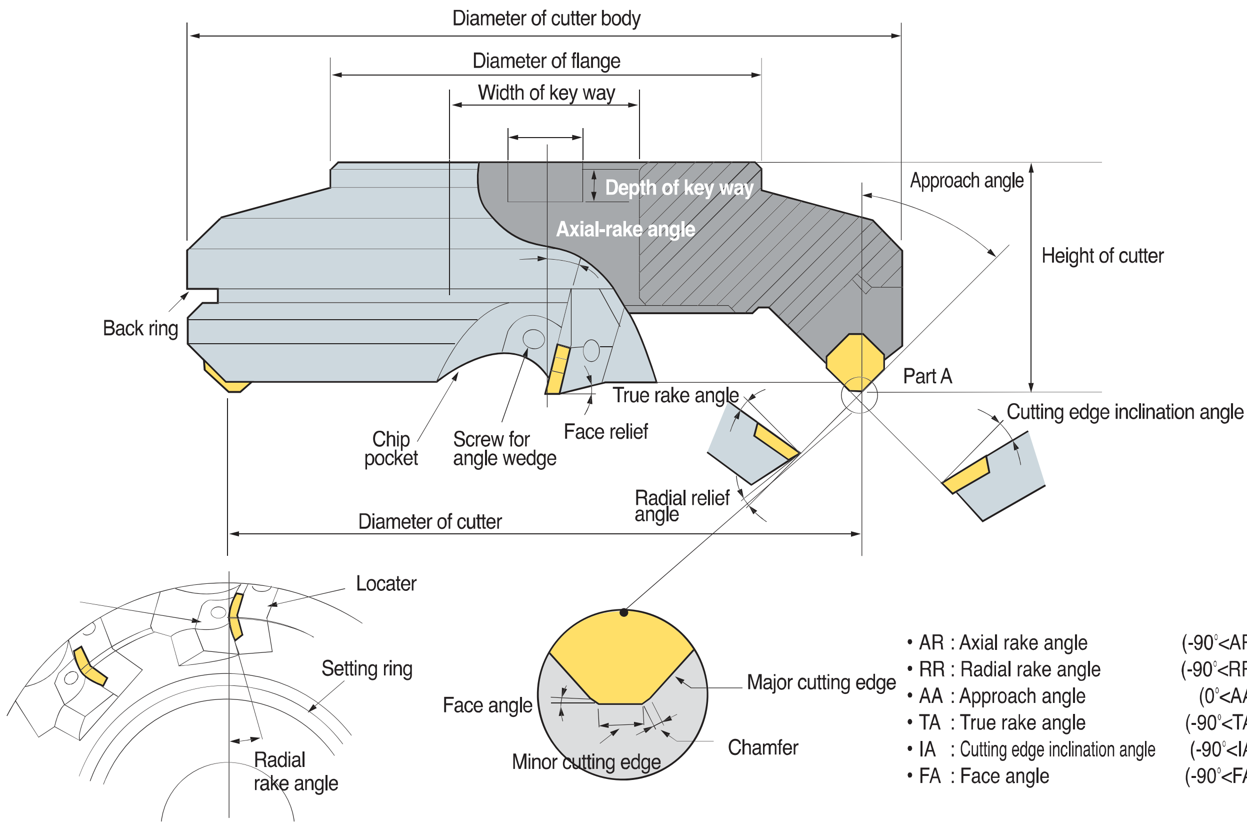
Milling cutter shape and designation

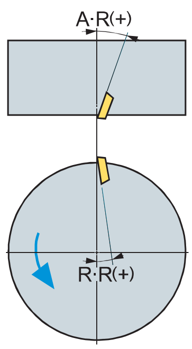
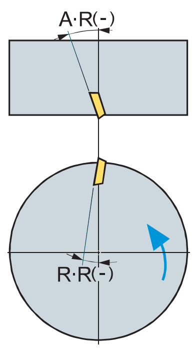
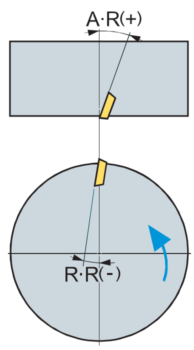
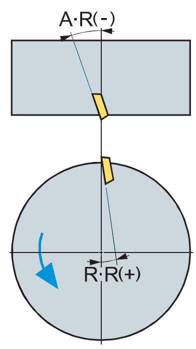


- AR : Axial rake angle $(-90^\circ < AR < 90^\circ)$
- RR : Radial rake angle $(-90^\circ < RR < 90^\circ)$
- AA : Approach angle $(0^\circ < AA < 90^\circ)$
- TA : True rake angle $(-90^\circ < TA < 90^\circ)$
- IA : Cutting edge inclination angle $(-90^\circ < IA < 90^\circ)$
- FA : Face angle $(-90^\circ < FA < 90^\circ)$

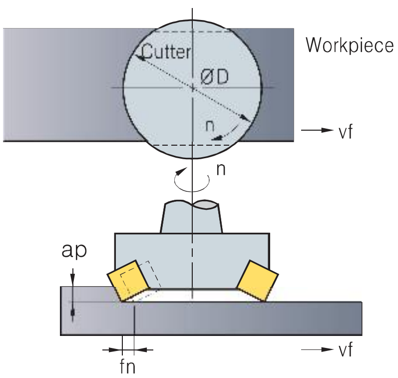
The terminology and functions of cutting edge angle

	Tool failure	Symbol	Function	Effects
1	Axial rake angle	A.R	Chip flow direction, Adhesion	-
2	Radial rake angle	R.R	Affecting on thrust	-
3	Approach angle	A.A	Chip thickness, Determines flow direction	(+) : Chip thickness become thinner, cutting force could be reduced.
4	True rake angle	T.A	Effective rake angle	(+) : Better cutting. Preventing adhesion, Weakening cutting edge strength. (-) : Cutting edge strength increases, easy to adhere
5	Cutting edge inclination angle	I.A	Determines chip flow direction	(+) : Good chip flow, cutting force decreases, Corner edge strength weakens
6	Face angle	F.A	Controlling surface roughness for finishing	(-) : Surface roughness improves
7	Relief angle	R.A	Controlling cutting edge strength, tool life and chattering	-

Features by combination of rake angle

	Double positive angle	Double negative angle	Posi - Negative angle	Nega - Positive angle
				
Use	• General machining of steel, cast iron, stainless steel • Machining soft steel that brings about built-up edge easily • Machining material having tendency to poor surface roughness	• Under interrupted cutting condition • Roughing of cast iron and steel	• Machining difficult to cut material • Roughing with deep depth of cut and wide width of cut in steel and cast iron	• Chip flows to center of cutter body
Advantages	• As for tough workpiece material It prevents built-up edge to improve surface roughness. • Low cutting load and better machinability	• Strong cutting edge. • Roughing of workpiece that has bad surface condition containing sand, mill scale • Double sided inserts can be applied(Economical). • Good chip control.	• Good chip flow and machinability. • Suitable for machining of difficult-to-cut material • Un-even partition clamping prevents chattering	-
Disadvantages	• Weak cutting edge strength. • Only single sided inserts are available (No economical). • Machine and cutter need enough power and rigidity.	• Machine and cutter need enough power and rigidity.	• Only single sided inserts are available (No economical)	• Since the chips flows toward the center of cutter. Chips scratch on machined surface. • Bad chip flow. • No economical

Major cutting formulas



● Cutting speed

$$vc = \frac{\pi \cdot D \cdot n}{1000} \text{ (m/min)}$$

- •vc : Cutting speed (m/min)
- •D : Diameter of tool (mm)
- •n : Revolution per minute (min^{-1})
- •π : Circular constant (3.14)

● Feed

$$fz = \frac{vf}{z \cdot n} \text{ (mm/t)}$$

- •fz : Feed per tooth (mm/t)
- •vf : Feed per minute (mm/min)
- •n : Revolution per minute (min^{-1})
- •z : Number of tooth

● Chip removal amount

$$Q = \frac{L \times vf \times ap}{1000} \text{ (cm}^3\text{/min)}$$

- •Q : Chip removal amount (cm^3/min)
- •L : Width of cut (mm)
- •vf : Table feed (mm/min)
- •ap : Depth of cut (mm)

● Power requirement

$$P_{kw} = \frac{Q \times kc}{60 \times 102 \times \eta} \qquad P_{hp} = \frac{P_{kw}}{0.75}$$

- •Pc : Power requirement (kW)
- •H : Horse power requirement (hp) (mm/min)
- •Q : Chip removal amount (cm^3/min)
- •kc : Specific cutting resistance (kgf/mm^2)
- •η : Machine efficiency rate (0.7~0.8)

● Machining time

$$T = \frac{60 \times Lt}{vf} \text{ (sec)}$$

- •T : Machining time (sec)
- •Lt : Total length of table feed (mm)(=Lw+D+2R)
- •Lw : The length of workpiece (mm)
- •D : The diameter of cutter body (mm)
- •vf : Table feed (mm/min)
- •R : Relief length (mm)

● True rake angle / Cutting edge inclination angle

True rake angle $\tan(T) = \tan(R) \times \cos(AA) + \tan(A) \times \sin(C)$

Cutting edge inclination angle $\tan(I) = \tan(A) \times \cos(AA) - \tan(R) \times \sin(C)$

Values of specific cutting resistance

Workpiece	Tensile strength (kg/㎟) and hardness	Specific cutting resistance according to various feed kc(MPa) 0.1 (mm/t)	0.2 (mm/t)	0.3 (mm/t)	0.4 (mm/t)	0.6 (mm/t)
Soft steel	52	220	195	182	170	158
Medium carbon steel	62	198	180	173	160	157
High carbon steel	72	252	220	204	185	174
Tool steel	67	198	180	173	170	160
Tool steel	77	203	180	175	170	158
Chrome manganese steel	77	230	200	188	175	166
Chrome manganese steel	63	275	230	206	180	178
Chrome molybdenum steel	73	254	225	214	200	180
Chrome molybdenum steel	60	218	200	186	180	167
Nickel Chrome molybdenum steel	94	200	180	168	160	150
Nickel Chrome molybdenum steel	HB352	210	190	176	170	153
Cast steel	52	280	250	232	220	204
Hardened cast iron	HRC46	300	270	250	240	220
Meehanite cast iron	36	218	200	175	160	147
Gray cast iron	HB200	175	140	124	105	97
Brass	50	115	95	80	70	63
Light alloy(Al - Mg)	16	58	48	40	35	32
Light alloy(Al - Si)	20	70	60	52	45	39

Chip removal amount(cm3/min) per rated horse power

Workpiece	Rated horse power	5Hp	10Hp	20Hp	30Hp	40Hp	50Hp
Steel	Soft	32	75	163	295	425	570
	Medium	26	55	127	212	310	425
	hard	18	41	93	163	228	310
Cast iron	Soft	52	116	260	455	670	880
	Medium	32	75	163	295	425	570
	hard	26	55	127	212	310	425
Bronze Brass	Soft	77	163	390	670	980	1,280
	Medium	54	118	275	490	700	910
	hard	26	55	127	245	325	425
Aluminum		90	195	440	780	1,110	1,500

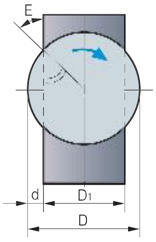
Selection of MILL-MAX diameter(D)

Selection by machine rigidity

Machine horse power(PS)	10~15	15~20	Over 20
Proper cutter body specification(mm)	ø80~ø100	ø125~ø160	ø160~ø200

Selection by machine rigidity

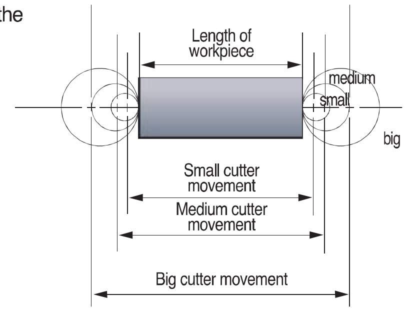
Workpiece	E	δ
Steel	+20°~-10°	3 : 2
Cast iron	Under +50°	5 : 4
Light alloy	Under +40°	5 : 3



D : External diameter of cutter body
D1 : Width of workpiece
d : Projected part of cutter body
E : Engage angle
δ : Ratio of cutter body and width of workpiece(D:D1)

Selection by machining time

The bigger size cutter the longer machining time.

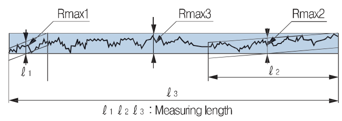
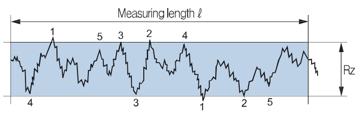
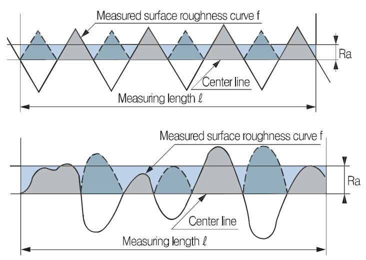


Selection by number of tooth

Workpiece	Steel	Cast iron	Light alloy
Number of tooth	D×(1~1.5)	D×(1~4)	D×1+α

ex) D=ø100 ⇒4″×(1~1.5)=4~6 D is the size of cutter body converted into inch size.

Classification of surface roughness

Type	Symbol	How to calculate	Measured value
Maximum height	Rmax	• The distance between the top of profile peak line and the bottom of profile valley line on this sampled portion is measured in the longitudinal magnification direction of roughness curve (Expressed by unit: µ). • Exclude extraordinary values(too small or big) that look like grooves or mountains.	
+10 point mean roughness	Rz	• Sampled from the roughness curve in the direction of its mean line, the sum of the average value of absolute value of the highest profile peaks and the depths of five deepest profile valleys measured in the vertical magnification direction is expressed by micro meter(µ).	
Arithmetic mean roughness	Ra	• Sampling only the reference length from the roughness curve in the direction of mean line , taking X-axis in the direction of mean line and Y-axis in the direction of longitudinal magnification of this sampled part and is expressed by micro meter(µ). • Generally, Read measured value by Ra measurer.	

Finish mark		▽▽▽▽	▽▽▽	▽▽	▽	~
Surface roughness	Rmax	0.8s	6.3s	25s	100s	Unspecified
	Rz	0.8z	6.3z	25z	100z	
	Ra	0.2a	1.6a	6.3a	25a	