Nidec
All for dreams

NIDEC MACHINE TOOL CORPORATION

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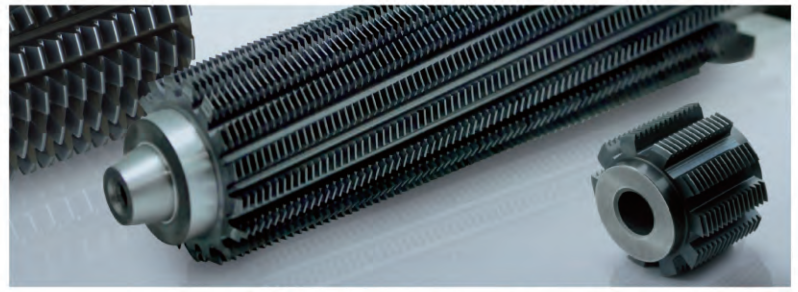
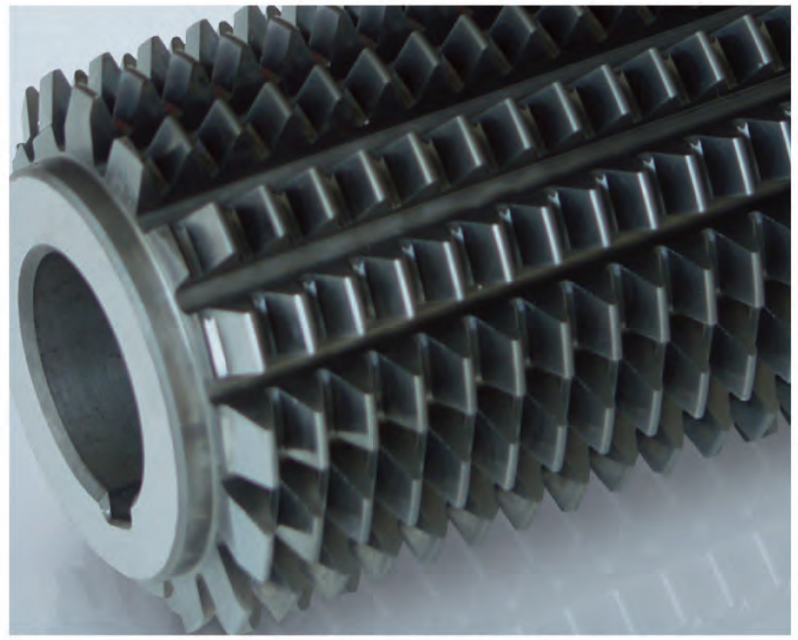
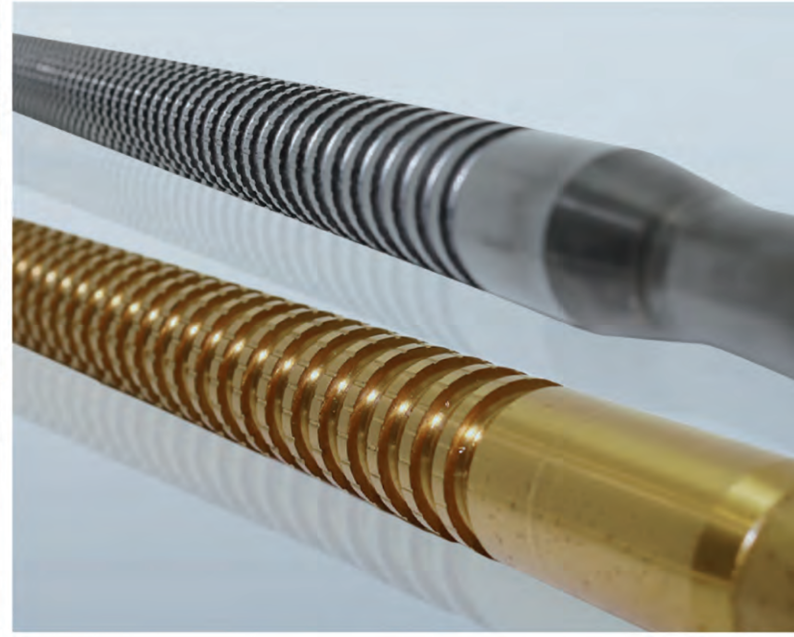
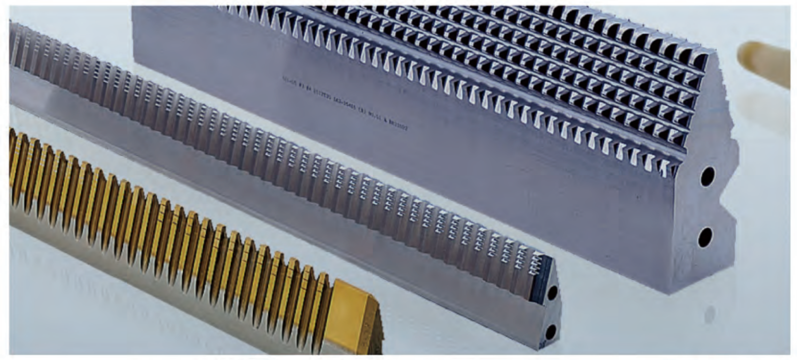
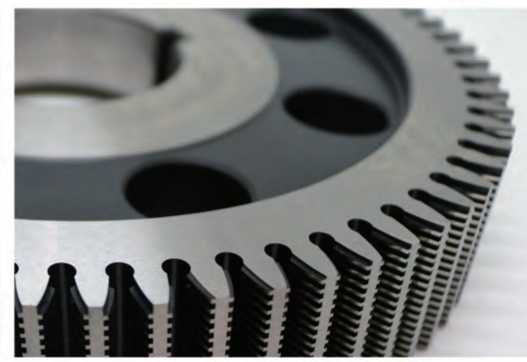


PRECISION CUTTING TOOLS HANDBOOK

HOBS / GEAR SHAPER CUTTERS / SHAVING CUTTERS
BROACHES / OTHER PRODUCTS





NIDEC MACHINE TOOL CORPORATION

www.nidec.com/en/nidec-machinetool/

As a leading company for gear manufacturing

Since the 1940s, we have been researching and developing specialized precision cutting tools for power transmission gears, aircraft engines and turbines.
In 1988, we were the first in the world to launch a complete dry-cut hobbing system that does not require any cutting fluids. Since then, we have continued to develop tool substrates and coating technologies that achieve both high production efficiency and reduced environmental impact.

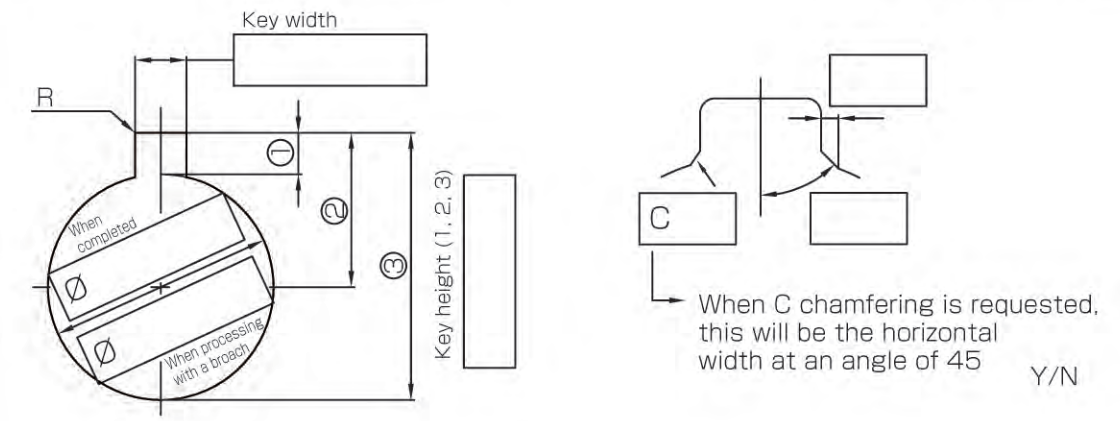
As "gearing professionals" who deliver both gear machines and gear cutting tools to our valued customers, we will continue to provide earth-friendly products with new technology while meeting the needs of customers around the world.

CONTENTS

Key Broach Design Specifications

Customer name:	Order no.:

Note: Even if you provide a workpiece drawing or broach supply drawing, make sure it is transcribed if it is difficult to read.
Make sure the ☐ sections are filled in. (Anything left blank will be treated as being left to our discretion.)

1	Broach supply drawing ( ) → No → Go to 2; Yes → Reference shank only → Go to 2; Yes → Has problems/Requires design change → Enter the details of the problem or reason for the change in 10.; Yes → Design according to supply drawing → Enter any comments in 10.
2	Workpiece drawing after broach processing ( ) → No → Go to 3; Yes → Go to 5
3	Workpiece dimensions after broach processing (include tolerances) *If chamfered, make sure ☐ is filled in. 
4	Cutting length ☐ No. of simultaneous cuts ___ Clamp (Yes / No) Product Material ☐ Hardness when cut ___
5	Broach appearance shape → Finishing teeth height ☐ Shank width ☐
6	Front shank: Dimensions to first tooth ☐ Nominal dimensions ☐ Standard ☐ Reference drawing number ☐ Rear shank: Required → Nominal dimensions ☐ Standard ☐ Reference drawing number ☐; Not required
7	Overall length specified (Yes / No) ☐ Tool material specified (Yes / No) ☐ Surface treatment specified (Yes / No) ☐
8	Broaching machine model: ___ Maximum pulling force ☐ Stroke ☐
9	Customer's information to be marked on cutters: ___
10	Remarks (order history, customer requests, etc.)

Tool manufacturing that meets global needs with four bases around the world

In order to meet the demands of customers around the world with technology, quality, and speed, we have manufacturing and development bases in Japan, as well as manufacturing facilities in the United States (Michigan and South Carolina) , India (Tamil Nadu) and China (Pinghu).
In the United States, we offer a lineup of products that specialize in high-precision mass production for aircraft and automobiles, with a focus on broach cutters and broaching machines.
In India, we have been able to ensure the high quality level as in Japan through technological exchanges since 1972, and our products have been highly praised by two-wheel and four-wheel vehicle manufacturers, giving us the top market share in the Indian market.
In China, we have installed a new factory and the latest equipment, and have established a system to support our customers locally.

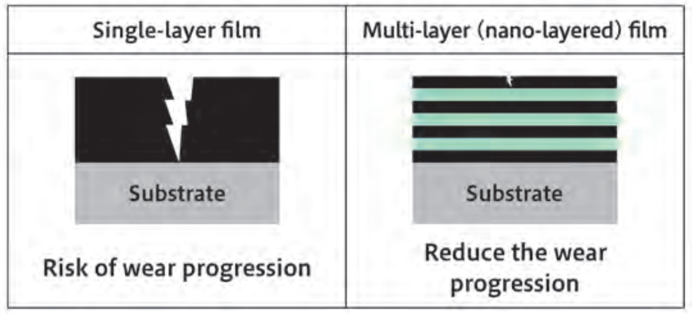
HOBS

Hobs, with their ability to create gears with superior efficiency, are widely used to make gears for automobiles, construction and industrial machinery, as well as for processing power transmission gears for marine vessels and aircraft. We manufacture tools with the optimum design parameters, such as outer diameter, overall length, bore diameter, and number of gashes, as well as tool substrates and coatings. We also provide tools to generate non-involute tooth profiles such as circular arcs, cycloidal, and sprocket tooth profiles. In addition, we can manufacture hobs with small-diameter bores, shank mounting and small module hobs.Hobs using Our MightyShield ΣII coating on their cutting edges provide all-round performance in any cutting situation, wet or dry, in a wide range of processing areas utilizing HSS hobs and carbide hobs.

MightyShield Σ II

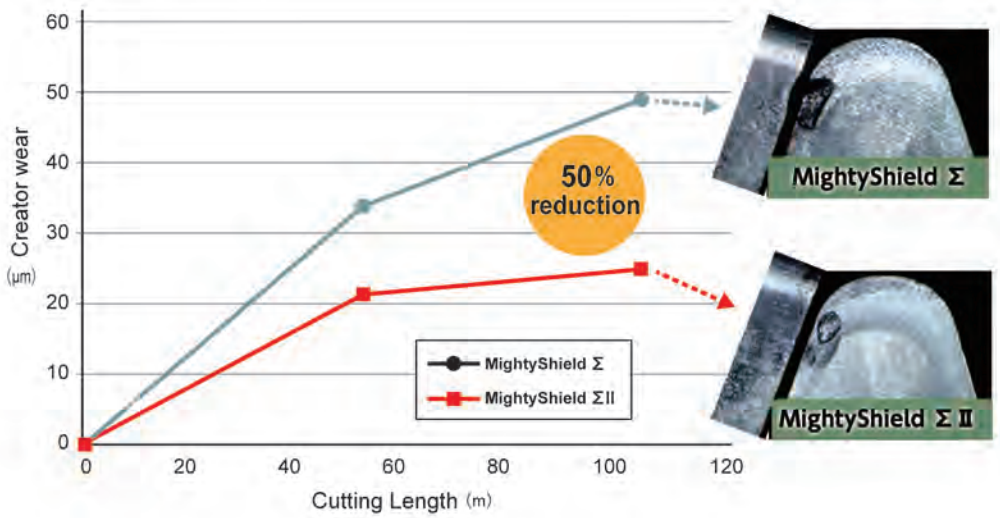
Features

- **Highly wear-resistant coating**
- **Achieved enhanced wear resistance and extended tool life with high-hardness film (HV 4,000) layered at the nano-level.**
- **Suitable for all machining ranges, from wet to high-speed dry cutting.**



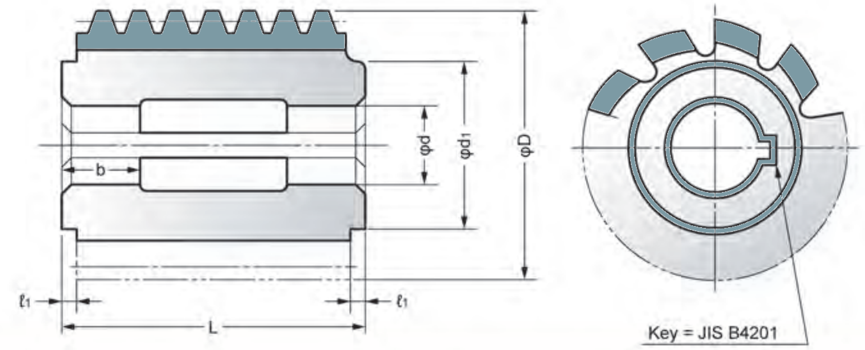
Example

Workpiece: m2.25, PA17.5°, HA23°, LH, Substrate: SCM420
Cutter: 3 starts, 16 flutes, with cutting face coating
Cutting conditions: Cutting speed: 300m/min Axial feed: 2.4 mm/rev
Climb cutting, Non-shift / Dry cutting



Dimensions and Precision Standard

■ Dimensions



Unit: mm

Module (m) Category 1	2	3	D	L	d Type A	d Type B	Reference N	d_1	b	$ℓ_1$
1			50	50	22	22.225	12	34	12	4
1.25										
1.5			55	55				36	14	
	1.75									
2			60	60			10	38	15	
	2.25									
2.5			65	65					16	
	2.75									
3			70	70	27	26.988		42	18	
		3.25								
	3.5		75	75				45	20	
		3.75	80							
4			85	80				50		
	4.5		90	85					22	
5			95	90						
	5.5		100	95	32	31.75	9	55	24	5
6			105	100					25	
		6.5	110	110					28	
	7		115	115						
8			120	130				60	32	
	9		125	145					36	
10			130	160					40	
	11		150	175	40	38.1		65	44	6
12			160	190					48	
	14		180	210			8	70	52	
16			200	230					58	
	18		220	250	50	50.8		80	62	
20			240	270					68	
	22		250	300					75	
25			270	320					80	

■ Precision Standard

Unit: μm

No.	Item	Standard diameter (mm) / Grade		Tolerance											
			Type A	8	10	13	22	–	27	32	40	50	–	60	80
			Type B	–	–	–	22.225	25.40	26.988	31.75	38.1	–	50.8	63.5	76.2
1	Bore diameter	AAA		+2.5 (H3) 0		+3 (H3) 0	+6 (H4) 0			+7 (H4) 0			+8 (H4) 0	+8 (H4) 0	+8 (H4) 0
		AA		+4 (H4) 0		+5 (H4) 0	+9 (H5) 0			+11 (H5) 0			+13 (H5) 0	+13 (H5) 0	+13 (H5) 0
		A		+6 (H5) 0		+8 (H5) 0									

No.	Item		Module / Grade	Margin or tolerance: 1 or more 2 or less	More than 2 3.5 or less	More than 3.5 6.3 or less	More than 6.3 10 or less	More than 10 16 or less	More than 16 25 or less
2	Boss	Peripheral runout	AAA	2	3	3	4	5	–
			AA	3	3	4	5	6	9
			A	5	5	6	8	10	14
3		Surface deflection	AAA	2	2	2	3	4	–
			AA	2	3	3	4	5	7
			A	4	4	5	6	8	11
4	Outside periphery	Gear cutting edge deflection	AAA	12	13	16	19	25	–
			AA	15	17	20	25	32	45
			A	24	26	32	40	50	71

Unit: μm

No.	Item		Grade		1 or more 2 or less	More than 2 3.5 or less	More than 3.5 6.3 or less	More than 6.3 10 or less	More than 10 16 or less	More than 16 25 or less
				Module →	Permissible value or tolerance					
5	Gash	Adjacent division error		AAA	12	13	16	19	25	–
				AA	15	17	20	25	32	45
				A	24	26	32	40	50	71
6		Cumulative division error		AAA	22	25	30	38	48	–
				AA	28	32	36	45	60	85
				A	45	50	60	70	95	132
7		Radial alignment		AAA	9	11	12	15	20	–
				AA	12	13	15	19	25	36
				A	18	21	25	30	40	56
8		Lead error		Grade	Tolerance: 32 mm or less	Tolerance: More than 32 mm				
				AAA	16	50				
				AA	20	60				
				A	25	80				
9	Profile	Profile error A	Single start	AAA	4	4	5	6	8	–
				AA	5	5	6	8	10	14
				A	8	8	10	12	16	22
				B	15	17	19	25	32	45
				C	30	34	40	48	63	90
			Threefold start	AAA	5	6	7	8		
				AA	7	7	8	11		
				A	11	12	14	17		
				B	21	24	28	34		
				C	42	48	56	67		
			Fivefold start	AAA	7	8				
				AA	8	10				
				A	13	15				
				B	26	30				
				C	53	60				
10		Tooth thickness error (-)	Single start	AAA	26	30	36	42	56	–
				AA	34	38	42	56	71	100
				A	34	38	42	56	71	100
			Threefold start	AAA	38	42	50	60		
				AA	48	53	60	75		
				A	48	53	60	75		
			Fivefold start	AAA	48	53				
				AA	60	67				
				A	60	67				
11		Cutter addendum error (+)	Single start	AAA	38	42	50	60	80	–
				AA	48	53	60	75	100	140
				A	48	53	60	75	100	140
			Threefold start	AAA	53	60	67	85		
				AA	67	71	85	106		
				A	67	71	85	106		
			Fivefold start	AAA	67	75				
				AA	85	95				
				A	85	95				
12	Lead	Adjacent error	Single start	AAA	3	4	4	6	7	–
				AA	4	5	6	7	9	12
				A	7	8	9	11	14	20
			Threefold start	AAA	5	5	6	8		
				AA	6	7	8	10		
				A	10	11	12	15		
			Fivefold start	AAA	6	7				
				AA	8	8				
				A	12	13				
13		1-axial pitch Cumulative error A	Single start	AAA	6	7	8	10	13	–
				AA	8	8	10	12	16	22
				A	12	13	16	19	25	36
			Threefold start	AAA	8	10	11	14		
				AA	11	12	14	17		
				A	17	19	22	28		
			Fivefold start	AAA	11	12				
				AA	13	15				
				A	21	24				
14		3-axial pitch Cumulative error	Single start	AAA	11	12	14	17	22	–
				AA	13	15	17	21	28	40
				A	21	24	28	34	45	63
			Threefold start	AAA	14	16	19	24		
				AA	18	20	24	30		
				A	28	32	38	48		
			Fivefold start	AAA	19	21				
				AA	24	26				
				A	38	42				

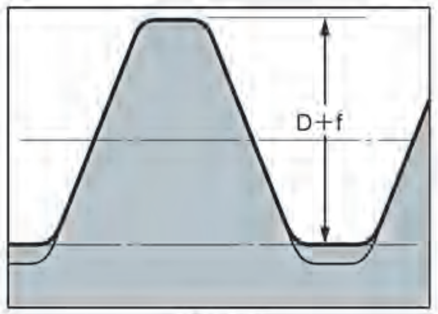
Unit: μm

No.	Item		Grade		1 or more 2 or less	More than 2 3.5 or less	More than 3.5 6.3 or less	More than 6.3 10 or less	More than 10 16 or less	More than 16 25 or less
				Module →	Tolerance or permissible tolerance					
15	Lead	Line of action adjacent pitch error	Single start	AAA	3	4	4	6	7	–
				AA	4	5	6	7	9	12
				A	7	8	9	11	14	20
			Threefold start	AAA	5	5	6	8		
				AA	6	7	8	10		
				A	10	11	12	15		
			Fivefold start	AAA	6	7				
				AA	8	8				
				A	12	13				
16		Line of action cumulative division error	Single start	AAA	8	8	10	12	16	–
				AA	10	11	12	15	20	28
				A	15	17	19	25	32	45
			Threefold start	AAA	11	12	14	17		
				AA	13	15	17	21		
				A	21	24	28	34		
			Fivefold start	AAA	13	15				
				AA	17	19				
				A	26	30				
17	Cutting face	Single pitch error	Single start	AAA	5	5	6	8	10	–
				AA	6	7	8	10	12	18
				A	10	11	12	15	20	28
18		Vicinal pitch error	Threefold start	AAA	5	6	7	8		
				AA	7	7	8	11		
				A	11	12	14	17		
			Fivefold start	AAA	7	8				
				AA	8	10				
				A	13	15				
19		3 Axial pitch error	Single start	AAA	8	10	11	14	18	–
				AA	11	12	14	17	22	32
				A	17	19	22	28	36	50
			Threefold start	AAA	12	13	15	19		
				AA	15	16	19	24		
				A	24	26	30	38		
			Fivefold start	AAA	15	17				
				AA	19	21				
				A	30	34				

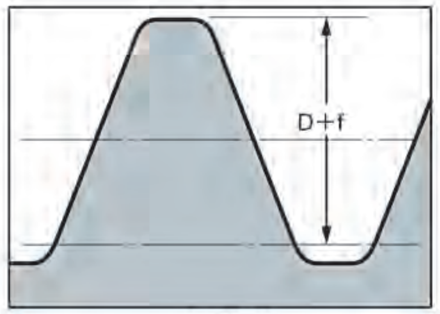
Remarks: These precision standards are extracted from JIS B4355-1998.

Profile

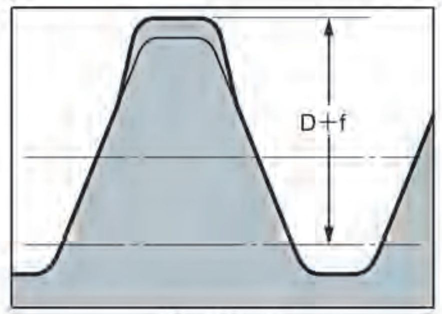
D+f: Whole depth



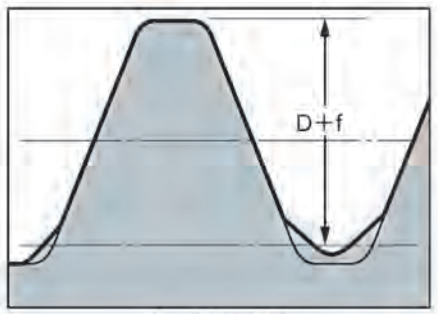
Topping



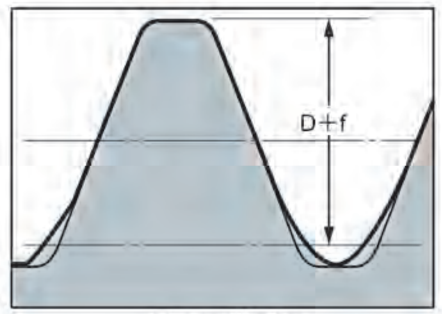
Standard



Protuberance



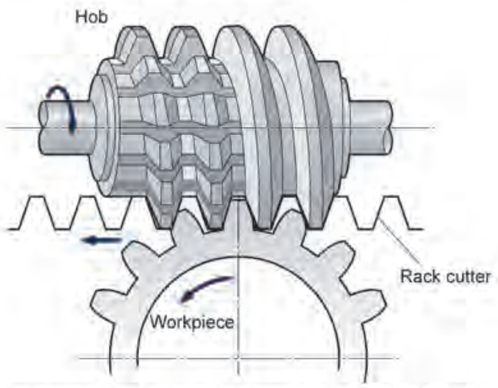
Semi-topping



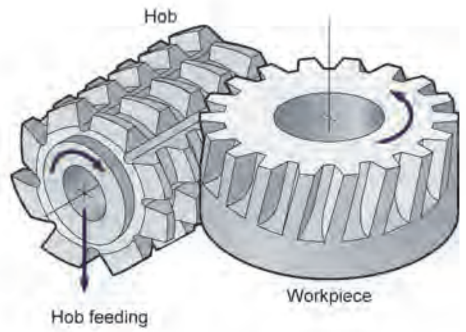
Tip modification

Cutting by Hobbing

Achieve highly efficient and accurate gear cutting—just mount a hob on the hobbing machine, position the hob and the workpiece like a rack and pinion, rotate them in sync, and feed the hob along the workpiece in the direction of the gear tooth width.



A hob can be seen either as multiple teeth or as a single tooth. One tooth of a workpiece is generated per rotation.

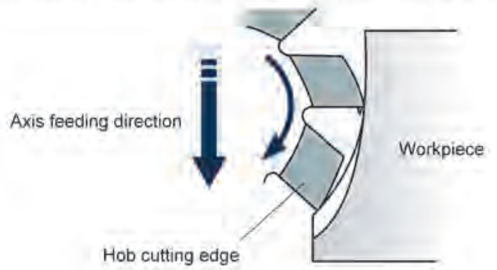


The hob is fed to a workpiece in the gear width (axial) direction. Processing efficiency may improve if the number of starts for the hob is increased, but the number of cutting teeth will decrease and cause an increase in the polygonal error.
The machine must have sufficient rigidity and strength.

Gear Cutting Methods in Hobbing

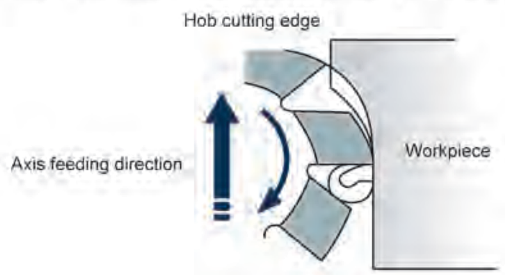
Conventional hobbing

The hob rotates from the top to the bottom face of a workpiece.



Climb hobbing

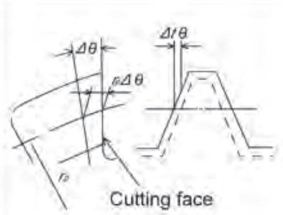
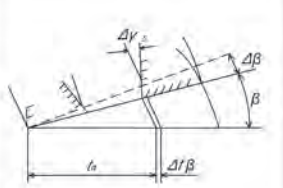
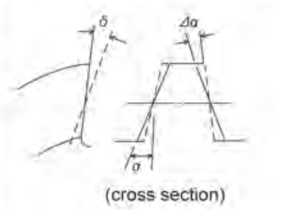
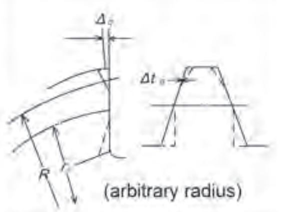
The hob rotates from the bottom to the top face of a workpiece.



Precautions for Sharpening

The cutting surfaces wear, so need to be ground off. This is called sharpening. If sharpening is not carried out properly, the hob will become less precise, and the following issues will occur.

$\Delta\gamma_\delta$=Hobbing lateral face lip clearance ($\tan\Delta\gamma_\delta=\tan\varepsilon\cdot\tan\alpha_n\cdot\cos\gamma$)
ε=external lip clearance, αn=tooth pressure angle, γ=hobbing feeding angle, $r\rho$=hobbing pitch circle diameter

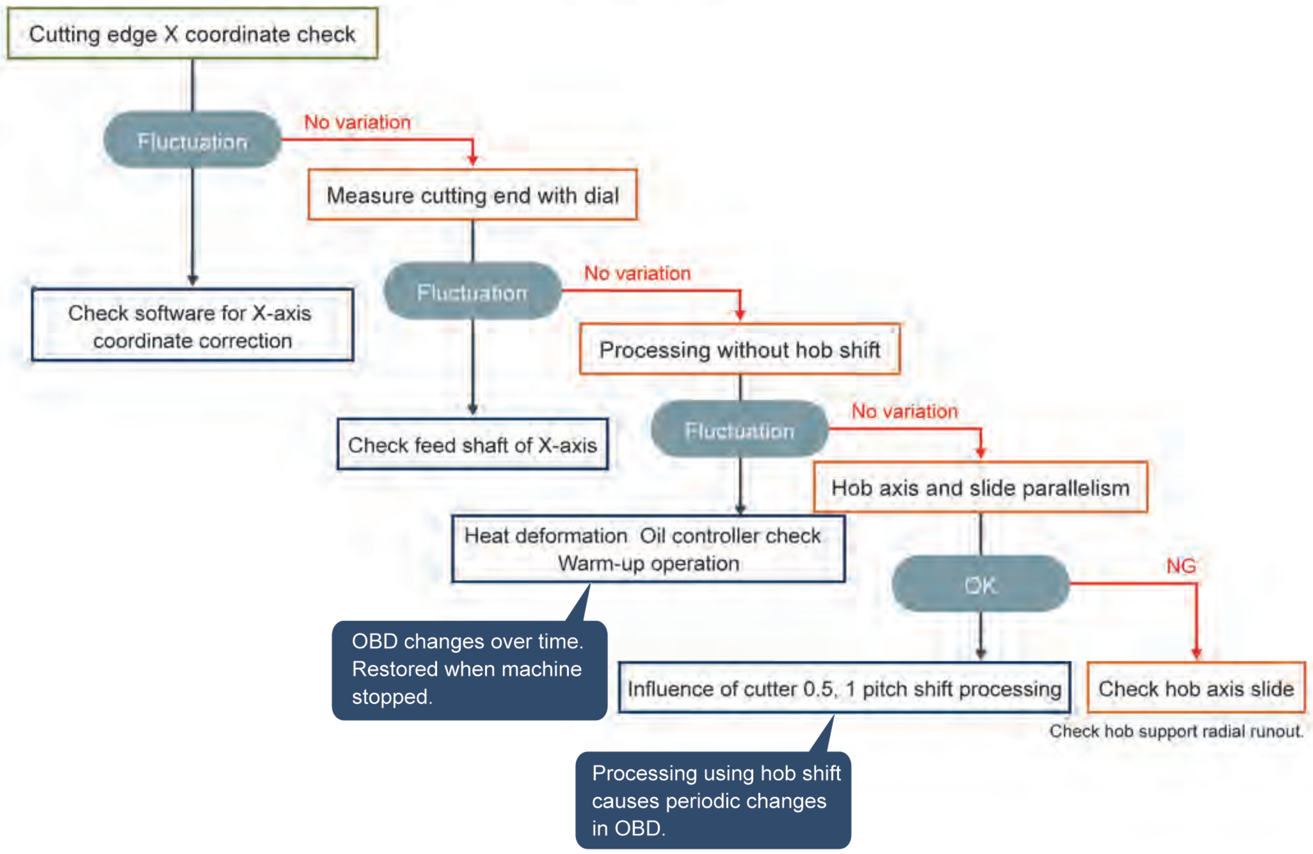
Flute spacing error caused by sharpening	Flute spacing angle error $\Delta\,\theta$ rad (spacing error)	Helix angle error $\Delta\,\beta$ rad (lead error)	Cutting face radial direction error δ deg (cutting face angle error)	Cutting face becomes uneven (radial alignment)
				
Effect on hob and formula for calculating this / Error in normal hobs	• Uneven pitch in cutting teeth (tooth profile deviation in machined gears) $\Delta t\theta=r_p\cdot\Delta\theta\cdot\tan\Delta\gamma_\delta$ • Pitch error of approx. 6 μm for every 0.1 mm	• Expansion and contraction of entire cutting edge pitch (workpiece gear pressure angle deviation) $\Delta t\beta=t_a\cdot\Delta\beta\cdot\tan\Delta\gamma_\delta$ • For every $\Delta\beta=1°$ expands/contracts at a rate of $\Delta t\beta=0.001t_a$ (t_a=axial pitch)	• Pressure angle error (workpiece gear pressure angle deviation) $\sin\Delta\alpha=\tan\delta\cdot\cos^2\alpha\cdot\tan\Delta\gamma_\delta$ • For every δ=3°, error of $\Delta\alpha$=10′	• Tooth profile error (tooth profile deviation in machined gears) $\Delta t_q=\frac{r_p}{R}\Delta_q\cdot\tan\Delta\gamma_\delta$ • For every Δ_q=0.1 mm, tooth profile error or 6 μm

Hobbing Problems and Causes

	Problem	Symptom	Cause
Workpiece	Large undulations	Tooth profile with large undulations	1. Hub runout
			2. Poor lead precision
			3. Poor cutting face pitch
			4. Excessive bore diameter
			5. Poor profile
			6. Inaccurate installation of the hob to the hob arbor
	Large collapse	Collapsed tooth form	1. Hub runout
			2. Poor hob profile
			3. Poor radial alignment
			4. Runout of workpiece during workpiece measurement
		Insufficient meshing length	1. Insufficient profile depth
			2. Excessive cutter tip point radius
			3. Poor cutter protuberance profile
			4. Cutter design error
	Pitch	Poor workpiece pitch	1. Hub runout
			2. Poor lead precision
			3. Poor cutting face pitch
			4. Inaccurate installation of the hob to the hob arbor
			5. Runout of workpiece during workpiece measurement
	Lead	Poor workpiece lead	1. Poor lead precision
			2. Poor hobbing machine precision
			3. Runout of workpiece during workpiece measurement
	Chamfering	Excessive or insufficient chamfering	1. Poor hob chamfering height
			2. Poor workpiece outer diameter size
			3. Cutting run-in size error
			4. Poor hob radial alignment
			5. Cutter design error
			6. Hob mounting angle error
		Difference in chamfering amount on each side	1. Poor hob chamfering height
			2. Poor lead precision
		Difference in chamfering amount by tooth	1. Hub runout
			2. Poor lead precision
	External diameter Tooth thickness Root diameter	Workpiece external diameter, tooth thickness, or root diameter defect (Topping profile hob)	1. Poor hob tooth thickness or depth dimensions
			2. Cutting run-in size error
			3. Poor hob radial alignment
			4. Cutter design error
			5. Hob mounting angle error
	Tear	Tear in tooth face or periphery	1. Interference at the end of the hob tooth
Cutter	Fractures	Started from crack	1. Grinding cracks during sharpening
			2. Grinding cracks during tooth profile grinding
			3. Cracking near cutting edge crater due to cutting heat
			4. Cracking in heat treatment process during fabrication
		Major fractures	1. Hob base material defect, excessive hardness, brittleness
			2. Run-in during rapid feeding
			3. Workpiece rotates during machining due to loose workpiece clamp
			4. Chips stuck in gashes due to insufficient or inappropriate direction cutting fluid discharge
			5. Cutting hard materials such as jigs
	Abnormal wear	Coating film stripping	1. Poor PVD processing
			• Poor preprocessing
			• Treatment process abnormality
			• Other
		Uneven crater wear	1. Uneven hob shift
		Uniform wear	1. Hardness of base material
			2. Poor material
			3. Poor heat treatment
		Wear in the joint tip radius connection	1. Angularity in the joint tip radius connection
		Wear from chips clogging in gashes	1. Narrow width of gash
			2. Chips stuck in gashes due to insufficient or inappropriate direction cutting fluid discharge

Standard Size Variation: Troubleshooting

If the OBD suddenly changes or fluctuates, check for the effects of swarf clogging, workpiece rotation, or tears.



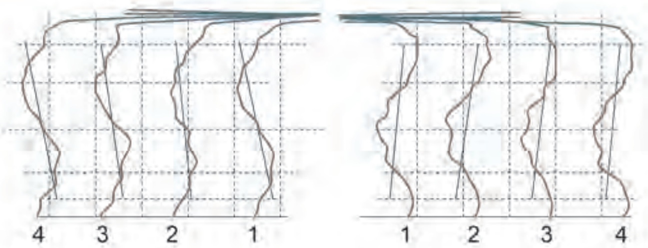
Effects of Cutting Load Fluctuations

■ Cause

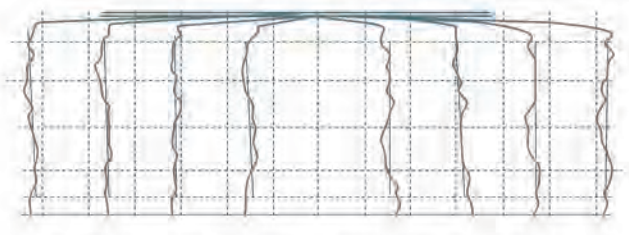
- Cutting force changes from 0 to Max to 0, deflection also changes.
- In particular, load fluctuation at the end of the cut affects machining accuracy.
- In addition, machine rigidity and clearance, mounting rigidity and holding rigidity, and the rigidity of the workpiece itself also have effects.

■ Verification Method

- if machining accuracy is poor, start with double cutting.
  - If it cleans up, the cause is flexing under load.
  - If it does not, the cause is machine precision.



Distortion of tooth profile due to cutting load fluctuations



Tooth profile improvement after double cutting

Hob Setting Angle Error and Tooth Thickness

■ Cause

A hob setting angle error may cause the tooth profile to remain unchanged or the tooth thickness to decrease. The method for discovering the amount of change is shown below.

■ Measures

Finding the amount of change

- Reduction in tooth thickness ΔW (for spur gears)

  $\Delta W = m_n \times \{\sin^2\gamma \times \Delta\varepsilon^2 / (2\tan\alpha_n)\} \times (g/\sin^3\gamma + Z)$

  m_n : Hob normal module
  α_n : Hob pressure angle
  Z : Number of workpiece teeth
  γ : Hob feed angle
  Δε : Hob mounting angle error
  g : Number of starts

- Helical gears

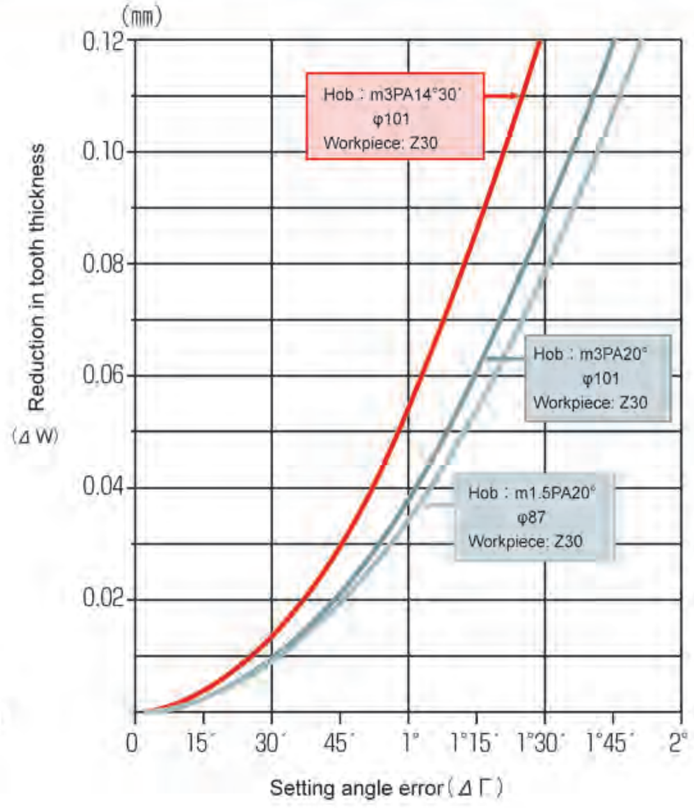
  Use the virtual number of teeth Z' instead of Z.

  $Z' = Z/\cos^3\beta$ Z : Number of helical gear teeth
  β : Gear helix angle

- Chamfering hob

  Chamfering amount decreases

  Decrease in chamfer amount ΔC $\Delta C = \Delta W / 2\tan\alpha_n$



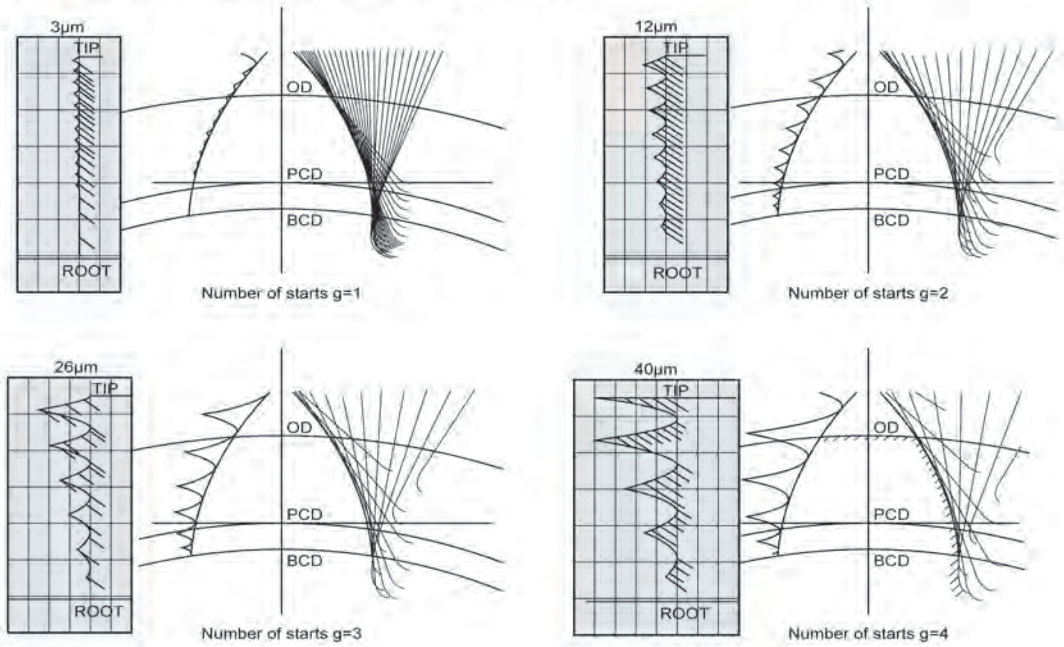
Number of Starts and Polygonal Error

■ How to find the polygonal error on the pitch circle

$$\Delta S = \frac{\pi^2 \times \sin\alpha_0 \times g^2 \times m_n}{4 \times l^2 \times Z}$$

g: Number of starts
l: Number of gashes
Z: Number of workpiece teeth

EXAMPLE $\alpha_0 = 25°$ $m_n = 4.5$ l = 12 Z=13 g=4 $\Delta S = 0.040\ m_n$



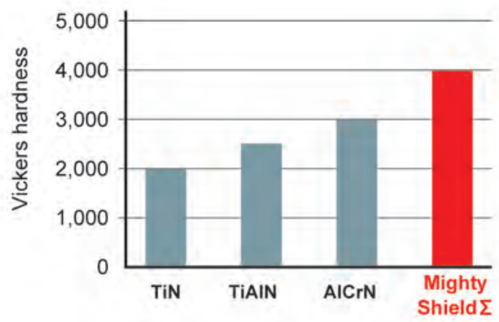
SHAPER CUTTERS

Shaper cutters are used for cutting teeth in shapes that hobs cannot handle. They are manufactured with our unique 7-axis NC profile grinding machines for involute and non-involute profiles such as circular arcs, cycloidal, and sprocket tooth profiles. We offer a lineup of high-quality, high-precision cutters that ensure smooth, high-precision tooth forms from tip to base, as well as provide long effective tooth lengths. Cutters with the MightyShield Σ coating we developed can be used for both wet and dry cutting, offering high efficiency and long life. Moreover, combining these with SS treatment also improves processing quality.

MightyShield Σ

Features

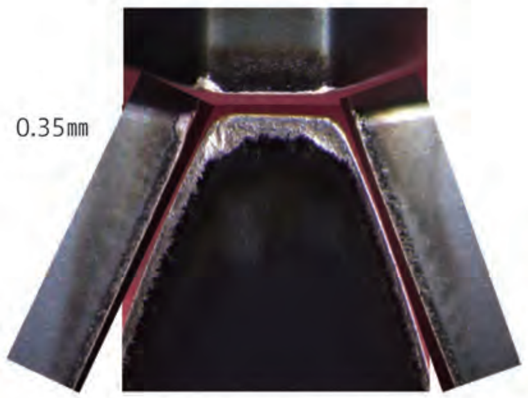
- Achieved enhanced wear resistance and extended tool life with high-hardness film (HV 4,000)
- Supports a wide range of machining applications (High-hardness components)
- Perform high capability in any cutting environment, whether dry or wet cutting



Examples

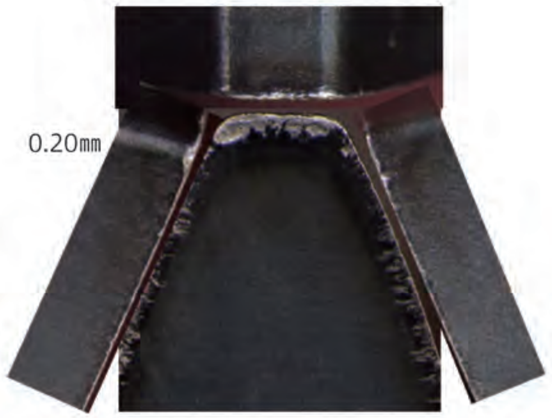
Workpiece: m4.5, PA20°, SPUR, NT90, ODφ490, Substrate: high hardness components
Cutter: NT31, ODφ165, Substrate: MX-1, Coating: MightyShield Σ
Machining conditions: Stroke rate: 65/90 str/min Rotary feed: 2.0/0.5 mm/st

Tool wear (after 30 pieces):



Super Dry III (with cutting face coating)

Tool wear (after 40 pieces):



MightyShield Σ (with cutting face coating)

About SS Treatment

SS treatment is the special treatment of surface finish on cutters.

Features

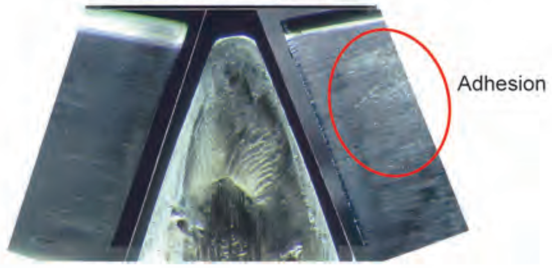
- **Reduces flaking and adhesion on workpiece tooth surfaces.**
- **Reduces adhesion on tool tooth surfaces.**
- **Special treatment to minimize the roughness of cutter tooth surfaces.**

Examples

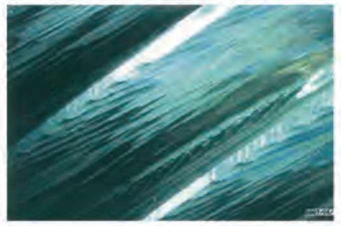
Workpiece: m2 PA20° HA35°LH NT29 ODφ79 Tooth width 25 Material: SCM420H
Cutter: ODφ160 φ160 Material: MAC B Black dynamic (no rake face coating)

Processing result by cutter without SS treatment

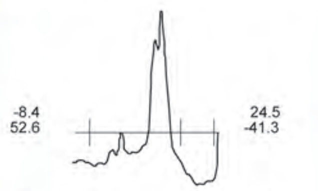
Cutter tooth surface condition



Workpiece cut tooth surface



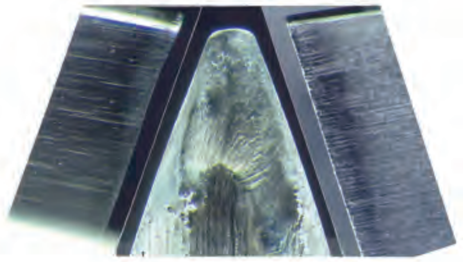
Tooth roughness measurement result



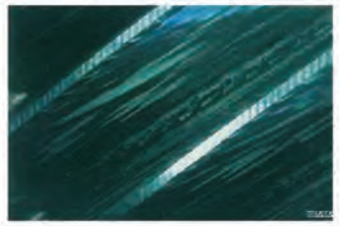
Flaking depth: Max value: 53 μm
Average value: 18.6 μm

Processing result by cutter with SS treatment

Cutter tooth surface condition



Workpiece cut tooth surface



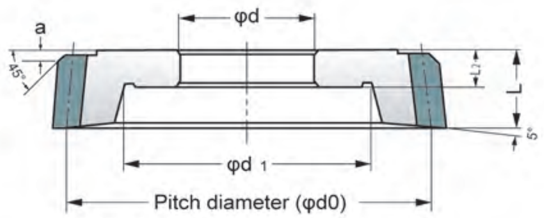
Tooth roughness measurement result

Flaking depth: Max value: 24 μm
Average value: 12.9 μm

Dimensions and Precision Standard

■ **Dimensions**

Disc type

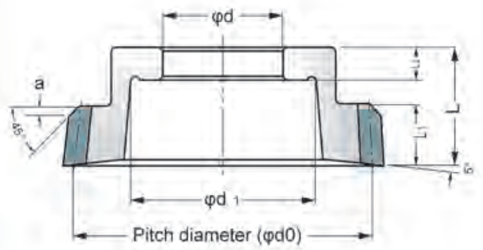


Unit: mm

Nominal size	Module (m)	Pitch diameter (d0) (approx.)	d	L	L_2	d_1*	a*
75	0.75 to 1	75	31.742	16	8	50	3
	1.25 to 2	75	31.742	18	8	50	3
	2.25 to 3.5	75	31.742	20	8	50	3
	3.75 to 5	75	31.742	22	10	50	3
100	1	100	31.742 or 44.450	18	10	65	4.5
	1.25 to 2	100		20	10	65	4.5
	2.25 to 3.5	100		22	10	65	4.5
	3.75 to 6	100		24	10	65	4.5
	6.5 to 7	105		28	12	65	4.5
125	1.5 to 2	125	44.450	22	10	85	4.5
	2.25 to 3.5	125	44.450	24	10	85	4.5
	3.75 to 6	125	44.450	26	12	85	4.5
	6.5 to 8	135	44.450	30	12	85	4.5
150	1.75 to 2	150	44.450	24	12	95	4.5
	2.25 to 3.5	150	44.450	26	12	95	4.5
	3.75 to 6	150	44.450	28	14	95	4.5
	6.5 to 10	150	44.450	32	14	95	4.5
175	2	175	44.450	26	14	110	4.5
	2.25 to 3.5	175	44.450	28	14	110	4.5
	3.75 to 6	175	44.450	30	14	110	4.5
	6.5 to 10	175	44.450	34	14	110	4.5
	11 to 12	175	44.450	36	16	110	4.5

- Tolerance between L and L2 is per JIS B 0405 Coarse Class
- Items with an asterisk can be customized as needed.

Bell type



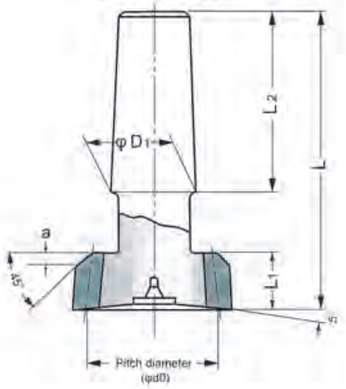
Unit: mm

Nominal size	Module (m)	Pitch diameter (d0) (approx.)	φd	L	L_1	L_2	d_1*	a*
50	0.75 to 1	50	19.050	30	12	8	28	3
	1.25 to 2	50	19.050	32	14	8	28	3
	2.25 to 3.5	50	19.050	34	16	8	28	3
	3.75 to 4	60	19.050	38	18	8	28	3
75	0.75 to 1	75	31.742	34	16	8	50	3
	1.25 to 2	75	31.742	36	18	8	50	3
	2.25 to 3.5	75	31.742	38	20	8	50	3
	3.75 to 5	80	31.742	42	22	10	50	3
100	1	100	31.742 or 44.450	38	18	10	65	4.5
	1.25 to 2	100		40	20	10	65	4.5
	2.25 to 3.5	100		42	22	10	65	4.5
	3.75 to 6	105		44	24	10	65	4.5
	6.5 to 7	110		50	28	12	65	4.5

● Tolerance between L, L1 and L2 is per JIS B 0405 Coarse Class

● Items with asterisk can be customized as needed.

Shank type



Unit: mm

Nominal dimensions	Module (m)	Pitch diameter (d0) (approx.)	L	L_1	L_2	D_1	Taper at shank section	a*	
25	0.75 to 0.9	25	80	10	40	18.0	1/20.020 0.049951	2	Morse taper No. 2
	1 to 1.5	25	80	12	40	18.0	1/20.020 0.049951	2	
	1.75 to 2.5	25	80	15	40	18.0	1/20.020 0.049951	2	
38	0.75 to 0.9	38	100	12	50	24.1	1/19.922 0.050196	2	Morse taper No. 3
	0.75 to 0.9	38	100	12	50	27.0	1/19.185 0.052125	2	Fellows taper
	1 to 1.75	38	100	15	50	24.1	1/19.922 0.050196	2	Morse taper No. 3
	1 to 1.75	38	100	15	50	27.0	1/19.185 0.052125	2	Fellows taper
	2 to 3	38	100	18	50	24.1	1/19.922 0.050196	3	Morse taper No. 3
	2 to 3	38	100	18	50	27.0	1/19.185 0.052125	3	Fellows taper
	3.25 to 4	38	125	18	50	24.1	1/19.254 0.05194	3	Morse taper No. 4
	3.25 to 4	45	125	18	50	27.0	1/19.185 0.052125	3	Fellows taper

● Tolerance between L and L1 is per JIS B 0405 Coarse Class •Items with asterisk can be customized as needed.

■ Precision Standard

No.	Item			Permissible value or tolerance – Grade AA	Grade A	Grade B
1	Bore diameter (d)	Standard size (mm)	19.050	+4 0	+6 0	+9 0
			31.742		+7 0	+11 0
			44.450			
	Shank deflection			3	4	5
2	Peripheral runout			7	10	15
3	Bottom surface deflection			3	4	6
4	Mounting surface deflection			5	5	7
5	Cutting face deflection			10	16	25
6	Cutting angle (min.)			±10	±14	±20
7	Side clearance angle (min.)					
8	Front clearance angle (min.)					

● For No. 1, bore diameter applies to the disc shape and bell shape, while shank deflection applies to the shank shape.

● For No.s 3 and 4, only applies to the disc shape and bell shape.

Unit: μm

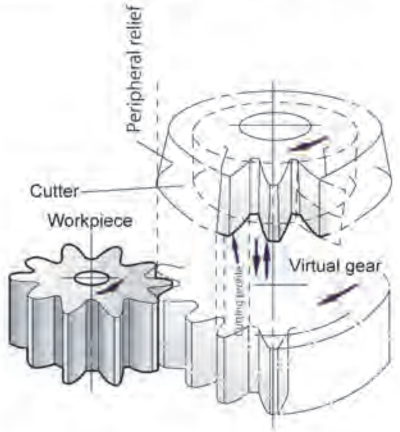
No.	Item	Grade	Nominal size	Permissible value or tolerance – Module (m): 0.75 or higher 1 or less	Over 1, 1.6 or less	Over 1.6 2.5 or less	Over 2.5 4 or less	Over 4 6 or less	Over 6 10 or less	Over 10 12 or less
9	Runout	AA	25, 38, 50	10	10	10	11	–	–	–
			75, 100	11	11	12	13	14	17	–
			125,150,175	–	12	13	14	15	18	23
		A	25, 38, 50	14	14	15	16	–	–	–
			75, 100	16	16	16	18	20	24	–
			125,150,175	–	18	19	20	22	26	32
		B	25, 38, 50	28	28	30	33	–	–	–
			75, 100	31	31	33	36	40	48	–
			125,150,175	–	35	37	40	45	52	65
10	Adjacent pitch error	AA	25, 38, 50	3	3	4	4	–	–	–
			75, 100	4	4	4	4	5	6	–
			125,150,175	–	4	5	5	6	7	9
		A	25, 38, 50	5	5	6	6	–	–	–
			75, 100	6	6	6	7	8	9	–
			125,150,175	–	7	7	8	8	10	13
		B	25, 38, 50	10	10	12	13	–	–	–
			75, 100	12	12	13	14	16	19	–
			125,150,175	–	14	15	16	18	21	27
11	Cumulative pitch error	AA	25, 38, 50	10	11	12	12	–	–	–
			75, 100	12	13	13	14	15	18	–
			125,150,175	–	14	15	15	17	20	24
		A	25, 38, 50	18	19	21	23	–	–	–
			75, 100	21	22	23	25	28	34	–
			125,150,175	–	25	26	28	32	37	46
		B	25, 38, 50	26	28	30	33	–	–	–
			75, 100	30	31	33	36	40	48	–
			125,150,175	–	35	37	40	45	52	65
12	Profile error (*)	AA	–	4	4	5	6	8	11	16
		A	–	8	9	10	13	16	22	32
		B	–	16	18	21	25	32	43	63
13	Tooth thickness (-)	AA	–	13	13	17	21	27	33	43
		A	–	21	21	27	33	43	53	67
		B	–	33	33	43	53	67	80	95

● Errors in the (*) (-) sides must not exceed 1/3 of the tolerance.

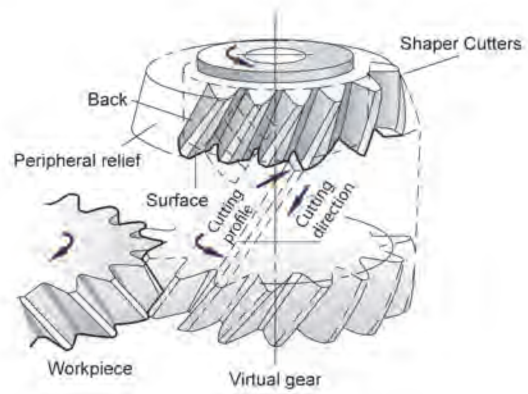
Processing by Shaper Cutters

Attach the shaper cutter to the gear shaping machine and perform gear cutting vertically from the upper to the lower section and then back to the upper section (non-cutting) in a reciprocal motion. As cutting cannot be performed during the return, it is not as efficient as hobbing, which allows continuous processing. To cut helical gears, a twisting motion must be used during the cutting stroke. This can be provided either by a helical guide, or by our ST series of electronic guide NC gear shapers.

Processing spur gear with gear shaping machine



Processing helical gear with gear shaping machine



■ Gear shaping

Operate the cutter by reciprocal motion along tooth lead

(1) Synchronous rotation of cutter and workpiece

(2) Reciprocal motion of the cutter

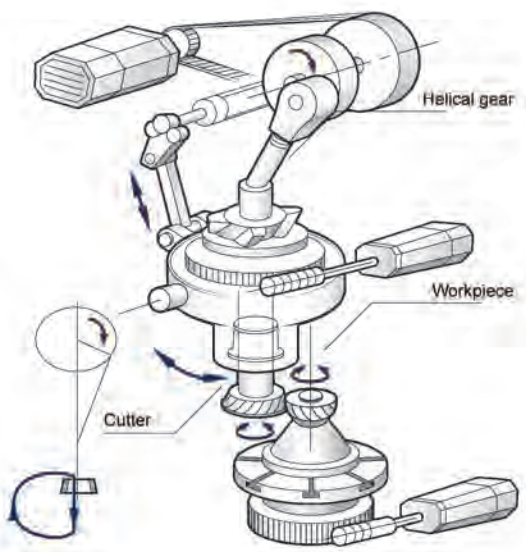
(3) Relieving motion of the cutter at returning

(4) Feed of the cutter

(5) Position of the cutter and the workpiece, stroke width

(6) Other

- Cutter clamp
- Workpiece clamp, replacement, etc.



■ How to find the cutter and helical guide lead

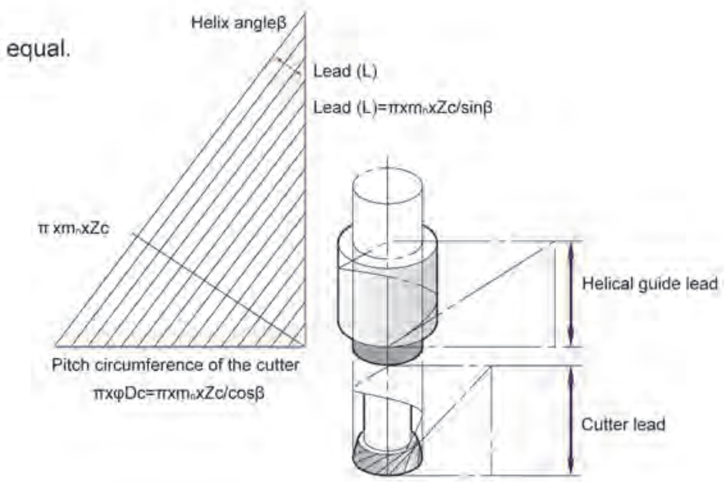
The lead between the cutter and the guide must be equal.

Lead (L)=$\pi \times m_n \times Zc/\sin\beta$

m_n : Normal module

Zc : Cutter teeth number

β : Cutter helix angle



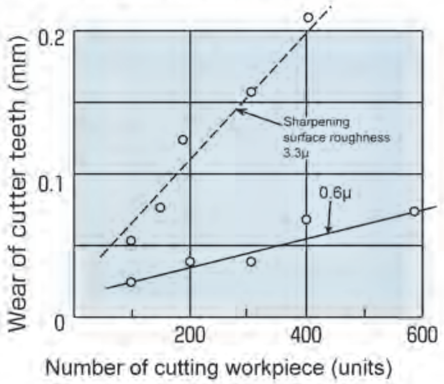
Hobs
Shaper Cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

Gear Shaping Problems and Causes

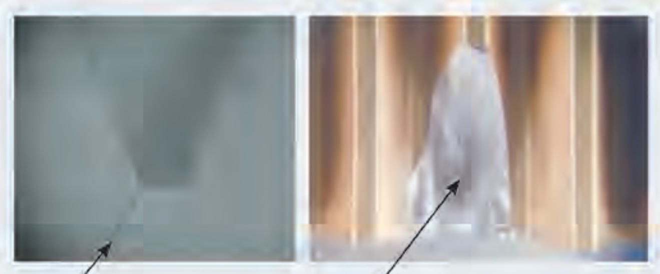
	Problem	Symptom	Cause
Workpiece	Workpiece profile	Workpiece profile error	1. Poor cutter tooth profile 2. Poor cutter face angle/sharpening angle 3. Poor gear shaping machine precision
		Gap in one tooth	1. Poor cutter runout precision 2. Poor cutter cumulative pitch precision
		Insufficient meshing length	1. Insufficient tooth depth 2. Excessive cutter tip point radius 3. Poor cutter protuberance profile
	Workpiece Cutter runout Pitch	Workpiece runout error	1. Poor cutter runout precision 2. Poor cutter and workpiece mounting precision
		Poor workpiece pitch	1. Poor cutter pitch precision 2. Poor gear shaping machine precision
	Lead	Workpiece lead error	1. Poor gear shaping machine precision 2. Insufficient workpiece rigidity 3. Poor workpiece mounting jig precision 4. Insufficient workpiece mounting jig rigidity
	Chamfering	Excessive or insufficient chamfering	1. Poor cutter chamfering height 2. Workpiece outer diameter size defect 3. Cutting run-in size error 4. Cutter sharpening angle error
		Difference in chamfering amount by the sides	1. Poor cutter chamfering height
		Gap in chamfering section	1. Insufficient tooth depth due to excessive run-in at chamfering section of helical shaper cutter
	Tear	Tear in workpiece	1. Flaking at the root of helical shaper cutter 2. Excessive run-in at sharpening face of helical shaper cutter 3. Sticky work material 4. Improper cutting conditions 5. Improper or deteriorated cutting oil 6. Relieving interference
Cutter	Fractures Abnormal wear	Major fractures	1. Cutter workpiece material defect Excessive rigidity, fragile 2. Improper cutting conditions Excessive cutting speed, feeding 3. Run-in during rapid feeding 4. Insufficient clamping force for cutter and workpiece 5. Excessive workpiece hardness 6. Relieving interference 7. Cutter contacting shoulder or clogging from chips in the gap 8. Fracture due to excessive incision of cutter during resharpening
		Abnormal wear	1. Cutter workpiece material defect Insufficient hardness 2. Poor PVD processing 3. Angularity in the joint tip radius 4. Items 2, 4, 5, 6, 7 in the fracture causes above may trigger abnormal wear 5. Cutting oil ran out

Relationship Between Sharpening Face Roughness and Tool Life

- **Cutter tooth roughness does not just shorten the life of the tool, but also causes fractures in the tooth due to Grinding burns or cracks.**



Cutter : m 1.75 NT 91
HSS
Workpiece: NT22, Width 8
SPUR
18CrMo4
HB 180
Conditions: 750/1124 str./min.
(33/50 /min.)
f = 1.02/0.38mm/str.

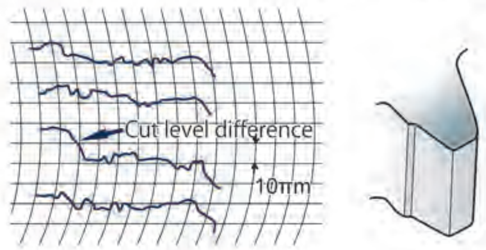


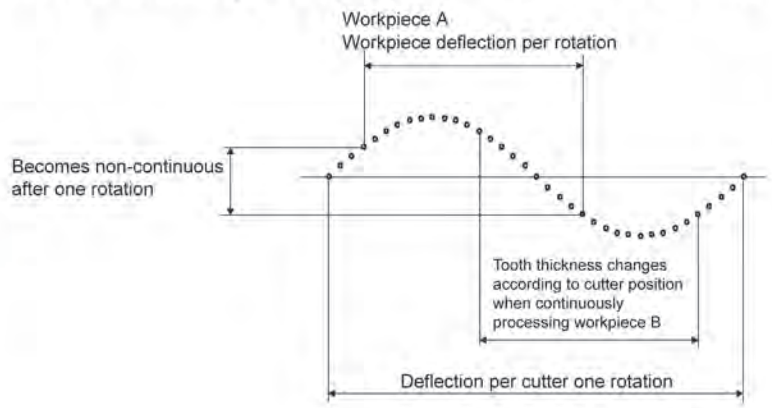
Grinding crack   Broken cutting edge caused by caused by grinding crack

Cut Level Irregularity

- **Large deflections during cutter mounting will cause discontinuity in the processed work after one rotation.**

Causes tooth profile irregularity.
Irregular OBD due to incision depth changing.





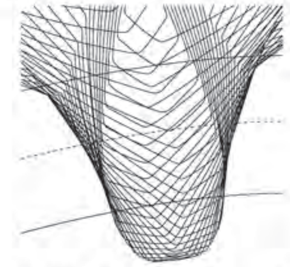
Causes of Profile Errors

- **Deflection of cutter tooth will lead to poor profile precision.**
- **A lack of smoothness of cutter or workpiece rotation will cause mismatches in the generation position and lead to deterioration of profile precision.**

Factors likely to change the cutting resistance :

- Unevenness cutter teeth balance (sharpening angle setting,uneven wear etc.)
- Error in the rotation precision of the master worm wheel (mounting error, uneven wear etc.)

(Reference) Diagram of gear cutting processing



Profiles near the left and right points in the pitch circle are not generated at the same time.

Conventional Method of Processing and High Circumferential Feed

Conventional processing   **High circumferential feed is effective for extending cutter life**

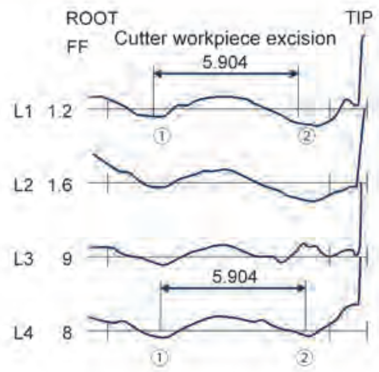
(Reference)
Diagram showing the end of incision after 3 rotations of a workpiece

Load concentrated on the edge in the conventional method while in the opposite side thin and long chips are removed so that cutter becomes easily worn.

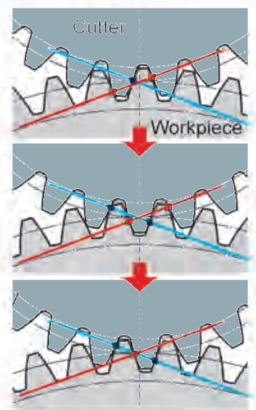
High circumferential feed means chips are removed thickly, so cutting teeth are distributed evenly, reducing wear.

Profile Undulations in Gears with Few Teeth

- **Gears with few teeth will decrease the contact ratio and increase load changes.This will cause the cutter and workpiece to shift, leading to tooth profile undulations.**
- **Reduce the cutting load to reduce tooth profile undulation.**



Undulations on profile



Meshing of cutter and workpiece

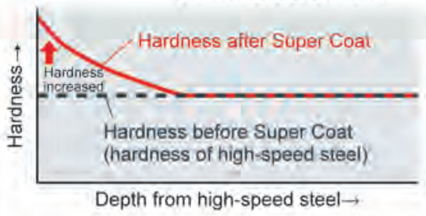
SHAVING CUTTERS

Shaving cutters are used for improving the quality and surface finish of the gear tooth flank after hobbing or sharpening. Of the four types of processing (1. Conventional, 2. Diagonal, 3. Underpass, 4. Plunge cut), plunge cut is frequently used in production lines for automobile and motorcycle gears due to its efficiency and long life. Our lineup of Super Coat Shaving Cutter, Hard MACH3 Shaving Cutter, and Fine Pitch Shaving Cutter offer superior performance thanks to improvements to tool life and workpiece teeth precision.

Super Coat Shaving Cutter

Features

- **Surface hardness increased 1.5 times over high speed steel, improving wear resistance.**
- **Hardened layer: 0.1 to 0.2 mm. Almost identical surface condition.**



Minimizes size changes and prevents serration depth variance.

Example

Workpiece: m2.7 PA20° HA28° RH (NT68 remove)
Tooth width 36 Material SCr420H
Cutter: NT79 ODφ225 Material MACH3 With Super Coat

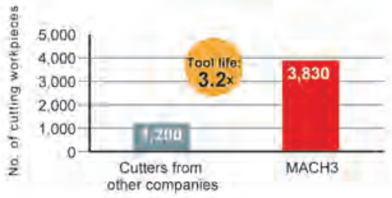
MACH3 Hard High Speed Steel

Features

- **Increased V. Co which helps prevent wear and micro-granularized carbides dispersed throughout to improve toughness (chipping resistance).**
- **Equalization and dispersal of carbides to give hardness and ensure grindability is unchanged.**

Example

Workpiece: m1.75 PA17.5° HA34° LH NT43 Tooth width 12.5
Material SCr420H
Cutter: NT97 HA19° RH Material MACH3 Plunge



Fine Pitch Shaving Cutter

Features

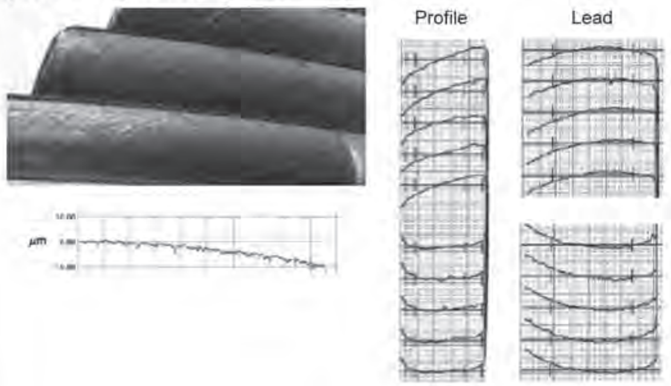
- **Reducing serration pitch spacing to smaller than standard improves tooth flank roughness.**
- **Optimized pitch size based on original design simulations to create high-precision tooth profiles.**

Example

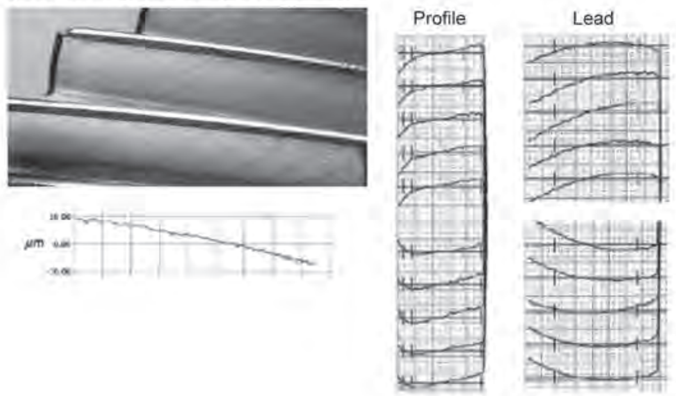
Extension of tool life and cost reduction with fine pitch + material change + Super Coat SVC

Workpiece: m1.7 PA17.5° HA36° NT45 Cutter: NT113 HA21° Improvement measures: High rigidity, fine pitch, super coating
Cutting conditions: Rotational speed 220 rpm, feed amount 0.4 mm/min. T_1:2 T_2:4 T_3:4 BM: 0.02 Plunge

Processed tooth surface with SVC of other manufacturer (wear after processing 1500 units)

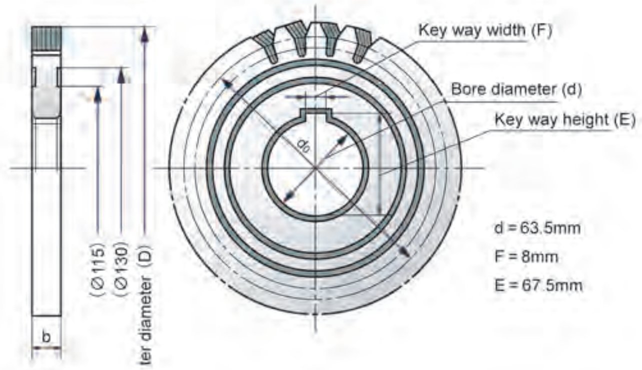


Processed tooth surface with Fine Pitch SVC (wear after processing 5500 units)



Dimensions and Precision Standard

■ Dimensions



Unit: mm

Nominal size	Module (m) Series 1	Module (m) Series 2	Width b	Reference: Standard diameter d_0	Reference: m×z	Reference: No. of teeth z
175	1		19.05 25.4	175	179.0	179
		1.125			176.6	157
	1.25				179.1	137
		1.375			176.7	127
	1.5				179.2	113
		1.75			176.8	97
	2				179.3	89
		2.25			176.9	79
	2.5				167.5	67
		2.75			167.8	61
	3				177.0	59
		3.5			164.5	47
	4				172.0	43
200	1		19.05 25.4	200	197.0	197
		1.125			201.4	179
	1.25				196.3	157
		1.375			204.9	149
	1.5				205.5	137
		1.75			197.8	113
	2				194.0	97
		2.25			200.3	89
	2.5				197.5	79
		2.75			200.8	73
	3				201.0	67
		3.5			206.5	59
	4				188.0	47
		4.5			193.5	43
	5				205.0	41
		5.5			203.5	37
	6				186.0	31
225	1.25		19.05 25.4	225	223.8	179
		1.375			215.9	157
	1.5				223.5	149
		1.75			222.3	127
	2				226.0	113
		2.25			211.7	97
	2.5				222.5	89
		2.75			217.3	79
	3				219.0	73
		3.5			213.5	61
	4				212.0	53
		4.5			211.5	47
	5				215.0	43
		5.5			225.5	41
	6				222.0	37
		7			217.0	31
	8				232.0	29

Unit: mm

Nominal size	Module (m) Series 1	Module (m) Series 2	Width b	Reference: Standard diameter d_0	Reference: m×z	Reference: No. of teeth z
300	1.5		31.75	300	268.5	179
		1.75			274.8	157
	2				298.0	149
		2.25			285.8	127
	2.5				282.5	113
		2.75			294.3	103
	3				291.0	97
		3.5			276.5	79
	4				292.0	73
		4.5			301.5	67
	5				295.0	59
		5.5			291.5	53
	6				282.0	47
		7			287.0	41
	8				296.0	37
		9			279.0	31
	10				290.0	29
		11			297.0	27
	12				276.0	23

- Module series are based on JIS B 1701-2.
- The width "b" can be changed to suit the helix angle, shaving method, etc.

■ Precision Standard

Unit: μm

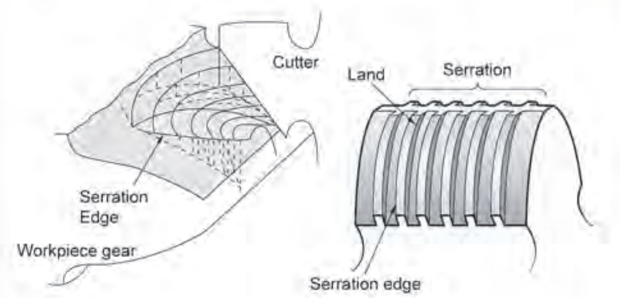
No.	Item			Permissible value or tolerance, Module (m): 1 or more 2 or less	Over 2 3.5 or less	Over 3.5 6.3 or less	Over 6.3 10 or less	Over 10 12 or less
1	Outer diameter D			±400				
2	Width b			±200				
3	Bore diameter d			−5 0				
4	Key way	Width F		+90 0				
		Height E		+300 0				
5	Peripheral runout			15				
6	Side face deflection			5				
7	Runout	Nominal size	225 mm or lower	14	14	14	15	—
			300mm	18	18	19	19	20
8	Pitch: Single pitch error	Nominal size	225 mm or lower	5	6	7	8	—
			300mm	5	6	7	8	9
	Pitch: Cumulative pitch error		225 mm or lower	17	18	18	19	—
			300mm	23	23	24	24	25
9	Total profile error	Nominal size	225 mm or lower	2	3	4	5	—
			300mm	3	4	4	5	6
10	Tooth thickness			0 - 25				
11	Tooth lead (every 25 mm)	Total lead error		7				
		Symmetricity		5				

- Total profile error can be applied when modifying cutter tooth profiles as well.
- Tooth thickness shows the tolerance for the tooth thickness corresponding to the outer diameter.

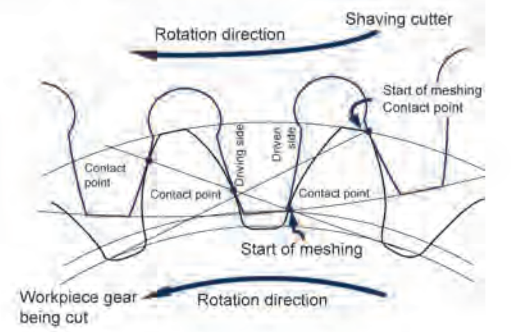
Processing Using Shaving Cutters

Adjust the crossed axes angle of a workpiece after hobbing or sharpening with a shaving cutter to between 5° to 15° and rotate after engaging the gear. The resultant sliding motion of the tooth surface enables fine finishing with only a small amount of cutting. As this is cost effective and suited to mass production, it is used in the production of gears for automobiles or construction machinery. Shaving cutter processing is only possible prior to heat treatment.

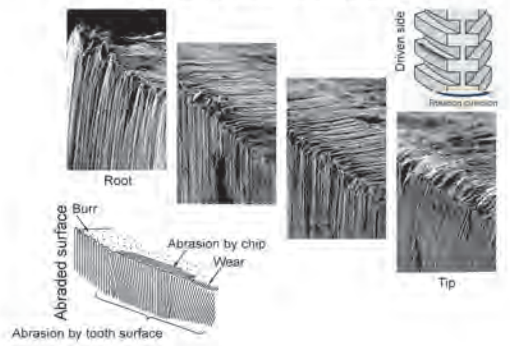
Movement of the cutter teeth on the gear teeth.



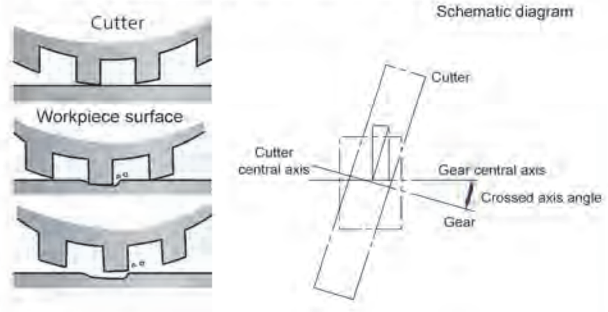
Meshing of shaving cutter and gear



Shaving cutter serration edge expansion

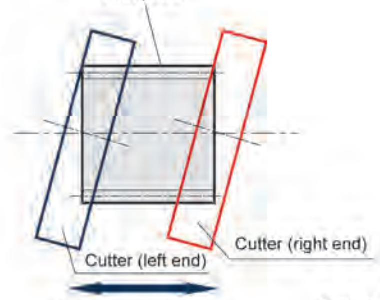


Shaving cutter cutting mechanism schematic



■ Conventional

Move cutter in parallel to workpiece axis



Cutter motion (feeding)

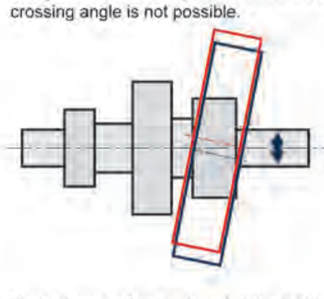
Each cylinder has point contact

1. Wider workpieces can be processed with narrow cutters.
2. Easy to share cutters among some different kinds of workpieces.
3. The motion of the machinery enables crowning and taper processing.
4. The cutter moves a long way compared to other methods.
5. Only the center of the cutter is used, wasting much of the tool.

■ Underpass

Move cutter at a right angle to workpiece axis

Cutter and workpiece interfere with each other in conventional processing as the tooth is adjacent to the workpiece and a sufficient crossing angle is not possible.

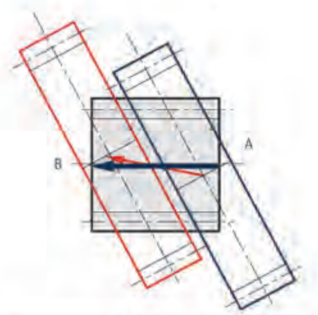


Moving the cutter from the lower location in blue to the upper location in red will move the contact point from left to right and allow processing of the entire tooth width of a workpiece.

1. Uses a cutter wider than the workpiece tooth width.
2. Requires sharpening for underpass processing
3. Requires sharpening for hollow tooth profile for crowing processing.

■ Diagonal

Move cutter diagonally to workpiece axis



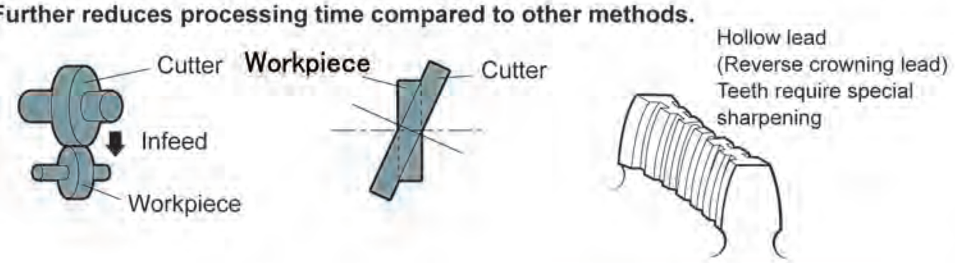
Moving the cutter in the direction of the red arrow if fed in a diagonal direction will move the meshing point from the right edge A to the left edge B of the workpiece.

1. The cutter moves less than the conventional processing, allowing for shorter processing times.
2. The entire width of the cutter can be used, increasing its tool life.

Hobs
Shaper Cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

■ Plunge cut

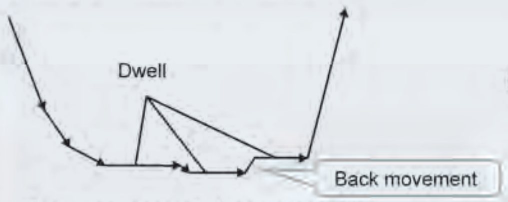
Does not move the cutter and workpiece during processing. Processing is only possible with a cutter that uses special sharpening.
Further reduces processing time compared to other methods.



Plunge shaving processing

1. Cutter width is wider than workpiece tooth width.
2. Specially designed to match the number of teeth of a workpiece.
3. Apply differential serration.
4. Requires machine rigidity and motor power.

Setting processing conditions



Basic sequence of plunge processing

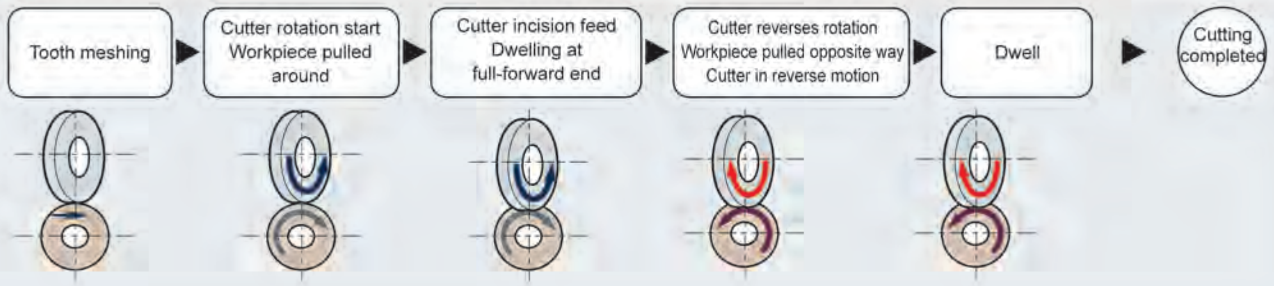
Cutting speed
Plunge, underpass: 145 m/min.
Diagonal, conventional: 120 m/min.

Note
The rotational speed of workpieces with a hole must be less than 2000 rpm.
For workpieces with a shaft, it is less than 1000 rpm.

Incision feeding (per workpiece rotation)
Axis: 0.5 μm
Hole: 1.5 μm
Traverse feeding (per workpiece rotation)
Diagonal, Conventional 0.2mm
Underpass 0.1mm
Plunge dwelling time
Regard 35 rotations of a workpiece as the benchmark

Sequence

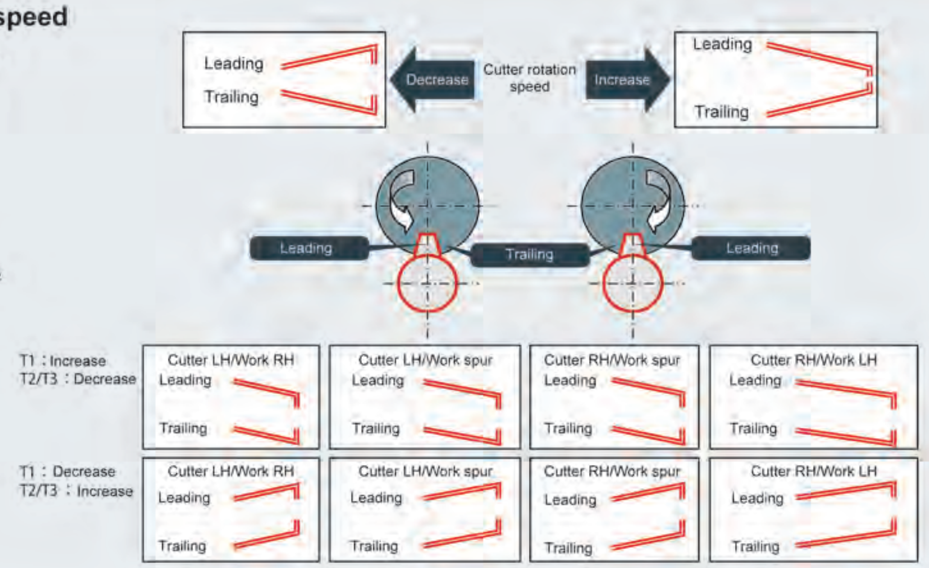
The normal shaving process is cutter-driven and the workpiece is rotated by it. Start processing after meshing the cutter and workpiece.
Use the cutting teeth at both sides and switch the cutter rotation direction to ensure stable precision.
In order to remove the looseness generated at incision, use dwell to ensure stable precision.



Improvement of Profile Precision

● **Impact of cutter rotation speed**
Adjustment is likely to cause the changes shown in the following diagram.

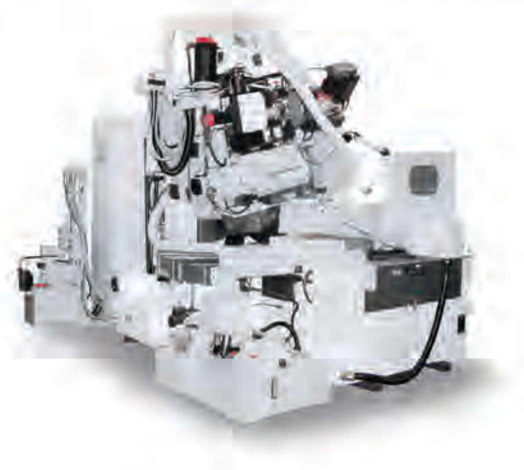
● **Impact of dwell timer**
Changes the leading/trailing cutting surface depending on the cutter rotation direction.



Gear Shaving Problems and Causes

	Problem	Symptom	Cause
Workpiece	Workpiece profile error (with manufacturer trial)	Large tooth profile error of the workpiece in the same trial processing	1. Different measuring machine used 2. Different measuring teeth 3. Different profile control point
		Passed trial processing by cutter manufacturer but failed trial processing by user	1. Different trial machine 2. Different trial conditions 3. Different precision difference in previous process(es) 4. Measurement error of trial workpiece by manufacturer 5. Vague manufacturer pass/fail judgment trial profile 6. Measurement error of trial workpiece by user
Cutter	Cutter teeth profile error	Cutter teeth profile does not meet user's request	1. Cutter teeth profile measurement error 2. Wrong cutter teeth profile (previous profile, etc.) or copied incorrectly 3. Design instructions error 4. Order instructions error
	Cutter life short	Low number of resharpenings	1. Shallow serrations • Difference between sides • Differences at tip or root • Circumference irregularity • Shallow overall
		Workpiece teeth profile collapse	1. Low cutter hardness 2. Complicated cutter teeth profile 3. Excessive shaving stock 4. Excessive workpiece hardness
	Fractures	Fracture before use	1. Fracture due to grinding crack during tooth profile grinding 2. Cracking during heat treatment 3. Fracture during transportation and handling
		Fracture during processing workpiece	1. Shoulder gear interference 2. Processing workpiece with the wrong specifications 3. Too many workpieces processed (wear) 4. Insufficient strength at cutter root 5. Improper serration alignment

Tips: Sharpening Method



ZA30A shaving cutter grinder

When the precision requirements cannot be met during shaving, the cutter is often considered to have reached the end of its life, and is resharpened.

During resharpening, ensure that worn (abraded) parts are removed properly. Check also for burrs and ensure that they are removed.

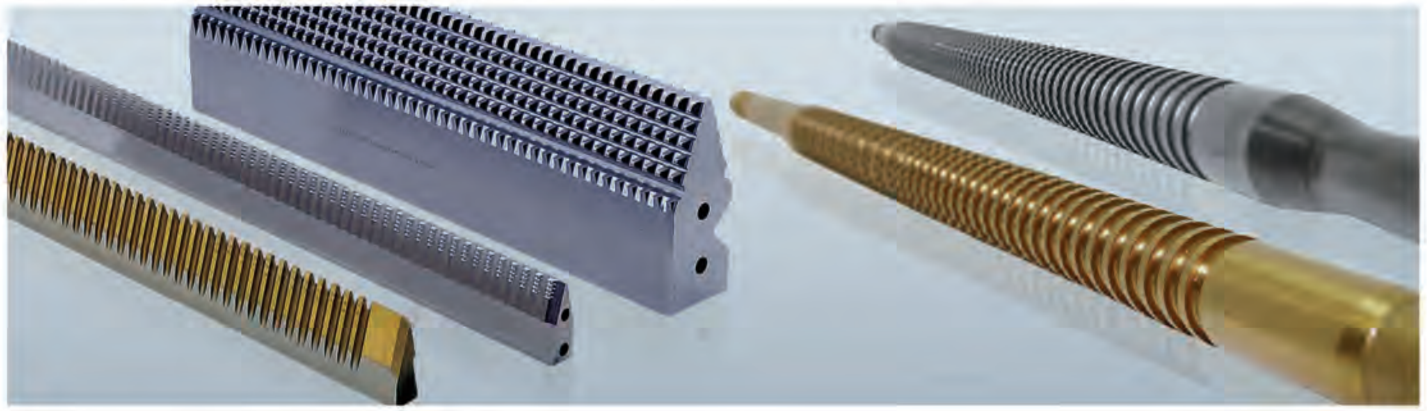
Our ZA30A shaving cutter tooth profile grinder can achieve reproducibility and ease of rearrangement while maintaining precision through numerical control.

It is important to control the number of workpieces, resharpen the tooth profile, and lead and removal stock of each cutter.

Hobs
Shaper Cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

BROACHES

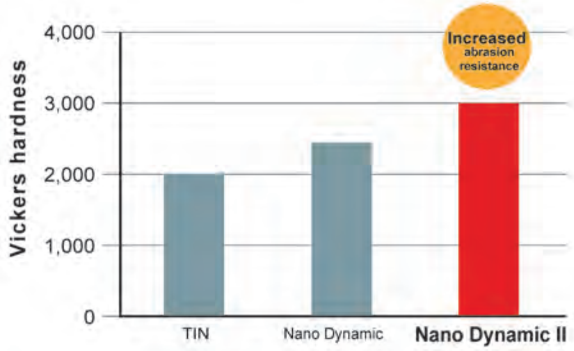
Broaches are divided into two groups: internal broaches for making splines and gears for automobile and other types of reduction gears and machine tools, and surface broaches for processing the surfaces of specially-shaped parts used to make power generator and jet engine turbine blade grooves and various industrial machinery. We design and produce a range of original broaches based on our long experience and expertise. We have a long track record of supporting the shapes and performance demanded by our customers.

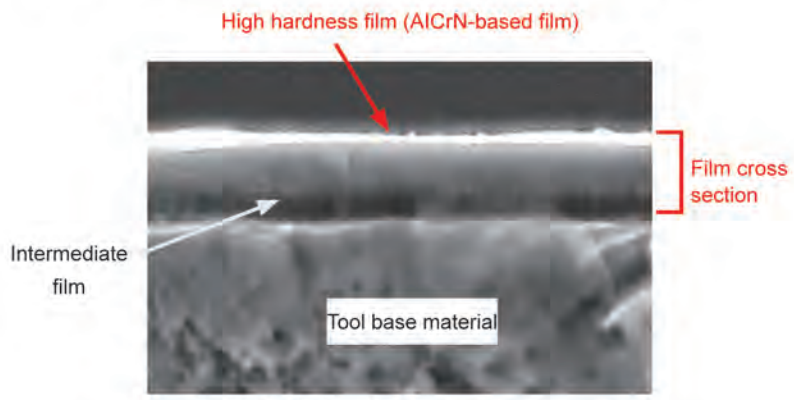


Nano Dynamic II

Features

- **Uses AlCrN coatings for superior heat resistance and anti-wear properties.**
- **Effective for dealing with corner wear of the cutting tooth.**
- **Effective even under conditions detrimental to tool life, such as difficult-to-cut material processing and broach cutting using water-soluble coolant.**





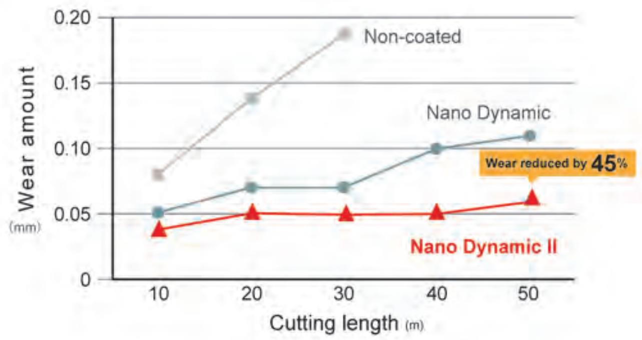
Structure of Nano Dynamic II

Super-hard film with excellent wear resistance and an intermediate layer with excellent adhesion to the base material.

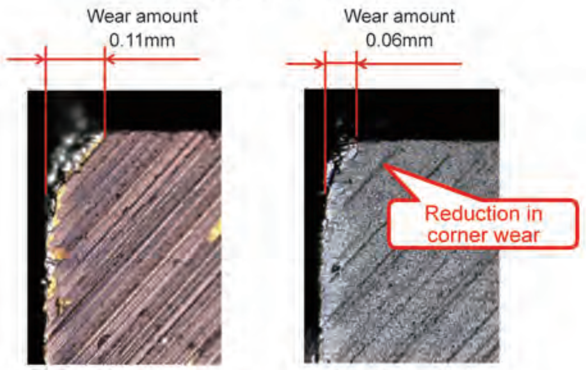
Example

Workpiece: Material S50C (hardness HB260)

Processing conditions: Cutting speed 5m/min. Cutting length 50m Oil coolant



Enlarged wear area



Nano Dynamic (our older coating) | Nano Dynamic II

MAC D Long-Life Broach

Features

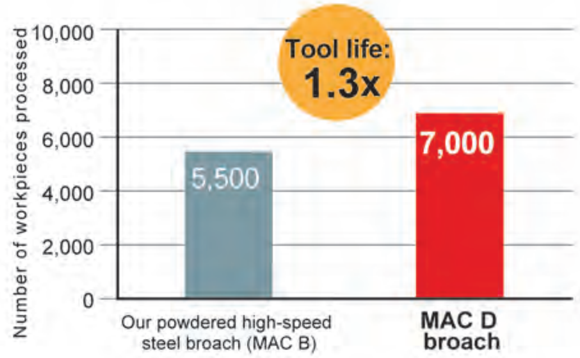
- **Uses MAC D powder high-speed steel which contains high levels of VC carbides for superior wear resistance.**

Example

Workpiece: ODφ90 7 grooves (groove width 10 × depth 4 × tooth width 15)

Material S55C

Cutter: Pot Broach



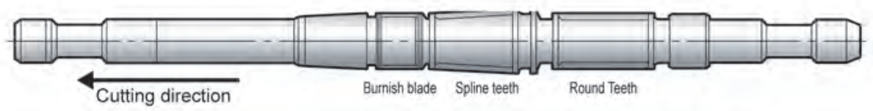
Eccentricity Preventing Broach

Features

- **Increased tooth fit by prioritizing burnish teeth.**

Previously: Spline teeth → Round teeth

Eccentricity-preventing broach: Burnish teeth → Spline teeth → Round teeth

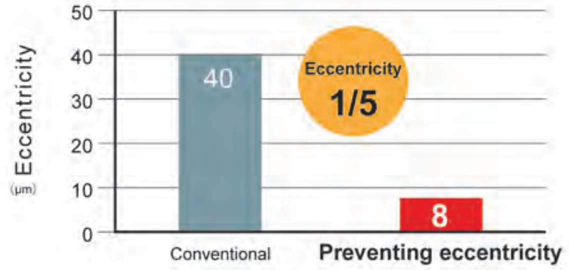


Example

Workpiece: Tooth width 19.5mm Material SCM420H

Cutter: Involute spline broach ODφ33 NT32 Coating TiN

Cutting conditions: Cutting speed 5m/min.

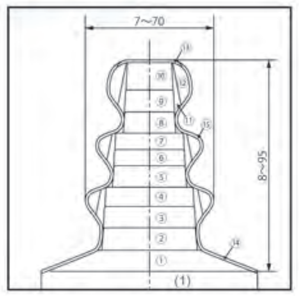


Fir Tree Broach

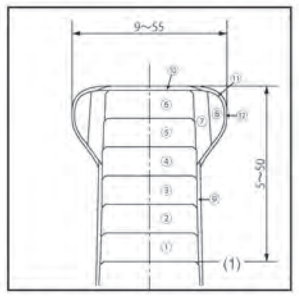
Features

- **Long tool life achieved by adopting high-alloy powder high-speed steel for difficult-to-machine materials.**
- **High reliability ensured by a dedicated line equipped with an advanced NC gear grinding machine and sharpening machine**

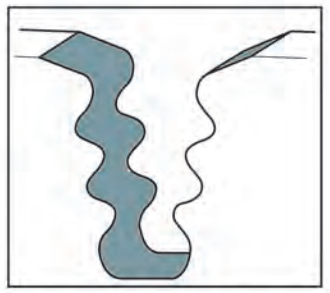
Examples



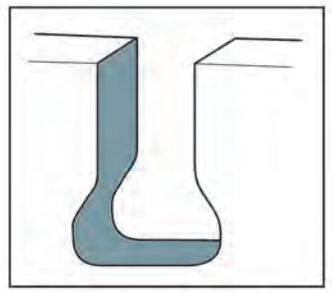
Fir tree broach layout and tooth profile size



Dovetail broach layout and tooth profile size



Groove machined with fir tree broach

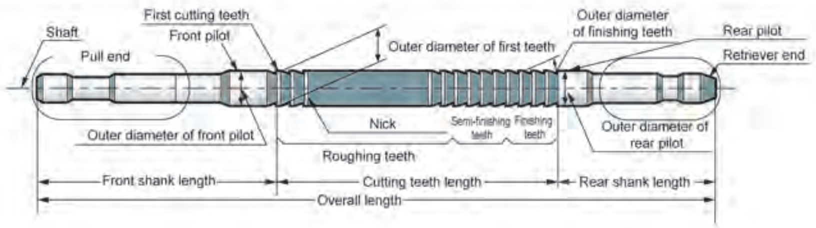


Groove machined with dovetail broach

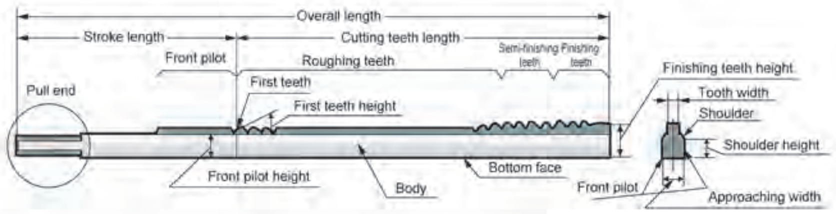
Hobs
Shaper Cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

Names of Broach Parts

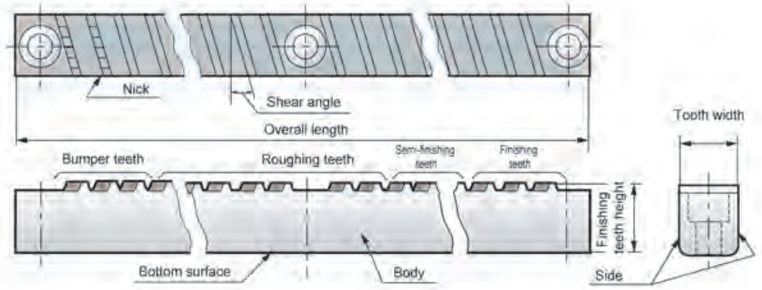
Internal broach



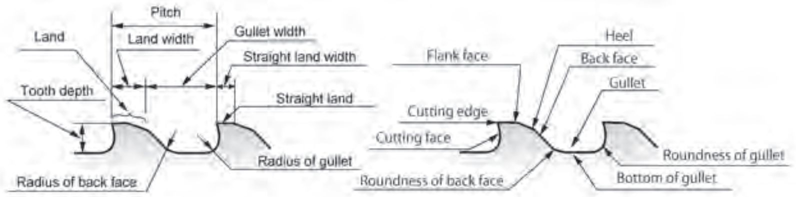
Keyway broach



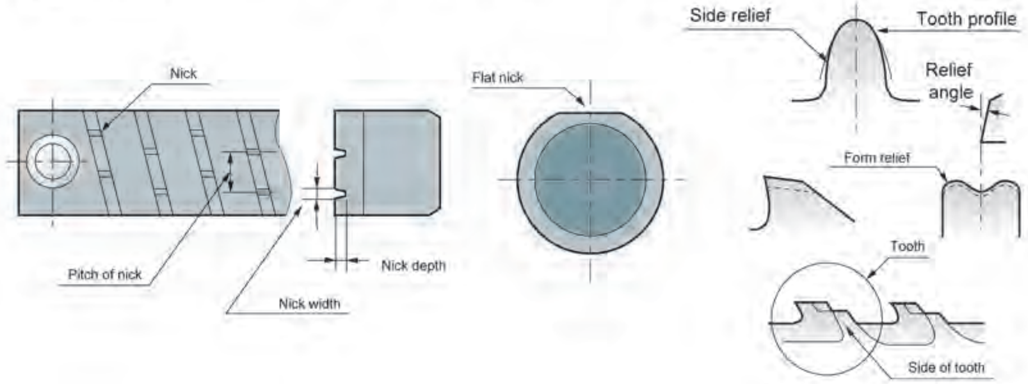
Surface broach



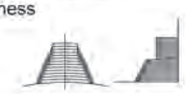
Teeth



Nick and relief

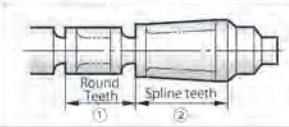
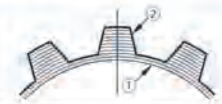
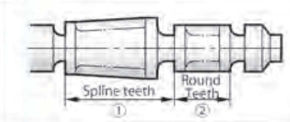
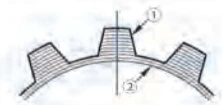
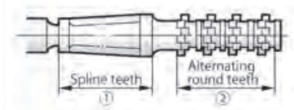
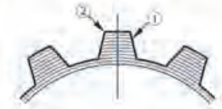
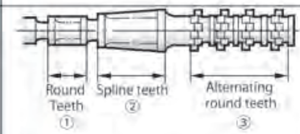
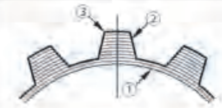


Cutting Methods

Cutting method	Features	Usage
Extending outward radially or upward 	Leaves a constant form land, so is easy to weld, but there is no change in tooth thickness due to resharpening. Also, tooth profile deformation can be reduced because the teeth fit the workpiece well.	General broaches
Extending outward and sizing radially or upward (double-cut) 	Has a small cutting force for finishing tooth profile so processing distortions are reduced. Particularly effective for thin workpieces.	Fir Tree Broach Broaches for high-precision use
Back taper 	The thickness of the teeth at the rear end of broach is slightly smaller and there is a tiny relief on the side of the broach tooth profile that improves cutting performance and prevents adhesion.	Broaches for long cutting lengths Broaches for workpieces prone to adhesion
Increasing tooth thickness or form 	Broach tooth profile can be accurately transferred to workpiece, allowing high tooth profile precision and improved finished surface roughness.	Broach for gears Broach for high-precision use

● The concentric circle stripes indicate the order of the machining process.

Types of Broaches with Round Teeth

Type		Cutting method		Features
Spline broach with front round teeth	 Round Teeth ①, Spline teeth ②		Machining with involute spline broach with front round teeth	If the pilot hole is precise enough, the pilot hole and spline groove concentricity improves. Simple broach structure
Spline broach with round rear teeth	 Spline teeth ①, Round Teeth ②		Machining with involute spline broach with round rear teeth	Standard broach with round teeth
Spline broach with alternating round teeth	 Spline teeth ①, Alternating round teeth ②		Machining with spline broach with alternating round teeth	Used when high concentricity of spline tooth grooves and a small diameter is required.
Spline broach with front round teeth and alternating round teeth	 Round Teeth ①, Spline teeth ②, Alternating round teeth ③		Machining with spline broach with alternating round teeth	Used when high concentricity of spline tooth grooves and a small diameter is required, and decentering from the pilot hole is not desired. However, if the pilot hole precision is low, decentering may become larger than using a spline broach with alternating round teeth.

• Numbers such as (1) and (2) indicate the order of the machining process.

Workpiece Hardness

The hardness of a workpiece suitable for broaching is generally HB200 to 230 (HRC14 to 21)., although up to HB300 (HRC32) is often used. Excessively soft steel may cause adhesion on the side of the tooth or the land resulting in a low finished surface quality, with tears or flaking. Workpieces harder than HB300 may shorten the life of the broach.

Cutting Speed

Cutting speed has an impact on both broaching accuracy and tool life. Use the recommended values for each material shown below as the guide to determine the cutting speed.

Unit: m/min.

Workpiece material		Cutting speed
Steel		3 to 8
Stainless steel	Tough-cutting (Martensite and austenite)	2.5
	Free-cutting (Ferrite)	6 to 8
Cast iron		10
Brass		10
Bronze		10
Aluminum		10
Magnesium		10

Calculation of Drawing Force F

F = f x n x Q (kgf)

f = Cutting resistance per unit (kgf/mm^2)
n = Number of teeth simultaneously used for cutting (pieces)
Q = Total cut area per tooth (mm^2)

(1) Calculating cutting resistance per unit f

Unit: kgf/mm²

Steel	Hardness	Up to HRC30	300
		HRC30 to HRC35	350
		HRC35 to HRC40	400
Malleable cast iron			200
Cast iron, bronze, aluminum			100

(2) Calculation of number of teeth simultaneously used for cutting n

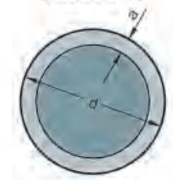
n = ℓ/P (pieces)

All values are rounded up to the nearest integer.

ℓ = Workpiece thickness (mm)
P = Broach tooth pitch (mm)

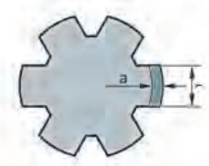
(3) Calculation of total cut area per tooth Q

Round hole



Q=π×d×a

Spline hole

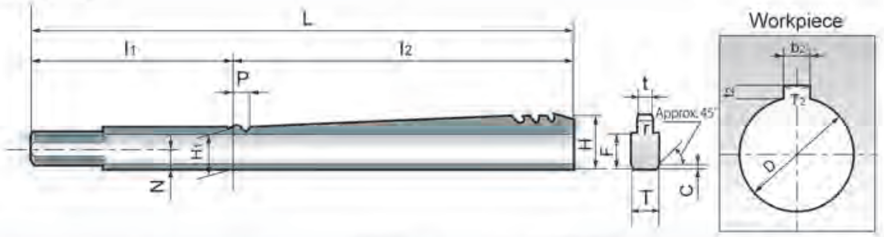


Q=a×t×m

d = Broach external diameter (mm)
t = Cutting width per tooth (mm)
m = Number of spline grooves (grooves)
a = Machining allowance per broach tooth (mm)

Dimensions and Precision Standard

■ Keyway broach shape and dimensions



Bearing No.	Edge width t: Standard size	Edge width t: Tolerance For sliding type D10	Edge width t: Tolerance For standard type JS9	Edge width t: Tolerance For clamping type P9	Broach width T: Standard size	Broach width T: Tolerance h7	Finishing teeth height H	1st tooth height H_1	Overall length L	Shank height l_1	Cutting teeth length l_2	Shoulder height F	Chamfering C
310016	3	+0.012 -0.002	-0.006 -0.020	+0.060 +0.046	5	0 -0.012	9	7.27	425	165	260	6	0.5
310028									530	185	345		
310045-2							8	7.13	475	220	255	5	
410028	4	+0.015 -0.003	-0.012 -0.030	+0.078 +0.060	5		9	6.68	600	185	415	5.5	0.5
410045-2							8	6.84	500	220	280	4.5	
412045					6		10	7.76	710	225	485	6	
412063-2							9	7.88	600	265	335	5	
513028	5	+0.015 -0.003	-0.012 -0.030	+0.078 +0.060	7	0 -0.015	11	8.10	630	190	440	6.5	0.8
513063-2							10	8.55	670	265	405	5.5	
515045					8		13	10.17	800	230	570	8	
515090-2							12	10.58	750	320	430	7	
618045	6	+0.015 -0.003	-0.012 -0.030	+0.078 +0.060	9		16	12.59	850	230	620	10	1
618063									1,000	270	730		
618112-2							14	12.29	900	365	535	8	
824045	8	+0.018 -0.004	-0.015 -0.037	+0.098 +0.076	12	0 -0.018	21	16.81	950	240	710	13	1.2
824063									1,120	280	840		
824090-2							19	16.90	850	330	520	11	
824140-2									1,120	430	690		
1030045	10	+0.018 -0.004	-0.015 -0.037	+0.098 +0.076	15		26	21.64	900	240	660	17	1.5
1030090									1,250	330	920		
1030112-2							23	20.82	950	375	575	14	
1030180-2									1,250	510	740		
1240045	12	+0.021 -0.006	-0.018 -0.045	+0.120 +0.093	17		32	27.58	950	250	700	23	1.5
1240090									1,250	340	910		
1240112-2							29	26.79	1,000	385	615	20	
1240180-2									1,250	520	730		
1445045	14	+0.021 -0.006	-0.018 -0.045	+0.120 +0.093	19	0 -0.021	34	28.88	1,000	250	750	24	2
1445090									1,320	340	980		
1445112-2							31	28.44	1,000	385	615	21	
1445180-2									1,250	520	730		
1650045	16	+0.021 -0.006	-0.018 -0.045	+0.120 +0.093	19		36	30.19	1,060	250	810	25	2
1650090									1,400	340	1,060		
1650112-2							33	30.09	1,060	385	675	22	
1650180-2									1,400	520	880		

- The pull and retriever ends are per the screw types specified in JIS B 4237.
- Tolerances of H and H1 are $^{0}_{-0.02}$ mm and $^{0}_{-0.03}$ mm respectively.
- Tolerances of L, l1 and l2 are ±5mm.
- Tolerance of N is the medium class specified in JIS B 0405.

(1) The bearing number shows the tooth width, minimum diameter of workpiece, and maximum cutting length, in that order.
"-2" at the end of the bearing number means that it draws twice.

Example 1. 3 1 0 0 1 6 — 3: Tooth width; 10: Minimum diameter; 016: Maximum cutting length

Example 2. 1 2 4 0 1 1 2 -2 — 12: Tooth width; 40: Minimum diameter; 112: Maximum cutting length; -2: Number of drawing times

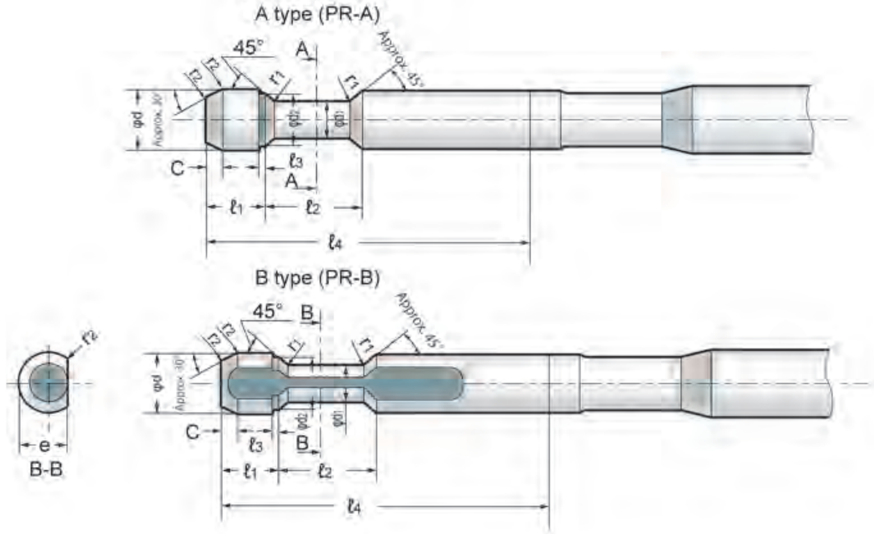
(2) The estimated load is generally calculated with the following formula.
Estimated load = (Cutting width) x (Cutting amount per tooth) x (Cutting resistance per unit) x (Number of teeth simultaneously used for cutting)
Next is an example of when the work cutting resistance per unit is 294 kPa.
Example: If the bearing number is 1240045, the estimated load is 12 x 0.08 x 2.94 x 5 = 14 kN

Unit: mm

Edge corner radius r	H-H1	Pitch P	Pull end nominal size	Height to center of screw N	Workpiece dimensions (reference values): Keyway width b_2	Keyway depth t_2	Corner radius r_2	Minimum diameter D	Maximum cutting length	Use conditions (for reference): Number of drawing times	Stroke	Estimated load kN
0.08 ~ 0.16	1.73	6	6	3.5	3	1.4	0.08 ~ 0.16	10	16	1	330	1
		8							28	1	440	2
	0.87	10							45	2	380	2
	2.32	8	6	3.5	4	1.8		10	28	1	510	3
	1.16	10							45	2	400	3
	2.24	10	8	4.5				12	45	1	610	3
	1.12	12							63	2	500	4
0.16 ~ 0.25	2.9	8	8	4.5	5	2.3	0.16 ~ 0.25	13	28	1	530	4
	1.45	12							63	2	570	5
	2.83	10	10	5.5				15	45	1	690	5
	1.42	14							90	2	640	6
	3.41	10	10	6	6	2.8		18	45	1	740	6
		12							63	1	890	7
	1.71	16							112	2	790	9
	4.19	10	14	8	8	3.3		24	45	1	830	8
		12							63	1	1,000	10
	2.1	14							90	2	730	12
		18							140	2	1,000	13
0.25 ~ 0.4	4.36	10	16	11	10	3.3	0.25 ~ 0.4	30	45	1	780	11
		14							90	1	1,130	16
	2.18	16							112	2	830	18
		20							180	2	1,130	23
	4.42	10	18	13	12	3.3		40	45	1	820	14
		14							90	1	1,120	19
	2.21	16							112	2	870	22
		20							180	2	1,190	27
	5.12	10	20	15	14	3.8		45	45	1	870	18
		14							90	1	1,120	22
	2.56	16							112	2	990	25
		20							180	2	1,370	32
	5.81	10	20	15	16	4.3		50	45	1	930	21
		14							90	1	1,270	29
	2.91	16							112	2	930	30
		20							180	2	1,270	41

- r is per r2 of the keyway dimensions in JIS B 1301.

■ Shape and dimensions of pull end of broach (round type)



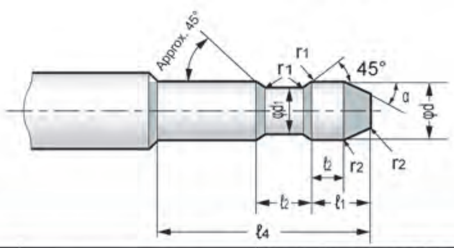
Unit: mm

Nominal size	Shank diameter d: Standard size	Shank diameter d: Tolerance	Neck diameter d_1: Standard size	Neck diameter d_1: Tolerance	Flat face height e: Standard size	Flat face height e: Tolerance	Head length ℓ_1	Neck length ℓ_2	Effective shank length ℓ_4 (minimum)	Flat face length ℓ_5 (minimum)	Reference: d_2	ℓ_3	c	r_1	r_2	s (mm^2)
8	8	-0.013 -0.036	6	-0.080 -0.170	6.5	-0.025 -0.047	12	20	90	60	7.8	1	2	0.4	1	27.1
(9)	9	-0.013 -0.036	6.8	-0.080 -0.170	7.4	-0.025 -0.047	12	20	90	60	8.8	1	2	0.4	1	35.1
10	10	-0.013 -0.036	7.5	-0.080 -0.170	8.25	-0.025 -0.047	14	22	100	65	9.8	1	3	0.4	1	42.9
(11)	11	-0.016 -0.043	8.2	-0.080 -0.170	9.1	-0.025 -0.047	14	22	100	65	10.8	1	3	0.4	1	51.5
12	12	-0.016 -0.043	9	-0.080 -0.170	10	-0.025 -0.047	14	22	100	65	11.8	1	3	0.4	1	62.2
(14)	14	-0.016 -0.043	10.5	-0.095 -0.205	11.75	-0.032 -0.059	16	25	110	75	13.7	2	4	0.6	1	85.1
16	16	-0.016 -0.043	12	-0.095 -0.205	13.5	-0.032 -0.059	16	25	110	75	15.7	2	4	0.6	1	111
(18)	18	-0.016 -0.043	13.5	-0.095 -0.205	15.25	-0.032 -0.059	16	25	110	75	17.7	2	4	0.6	1	141
20	20	-0.020 -0.053	15	-0.095 -0.205	17	-0.032 -0.059	18	28	125	85	19.7	2	5	0.6	1	175
(22)	22	-0.020 -0.053	16.5	-0.095 -0.205	18.75	-0.040 -0.073	18	28	125	85	21.7	2	5	0.6	1	212
25	25	-0.020 -0.053	19	-0.110 -0.240	21.5	-0.040 -0.073	18	28	125	85	24.7	2	5	0.6	1	281
(28)	28	-0.020 -0.053	21	-0.110 -0.240	24	-0.040 -0.073	20	32	140	95	27.6	3	6	1	1.6	344
32	32	-0.025 -0.064	24	-0.110 -0.240	27.5	-0.040 -0.073	20	32	140	95	31.6	3	6	1	1.6	450
(36)	36	-0.025 -0.064	27	-0.110 -0.240	31	-0.050 -0.089	20	32	140	95	35.6	3	6	1	1.6	570
40	40	-0.025 -0.064	30	-0.110 -0.240	34.5	-0.050 -0.089	25	40	160	110	39.5	3	8	1	2.5	704
(45)	45	-0.025 -0.064	34	-0.120 -0.280	39	-0.050 -0.089	25	40	160	110	44.5	3	8	1	2.5	905
50	50	-0.025 -0.064	38	-0.120 -0.280	43.5	-0.050 -0.089	25	40	160	110	49.5	3	8	1	2.5	1130
(56)	56	-0.030 -0.076	42	-0.130 -0.290	48.5	-0.050 -0.089	32	50	180	130	55.4	3	10	1.6	4	1380
63	63	-0.030 -0.076	48	-0.130 -0.290	55	-0.060 -0.106	32	50	180	130	62.4	3	10	1.6	4	1810
(70)	70	-0.030 -0.076	53	-0.140 -0.330	61	-0.060 -0.106	32	50	180	130	69.4	3	10	1.6	4	2200
80	80	-0.030 -0.076	60	-0.140 -0.330	69.5	-0.060 -0.106	40	63	200	150	79.2	3	12	1.6	6	2820
(90)	90	-0.036 -0.090	68	-0.150 -0.340	78.5	-0.060 -0.106	40	63	200	150	89.2	3	12	1.6	6	3630
100	100	-0.036 -0.090	75	-0.150 -0.340	87	-0.072 -0.126	40	63	200	150	99.2	3	12	1.6	6	4410

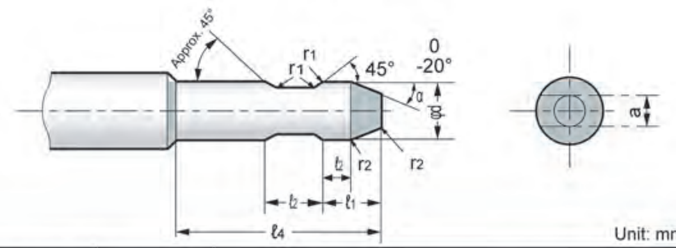
- The value of S is the B-B cross-sectional area of B type and calculated with the standard sizes of d, d1 and e.
- Values in parentheses should be avoided as much as possible.
- Tolerances of ℓ1 and ℓ2 are the rough class specified in JIS B 0405.
- ℓ4 and ℓ5 show the values when d and e satisfy their tolerable ranges respectively.

■ Shape and dimensions of retriever end of broach

Round type (FR)



Trapezoid type (FT)



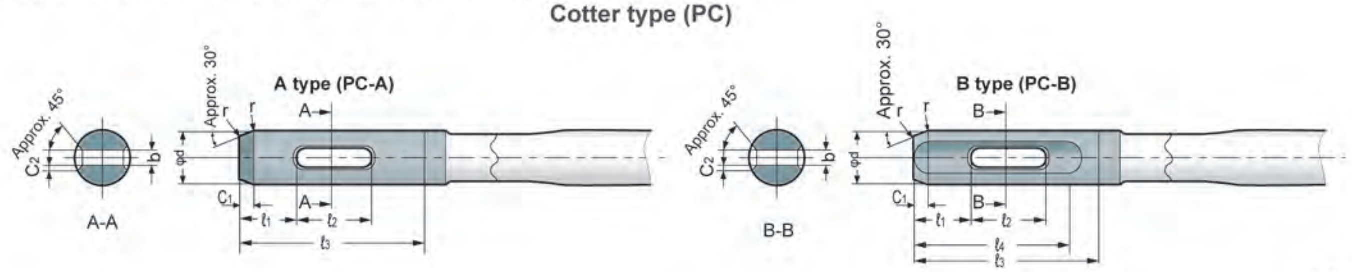
Unit: mm

Nominal size	Shank diameter d		Neck diameter or flat face width d_1 or a		Head length Length to mounting groove ℓ_1	Neck length Mounting groove length ℓ_2	Effective shank length ℓ_4 (minimum)	Reference			
	Standard size	Tolerance	Standard size	Tolerance				ℓ_3	r_1	r_2	α
12	12	$^{-0.016}_{-0.043}$	9	$^{-0.080}_{-0.170}$	16	16	60	8	0.4	1	10°
16	16	$^{-0.016}_{-0.043}$	12	$^{-0.095}_{-0.205}$	16	16	60	8	0.4	1	20°
20	20	$^{-0.020}_{-0.053}$	15	$^{-0.095}_{-0.205}$	20	20	70	10	0.6	1.6	20°
25	25	$^{-0.020}_{-0.053}$	18	$^{-0.095}_{-0.205}$	20	20	70	10	0.6	1.6	20°
32	32	$^{-0.025}_{-0.064}$	24	$^{-0.110}_{-0.240}$	25	25	80	12	0.8	2.5	20°
40	40	$^{-0.025}_{-0.064}$	30	$^{-0.110}_{-0.240}$	25	25	80	12	0.8	2.5	30°
50	50	$^{-0.025}_{-0.064}$	38	$^{-0.120}_{-0.280}$	28	32	90	16	1	4	30°
63	63	$^{-0.030}_{-0.076}$	49	$^{-0.130}_{-0.290}$	28	32	90	16	1	4	30°
80	80	$^{-0.030}_{-0.076}$	66	$^{-0.140}_{-0.330}$	32	40	110	20	1.6	6	30°
100	100	$^{-0.036}_{-0.090}$	86	$^{-0.170}_{-0.390}$	32	40	110	20	1.6	6	30°

● Tolerances of ℓ_1 and ℓ_2 are the rough class specified in JIS B 0405.

■ Shape and dimensions of pull end of broach

Cotter type (PC)



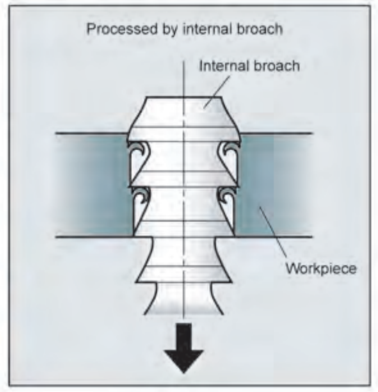
Unit: mm

Nominal size	Shank diameter d		Cotter hole width b		Length to cotter hole ℓ_1	Cotter hole length ℓ_2	Effective shank length ℓ_3 (minimum)	Reference					
	Standard size	Tolerance	Standard size	Tolerance				ℓ_4	t	C_1	C_2	r	s (mm²)
10	10	$^{-0.013}_{-0.035}$	3	$^{+0.4}_{0}$	16	20	70	50	9	3	0.4	1	48.6
(11)	11	$^{-0.016}_{-0.043}$	3	$^{+0.4}_{0}$	16	20	70	50	10	3	0.4	1	61.9
12	12	$^{-0.016}_{-0.043}$	3	$^{+0.4}_{0}$	16	25	70	50	11	3	0.4	1	76.9
(14)	14	$^{-0.016}_{-0.043}$	3.5	$^{+0.5}_{0}$	18	25	80	60	12	4	0.4	1	102
16	16	$^{-0.016}_{-0.043}$	4	$^{+0.5}_{0}$	18	25	80	60	14	4	0.4	1	135
(18)	18	$^{-0.016}_{-0.043}$	4.5	$^{+0.5}_{0}$	18	25	80	60	16	4	0.4	1	171
20	20	$^{-0.020}_{-0.053}$	5	$^{+0.5}_{0}$	18	25	80	60	18	4	0.4	1	212
(22)	22	$^{-0.020}_{-0.053}$	5.5	$^{+0.5}_{0}$	20	32	90	70	20	5	0.6	1.6	258
25	25	$^{-0.020}_{-0.053}$	6	$^{+0.5}_{0}$	20	32	90	70	22	5	0.6	1.6	335
(28)	28	$^{-0.020}_{-0.053}$	7	$^{+0.6}_{0}$	20	32	90	70	25	5	0.6	1.6	415
32	32	$^{-0.025}_{-0.064}$	8	$^{+0.6}_{0}$	20	32	90	70	28	5	0.6	1.6	538
(36)	36	$^{-0.025}_{-0.064}$	9	$^{+0.6}_{0}$	22	40	100	80	32	6	1	2.5	685
40	40	$^{-0.025}_{-0.064}$	10	$^{+0.6}_{0}$	22	40	100	80	36	6	1	2.5	850
(45)	45	$^{-0.025}_{-0.064}$	11	$^{+0.7}_{0}$	22	40	100	80	40	6	1	2.5	1080
50	50	$^{-0.025}_{-0.064}$	12	$^{+0.7}_{0}$	22	40	100	80	45	6	1	2.5	1350
(56)	56	$^{-0.030}_{-0.076}$	14	$^{+0.7}_{0}$	25	50	120	100	50	8	1.6	4	1660
63	63	$^{-0.030}_{-0.076}$	16	$^{+0.7}_{0}$	25	50	120	100	56	8	1.6	4	2080
(70)	70	$^{-0.030}_{-0.076}$	18	$^{+0.7}_{0}$	32	56	140	120	63	10	1.6	4	2570
80	80	$^{-0.030}_{-0.076}$	20	$^{+0.8}_{0}$	32	56	140	120	70	10	1.6	4	3360
(90)	90	$^{-0.036}_{-0.090}$	22	$^{+0.8}_{0}$	40	63	160	140	80	12	2.5	6	4320
100	100	$^{-0.036}_{-0.090}$	25	$^{+0.8}_{0}$	40	63	160	140	90	12	2.5	6	5310

● The value of S is the B-B cross-sectional area of B type and calculated with the standard sizes of d and b.However, this assumes no chamfering C_2.
● Values in parentheses should be avoided as much as possible.
● Tolerances of ℓ_1 and ℓ_2 are the rough class specified in JIS B 0405.
● ℓ_3 shows the value when d satisfies its tolerable range.

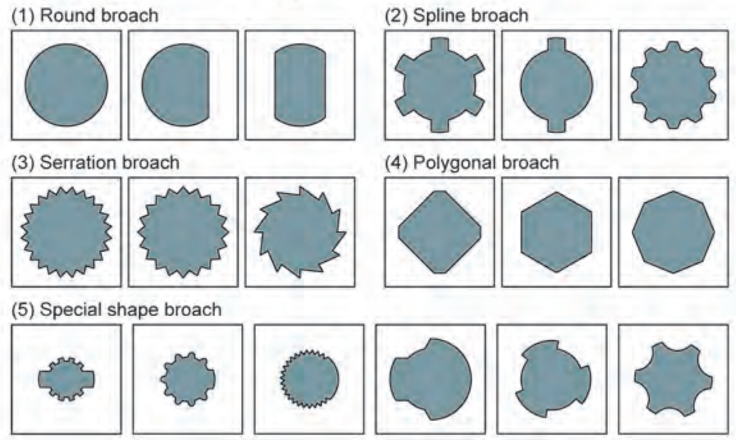
Processing Using Broaches

■ Processing using internal broaches

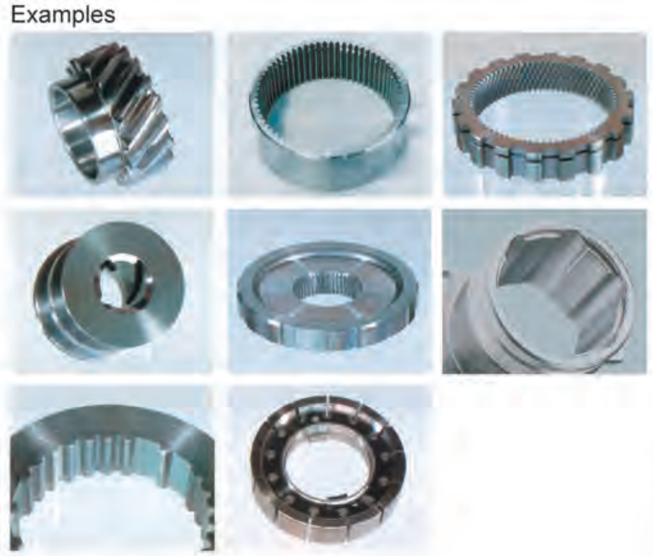


An internal broach can create the specific shape required for the internal surface of a workpiece efficiently and with high precision. Normally, the internal broach is inserted into a pilot hole which is made on the workpiece before machining. Various hole shapes can be created by selecting the optimum cutting edge shape and cutting method (for example, round, square, or polygonal, or various kinds of spline or tapered holes).

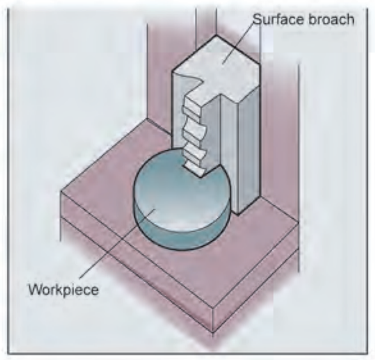
Examples of machining results



Examples

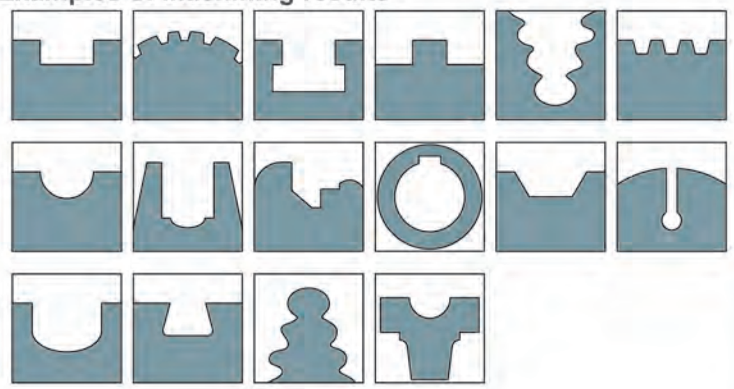


■ Processing using surface broaches



An surface broach can create the specific shape of the outer surface of a workpiece efficiently and with high precision. Roughing and finishing can be conducted at the same time, which means significantly higher productivity than milling, plaining and grinding. It can machine many different shapes (for example, plane surfaces, contoured surfaces, grooves, concave-convex surfaces, gears, turbine blade roots, or turbine disc grooves) and their outline can be either as simple as a keyway or as complex such as a fir tree.

Examples of machining results



Examples

How to Resharpen Broach Teeth

■ Resharpening timing

Normally, resharpen the teeth when the symptoms below show in the broach, workpiece, or broaching machine. In actuality, using the number of machined workpieces as a guide for when symptoms appear is more common.

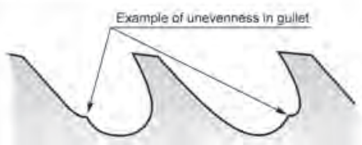
Broaches	• Whitish land due to wearing appears on the cutting edge. • Abnormal wear, chipping or cracking occurs on the cutting edge. • Chips start to get stuck in the gullet.
Workpiece	• Machined size is smaller than normal (thickness gauge cannot fit in). • Machined surface is rougher than normal. • Excessive heat is generated after machining.
Broaching machine	• Cutting force is abnormally high.

■ Precautions for resharpening

Tool	• Remove anything adhering to the cutting face. • Fix any serious warping of the tool. • Securely fix the tool to the sharpening machine. • (If there are cracks on the cutting edge that cannot be removed by resharpening, contact us.)
Grinding wheel	• Use a sharp CBN grinding wheel. • To increase grinding efficiency, use a grinding wheel with as large a diameter as possible. • Regularly dress the grinding wheel.
Grinding condition	• Grinding amount: Grind the same amount on each tooth to remove the worn parts. • Grinding rate: 1,800 to 2,000 m/mi • (For internal broaches, use a workpiece rotation of about 30 m/min.)
Other	• For internal broaches, be careful to prevent interference between the tool and the grinding wheel (see how to determine the grinding wheel angle for resharpening internal broach teeth shown to the right). • Use a well-maintained sharpening machine. • Make sure that the grinding fluid has not deteriorated, and supply the appropriate amount.

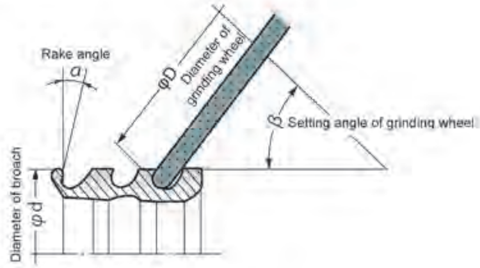
■ What to check after resharpening

- ☑ Have you completely removed all wear and cracks in the cutting edge?
- ☑ Is it free from grinding burns?
- ☑ Is the finished surface roughness no more than 3.2?
- ☑ Is there no significant unevenness in the gullet that would prevent chip expulsion?
  (See figure below)
- ☑ Have you degaussed the broach?

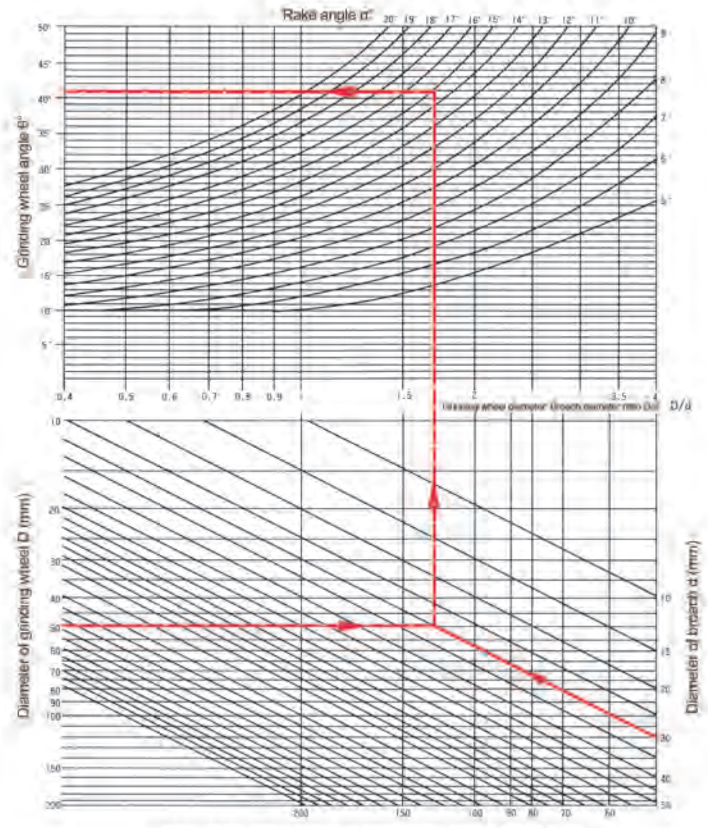


■ Grinding wheel angle for resharpening internal broach teeth

Unlike surface broaches, internal broaches cannot be resharpened correctly if the diameter and setting angle of the grinding wheel are not appropriate, as the grinding wheel and the tool will interfere with each other. See the relationship between broach shape (outer diameter and rake angle) below for reference.



If you resharpen a broach of diameter d=30 with a grinding wheel of diameter D=50 and the cutting edge hook angle is α=15°, the appropriate setting angle of the grinding wheel is β=41°.



Grinding wheel setting angles for resharpening internal broach teeth

Broaching Problems and Causes

■ Internal broach

	Problem	Symptom	Cause
Workpiece	Major diameter Minor diameter	Major or minor diameter exceeds tolerance	1. Broach dimensions exceed tolerance 2. Affected by burrs 3. Flaking
		Major or minor diameter below tolerance	1. Broach dimensions below tolerance 2. Shrinking due to poor sharpness 3. Shrinking due to springback 4. Shrinking due to cutting heat
	Inner pin diameter	Inner pin diameter exceeds tolerance	1. Broach over-pin diameter exceeds tolerance 2. Affected by burrs 3. Poor tooth profile 4. Caused by flaking 5. Caused by decentering
		Inner pin diameter below tolerance	1. Broach over-pin diameter below tolerance 2. Poor tooth profile 3. Shrinking due to poor sharpness 4. Shrinking due to springback 5. Shrinking due to cutting heat
	Machined surface	Flaking Scraping Edge chipping Chattering	1. Interference from parts other than teeth 2. Excessive cutting allowance 3. Inappropriate face angle 4. Cutting edge is worn, cracked or chipped 5. Adhesion on side of teeth 6. Shear drop 7. Improper cutting conditions 8. Improper or deteriorated cutting oil 9. Insufficient rigidity of broaching machine 10. Difficult-to-machine workpiece
	Decentering	The drawing hole is displaced with reference to the outer circumference.	1. Uneven circumference due to worn teeth 2. Broach is warped 3. Surface contacting teeth is deflected 4. Unbalanced cutting
Broach	Cracked teeth Broken teeth	Cracked teeth Broken teeth  Gullet unevenness	1. Chips stuck due to faulty gullet shape • Excessive land width • Insufficient gullet depth • Gullet depth unevenness 2. Chips stuck due to poor cutting edge 3. Excessive cutting allowance per tooth • Incorrect design dimensions • Faulty processing of adjacent pitch 4. Machined workpiece is longer than specified in design standard 5. Workpiece chipping or being displaced during processing

■ Surface broach

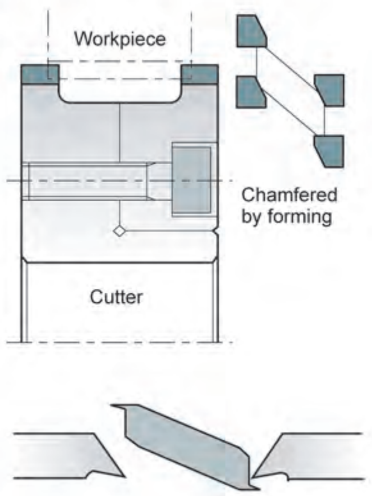
	Problem	Symptom	Cause
Workpiece	Key size	Key width error of a workpiece	1. Broach teeth width outside specifications 2. Shrinking due to poor sharpness
		Faulty workpiece key height	1. Broach height outside specifications 2. Jig size not correct
	Machined surface	Flaking Scraping Edge chipping Chattering	1. Interference from parts other than teeth 2. Excessive cutting allowance 3. Inappropriate face angle 4. Cutting edge is worn, cracked or chipped 5. Adhesion on side of teeth 6. Shear drop 7. Interference from chips 8. Improper cutting conditions 9. Improper or deteriorated cutting oil 10. Insufficient rigidity of broaching machine 11. Difficult-to-machine workpiece
Broach	Cracked teeth Broken teeth	Cracked teeth Broken teeth	1. Chips stuck due to faulty gullet shape • Excessive land width • Insufficient gullet depth • Gullet depth unevenness 2. Chips stuck due to poor cutting edge 3. Excessive cutting allowance per tooth • Incorrect design dimensions • Faulty processing of adjacent pitch 4. Machined workpiece is longer than specified in design standard 5. Workpiece chipping or being displaced during processing

OTHER PRODUCTS

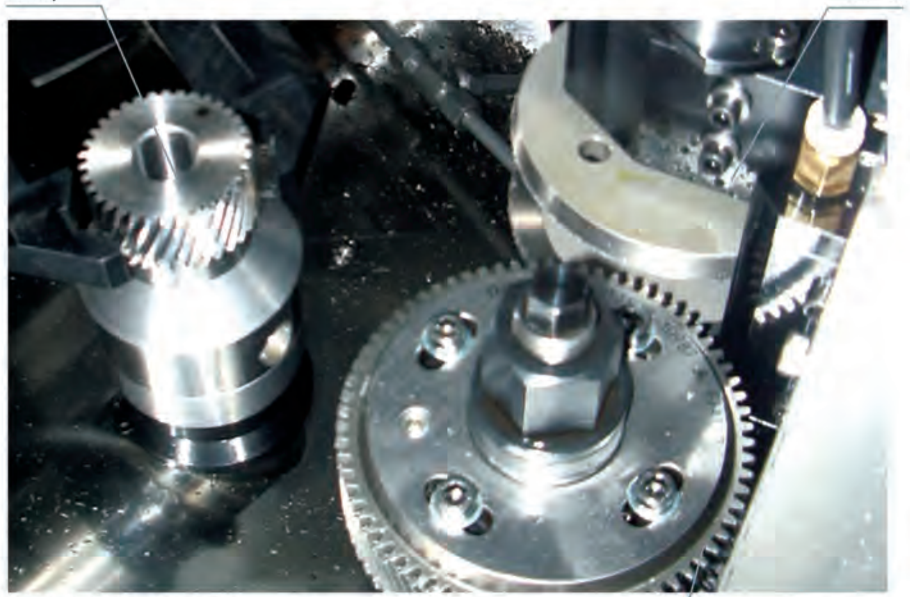
Chamfering tools (Forming method)

Chamfering tool (Forming method) is used for the gear edge. Chamfering operation is involved 2 phases, firstly, the gear shaped (2) forming tools mesh and engage the workpiece and plastically deform the material. Secondly, the (2) disk type bite tools remove the burr on the top and bottom face of gear.

Chamfering mechanism



Burrs at the end faces are removed with tool bit.



GE15A Deburring Unit

Chamfering tools (Generating method)

Chamfering machine CF26A

For ultimate performance of our CF26A chamfering machine, we have developed special chamfering tools for our machines. Our own cutting-edge design algorithm achieves the optimal chamfer shape at every each gear tooth profile with an individual tool design. Moreover, these tools can be sharpened and recoated to reduce the production costs significantly.

Principles

- **Generating cutting method (same principle as hobbing process)**

Before chamfering with CF26A

After chamfering with CF26A

Skiving Cutter

Skiving process can reduce cycle time by approximately 80% compared to shaping process, and is more flexible than broaching as skiving process enables to adjust pressure angle, lead, tooth thickness by cutting condition parameters without reprofiling the cutter tooth. Skiving process also has the great advantage of being highly versatile and capable of machining all types of gears, including external , internal and stepped gears as far as having no interference between workpiece and cutter. On the other hand, as skiving process involves sliding machining and machining with a negative rake angle, there is an impression that tool wear progresses quickly. However our developed material GRANMET SK with our proprietary MigtyShield Σ coating provide longer tool life beyond your expectation.

Gear skiving

Features of gear skiving

- **Cycle time is reduced by approximately 80% compared to shaping process**
- **Higher flexibility than broaching as skiving process is enable to adjust pressure angle, lead, tooth thickness by cutting condition parameters without reprofiling the cutter tooth.**

Features of substrate GRANMET SK

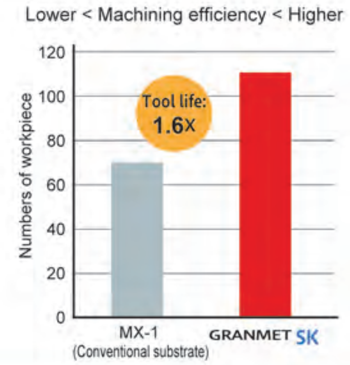
- **Stable performance at sliding machining**
- **Fine uniformed particle powder high speed steel specialized for machining of difficult–to–machine materials**

MightyShield Σ

- **Achieved enhanced wear resistance and extended tool life with high-hardness film (HV 4,000)**
- **Perform high capability in any cutting environment, whether dry or wet cutting**

Cutting result (High hardness gear)

Workpiece : m1.5, PA20°, NT70, HA20°,
Substrate : SCM440 (HB270-300)
Cutter : NT35 SPUR
Substrate : MX-1 (conventional product)/ GRANMET SK
Coating : MightyShield Σ
Cutting conditions : Cutting speed 70m/min
Axial feed 0.4-0.1mm/rev
Number of machining passes : 5 passes



Comparison of internal gear cutting method

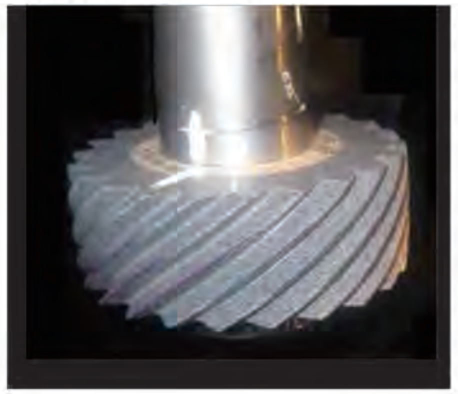
	Gear Shaping Machines	Broaches	Shaper Cutters
Gear Accuracy	ISO Class 6-7	ISO Class 6-7	ISO Class 4-5
Cycle time			
Cost Per Piece (ratio)	With coating		With coating
Internal gear with step gear	Available	Not available	with limitations
Features	Productivity is low. It's almost possible to cut all types of internal gears.	High Productivity Not available for stepped internal gear	Good on both the productivity and the accuracy, and the tool life can be improved with our substrate and coating technologies

Master Gear

The master gear is used as a master for engagement testers or for comparative measurements of tooth thickness.Our master gears can provide the high precision of the JIS M0 class.

Grinding Wheel, Dressing Gear and Disc Dresser for ZI Series

■ Shaped grinding wheel

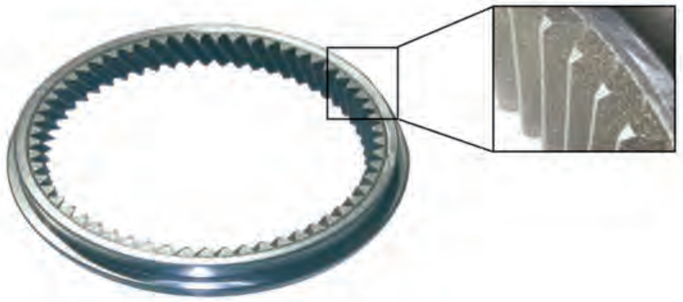


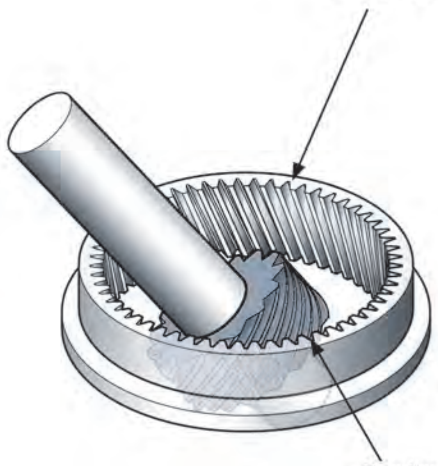
These are used for our ZI series generative threaded wheel internal gear grinding machines. The grinding wheel will be dressed to its final shape and accuracy on the grinding machine.

The dressing gear is made by electrocoating diamond abrasives onto the same shaped base metal as the workpiece and engages with the grinding wheel when meshing with it.

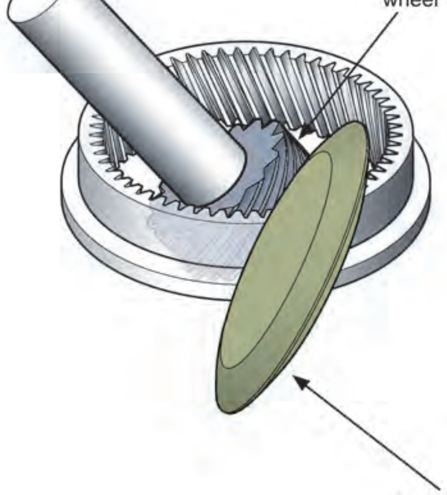
The optional disc dresser has the same cross-sectional shape as the workpiece and moves along the teeth lead of the grinding wheel when shaping it.

■ Dressing gear





■ Disc dresser



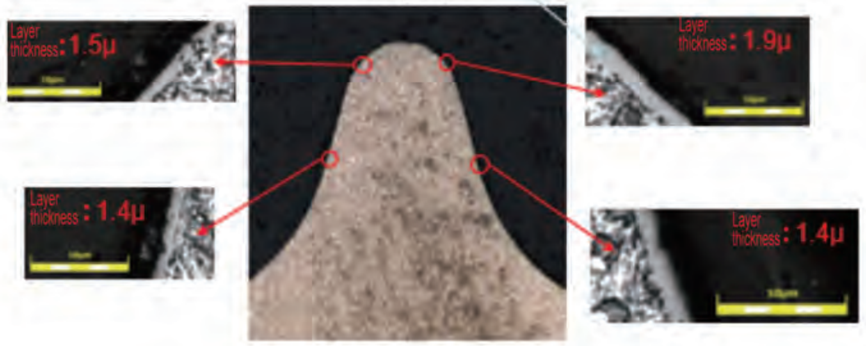
Super fine pitch tools for small module

Hob and shaper cutters specialized for processing small and special gears such as small modules (0.5 mn or less), complex and special profiles, high precision (cumulative pitch of 10μ m), and high hardness (HB280 or more) gears used in robot reducers, etc. In order to achieve the customer's request, we have developed high-precision coating and high-hardness substrates, as well as we have introduced the latest production line that incorporates our manufacturing know-how.

■ Mighty Shield μ

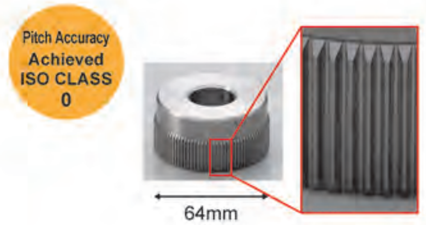
- **High wear resistance coating for Super-fine pitch tools**
- **Uniformed coating layer from the top to the bottom of the tooth prevents the tooth profile error even at the recoating**

Coating Layer



Cutting result (GE15FR Plus)

Workpiece : m0.4 NT60
SPUR face width 15mm
Substrate SCM415
Cutter : ODφ32mm
Start 1
Substrate Carbide
Conditions : Spindle Speed 8000min-1
Cutting speed : 804m/min
Axial feed : 0.4 mm/t.rev



■ Production range

Hob Cutter	Module	m 0.14 or lager (*1)
	Outer diameter	Min.φ20mm (Bore type) φ12mm (Shank type)
	Overall length(Tooth length)	Max. 50mm ＊Depends on module
	Inner diameter	Min.φ10mm
	Substrate	MACH series, MAC series, Carbide
	Coating	MightyShield-μ (m1.0 or less)
	Tooth gash lead	Straight
Bell type Pinion Cutter	Module	m 0.14 or lager (*1)
	Outer diameter	Min. φ30mm ＊Depends on module
	Overall length	Depends on Outer diameter size
	Inner diameter	Min.φ12.7mm
	Substrate	GRANMET SK(Recommendation)/ MACH series, MAC series, Carbide
	Coating	MightyShield-μ
	Helix angle	Max. 45°Depends on the shape of the workpiece (*2)
Shank type Pinion Cutter	Module	m 0.14 or lager (*1)
	Outer diameter	φ12mm ＊Depends on module
	Overall length	Depends on shape and outer diameter size of the workpiece
	Inner diameter	MT2、MT3
	Substrate	GRANMET SK(Recommendation)/ MACH series, MAC series, Carbide
	Coating	MightyShield-μ
	Helix angle	Max. 45°Depends on the shape of the workpiece (*2)

*1 : Please contact your sales if module is less than stated.
*2 : Preliminary engineering review required.
※Manufacturing accuracy
Hob : Tooth profile deviation±3μm
3 axial pitch 8μm
Pinion : Tooth profile deviation±3μm Runout 5μm

Hobs
Shaper cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

Robot Camera

This device automatically takes clear pictures of tool cutting edges and saves them as image data. The imaging locations of tool edges are automatically determined by just inputting the tool specification to the device. It is possible to accurately detect the damage on the cutting edge, peeling of the coating and wear status, etc., and confirm whether the tool appearance is normal or not. This device enables customers to use tools in optimal conditions, reducing the frequency of machine stoppages due to abnormal tool wear and other problems, thereby improving productivity.

■ Robot Camera SPEED High Speed Hob Cutter Observation Device

Features

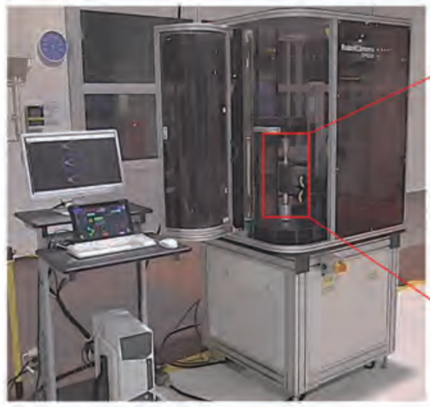
High speed positioning and shooting based on the tool specification

Machine dimensions (std. spec)

900mm×950mm×1820mm

Target part

Hob cutter (Straight gashes, Spiral gashes)
Outer diameter:20-130mm /Overall length:50-350mm
Weight: up to 20kg



Shooting example

Hob cutter specification
m 2.25
PA 17.5°
3 starts 16 flutes
Φ75×L150
NT : 300
Cycle time : 4 mins.

Optional spec

Wear checking /Burr height checking/ Wear amount measurement

■ Robot Camera MAX Broach Cutter Observation Device * Available for any long-shaft part

Features

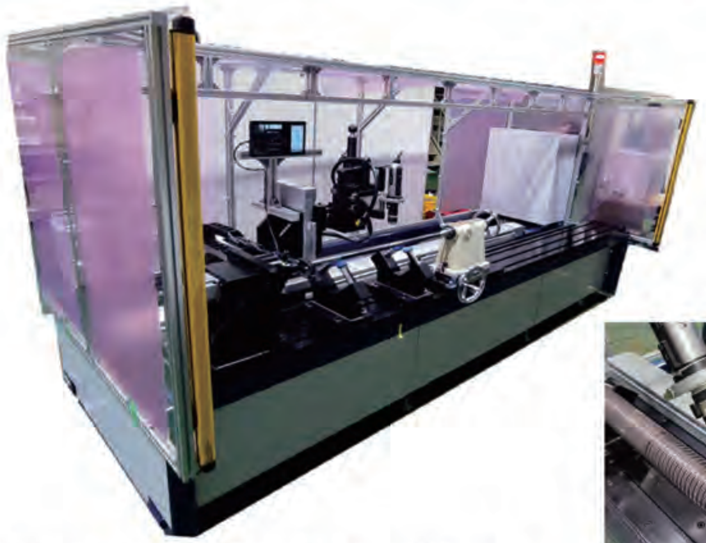
Automatic positioning and shooting

Machine dimensions (std. spec)

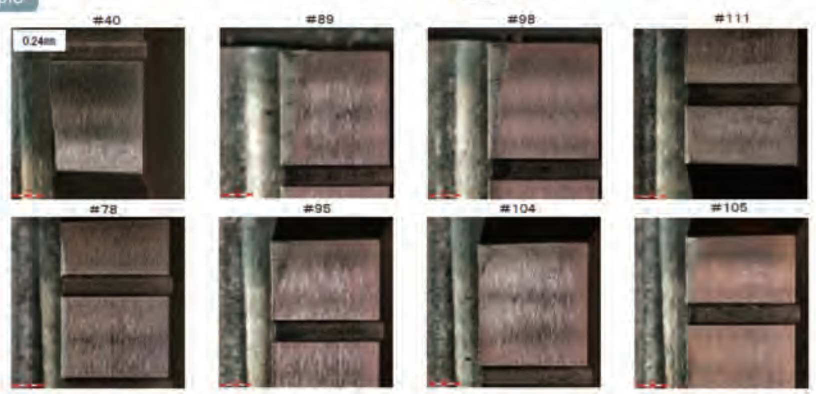
1370mm×1800mm×4560mm

Target part (std. spec)

Broach cutters (Straight/Helical)
Max. Length : 2,300mm
Max. Diameter : 200mm
Max. Weight : 300kg



Shooting example



Tool Materials and Coating

■ Materials

	Material	Wear resistance	High-temperature hardness	Chipping resistance	Appropriate tool	Usage
Dissolution high speed steel	MACH3				Shaving	Tool life measures
	MACH5				Hob	Standard material for wet use
	MACH7					Standard material for dry use
	MACH11					For wet and dry use Tool life measures
	MACH13					For wet and dry use Chipping measures
Powder high speed steel	MAC A				Shaping	Chipping measures (Not recoated)
	MAC B				Shaping	Standard material
					Hob / Broach	Standard material for chipping measures
	MAC C				Hob	For hard-to-cut / high hardness materials
	MAC D				Broach	Material for hard-to-cut / high hardness materials Tool life measures
	MAC L				Shaping	Hard-to-cut (high hardness) material measures
	MX-1				Shaping / Hob	Material for hard-to-cut / high hardness materials Tool life measures
GRANMET GRANMET SF					Hob	For high-speed cutting For recoating
GRANMET GRANMET BR					Broach	Corner wear measures
GRANMET GRANMET SK					Skiving tool	For hard-to-cut / high hardness materials

Material		Wear resistance	Appropriate tool	Usage
Carbide (●●)	H series	5 times than High Speed Steel	Hob Cutter	For High-hardness material/ For high speed material Available for re-coating
	S series	3 times than High Speed Steel	Skiving / Shaper Cutter	For High-hardness material Available for re-coating

■ Coating

Coating Name	Wear resistance	Heat resistance	For processing	Features	Hob	Shaping	Shaving	Broach
TiN			Wet	General-purpose wet coating	○*	○*		○
Nano Dynamic			Wet	Coating for broach For roughness/wear measures				○
Nano Dynamic II			Wet	Coating for broach For hard-to-cut/wear measures				○
MightyShield Epsilon MightyShield ε			Wet	Coating for shaving For wear measures (sharp edge maintenance)			○	
Black Dynamic			Wet	General-purpose wet coating	○	○		
SuperDry			Dry	General-purpose wet coating	○	○		
SuperDry III			Dry	For wear (crater wear) measures Dry coating	○	○		
MightyShield Sigma MightyShield Σ			Wet & Dry	Coating for wear measures From wet to high-speed dry For all processing areas	○	○		
MightyShield Micros MightyShield μ			Wet & Dry	Coating for small modules Coating for wear measures (thin film, even coating)	○	○		
MightyShield SigmaII MightyShield Σ II			Wet & Dry	Coating for wear measures From wet to high-speed dry For all processing areas	○	○		
MightyShield alpha MightyShield α			Wet & Dry	Profile deviation under 20% Available for Carbide substrate	○	○		

• Please contact us in advance to place an order for items marked with an asterisk.

Estimates / Design Specifications

Hob / Shaving Cutter Design Specifications

Customer name:	Order no.: -H	Order no.: -H

Workpiece specifications	
Part name	
Part no.	
Module / DP	
Pressure angle	
No. of teeth	
Helix angle	RH/LH, Spur
Outer diameter	
Root diameter / Tooth depth	
Amount of profile shift / Factor	
Tooth thickness at hobbing	
Tooth thickness	
Over-pin diameter	(φ)
Base tangent length	T =
Tooth thickness at shaving	
Tooth thickness	
Over-pin diameter	(φ)
Base tangent length	T =
Shaving stock	
Per tooth thickness	
For over-pin diameter	
For base tangent length	

Chamfering	
Amount (after gear cutting/after SV)	
Diameter created (after gear cutting/after SV)	
Chamfering profile	
Profile management diameter	
TIF diameter	
Length of meshing normal	
Rotation angle (scope)	
Rotation angle (start)	
or target workpiece specifications	
No. of teeth	
Outer diameter	
Distance between centers	
Workpiece shape (has / does not have steps)	
Tooth width	
Material / Hardness	
Accuracy	

Hob processing conditions				
Cutting speed	m/min. (r.p.m)			
Feed	Radial	mm/rev.		
	Axial	mm/rev.		
Processing method	Climb / Conventional			
No. of parts managed				
Hob shift	mm/item			
Hobbing machine				
SV processing conditions				
Processing method	Conventional / Diagonal			
	Underpass / Plunge			
No. of rotations	r.p.m			
Feed	mm/min. (μm/rev.)			
No. of cuts	times	T 1		Normal / Reverse
		T 2		Normal / Reverse
Idling	times	T 3		Normal / Reverse
		B M		mm
Shaving machine				
Maximum cutter diameter				
Minimum axis distance				
Maximum cutter width				

Hob Cutter Specifications		
Customer tool no.		
Outer diameter		Specified / Discretionary
Overall length		Specified / Discretionary
Bore diameter	JIS Standard	Specified / Discretionary
Bore / Edge surface key	JIS Standard	
No. of starts		Specified / Discretionary
Rake angle		None / Specified
No. of gashes		Specified / Discretionary
Usage	Finishing / Pre-shaving / Pre-grinding	
Cutter tooth profile	With chamfering / With cob / topping	
Cutter accuracy	JIS A JIS AA JIS AAA Other ( )	
Cutter material		Specified / Discretionary
Coating (required / not required)	TiN / Black Dynamic / SuperDry I, II, III MightyShield Σ / Other	

Shaving Cutter Specifications		
Customer tool no.		
Grinding method	Semi-grand Grand (with/without trial)	
No. of teeth		Specified / Discretionary
Nominal diameter		shape (inches)
Bore diameter		
Tooth width		Specified / Discretionary
Material	SKH51 / MACH3	Specified / Discretionary
Surface treatment	None / Homo treatment Super Coat / MightyShield ε	
Cutter curve	Tool / Specified / Assumed	
Cutter lead	Tool / With hollow / Specified	
Workpiece curve	Tool / Specified separately	
Workpiece lead	Tool / Specified separately	
Processing/measuring stance	Specified / Discretionary	

Special notes

Shaping Cutter / Shaving Cutter Design Specifications

Customer name:	Order no.: -H	Order no.: -H

Workpiece specifications	
Part name	
Part no.	
Module / DP	
Pressure angle	
No. of teeth	
Helix angle	RH/LH, Spur
Outer diameter	
Base diameter (minor diameter) / Tooth depth	
Amount of profile shift / Factor	
Tooth thickness at hobbing	
Tooth thickness	
Over-pin diameter	(φ)
Base tangent length	T =
Tooth thickness at shaving	
Tooth thickness	
Over-pin diameter	(φ)
Base tangent length	T =
Shaving stock	
For tooth thickness	
For over-pin diameter	
For base tangent length	

Chamfering	
Amount (after gear cutting / after SV)	
Diameter created (after gear cutting/after SV)	
Chamfering profile	
Profile management diameter	
TIF diameter	
Length of meshing normal	
Rotation angle (scope)	
Rotation angle (start)	
or target workpiece specifications	
No. of teeth	
Outer diameter	
Distance between centers	
Workpiece shape (has / does not have steps)	
Tooth width	
Material / Hardness	
Accuracy	

Shaping processing conditions				
No. of strokes	Strokes/minute			
Circumference feed	mm/rev			
Stroke length	mm			
No. of cuts				
No. of parts managed				
Gear shaping machine				
Helical guide				
SV processing conditions				
Processing method	Conventional / Diagonal			
	Underpass / Plunge			
No. of rotations	r.p.m			
Feed	mm/min. (μm/rev.)			
No. of cuts	times	T 1		Normal / Reverse
		T 2		Normal / Reverse
Idling	times	T 3		Normal / Reverse
		B M		mm
Shaving machine				
Maximum cutter diameter				
Minimum axis distance				
Maximum cutter width				

Shaper Cutter Specifications		
Customer tool no.		
Outer diameter		Specified / Discretionary
No. of teeth		Specified / Discretionary
Overall length		Specified / Discretionary
Bore diameter	JIS Standard	Specified / Discretionary
Bore / Edge surface key	With / Without	
Cutter type	Disc / Bell / Shank	
Usage	Finishing / Pre-shaving / Pre-grinding	
Cutter tooth profile	With chamfering / With cob / topping	
Shank shape		Specified / Discretionary
Cutter accuracy	JIS A JIS AA Other ( )	
Cutter material		Specified / Discretionary
Coating (required / not required)	TiN / Black Dynamic / SuperDry I, II, III MightyShield Σ / Other	

Shaving Cutter Specifications		
Customer tool no.		
Grinding method	Semi-grand Grand (with/without trial)	
No. of teeth		Specified / Discretionary
Nominal diameter		shape (inches)
Bore diameter		
Tooth width		Specified / Discretionary
Material	SKH51 / MACH3	Specified / Discretionary
Surface treatment	None / Homo treatment Super Coat / MightyShield ε	
Cutter curve	Tool / Specified / Assumed	
Cutter lead	Tool / With hollow / Specified	
Workpiece curve	Tool / Specified separately	
Workpiece lead	Tool / Specified separately	
Processing/measuring stance	Specified / Discretionary	

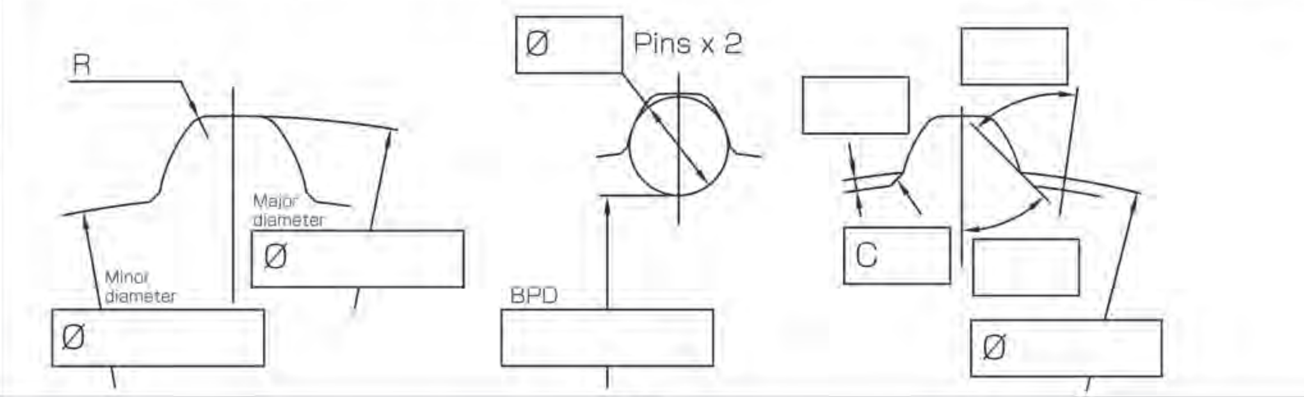
Special notes

Estimates / Design Specifications

Involute Spline Broach Design Specifications

Customer name:	Order no.:

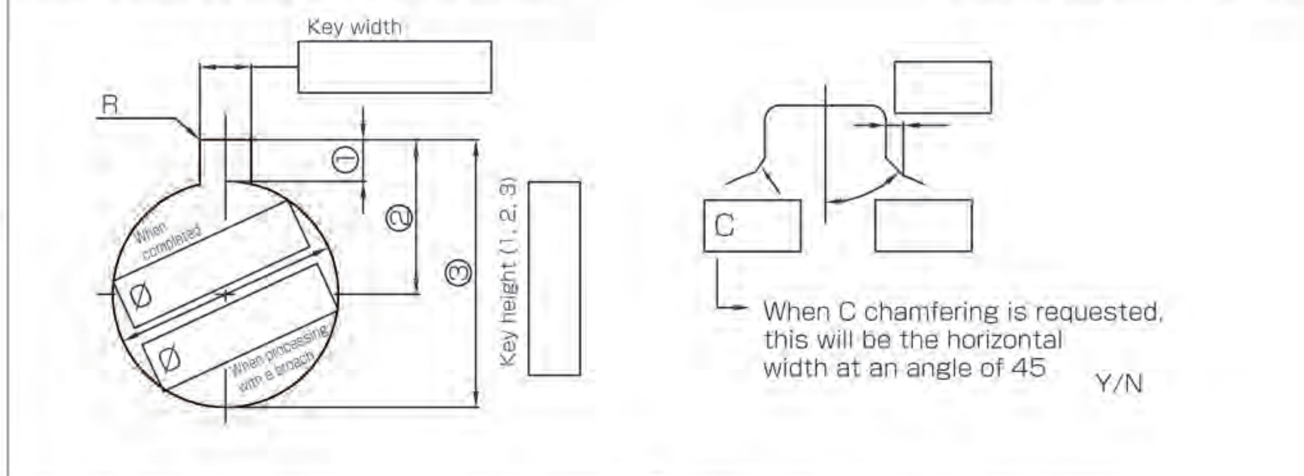
Note: Even if you provide a workpiece drawing or broach supply drawing, make sure it is transcribed if it is difficult to read.
Make sure the ☐ sections are filled in. (Anything left blank will be treated as being left to our discretion.)

1	Broach supply drawing ( ) → No → Go to 2; → Yes → Reference shank only → Go to 2; Has problems/Requires design change → Enter the details of the problem or reason for the change in 12; Design according to supply drawing → Enter any comments in 12.
2	Workpiece drawing after broach processing ( ) → No → Go to 3; Yes → Go to 6
3	Nominal dimensions → m, DP ☐ × PA ☐ × NT ☐
4	Workpiece dimensions after broach processing (include tolerances) *If chamfered, make sure ☐ is filled in. 
5	Cutting length ☐ No. of simultaneous cuts ____ Clamp → Yes / No Product Material ☐ Hardness when cut ____
6	Lower hole dimensions Ø ☐ → Comparison with workpiece minor diameter after processing → Round teeth → Required (Front, Back, Both) / Not required
7	Broach target dimensions → Major diameter Ø ☐ Minor diameter Ø ☐ BPD ☐
8	Front shank: Dimensions to first tooth ☐ Nominal dimensions ☐ Standard ☐ Reference drawing number ☐; Position determination → Required → Mountain-centered / Valley-centered / Other → Enter the details in 12.; Not required
	Rear shank: Required → Nominal dimensions ☐ Standard ☐ Reference drawing number ☐; Not required
9	Overall length specified → Yes / No ☐ Tool material specified → Yes / No ☐ Surface treatment specified → Yes / No ☐
10	Broaching machine model: ____ Maximum pulling force ☐ Stroke ☐
11	Customer's information to be marked on cutters: ____
12	Remarks (order history, customer requests, etc.)

Key Broach Design Specifications

Customer name:	Order no.:

Note: Even if you provide a workpiece drawing or broach supply drawing, make sure it is transcribed if it is difficult to read.
Make sure the ☐ sections are filled in. (Anything left blank will be treated as being left to our discretion.)

1	Broach supply drawing ( ) → No → Go to 2; → Yes → Reference shank only → Go to 2; Has problems/Requires design change → Enter the details of the problem or reason for the change in 10.; Design according to supply drawing → Enter any comments in 10.
2	Workpiece drawing after broach processing ( ) → No → Go to 3; Yes → Go to 5
3	Workpiece dimensions after broach processing (include tolerances) *If chamfered, make sure ☐ is filled in. 
4	Cutting length ☐ No. of simultaneous cuts ____ Clamp → Yes / No Product Material ☐ Hardness when cut ____
5	Broach appearance shape → Finishing teeth height ☐ Shank width ☐
6	Front shank: Dimensions to first tooth ☐ Nominal dimensions ☐ Standard ☐ Reference drawing number ☐
	Rear shank: Required → Nominal dimensions ☐ Standard ☐ Reference drawing number ☐; Not required
7	Overall length specified → Yes / No ☐ Tool material specified → Yes / No ☐ Surface treatment specified → Yes / No ☐
8	Broaching machine model: ____ Maximum pulling force ☐ Stroke ☐
9	Customer's information to be marked on cutters: ____
10	Remarks (order history, customer requests, etc.)