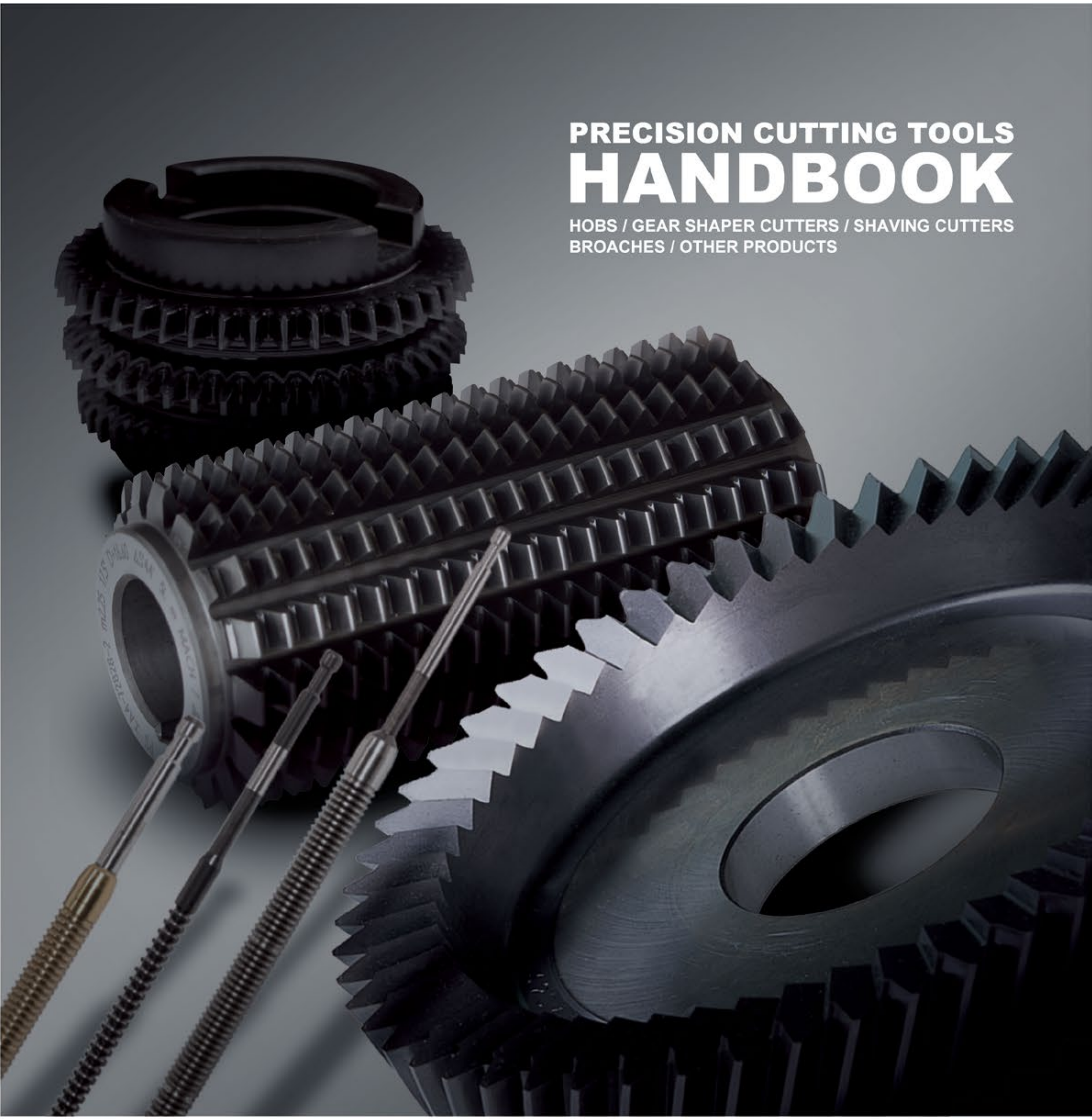
Nidec

All for dreams



PRECISION CUTTING TOOLS HANDBOOK

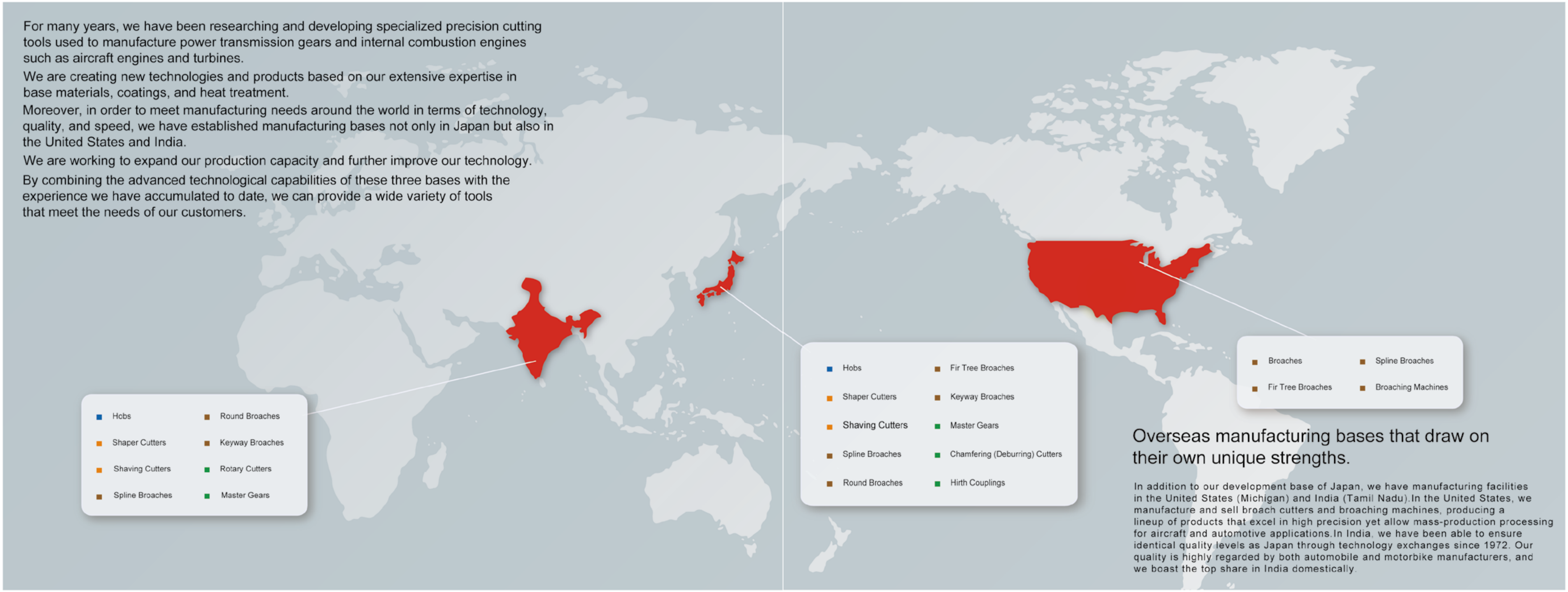
HOBS / GEAR SHAPER CUTTERS / SHAVING CUTTERS
BROACHES / OTHER PRODUCTS

NIDEC MACHINE TOOL CORPORATION

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

A Manufacturing System with Three Global Bases to Respond to Global Needs

For many years, we have been researching and developing specialized precision cutting tools used to manufacture power transmission gears and internal combustion engines such as aircraft engines and turbines.
We are creating new technologies and products based on our extensive expertise in base materials, coatings, and heat treatment.
Moreover, in order to meet manufacturing needs around the world in terms of technology, quality, and speed, we have established manufacturing bases not only in Japan but also in the United States and India.
We are working to expand our production capacity and further improve our technology.
By combining the advanced technological capabilities of these three bases with the experience we have accumulated to date, we can provide a wide variety of tools that meet the needs of our customers.



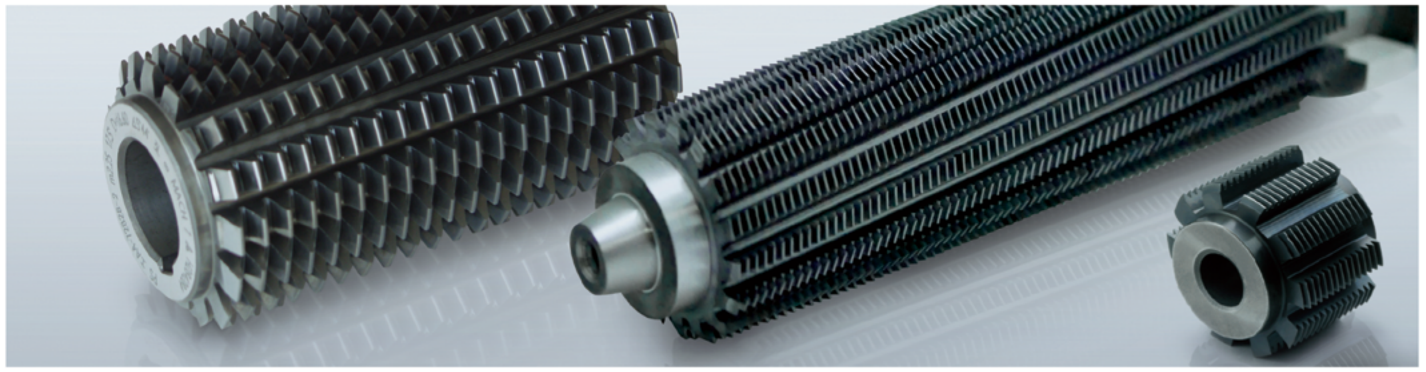
Overseas manufacturing bases that draw on their own unique strengths.

In addition to our development base of Japan, we have manufacturing facilities in the United States (Michigan) and India (Tamil Nadu).In the United States, we manufacture and sell broach cutters and broaching machines, producing a lineup of products that excel in high precision yet allow mass-production processing for aircraft and automotive applications.In India, we have been able to ensure identical quality levels as Japan through technology exchanges since 1972. Our quality is highly regarded by both automobile and motorbike manufacturers, and we boast the top share in India domestically.

CONTENTS

HOBS

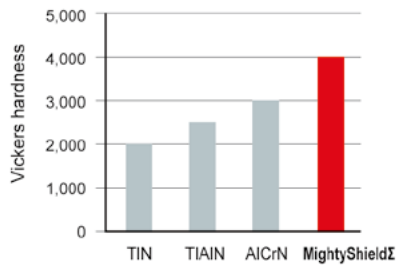
Hobs, with their ability to create gears with superior efficiency, are widely used in automobiles, construction and industrial machinery, as well as for processing power transmission gears for marine vessels and aircraft. We can manufacture tools with the optimum combination of dimensions, such as outer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



MightyShield Σ

Features

- **Longer tool life with coating film that offers superior wear resistance (film hardness: Hv 4,000)**
- **Supports a wide range of processing areas (HSS hobs, carbide hobs).**
- **Wet or dry, maximum performance whatever the cutting environment.**



Example

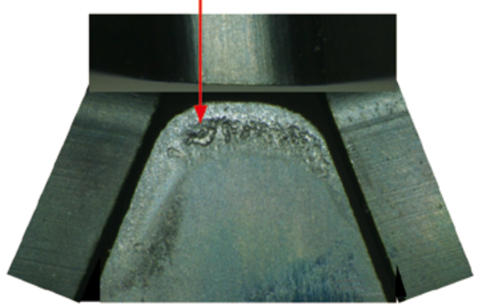
Combined with GRANMET SF, a new material for hobs (cutting speed: 350 m/min)

Combining the new GRANMET SF material with MightyShield Σ allows

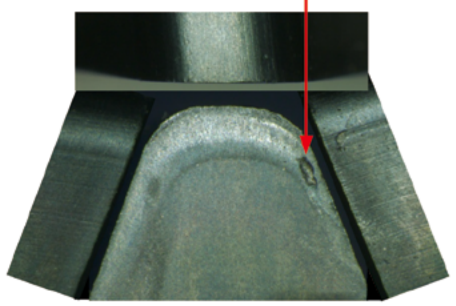
- **Cutting speeds in excess of 300 m/min.**
- **Wet and dry cutting.**
  (No cracks in the cutting edge during wet cutting)

Workpiece: m 2.7 PA 20° HA 30° NT 69 Material: Carburized steel
Cutter: 4 starts 16 Z Material: GRANMET SF Coating: Mighty Shield Σ
Cutting conditions: Cutting speed: 350 m/min Axial travel: 2.3 mm/rev
Processing No.: 50 (non-shift) Wet (water-lubricated) and dry cutting

Equivalent level of wear in both wet and dry cutting.



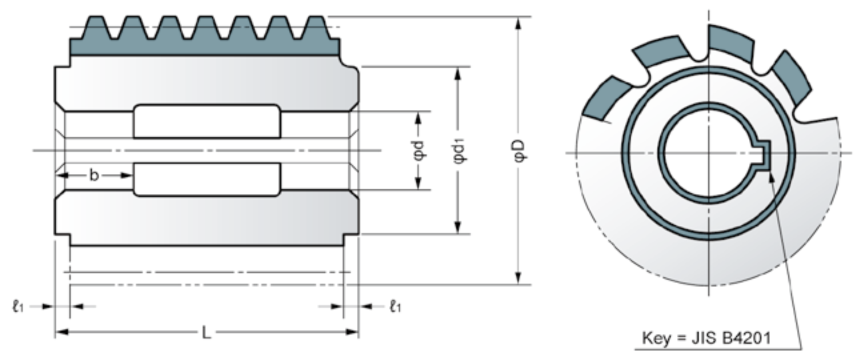
Wet cutting



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	Grade \ Standard diameter (mm)	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		Grade \ Module	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		Module / Grade		Permissible value 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
5	Gash	Vicinal division error		AAA	12	13	16	19	25	–
				AA	15	17	20	25	32	45
				A	24	26	32	40	50	71
6	Gash	Cumulative division error		AAA	22	25	30	38	48	–
				AA	28	32	36	45	60	85
				A	45	50	60	70	95	132
7	Gash	Radial alignment		AAA	9	11	12	15	20	–
				AA	12	13	15	19	25	36
				A	18	21	25	30	40	56
8	Gash	Lead error	Grade		Tolerance: 32 mm or less	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	Profile	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	Profile	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	Tooth ridge	Vicinal 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	Tooth ridge	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	Tooth ridge	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				

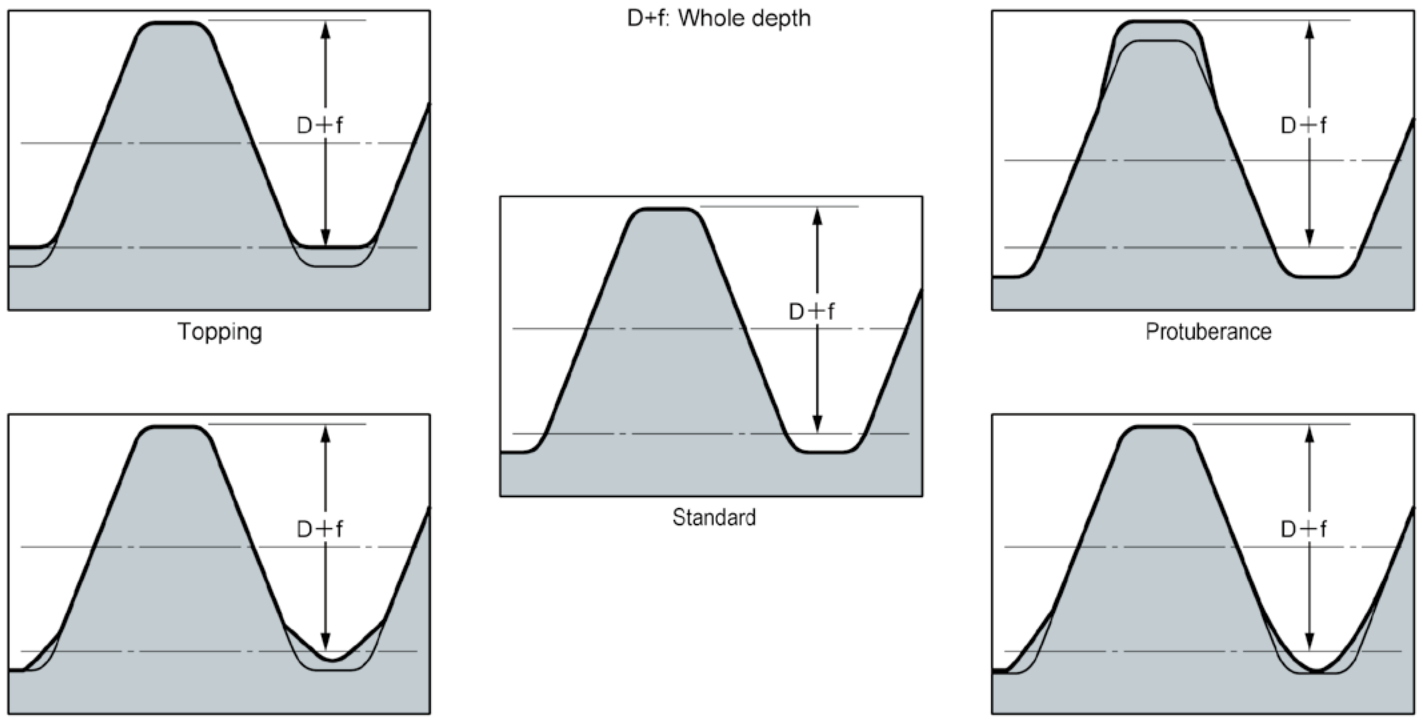
Unit: μm

No.	Item		Module / Grade		Tolerance or permissible 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
15	Tooth ridge	Line of action vicinal 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	Tooth ridge	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	Cutting face	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	Cutting face	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

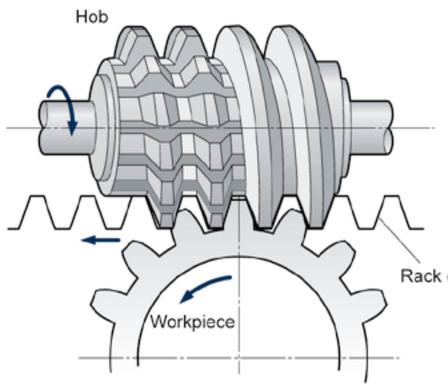


Topping, Standard, Protuberance, Semi-topping, Tip modification

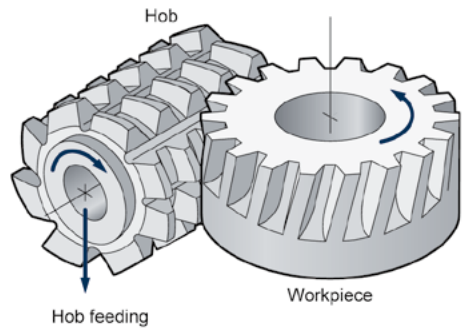
Hobs
Shaper Cutters
Shaving Cutters
Broaches
Other Products
Materials and Coatings for Tools
Estimates / Design Specifications

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.

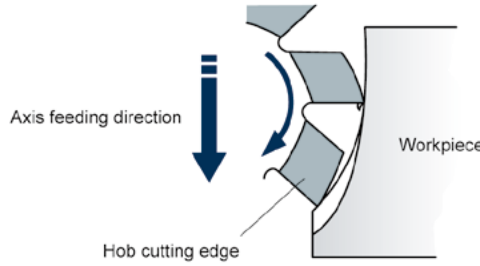


The hob is fed to a workpiece in the gear width direction. Processing efficiency may improve if the number of starts for the hob is increased, but the number of cutting teeth will decrease and cause an increase in the polygonal error.
The machine must have sufficient rigidity and strength.

Gear Cutting Methods in Hobbing

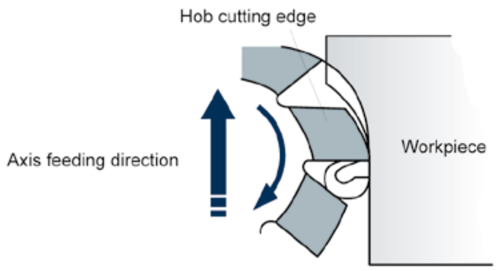
Conventional hobbing

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



Climb hobbing

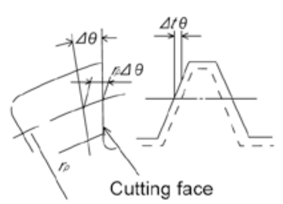
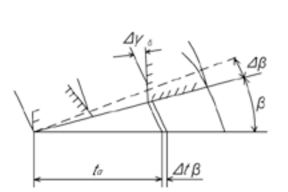
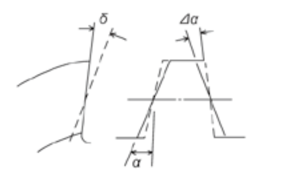
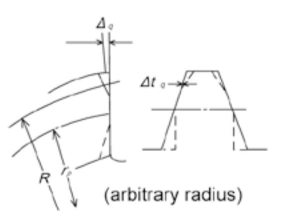
The hob rotates from the bottom to the top face of a workpiece.



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_p=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) $\Delta t\beta=t_\alpha\cdot\Delta\beta\cdot\tan\Delta\gamma_\delta$ • For every $\Delta\beta$=1° expands/contracts at a rate of $\Delta t\beta=0.001t_\alpha$ (t_α=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

Hobs
Shaper Cutters
Shaving Cutters
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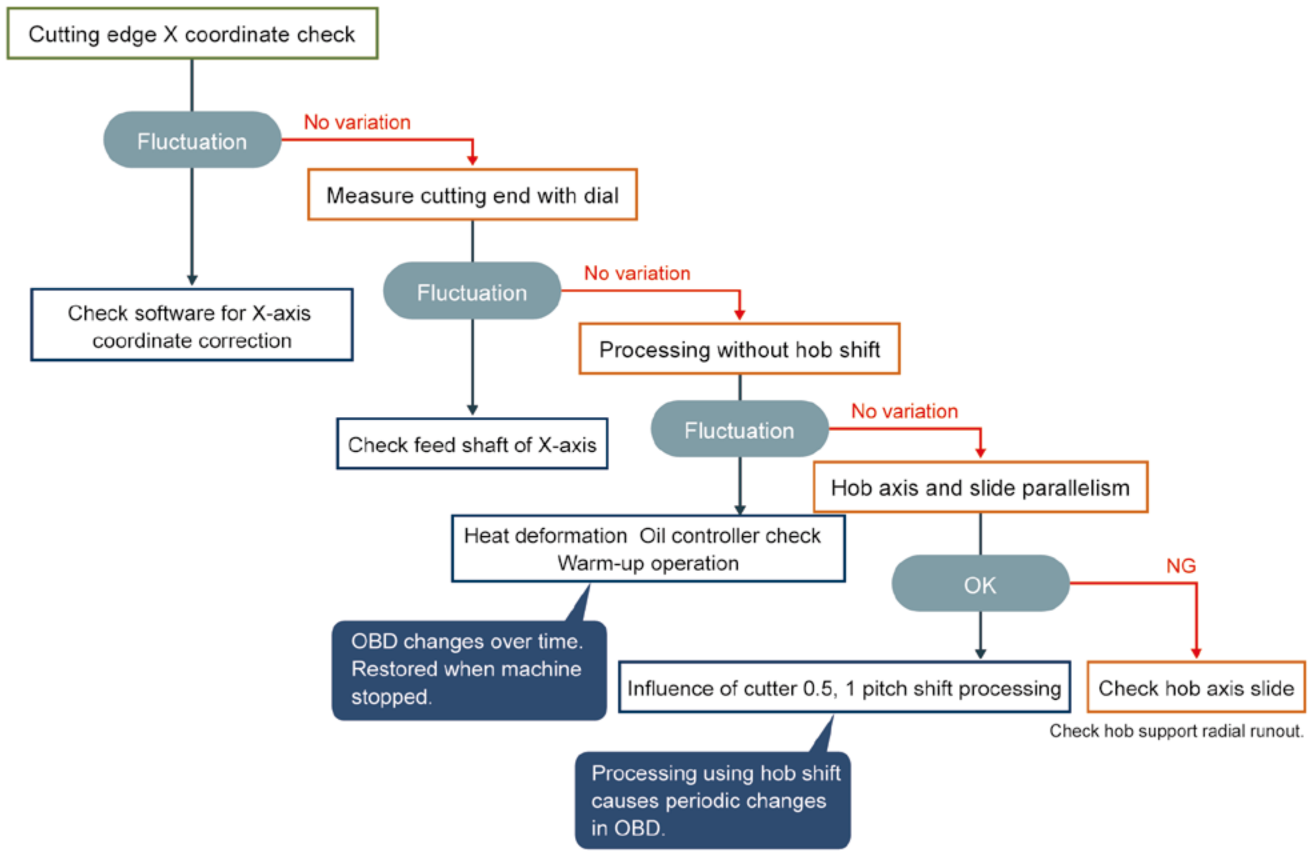
Standard Size Variation: Troubleshooting

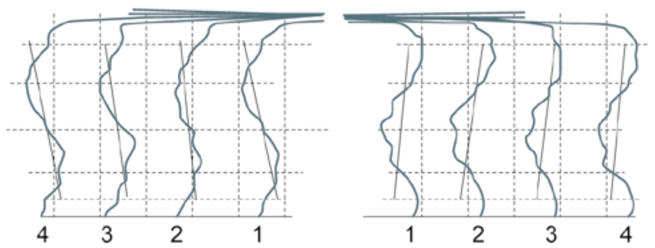
If the OBD suddenly changes or fluctuates, check for the effects of swarf clogging, workpiece rotation, or tears.



Effects of Cutting Load Fluctuations

■ Cause

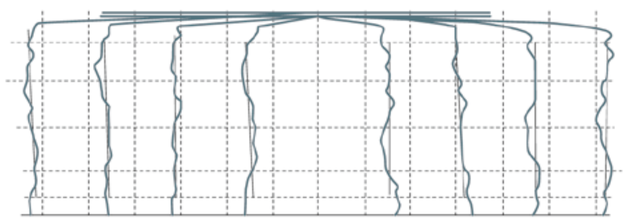
- Cutting force changes from 0 to Max to 0, deflection also changes.
- In particular, load fluctuation at the end of the cut affects machining accuracy.
- In addition, machine rigidity and clearance, mounting rigidity and holding rigidity, and the rigidity of the workpiece itself also have effects.



Distortion of tooth profile due to cutting load fluctuations

■ 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.


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)

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

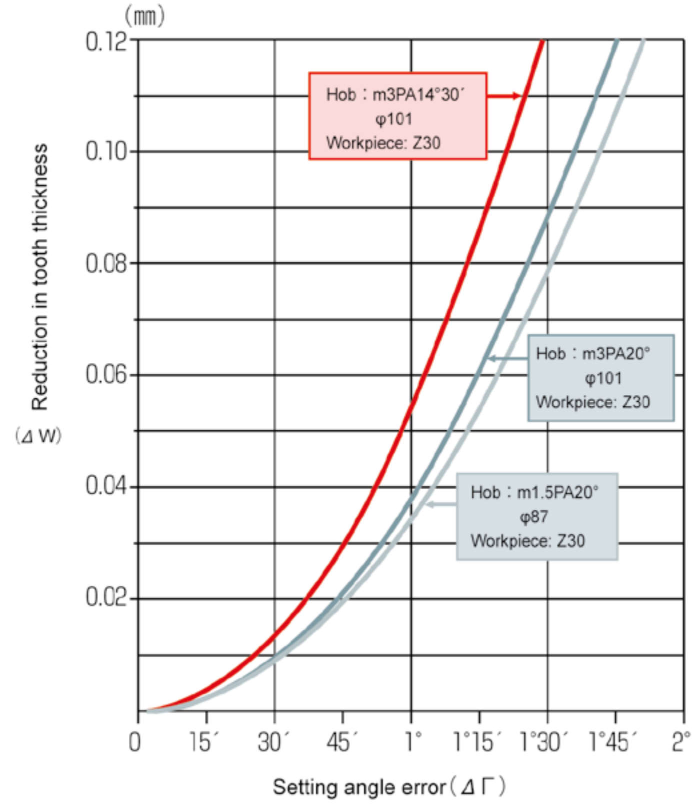
  m_n : Hob normal module
  α_n : Hob pressure angle
  Z : Number of workpiece teeth
  γ : Hob feed angle
  Δε : Hob mounting angle error
  g : Number of starts

- 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 $\Delta C = \Delta W / 2\tan\alpha_n$



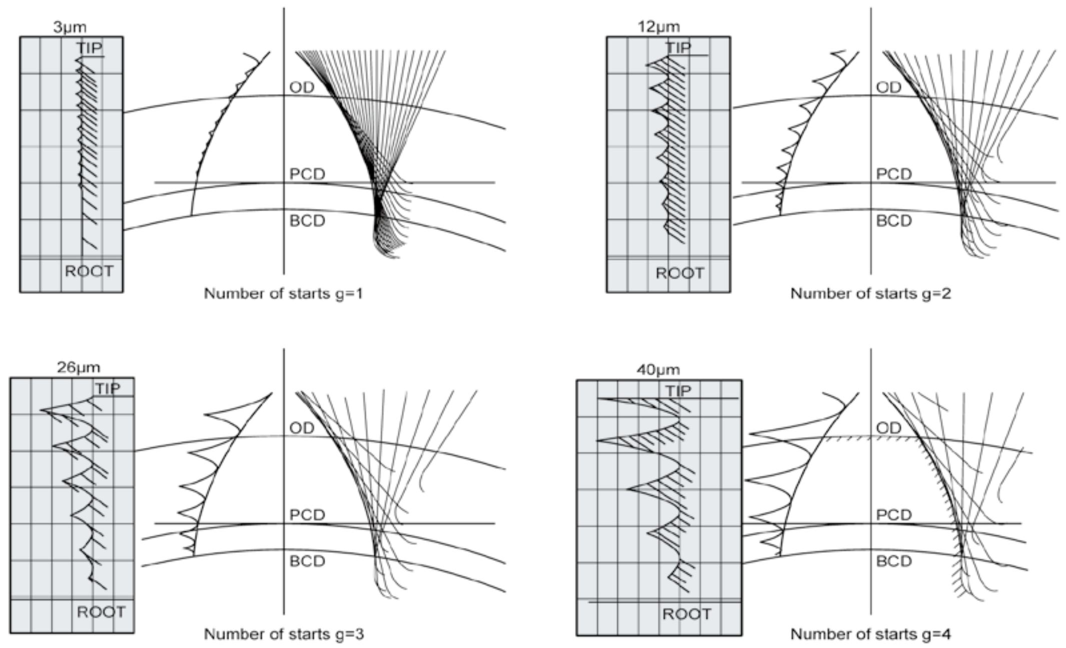
Number of Starts and Polygonal Error

■ 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 $\Delta S = 0.040\ m_n$



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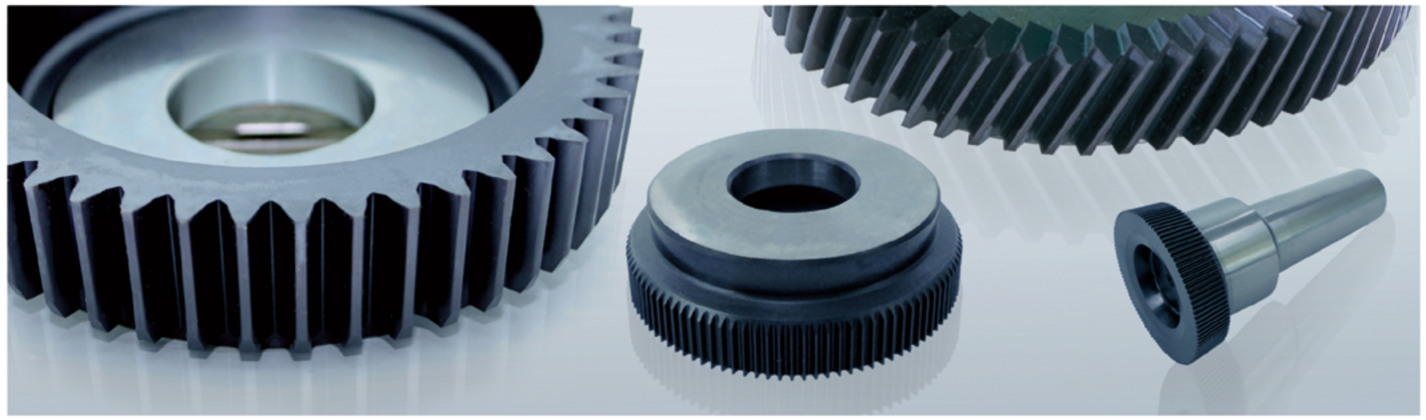
SHAPER CUTTERS

Shaper cutters are used to process tools for cutting teeth in shapes that hobs cannot handle easily. They are manufactured with our unique 7-axis NC profile grinding machines for involute and non-involute profiles such as circular arcs, cycloids, 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 SuperDry series 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.

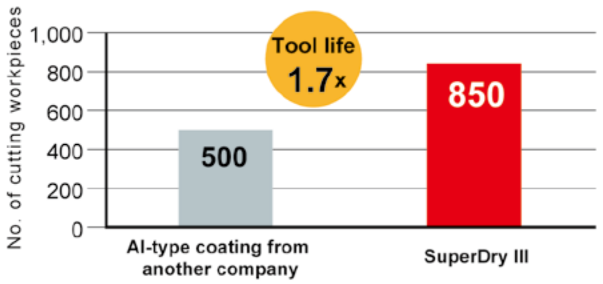


SuperDry III

Features

- Harder at high temperatures, improved wear resistance.
- Improved film structure for better adhesiveness.
- Can be used on materials that are hard to cut.
- Increases efficiency and productivity through high-speed processing.

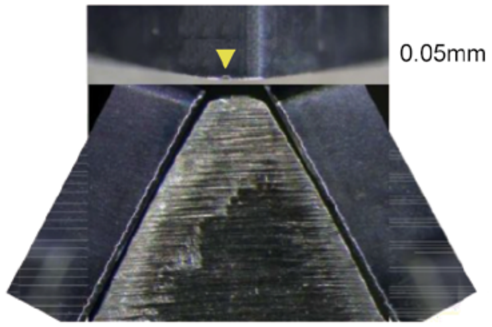
Workpiece: m4 SPUR NT40 (inner teeth) ODφ170 Material: FCD
Cutter: NT26 ODφ113 Material: MX-1 Coating: SD III (with rake face coating)
Cutting conditions: No. of strokes: 290/430/430 str/min
Circumferential feed: 3.0/1.5/1.0 mm/str
Radial feed: 0.01/0.01/0.01 mm/str



Examples

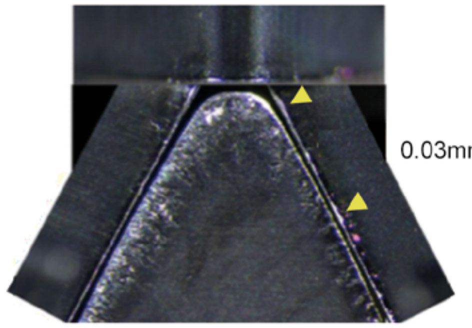
Workpiece: m2 PA30° SPUR NT27 ODφ52 Material: SCM420
Cutter: NT62 ODφ127 Material: MAC B Coating: SD III (SS-processed)
Cutting conditions: No. of strokes: 1100/1100/800 str/min Circumferential feed: 1.5/1.5/0.5mm/str

Tool wear (after 150 pieces):



Black dynamic (no cutting face coating)

Tool wear (after 3500 pieces):



SuperDry III + SS treatment (with cutting face coating)

About SS Treatment

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

Features

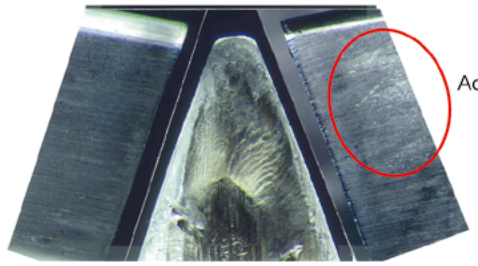
- **Deals with flaking and adhesion on workpiece tooth surfaces.**
- **Deals with adhesion on tool tooth surfaces.**
- **Special treatment to minimize the roughness of cutter tooth surfaces.**

Examples

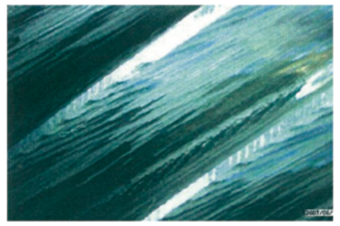
Workpiece: m2 PA20° HA35°LH NT29 ODφ79 Tooth width 25 Material: SCM420H
Cutter: ODφ160 φ160 Material: MAC B Black dynamic (no rake face coating)

Processing result by cutter without SS treatment

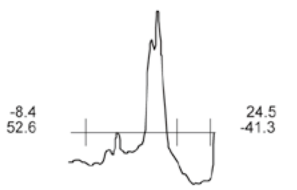
Cutter tooth surface condition



Workpiece cut tooth surface



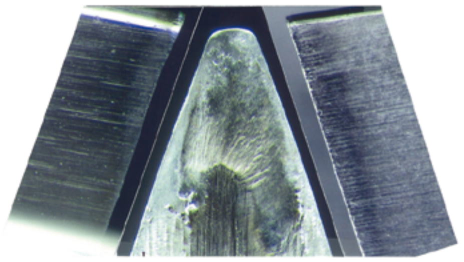
Tooth roughness measurement result



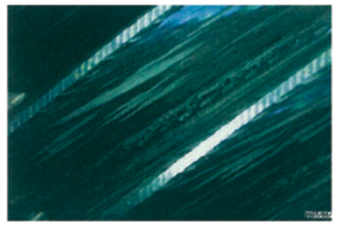
Flaking depth: Max value: 53 μm
Average value: 18.6 μm

Processing result by cutter with SS treatment

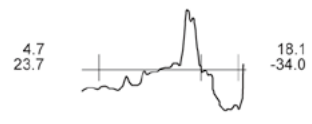
Cutter tooth surface condition



Workpiece cut tooth surface



Tooth roughness measurement result

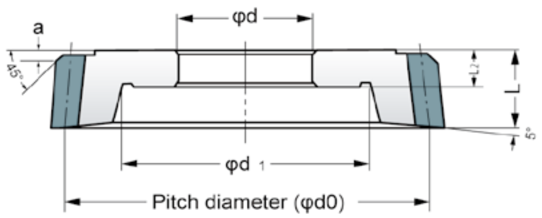


Flaking depth: Max value: 24 μm
Average value: 12.9 μm

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.

Hobs
Shaper cutters
Shaving Cutters
Broaches
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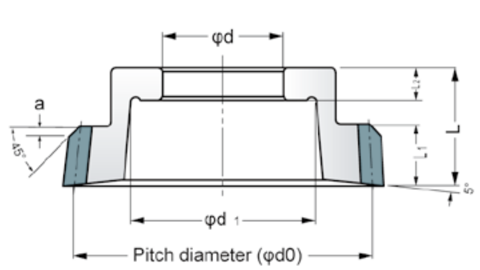
Bell type

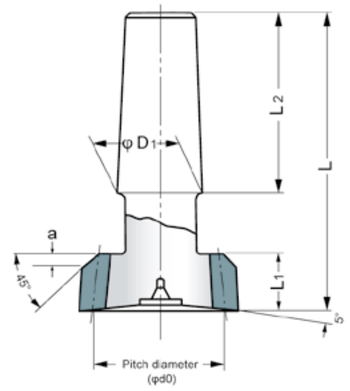


Unit: mm

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 dimen-sions	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: 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

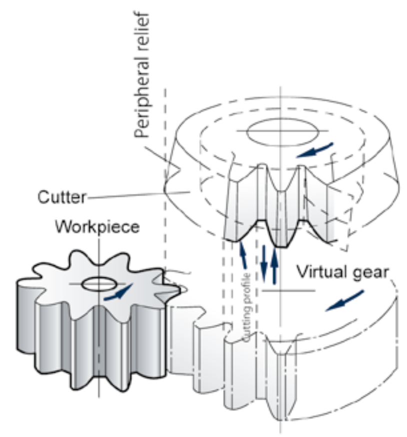
No.	Item	Grade	Nominal size	Permissible value or tolerance — Module (m): 0.75 or higher 1 or less	Over 1, 1.6 or less	Over 1.6 2.5 or less	Over 2.5 4 or less	Over 4 6 or less	Over 6 10 or less	Over 10 12 or less
9	Runout	AA	25, 38, 50	10	10	10	11	–	–	–
			75, 100	11	11	12	13	14	17	–
			125,150,175	–	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.

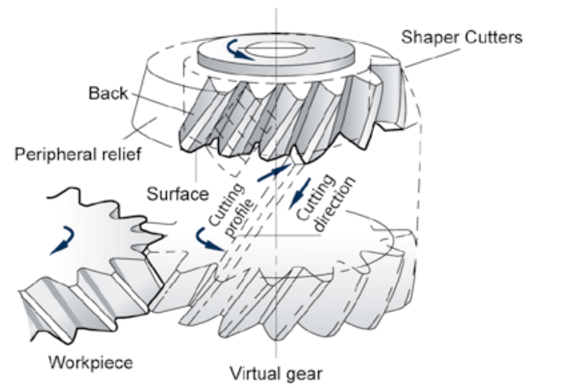
Processing by Shaper Cutters

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. While a helical guide is required during helical gear processing, which involves torsional motion, our lineup features the guideless ST series (NC gear shaper).

Processing spur gear with gear shaping machine



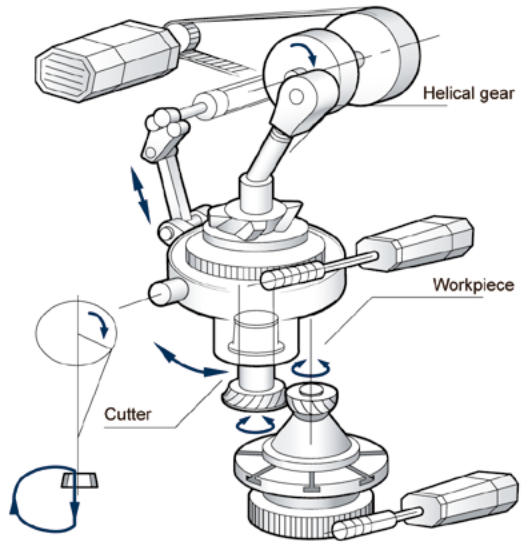
Processing helical gear with gear shaping machine



■ 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

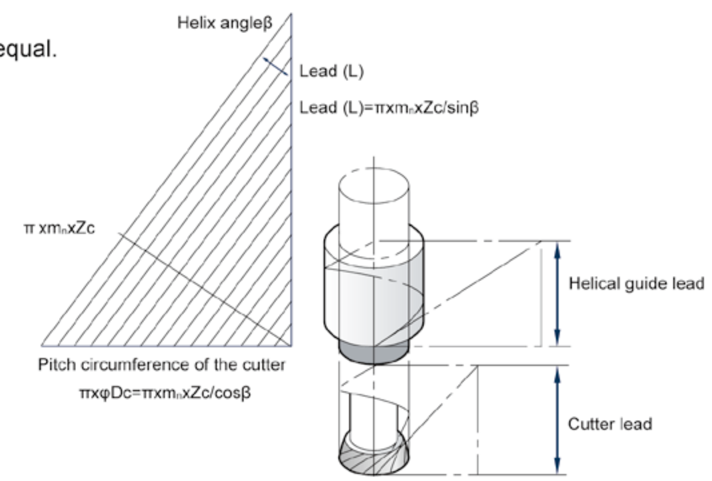
The lead between the cutter and the guide must be equal.

Lead (L)=π×mn×Zc/sinβ

m_n : Normal module

Zc : Cutter teeth number

β : Cutter helix angle

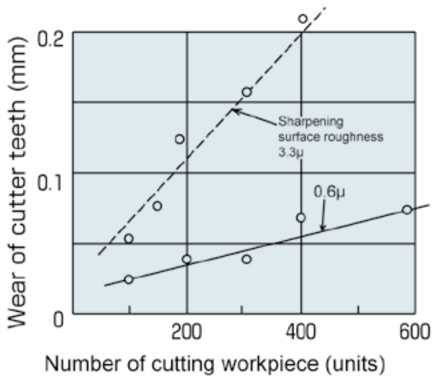


Gear Shaping Problems and Causes

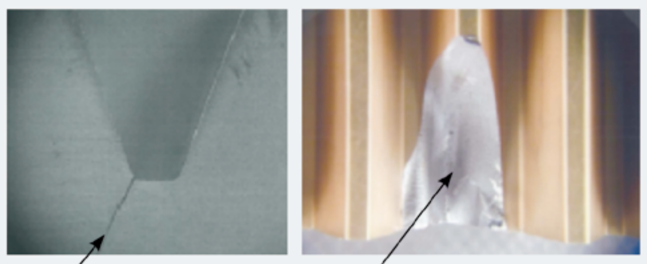
	Problem	Symptom	Cause
Workpiece	Workpiece profile	Workpiece profile error	1. Poor cutter tooth profile 2. Poor cutter face angle/sharpening angle 3. Poor gear shaping machine precision
		Gap in one tooth	1. Poor cutter runout precision 2. Poor cutter cumulative pitch precision
		Insufficient meshing 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.

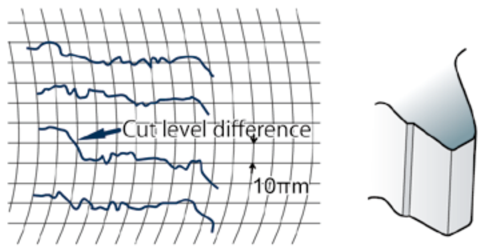


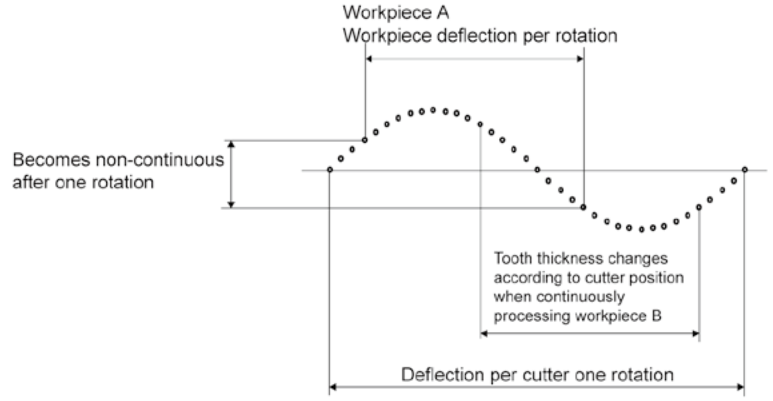
Grinding crack   Broken cutting edge caused by caused by grinding crack

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.





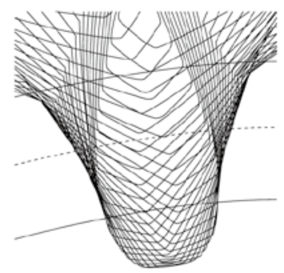
Causes of Profile Errors

- **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 of the biting:

- 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.)

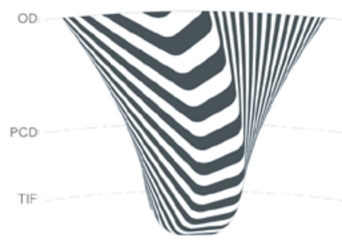
(Reference) Diagram of gear cutting processing



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

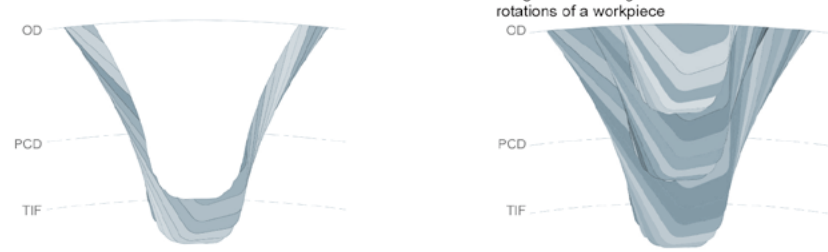
Conventional processing



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 is effective for extending cutter life

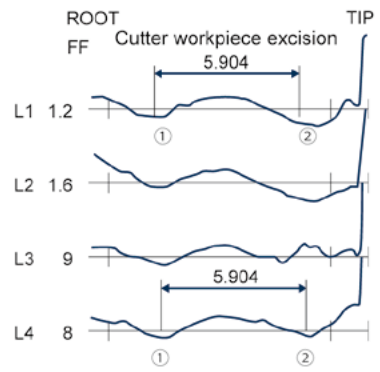
(Reference)
Diagram showing the end of incision after 3 rotations of a workpiece



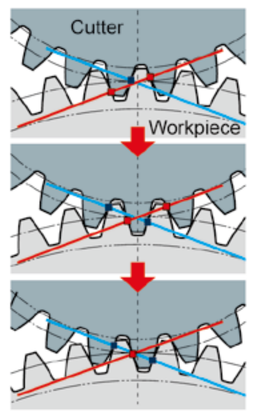
High circumferential feed means chips are removed thickly, so cutting teeth are distributed evenly, reducing wear.

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

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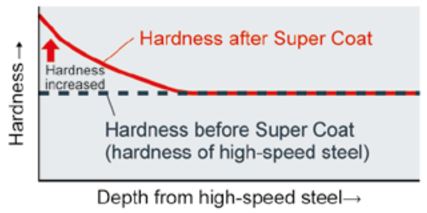
SHAVING CUTTERS

Shaving cutters are used for shaving off tiny amounts of the gear tooth surface after processing with hob or shaper cutters. 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 motorbike 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.**

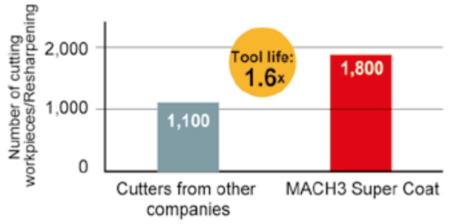


Minimizes size changes and prevents serration depth variance.

Example

Workpiece: m2.7 PA20° HA28° RH NT68 ODφ116 Tooth width 36
Material SCr420H

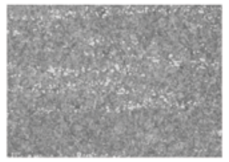
Cutter: NT79 ODφ225 Material MACH3 With Super Coat



MACH3 Hard High Speed Steel

Features

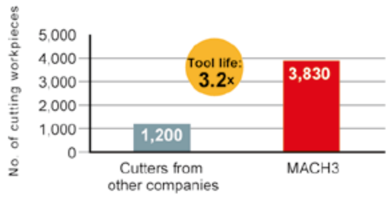
- **Increased V. Co which helps prevent wear and micro-granularized carbides dispersed throughout to improve toughness (chipping resistance).**
- **Equalization and dispersal of carbides to give hardness and ensure grindability is unchanged.**



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 face roughness.**
- **Optimized pitch size based on original design simulations to create high-precision tooth profiles.**

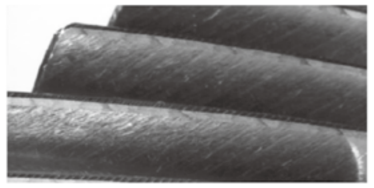
Example

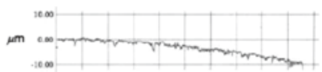
Extension of tool life and cost reduction with fine pitch + material change + Super Coat SVC

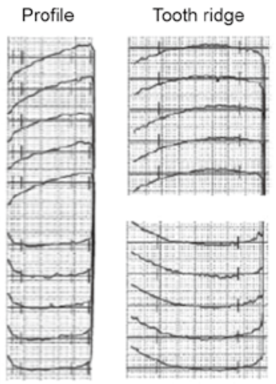
Workpiece: m1.7 PA17.5° HA36° NT45° Cutter: NT113 HA21° Improvement measures: High rigidity, fine pitch, super coating

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

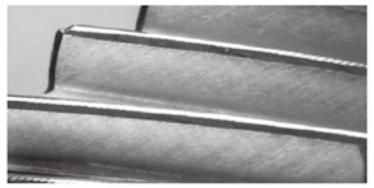
Processed tooth surface with SVC of other manufacturer (wear after processing 1500 units)

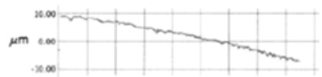


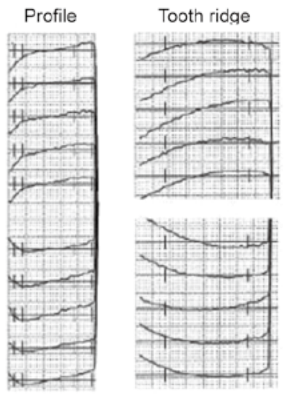




Processed tooth surface with Fine Pitch SVC (wear after processing 5500 units)

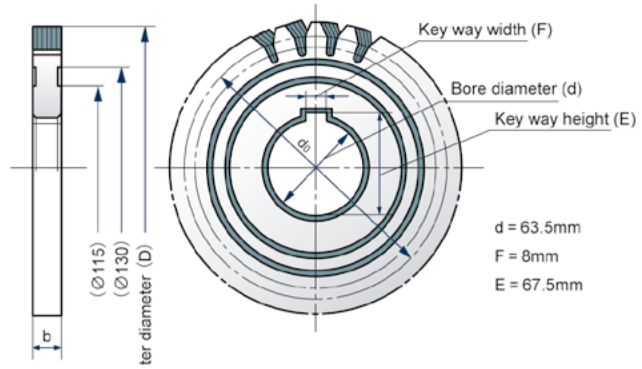






Dimensions and Precision Standard

■ 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

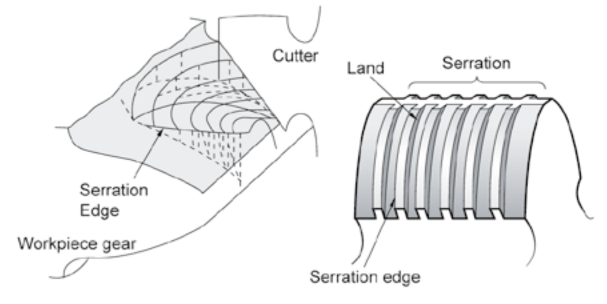
No.	Item			Permissible value or tolerance – Module (m): 1 or more 2 or less	Over 2 3.5 or less	Over 3.5 6.3 or less	Over 6.3 10 or less	Over 10 12 or less
1	Outer diameter D			±400				
2	Width b			±200				
3	Bore diameter d			−5 / 0				
4	Key way	Width F		+90 / 0				
		Height E		+300 / 0				
5	Peripheral 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	225 mm or lower	5	6	7	8	—
			300mm	5	6	7	8	9
		Cumulative pitch error	225 mm or lower	17	18	18	19	—
			300mm	23	23	24	24	25
9	Total profile error		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.

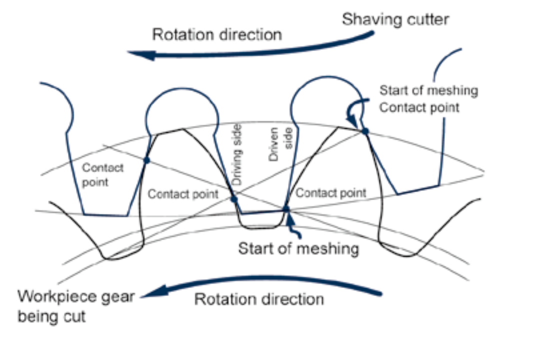
Processing Using Shaving Cutters

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 cheap 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. (Following heat treatment, use profile grinding.)

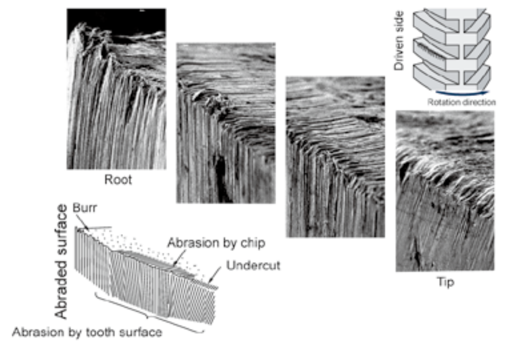
Movement of the cutter teeth on the gear teeth.



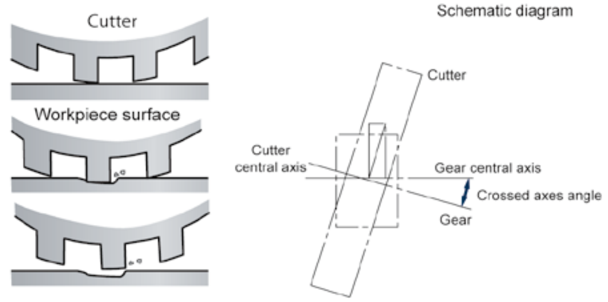
Meshing of shaving cutter and gear



Shaving cutter serration edge expansion

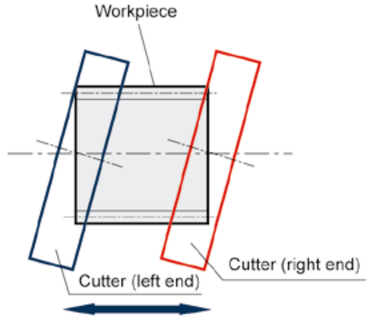


Shaving cutter cutting mechanism schematic



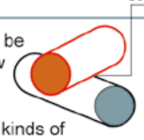
■ Conventional processing

Move cutter in parallel to workpiece axis



Cutter motion (feeding)

Each cylinder has point contact

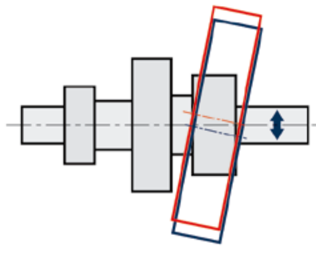


1. Wider workpieces can be processed with narrow cutters.
2. Easy to share cutters among some different kinds of workpieces.
3. The motion of the machinery enables crowning and taper processing.
4. The cutter moves a long way compared to other methods.
5. Only the center of the cutter is used, wasting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

■ Underpass processing

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.

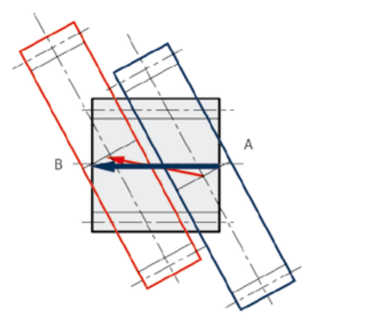


Moving the cutter from the lower location in blue to the upper location in red will move the contact point from left to right and allow processing of the entire tooth width of a workpiece.

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 processing

Move cutter diagonally to workpiece axis

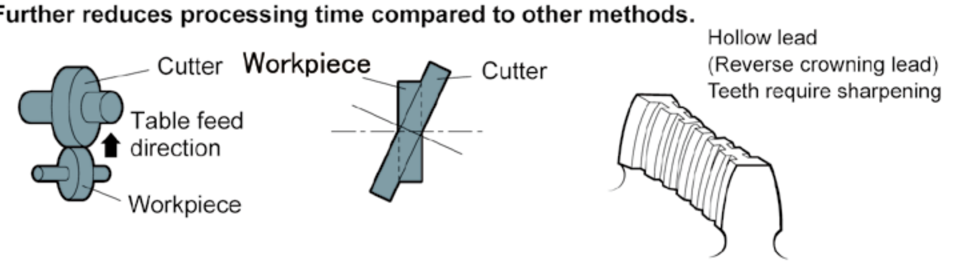


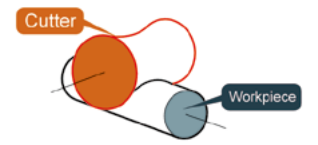
Moving the cutter in the direction of the red arrow if fed in a diagonal direction will move the meshing point from the right edge A to the left edge B of the workpiece.

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.

■ Plunge processing

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.

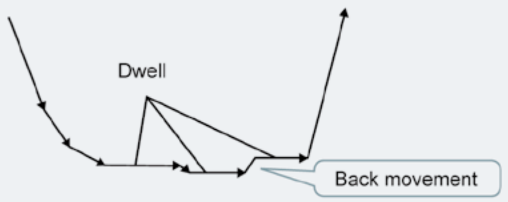




Plunge shaving processing

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

Setting processing conditions



Basic sequence of plunge processing

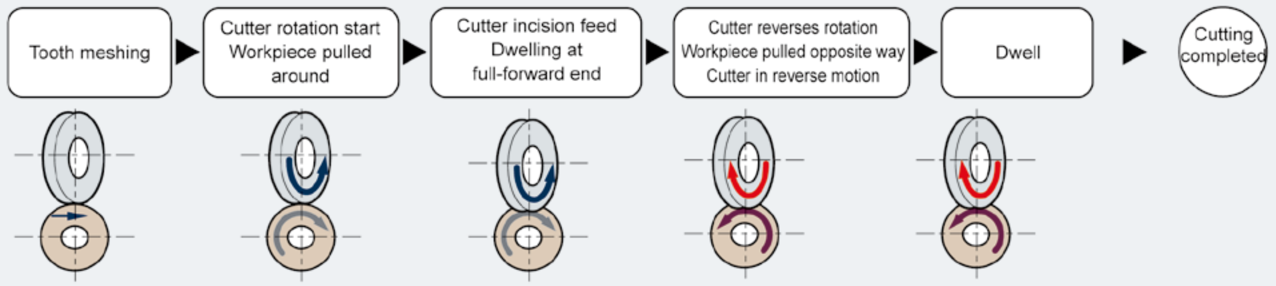
Cutting speed
Plunge, underpass: 145 m/min.
Diagonal, conventional: 120 m/min.

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.



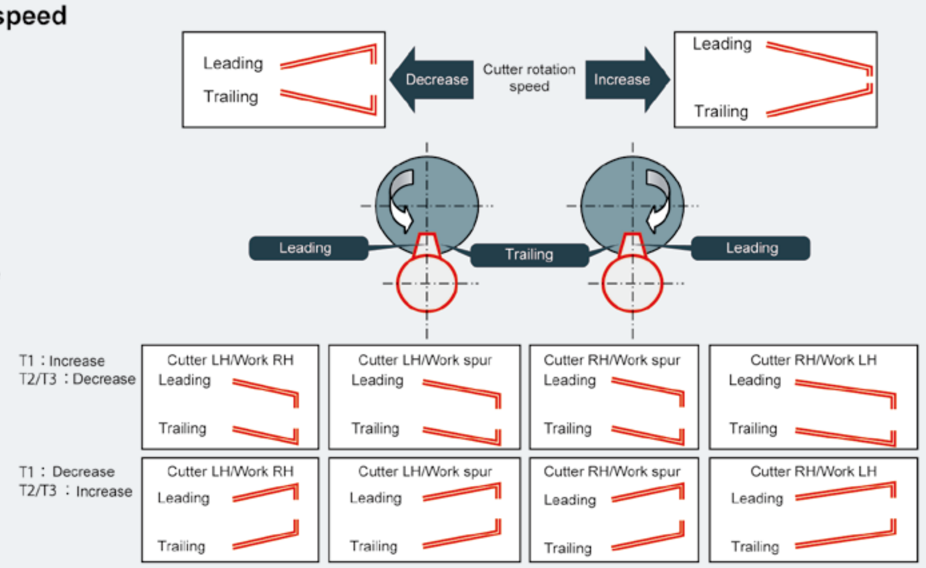
Improvement of Profile Precision

● Impact of cutter rotation speed

Adjustment is likely to cause the changes shown in the following diagram.

● Impact of dwell timer

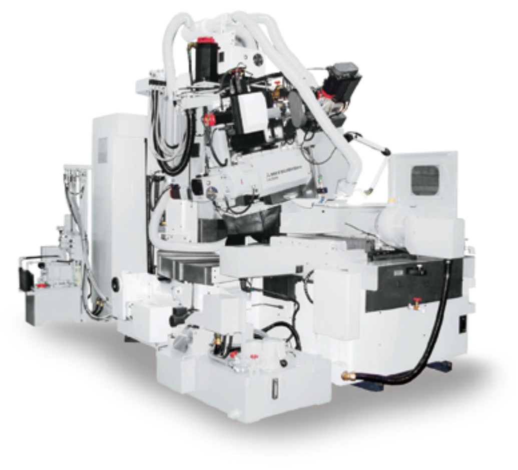
Changes the leading/trailing cutting surface depending on the cutter rotation direction.



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.

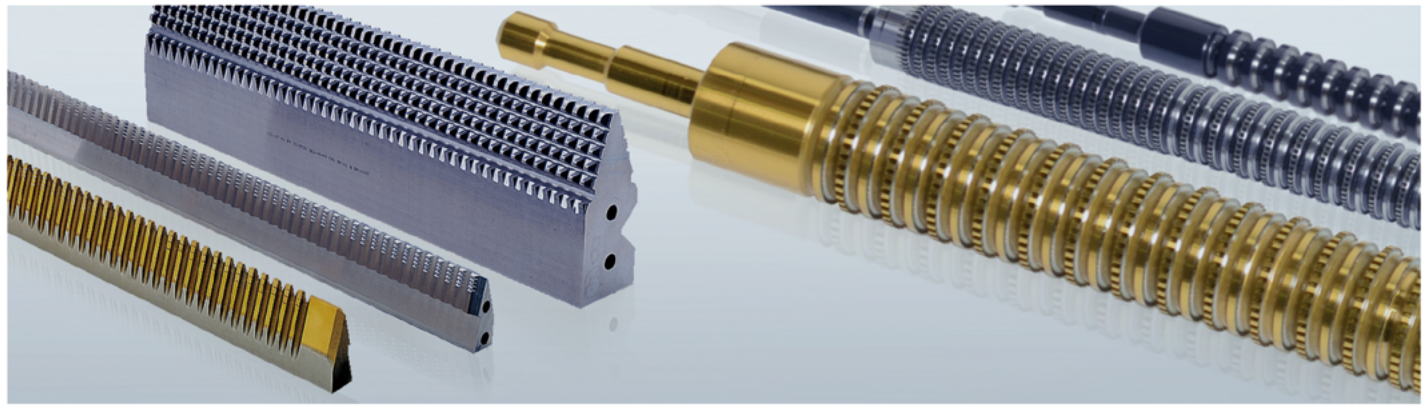
During resharpening, ensure that worn (abraded) parts are removed properly. Check also for burrs and ensure that they are removed.

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 and resharpen the tooth profile and lead of each cutter.

BROACHES

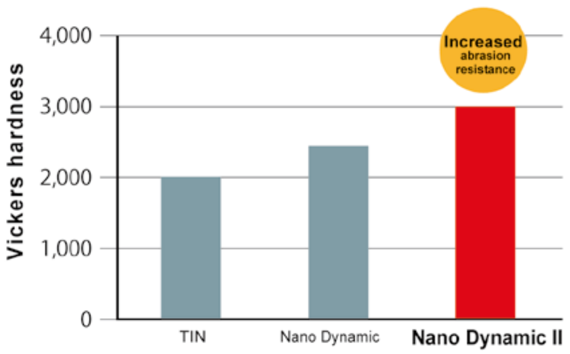
Broaches are divided into two groups: internal broaches for making spline holes used to process automobile reduction gears and machine tools, and surface broaches for processing the surfaces of specially-shaped parts used to make power generator and jet engine turbine blade grooves and various industrial 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.

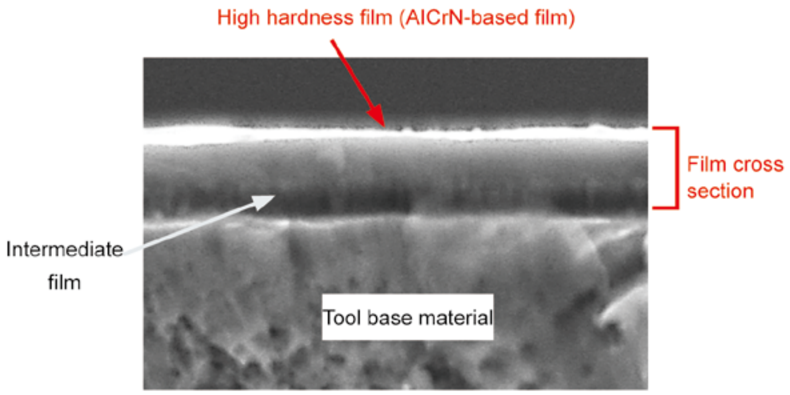


Nano Dynamic II

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.**





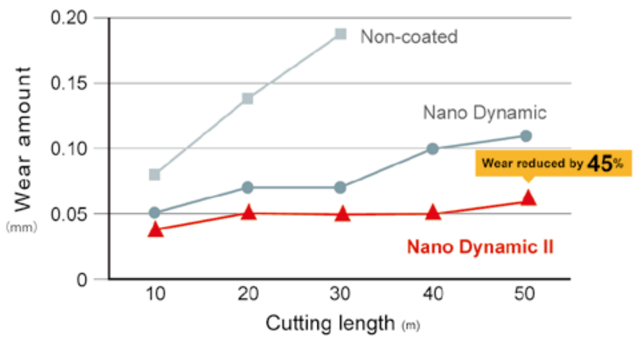
Structure of Nano Dynamic II

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

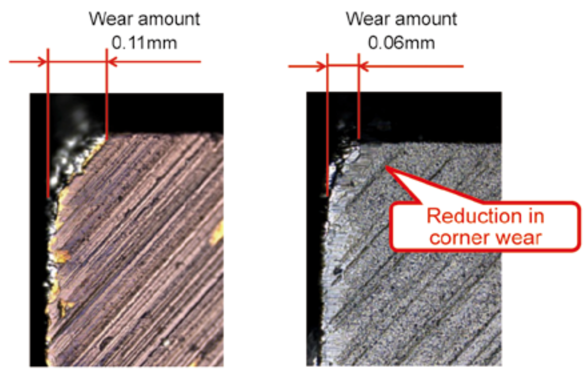
Example

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

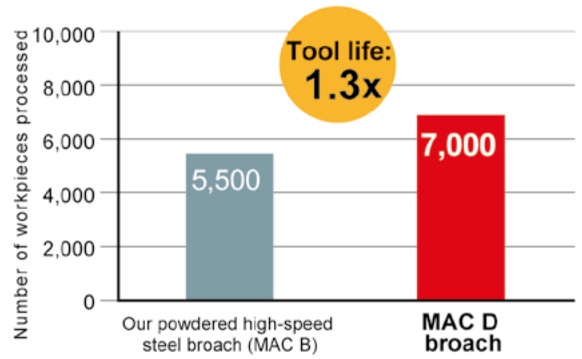
- **Uses MAC D powder high-speed steel which contains high levels of VC carbides for superior wear resistance.**

Example

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

Material S55C

Cutter: Pot Broach



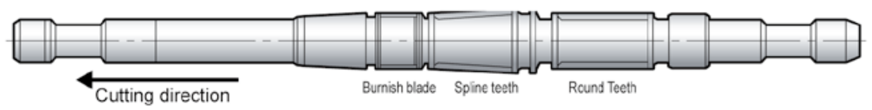
Eccentricity Preventing Broach

Features

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

Previously: Spline teeth → Round teeth

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

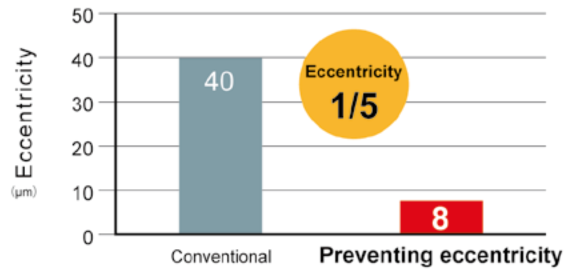


Example

Workpiece: Tooth width 19.5mm Material SCM420H

Cutter: Involute spline broach ODφ33 NT32 Coating TiN

Cutting conditions: Cutting speed 5m/min.

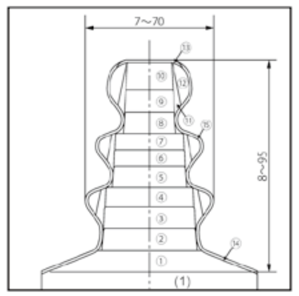


Fir Tree Broach

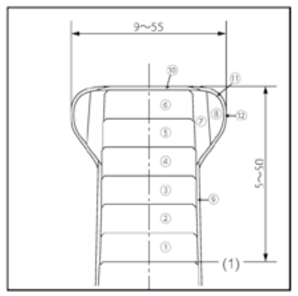
Features

- **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**

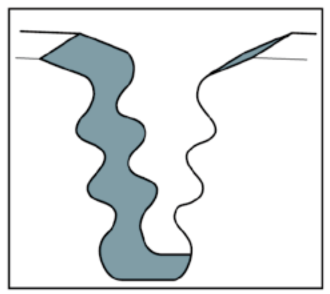
Examples



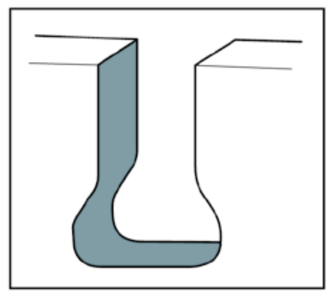
Fir tree broach layout and tooth profile size



Dovetail broach layout and tooth profile size



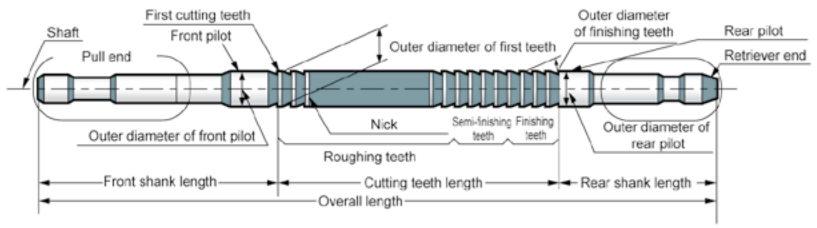
Groove machined with fir tree broach



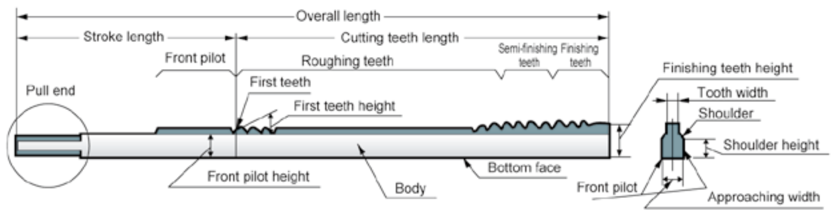
Groove machined with dovetail broach

Names of Broach Parts

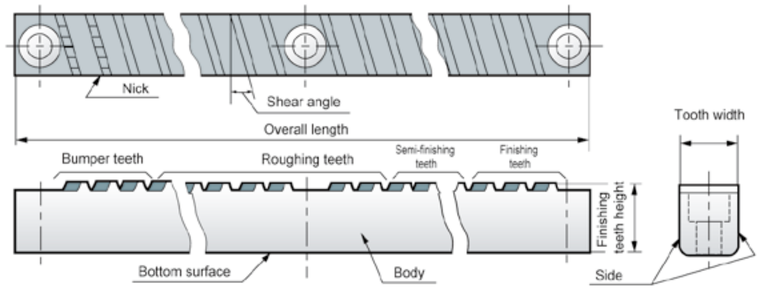
Internal broach



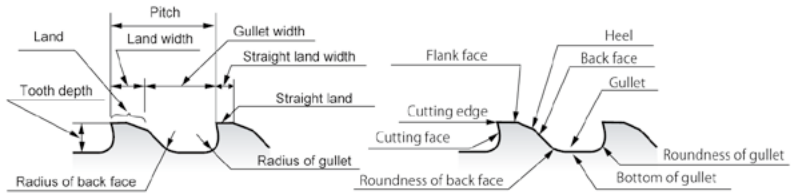
Keyway broach



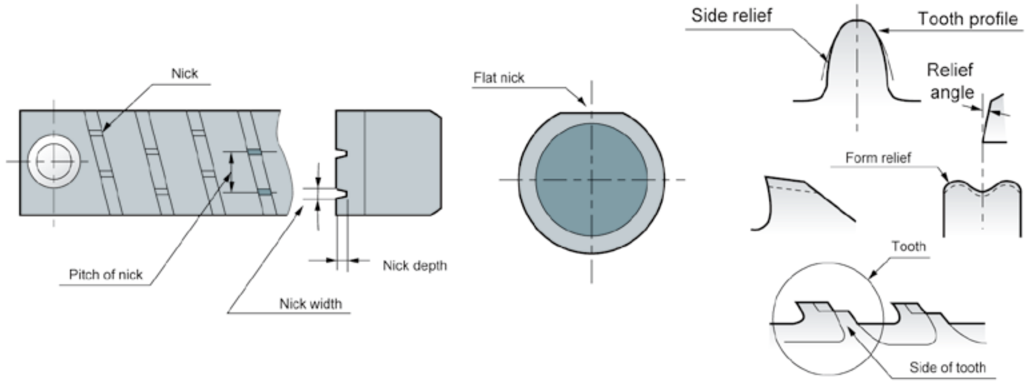
Surface broach



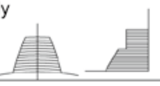
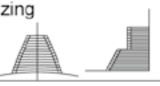
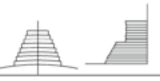
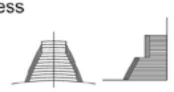
Teeth



Nick and relief

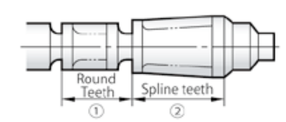
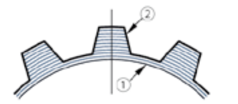
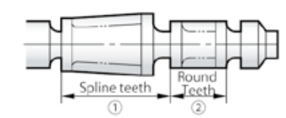
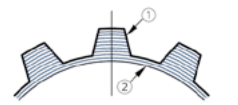
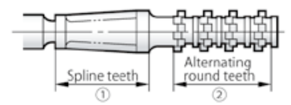
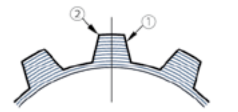
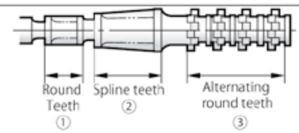
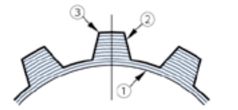


Cutting Methods

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			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			Machining with involute spline broach with round rear teeth	Standard broach with round teeth
Spline broach with alternating round teeth			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			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/mm^2

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

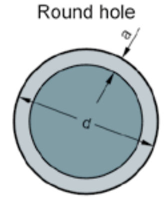
n = ℓ/P (pieces)

All values are rounded up to the nearest integer.

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

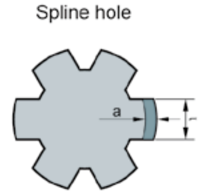
(3) Calculation of total cut area per tooth Q

Round hole



Q=π×d×a

Spline hole

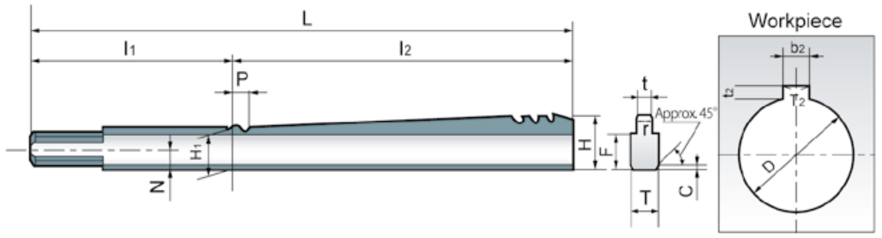


Q=a×t×m

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	Tolerance For sliding type D10	Tolerance For standard type JS9	Tolerance For clamping type P9	Broach width T Standard size	Tolerance h7	Finishing teeth height H	1st tooth height H1	Overall length L	Shank height l1	Cutting teeth length l2	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	26.88	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 10 016 — 3: Tooth width; 10: Minimum diameter; 016: Maximum cutting length

Example 2. 12 40 112 -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

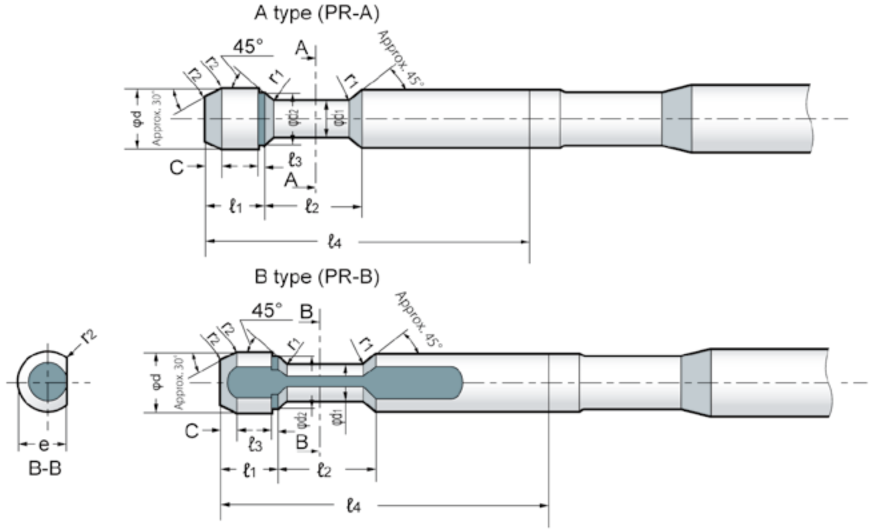
Edge corner radius r	H−H1	Pitch P	Pull end nominal size	Height to center of screw N	Keyway width b2	Keyway depth t2	Corner radius r2	Minimum diameter D	Maximum cutting length	Number of drawing times	Stroke	Estimated load kN
0.08 ~ 0.16	1.73	6	6	3.5	3	1.4	0.08 ~ 0.16	10	16	1	330	1
		8							28	1	440	2
	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)

Round type (PR)
A type (PR-A)

B type (PR-B)



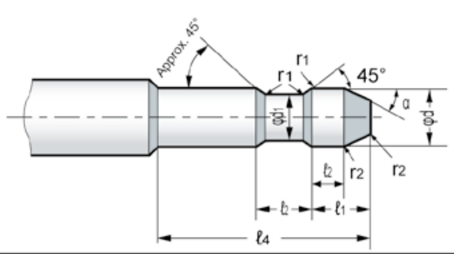
Unit: mm

Nominal size	Shank diameter d Standard size	Shank diameter d Tolerance	Neck diameter d1 Standard size	Neck diameter d1 Tolerance	Flat face height e Standard size	Flat face height e Tolerance	Head length ℓ1	Neck length ℓ2	Effective shank length ℓ4 (minimum)	Flat face length ℓ5 (minimum)	Reference d2	Reference ℓ3	Reference c	Reference r1	Reference r2	Reference s (mm²)
8	8	−0.013 −0.035	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 −0.035	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 −0.035	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

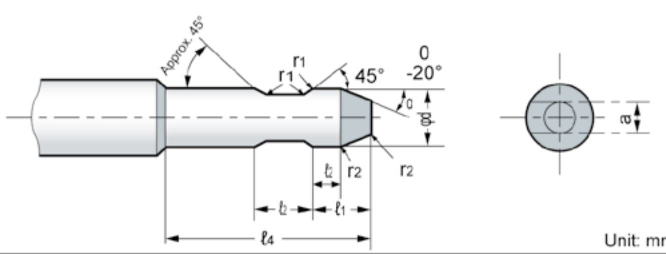
- The value of S is the B-B cross-sectional area of B type and calculated with the standard sizes of d, d1 and e.
- Values in parentheses should be avoided as much as possible.
- Tolerances of ℓ1 and ℓ2 are the rough class specified in JIS B 0405.
- ℓ4 and ℓ5 show the values when d and e satisfy their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

■ Shape and dimensions of retriever end of broach

Round type (FR)



Trapezoid type (FT)



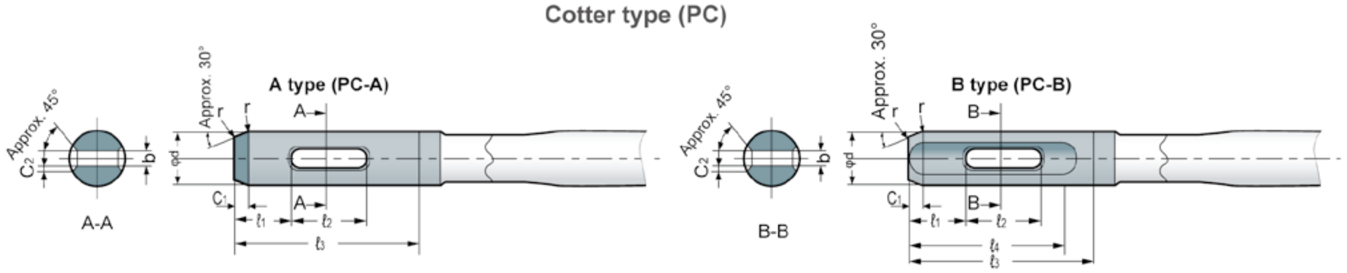
Unit: mm

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)



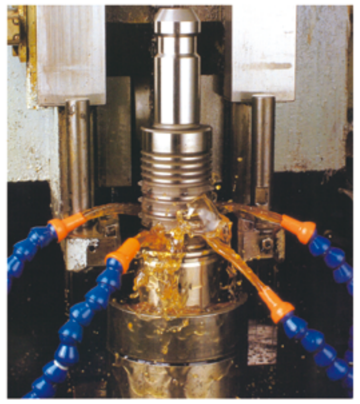
Unit: mm

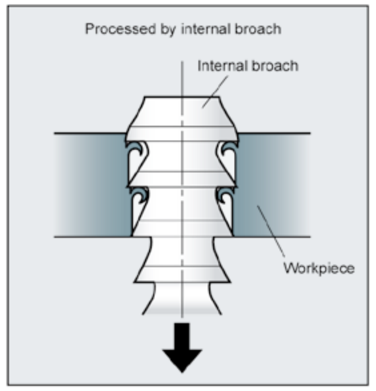
Nominal size	Shank diameter d		Cotter hole width b		Length to cotter hole ℓ_1	Cotter hole length ℓ_2	Effective shank length ℓ_3 (minimum)	Reference					
	Standard size	Tolerance	Standard size	Tolerance				ℓ_4	t	C_1	C_2	r	s (mm^2)
10	10	$^{-0.013}_{-0.035}$	3	$^{+0.4}_{0}$	16	20	70	50	9	3	0.4	1	48.6
(11)	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



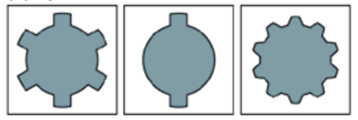


An internal broach can create the specific shape required for the internal surface of a workpiece efficiently and with high precision. Normally, the internal broach is inserted into a pilot hole which is made on the workpiece before machining. Various hole shapes can be created by selecting the optimum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

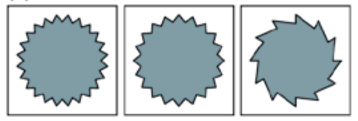
Examples of machining results

(1) Round broach

(2) Spline broach

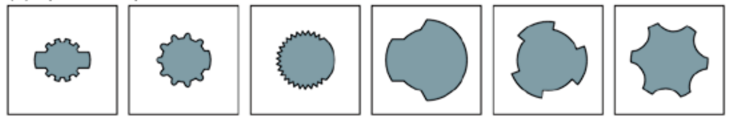


(3) Serration broach



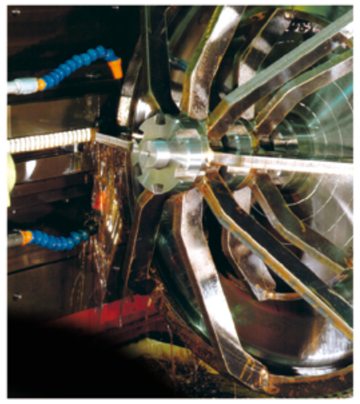
(4) Polygonal broach

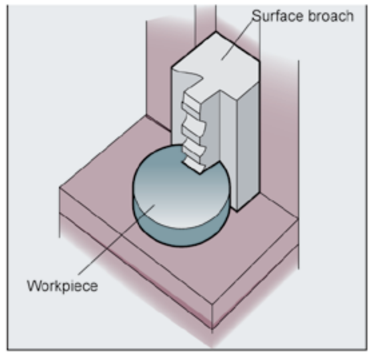
(5) Special shape broach



Examples

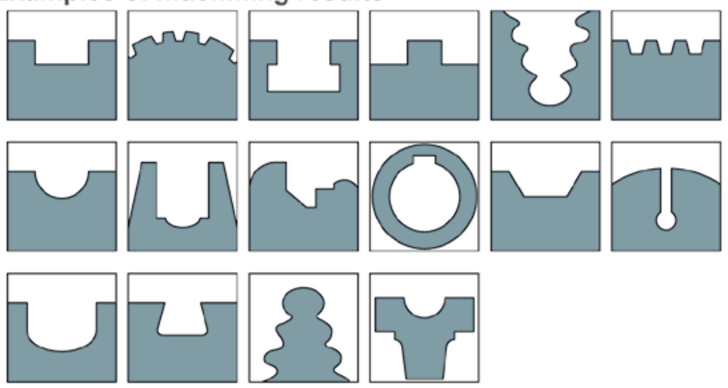
■ Processing using surface broaches



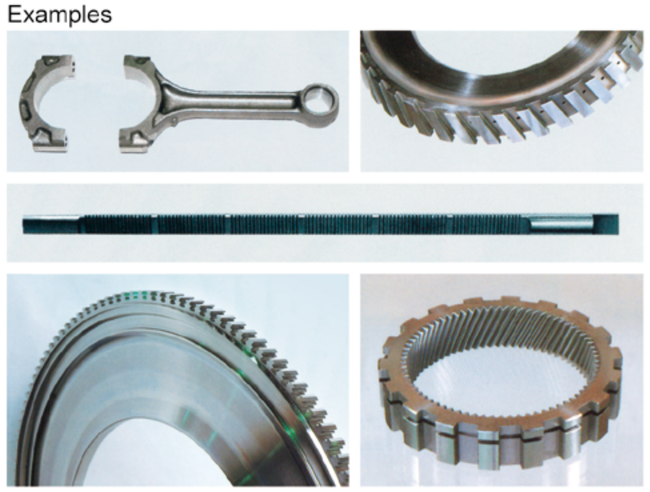


An surface broach can create the specific shape of the outer surface of a workpiece efficiently and with high precision. Roughing and finishing can be conducted at the same time, which means significantly higher productivity than milling, plaining and grinding. It can machine many different shapes (for 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



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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.

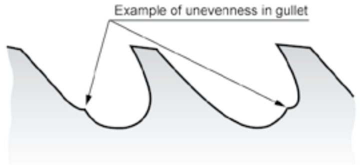
Broaches	• Whitish land due to wearing appears on the cutting edge. • Abnormal wear, chipping or cracking occurs on the cutting edge. • Chips start to get stuck in the gullet.
Workpiece	• Machined size is smaller than normal (thickness gauge cannot fit in). • Machined surface is rougher than normal. • 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.

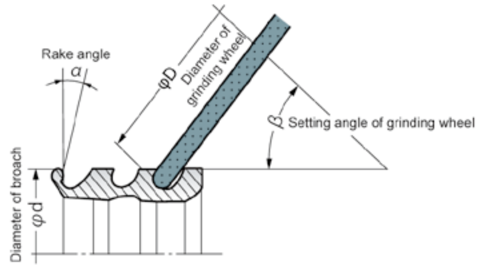
■ What to check after resharpening

- ☑ 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?

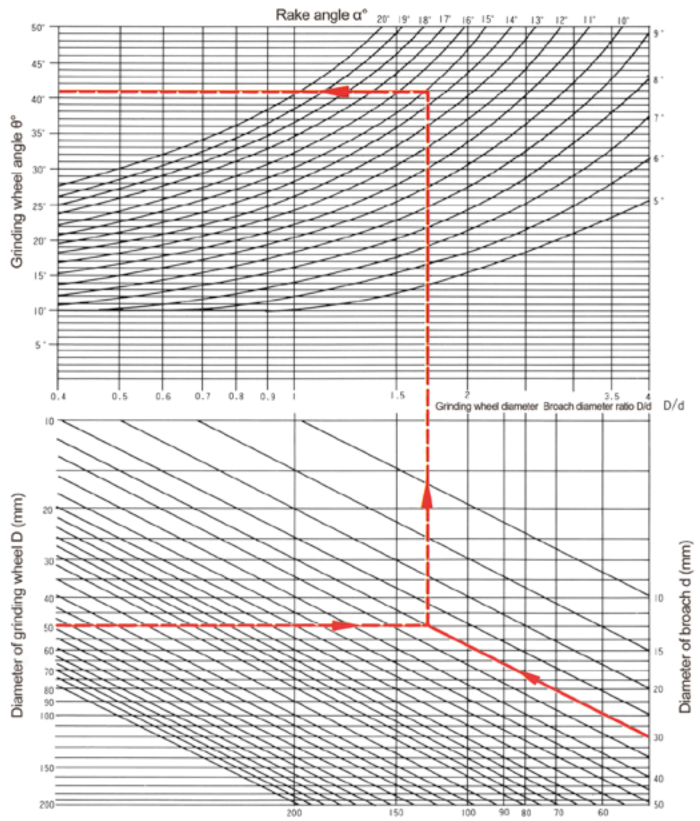


■ Grinding wheel angle for resharpening internal broach teeth

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

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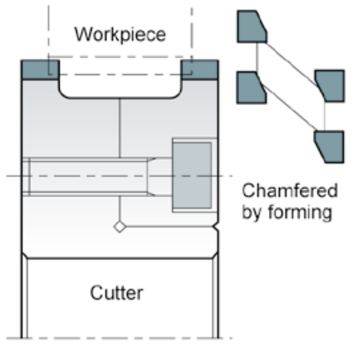
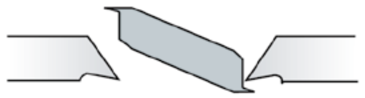
OTHER PRODUCTS

Chamfering Cutter (Deburring Cutter)

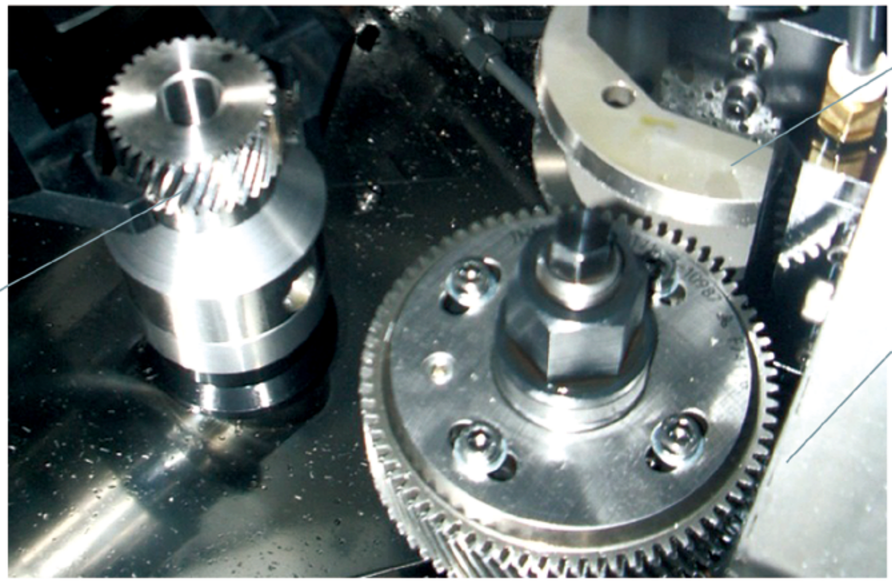
The chamfering cutter is used for chamfering gear edge of automobile and motorcycle reducers. After processing with hobs and shaper cutters, both edges of the gear are rolled (formed) and chamfered. Burrs that occurred in the previous processes are removed during chamfering.

Chamfering mechanism





Burrs at the end faces are removed with tool bit.



GE15A Deurring Unit

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.

Burnishing Cutter

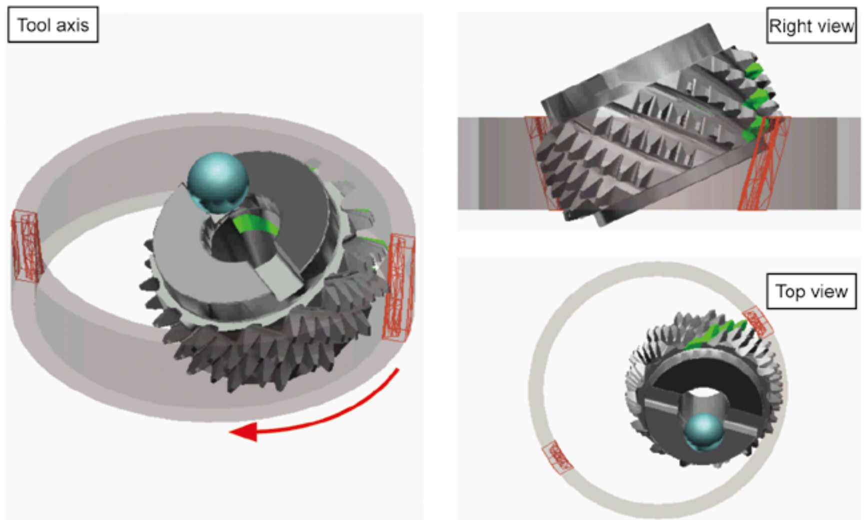
The burnishing cutter is used for tapering along the teeth lead of the spline after broaching.
(This is to prevent the gear from coming off.)

Super Skiving Cutter

The technology developed with the ZI20A internal gear grinding machine has been applied to the super skiving cutter, allowing the fastest, high-precision cutting of internal gears. It solves the issue of tool life that was a problem with previous shaper cutters, allowing stable tool life.

Skiving processing

Processing using super skiving



Tool shape

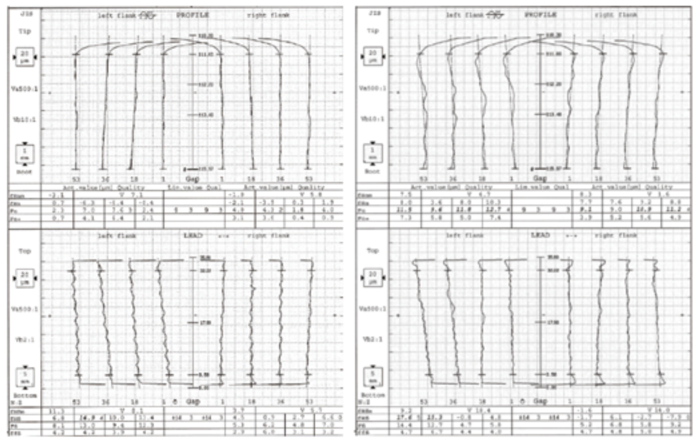
Removing the pin to disassemble it allows re-grinding in the same way as for a shaper cutter.

Example

Workpiece: Internal gear m1.5 HA20° NT70 ODφ110 Tooth length 3.65 Tooth width 40 Material SCM415 (HB180)
Cutter: NT46 (total tooth number: 138 = 3 x 46 each of finishing teeth / rough teeth (2) / rough teeth (1)) SPUR material MX-1
Coating: MightyShield Σ
Cutting conditions: No. of rotations: 1,250/1,600 min-1 Ax feed 0.45/0.15mm/t.rev. C/T 60 secs. Double-cut
Processing machine: MSS300 Super Skiving Machine

Wear status (after processing 1,200 pieces): 0.24mm

Processing precision



Initial processing: ISO6 class After processing 1,200 pieces: ISO7 class

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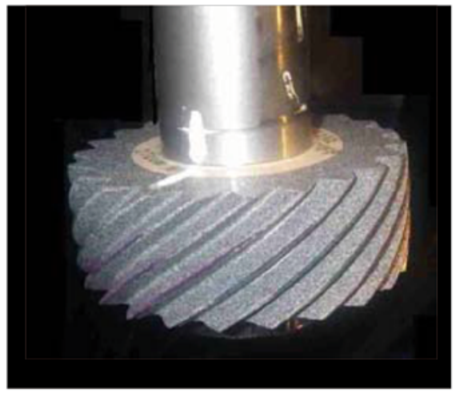
Grinding Wheel, Dressing Gear and Disc Dresser for ZI Series

■ Shaped grinding wheel



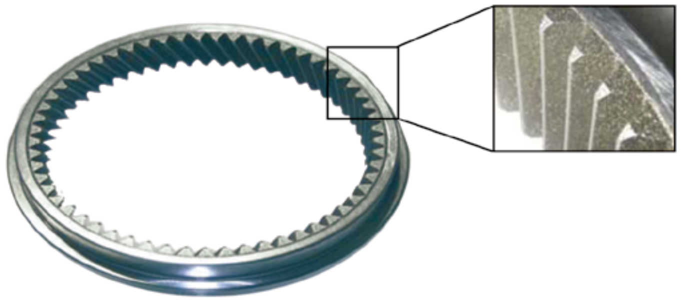
These are used for our ZI series gear grinding machines.

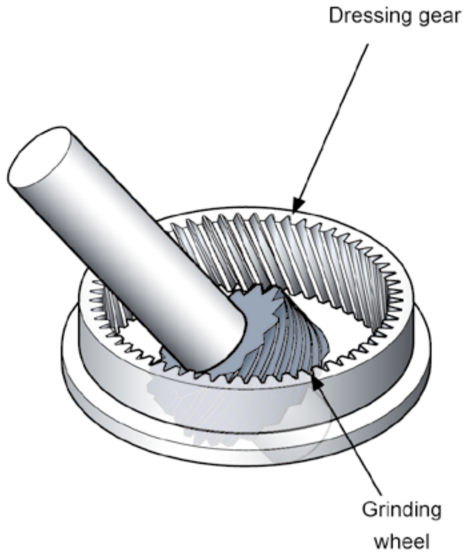
The grinding wheel is roughly shaped, and will be reshaped to its final shape and accuracy on the grinding machine.

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 shaping and toothing it.

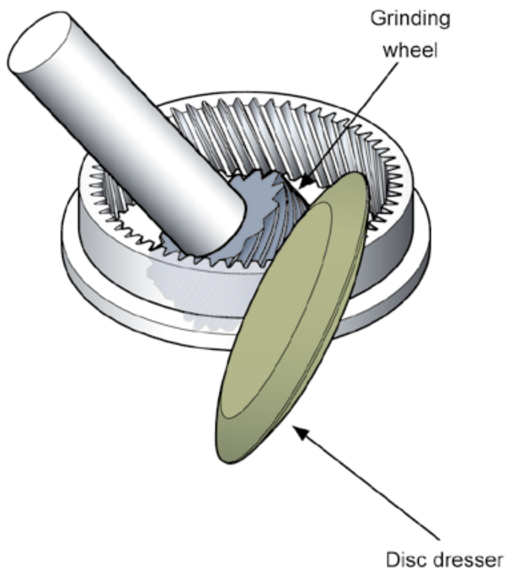
The disc dresser has the same cross-sectional shape as the workpiece and moves along the teeth lead of the grinding wheel when shaping and toothing it.

■ Dressing gear





■ Disc dresser



Hirth Couplings

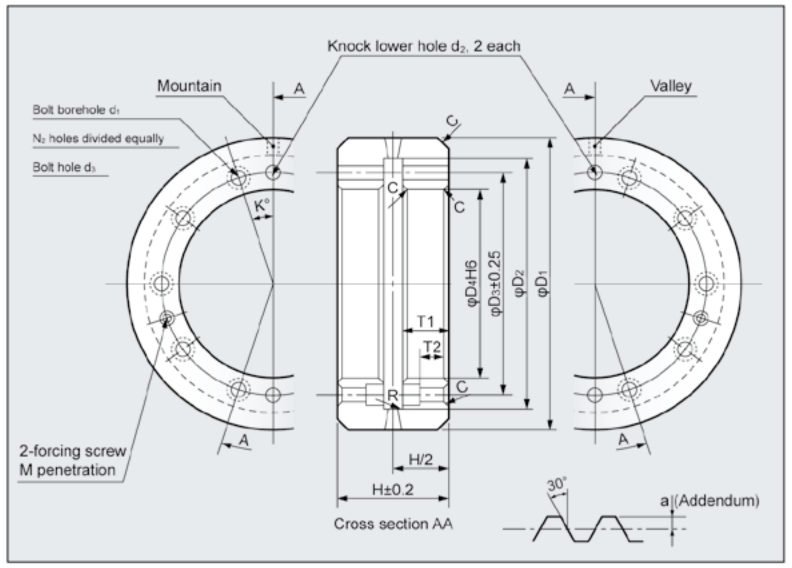
These are used for the high-precision angular division of cutter holders and index tables, and can go down to just 1°.

■ Double Hirth

Formula breakdown

320 – 225 – 72T

- No. of teeth (N_1)
- Internal diameter (D_4)
- External diamete (D_1)

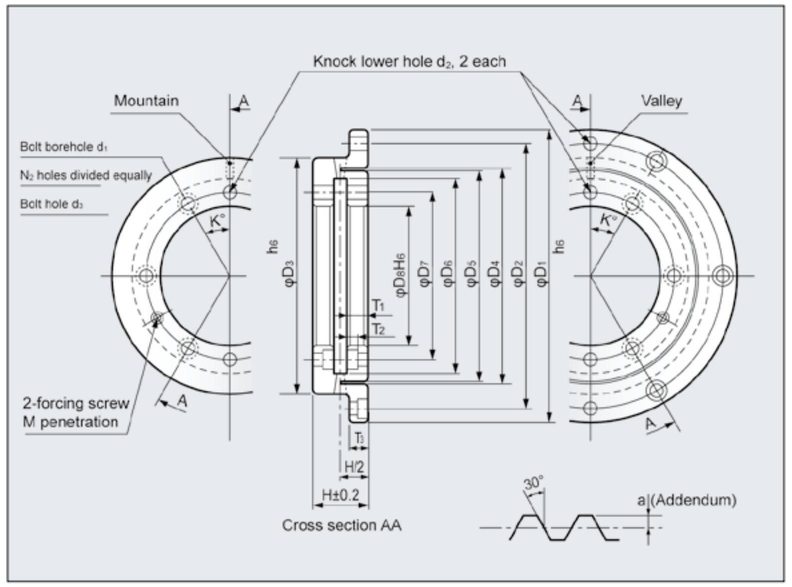


■ Triple Hirth

Formula breakdown

355 – 300 – 215 – 72T

- No. of teeth (N_1)
- Internal diameter (D_8)
- External diameter (D_3)
- External diameter (D_1)



Dimensions Tables

Double Hirth coupling dimensions table

Formula No. \ Item	D_1	D_2	D_3	D_4	d_3	H	K	T_1	Lift amount	α Addendum	Allowable clamp force N
60- 30- 24T	60	48	45	30	5.5	24	45°	9	3.5	1.5	19,600
60- 30- 30T									3.0	1.2	19,600
80- 40- 24T	80	68	55	40	5.5	24	30°	9	3.5	1.5	19,600
80- 40- 30T									3.0	1.2	19,600
100- 55- 24T	100	85	70	55	6.6	26	30°	10	3.5	1.5	24,500
100- 55- 30T									3.0	1.2	24,500
120- 70- 24T	120	100	85	70	6.6	26	30°	10	3.5	1.5	33,300
120- 70- 30T									3.0	1.2	33,300
120- 70- 36T									2.5	1.0	33,300
150- 85- 24T	150	130	110	85	9	34	30°	13	3.5	1.5	33,300
150- 85- 30T									3.0	1.2	33,300
150- 85- 36T									2.5	1.0	33,300
160-100- 24T	160	140	118	100	9	40	22.5°	16	3.5	1.5	33,300
160-100- 30T									3.0	1.2	33,300
160-100- 36T									2.5	1.0	33,300
160-100- 48T									3.5	1.5	68,600
160-100- 72T									2.5	1.0	68,600
170- 90- 30T	170	138	115	90	9	40	30°	16	3.5	1.5	65,700
170- 90- 36T									3.0	1.25	65,700
170- 90- 48T									3.5	1.5	105,800
170- 90- 72T									2.5	1.0	105,800
180-120- 30T	180	160	140	120	9	40	22.5°	16	3.5	1.5	43,100
180-120- 36T									3.0	1.25	43,100
180-120- 48T									3.5	1.5	68,600
180-120- 72T									2.5	1.0	68,600
200-115- 30T	200	168	145	115	9	40	22.5°	16	3.5	1.5	66,600
200-115- 36T									3.0	1.25	66,600
200-115- 48T									3.5	1.5	107,800
200-113- 72T									2.5	1.0	107,800
220-143- 36T	220	190	170	143	9	40	30°	16	3.5	1.5	76,400
220-143- 48T									3.0	1.2	81,300
220-143- 60T									3.5	1.5	127,400
220-143- 72T									3.0	1.25	127,400
240-155- 48T	240	208	185	155	11	40	22.5°	16	4.0	1.75	127,400
240-155- 60T									3.5	1.4	127,400
240-155- 72T									3.0	1.17	127,400
240-155- 96T									3.5	1.5	215,600
250-160- 48T	250	226	195	160	11	40	22.5°	16	4.0	1.75	98,000
250-160- 60T									3.5	1.4	98,000
250-160- 72T									3.0	1.17	98,000
250-160- 96T									3.5	1.5	166,600
270-185- 48T	270	238	215	185	11	40	18°	16	4.0	1.75	127,400
270-185- 60T									3.5	1.4	127,400
270-185- 72T									3.0	1.17	127,400
270-185- 96T									3.5	1.5	215,600

Formula No. \ Item	D_1	D_2	D_3	D_4	d_3	H	K	T_1	Lift amount	α Addendum	Allowable clamp force N
280-195- 48T	280	248	224	195	11	50	18°	21	4.0	1.75	127,400
280-195- 60T									3.5	1.4	127,400
280-195- 72T									3.0	1.17	127,400
280-195- 96T									3.5	1.5	215,600
320-225- 48T	320	288	260	225	14	58	18°	25	3.5	1.5	107,800
320-225- 72T									2.5	1.0	107,800
320-225- 96T									3.5	1.5	215,600
320-225-120T									3.0	1.2	215,600
320-225-360T									1.0	0.35	196,00
350-245- 48T	350	310	280	245	14	58	18°	25	3.5	1.5	137,200
350-245- 72T									2.5	1.0	137,200
350-245- 96T									3.5	1.5	274,400
350-245-120T									3.0	1.2	274,400
350-245-360T									1.0	0.35	235,200
400-295- 48T	400	360	330	295	14	60	15°	26	3.5	1.5	137,200
400-295- 72T									2.5	1.0	137,200
400-295- 96T									3.5	1.5	274,400
400-295-120T									3.0	1.2	274,400
400-295-360T									1.0	0.35	235,200
420-300- 48T	420	398	360	300	14	60	15°	26	3.5	1.5	78,400
420-300- 72T									2.5	1.0	78,400
420-300- 96T									3.5	1.5	156,800
420-300-120T									3.0	1.2	156,800
420-300-360T									1.0	0.35	137,200
450-340- 48T	450	418	387	340	14	60	15°	26	3.5	1.5	107,800
450-340- 72T									2.5	1.0	107,800
450-340- 96T									3.5	1.5	225,400
450-340-120T									3.0	1.2	225,400
450-340-360T									1.0	0.35	196,000
520-405- 48T	520	480	440	405	14	60	15°	26	3.5	1.5	137,200
520-405- 72T									2.5	1.0	137,200
520-405- 96T									3.5	1.5	274,400
520-405-120T									3.0	1.2	274,400
520-405-360T									1.0	0.35	245,000
600-490- 48T	600	560	530	490	14	70	15°	26	4.5	2.0	186,200
600-490- 72T									4.0	1.75	245,000
600-490- 96T									3.5	1.5	274,400
600-490-120T									3.5	1.5	352,800
600-490-360T									2.0	0.75	529,200

Triple Hirth coupling dimensions table

Formula No. \ Item	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	d_1	d_2	d_3	H	K	T_1	T_2	T_3	Bolt No. N_2	M and bolt	Addendum	Allowable clamp force N
210-170-100- 48T	210	190	170	156	155	140	120	100	14	8	9	40	*30° / 22.5°	16.5	8	14	*6 / 8	M8	1.75	117,600
210-170-100- 72T																			1.5	147,000
210-170-100-120T																			1.2	196,000
210-170-100-360T																			0.25	117,600
240-200-130- 48T	240	220	200	186	185	170	150	130	14	8	9	40	*22.5° / 18°	16.5	8	14	*8 / 10	M8	1.75	117,600
240-200-130- 72T																			1.5	147,000
240-200-130-120T																			1.0	166,600
240-200-130-360T																			0.25	127,400
320-270-190- 48T	320	295	270	256	255	240	215	190	17.5	12	11	40	*18° / 15°	16.5	10	14	*10 / 12	M10	1.75	117,600
320-270-190- 72T																			1.5	147,000
320-270-190-120T																			1.0	166,600
320-270-190-360T																			0.35	176,400
355-300-215- 48T	355	325	300	286	285	270	245	215	20	12	14	50	15°	21	12	19	12	M12	1.75	117,600
355-300-215- 72T																			1.5	156,800
355-300-215-120T																			1.0	166,600
355-300-215-360T																			0.35	176,400
390-335-250- 48T	390	360	335	321	320	305	280	250	20	12	14	50	15°	21	12	19	12	M12	1.75	117,600
390-335-250- 72T																			1.5	156,800
390-335-250-120T																			1.0	166,600
390-335-250-360T																			0.35	176,400
480-425-340- 48T	480	450	425	411	410	395	370	340	20	12	14	50	15°	21	12	19	12	M12	1.75	117,600
480-425-340- 72T																			1.5	156,800
480-425-340-120T																			1.0	176,400
480-425-340-360T																			0.5	264,600
595-540-455- 48T	595	565	540	526	525	510	485	455	20	12	14	55	15°	21	12	20.5	12	M12	1.75	117,600
595-540-455- 72T																			1.5	156,800
595-540-455-120T																			1.0	176,400
595-540-455-360T																			0.5	264,600

• Items with asterisks show the outer one at the top and the inner one at the bottom.

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

■ Coating

Coating Name	Wear resistance	Heat resistance	For processing	Features	Hob	Shaping	Shaving	Broach
TiN			Wet	General-purpose wet coating	○*	○*		○
Nano Dynamic II			Wet	Coating for broach For hard-to-cut/wear measures				○
Nano Dynamic			Wet	Coating for broach For roughness/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 dry coating	○	○		
SuperDry II*			Dry	Dry coating for wear measures	○	○		
SuperDry III			Dry	For wear (crater wear) measures Dry coating	○	○		
MightyShield Sigma MightyShield ∑			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)	○	○		

• 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

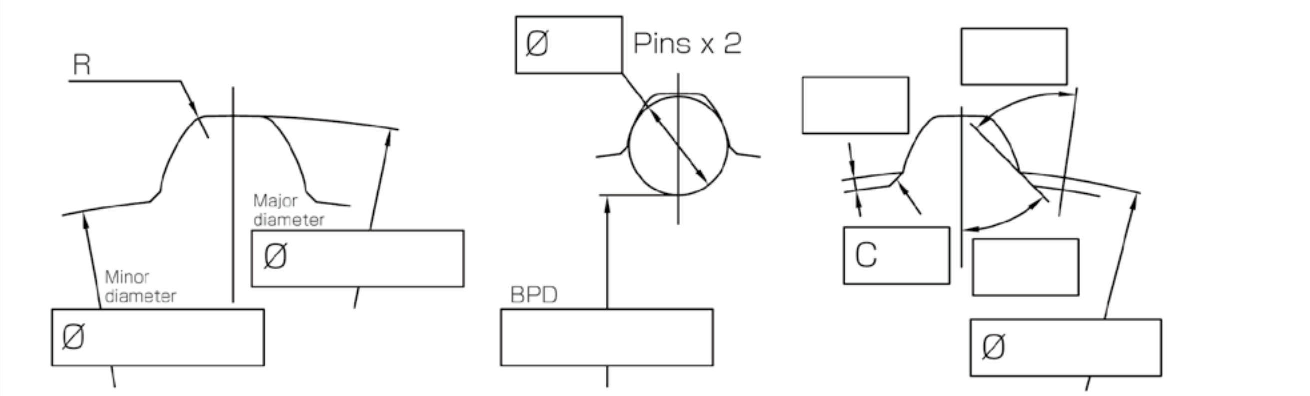
Special notes

Estimates / Design Specifications

Involute Spline Broach Design Specifications

Customer name:	Order no.:

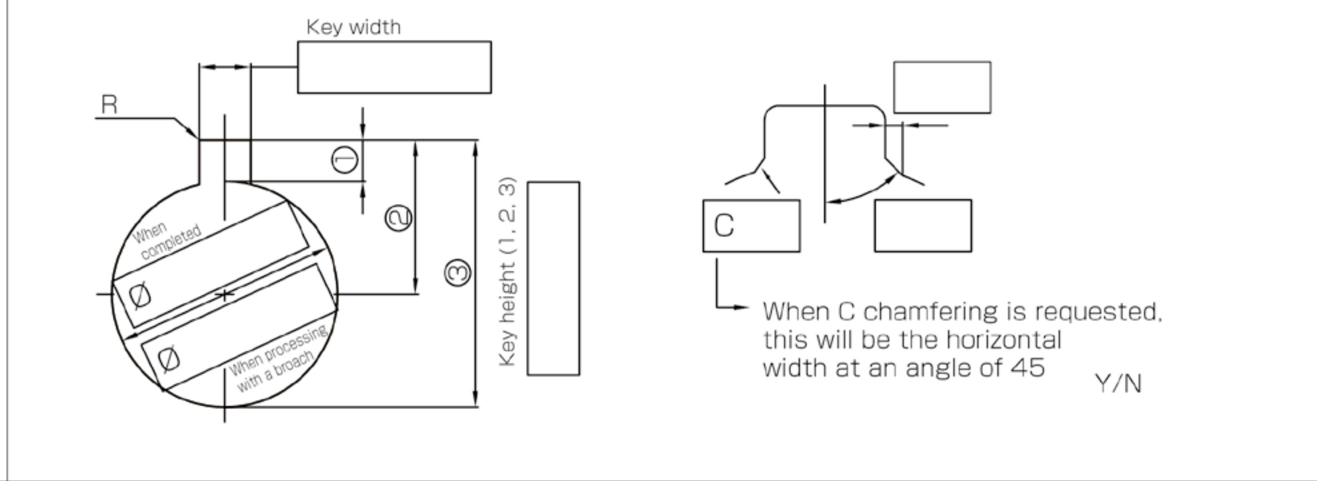
Note: Even if you provide a workpiece drawing or broach supply drawing, make sure it is transcribed if it is difficult to read.
Make sure the ☐ sections are filled in. (Anything left blank will be treated as being left to our discretion.)

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.)

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NIDEC MACHINE TOOL CORPORATION

Headquarters

130, Rokujizo, Ritto, Shiga, Japan 520-3080
Tel.: (077) 553-3300 Fax: (077) 552-3745

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

For your inquires about cutting tools
Sales Department 1

Phone: +81-77- 552-9766
Facsimile: +81-77-553-1404

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