10,000	6,900	5,200	4,100	3,400	2,600	2,100	1,700
	Feed rate v_f (mm/min)	3,200	3,730	3,950	3,900	4,080	4,160	4,200	3,880
	a_p (mm)	0.12	0.19	0.24	0.29	0.36	0.48	0.48	0.48
	a_e (mm)	0.5	0.7	1	1.3	1.5	2	3	4
Hardened steel (45～55HRC) H13, L6	Revolution *n* (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	Feed rate v_f (mm/min)	2,560	2,860	3,040	3,040	3,240	3,200	3,200	2,960
	a_p (mm)	0.08	0.13	0.17	0.20	0.25	0.34	0.34	0.34
	a_e (mm)	0.5	0.7	1	1.3	1.5	2	3	4
Hardened steel (55～60HRC) D2, M2	Revolution *n* (min^{-1})	8,000	5,300	4,000	3,200	2,700	2,000	1,600	1,300
	Feed rate v_f (mm/min)	1,275	1,425	1,525	1,525	1,625	1,600	1,600	1,488
	a_p (mm)	0.06	0.10	0.12	0.14	0.18	0.24	0.24	0.24
	a_e (mm)	0.5	0.7	1	1.3	1.5	2	3	4

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

HGOR-TH



Side cutting

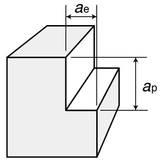
Work material (Hardness)	Depth of cut DC:Tool dia. (mm)	Cutting condition	Tool dia. DC (mm)					
			φ6	φ8	φ10	φ12	φ16	φ20
Cast Iron, Carbon steel, Alloy steel (200～250HB) Cast Iron, 1050	a_p≦1.5DC	Revolution *n* (min^{-1})	5,836	4,377	3,501	2,918	2,188	1,751
	a_e=0.1DC	Feed rate v_f (mm/min)	934	875	840	817	788	770
Alloy steel (25～35HRC)	a_p≦1.5DC	Revolution *n* (min^{-1})	4,775	3,581	2,865	2,387	1,790	1,432
	a_e=0.1DC	Feed rate v_f (mm/min)	668	645	630	621	609	573
Pre-hardened steel (35～45HRC) P21	a_p≦1DC	Revolution *n* (min^{-1})	4,244	3,183	2,546	2,122	1,592	1,273
	a_e=0.07DC	Feed rate v_f (mm/min)	509	509	509	509	509	458
Hardened steel (45～55HRC) H13, L6	a_p≦1DC	Revolution *n* (min^{-1})	3,714	2,785	2,228	1,857	1,393	1,114
	a_e=0.05DC	Feed rate v_f (mm/min)	223	223	223	223	223	201

【Note】

① Use a highly rigid and accurate machine as possible.
② These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
③ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.
④ To increase efficiency even further, increase the rotation speed and the feed rate by the same ratio.

Recommended Cutting Conditions (Metric)

HGOS2-PN HGOS4-PN



Side cutting

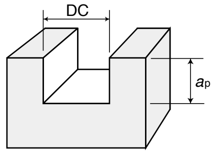
Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy				Cast iron, Carbon steel (150～200HB) No.35 B, 1050, 1055				Stainless steel (25～35HRC) 304, 316			
		Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm
0.2	0.4	66,879	669	0.300	0.010	55,732	557	0.300	0.010	33,439	301	0.300	0.008
0.3	0.6	44,586	446	0.450	0.015	37,155	372	0.450	0.015	22,293	201	0.450	0.012
0.4	0.8	38,217	382	0.600	0.020	27,866	279	0.600	0.020	16,720	150	0.600	0.016
0.5	1	38,217	382	0.750	0.025	25,478	255	0.750	0.025	15,287	138	0.750	0.020
0.6	1.2	41,401	662	0.900	0.030	26,539	425	0.900	0.030	15,924	229	0.900	0.024
0.7	1.4	35,487	568	1.050	0.035	29,572	473	1.050	0.035	17,743	256	1.050	0.028
0.8	1.6	33,439	535	1.200	0.040	25,876	414	1.200	0.040	15,525	224	1.200	0.032
0.9	1.8	33,970	544	1.350	0.045	24,770	396	1.350	0.045	14,862	214	1.350	0.036
1	2	38,217	764	1.500	0.050	25,478	510	1.500	0.050	15,287	275	1.500	0.040
1.5	3	28,025	561	2.250	0.150	21,231	425	2.250	0.150	12,739	229	2.250	0.135
2	6	21,019	631	3.000	0.200	17,516	525	3.000	0.200	10,510	284	3.000	0.180
2.5	8	16,815	504	3.750	0.250	14,013	420	3.750	0.250	8,408	227	3.750	0.225
3	8	15,287	611	4.500	0.300	11,677	467	4.500	0.300	7,006	252	4.500	0.270
3.5	10	13,103	524	5.250	0.350	10,919	437	5.250	0.350	6,551	236	5.250	0.315
4	11	11,465	573	6.000	0.400	9,554	478	6.000	0.400	5,732	258	6.000	0.360
4.5	11	10,191	510	6.750	0.450	8,493	425	6.750	0.450	5,096	229	6.750	0.405
5	13	9,172	550	7.500	0.500	7,643	459	7.500	0.500	4,586	248	7.500	0.450
5.5	13	8,338	500	8.250	0.550	6,948	417	8.250	0.550	4,169	225	8.250	0.495
6	13	7,643	459	9.000	0.600	6,369	382	9.000	0.600	3,822	206	9.000	0.540
7	16	6,551	459	10.500	0.700	5,460	382	10.500	0.700	3,276	206	10.500	0.630
8	19	5,732	401	12.000	0.800	4,777	334	12.000	0.800	2,866	181	12.000	0.720
9	19	5,096	408	13.500	0.900	4,246	340	13.500	0.900	2,548	183	13.500	0.810
10	22	4,586	459	15.000	1.000	3,822	382	15.000	1.000	2,293	206	15.000	0.900
12	26	3,822	459	18.000	1.200	3,185	382	18.000	1.200	1,911	206	18.000	1.080
16	35	2,866	401	24.000	1.600	2,389	334	24.000	1.600	1,433	181	24.000	1.440
20	40	2,293	367	30.000	2.000	1,911	306	30.000	2.000	1,146	165	30.000	1.800

Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25～35HRC) P20, H13, L6				Pre-hardened steel (35～45HRC) P21				Hardened steel (45～52HRC) H13			
		Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	a_e mm
0.2	0.4	33,439	301	0.300	0.008	26,752	217	0.300	0.006	16,720	105	0.300	0.006
0.3	0.6	22,293	201	0.450	0.012	17,834	144	0.450	0.009	11,146	70	0.450	0.009
0.4	0.8	16,720	150	0.600	0.016	13,376	108	0.600	0.012	8,360	53	0.600	0.012
0.5	1	15,287	138	0.750	0.020	12,229	99	0.750	0.015	7,643	48	0.750	0.015
0.6	1.2	15,924	229	0.900	0.024	12,739	165	0.900	0.018	7,962	80	0.900	0.018
0.7	1.4	17,743	256	1.050	0.028	14,195	184	1.050	0.021	8,872	89	1.050	0.021
0.8	1.6	15,525	224	1.200	0.032	12,420	161	1.200	0.024	7,763	78	1.200	0.024
0.9	1.8	14,862	214	1.350	0.036	11,890	154	1.350	0.027	7,431	75	1.350	0.027
1	2	15,287	275	1.500	0.040	12,229	198	1.500	0.030	7,643	96	1.500	0.030
1.5	3	12,739	229	2.250	0.135	10,191	165	2.250	0.120	6,369	80	2.250	0.045
2	6	10,510	284	3.000	0.180	6,115	149	3.000	0.160	5,732	108	3.000	0.060
2.5	8	8,408	227	3.750	0.225	5,707	139	3.750	0.200	5,350	101	3.750	0.075
3	8	7,006	252	4.500	0.270	5,096	165	4.500	0.240	4,777	120	4.500	0.090
3.5	10	6,551	236	5.250	0.315	4,659	151	5.250	0.280	4,368	110	5.250	0.105
4	11	5,732	258	6.000	0.360	4,331	175	6.000	0.320	4,061	128	6.000	0.120
4.5	11	5,096	229	6.750	0.405	4,076	165	6.750	0.360	3,822	120	6.750	0.135
5	13	4,586	248	7.500	0.450	3,873	188	7.500	0.400	3,631	137	7.500	0.150
5.5	13	4,169	225	8.250	0.495	3,706	180	8.250	0.440	3,474	131	8.250	0.165
6	13	3,822	206	9.000	0.540	3,397	165	9.000	0.480	3,185	120	9.000	0.180
7	16	3,276	206	10.500	0.630	2,912	165	10.500	0.560	2,730	120	10.500	0.210
8	19	2,866	181	12.000	0.720	2,548	144	12.000	0.640	2,389	105	12.000	0.240
9	19	2,548	183	13.500	0.810	2,265	147	13.500	0.720	2,123	107	13.500	0.270
10	22	2,293	206	15.000	0.900	2,038	165	15.000	0.800	1,911	120	15.000	0.300
12	26	1,911	206	18.000	1.080	1,699	165	18.000	0.960	1,592	120	18.000	0.360
16	35	1,433	181	24.000	1.440	1,274	144	24.000	1.280	1,194	105	24.000	0.480
20	40	1,146	165	30.000	1.800	1,019	132	30.000	1.600	955	96	30.000	0.600

【Note】
① PN Coating is less electro conductive. Therefore, electric transmitted measuring systems may not work.
② The cutting conditions given above is applied to 2 flutes type end mills. As for 4 flutes type, increase the feed rate by 1.5 times.
③ Use a highly rigid and accurate machine as possible.
④ Use the appropriate coolant for the work material and machining shape.
⑤ These conditions are for general guidance; in actual machining conditions adjust the parameters according to your actual machine and work-piece conditions.
⑥ If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

HGOS2-PN

Slotting



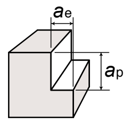
Tool dia. DC (mm)	Flute length APMX (mm)	Copper alloy, Aluminium alloy			Cast iron, Carbon steel (150〜200HB) No.35 B, 1050, 1055			Stainless steel (25〜35HRC) 304, 316		
		Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm
0.2	0.4	58,678	235	0.01	53,344	213	0.01	37,341	157	0.01
0.3	0.6	39,119	156	0.02	35,563	142	0.02	24,894	120	0.02
0.4	0.8	35,032	140	0.02	26,672	107	0.02	22,293	103	0.02
0.5	1	31,529	126	0.03	25,478	102	0.03	20,064	103	0.03
0.6	1.2	32,113	180	0.03	23,885	191	0.03	20,435	143	0.03
0.7	1.4	30,027	240	0.04	25,023	200	0.04	19,108	161	0.04
0.8	1.6	28,463	228	0.04	23,885	191	0.04	18,113	152	0.04
0.9	1.8	27,247	218	0.05	23,001	184	0.05	17,339	143	0.05
1	2	28,025	215	0.05	22,293	175	0.05	17,834	125	0.05
1.5	3	21,019	210	0.08	16,985	170	0.08	12,739	115	0.08
2	6	15,764	189	0.12	14,331	172	0.12	8,917	96	0.12
2.5	8	12,611	151	0.18	11,465	138	0.18	7,643	83	0.18
3	8	11,677	163	0.30	9,554	134	0.30	6,794	86	0.30
3.5	10	10,009	140	0.35	9,099	127	0.35	6,187	78	0.35
4	11	8,758	140	0.60	7,962	127	0.60	5,732	83	0.60
4.5	11	7,785	125	0.90	7,077	113	0.90	4,034	58	0.90
5	13	7,006	140	1.25	6,369	127	1.25	3,822	69	1.25
5.5	13	6,369	127	1.38	5,790	116	1.38	3,648	66	1.38
6	13	5,839	160	1.80	5,308	150	1.80	3,503	90	1.80
7	16	5,005	200	2.45	4,550	182	2.45	3,139	113	2.45
8	19	4,379	215	3.20	3,981	200	3.20	1,672	125	3.20
9	19	3,892	234	4.05	3,539	212	4.05	1,486	146	4.05
10	22	3,503	210	5.00	3,185	191	5.00	1,338	134	5.00
12	26	2,919	234	6.00	2,654	212	6.00	1,115	103	6.00
16	35	2,189	219	8.00	1,990	199	8.00	975	100	8.00
20	40	1,752	210	10.00	1,592	191	10.00	836	103	10.00

Tool dia. DC (mm)	Flute length APMX (mm)	Alloy steel (25〜35HRC) P20, H13, L6			Pre-hardened steel (35〜45HRC) P21			Hardened steel (45〜52HRC) H13		
		Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm	Revolution n min^{-1}	Feed rate v_f mm/min	a_p mm
0.2	0.4	24,005	122	0.01	14,936	56	0.01	8,402	34	0.01
0.3	0.6	16,003	109	0.02	9,958	50	0.01	5,601	30	0.01
0.4	0.8	14,331	103	0.02	8,917	56	0.02	5,016	34	0.02
0.5	1	12,898	93	0.03	8,025	51	0.02	4,514	31	0.02
0.6	1.2	13,137	112	0.03	8,174	51	0.03	4,598	31	0.02
0.7	1.4	12,284	125	0.04	7,643	58	0.03	4,299	35	0.03
0.8	1.6	11,644	119	0.04	7,245	55	0.04	4,075	33	0.03
0.9	1.8	11,146	133	0.05	6,936	61	0.04	3,901	37	0.04
1	2	11,465	125	0.05	7,134	58	0.05	4,013	35	0.04
1.5	3	9,554	114	0.08	5,945	52	0.07	3,344	32	0.06
2	6	7,166	122	0.12	4,459	56	0.11	2,508	34	0.10
2.5	8	5,732	97	0.18	3,567	45	0.16	2,006	27	0.14
3	8	4,777	81	0.30	2,972	37	0.27	1,672	23	0.24
3.5	10	4,095	104	0.35	2,548	48	0.32	1,433	29	0.28
4	11	3,583	91	0.60	2,229	42	0.54	1,254	26	0.49
4.5	11	3,185	92	0.90	1,982	50	0.81	1,115	30	0.73
5	13	2,866	103	1.25	1,783	45	1.13	1,003	27	1.01
5.5	13	2,606	89	1.38	1,621	41	1.24	912	25	1.11
6	13	2,389	105	1.80	1,486	48	1.62	836	30	1.46
7	16	2,047	122	2.45	1,274	56	2.21	717	34	1.98
8	19	1,075	120	3.20	669	54	2.88	376	33	2.59
9	19	955	114	4.05	594	52	3.65	334	32	3.28
10	22	860	117	5.00	535	54	4.50	301	33	4.05
12	26	717	110	6.00	446	51	5.40	251	31	4.86
16	35	627	107	8.00	390	49	7.20	219	30	6.48
20	40	537	100	10.00	334	51	9.00	188	31	8.10

【Note】 The 4 flutes not suitable for slotting.

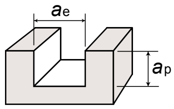
HGOSH4-TH

Side milling



Work Material (Hardness)	Cutting range	Depth of cut mm	Cutting conditions	Tool dia. DC (mm)								
				φ1	φ1.5	φ2	φ3	φ4	φ6	φ8	φ10	φ12
Carbon steel Alloy Steel (200～250HB) 1050	High speed	a_p=1.5DC	Revolution n (min^{-1})	47,800	31,800	23,800	16,000	12,000	8,000	6,000	4,800	4,000
		a_e=0.1DC	Feed rate v_f (mm/min)	1,500	1,600	1,700	1,800	1,900	2,200	2,400	2,200	2,100
	General	a_p=1.5DC	Revolution n (min^{-1})	28,600	19,100	14,300	9,600	7,200	4,800	3,600	2,900	2,400
		a_e=0.15DC	Feed rate v_f (mm/min)	690	760	830	860	920	1,080	1,150	1,070	1,000
Alloy steel P20	High speed	a_p=1.5DC	Revolution n (min^{-1})	41,400	27,600	20,700	14,000	10,000	6,900	5,200	4,100	3,500
		a_e=0.05DC	Feed rate v_f (mm/min)	1,160	1,330	1,330	1,400	1,400	1,700	1,900	1,700	1,600
	General	a_p=1.5DC	Revolution n (min^{-1})	28,600	19,100	14,300	9,600	7,200	4,800	3,600	2,900	2,400
		a_e=0.1DC	Feed rate v_f (mm/min)	580	690	740	770	830	970	1,040	960	900
Pre-hardened steel (35～45HRC) P21	High speed	a_p=1.5DC	Revolution n (min^{-1})	35,000	23,300	17,500	12,000	8,800	5,800	4,400	3,500	2,900
		a_e=0.05DC	Feed rate v_f (mm/min)	700	930	980	1,100	1,100	1,300	1,400	1,300	1,200
	General	a_p=1.5DC	Revolution n (min^{-1})	25,500	17,000	12,700	8,500	6,400	4,200	3,200	2,500	2,100
		a_e=0.07DC	Feed rate v_f (mm/min)	460	510	560	610	660	750	820	740	700
Hardened steel (45～55HRC) H13	High speed	a_p=1.5DC	Revolution n (min^{-1})	31,800	21,200	15,900	11,000	8,000	5,300	4,000	3,200	2,700
		a_e=0.02DC	Feed rate v_f (mm/min)	640	760	830	860	900	1,040	1,120	1,030	980
	General	a_p=1.5DC	Revolution n (min^{-1})	22,300	14,800	1,1100	7,400	5,600	3,700	2,800	2,200	1,900
		a_e=0.05DC	Feed rate v_f (mm/min)	360	410	440	460	500	580	630	570	550

Slotting



Work Material (Hardness)	Cutting range	Depth of cut mm	Cutting conditions	Tool dia. DC (mm)								
				φ1	φ1.5	φ2	φ3	φ4	φ6	φ8	φ10	φ12
Carbon steel Alloy Steel (200～250HB) 1050	High speed	a_p≦0.5DC	Revolution n (min^{-1})	25,500	17,000	12,700	8,500	6,400	4,200	3,200	2,500	2,100
		a_e=1DC	Feed rate v_f (mm/min)	720	750	810	820	920	1,010	1,090	950	880
	General	a_p≦1DC	Revolution n (min^{-1})	19,100	12,700	9,500	6,400	4,800	3,200	2,400	1,900	1,600
		a_e=1DC	Feed rate v_f (mm/min)	380	430	450	490	550	610	650	580	540
Alloy steel P20	High speed		Revolution n (min^{-1})									
			Feed rate v_f (mm/min)									
	General	a_p≦0.5DC	Revolution n (min^{-1})	19,100	12,700	9,500	6,400	4,800	3,200	2,400	1,900	1,600
		a_e=0.1DC	Feed rate v_f (mm/min)	340	380	400	440	500	550	590	520	480
Pre-hardened steel (35～45HRC) P21	High speed		Revolution n (min^{-1})									
			Feed rate v_f (mm/min)									
	General	a_p≦0.5DC	Revolution n (min^{-1})	17,500	11,700	8,800	5,800	4,400	2,900	2,200	1,800	1,500
		a_e=1DC	Feed rate v_f (mm/min)	280	300	330	360	410	450	480	440	400
Hardened steel (45～55HRC) H13	High speed		Revolution n (min^{-1})									
			Feed rate v_f (mm/min)									
	General	a_p≦0.2DC	Revolution n (min^{-1})	16,000	10,600	8,000	5,300	4,000	2,700	2,000	1,600	1,300
		a_e=1DC	Feed rate v_f (mm/min)	190	210	240	240	280	310	330	290	260

【Note】

①Use the high-rigidity and high accuracy machine as possible
②These Recommended Cutting Conditions indicate only the rule of a thumb for the cutting conditions. In actual machining, the condition should be adjusted according to the machining shape, purpose and the machine type.
③If the rpm available is lower than that recommended please reduce the feed rate to the same ratio.

⚠ Safety notes

1. Cautions regarding handling

(1) When removing the tool from its case (packaging), be careful that the tool does not pop out or is dropped. Be particularly careful regarding contact with the tool flutes.
(2) When handling tools with sharp cutting flutes, be careful not to touch the cutting flutes directly with your bare hands.

2. Cautions regarding mounting

(1) Before use, check the outside appearance of the tool for scratches, cracks, etc. and that it is firmly mounted in the collet chuck, etc.
(2) If abnormal chattering, etc. occurs during use, stop the machine immediately and remove the cause of the chattering.

3. Cautions during use

(1) Before use, confirm the dimensions and direction of rotation of the tool and milling work material.
(2) The numerical values in the standard cutting conditions table should be used as criteria when starting new work. The cutting conditions should be adjusted as appropriate when the cutting depth is large, the rigidity of the machine being used is low, or according to the conditions of the work material.
(3) Cutting tools are made of a hard material. During use, they may break and fly off. In addition, cutting chips may also fly off. Since there is a danger of injury to workers, fire, or eye damage from such flying pieces, a safety cover should be attached when work is performed and safety equipment such as safety goggles should be worn to create a safe environment for work.
(4) There is a risk of fire or inflammation due to sparks, heat due to breakage, and cutting chips. Do not use where there is a risk of fire or explosion. **Please caution of fire while using oil base coolant, fire prevention is necessary.**
(5) Do not use the tool for any purpose other than that for which it is intended.

4. Cautions regarding regrinding

(1) If regrinding is not performed at the proper time, there is a risk of the tool breaking. Replace the tool with one in good condition, or perform regrinding.
(2) Grinding dust will be created when regrinding a tool. When regrinding, be sure to attach a safety cover over the work area and wear safety clothes such as safety goggles, etc.
(3) This product contains the specified chemical substance cobalt and its inorganic compounds. When performing regrinding or similar processing, be sure to handle the processing in accordance with thelocal laws and regulations regarding prevention of hazards due to specified chemical substances.

Notes

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