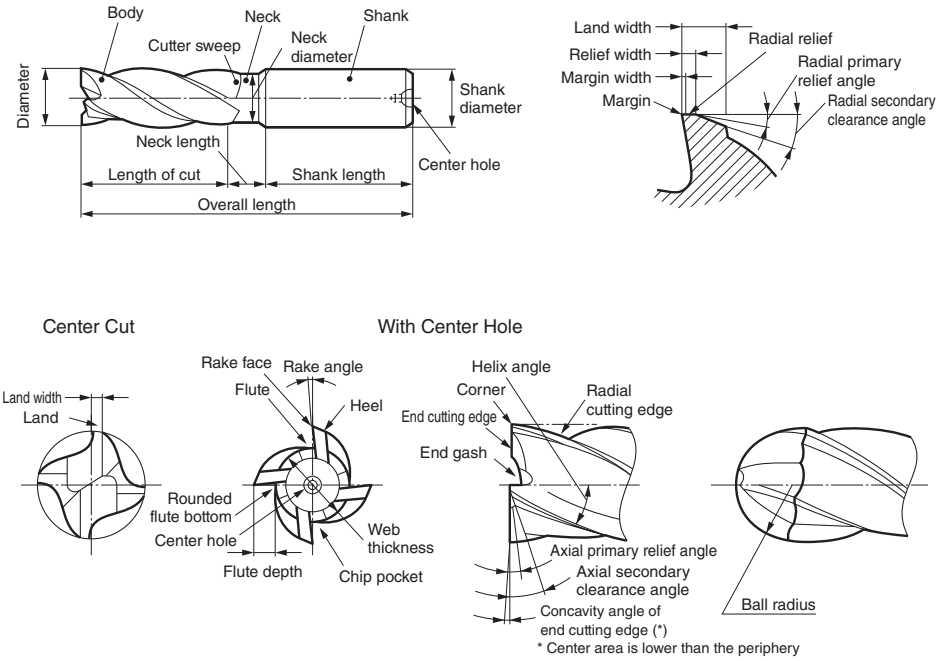
■ Parts of an Endmill



■ Calculating Cutting Conditions (Square Endmill)

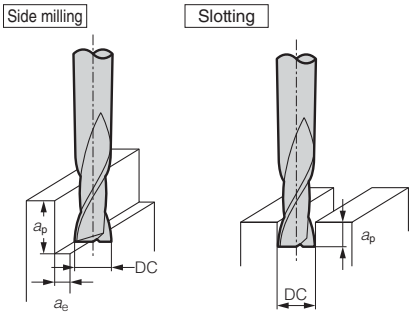
● Calculating Cutting Speed

$$v_c = \frac{\pi \times DC \times n}{1{,}000} \qquad n = \frac{1{,}000 \times v_c}{\pi \times DC}$$

● Calculating Feed Rate Per Revolution and Per Tooth

$$v_f = n \times f \qquad f = \frac{v_f}{n}$$

$$v_f = n \times f_z \times z \qquad f_z = \frac{f}{z} = \frac{v_f}{n \times z}$$

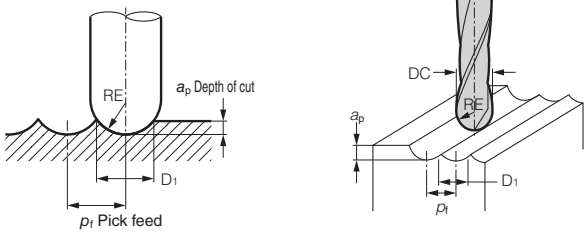


(Ball Endmill)

● Calculating Notch Width (D_1)

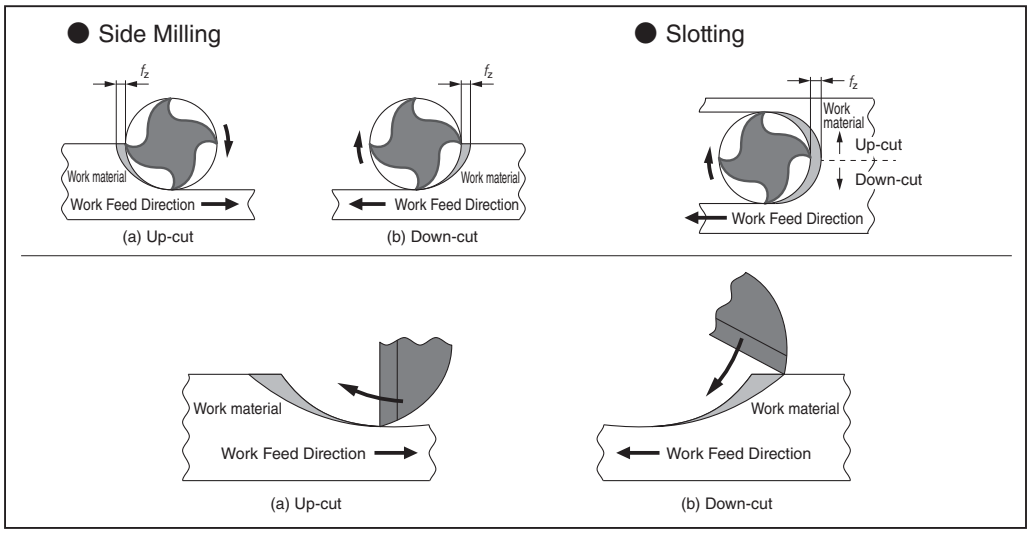
$$D_1 = 2 \times \sqrt{2 \times RE \times a_p - a_p^2}$$

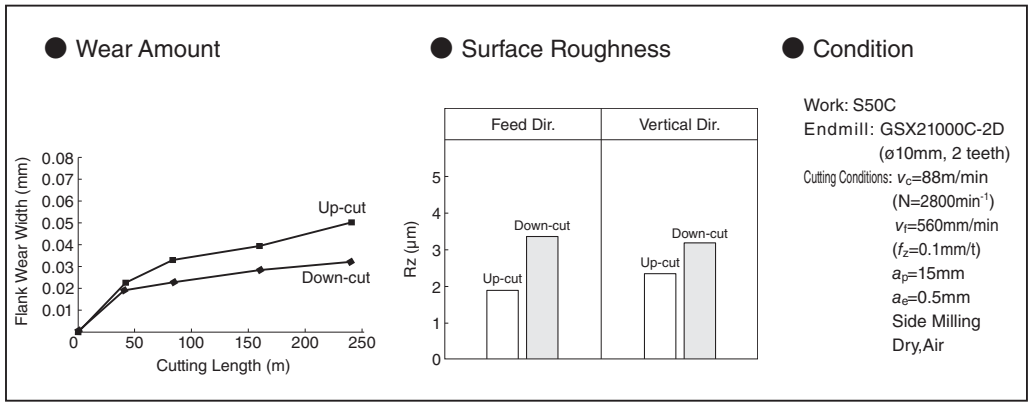
● Cutting speed and feed rate (per revolution and per tooth) are calculated using the same formula as square endmill.



v_c : Cutting speed (m/min)
π : ≈ 3.14
DC : Endmill diameter (mm)
n : Spindle speed (min^{-1})
v_f : Feed rate (mm/min)
f : Feed rate per revolution (mm/rev)
f_z : Feed rate per tooth (mm/t)
z : Number of teeth
a_p : Axial Depth of Cut (mm)
a_e : Radial Depth of Cut (mm)
RE : Ballnose Radius

■ Up-cut and Down-cut

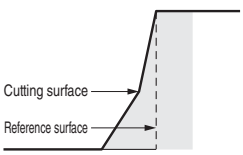




■ Relation Between Cutting Condition and Deflection

Endmill Specifications			Side Milling: Work: Pre-hardened steel (40HRC) Cutting Conditions: v_c=25m/min a_p=12mm a_e=0.8mm		Slotting: Work: Pre-hardened steel (40HRC) Cutting Conditions: v_c=25m/min a_p=8mm a_e=8mm	
Cat. No.	Number of Teeth	Helix Angle	Feed rate 0.16mm/rev Style		Feed rate 0.11mm/rev Style	
			Up-cut	Down-cut	Up-cut	Down-cut
GSX20800S-2D	2	30°				
GSX40800S-2D	4	30°				
Results			· The tool tip tends to back off with the down-cut. · 4 teeth offers more rigidity and less backing off.			

Endmill Specifications			Slotting: Work: Pre-hardened steel (40HRC) Cutting Conditions: v_c=25m/min a_p=8mm a_e=8mm	
Cat. No.	Number of Teeth	Helix Angle	Feed rate 0.05mm/rev Style	Feed rate 0.03mm/rev Style
			Up-cut / Down-cut	Up-cut / Down-cut
GSX20800S-2D	2	30°		
GSX40800S-2D	4	30°		
Results			· The side of the slot tends to cut into the up-cut side toward the bottom of the slot. · 4 teeth offers higher rigidity and less deflection.	



■ Troubleshooting for Endmilling

	Failure	Cause		Remedies
Cutting Edge Failure	Excessive Wear	Cutting Conditions Tool Shape Tool Material	· Cutting speed is too fast · Feed rate is too fast · The flank relief angle is too small · Insufficient wear resistance	· Decrease cutting speed and feed rate. · Change to an appropriate flank relief angle · Select a substrate with more wear resistance · Use a coated tool
	Chipping	Cutting Conditions Machine Area	· Feed rate is too fast · Cutting depth is too deep · Tool overhang is too long · Work clamps are weak · Tool is not firmly attached	· Decrease cutting speed. · Reduce depth of cut · Adjust tool overhang for correct length · Clamp the work piece firmly · Make sure the tool is seated in the chuck properly
	Tool Fracture	Cutting Conditions Tool Shape	· Feed rate is too fast · Cutting depth is too deep · Tool overhang is too long · Cutting edge is too long · Web thickness is too small	· Decrease cutting speed. · Reduce depth of cut · Reduce tool overhang as much as possible · Select a tool with a shorter cutting edge · Change to more appropriate web thickness
Others	Shoulder Deflection	Cutting Conditions Tool Shape	· Feed rate is too fast · Cutting depth is too deep · Tool overhang is too long · Cutting on the down-cut · Helix angle is large · Web thickness is too thin	· Decrease cutting speed. · Reduce depth of cut · Adjust tool overhang for correct length · Change directions to up-cut · Use a tool with a smaller helix angle · Use a tool with the appropriate web thickness
	Unsatisfactory Machined Surface Finish	Cutting Conditions	· Feed rate is too fast · Packing of chips	· Decrease cutting speed. · Use air blow · Use an insert with a larger relief pocket.
	Chattering	Cutting Conditions Tool Shape Machine Area	· Cutting speed is too fast · Cutting on the up-cut · Tool overhang is too long · Rake angle is large · Work clamps are weak · Tool is not firmly attached	· Decrease the cutting speed · Change directions to down-cut · Adjust tool overhang for correct length · Use a tool with an appropriate rake angle · Clamp the work piece firmly · Make sure the tool is seated in the chuck properly
	Packing of Chips	Cutting Conditions Tool Shape	· Feed rate is too fast · Cutting depth is too deep · Too many teeth · Packing of chips	· Decrease cutting speed. · Reduce depth of cut · Reduce number of teeth · Use air blow