Anchor
Precision Tools

NACHI

Precision Tools

Gear Cutting Tools & Broaches

Pursuing advanced high-speed technology that is both user and environmentally friendly

Since developing Japan's first broaching machine in the late 1920s, Fujikoshi has developed a variety of tools and machine tools to handle advancements in production systems. Fujikoshi continues to lead the way by developing machining systems that integrate tools and machines.

Index

Gear Cutting Tools

Guidance

Technical Introduction

Hobs

Gear Shaper Cutters

Shaving Cutters

Forming Racks

Other Types of Gear Cutting Tools

Broaches

Technical Introduction

Guidance

Internal Broaches

Surface Broaches

Design of Broach

Essential Points and Notice for Broaching Process

Pull End

Retrievr End

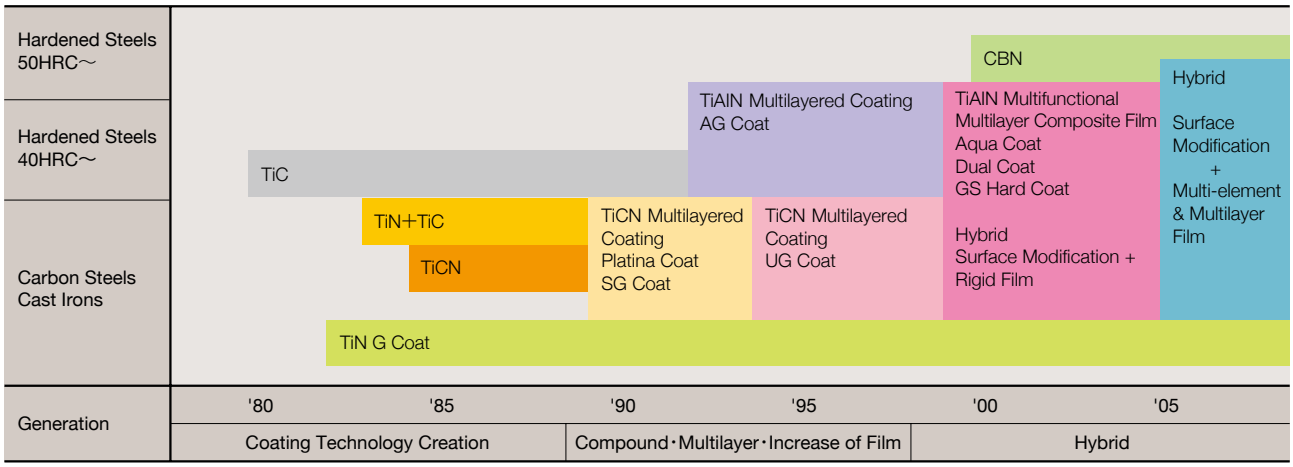
GPA

Materials and Coating of Gear Cutting Tools

Gear Cutting Tool Material

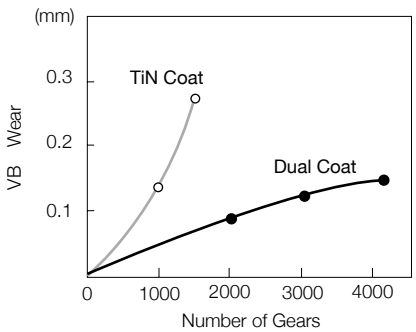
Tool Material		Hobs	Gear Shaper Cutters	Shaving Cutters	Forming Racks	Features
HSS	HSD				○	Toughness Up
	SKH51	△	△	○		Toughness Up
	SKH55	○	○			Standard
	FM34D	○				Crater Wear Resistance
	FM29A			○		Wear Resistance
	FM23A			○		Wear Resistance
Power HSS	FAX31		○			
	FAX38	○	○	△		Heat Resistance
	FAX55	△	△			Wear Resistance
Carbide		○				
Surface Treatment	Nitride	○		○		
	TiN	○	○		○	
	Dual	○	○		○	

Coating Technology



NACHI's coating technology developed from research on physical vapor deposition (PVD) ion plating. By using the peculiarities of ionization acceleration technology, surfaces can be coated with multiple layers of TiN, TiC and TiCN.
The tool life of coated products are extended to five times those of uncoated products because the coatings have very good wear resistance and solvent resistance.
It makes high speed and high performance possible and greatly reduces total costs.

Performance of Dual Coat Hob



Hob : φ95×L150×φ31.75, 3Thread, RH, 12Number of Teeth, FM34D
Workpieces : m1.75×PA17.5°×30T×30RH, Tooth Width18mm, SCr420, 150HB
Cutting Condition : Cutting Speed V=150m/min, Feed F=2.0mm/rev, Cutting Face Non Coat, Dry Hobbing

Hobbing of hardened gear is possible

Hard Hobbing

Suitable for high accuracy gear hobbing of the shaft and small module which was difficult in grinding
Realized high accuracy by hob and spindle one body tooth profiles grinding
Achieved longer tool life by Hyper Dual coat and herd metal of new development

Carbide Hob

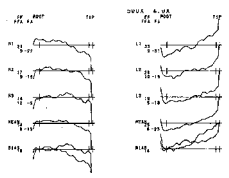
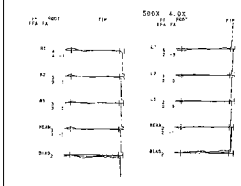
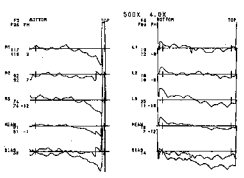
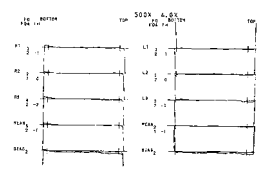
Carbide Hob with shank

Work Piece

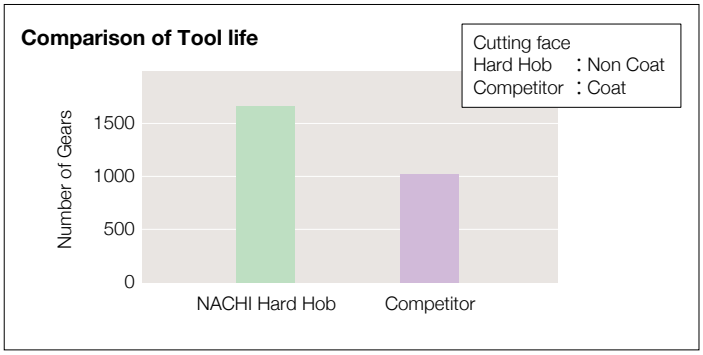
Before

After

Accuracy

	Before Hard Hobbing	After Hard Hobbing		Before Hard Hobbing	After Hard Hobbing
Profils Error			Lead Error		

Performance



KE250 (Kashifuji)

Workpiece		Hob Specifications		Cutting Conditions	
Module	2	Outside Dia.	50mm	Cutting Speed	2.5mm/rev
Number of Teeth	6	Overall Length	100	Feed	2.5mm/rev
Pressure Angle	20°	Threads	1	Cutting Method	Climb Cutting
Tooth Width	28mm	Flutes	12	Coolant	—
Material	SCM420(60HRC)				

Realize High Speed Dry Hobbing of 250m/min

High Speed Dry Hobbing

Both and hobbing are perfomed by one hob.
A long tool life is ensured even in high speed dry hobbing.
Dual coat improves in wear resistance and the heat-resistant oxidation.
Coherence and tenacity, anti-welding improve, too.
New steel class is good in heat-resistant shock and chipping resistance, wear resistance.

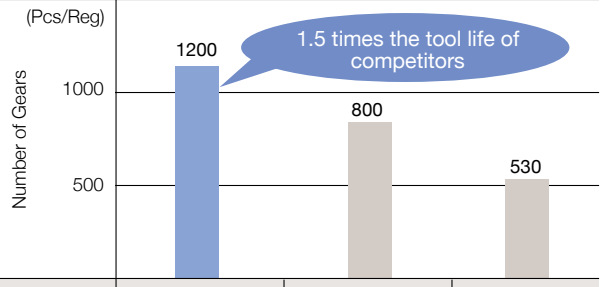
Dual Cut Hob

Dry Hobbing

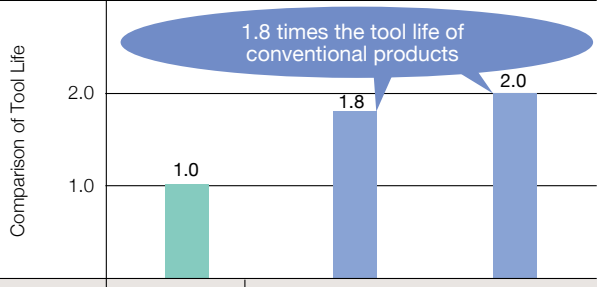
Performance

Comparison of tool life

Method	High Speed Dry Hobbing		
Cutting Speed	150m/min		
Hob	Dual Cut Hob	Competitor A	Competitor B



Method	Wet	High Speed Dry Hobbing
Cutting speed	120m/min	160m/min
Hob	Conventional	Dual Cut Hob

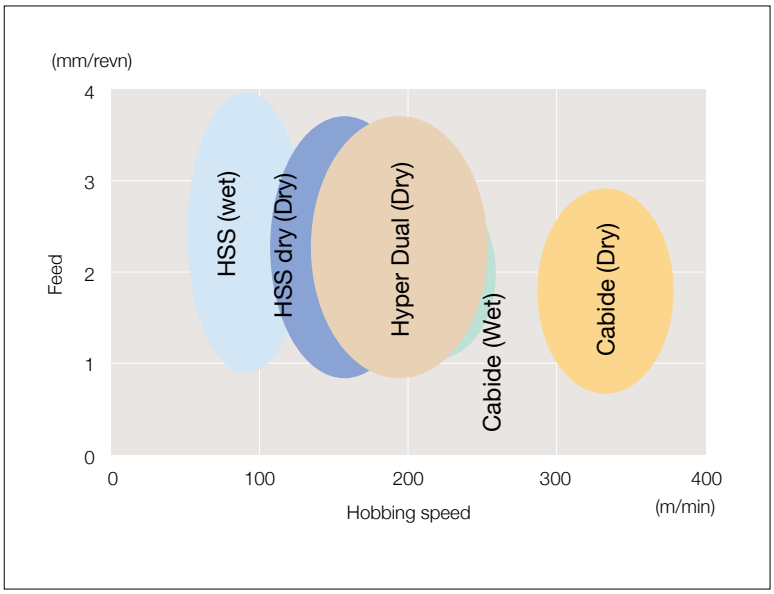


Workpiece		Hob Specifications		Cutting Conditions	
Module	2.5	Outside Dia.	85	Feed Rate	2.5mm/rev
Number of Teeth	65	Overall Length	200	Cutting Method	Climb Cutting
Tooth Width	30mm	Threads	4THD		
Material	SCR420	Flutes	16		

Workpiece		Hob Specifications		Cutting Conditions	
Module	2.8	Outside Dia.	105	Feed Rate	2.2mm/rev
Number of Teeth	48	Overall Length	150	Cutting Method	Climb Cutting
Tooth Width	——	Threads	3THD	Cutting Length	210m
Material	SCR420H	Flutes	14		

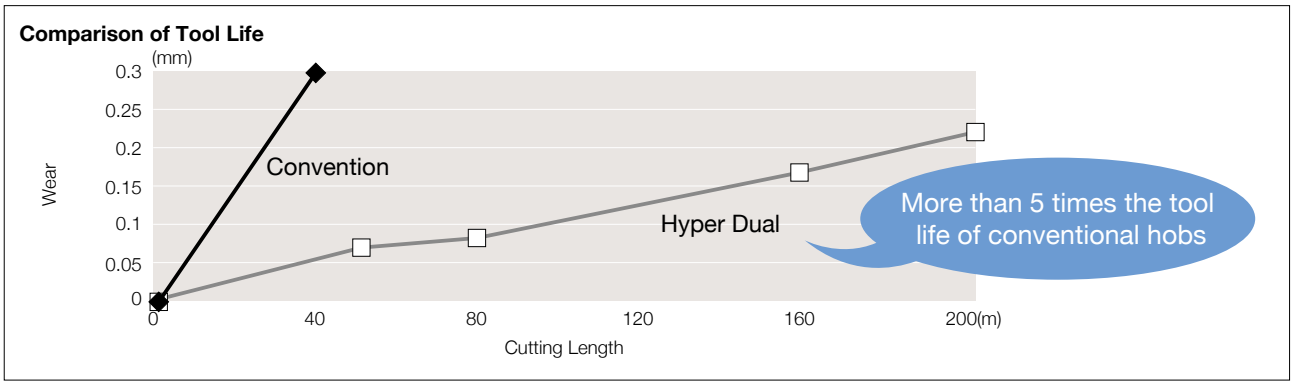
Hyper Dual Cut Hob Features

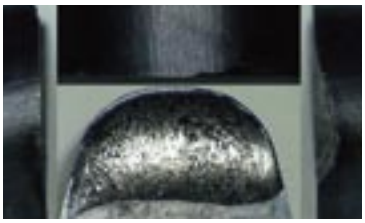
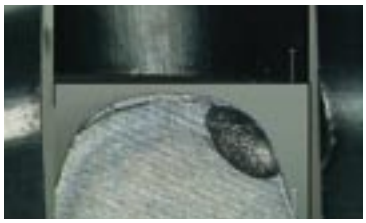
As for the Hyper Dual coating, high speed dry processing more than 200m/min is possible, too.



Hyper Dual Cut Hob

Performance



Convention	Hyper Dual Hobs	
		
40m Cutting Length	40m Cutting Length	200m Cutting Length

Workpiece		Hob Specifications		Cutting Conditions	
Module	2.87	Outside Dia.	90mm	Cutting Speed	250m/min
Pressure Angle	15°	Threads	3	Feed	2.2mm/rev
Tooth Width	50mm	Flutes	12	Cutting Method	Climb Cutting
Material	SCM420(180HB)			Coolant	—

Realize High-speed Shaving

High Performance Shaving Cutter

Realize high speed, high feed shaving by improvement of serration and high rigidity design of a shaving cutter.
Longer tool life by adoption of shaving cutter materials of new development.
Adopt serration form to leave both end land in plunge cut shaving.

High Performance Shaving Cutter

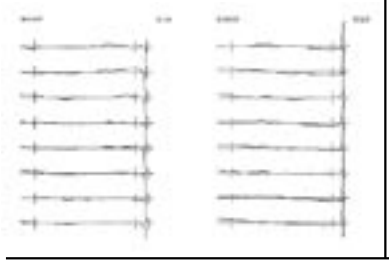
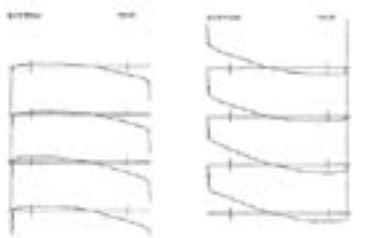
Performance

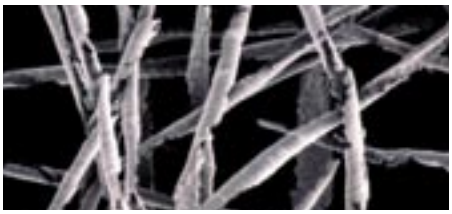
Comparison of Tool Life

Gear	Tool Life (pcs)
Workpiece m2.89, PA23˚, 12T, SPUR Cutter 225 Type, 12˚RH, Conventional	Competitor HSS 2500 NACHI 3700
Workpiece m2.25, PA20˚, 27T, SPUR Cutter 225 Type, 15˚RH, Conventional	SKH51 1650 NACHI 3500
Workpiece m2.25, PA17.5˚, 79T、28˚LH Cutter 200 Type, 15.5˚RH, Plunge Cut	Competitor HSS 2800 NACHI 5000
Workpiece m1.75, PA17.5˚, 46T, 36˚LH Cutter 200 Type, 21˚RH, Plunge Cut	SKH51 2500 NACHI 4200

Serration Form to Leave Both End Land

Finished Accuracy

Profile Error	Lead Error
	



Chip

Workpiece		Cutter Specifications		Shaving Conditions	
Module	2	Outside Dia.	225 Type	Shaving Method	Plunge Cut
Number of Teeth	75	Number of Teeth	113	Cutter Rotation	280min^{-1}
Tooth Width	25mm	Helix Angle	13˚LH	Cutter Feed	0.45mm/min
Helix Angle	28˚RH			Cycle Time	32second

Suitable Cutter Design by FEM

Clean in MQL Roll Forming

Dual Forming Rack

Special surface treatment improves in wear resistance and lubrication, and realize MQL roll forming.
Longer tool life in both conditions of conventional oil coolant and MQL roll forming.

Dual Forming Rack

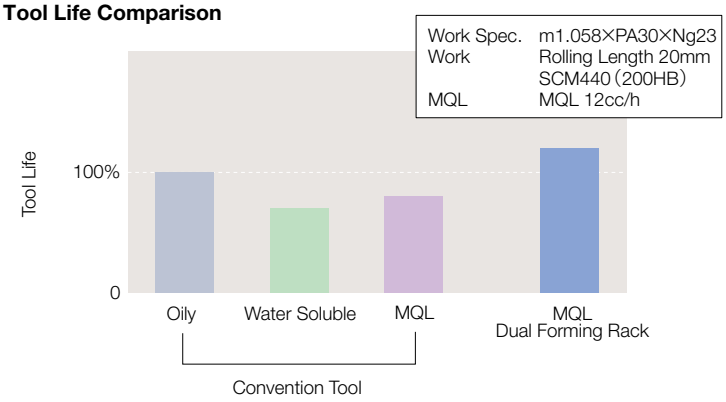
MQL Roll Forming

Conventional

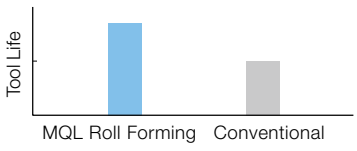
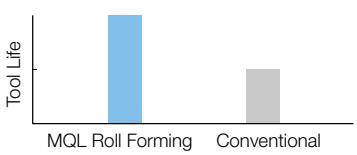
PFM-610E

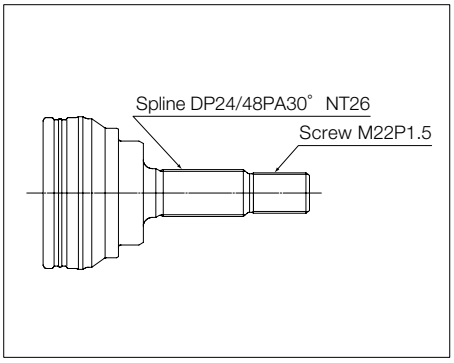
Performance

Tool Life Comparison



MQL Roll Forming Example by Use of NC Roll Forming Machine.

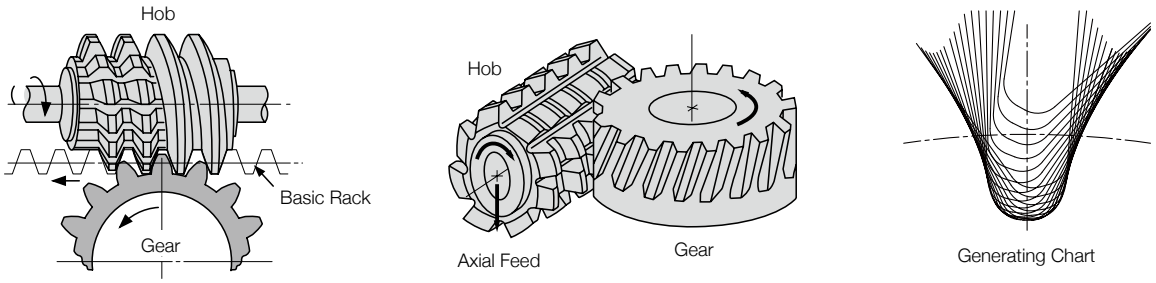
Spline DP 24/48 PA 30° NT26 Rack Type 24in. Machine PFM610E	
Screw M 22 P 1.5 Rack Type 13in. Machine PFM330E	



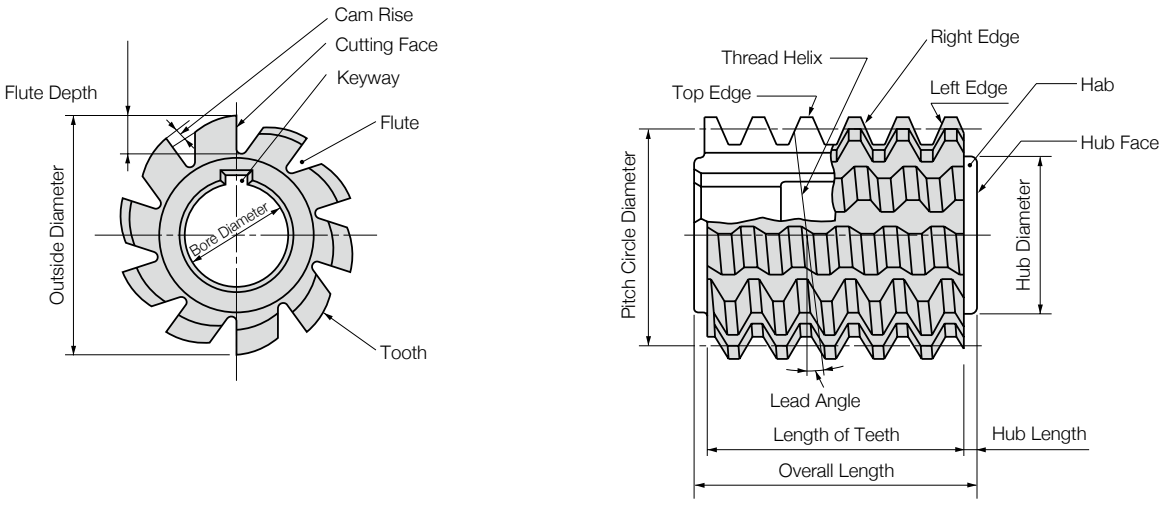
Features of Gear Cutting Hobs

Hob is the cutting tool which has the rack cutting teeth on its body as the shape of a screw.
The basic rack (rack cutting teeth) projects the rotating hob which has teeth in a screw pattern to generate the gear.
Work piece is rotated so that it may gear with this basic rack, and feeding a hob in the lead direction generates the gear.

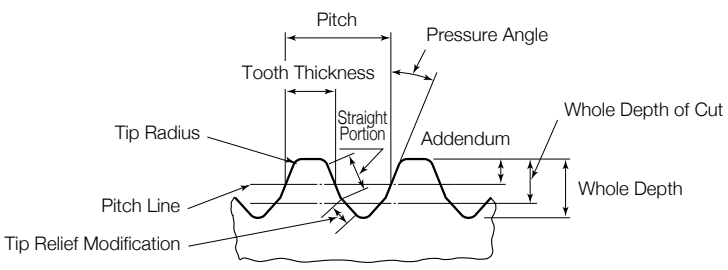
Hob Cutting Action



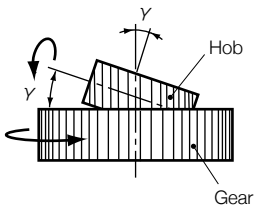
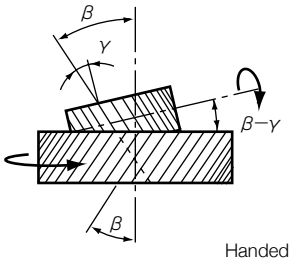
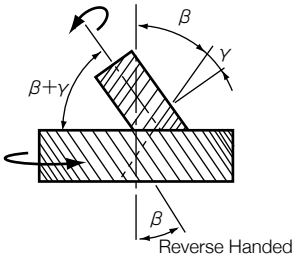
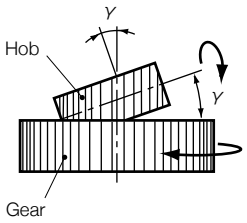
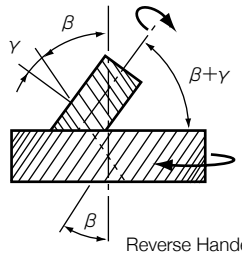
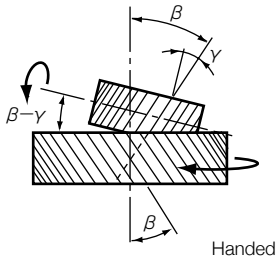
Hob Nomenclature



Normal Section of Hob Tooth Profile



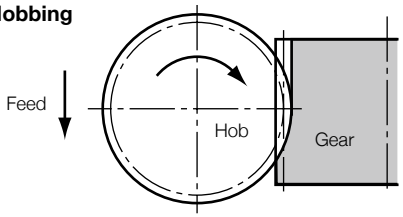
Inclination Angle of Hob

Hob \ Gear		Spur Gear	Helical Gear: Right Helix	Helical Gear: Left Helix
Tooth Lead Angle of Hob	Right			
	Left			

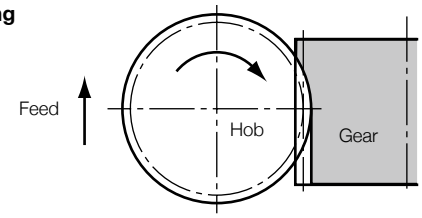
β: Helix Angle of Gear
γ: Tooth Lead Angle of Hob

Hobbing Methods and Comparison

Conventional Hobbing



Climb Hobbing

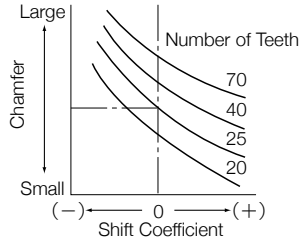


Elements \ Hobbing	Comventional		Climb	
	Spur	Helical	Spur	Helical
Flank Wear of Hob	×		○	
Surface Roughness	○		×	
Chip Removal	○	×	×	○
Bite of Chip	×		○	

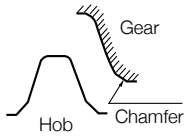
Common Design

In case of the gears with the same module and pressure angle, it can be used with a common designed hob, even if a number of teeth and helix angle are differ.
However, the amount of the chamfer changes depending on the number of teeth a semi-topping hob has.

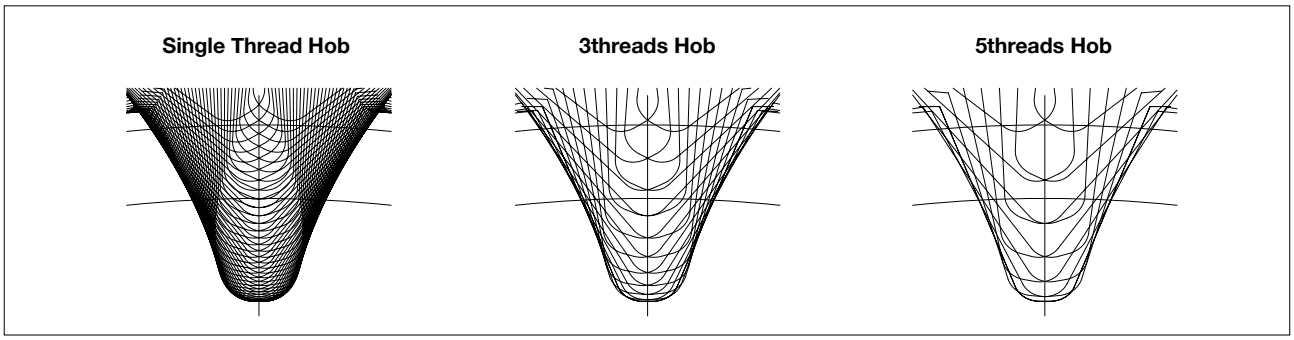
Chamfer of Gear



Semi-topping Tooth Profile



Gear Generation Line Chart of Multi-thread Gear Hob



Features of Multi-thread Gear Hob

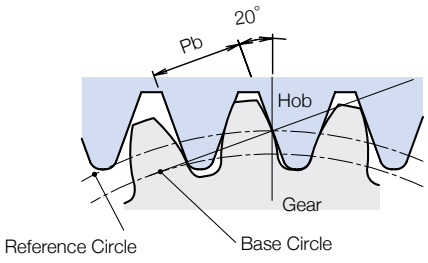
Merits	Demerits
Processing Efficiency Improves	Tooth profile error is large
Because chip thickens, 1.Chipping of tooth edge is effective 2.Flank wear is controlled	Use of high rigidity hobbing machine

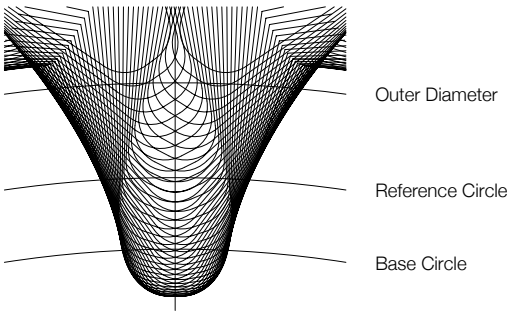
Short Pitched Hob Design

Applications of short pitch hobs

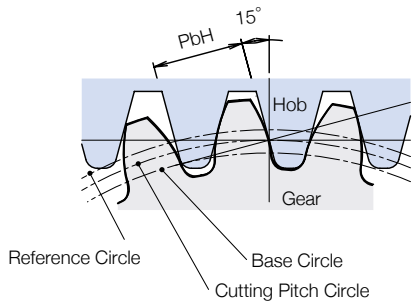
1. When the tip radius of hob is too small by the original pressure angle due to narrow space width on root diameter of gear.
2. When the space width on bottom of hob teeth is too narrow for manufacturing hob by the original pressure angle.
3. If change chip flow, and take cutting edge chipping measures.

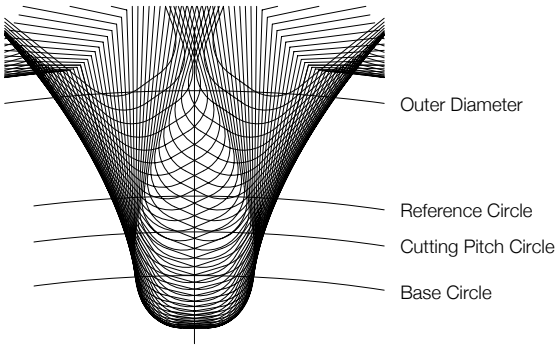
Mesh with Normal Hob



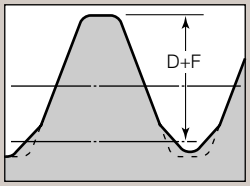
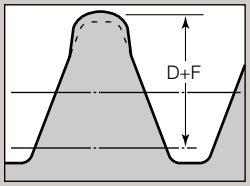
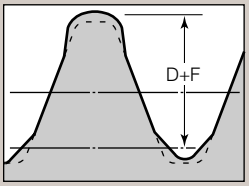


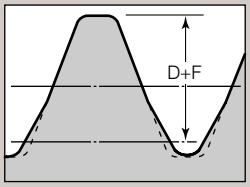
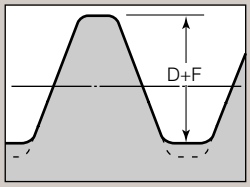
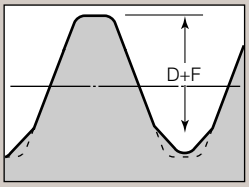
Mesh with Short Pitched Hob





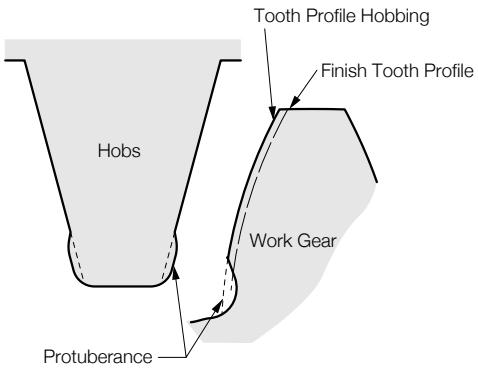
Tooth Profiles of Hobs

	 Semi-topping	 Protuberance	 Semi-topping and Protuberance
Finishing Use	S-TOP	–	–
Pre-shaving Use	PS	PP	PSP
Pre-grinding Use	PGS	PGP	PGSP

	 Modified Tooth Crest	 Topping	 Topping and Semi-topping
Finishing Use		TOP	
Pre-shaving Use			
Pre-grinding Use			

D+F:Whole Depth of Cut

Tooth Profile with Protuberance



NACHI Accuracy of Gear Hobs

Unit : μm

Hob Elements	Grade	Tolerance											
		Bore Diameter(mm)											
		8	10	13	22	–	27	32	40	50	60	–	80
		–	–	–	22.225	25.4	26.988	31.75	38.1	50.8	63.5	76.2	–
Bore Diameter	AA	0～+4		0～+5	0～+9			0～+11			0～+13		
	A	0～+6		0～+8									

Hob Elements			Grade	Tolerance			
				Module			
				0.1≦m≦0.25	0.25＜m≦0.6	0.6＜m＜1	
Runout	Hub Diameter		AA	5	5	5	
			A	5	5	5	
	Hub Face		AA	3	3	3	
			A	5	5	5	
	Outside Diameter		AA	8	10	12	
			A	12	16	20	
Flute	Ajacent Flute Spacing		AA	10	10	12	
			A	12	12	16	
	Accumulative Flute Spacing		AA	19	19	22	
			A	25	25	32	
	Radial Alignment of Flutes		AA	6	6	8	
			A	10	10	12	
	Lead Over Cutting Face Width(±)		Overall Length(mm)				
			Lead Over Cutting Face Width				
Lead	Adjacent Error		AA	–	–	4	
			A			8	
	In Any One Turn of Helix	1 Thread	AA	–	–	7	
			A			11	
		2 Threads	AA	–	–	–	
			A				
		3 Threads	AA	–	–	–	
			A				
		4 Threads	AA	–	–	–	
			A				
		5 Threads	AA	–	–	–	
			A				
	In Any Three Turn of Helix	1 Thread	AA	–	–	–	
			A				
		2 Threads	AA	–	–	–	
			A				
Cutting Face	Single Pitch Error(±)		AA	4	4	5	
			A	6	6	8	
	Adjacent Error	2 Threads	AA	–	–	–	
			A				
		3 Threads	AA	–	–	–	
			A				
		4 Threads	AA	–	–	–	
			A				
		5 Threads	AA	–	–	–	
			A				
	Three Pitch Error(±)	1 Thread	AA	8	8	10	
			A	12	12	16	
		2 Threads	AA	–	–	–	
			A				
		3 Threads	AA	–	–	–	
			A				
		4 Threads	AA	–	–	–	
			A				
		5 Threads	AA	–	–	–	
			A				
Action	Adjacent Error		AA	–	–	–	
			A				
	Length of Action		AA	–	–	–	
			A				
Profile	Tooth Profile Error		AA	2	3	4	
			A	3	5	6	
	Tooth Thickness(−)		AA	16	16	16	
			A	20	20	20	

Remarks : Lead Error is applied in pressure angle of less than 35˚, and tolerance of pressure angle of over 35˚ is 1.5 time of table value.
Profile Error is applied in pressure angle of less than 35˚, and tolerance of pressure angle of over 35˚ is 1.5 time of table value.

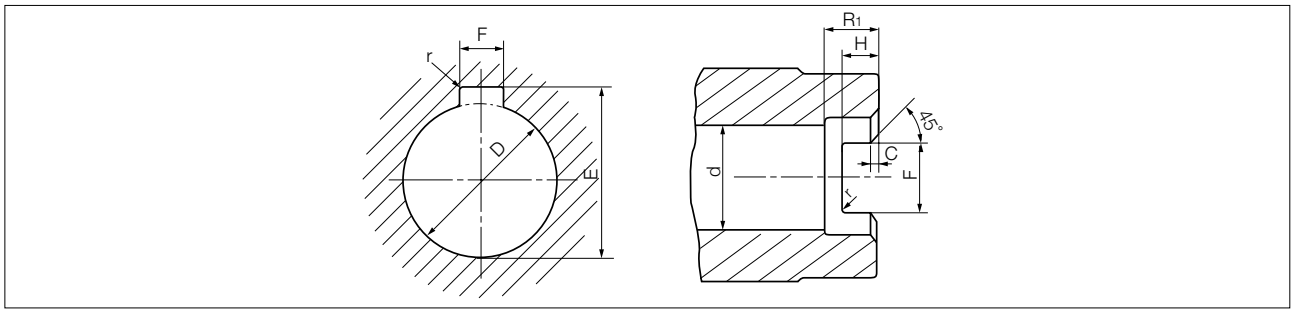
Unit : μm

Hob Elements	Tolerance		
	Dimension(mm)		
	D or L≦30	30＜D or L≦120	120＜D or L≦400
Outside Diameter & Overall Length	±500	±800	±1200

Unit : μm

	Tolerance						
	Module						
	1≦m≦1.6	1.6＜m≦2.5	2.5＜m≦4	4 ＜m≦6.3	6.3＜m≦10	10＜m≦16	16＜m≦25
	5 5	5 5	5 6	6 8	6 10	– 12	– 16
	3 5	3 5	4 5	5 6	5 8	– 10	– 12
	16 25	16 25	20 25	25 32	32 40	– 50	– 63
	14 22	16 25	16 25	19 30	24 38	– 50	– 70
	26 42	30 48	30 48	36 55	45 70	– 96	– 130
	10 16	12 20	16 25	20 32	25 40	– 50	– 63
	L≦35	35＜L≦50	50＜L≦100	100＜L≦150	150＜L≦200	L＞200	
	25	40	60	80	100	120	
	5 8	5 8	6 10	8 12	10 16	– 20	– 25
	7 11	8 12	10 16	12 20	16 25	– 32	– 40
	8 12	8 14	11 18	14 22	18 28	– 36	–
	8 12	10 16	12 20	16 25	– 32	–	–
	9 14	11 18	14 22	– 28	–	–	–
	9 14	11 18	14 22	– 28	–	–	–
	12 20	12 20	16 25	20 32	25 40	– 50	– 63
	12 18	14 22	18 28	22 36	28 45	– 56	–
	5 8	6 10	8 12	10 16	12 20	– 25	– 32
	5 8	6 10	8 12	10 16	12 20	16 25	–
	6 9	7 11	8 14	11 18	14 22	–	–
	6 10	8 12	10 16	– 20	–	–	–
	6 10	8 12	10 15	– 20	–	–	–
	10 16	10 16	12 20	16 25	20 32	– 40	– 50
	11 18	11 18	14 22	18 28	– 36	– 45	–
	11 18	11 18	14 22	18 28	– 36	–	–
	14 22	14 22	18 28	– 36	–	–	–
	14 22	14 22	18 28	– 36	–	–	–
	5 –	5 –	6 –	7 –	9 –	–	–
	11 –	11 –	13 –	16 –	20 –	–	–
	5 8	6 10	8 12	10 16	14 22	22 36	36 56
	20 20	20 20	25 25	25 32	32 40	– 50	– 63

Standard Keyways for Hobs



Type of Axial Keyways (JIS B 4201-1998)

Type A — Unit : mm

Bore Diameter D	Height of Keyway E		Width of Keyway F		Corner Radius (ref)
Size	Size	Tolerance	Size	Tolerance	r
10	11.5	+0.25 0	3	+0.160 +0.060	0.4
13	14.6				
16	17.7		4	+0.19 +0.07	0.6
19	21.1		5		1
22	24.1		6		
27	29.8		7	+0.23 +0.08	1.2
32	34.8		8		
40	43.5	+0.3 0	10		
50	53.5		12	+0.275 +0.095	1.6
60	64.2		14		2
80	85.5		18		

Type B — Unit : mm

Bore Diameter D	Height of Keyway E		Width of Keyway F		Corner Radius (ref)
Size	Size	Tolerance	Size	Tolerance	r
12.7	14.2	+0.25 0	2.39	+0.31 +0.13	0.5
15.875	17.7		3.18		0.8
19.05	20.9				
22.225	24.1				
26.988	29.4		6.35		1.2
31.75	35.2		7.92	+0.32 +0.14	1.6
38.1	42.3		9.52	+0.89 +0.25	
50.8	55.8		12.7		
63.5	69.4		15.87		
76.2	82.9		19.05		2.4

Type of Clutch Keyways

Unit : mm

Bore Diameter d		Width of Keyway F		Depth of Keyway H		Corner Radius(ref) r	R1	C	Eccentricity (1)
Type A	Type B	Size	Tolerance	Size	Tolerance (H12)				
10		6.4	+0.043 0	4.5	+0.12 0	1		0.5	0.030
13	12.7	8.4		5	+0.150 0				
16	15.875			5.6				0.6	
19	19.05	10.4		6.3		1.2			
22	22.225						7		0.040
27	26.988	12.4		7.0			8	0.8	
32	31.75	14.4		8.0		1.6	9		
40	38.1	16.4		9.0		2.0	10	1.0	
50	50.8	18.4	+0.052 0	10.0			11		
60	63.5	20.5		11.2	+0.180 0		12		0.050
80	76.2	24.5		14.0		2.5	15	1.2	

(1) This shows the tolerance between the bore diameter axis and the center line of the clutch keyway.

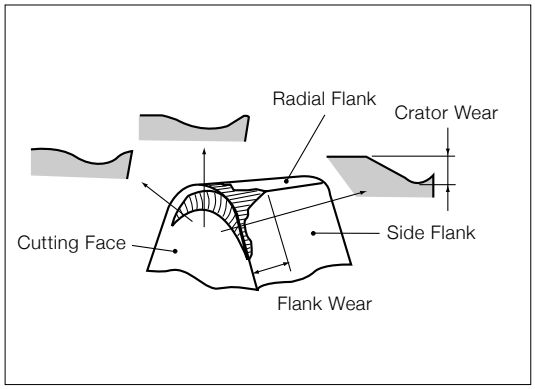
Cutting Condition (In case of m2~2.5)

Elements	Cutting Condition			
	Work Material	Cutting Speed[Note1] (m/min)	Axial Feed (mm/rev)[Note2]	
			Threads 1～2	Threads 3～5
Cutting Speed and Axial Feed	S45C以上	40～(70)〔100〕	1.5～2.5	1.0～2.0
	SCM440	50～(80)〔100〕	2.0～3.0	1.5～2.5
	SCM420 SCr 420	60～(110)〔140〕	2.5～3.5	2.0～3.0
	FCD 70	40～(50)	2.0～3.0	1.5～2.5
Radial Feed	Please avoid radial feed not to promote the cutter damage.			
Work Rotation	Hob Rotation : Q No. of Thread : TH No. of Teeth : Z Work Rotation $= TH \times \frac{Q}{Z} (min^{-1})$			
Depth of Cut	By work specification			
Shifting	0.1m～0.5m（m : Module）			

Note1 （ ）; in the case of coating hob. 〔 〕; in the case of dual coating.
Note2 Feed is different from a processing aim (finishing, pre-shaving) by necessary surface roughness, accuracy.

Regrinding

Damage to the cutting edge of a hob is generally separated into flank wear and crater wear depending on the location of the wear. The most economical way for regrinding is when the flank wear is approx. 0.2 mm wide or if the crater wear is approx. 0.1 mm deep. We recommend regrinding to a depth of 0.1 mm + existing wear. It is also important to choose a sharp grinding tool and to be careful that the heat from grinding does not dull the teeth and that grinding cracks do not occur. Specifically with high alloy powder high-speed steel, avoid creep feed grinding, use light grinding stock or high-speed feed grinding.



Example

Tool Material	Wheel Dia.	Wheel Rotation	Feed	Depth of Cut		Cutting Oil
HSS	200mm	2200～3000min^{-1}	300～600mm/min	Roughing	0.10～0.15mm	Non-water Soluble Oil
				Finishing	0.02～0.05mm	
Powder HSS	200mm	2200～3000min^{-1}	300～600mm/min	Roughing	0.05～0.10mm	
				Finishing	0.01～0.02mm	

Wheel	
Abrasive	CBN (Resinoid)
Grain Size	100
Concentration	100
Grade	R

Regrinding points

A guideline for the economical point for regrinding is when the flank wear is approximately 0.2 mm wide.
Be careful of grinding burn with dressing grinding wheel and keeping it very sharp.

Solid Gear Hobs Standard Dimensions

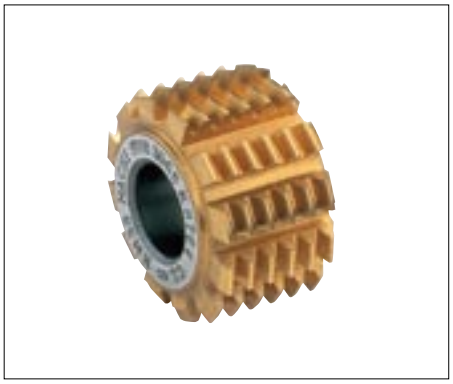
This table shows standard hob dimensions suited for gear cutting.
NACHI can also manufacture various sizes of solid hobs.

Unit : mm

Module m	Diametral Pitch DP	Outside Dia. D	Overall Length L	Bore Diameter (d)		No. of Flutes N
				Type A	Type B	
	26	50	50	22	22.225	12
1	24	50	50			
	22	50	50			
1.25	20	50	50			
	18	55	55			
1.5	16	55	55			
1.75	14	55	55			
2	12	60	60			10
2.25	11	60	60			
2.5	10	65	65			
2.75	9	65	65			
3	8	70	70	27	26.988	
3.25		70	70			
3.5		75	75			
3.75	7	80	75			
4	6	85	80			
4.5	5 ½	90	85			
5	5	95	90			
5.5	4 ½	100	95	32	31.75	9
6		105	100			
6.5	4	110	110			
7	3 ½	115	115			
8	3	120	130			
9	2 ¾	125	145			
10	2 ½	130	160			
11	2 ¼	140	175	40	38.1	
12		150	190			
	2	170	200			8
14		170	210			
	1 ¾	190	220			
16	1 ½	190	230			
18		210	250	50	50.8	
20	1 ¼	220	270			
22		230	300			
25	1	250	320			

Fine Pitch Gear Hobs Standard Dimensions

This table shows standard hob dimensions suitable in manufacture of small gears such as watch.
There are two types of Non-Topping and Topping.



8 Type — Unit : mm

Module m	Diametral Pitch DP	Outside Dia. D	Overall Length L	Bore Diameter d	No. of Flutes N
0.1		24	8	8	12
0.15		24	8		
0.2		24	8		
0.25	96	24	8		
0.3		24	10		
0.35	72	24	10		
0.4	64	24	10		
0.45	56	24	10		
0.5	48	24	10		
0.55		24	10		
0.6	44	24	12		
0.65	40	24	12		
0.7	36	24	12		
0.75		24	12		
0.8	32	24	12		
	30	24	12		
0.9	28	24	12		
	26	24	12		
1		24	12		

10 Type — Unit : mm

Module m	Diametral Pitch DP	Outside Dia. D	Overall Length L	Bore Diameter d	No. of Flutes N
0.2		32	12	10	12
0.25	96	32	12		
0.3		32	12		
0.35	72	32	12		
0.4	64	32	15		
0.45	56	32	15		
0.5	48	32	20		
0.55		32	20		
0.6	44	32	20		
0.65	40	32	20		
0.7	36	32	20		
0.75		32	20		
0.8	32	32	20		
	30	32	20		
0.9	28	32	20		
	26	32	20		
1		32	20		
	24	40	25		10
	22	40	25		
1.25	20	40	25		
1.5		40	25		
1.75		40	30		
2		40	30		

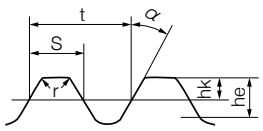
13 Type — Unit : mm

Module m	Diametral Pitch DP	Outside Dia. D	Overall Length L	Bore Diameter d	No. of Flutes N
0.2		32	12	13	12
0.25	96	32	12		
0.3		32	12		
0.35	72	32	12		
0.4	64	32	15		
0.45	56	32	15		
0.5	48	32	20		
0.55		32	20		
0.6	44	32	20		
0.65	40	32	20		
0.7	36	32	20		
0.75		32	20		
0.8	32	32	20		
	30	32	20		
0.9	28	32	20		
	26	32	20		
1		32	20		
	24	40	25		10
	22	40	25		
1.25	20	40	25		
1.5		40	25		
1.75		40	30		
2		40	30		

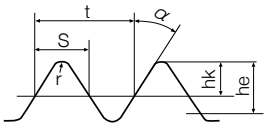
Involute Spline Hobs Tooth Profile

This table shows Hob Tooth Profile of involute spline and serration.

Involute Spline Hob Tooth Profile

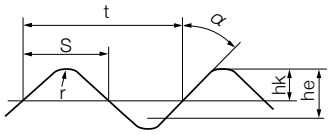


Flat Root



Fillet Root

Involute Serration Hob Tooth Profile



Involute Spline Hobs Tooth Profile

Unit : mm

Standard / Elements	D2001-1959	B1603-1995 ANSI B92.2M-1980 (Metric)		ANSI B92.2-1980 (Inch)			DIN 5480-1964
	Flat Root	Flat Root	Fillet Root	Flat Root	Fillet Root DP≧16	Fillet Root DP≦12	Flat Root
Module/DP	m	m		DP/DPS			m
Pressure Angle (α)	20°	30°		30°			30°
Addendum (hk)	1.0m	0.75m	0.9m	1.35/DPS	2.0/DPS	1.8/DPS	0.6m
Whole Depth of Cut	1.2m	1.25m	1.4m	2.35/DPS	3.0/DPS	2.8/DPS	1.2m
Tip Radius (r)	0.3m	0.2m	0.4m	0.075/DPS	0.36/DPS	0.46/DPS	0.16m
Normal Pitch (t)	πm	πm		25.4π/DP			πm
Tooth Thickness (s)	t/2	t/2		t/2			t/2

Involute Serration Hob Tooth Profile

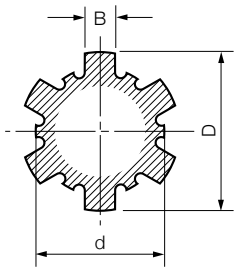
Unit : mm

Standard / Elements	D1602-1960	B1603-1995 ANSI B92.2M (Metric)		ANSI B92.2-1980 (Inch)	
Module/DP	m	m		DP/DPS	
Pressure Angle (α)	45°	37.5°	45°	37.5°	45°
Addendum (hk)	0.5m	0.7m	0.6m	1.53/DPS	1.1/DPS
Whole Depth of Cut	1.0m	1.15m	1.0m	2.53/DPS	2.1/DPS
Tip Radius (r)	0.4476m	0.3m	0.25m	0.4/DP	0.327/DP
Normal Pitch (t)	πm	πm		25.4π/DP	
Tooth Thickness (s)	1.3708m	t/2		t/2	1.3708/DP

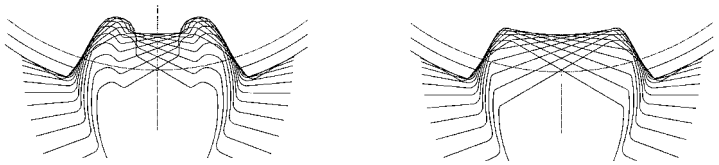
Parallel Side Spline Hobs Standard Dimensions

This table shows standard hob dimensions to manufacture parallel side spline.

Parallel Side Spline



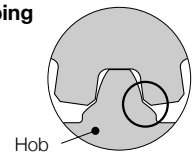
Generating Curve



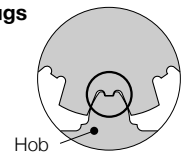
Unit : mm

Size	Hob Dimensions				Spline Dimensions (JIS B 1601-1996 J Type)									
					Type 1					Type 2				
	Outside Dia. D	OAL L	Bore Dia. D		No. of Spline N	Minor Dia. d	Major Dia. D	Width B	Chamfer f	No. of Spline N	Minor Dia. d	Major Dia. D	Width B	Chamfer f
			Type A	Type B										
11	60	60	22	22.225	–					6	11	14	3	0.3
13											13	16	3.5	
16											16	20	4	
18											18	22	5	
21	75	75	27	26.988							21	25	5	
23					6	23	26	6	0.3		23	28	6	
26						26	30	6			26	32	6	0.4
28						28	32	7			28	34	7	
32						32	36	8			32	38	8	
36						36	40	8			36	42	8	
42						42	46	10			42	48	10	
46	95	90	32	31.75		46	50	12			46	54	12	0.5
52						52	58	14	0.4		52	60	14	
56	115	115	32	31.75		56	62	14			56	65	14	
62						62	68	16			62	72	16	
72	135	175	40	38.1		72	78	18			72	82	18	
82						82	88	20			82	92	20	
92	145	190				92	98	22			92	102	22	
32	75	75	27	26.988	8	32	36	6		8	32	38	6	0.4
36						36	40	7			36	42	7	
42						42	46	8			42	48	8	
46	95	90	32	31.75		46	50	9			46	54	9	0.5
52						52	58	10	0.5		52	60	10	
56						56	62	10			56	65	10	
62						62	68	12			62	72	12	
72	115	115	32	31.75	10	72	78	12		10	72	82	12	
82						82	88	12			82	92	12	
92						92	98	14			92	102	14	
102						102	108	16			102	112	16	
112						112	120	18			112	125	18	

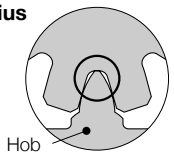
With Semi-topping



With Lugs



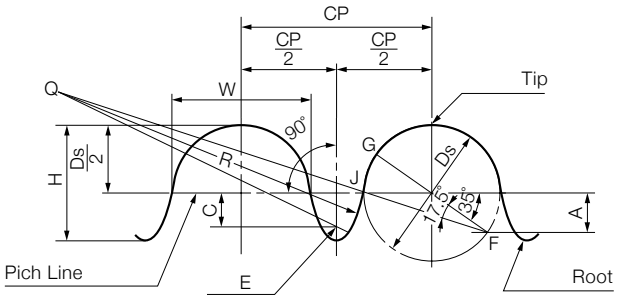
With Full Radius



Roller Chain Sproket Hobs Standard Dimensions

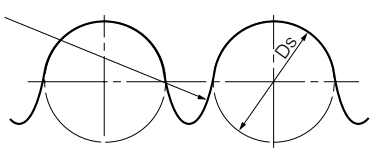
This hob is used to manufacture sproket wheels according to ANSI B29.1, ASA B29.1, DIN 8196, JIS B 1802, BS 228, and this table shows standard hob dimensions.

Basic Rack Tooth Profile (JIS B 1802 S Type)

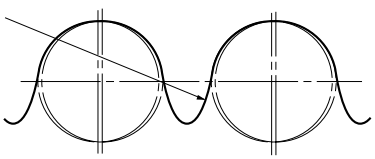


Unit : mm

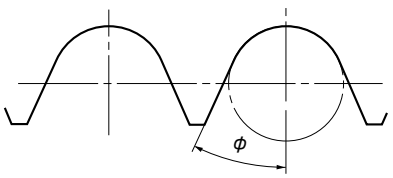
Chain Pitch (CP)	Roller Dia. (RD)	Hob Dimensions				
		Outside Dia. D	Overall Length L	Bore Dia. d		No. of Flutes N
				Type A	Type B	
6.35	3.3	60	60	22	22.225	12
9.525	5.08	65	65			
	6.35					
12.7	7.77	75	75	27	26.988	10
	7.94					
15.875	10.16	85	90			
19.05	11.91	90	105			
25.4	15.875	110	125	32	31.75	9
31.75	19.05	120	140			
38.1	22.225	130	170			
44.45	25.4	160	190	40	38.1	
50.8	28.575	170	210			
57.15	35.72	190	240			
63.5	39.688	210	260	50	50.8	
76.2	47.625	240	310			



JIS B 1802 Type S
ASA B29.1 Type 2
ANSI B29.1



JIS B 1802 Type U
ASA B29.1 Type 1

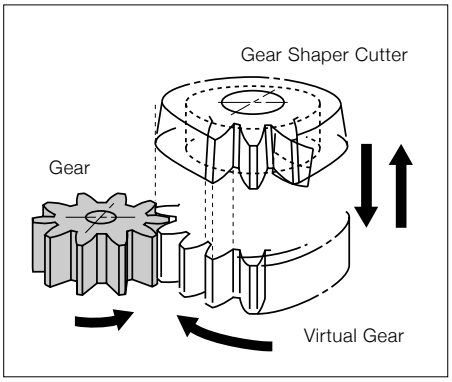


DIN 8196 ϕ:24°
BS 228 ϕ:25°

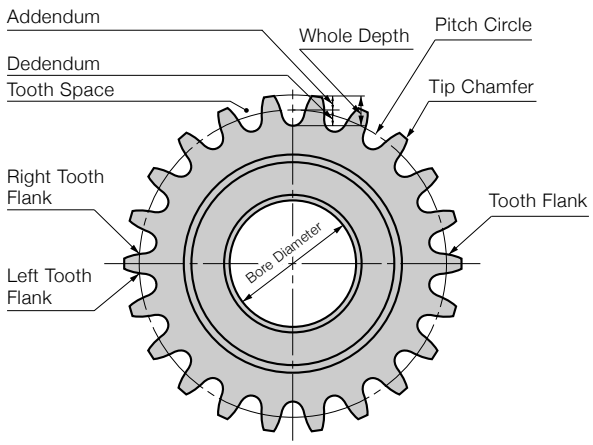
Gear Shaper Cutters

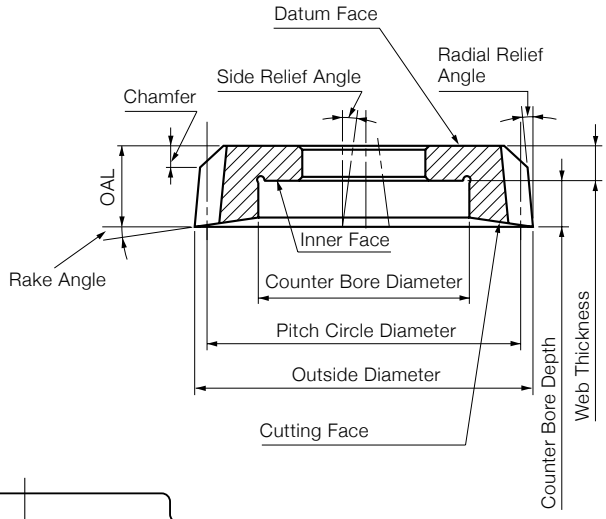
Gear shaper cutter is the gear cutting tool for generating the gear teeth. The both gear and cutter are mounted on the gear shaper machine. Then a symmetrical motion of rotation and reciprocating generates the gear teeth.
1. Generating internal gears and shoulder gears
2. Generating omitted teeth, combined one or variable tooth thickness.

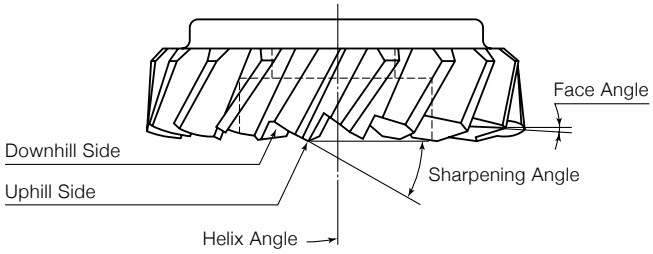
Gear Shaper Cutters



Gear Shaper Cutters Nomenclature

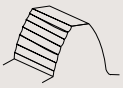
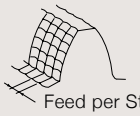




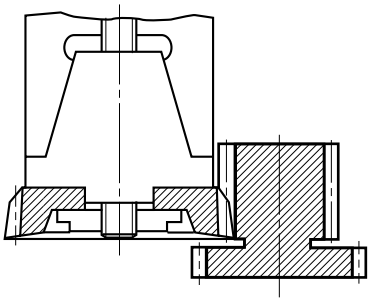


Helical Gear Shaper Cutter

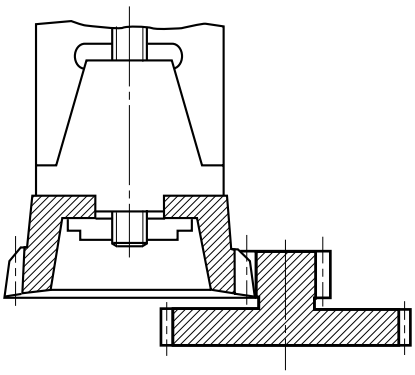
Gear Cutting Comparison of Gear Shaper Cutter and Hob

Work Gear	Gear Shaper Cutters	Hobs
Tooth Width	Thin thing	Thick thing
Type	Suitable for cutting of internal gear and Shoulder gear	Cutting of internal gear and Shoulder gear is not possible
Accuracy	Pitch Error Large Tooth Profile Error Small Surface Roughness Small  After Gear Shaper Cutting	Pitch Error Small Tooth Profile Error Large Surface Roughness Large  Feed per Stroke After Hobbing
Others	Regrinding is easy Heavy cutting is not made Cutters are different, and need a helical guide by helix angle of gear	Must hold down a gach spacing error in regrinding Heavy cutting is easy In one hob, can do gear processing of various helix angle Pitch of a processing gear is related to a master warm of hobbing machine

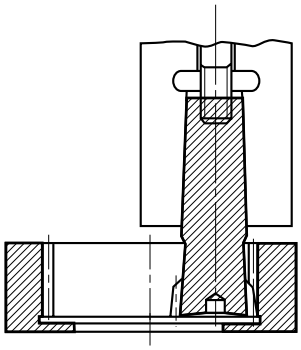
Types of Gear Shaper Cutters



Disk Type for Shoulder Gears



Deep Counterbore Type with Recessed Nut



Shank Type for Small Diameter Internal Gear

NACHI Accuracy of Gear Shaper Cutters

Unit : μm

Cutter Elements		Tolerance	
		Grade	
		AA	A
Bore Diameter d	d≦18	0～+3	0～+5
	18＜d≦30	0～+4	0～+6
	30＜d≦50	0～+4	0～+7
	50＜d≦80	0～+5	0～+8
	80＜d≦120	0～+6	0～+10
Shank Runout		2	3
Outside Diameter Runout		7	10
Datum Face Runout		5	5
Inner Face Runout		5	5
Cutting Face Runout		10	16
Face Angle(min.)		±5	±14
Side Relief Angle(min.)		±5	
Radial Relief Angle(min.)		±5	

Unit : μm

Cutter Elements	Tolerance		
	Module		
	Under Type 38 and m＜1.5	1.5≦m＜5	m≧5
Outside Diameter	+200～−400	±400	±500

Unit : μm

Cutter Elements	Grade	Type	Tolerance						
			Module						
			0.5≦m≦1	1＜m≦1.6	1.6＜m≦2.5	2.5＜m≦4	4＜m≦6	6＜m≦10	10＜m≦16
Tooth Space Runout	AA	25、38、50	15(19)	15(19)	11(14)	11(14)	−	−	−
		75、100	16(20)	16(20)	12(15)	13(17)	14(18)	17(22)	−
		125、150、175	−	16(20)	13(17)	14(18)	15(19)	18(23)	−
	A	25、38、50	19(25)	18(23)	17(22)	16(20)	−	−	−
		75、100	19(25)	19(25)	18(23)	18(23)	20(26)	24(31)	−
		125、150、175	−	20(26)	19(25)	20(26)	22(28)	26(34)	32(41)
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	−
	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
Accumulative Pitch Error	AA	25、38、50	11	12	13	14	−	−	−
		75、100	12	13	14	15	17	20	−
		125、150、175	−	15	16	17	19	22	−
	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
Profile Error	AA	−	6	6	7	9	11	15	−
	A	−	8	9	10	13	16	22	22
Tooth Thickness(−)	AA	−	13	13	17	21	27	33	−
	A	−	21	21	27	33	43	53	53

Remarks : Value in ( ) is applied to the pressure angle of less than 15 degrees.

Cutting Condition
(In the case of coated shaper cutter)

Elements	Cutting Condition (Note2)	
Cutting Speed (Note1)	Blister Steel S45C FCD70	40～80m/min 30～50m/min 20～40m/min
Rotary Feed	0.2～3.0mm/Stroke	
Radial Feed	0.002～0.01mm/Stroke	
Back Off	0.2～0.8mm	
Offset	By Direction of Revolution and Gear Spec.	
Depth of Cut	By Gear Spec.	

Note1.Cutting speed is calculated on cutting length and numbers of cutter stroke.

b Work width (mm)
Wc Numbers of stroke (str/min)
V Cutting speed (m/min)

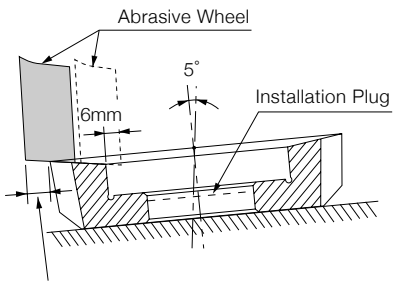
$$V = \frac{Wc \cdot (b+6) \cdot \pi}{1000}$$

Note2.Please note that cutting speed should be selected based upon gear shaper machine.

Regrinding

Regrinding with disc type and hub type gear shaper cutters is done with a rotary surface grinder.
When grinding is done, the cutter is placed in the center of the table and attached with magnetic clamps (or inserted into taper shank cutter holders if it's a shank type).
Next, the proper rake angle (generally 5°) is set on the magnetic chuck and regrinding is done as shown in the diagram.

Regrinding Method



The position of grinding wheel is determined based on the depth of tooth space.

Example

Tool Material	Wheel Dia.	Wheel Rotation	Wheel Speed	Depth of Cut		Cutting Oil
HSS	305mm	1500min^{-1}	1500m/min	Roughing	0.02～0.05mm	Noritake NK55
				Finishing	0.02mm	
Power HSS	305mm	1500min^{-1}	1500m/min	Roughing	0.02mm	Soluble Oil
				Finishing	0.01～0.02mm	

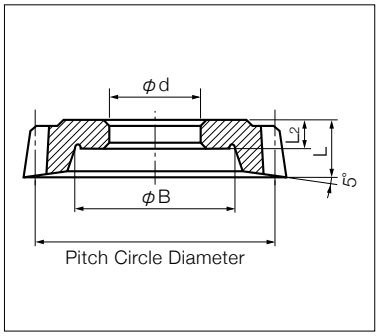
Wheel	
Abrasive	C
Grain Size	220
Structure	9
Grade	H

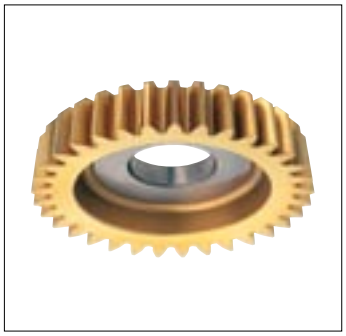
Regrinding points

A guideline for the most economical points for regrinding is when the flank wear is approx. 0.2 mm wide.
Be careful of grinding burn with dressing grinding wheel and keeping it very sharp.

Disk Type Shaper Cutters Type I Standard Dimensions

This type of cutter is used in cutting spur gears or splines, and this table shows standard dimensions.





Unit : mm

Module m	Diametral Pitch DP	Type 50					Type 75					Type 100				
		No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)
0.3		164	8	6.5	19.05	28	–					–				
	80	164														
0.35		142														
0.4		126														
	60	120														
0.45		110														
0.5		100	10				150	14	8	31.742	50					
0.55		90					136									
0.6		84					126									
	40	80					120									
0.65		76					116									
0.7		72					108									
	36	72					108									
0.75		66	12				100	16								
	32	64					96									
0.8		64					94									
	30	60					90									
0.9		56					84									
	28	56					84									
	26	52					78									
1.0		50					76					100	18	10	31.742 or 44.450	65
	25	50	14				76	18				100	20			
	24	48					72					96				
	22	44					66					88				
1.25		40					60					80				
	20	40					60					80				
	18	36					54					72				
1.5		34					50					66				
	16	32					48					64				
1.75		28					44					56				
	14	28					42					56				
2		25					38					50				
	12	24	16	8			36	20				48	22			
2.25		23					34					44				
	11	22					33					44				
2.5		20					30					40				
	10	20					30					40				
2.75		19					28					36				
	9	18					27					36				
3		17					25					33				
	8	16					24					32				
3.25		16					23					30				
3.5		15					22					28				
	7	14	18				21	22	10			28	24			
3.75		14					20					26				
4		13					19					25				
	6	–					18					24				
4.5							17					22				
	5½						17					22				
5							16					20				
	5						–					20				
5.5												19				
	4½											18				
6												17				
	4											16	28	12		
6.5												16				
7												15				
												14				
8												13				

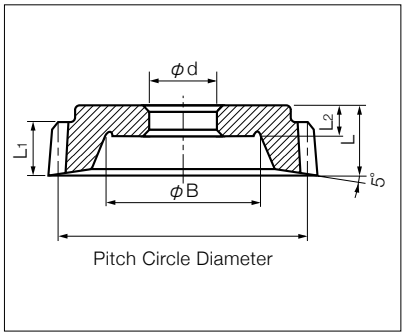
Next Page

Unit : mm

Module	Diametral Pitch	Type 125					Type 150					Type 175				
m	DP	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	B (Ref.)
1		126	20	10	44.450	85	150	22	12	44.450	95	—				
	25	126					150									
	24	120					142									
	22	110					130									
1.25		100					120									
	20	100					120									
	18	90					106									
1.5		84	22				100					116	26	14	44.450 or 58.735	110
	16	80					94					110				
1.75		72					86	24				100				
	14	70					82					96				
2		64					75					88				
	12	60	24				70	26				82	28			
2.25		56					66					78				
	11	54					64					76				
2.5		50					60					70				
	10	50					60					68				
2.75		46					54					64				
	9	45					54					62				
3		42					50					58				
	8	40					48					56				
3.25		38					46					54				
3.5		36					44					50				
	7	35	26	12			42	28	14			48	30			
3.75		34					40					47				
4		32					38					44				
	6	30					36					42				
4.5		28					34					39				
	5 ½	28					33					38				
5		25					30					35				
	5	25					30					34				
5.5		23					28					32				
	4 ½	22					27					30				
6		21					25					29				
	4	20	30				24	32				28	34			
6.5		20					23					27				
7		19					22					25				
	3 ½	18					21					24				
8		17					19					22				
	3	—					18					21				
9							17					19				
10							15					18				
	2 ½											17	36	16		
11												16				
12												15				

Disk Type Shaper Cutters Type Ⅱ Standard Dimensions

This type of cutter is used in cutting helical gears, and this table shows standard dimensions.

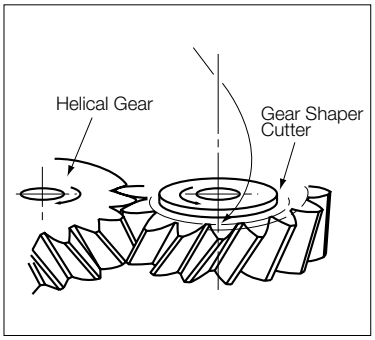


Unit : mm

Module	Diametral Pitch	Type 50					Type 75					Type 100				
m	DP	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)
0.3		12	8	6.5	19.050	28	—					—				
	80															
0.35																
0.4																
	60															
0.45																
0.5		14	10				16	14	6.5	31.742	50					
0.55																
0.6																
	40															
0.65																
0.7																
	36															
0.75		16	12				20	16	8							
	32															
0.8																
	30															
0.9																
	28															
	26															
1.0		18	14				22	18				24	18	10	31.742 or 44.450	65
	25															
	24															
	22															
1.25																
	20															
	18											26	20			
1.5																
	16															
1.75																
	14															
2																
	12	20	16	8			24	20				28	22			
2.25																
	11															
2.5																
	10															
2.75																
	9															
3																
	8															
3.25																
3.5																
	7	22	18				26	22	10			30	24			
3.75																
4																
	6	—					—					—				
4.5																
	5 ½															
5																
	5															
5.5																
	4 ½															
6																
	4															
6.5												34	28	12		
7																
	3 ½															
8																

Helical Gear Shaper Cutters Dimensions

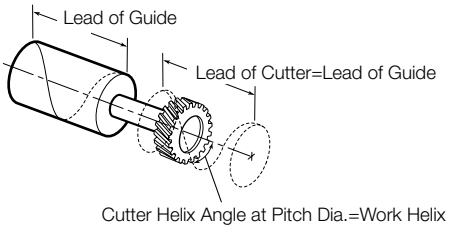
This type of cutter is used to cut helical gear.
The No. of cutter Teeth is determined by module and helix angle of gear and the helical guide.
When ordering the helical shaper cutter, please specify the guide lead on addition to the cutter and work dimensions. Shared calculation is necessary.
NC guide gear shaping machine does not need a helical guide.

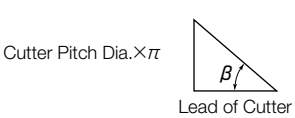


Unit : mm

Module m	Diametral Pitch DP	Type 125 OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)	Type 150 OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)	Type 175 OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)
1		26	20	10	44.450	85	28	22	12	44.450	95	—				
	25															
	24															
	22															
1.25																
	20															
	18															
1.5		28	22				30	24				36	26	14	44.450 or 58.735	110
	16															
1.75																
	14															
2																
	12	30	24				34	26					28			
2.25																
	11															
2.5																
	10															
2.75																
	9															
3																
	8															
3.25							36	28	14			40	30			
3.5																
	7															
3.75																
4																
	6															
4.5																
	5 ½	32	26	12												
5																
	5															
5.5																
	4 ½															
6																
	4					80	40	32				44	34			
6.5																
7		36	30													
	3 ½															
8																
	3	—					—					48	36	16		100
9																
10																
	2 ½															
11																
12																

Helical Guide



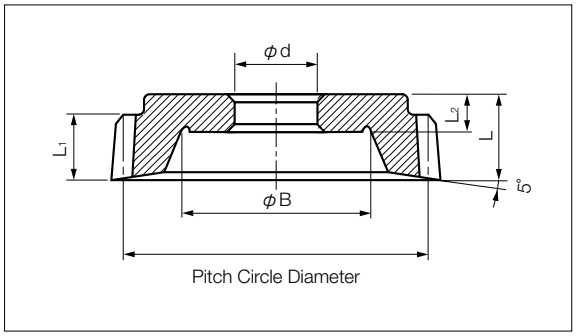


m : Normal Module
Zc : No. of Cutter Teeth
βc : Helix Angle of Cutter
L : Lead Of Guide

$$L = \frac{m \times \pi \times Zc}{\sin \beta c}$$

Disk Type Shaper Cutters Type Ⅲ Standard Dimensions

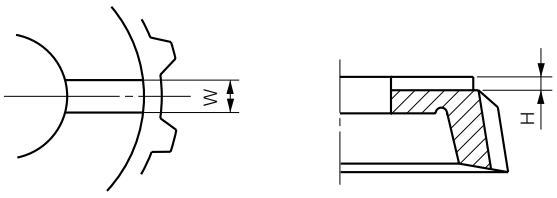
This type cutter is used in cutting larger module gears, and this table shows standard dimentions.



Unit : mm

Module m	Diametral Pitch DP	Type 200						Type 250					
		No. of Teeth	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	B (Ref.)	No. of Teeth	OAL L	Web Thickness L_2	Tooth Width L_1	Bore Dia. d	B (Ref.)
8		25	40	24	18	58.735 or 76.200	135						
	3	24											
9		23											
10		21						25	50	30	20	76.200 or 101.600	170
	2 ½	20						25					
12		17						21					
	2							20					
14								18					
16								16					

Clutch Keyway Dimensions

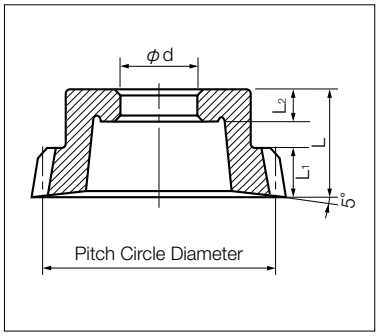


Unit : mm

W				H	
For Positioning		For Stopper			
Size	Tolerance	Size	Tolerance	Size	Tolerance
5.0	+0.015 0	5.0	+0.1 0	1.6	+0.4 0
6.5		6.5		3.2	
8.0		8.0			
9.5	+0.025 0	9.5			
12.5		12.5			
16.0		16.0			

Deep Counterbore Type Shaper Cutters Standard Dimensions

This type of cutter is used in cutting internal gears or shoulder gears, and this table shows standard dimentions.

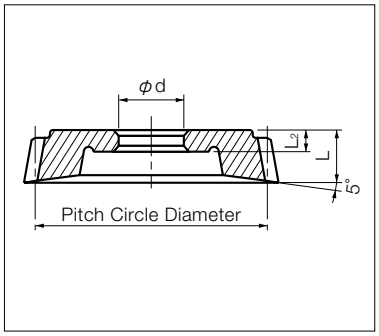


Unit : mm

Module	Diametral Pitch	Type 50					Type 75					Type 100					Type 125				
m	DP	No. of Teeth	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	No. of Teeth	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	No. of Teeth	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d	No. of Teeth	OAL L	Tooth Width L_1	Web Thickness L_2	Bore Dia. d
0.3		164	22	8	8	19.05	–					–					–				
	80	164																			
0.35		142																			
0.4		126																			
	60	120																			
0.45		110																			
0.5		100	24	10			150	32	14	8	31.742										
0.55		90					136														
0.6		84					126														
	40	80					120														
0.65		76					116														
0.7		72					108														
	36	72					108														
0.75		66	30	12			100	34	16												
	32	64					96														
0.8		64					94														
	30	60					90														
0.9		56					84														
	28	56					84														
	26	52					78														
1.0		50					76					100	38	18	10	31.742 or 44.450	126			10	44.450
	25	50	32	14			76	36	18			100	40	20			126	40	20		
	24	48					72					96					120				
	22	44					66					88					110				
1.25		40					60					80					100				
	20	40					60					80					100				
	18	36					54					72	40	20			90				
1.5		34					50					66					84				
	16	32					48					64					80				
1.75		28					44					56					72	42	22		
	14	28					42					56					70				
2		26					38					50					64				
	12	25	34	16			36	38	20			48	42	22			60	44	24		
2.25		24					34					44					56				
	11	24					32					44					54				
2.5		23					30					40					50				
	10	23					30					40					50				
2.75		22					28					36					46				
	9	22					27					36					45				
3		20					26					34					42				
	8	19					25					32					40				
3.25		19					24					30					38				
3.5		18					23					28					36				
	7	17	38	18			22	42	22	10		28	44	24			35	48	26	12	
3.75		16					21					27					34				
4		16					20					25					32				
	6	–					19					24					30				
4.5							18					23					28				
	5½						18					22					28				
5							17					21					25				
	5						–					21					25				
5.5												20					23				
	4½											20					22				
6												19					21				
	4											18	50	28	12		20	50	30		
6.5												17					20				
7												16					19				
	3½											16					18				
8												15					17				

Sproket Shaper Cutters Standard Dimensions

This cutter is used to manufacture sproket wheels, and this table shows standard dimensions.



Unit : mm

Chain Pitch CP	Type 75				Type 100				Type 125			
	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d	No. of Teeth	OAL L	Web Thickness L_2	Bore Dia. d
6.35	36	18	8	31.742	48	22	10	31.742 or 44.450	60	24	10	44.450
9.525	24				32				40			
12.7	18				24				30			
15.875	14				20				24			
19.05	12				16				20		12	
25.4	—	—	—	—	12				15			
31.75	—	—	—		—	—	—	—	12			

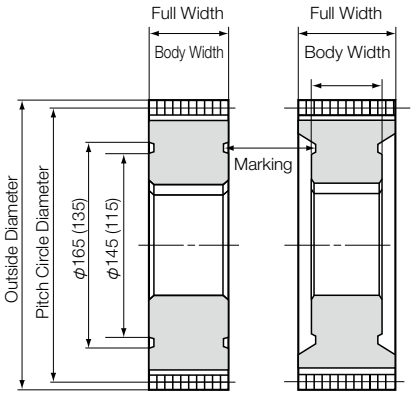
Shaving Cutters

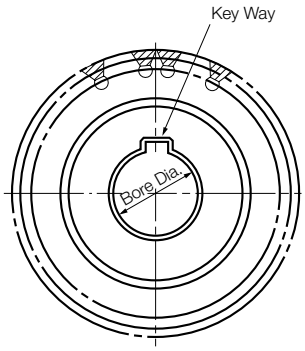
Shaving cutter is the gear cutting tool that have many serrated grooves at the tooth flanks.
The both gear and the cutter is mounted on the shaving machine with intersecting angle.
Then it makes sliding action on these flanks by rotating shaving cutter to finish the flanks of the gear teeth.
Features of shaving
1. Short finishing tact time
2. Easy to modify the gear profile and lead form such as crowning form

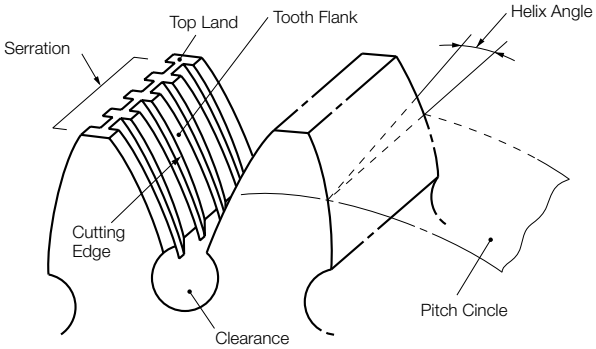
Before Shaving

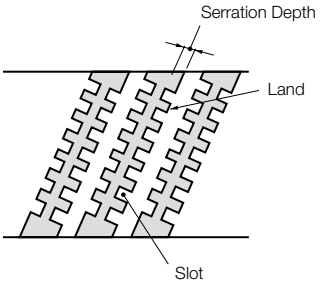
After Shaving

Shaving Cutter Nomenclature

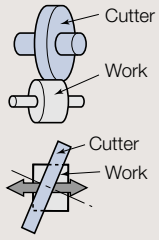
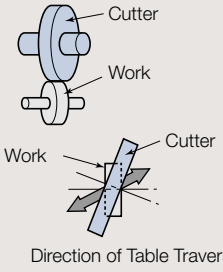
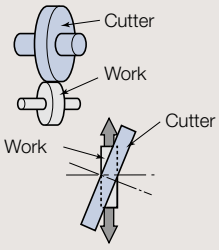
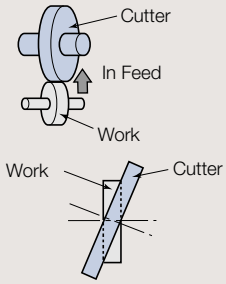




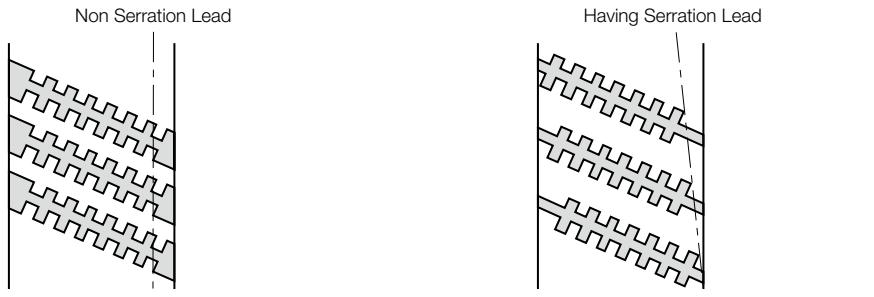




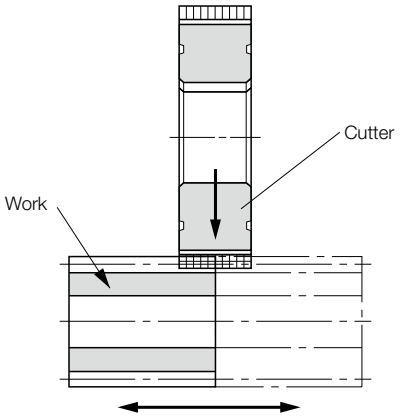
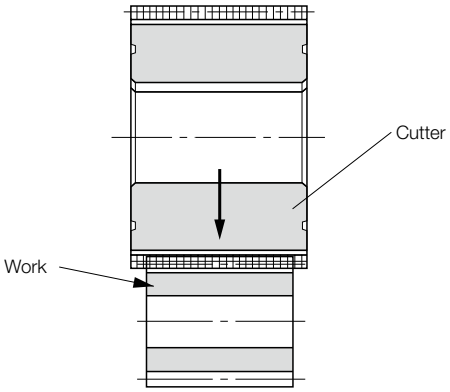
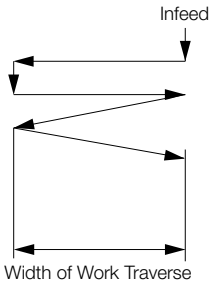
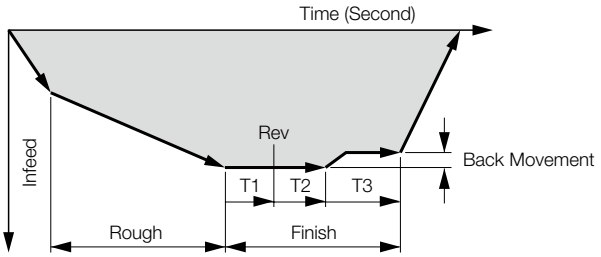
Shaving Methods and Features

Shaving Methods		Features	Figure
Table Traverse	Conventional Shaving	This is most common shaving method and the tooth of gear is very finely finished. In this shaving, work gear is fed along a path parallel to its axis, with the center of the tool passing from one edge of the gear face to the opposite edge. Crowned gear teeth are produced by rocking the table during the shaving cycle. This process is particularly adaptable to shaving wide-faced gears.	
	Diagonal Shaving	This method is used in finishing of automobile gears. In this shaving, work gear is reciprocated across the cutter in a path between zero to 90˚to the work gear axis. Normaly this angle is from 15˚to 35˚. The direction of rotation is reversed at each end to the stroke. Tooth-crowning is produced by a reverse-crowned cutter in this process.The cutter may be narrower than the work gear. The cutting time is shorter than the Conventinal Shaving.	
	Underpass Shaving	This is used mainly for shaving shoulder gears. The work gear is reciprocated across the cutter at an angle of 90˚ to the work gear axis. The direction of rotation is reversed at each end to the stroke. The cutter is wider than the work gear and is provided with a differential serration. Tooth-crowning is produced by a reverse-crowned cutter in this process.	
Plunge cut Shaving		Of the four methods, this method has the shortest shaving time and produces high quality finished tooth profile, making it most suitable for high production. The work gear is fed in the gear's radius direction. The cutter is wider than the work gear, and is provided with specially designed differential serration. Tooth-crowning is produced by a reverse-crowned cutter in this process.	

Serration

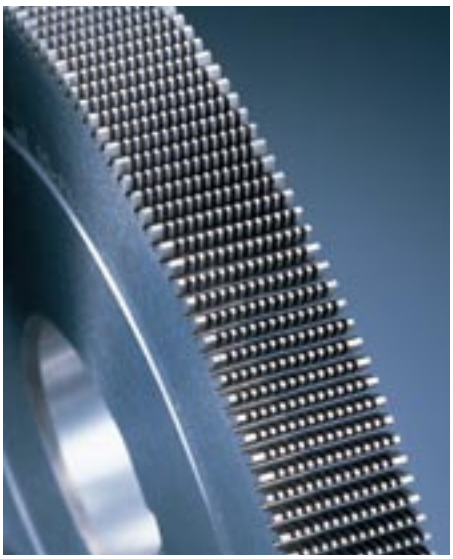


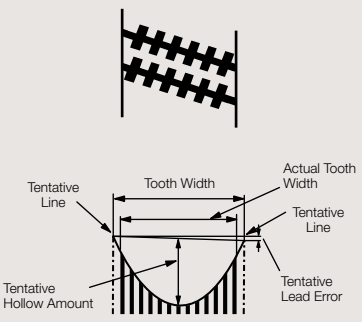
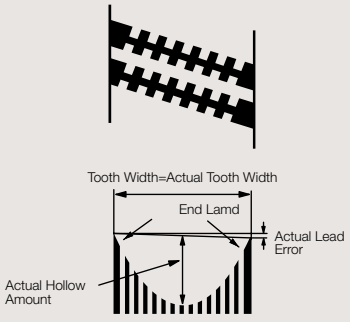
Shaving Mechanism and Cycle Diagram

	Traverse Type Conventional	Plunge Cut Type
Shaving Mechanism		
Serration	Normal Serration (Parallel)	Differential Serration
Cycle Diagram		

Plunge Cut Shaving Cutter

Reading accuracy improvent of lead
Strength improvement of end land
Recommend in less than gear width 32mm



Conventional	Leave Both End Land
	

NACHI Accuracy of Shaving Cutters

Unit : μm

Cutter Elements	Type	Grade	Tolerance							
			Module							
			0.8≦m≦1.2	1.2<m≦1.6	1.6<m≦2.5	2.5<m≦4	4<m≦6.3	6.3<m≦10	10<m≦16	16<m≦20
Outside Diameter		A	±300		±400		±600			
		B	+300 +100			+600 +300	+700 +300			
Tooth Thickness		A	0 −25				0 −40		0 −60	
		B	+50 0			±30	±50			−
Outside Diameter Runout		A	15							
		B	20				25		−	−
Face Runout			5							
Tooth Space Runout	Under 250	A	13	15	15	15	16	−	−	−
	300, 325		−	−	−	−	−	16	18	−
	400		−	−	−	−	−	18	20	22
	Under 250	B	48	50	52	57	63	−	−	−
	300, 325		−	−	−	−	−	81	−	−
	400		−	−	−	−	−	−	−	−
Adjacent Pitch Error	Under 250	A	4	4	4	4	5	−	−	−
	300, 325		−	−	−	−	−	5	5	−
	400		−	−	−	−	−	5	5	6
	Under 250	B	−	−	−	−	−	−	−	−
	300, 325		−	−	−	−	−	−	−	−
	400		−	−	−	−	−	−	−	−
Accumulative Pitch Error	Under 250	A	8	8	18	20	23	−	−	−
	300, 325		−	−	−	−	−	25	28	−
	400		−	−	−	−	−	28	30	35
	Under 250	B	68	71	74	81	90	−	−	−
	300, 325		−	−	−	−	−	115	−	−
	400		−	−	−	−	−	−	−	−
Lead Error	Lead	A	±5/25.4mm				±7/25.4mm			
		B	±15/25.4mm				±17/25.4mm		−	−
	Symmetricity	A	5							
		B	−							
Profile Error (*)		A	±2			±3		±4	±5	±6
		B	−							

Remarks 1 : Grade A are applied to Ground cutters. Grade B is applied to Semi-ground cutters.
Remarks 2 : Indicades tolerance on tooth thickness corresponding to the outside diameter.

Warranty Specitications of Cutter

Cutter Warranty	New Cutter	Regrinding Cutter
Semi-ground Cutter (Grinding on Bore and Keyway)	○	
Cutter Warranty (Without Trial Test)	○	○
Work Warranty (With Trial Test)	○	○

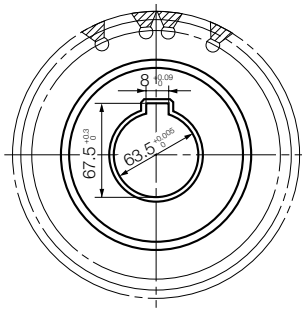
Standard Number of Cutter Teeth

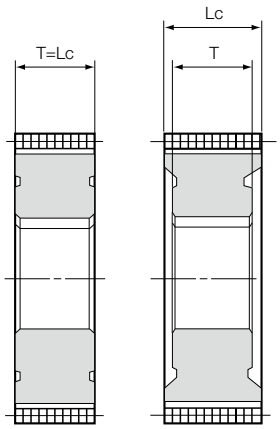
Type	Module m	No. of Teeth
175	0.8	214
	1.0	173
	1.25	137
	1.5	113
	1.75	97
	2.0	89
	2.25	79
	2.5	67
	2.75	61
	3.0	59
	3.25	53
	3.5	※ 47
	3.75	※ 47
	4.0	※ 43
200	1.0	197
	1.25	151
	1.5	137
	1.75	113
	2.0	97
	2.25	89
	2.5	79
	2.75	73
	3.0	67
	3.25	61
	3.5	59
	3.75	53
	4.0	※ 47
	4.5	※ 43
	5.0	※ 41
	5.5	※ 37
	6.0	※ 33

Type	Module m	No. of Teeth
225	1.25	173
	1.5	151
	1.75	121
	2.0	113
	2.25	97
	2.5	89
	2.75	79
	3.0	73
	3.25	67
	3.5	61
	3.75	59
	4.0	53
	4.5	※ 47
	5.0	※ 43
	5.5	※ 41
	6.0	※ 30
300	4.0	73
	4.5	67
	5.0	59
	5.5	53
	6.0	※ 47
	6.5	※ 43
	7.0	※ 43
	8.0	※ 37
	9.0	※ 31
	10.0	※ 29
	11.0	※ 27
	12.0	※ 25

※ : Less than pressure angle 17.5° are not applied

Simple Calculation for Cutter Width





m :Module
b :Gear Width
Σ :Crossed Axis Angle

1. Plunge Cut shaving
$Lc = b \times \cos\Sigma + 3m\pi \times \sin\Sigma + 5$

2. Under Pass shaving

$$Lc = \frac{b}{\cos\Sigma} + 3m\pi \times \sin\Sigma + 2$$

3. Diagonal shaving
(Travel Angle θ)

$$Lc = \frac{b \cdot \tan\theta}{\sin\Sigma + \cos\Sigma \times \tan\theta} + 3m\pi \times \sin\Sigma + 4$$

4. Conventional shaving
Module≦6:Lc=25.4mm
Module>6:Lc=31.75/32.0mm

Cutter width : T (A Standard Example)

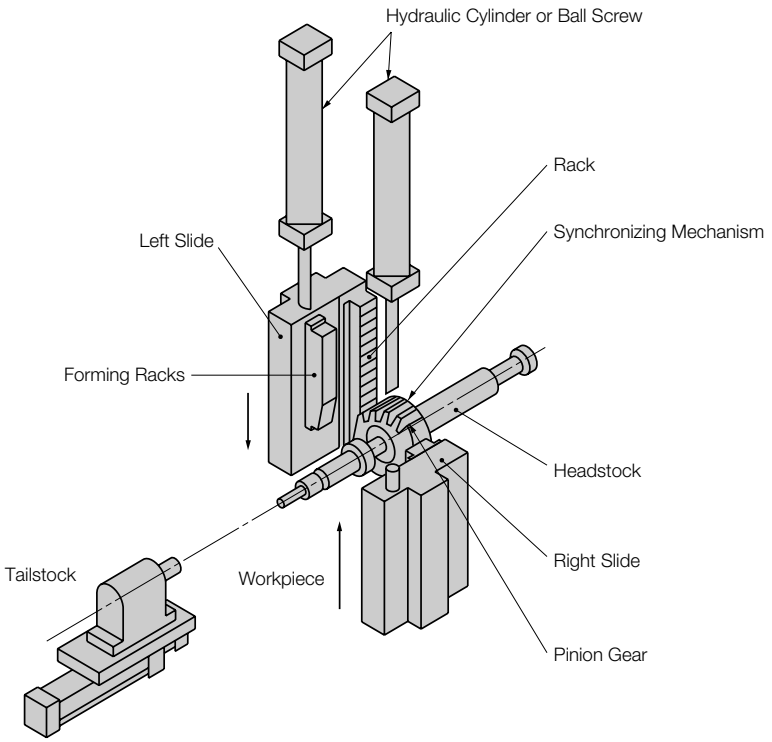
inch	19.05	25.4	31.75	38.1	44.45	50.8
Metric	20.0	25.4	32.0	38.0	44.0	50.0

Forming Racks

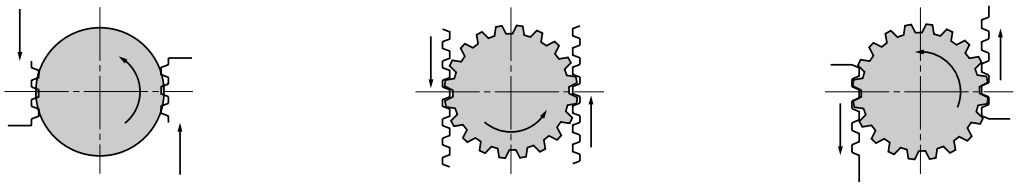
Forming Racks are used in pairs to roll the teeth into the workpiece, and have next features.
Rolling is generally completed in a few seconds and is a far more efficient than hobbing.
This method can achieve better accuracy than cylindrical dies rolling.

Rolling Principles

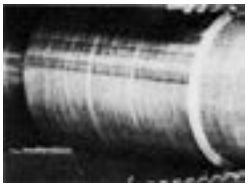
Vertical Rolling Machine



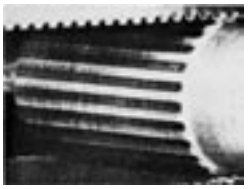
Rolling Process



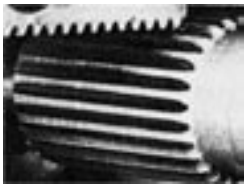
(1)



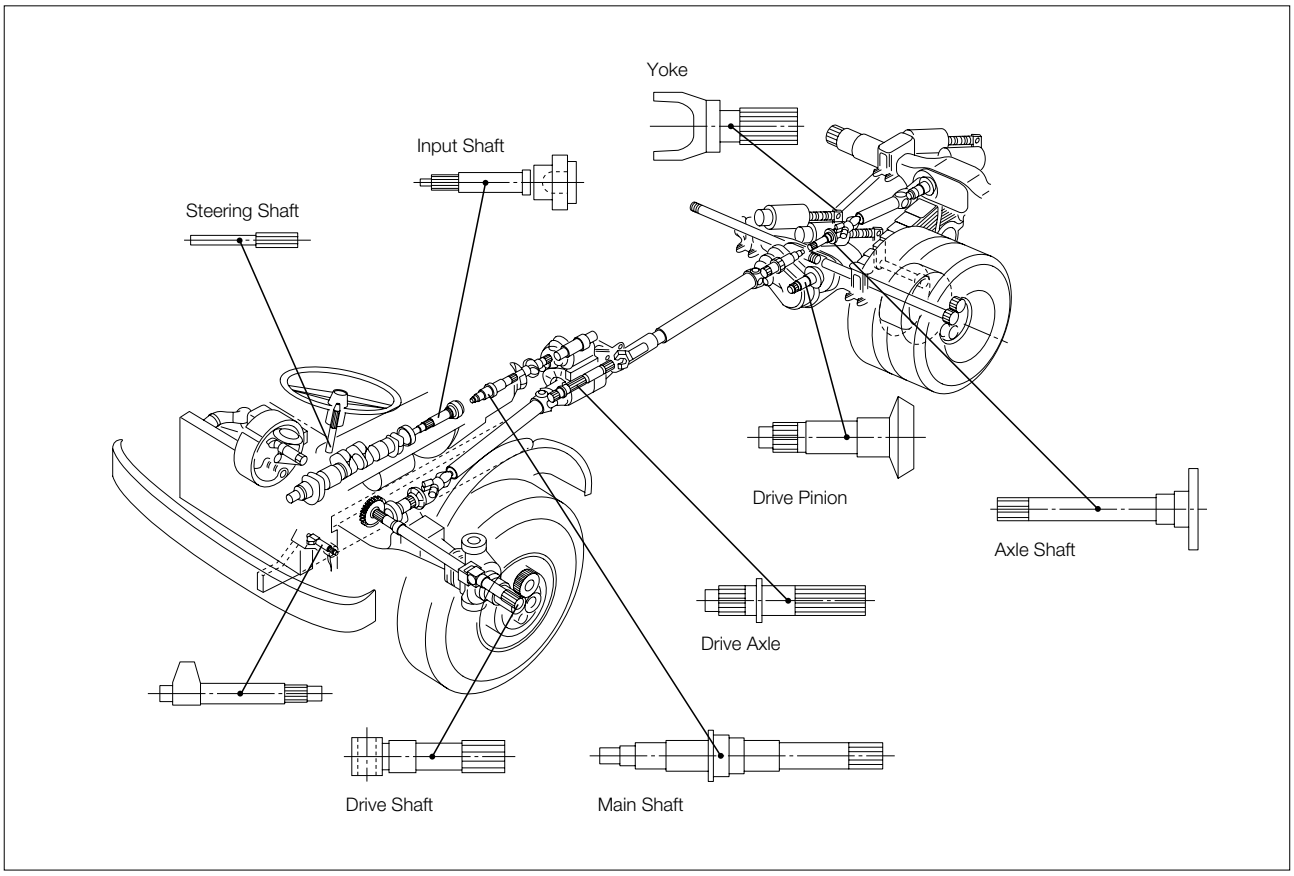
(2)



(3)



Example of automotive parts



Example Workpieces

Forming Rack is for large volume production of parts with involute spline, involute serration, thread, worm and others.


Spline + Thread


Worm Screw

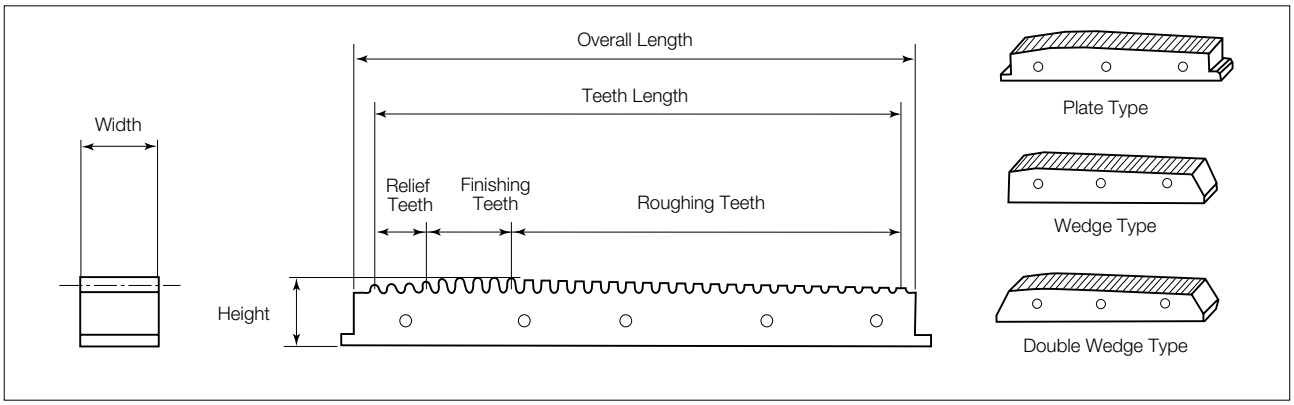

Oil Groove (Helix Angle 0°)


Number of The Small Teeth Gear


Oil Groove (Helix Angle 30°) + Spline


Worm

Type of Racks and Basic Dimensions



Applicable Machine	Plate Type	Wedge Type	Double Wedge Type	ATC Type
	Vertical or Horizontal Rolling Machine	Vertical Rolling Machine	Horizontal Rolling Machine	Vertical Rolling Machine with ATC

Unit : mm

Type	Types & Dimensions							
	Plate Type		Wedge Type		Double Wedge Type		ATC Type	
	Teeth Length	Overall Length	Teeth Length	Overall Length	Teeth Length	Overall Length	Teeth Length	Overall Length
7	178	210	178	195	178	202	178	178
9	229	261	229	245	229	253	229	229
11	280	312	280	295	280	304	280	280
13	331	362	331	346	331	355	331	331
16	407	439	407	422	407	431	407	407
20	508	540	508	523	508	532	508	508
24	610	642	610	623	610	634	610	610
28	712	744	712	725	712	736	712	712
32	813	845	813	826	813	837	813	813
36	915	947	915	928	915	939	915	915
42	1067	1099	–	–	1067	1091	–	–
48	1220	1252	–	–	1219	1243	–	–

Tool life & Regrinding

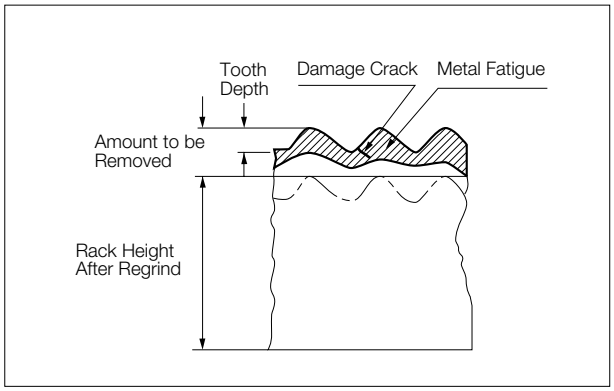
The hardness of work and the pressure angle have the largest influence on life. Hardness of less than 200HB is recommended. (see table 1) On other hand, a larger pressure angle increases life. (see table 2)
The tools are reground by removing the worn metal, and regrinding may be allowed for 3~4 times. But the life become lower as a result of regrinding.

Prectical Handness

Pressure Angle	Practical Hardness	Maximum Hardness
30°	285HB less	300HB
37.5°	310HB less	330HB
45°	330HB less	350HB

Tool Life of S35C~S45C Steel

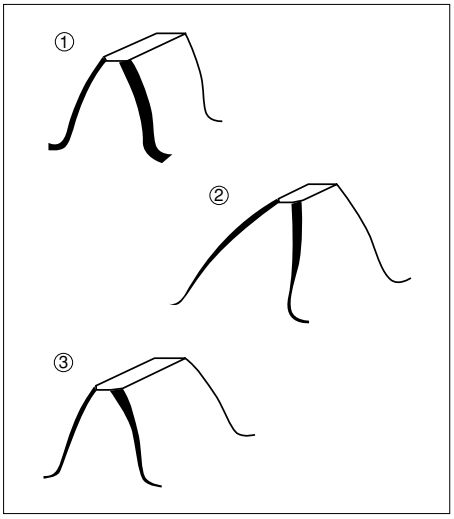
Hardness / Pressure Angle	200HB	260HB	320HB	340HB
30°	100,000	55,000	12,000	–
45°	150,000	62,000	30,000	25,000

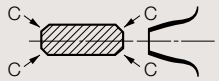
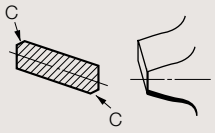
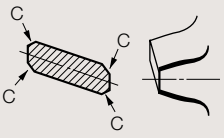


Gear Chamfering Tools

Deburring Cutters

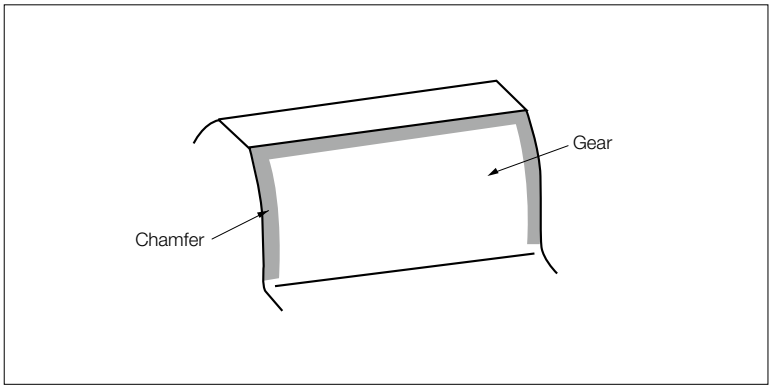
This tool is used to create chamfer on the gear hobbed or shaped
There are two types of tool. One type chamfers two corners of the tooth, while the other chamfers all four corners.
Special type of Deburring Cutter includes the follows(see sketch at right)
①Chamfer includes the root corner
②Chamfer parallel to the taper face
③Chamfer a taper from the tooth tip to root
This tool is made up of two gears, and can be adjusted.



Gear \ Chamfer	2 Corner Chamfer	All Corner Chamfer
Spur Gear	—	
Helical Gear		

Electro-Deposited Burnishing Tools

This is an electro-deposited diamond tool used for removing burrs or hit marks from heat treated gear corners.



Reverse Lead Taper Tooth Forming Tool

This tool efficiently forms a reverse lead taper on synchronizer sleeve of transmission. This process is done after broaching or shaping of the part.

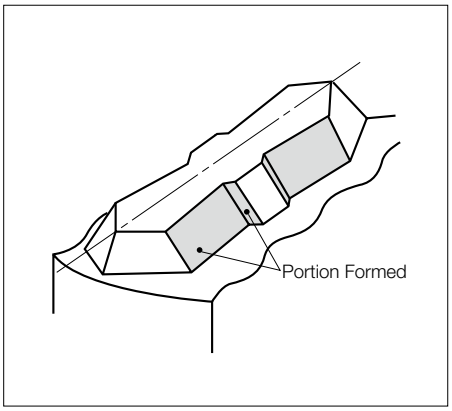
Rolling Tool

This tool forms a reverse lead taper by pushing into the radial direction of work while rolling.

- The Accuracy of the taper angle is within ±15'
- The burrs after rolled are so big as to be removed by Broaches or other tools

Rolling Tool

Work Piece



Realize finishing of 50-60 HRC herdend material Fruit broaching time is high efficiency for one second.

Hard Broaches

Highly precise broaching of the high hardness materials(50-60HRC).
Sectional carbide broach and hard broaching machine are used, and a high speed broaching in cutting speed 60m/min.
True cutting time is less than for one second.
Environment-Friendly with MQL system. No need for work piece washing out and dealing with waste fluid.

Hard Broach

Sample

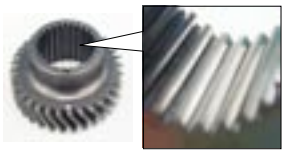
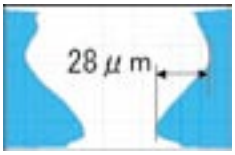
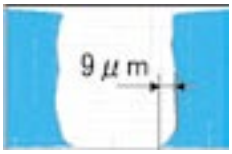
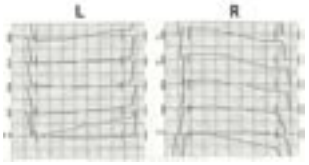
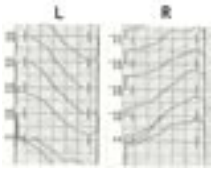
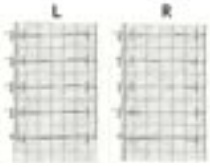
HW-5008

Applications

Involute spline hole (gear part for autos), CVT ball groove, various variant holes

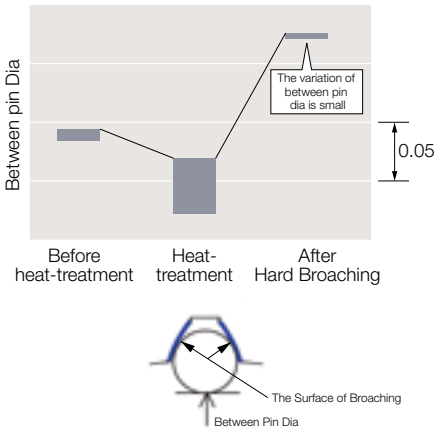
Features

Comparison of finished teeth

	Before	After
Appearance		
Squareness		
Profile		
Lead		

Work
No.of teeth : 24
Normal Module : 1
Normal Pressure Angle : 45°
Pitch Dia. : 24.000
Dia. : 16.971
Major Dia. : 25.46
Minor Dia. : 23.76

Between pin Dia.



Realize MQL broaching for the first time in the world

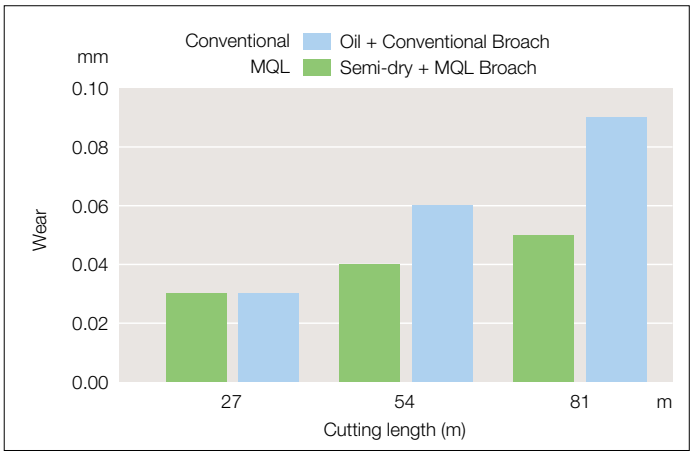
Broach for MQL

MQL broach cuts down the running cost by 15% comparing with coolant oil used.
Reduce a washing operation after broaching and improve the working efficiency.

Applications

Involute Spline, Involute Serratrion

Features



Work piece		S45C(200HB)
Broach		m2xPA30xNT16
Cutting conditions	Broaching speed	5m/min
	Cutting depth	0.06mm/Dia

What' MQL

MQL = Minimum Quantity Lubrication
= Mist Machining = Semi Dry Machining

Use a very small quantity of oil of 1～3cc per one hour, make oil mist of 1～2μm and machining while jetting in cutting edge.

MQL Broach

MQL Broaching
Realize a small amont of coolant broaching by turning cutting oil into mist.

Conventional
Too much quantity of oil is required.

NBM-5008

Realize balance and excellent accuracy

Off-normal Gullet Helical Broach PAT.

Off-normal Gullet" Helical Broach is the best broach to ensure accuracy of internal helical gears.
The angular design of gullet provides the best balanced cutting.
Improve accuracy of workpiece and tool life.

Assembly type

Solid type

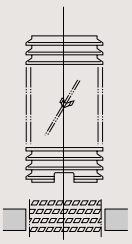
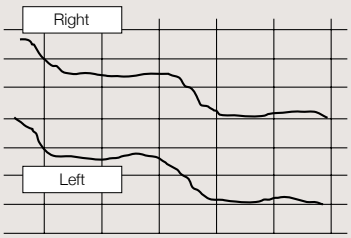
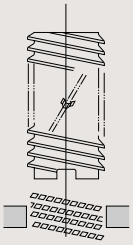
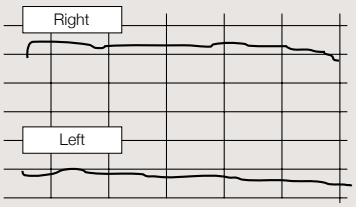
Internal helical gear

Applications

Internal Helical gears of Automatic Transmission

Features

Comparison of Lead Error

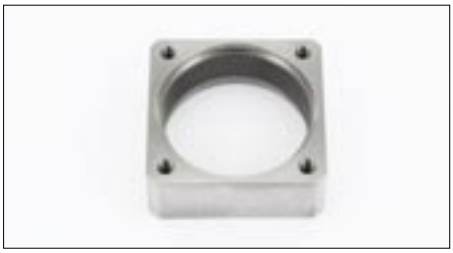
	Gullet	Comparison of Lead Error
Conventional Gullet		
Off-normal Gullet		

The lead error is improved by locating finishing teeth on spiral gash. (off-normal gullet) PAT.

Realize Broaching of Module 0.245

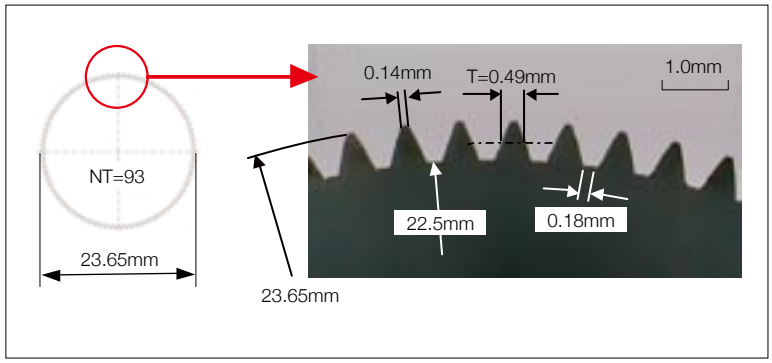
Micro Module Broaching

Best for highly accuracy broaching of a micro module
Apply to a standard gear of whole depth 2.25m

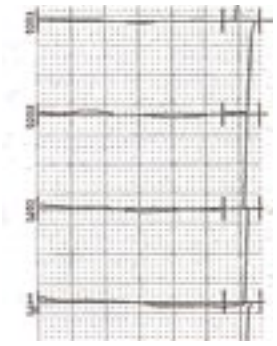
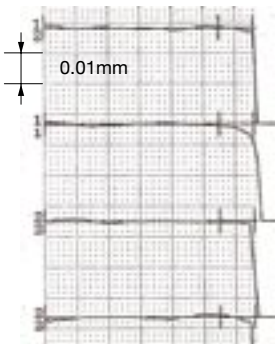
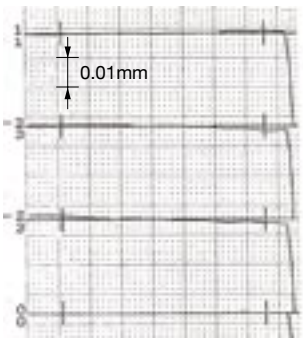


Applications

Compactification of planetary gear



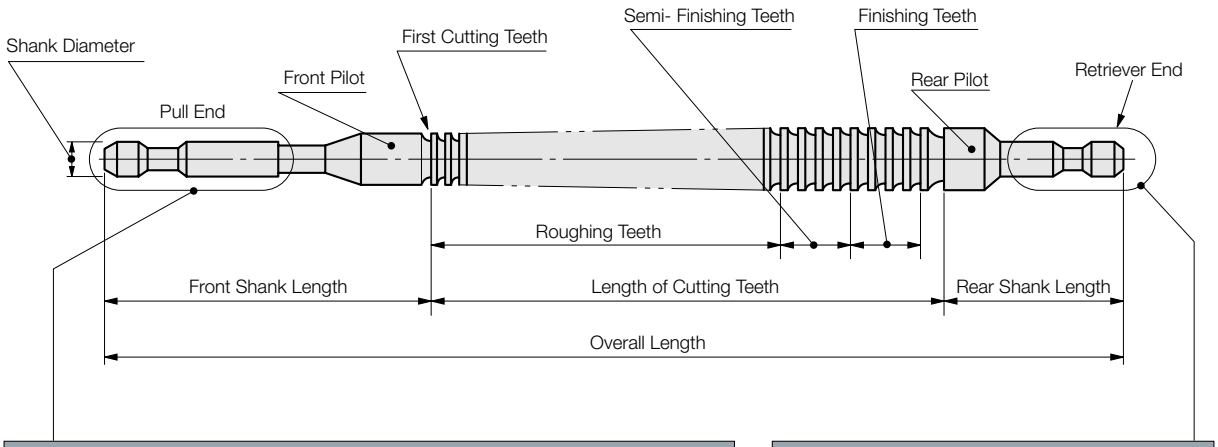
NBV-3-6 MNC

Profile error		Lead error	
Left	Right	Left	Right
			

Cutting conditions			
Machine	Vertical Machine NBM 5008	Cutting Oil	Mist
Work	SCM 435	Broach Length	900mm (Length of Cutting Teeth 290 mm)
Cutting speed	3m/min	Pulling Load	8.8KN (0.9Ton)

Terms

Internal Broaches

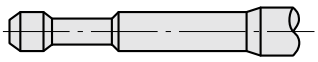


Types of Pull Ends

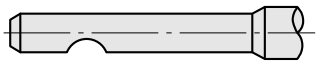
(1) Cotter Type

(3) Threaded Type

(2) Jaw/ Claw Type

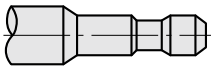


(4) Pin Type

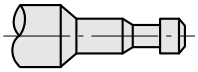


Types of Retriever Ends

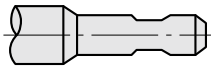
(1) RoundNeck Type



(2) Jaw/ Claw Type

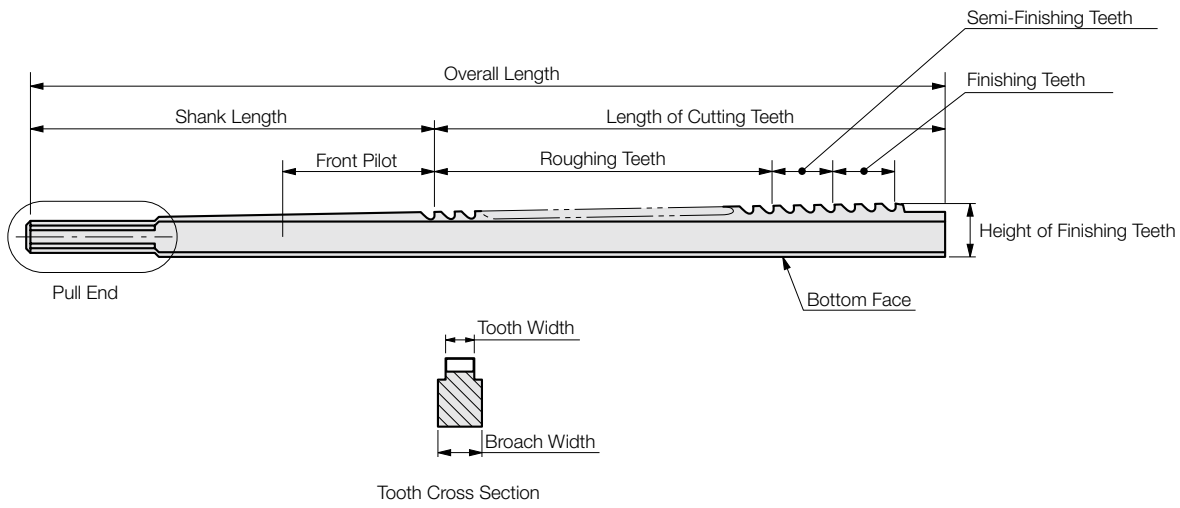


(3) Trapezoid Type (Flat Type)

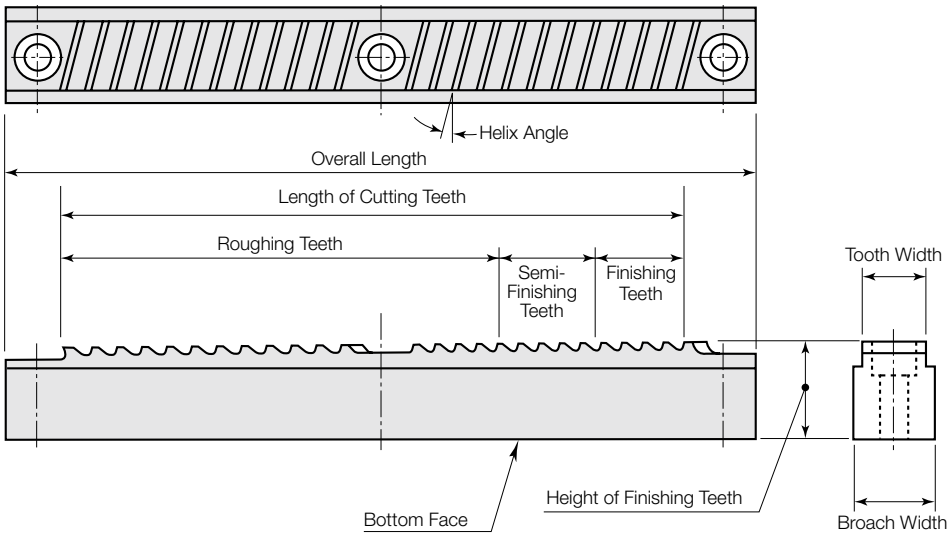


Roughing teeth	The cutting teeth to conduct main cutting.
Semi-finishing teeth	The cutting teeth having small cutting amount to be arranged before the finishing teeth.
Finishing teeth	The cutting teeth to finishing the workpiece to the specific dimensions . These are constituted usually with several cutting teeth of the same dimensions. Further, the cutting teeth after second one are called also as preparatory teeth.

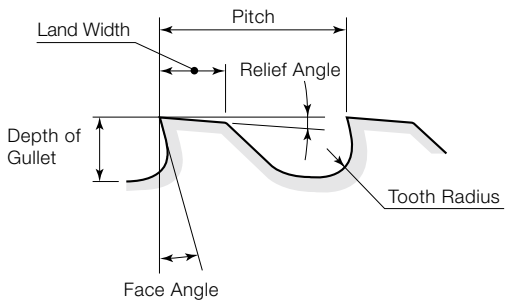
Keyway Broach



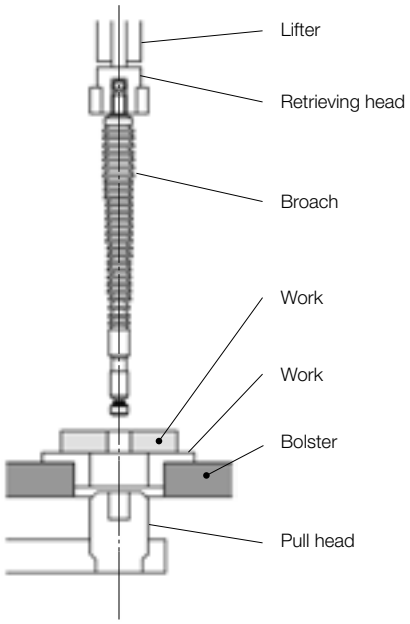
Slab Broach



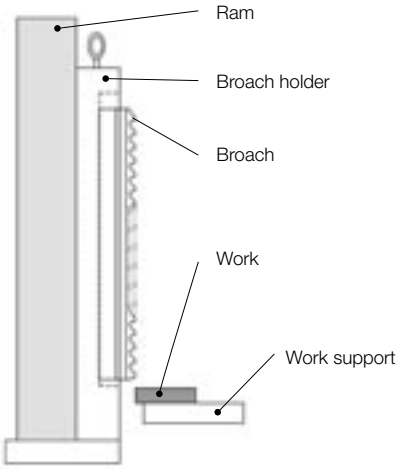
Gullet

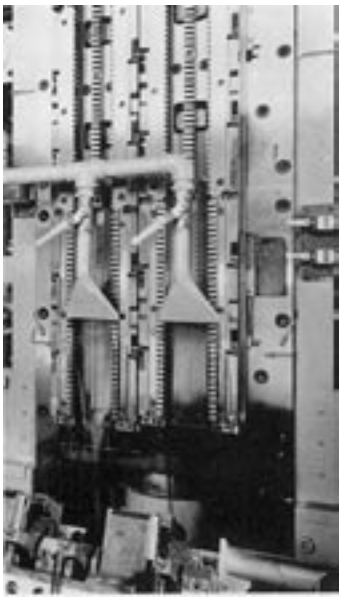


Internal broaching machine

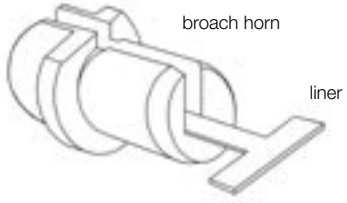


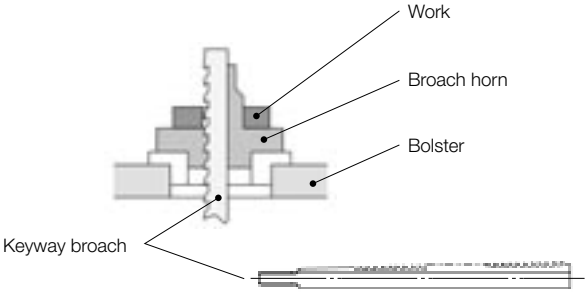
Surface broaching machine





Work support of keyway broaching

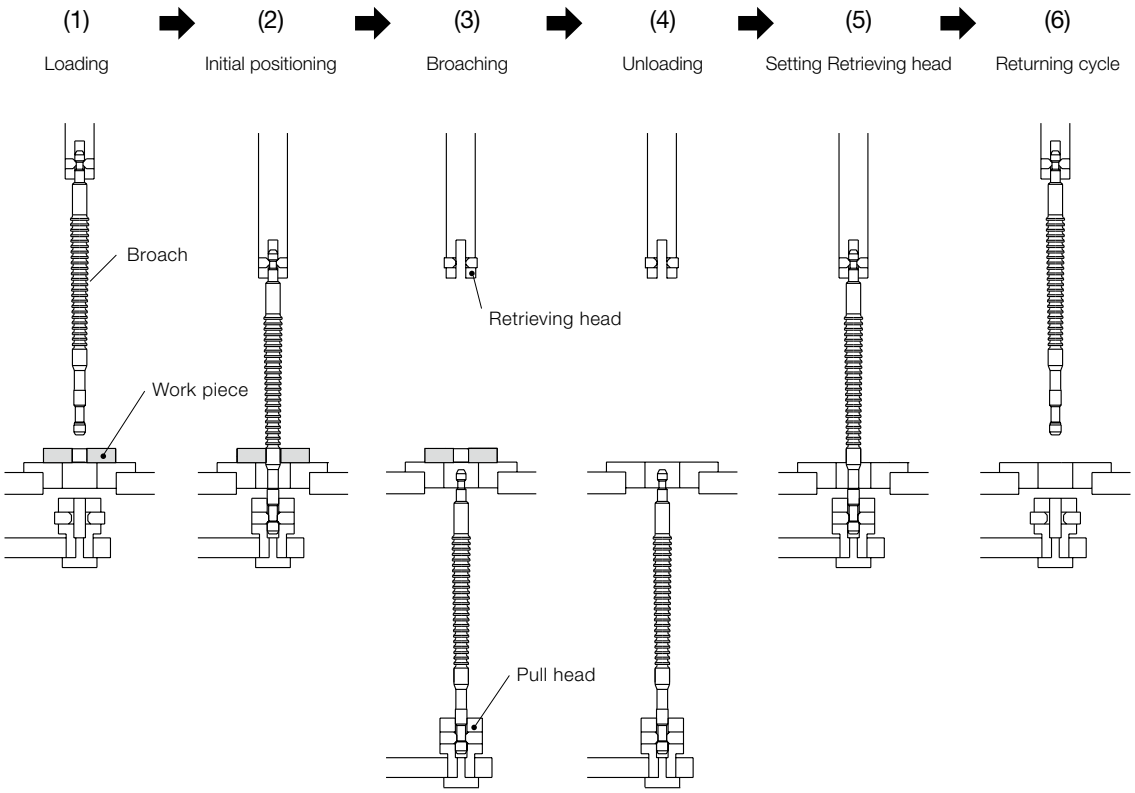




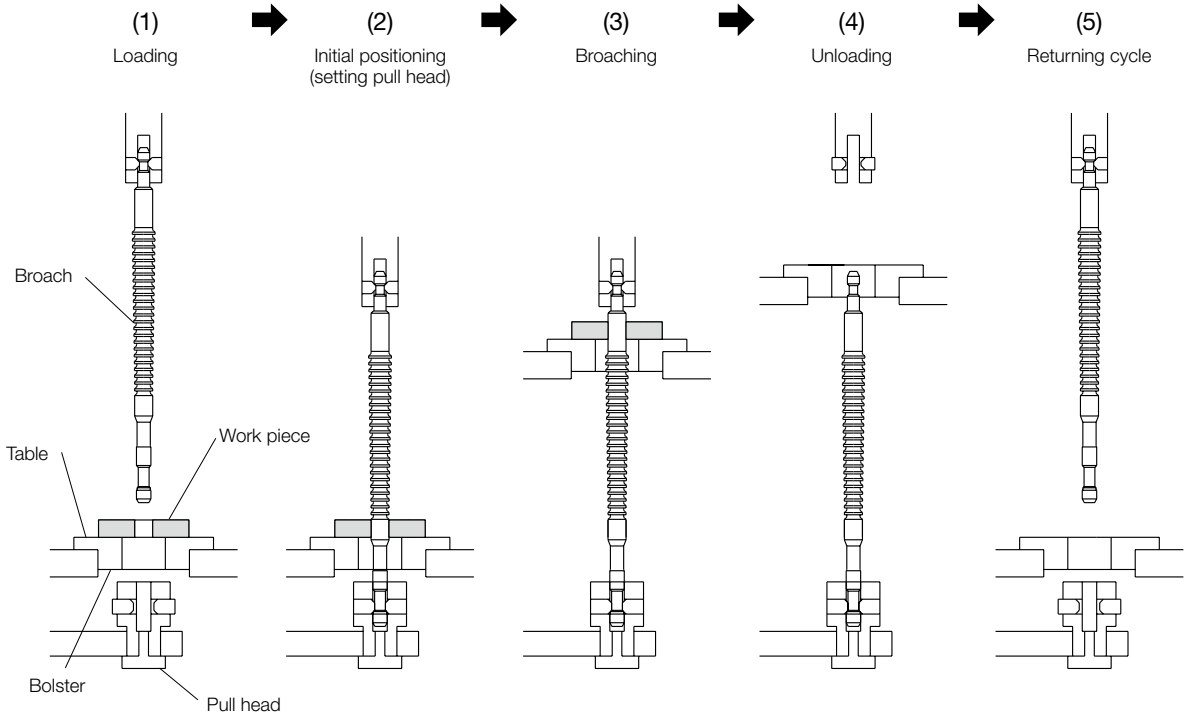
Broaching

Vertical internal broaching machine

Broach transfer type



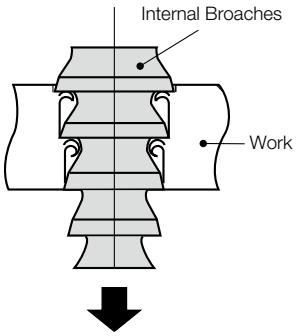
Work transfer type



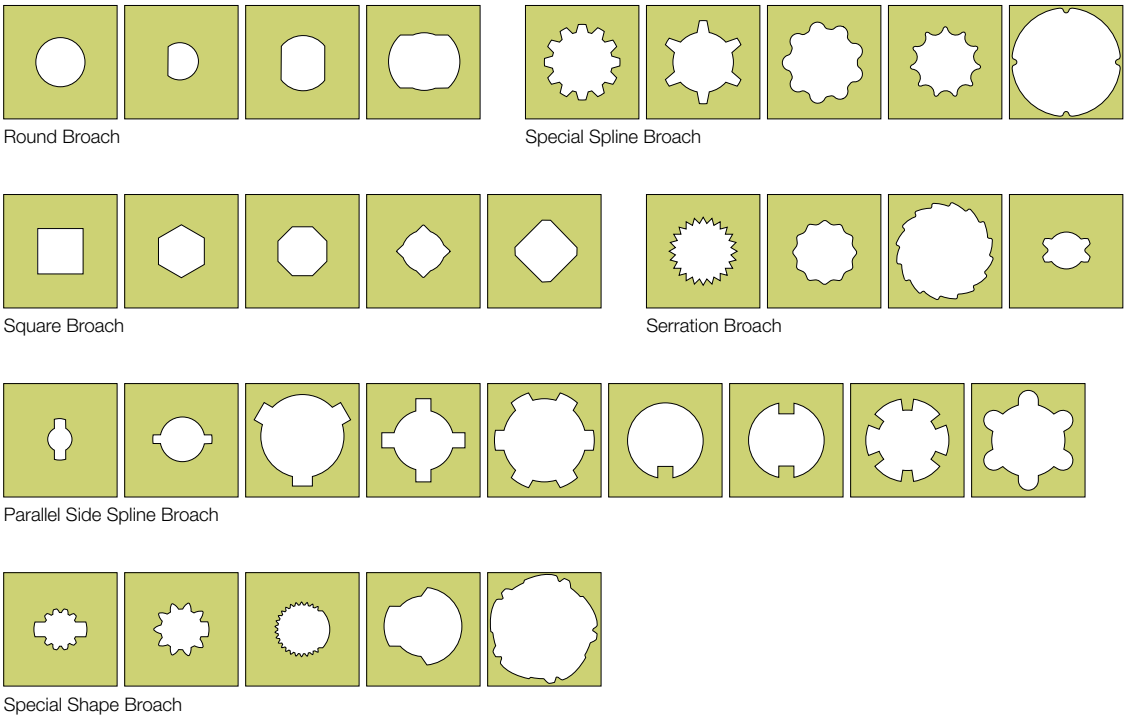
Internal Broaching

As for the internal broach, shape of indispensability can finish the inside of the cover crops.
A lower hole is opened to the cover crops beforehand and usually machines it through an internal broach in this hole.

Internal Broaching Process

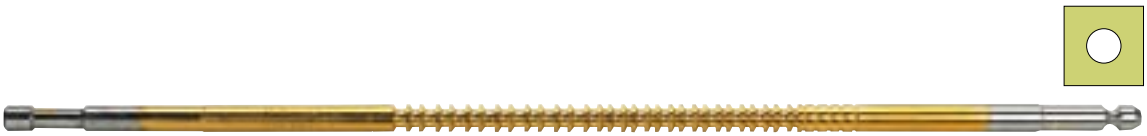


Work piece sample



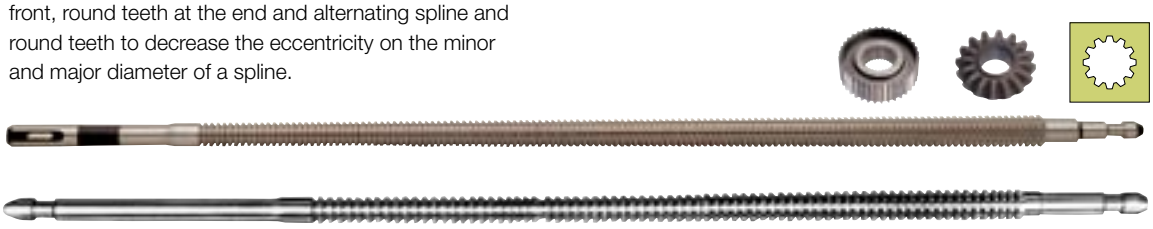
Round Broaches

Round broaches are finishing broaches used for highly precise round holes. There is burnishing broach to improve surface finish.



Involute Spline Broaches

Involute Spline Broaches are used in automotive mass-production.
There are three types of broaches with round teeth at the front, round teeth at the end and alternating spline and round teeth to decrease the eccentricity on the minor and major diameter of a spline.



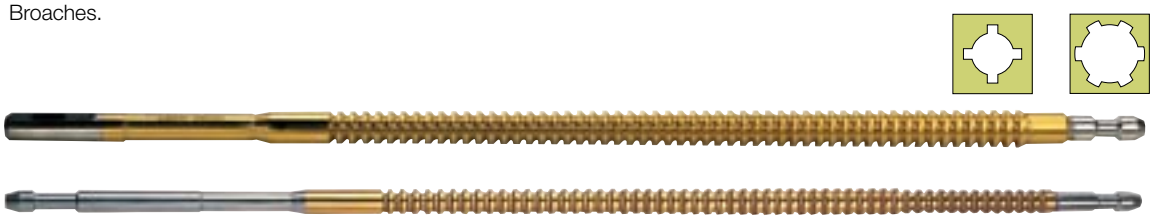
Round teeth at the front

Round teeth at the end

Alternating spline and round teeth

Parallel Side Spline Broaches

In track part or machine part production,
Parallel Side Broaches are mainly used, There are broaches with round teeth as well as Involute Spline Broaches.



Round teeth at the end

Push Broaches

Broaching is generally done by pulling, but in cases where the cutting stock is small. Push Broaches will be used.

Complicated Formed Spline Broaches

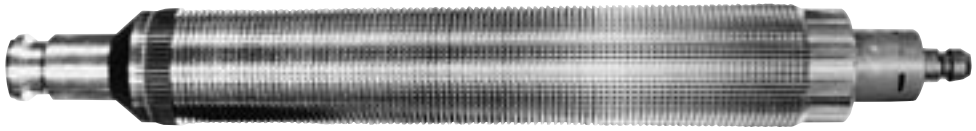
Various complicated formed broaches can be manufactured such as Outer Rotor Spline Broach and others.

Built-up Broaches

This broach is assembled of some broaches and used instead of solid broach to obtain more tool life and more accuracy of workpiece.

Large Diameter Broaches

NACHI can manufacture broaches with an outside diameter of 300mm and a weight of 500kg, and precise shell-type broaches for internal gears.

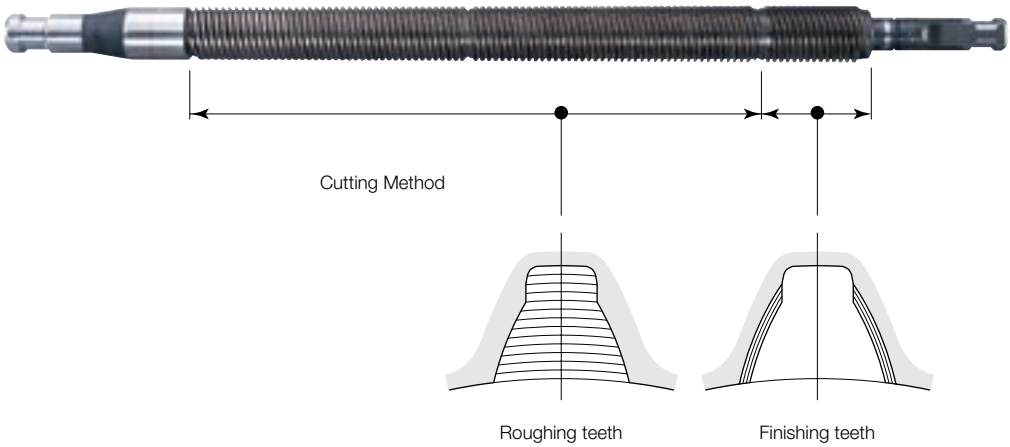


Helical Broaches

All of internal helical gears of automotive AT are fabricated by this helical broaches. This assembly broach design has a front roughing section and a removable floating shell-type finishing section with full involute teeth in rear section.

Assembly type

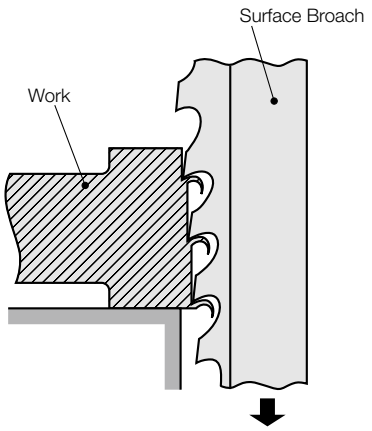
Solid type



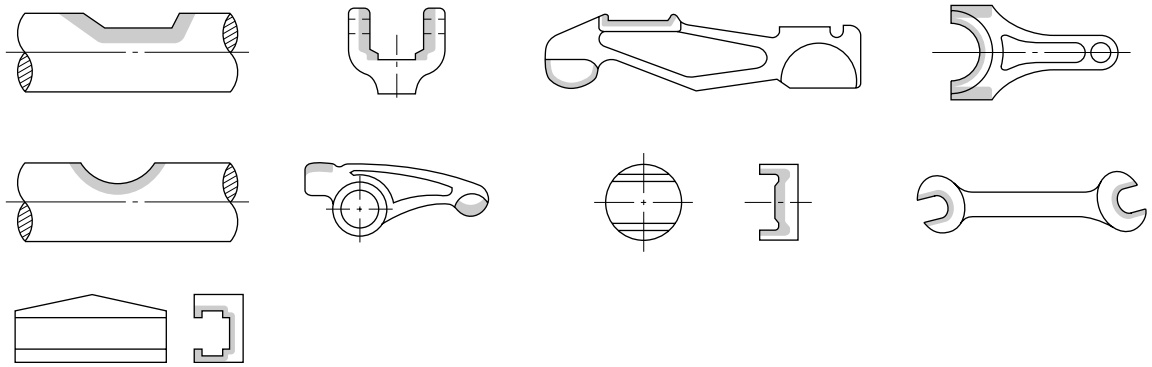
Surface Broaching

Used to remove metal from an external surface to produce a flat or contoured surface. It is more economical than milling cutter because of broaches allows roughing and finishing operation be continued.

Surface Broaching Process



Workpiece Sample

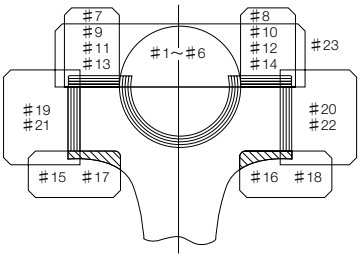


Connecting Rod Broaches

This is a broach to cut connecting rod and cap which is main part of engines.
NACHI can design and manufacture broaches and also broach holders.

Connecting Rod & Cap

Connecting Rod Cutting Method



Disc Brake Broaches

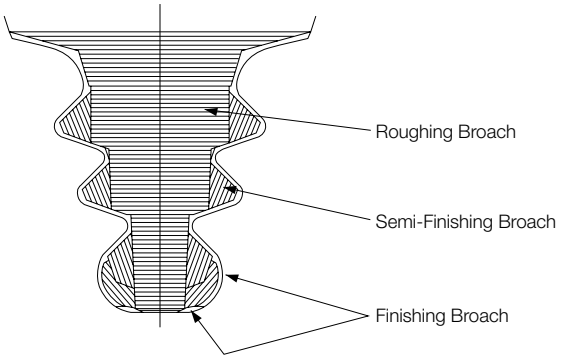
Mounting for Disk Brake

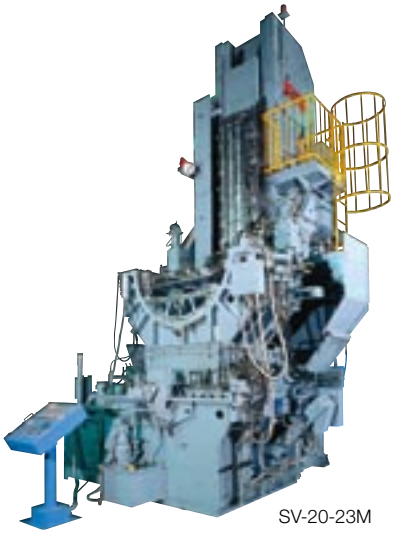
NSL-T Series

Fir Tree Type Broaches

These broaches are suitable for turbine rotor disk blade groove broaching of aircraft, ships and generators. Turbine rotors discs have a number of grooves in a christmas tree shapes which require high accuracy and their material is usually very hard to cut.
NACHI can manufacture highly precise chrismas tree type broaches.

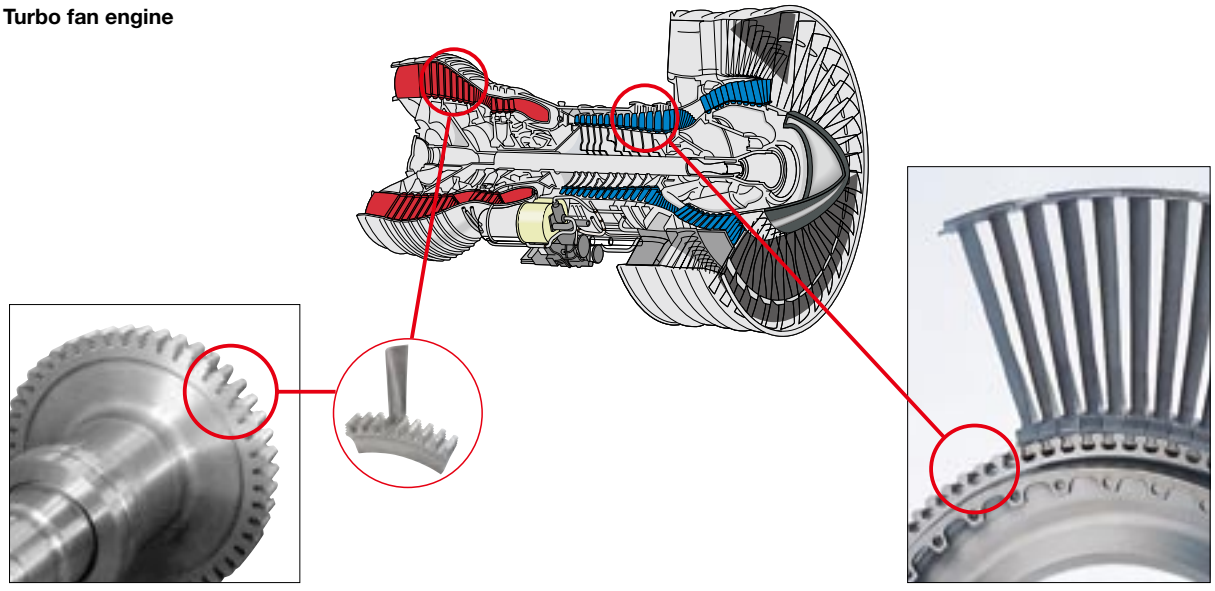
Fir Tree Broach Cutting Method





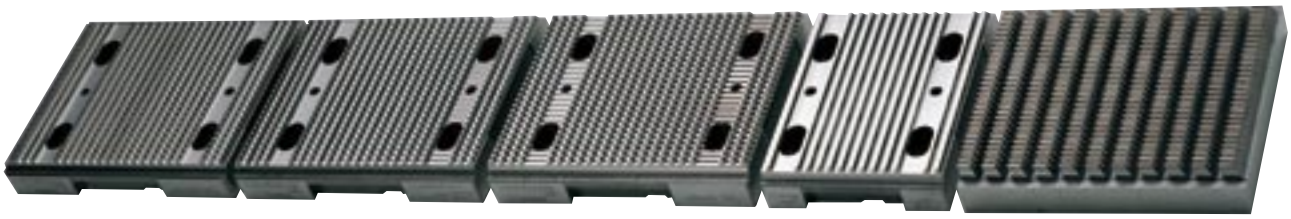
SV-20-23M

Turbo fan engine



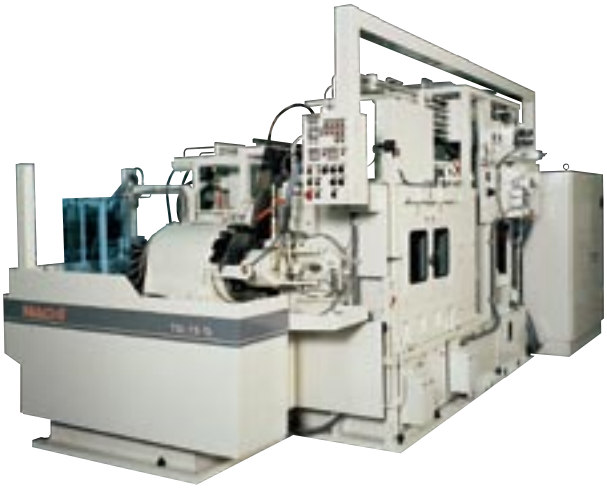
Steering Rack Broaches

This is used in broaching of automobile steering rack.
NACHI can manufacture broaches such as variable tooth thickness type, form relief type and inserted blade type.



Steering Rack Broaches

Steering Rack Bar

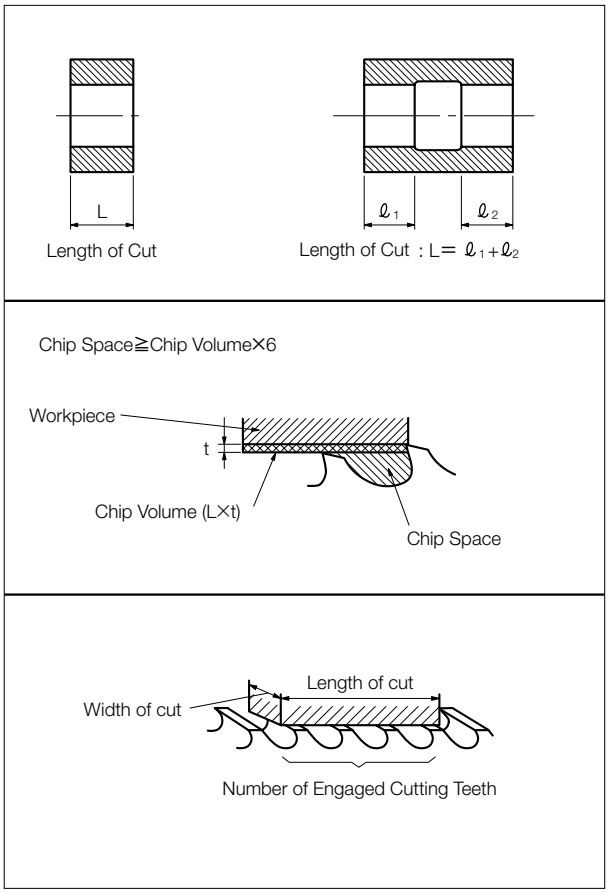


TSL-7.5-15

Main Design of Broach

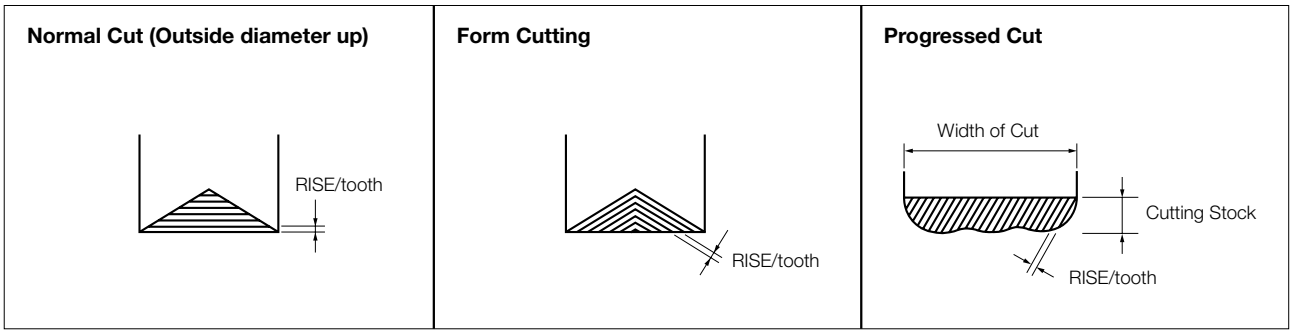
Basic Design

1. Pull End Shape
   This is determined based upon the broaching machine pull head.
2. Retriever End Shape
   This is determined based upon the broaching machine retriever head.
3. Tooth Pitch
   ·Pitch(P)=1.2～2.0$\sqrt{L}$
   ·The pitch is determined so that the chip do not become jammed in the chip space. The chip space must be larger 6 times than chip volume.
   ·Number of engaged cutting teeth(n)
   Normally more than 2 teeth cut at the same to time.
   n=L/P (raise decimals and above to the whole number)



Cutting Method

Cutting methods can be divided generally into, normal cutting, outline cutting and progressed cutting.



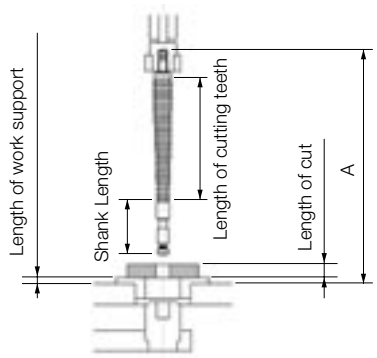
Calculation of Pulling Load

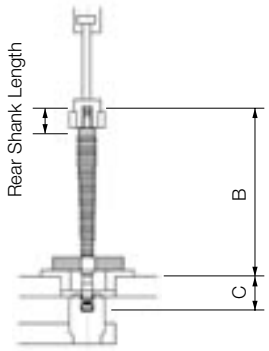
●Estimated Load (kN) =Width of Cut (mm)
× Cutting depth/Tooth (mm) × Number of engaged cutting teeth
× Specific cutting resisitance (kN/mm^2)
●Safty Load (kN) =1.8 × Estimated Load
An example calculation
Parallel side spline:20×16×4×6SP
Material:Alloy Steels, Length of Cut=25mm
●Pitch=1.5×$\sqrt{}$25=7.5
●Number of Engaged Cutting teeth=25/7.5=3.3 → 4
●Cutting Depth/Tooth = 0.025mm
●Specific Cutting Force = 2.94kN/mm^2
●Estimated Load = (4×6)×0.025×2.94×4=7kN
●Safty Load = 1.8×7=12.6kN

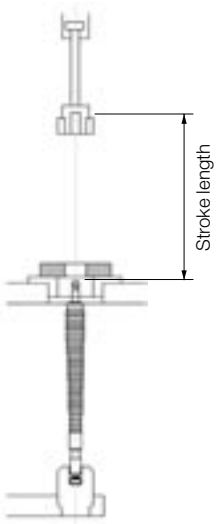
Work Material	Cutting depth/Tooth (μm)			Specific cutting Force (kN/mm^2)
	Round Broach	Spline Broach	Surface Broach	
Carbon Steels	10～20	25～30	30～70	2.94～3.92
Alloy Steels	10～20	25～30	30～70	2.94
Cast Irons	25～40	25～40	50～75	1.96
Malleable Cast Irons	25～35	25～35	50～75	1.35～2.94
Stainless Steels	20～30	20～30	30～60	3.92
Non-ferrous Alloys	35～50	30～40	60～100	0.98～1.96

Broach Length and Machine Stroke

Broach length is limited by machine stroke and fixture
●Length of Cutting Teeth + Rear Shank Length < Max. machine stroke − Length of Cut
●Required stroke = Length of Cutting Teeth + Rear Shank Length + Length of Cut < Max. machine stroke



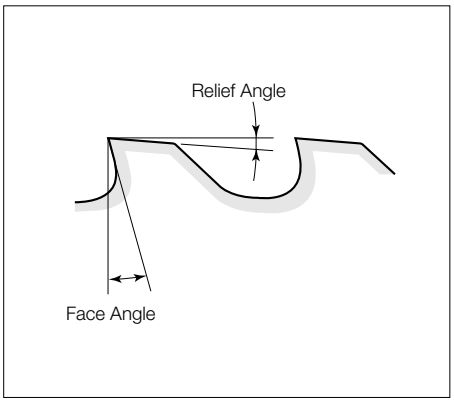




Broach Length(Max) = A(Max) − (Length of Work Support + Length of Cutting Teeth)
Broach Length(Min) = B(Min) − C(Min)

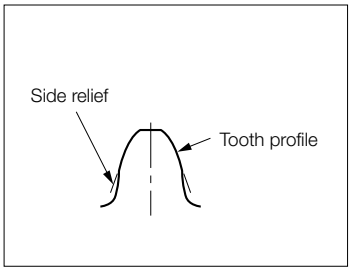
Face Angle, Relief Angle

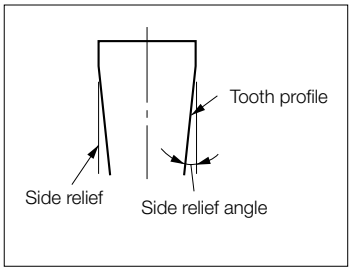
Work Material		Face Angle	Relief Angle
Steels	Low Tensile Strength	13～20°	2°
	Mid Tensile Strength	10～15°	2°
	High Tensile Strength	10～13°	2°
Cast Iron, Malleable Cast Iron		10°	2°
Bronze, Brass		3°	0.5°
Alminum Alloys		15～20°	2°



Side Relief

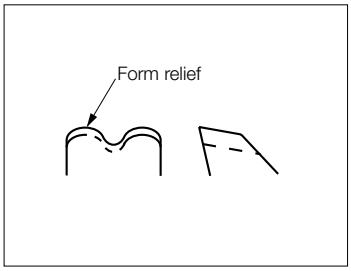
The relief to relieve from the form cut with remaining the part near the cutting edge.





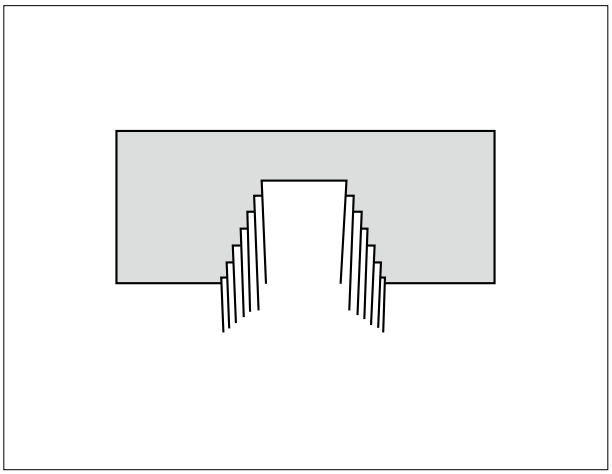
Form Relief

The relief to relieve by the same form as the tooth profile .



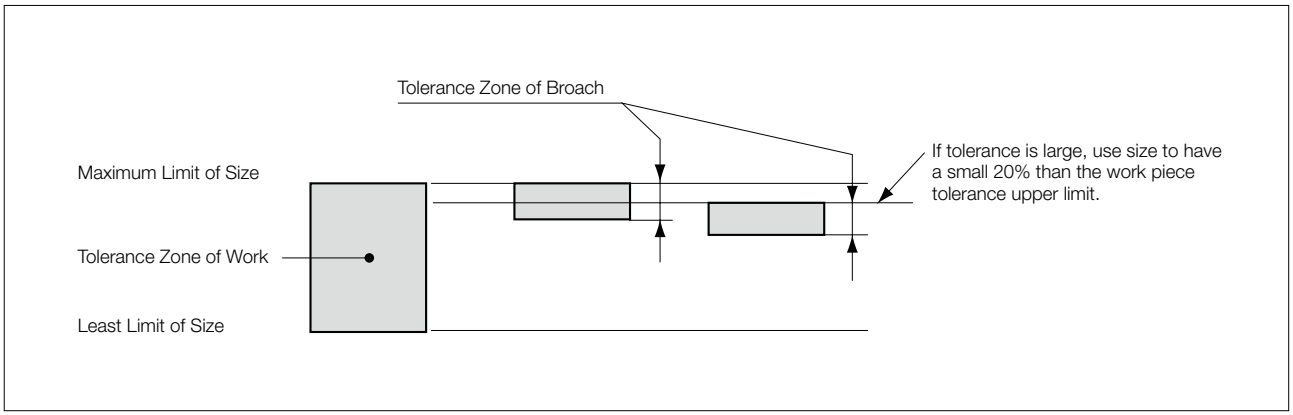
Back taper

The back taper is a method for making back tapered side relief on a broach for splines, serrations and involute splines.

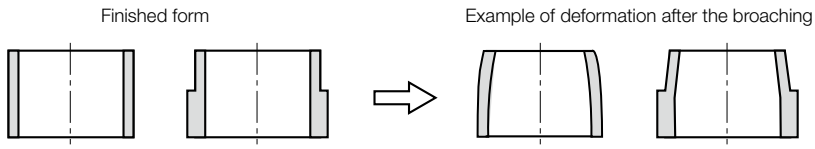


Finished size of broaches

Generally, it is set its target size of broach to the upper limit of the tolerance band of the work piece.
For example, if the finished size of the work piece is $\phi 25^{+33}_{0}$, then set the target size of the broach to ϕ25.033.
However, if the work piece has a large tolerance, use a target value that is 20% smaller than the maximum tolerance of the work piece.
The actual finishing size of work piece is affected by its hardness, shape, cutting length as well as the thickness of the part and the cutting conditions (cutting speed cutting, cutting fluid etc.) which may change the dimensions of the work piece after broaching.
Because of this, set the broaches target size a little larger in advance, and do a few trials to decide with consideration to what is needed.



Example of Thin Woll Thickness



The work materials while broaching in order to receive thrust, plastic deformation occurs.
Because of that, the work materials after the broaching have the case that becomes smaller than the finished size of broaches.

Workpiece Hardness

Part hardness of 200～230HB is generally used for broaching,
however parts with a hardness up to 300HB are widly broached.
If extremely soft steel is broached, it causes tearing on the surface on part.
Hardness over 300HB shortens the tool life.

Cutting Speed

Cutting Speed infuences the accuracy, the workpiece roughness and tool life.
The table right shows recommended cutting speed.

Work Material		Cutting Speed
Steels		3～8m/min
Stainless Steels	Tough	2～5m/min
	Free Machining	6～8m/min
Cast Iron, Malleable Cast Iron		10m/min
Bronze, Brass		10m/min
Alminum Alloys		10m/min
Magnesium		10m/min

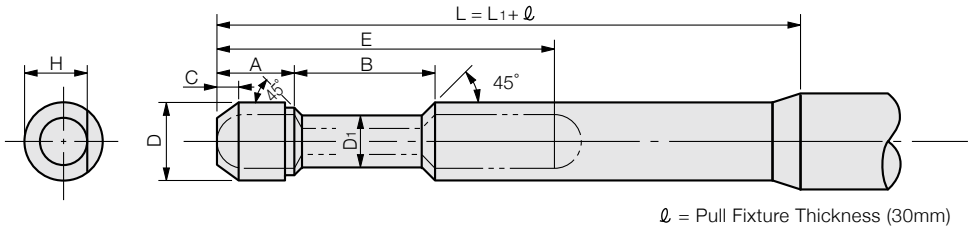
Cutting Fluids

Cutting fluid influences broach life, accuracy and efficiency, according to what type it is. It is essential to select a suitable cutting fluid depending on the work piece material. The table, on the under table, shows recommended cutting fluids. Environmentally friendly chlorine-free coolants are also supported. Specifically types of cutting fluids that contain large amounts of inorganic additives, which are not inferior in terms of maintaining performance in piece count, machining active sulfuric chloride with its large amounts of chlorine.
On top of that, we have extensive experience in MQL machining, improving work environments, eliminating cleaning processes, reducing energy, and increasing tool life.

MQL : Minimum Quantity of Lubrication

Work Material	Cutting Fluids
Steels	Active sulfur type oil
Stainless steels	Active sulfur type oil
Cast Iron	Water soluble Oil or Dry
Copper Alloy	Compound Oil
Alminum Alloys	Water soluble Oil

Jaw Pull End Standard Dimensions



ℓ = Pull Fixture Thickness (30mm)

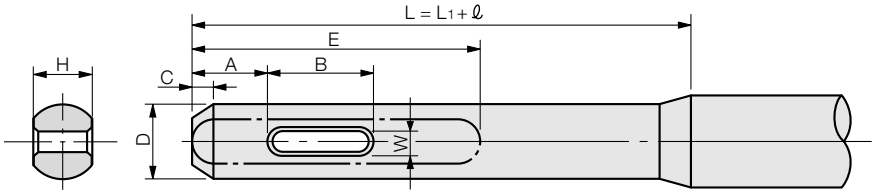
Unit : mm

Pre-broached Hole Diameter d	Shank Diameter D		Neck Diameter D1		Length to Neck A	Neck Length B	Chamfer Length C	Flat Width E	Flat Height H		Max. Load Permitted (kN)	Length to Front Pilot L Type1	Type2	Type3
10.5＜d≦12.5	10	0 −0.022	7.5	0 −0.08	12	25	3	80	8.5	−0.04 −0.076	10	150	170	180
12.5＜d≦14.5	12	0 −0.027	9						10.5	−0.05 −0.093	20	150	170	180
14.5＜d≦16.5	14		10.5	0 −0.10					12		30	150	170	180
16.5＜d≦18.5	16		12		15	30	4	90	13.5		40	160	180	190
18.5＜d≦20.5	18		13.5						15		50	160	180	190
20.5＜d≦22.5	20	0 −0.033	15						17		70	170	190	200
22.5＜d≦26	22		16.5						18.5	−0.065 −0.117	80	170	190	200
26 ＜d≦29	25		19	0 −0.15	18	35	5	100	21.5		110	180	200	210
29 ＜d≦33	28		21						24		130	180	200	210
33 ＜d≦37	32	0 −0.039	24					110	27.5		180	–	210	220
37 ＜d≦41	36		27						31	−0.08 −0.142	220	–	210	220
41 ＜d≦47	40		30		20	40	6	120	34.5		280	–	225	235
47 ＜d≦52	45		34	0 −0.20					39		360	–	225	235
52 ＜d≦57	50		38						43.5		450	–	225	235
57 ＜d≦62	55	0 −0.046	41		25	50	8		48		550	–	235	245
62 ＜d≦67	60		45					140	53	−0.1 −0.174	630	–	235	245
67 ＜d≦72	65		48						57		720	–	235	245
72 ＜d≦78	70		52		30		10	170	60		850	–	–	255
d＞78	75		56						65		1000	–	–	255

As Length to Front Pilot is changed by type of Broaching Machine, it's necessary to select by next table.

Type	Applicable Broaching Machine
1	NBV-5, 7.5 NBM BV-T5, T7.5, T10 NUV-10
2	NUV-15
3	BV-T15, T20 NUV-20

Cotter Pull End Standard Dimensions



ℓ = Pull Fixture Thickness (30mm)

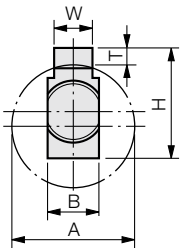
Unit : mm

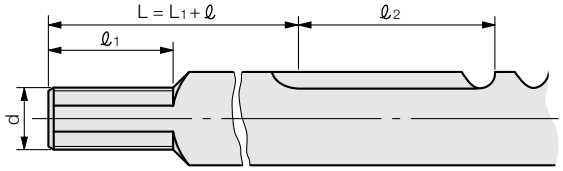
Pre-broached Hole Diameter d	Shank Diameter D		Length to Cotter Hole A	Cotter Hole Length B	Cotter Hole Width W	Chamfer Length C	Flat Width H	Flat Length E	Max. Load Permitted (kN)	Length to Front Pilot L		
										Type1	Type2	Type3
10.5 <d≦12.5	10	0 −0.022	16	16	3	3	9	50	20	170	190	220
12.5 <d≦14.5	12	0 −0.027	18	18	3.5		10		30	175	195	225
14.5 <d≦16.5	14				4		12		40	175	195	225
16.5 <d≦18.5	16			20	5	4	14	55	50	180	200	230
18.5 <d≦20.5	18				5.5		16		60	180	200	230
20.5 <d≦22.5	20	0 −0.033		25	6.5		18	60	70	185	205	235
22.5 <d≦26	22		20				20		100	185	205	235
26 <d≦29	25			32	7	5	22	65	130	195	215	245
29 <d≦33	28						25	70	170	195	215	245
33 <d≦37	32	0 −0.039			8		28		230	195	215	245
37 <d≦41	36		22	40	9		33	80	280	205	225	255
41 <d≦47	40				11	6	36		340	205	225	255
47 <d≦52	45				13		40		420	205	225	255
52 <d≦57	50		25	45	14		45	90	530	215	235	265
57 <d≦62	55	0 −0.046				8	50		660	215	235	265
62 <d≦67	60			50	16		55	100	770			270
67 <d≦72	65						58		950			270
72 <d≦78	70		30	55	18	10	63	110	1080			280
d>78	75						68		1270			280

As Length to Front Pilot is changed by type of Broaching Machine, it's necessary to select by next table.

Type	Applicable Broaching Machine
1	NBV-5, 7.5 NBM BV-T5, T7.5, T10 NUV-10
2	NUV-15
3	BV-T15, T20 NUV-20

Threaded Pull End Standard Dimensions





ℓ = Pull Fixture Thickness
ℓ2 > Part Length×2

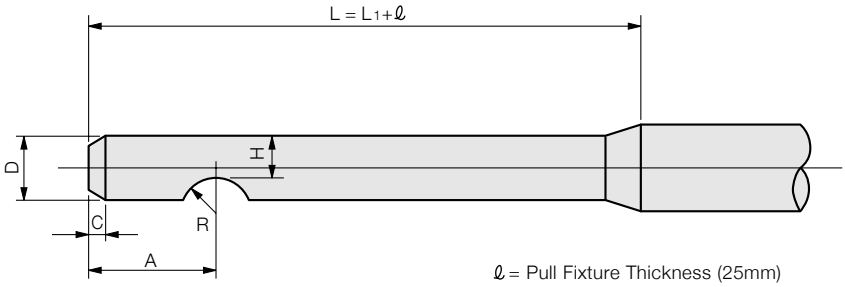
Unit : mm

Keyway Width W × Keyway Depth T	Minimum Diameter A	Height of Finshing Teeth H	Broach Width B		Thread Size d	Thread Length ℓ1	Max. Load Permitted (kN)	Length to Front Pilot L		
								Type1	Type2	Type3
3×1.5	10	9	5	0 −0.012	M 6×1.0	20	10	125	145	175
3×1.5	12	10				20	10	125	145	175
4×2	10	9				20	10	125	145	175
4×2	12	10	6		M 8×1.25	25	12	130	150	180
4×2	15	13	7	0 −0.015		25	12	130	150	180
5×2.5	13	11				25	12	130	150	180
5×2.5	15	13	8		M10×1.5	30	19	135	155	185
5×2.5	18	16	9			30	19	135	155	185
6×3	18	16				30	19	135	155	185
6×3	22	19	11	0 −0.018	M12×1.75	35	28	145	165	195
7×3.5	18	16	9	0 −0.015	M10×1.5	30	19	140	160	190
7×3.5	22	19	11	0 −0.018	M12×1.75	35	28	145	165	195
8×3.5	24	21	12		M14×2.0	40	39	150	170	200
10×4	30	26	15		M16×2.0	40	54	150	170	200
12×4	40	32	17		M18×2.5	50	66	160	180	210
15×5.5	50	36	19	0 −0.021	M20×2.5	50	85	160	180	210

As Length to Front Pilot is changed by type of Broaching Machine, it's necessary to select by next table.

Type	Applicable Broaching Machine
1	NBV-5, 7.5 NBM BV-T5, T7.5, T10 NUV-10
2	NUV-15
3	BV-T15, T20 NUV-20

Pin Pull End Standard Dimensions



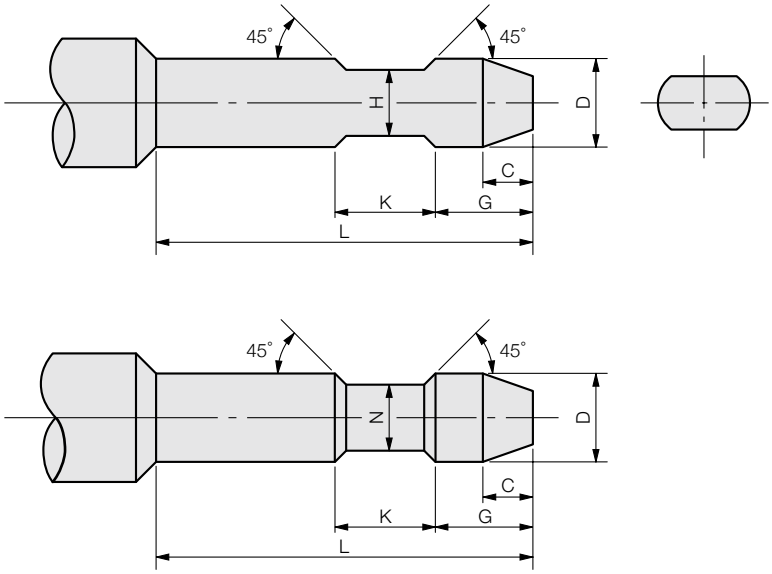
Unit : mm

Pre-broached Hole Diameter d	Shank Diameter D		Length from Pin Center A	Chamfer Length C	Pin Gullet Height H		Gullet Radius R		Max. Load Permitted (kN)	Length to Front Pilot L Type1	Length to Front Pilot L Type2
3.3 <d≦ 3.7	3.2	0 −0.018	10	0.5	2.2	0 −0.1	2.5	+0.2 0	2	145	165
3.7 <d≦ 4.1	3.6				2.5				3		
4.1 <d≦ 4.6	4		12	1	2.8		3		4		
4.6 <d≦ 5.1	4.5				3.2	0 −0.15			5		
5.1 <d≦ 5.6	5		13		3.5				6	150	170
5.6 <d≦ 6.2	5.5				4				7		
6.2 <d≦ 7.2	6				4.5				9		
7.2 <d≦ 8.2	7	0 −0.022	14	1.5	5	0 −0.2	4	+0.3 0	13		
8.2 <d≦ 9.2	8		16		5.5		4.5		14		
9.2 <d≦ 10.2	9		18		6.5		5		19	155	175
10.2 <d≦ 11.2	10		20	2	7	0 −0.25	5.5		23		
11.2 <d≦ 12.5	11	0 −0.027	22		8		6		29	160	180
d> 12.5	12		25		8.5		7		35		

As Length to Front Pilot is changed by type of Broaching Machine, it's necessary to select by next table.

Type	Applicable Broaching Machine
1	NBV-5, 7.5 NBM BV-T5, T7.5, T10 NUV-10
2	NUV-15

Spring Retriever End Standard Dimensions



Unit : mm

Pre-broached Hole Diameter d	Shank Diameter D		Flat Width or Neck Diameter H, N		Length to Neck G	Neck Length K	Chamfer Length C	Length to Rear Pilot L	Broach Weight Permitted (kg)
18<d≦ 23	15	−0.006 −0.033	11	0 −0.1	16	16	8	60	12.6
23<d≦ 29	20	−0.007 −0.04	14		20	20		70	17.5
29<d≦ 35	25		18						19.6
35<d≦ 41	30		22	0 −0.15	25	25	10	80	21.7
41<d≦ 47	35	−0.009 −0.048	26						23.1
47<d≦ 55	40		30						51
55<d≦ 65	45		34	0 −0.2					55
65<d≦ 75	50		38		30	30	12	90	59
75<d≦ 100	60	−0.01 −0.056	48						89
d> 100	75		63						105

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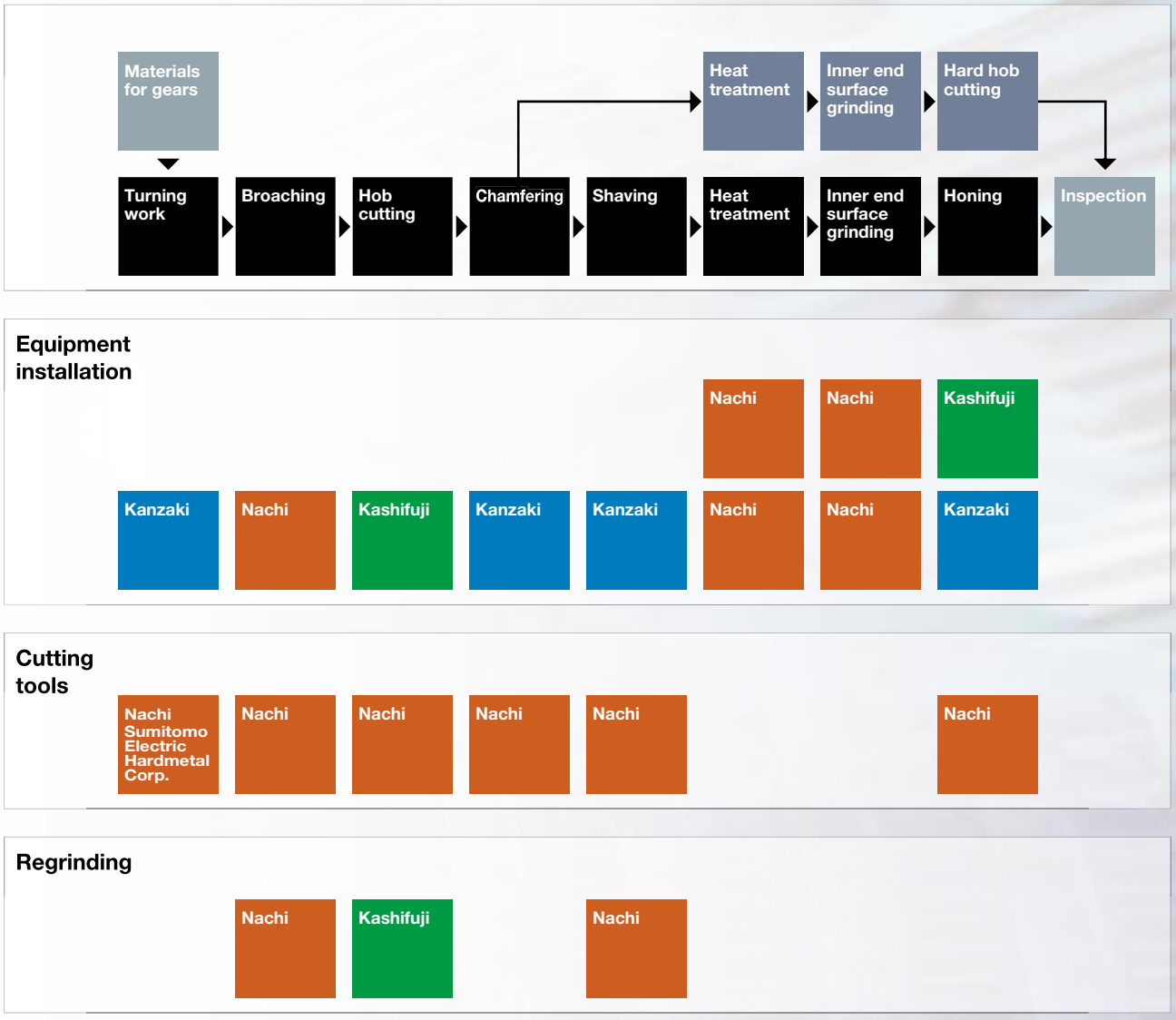
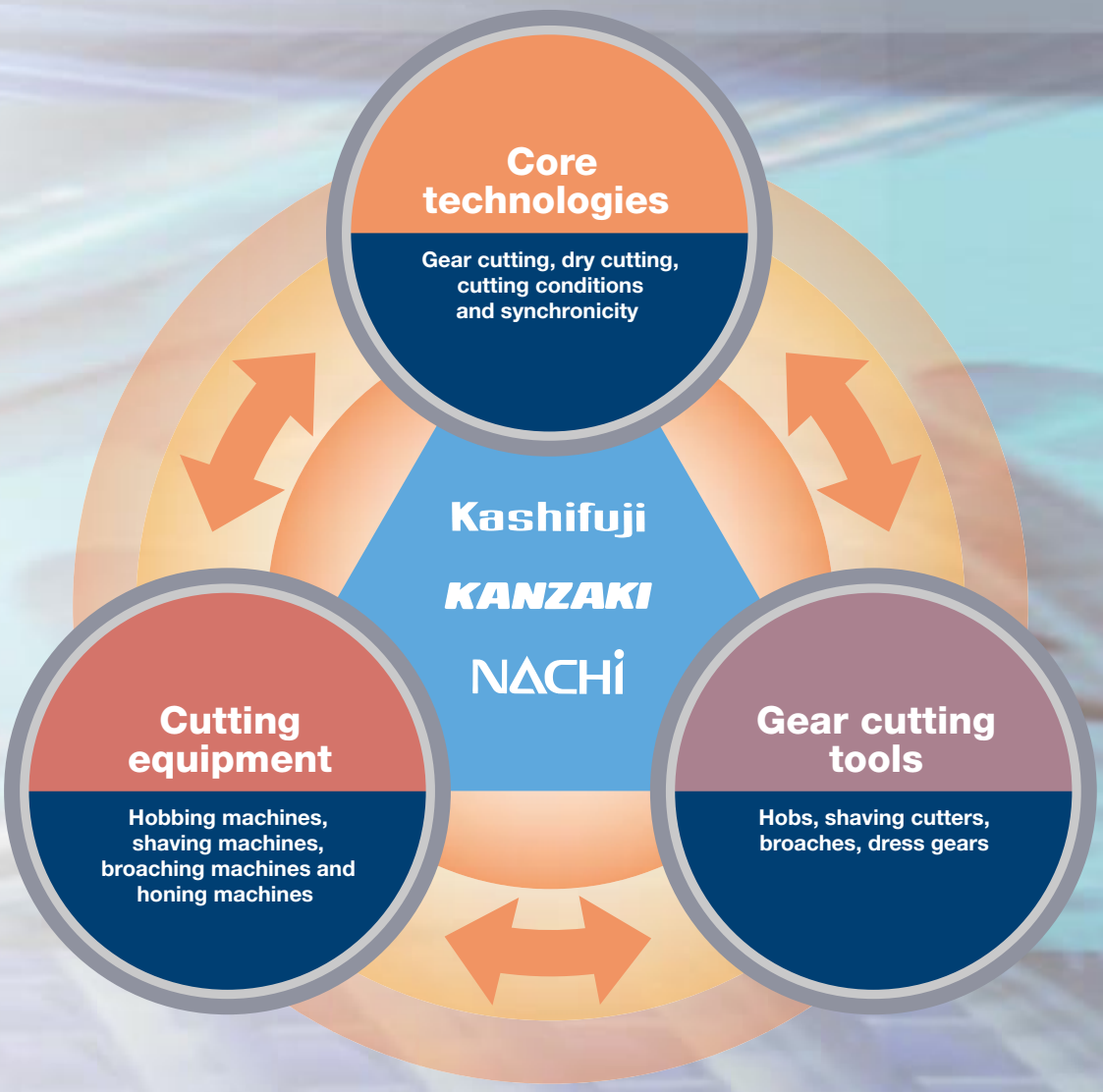
Gear Cutting Process Task Assignments for Tools and Machinery



Gear Production Alliance



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