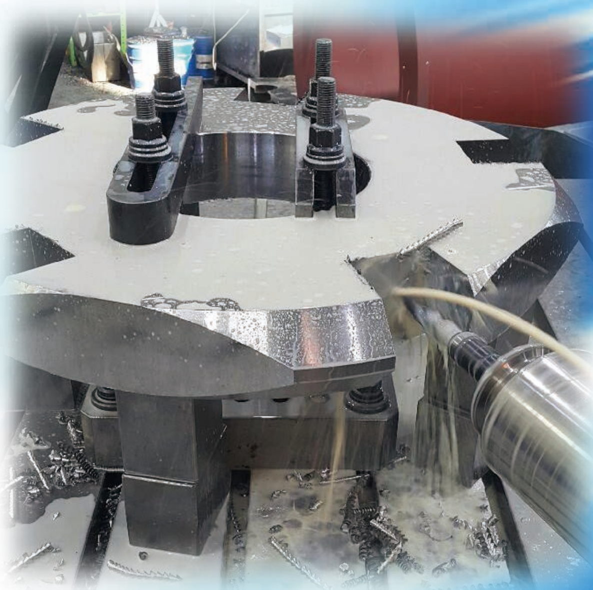
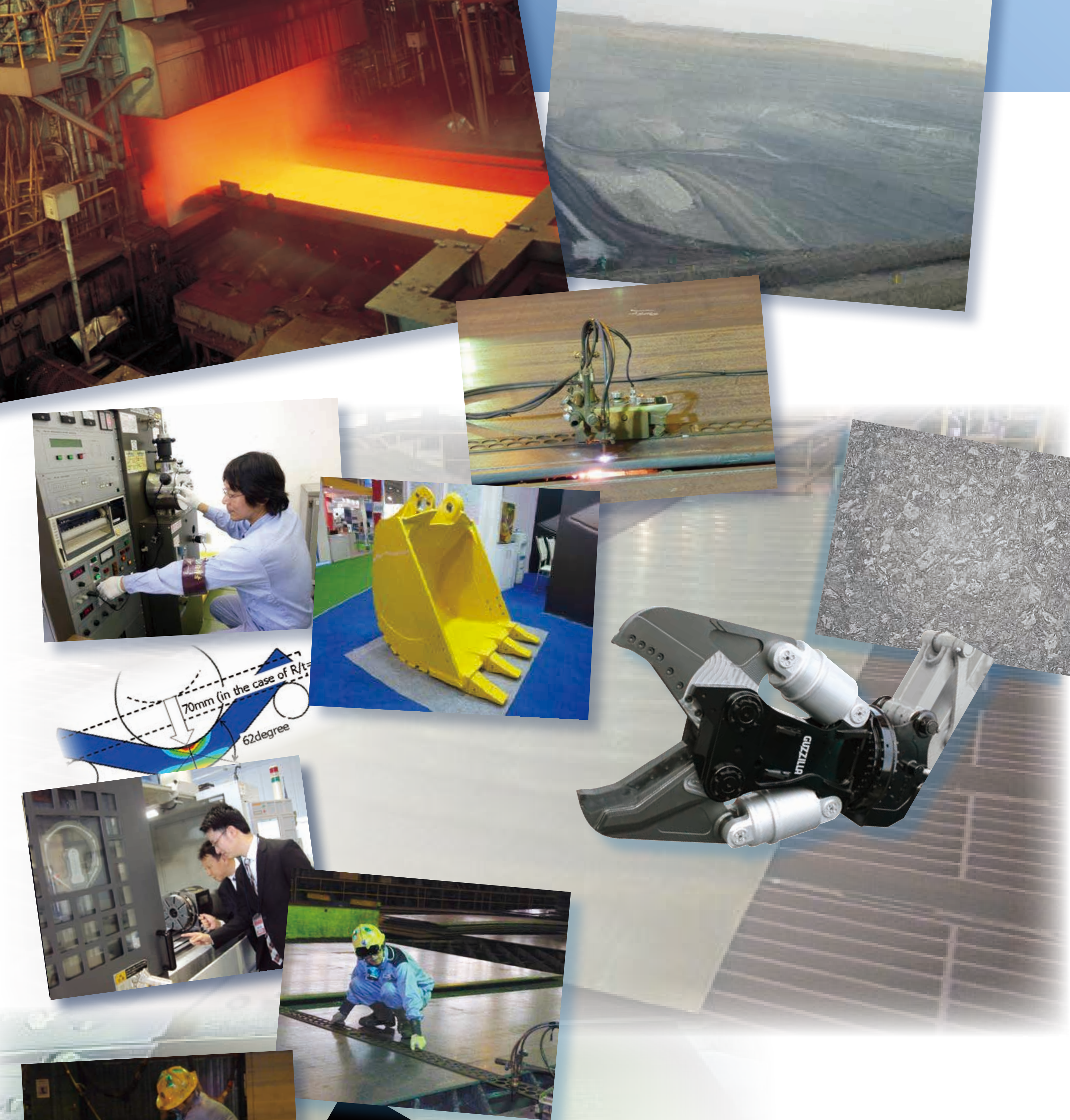
Guidelines for fabrication
JFE's Abrasion-Resistant Steel Plate
EVERHARD™

- Machining -



EVERHARD™
JFE's Abrasion-Resistant Steel Plate
Reliable Forever

JFE Steel Corporation



Contents

EVERHARD is a registered trademark of JFE Steel Corporation in Japan

Guidelines for Fabrication of JFE's Abrasion-Resistant Steel Plate EVERHARD: Machining

In 1955, JFE Steel Corporation began manufacturing an abrasion-resistant steel called "EVERHARD" before any other company in Japan. Since then, EVERHARD has been used in a wide range of applications, beginning with industrial machinery and also including construction and civil engineering machinery, mining machinery and agricultural machinery. Today, EVERHARD is recognized as an indispensable line of products that provides complete customer satisfaction.

This catalog, "Guidelines for Fabrication of JFE's Abrasion-Resistant Steel Plate EVERHARD: Machining," was prepared in the hope that all customers who choose EVERHARD can effectively use its outstanding performance with full confidence. We hope that customers will find this information useful.

Thank you for choosing EVERHARD, and we look forward to continuing to serve you.

■ Features of EVERHARD

Type	Features	Brand name
C (Standard Series)	Standard general-purpose EVERHARD. Economical standard alloy design that prioritizes the hardness of the steel plate. The surface hardness range is strictly controlled, reducing variations in workability.	**EVERHARD-C340**
		EVERHARD-C400
		EVERHARD-C450
		EVERHARD-C500
		EVERHARD-C550
C-LE (High Toughness Series)	Guarantees low temperature toughness at -40°C (-40°F). Lineup abrasion-resistant products up to Brinell hardness 500 grade. The composition design considers internal hardness.	**EVERHARD-C400LE**
		EVERHARD-C450LE
		EVERHARD-C500LE
SP (Super Abrasion-Resistant)	A special grade EVERHARD product that exceeds the high performance of conventional EVERHARD. Provides abrasion resistance exceeding Brinell hardness 500 grade.	**EVERHARD-SP**

The technical information presented in this catalog was prepared based on current technology in an effort to improve the performance of EVERHARD and is subject to change with the progress of development. Because this technical information describes typical properties of EVERHARD, JFE Steel cannot accept responsibility for performance in individual cases. In case of problems, please consult with JFE Steel.

For High Quality Machining

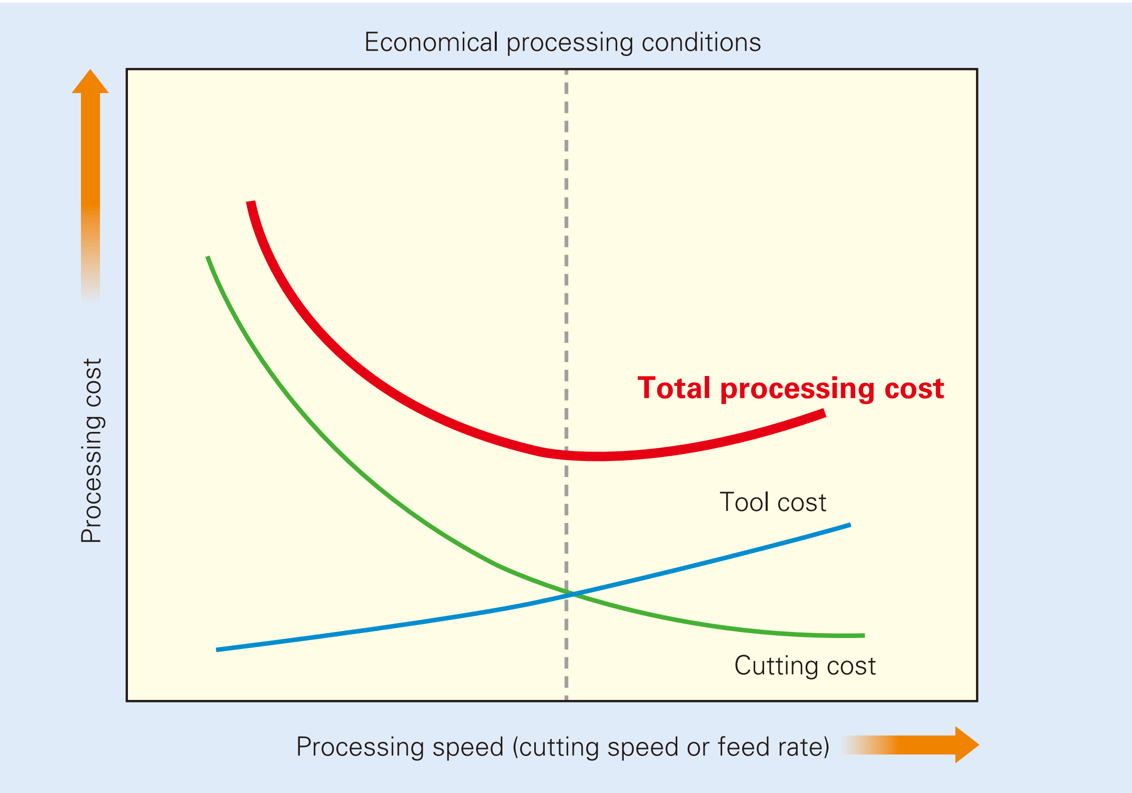
This catalog summarizes the basic processing guidelines for EVERHARD in machining, and presents recommended cutting conditions for safe, economical, worry-free machining.

Abrasion-resistant steel plates can be machined by using high speed steel (HSS) tools or cemented carbide tools. However, due to the high strength and hardness of abrasion-resistant steel in comparison with general structural steels, machining is not easy. Depending on the selection of machining conditions, processing time may be long, or processing costs may increase due to severe tool damage.

The relationship between processing cost and processing speed (cutting speed or feed rate) is shown below. When the processing speed is slow, tool damage decreases, but the processing time is longer, resulting in higher labor costs and longer delivery times. Thus, slower processing speeds increase cutting costs. On the other hand, when the processing speed is fast, cutting costs decrease, but tool breakage or wear occurs more easily, and this results in a higher tool cost.

As shown in the figure, the total processing cost is the sum of the tool cost and cutting cost. These guidelines propose machining conditions for minimizing the total processing cost.

Because the most economical processing conditions will differ depending on the processing method and type of tool, the following pages present general notes on machining, and the recommended conditions for each processing method and type of tool.

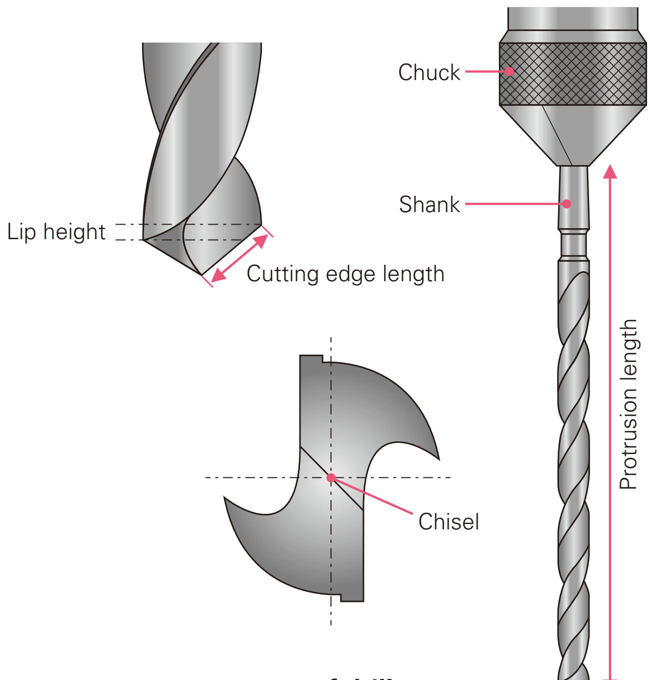


Checkpoints for Machining

General Notes

Item		Main Recommendations / Notes
1	Plate fixing	● Fix the plate (work material) securely by using steel spacers. Movement of the plate during processing due to inadequate fixing, etc. is dangerous, and increases the possibility of short tool life or tool breakage.
2	Tool fixing	● Install the tool on the main shaft using a suitable collet for the tool diameter. Set the protrusion length of the tool from the collet to be as small as possible, and adequately tighten. If the protrusion length of the tool is too long or if tightening is inadequate, rigidity will be reduced, increasing the possibility of tool breakage. ● If the plate is thick and a long tool protrusion length is unavoidable, reduce the feed rate or the cutting depth from the standard cutting conditions. Use of a tool with a long shank length is also effective.
3	Cutting fluid	● Provide an adequate supply of cutting fluid. Either a water soluble fluid and oil-based fluid can be used. If the cutting fluid feed rate is inadequate, the temperature of the tool edge can easily rise, resulting in increased wear and a higher possibility of breakage. If the machining equipment has an internal oil feeding capability, we recommend use of internal oil feeding.
4	Tool selection	● If tool cost is the first priority, a HSS tool is recommended. If processing speed is the priority, a cemented carbide tool should be used. ● Select a tool with a suitable blade length for the thickness of the plate to be machined. If the tool length is too long, the protrusion length will also be large; this will reduce rigidity and increase the possibility of tool breakage. ● Do not use a tool if the blade edge shape is defective. In case of regrinding, perform grinding carefully to minimize eccentricity of the chisel and differences in the lip height.

Example of fixed plate (work material)



Names of drill parts

Drilling

Hole drilling is the most general type of machining. Efficient machining is possible by setting the following cutting conditions.

Recommended Processing Conditions for HSS Tools

Although processing speed (cutting speed or feed rate) is limited, tool costs can be held down by using HSS tools.

	JFE HITEN780LE	EVERHARD C400, C400LE	EVERHARD C450, C450LE	EVERHARD C500, C500LE	EVERHARD C550	EVERHARD SP
Cutting speed Vc [m/min]	22	17	10	—	—	(8)
Tool diameter D [mm]	Feed rate: f [mm/rev] / Number of revolutions: n [rpm]					
5	0.09 / 1400	0.08 / 1080	0.07 / 640	—	—	(0.07 / 520)
10	0.17 / 700	0.16 / 540	0.14 / 320	—	—	(0.14 / 260)
15	0.26 / 470	0.23 / 360	0.18 / 210	—	—	(0.18 / 170)
20	0.26 / 350	0.23 / 270	0.18 / 160	—	—	(0.18 / 130)

1. The cutting conditions shown above are recommended based on machining data collected when using a cobalt high speed steel drill, external feed of a water soluble cutting fluid.
2. When drilling EVERHARD C500 / C500LE and C550, use of a cemented carbide tool, not HSS tool, is recommended.
3. ( ): Indicates that drilling of EVERHARD SP with a HSS tool is also possible; therefore, we recommend checking the progress of drilling under the above conditions to confirm that satisfactory drilling is possible.

Recommended processing conditions for Carbide Tools

Higher cutting speeds are possible by selecting a cemented carbide tool. If machining speed is a priority, please use a cemented carbide tool.

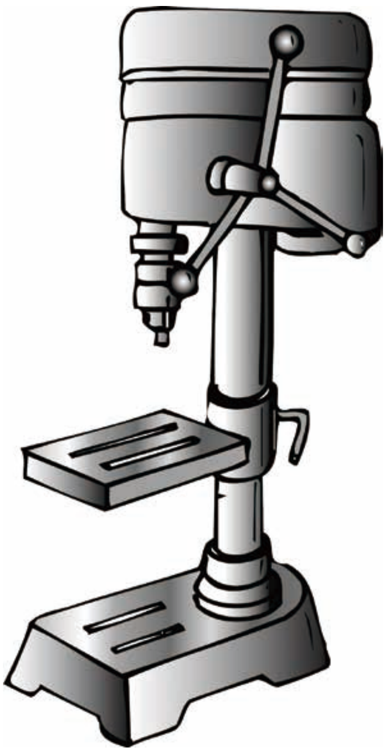
	JFE HITEN780LE	EVERHARD C400, C400LE	EVERHARD C450, C450LE	EVERHARD C500, C500LE	EVERHARD C550	EVERHARD SP
Cutting speed Vc [m/min]	140	90	70	50	30	50
Tool diameter D [mm]	Feed rate: f [mm/rev] / Number of revolutions: n [rpm]					
5	0.17 / 9000	0.16 / 5600	0.12 / 4500	0.08 / 3200	0.04 / 1900	0.08 / 3200
10	0.26 / 4500	0.24 / 2800	0.19 / 2200	0.14 / 1600	0.07 / 950	0.14 / 1600
15	0.32 / 3000	0.30 / 1900	0.22 / 1500	0.16 / 1100	0.08 / 630	0.16 / 1100
20	0.32 / 2200	0.30 / 1400	0.22 / 1100	0.16 / 800	0.08 / 480	0.16 / 800

1. In the table of cutting conditions shown above, the conditions are recommended based on processing data collected when using a cemented carbide drill and internal feed of a water soluble cutting fluid.

Troubleshooting

Thanks to the efforts of machining tool makers, many tools are commercially available. The recommended conditions for drilling will differ depending on conditions such as the type of tool, coating, etc. If smooth machining is not possible when using the preceding recommended conditions, please review the conditions referring to the following points.

Item	Main Recommendations / Notes
Breakage of drill tool	• Check General Notes (p. 3). • Reduce the feed rate.
Wear of outer periphery of drill	• Check General Notes (p. 3). • Reduce the cutting speed. • Increase the concentration of the cutting fluid, or increase the supply rate of the cutting fluid.
Cracking of outer periphery of drill	• Check General Notes (p. 3). • Reduce the feed rate.
Cracking of chisel	• Check General Notes (p. 3). • Reduce the feed rate during biting.
Long cutting chips	• Increase the feed rate. • Increase the supply rate of the cutting fluid, or increase the fluid supply pressure.
Chips clogging	• Reduce the cutting speed or feed rate. • Increase the supply rate of the cutting fluid, or increase supply pressure.

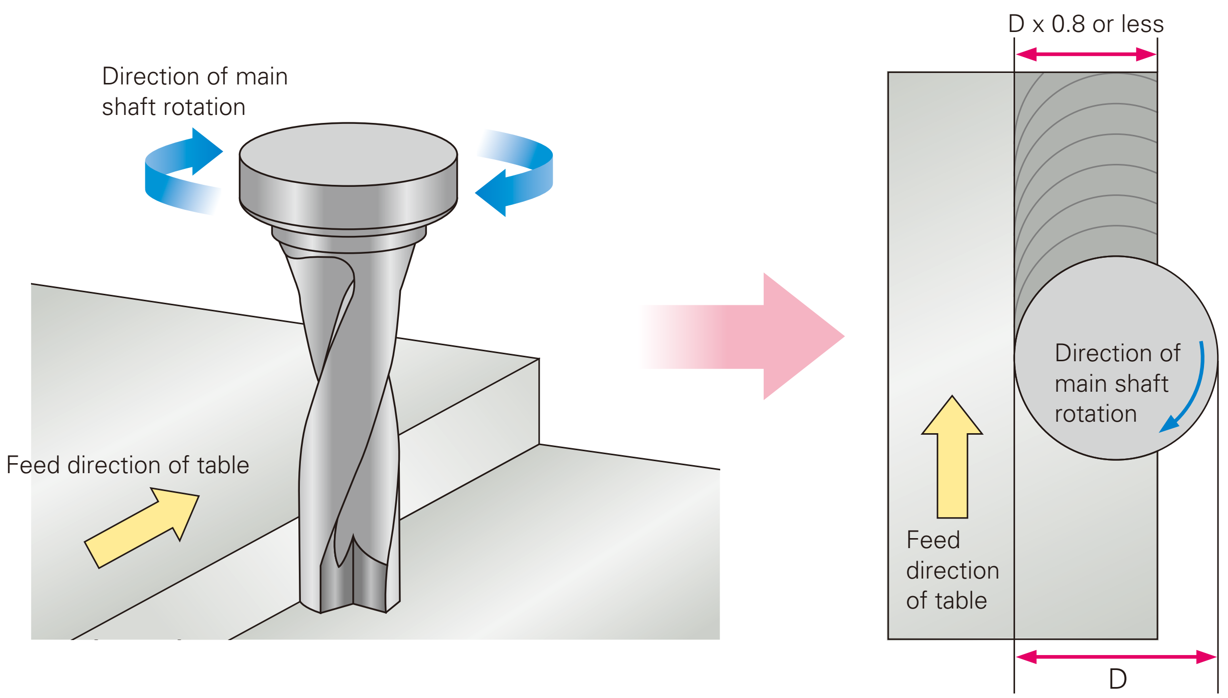


Milling

Hole drilling is a continuous cutting process, in which the steel plate (work material) and the tool are in contact at all times. In contrast to this, milling is an intermittent cutting process, and there are breaks in the contact between the tool and the plate (work material). Therefore, in milling, the tool is temporarily separated from the plate (work material), and then impacts on the plate again at high speed. As a result, damage or breakage of the tool occurs easily. When performing milling, please note the following points, in addition to the Recommendations / Notes on p. 3.

■ Notes on Milling

Item		Main Recommendations / Notes
1	**Machining direction**	● When milling abrasion-resistant steel plates, we recommend down-cutting. Although it may be possible to perform machining more easily by up-cutting with low-rigidity machines, in other cases, tool wear can be reduced by down-cutting.
2	**Cutting width**	● Select machining conditions so that the cutting width is 80% or less of the tool (cutter) diameter.
3	**Cutting depth**	● When cutting a steel plate with scale, tool wear can be reduced by increasing the cutting depth so that the hard scale part is not cut by the tip of the blade edge. ● Tool wear can also be reduced by adjusting the cutting depth to avoid cutting work-hardened parts.



Cutting direction and cutting width during miiling

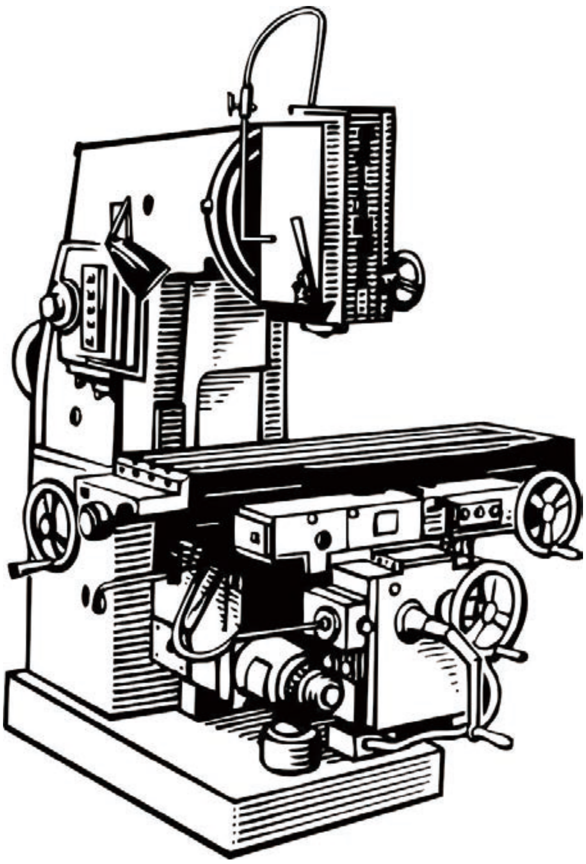
Machining Conditions for Milling (Example)

	Cutting speed Vc [m/min]	Feed per tooth [mm/tooth]	Depth of cut in shaft direction [mm]	Depth of cut in diameter direction [mm]	Coolant (cutting fluid)
EVERHARD-C400LE	90	0.15	0.5	30	Not used.

1. These cutting conditions are machining data for face milling when using a cemented carbide throwaway tip.

Troubleshooting

Item	Main Recommendations / Notes
Early tip wear	• Use a tip with higher wear resistance. • Reduce the cutting speed.
Cracking of tip	• Check General Notes (p. 3) and Notes on Milling (p. 6). • Reduce the feed rate or depth of cut. • Do not use a cutting fluid.
Chips clogging	• Increase the cutting speed or feed rate.

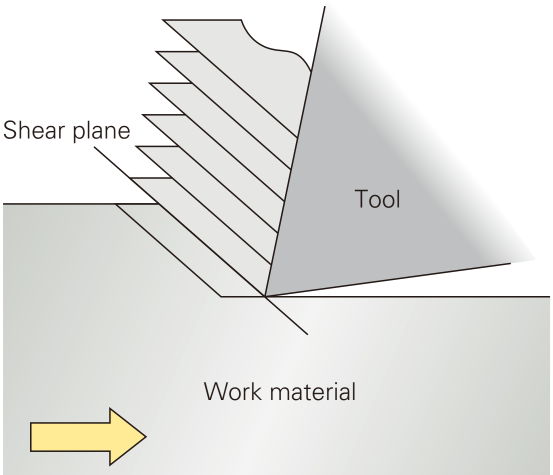


[Commentary] Machining and Tool Wear

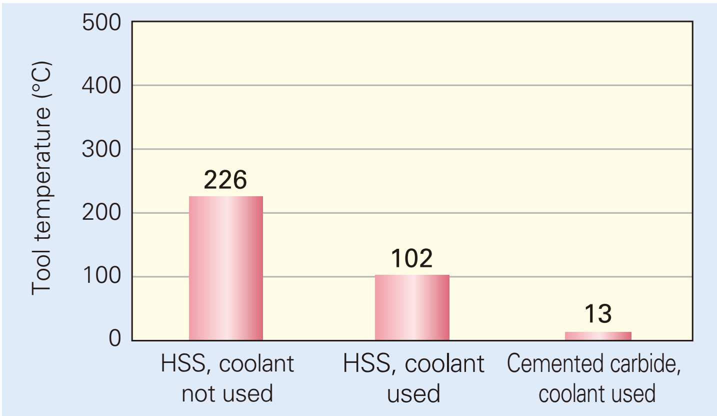
Machining is a working method in which a steel plate (work material) is cut to a specified shape while discharging chips, by performing working by moving a tool relative to the plate. Machining of metals is performed by the action of continuous shear stress. The work material receives shear stress from the tool and undergoes large deformation due to shear strain. As a result, sliding occurs along the shear plane, and chips are formed.

Wear of the cutting tool itself also progresses due to cutting of the steel plate (work material), and the tool finally reaches the end of its useful life. However, the degree of cutting tool wear differs depending on the machining conditions. For example, because the temperature rise of the tool differs depending on whether a cutting fluid (coolant) is used or not, even when using the same HSS tool, tool wear will also differ. It is possible to reduce tool temperature rise and tool wear by using a cemented carbide tool.

In preparing these guidelines, the recommended machining conditions were studied by a detailed investigation of the relationship between tool wear and differences in machining conditions.



Relationship of cutting tool and work material during machining



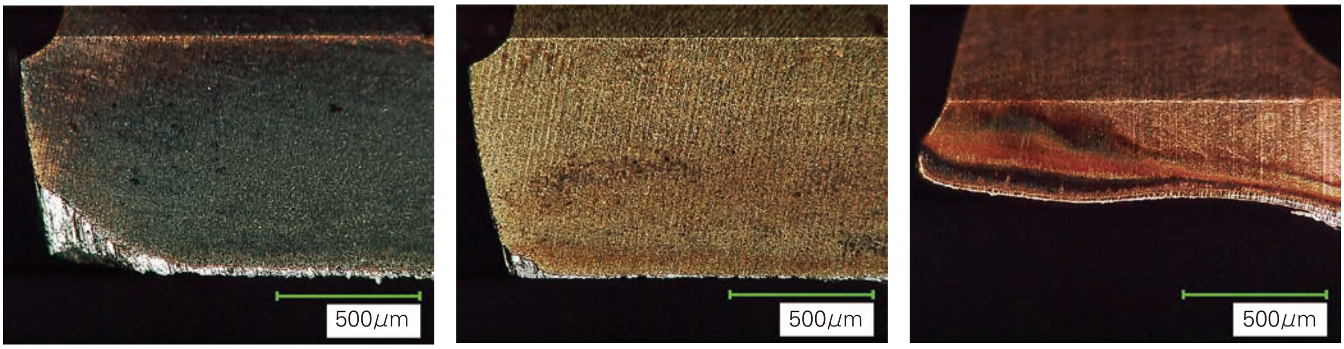
Ex: Relationship of machining conditions and tool temperature

S45C is used as a work material.

HSS, coolant not used: Circumferential speed = 20 m/min, feed rate: 0.2 mm/rev

HSS, coolant used: Circumferential speed = 20 m/min, feed rate: 0.2 mm/rev

Cemented carbide, coolant used: Circumferential speed = 90 m/min, feed rate: 0.2 mm/rev

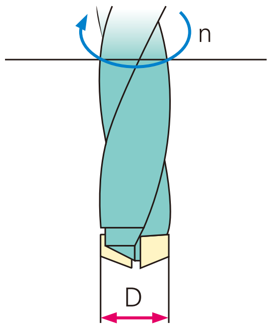


HSS, coolant not used | HSS, coolant used | Cemented carbide, coolant used

Photos of cutting edge tip after machining

[Reference] Equations for Drilling / Milling

■ Equation for Drilling



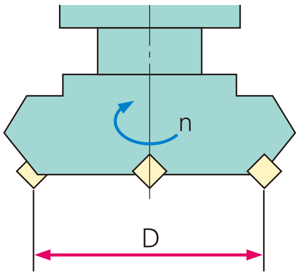
● **Cutting speed [Vc]**

$$Vc = \frac{\pi \cdot D \cdot n}{1000} \quad [m/min]$$

*Divided by 1000 to convert mm to m.

Vc [m/min]: Cutting speed
π: Ratio of circumference to diameter
D [mm]: Drill diameter
n [min^{-1}]: Main shaft rotational speed

■ Equations for Milling



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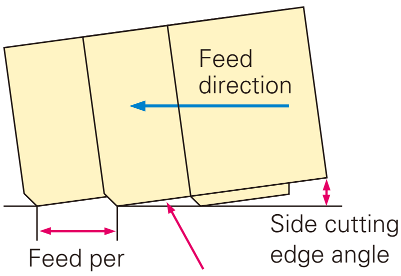
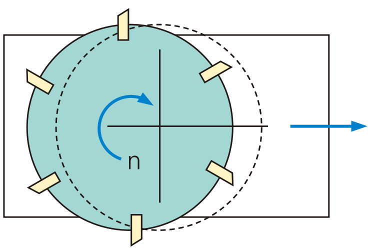


● **Feed per tooth [fz]**

$$fz = \frac{Vf}{z \cdot n} \quad [mm/tooth]$$

fz [mm/tooth]: Feed rate per tooth
Vf [mm/min]: Table movement per 1 min
z: Number of teeth
n [min-1]: Main shaft rotational speed



● **Table speed [Vf]**

$$Vf = fz \cdot z \cdot n \quad [mm/min]$$

Vf [mm/min]: Table movement per 1 min
fz [mm/tooth]: Feed rate per tooth
z: Number of teeth
n [min-1]: Main shaft rotational speed

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