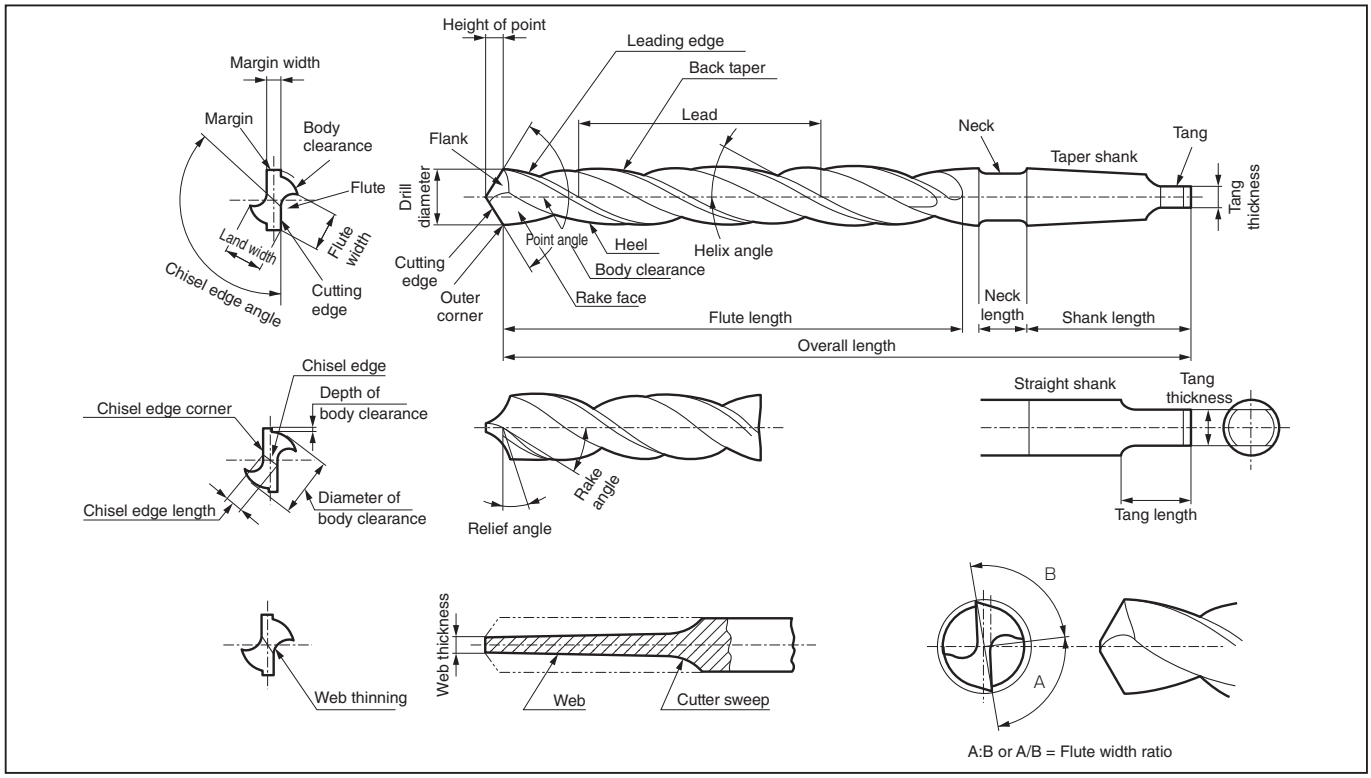
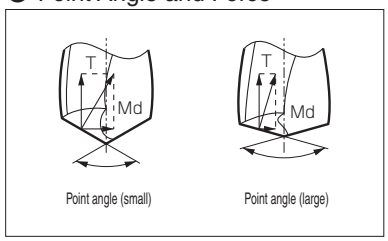
■ Parts of a Drill

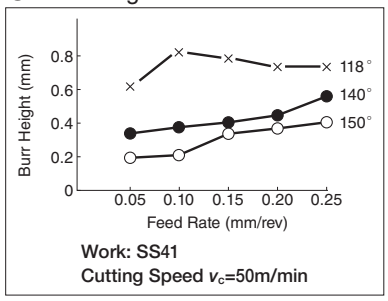


● Point Angle and Force



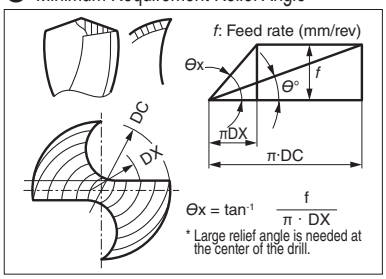
When point angle is large, thrust becomes large but torque becomes small.

● Point Angle and Burr

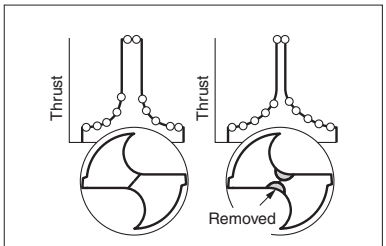


When point angle is large, burr height becomes low.

● Minimum Requirement Relief Angle



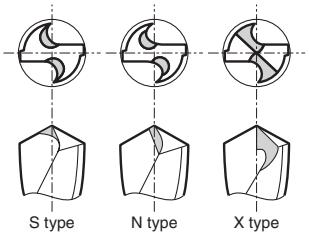
● Web Thickness and Thrust



Web thinning decreases the thrust concentrated at the chisel edge, makes the drill edge sharp, and improves chip control.

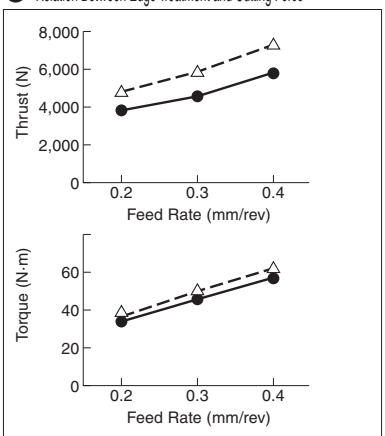
● Decrease Chisel Width by Thinning

Typical types of thinning



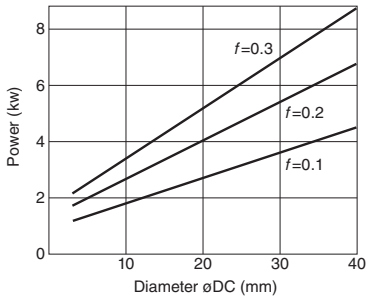
S type: Standard type used generally.
N type: Suitable for thin web drills.
X type: For hard-to-cut material or deep hole drilling. Drill starts easier.

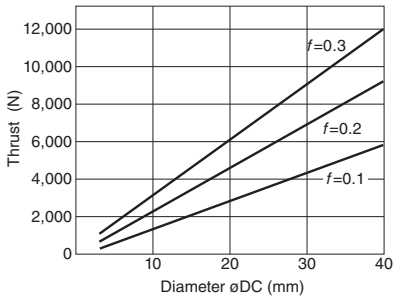
● Relation Between Edge Treatment and Cutting Force



Drill : Multi-drill KDS215MAK
Width : ● → 0.15mm △ → 0.23mm
Work : S50C (230HB)
Cutting Conditions : v_c=50m/min, Wet

■ Reference of Power Requirement and Thrust





f: Feed rate (mm/rev)

Work material: S48C (220HB)

■ Cutting Condition Selection

● Control Cutting Force for Low Rigid Machine

The following table shows the relation between edge treatment width and cutting force. If a problem caused by cutting force occurs, reduce either the feed rate or the edge treatment width.

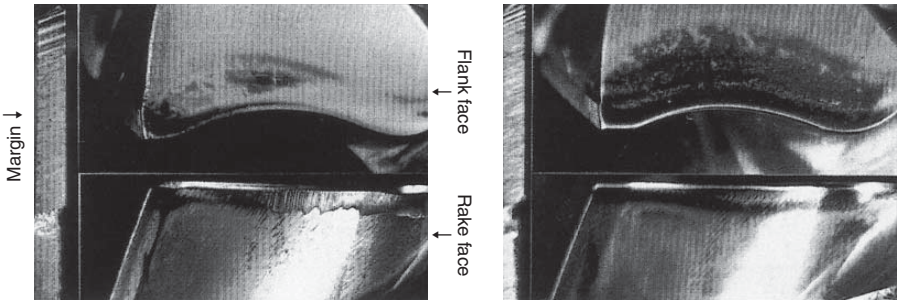
Cutting Conditions		Edge Treatment Width			
		0.15mm		0.05mm	
v_c(m/min)	*f*(mm/rev)	Torque (N·m)	Thrust (N)	Torque (N·m)	Thrust (N)
40	0.38	12.8	2,820	12.0	2,520
50	0.30	10.8	2,520	9.4	1,920
60	0.25	9.2	2,320	7.6	1,640
60	0.15	6.4	1,640	5.2	1,100

Drill : ø10mm
Work : S50C 230HB

● High Speed Machining Recommendation

If there is surplus capacity with enough machine power and sufficient rigidity, adopting higher efficiency conditions would improve the tool life; however, sufficient amount of coolant must be supplied.

Wear Example

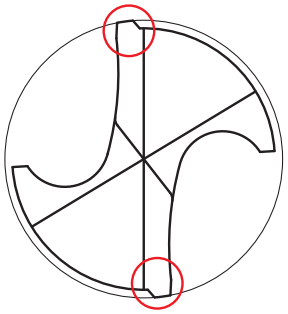


v_c=60m/min v_c=120m/min

Work : S50C (230HB)
Cond.: *f* = 0.3mm/rev
H = 50mm
Life : 600holes (Cutting length: 30m)

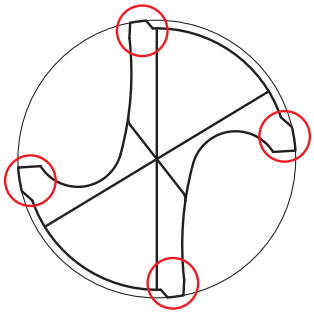
■ Explanation of Margins (Difference between single and double margins)

● Single Margin (2 guides: circled parts)



● Shape used on most drills

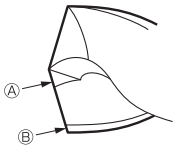
● Double Margin (4 guides: circled parts)



● 4-point guiding reduces hole bending and undulation for improved stability and accuracy during deep hole drilling.

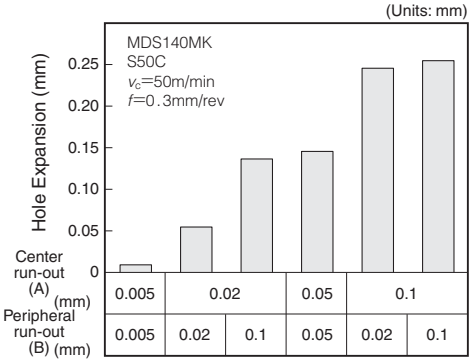
■ Run-out Accuracy

For the run-out accuracy of web-thinned drills, not only the difference in lip height (B) but also the run-out after thinning (A) is important.



(A): The run-out accuracy of thinning point
(B): The difference of the lip height

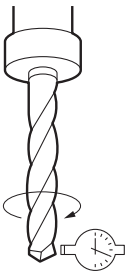
(Units: mm)



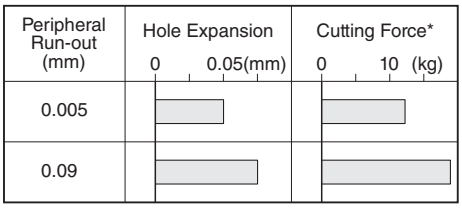
■ Peripheral Run-out Accuracy when Tool Rotates

● When the tool rotates

The peripheral run-out accuracy of the drill mounted on the spindle should be controlled within 0.03mm. If the run-out exceeds the limit, the drilled hole will also become large causing an increase in the horizontal cutting force, which may result in drill breakage.



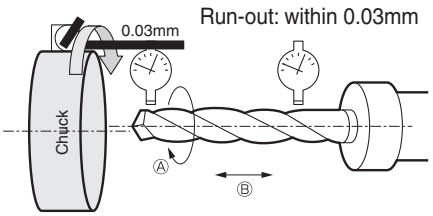
Run-out: within 0.03mm



* Horizontal cutting force.
Drill: MDS120MK Work material: S50C (230HB)
Cutting Conditions: v_C=50m/min, f=0.3mm/rev, H=38mm
Water soluble coolant

● When the work material rotates

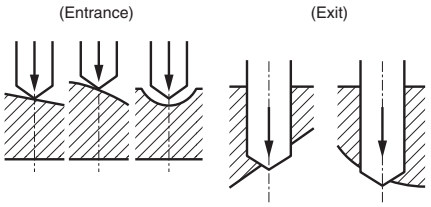
Not only the peripheral run-out at the drill edge (A) but also the concentricity at (B) should be controlled within 0.03mm.



■ Influence of Work Material Surface

● Work material with slanted or uneven surface

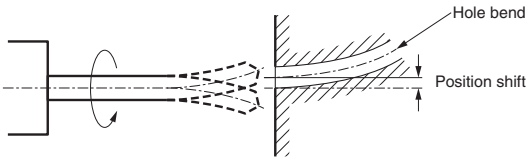
If the surface of the hole entrance or exit is slanted or uneven, decrease the feed rate to 1/3 to 1/2 of the recommended cutting condition.



■ How to Use a Long Drill

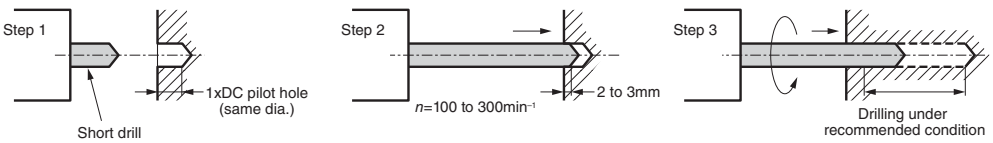
● Problem

When using a long drill (XHGS type), DAK type drill, SMDH-D type drill, or SMDH-12.5D type drill at high rotation speeds, the run-out of the drill tip may cause a deviation of the entry point as shown on the right, bending the drill hole and resulting in drill breakage.

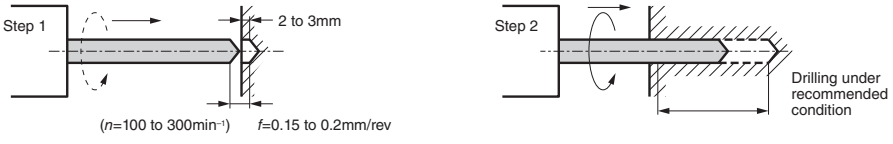


● Remedies

Method 1



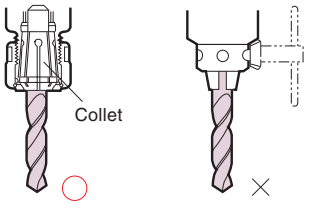
Method 2 * Low rotational speed minimises centrifugal forces and prevents drill bending.

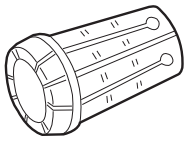


■ Drill Maintenance

(1) Collet Selection and Maintenance

- Ensure proper chucking of drills to prevent vibration. Collet chucks (thrust bearing type) provide strong and secure grip force.
  (Drill chucks and keyless chucks are not suitable for MultiDrills as they have a weaker grip force.)
- When replacing drills, regularly remove cutting debris inside the collet by cleaning the collet and the spindle with oil. Repair marks with an oilstone.

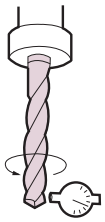




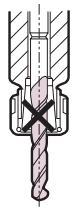
If there are marks, repair with an oilstone or change to a new one.

(2) Drill Installation

- The peripheral run-out of the drill mounted on the spindle should be controlled within 0.03mm.
- Do not chuck on the drill flute.
  (If drill flute inside the holder, chip removal will be obstructed thus causing damage to the drills.)



Edge run-out to be within 0.03mm.



Do not grip on the drill flute.

■ Using Cutting Oil

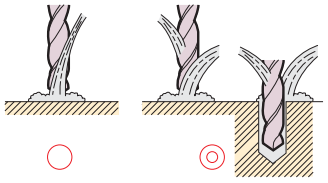
(1) Choosing of Cutting Oil

- If cutting speed is more than 40m/min, cutting oil JISW1 type 2 is recommended for its good cooling effect & chip removal ability as it is highly soluble.
- If cutting speed is below 40m/min and longer tool life is a priority, non-water cutting oil JISA1 type 2, an activated sulphuric chloride oil, is recommended for its lubricity.
  * Non-water soluble oil may be flammable. To prevent fire, a substantial amount of oil should be used to cool the component so that smoke or heat will not be generated.

(2) Supply of Coolant

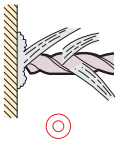
- If using an external supply of coolant, fill a substantial amount from the inlet. Oil pressure range: 0.3 to 0.5 MPa, oil level range: 3 to 10 ℓ/min.
- If using an internal supply of coolant (Ex: HK Type) for holes For holes ø4 or smaller, the oil pressure must be at least 1.5MPa to ensure a sufficient supply of coolant.
  holes ø6 or larger: 0.5 to 1.0 MPa for hole depths below 3 times the drill diameter, and 1 to 2 MPa or more for hole depths more than 3 times the diameter.

- External supply of coolant
- Vertical drilling



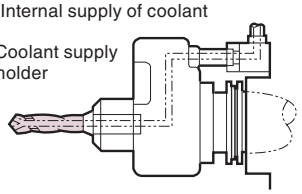
Use high pressure at entrance — Easy usage

- Horizontal drilling

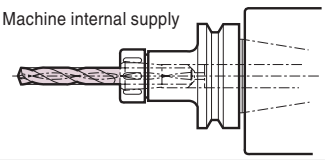


Use high pressure at entrance

- Internal supply of coolant
- Coolant supply holder



- Machine internal supply

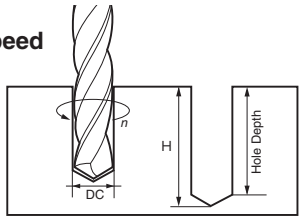


■ Calculation of Power Consumption and Thrust

● Calculating Cutting Speed

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

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



● Calculating Feed Rate Per Revolution and Per Tooth

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

● Calculation of Cutting Time

$$T = \frac{H}{v_f}$$

v_c : Cutting Speed (m/min)
π : Circular Constant ≈ 3.14
DC : Drill Diameter (mm)
n : Spindle Speeds (min^{-1})
v_f : Feed Rate (mm/min)
f : Feed Rate per Revolution (mm/rev)
H : Drilling Depth (mm)
T : Cutting Time (min)
HB : Brinell Hardness

● Calculation of Power Consumption and Thrust

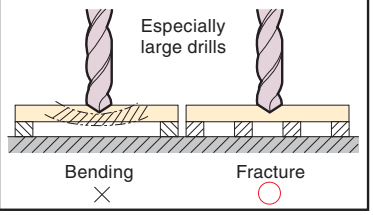
$$\text{Power Consumption(kW)} = HB \times DC^{0.68} \times v_c^{1.27} \times f^{0.59} / 36{,}000$$

$$\text{Thrust(N)} = 0.24 \times HB \times DC^{0.95} \times f^{0.61} \times 9.8$$

* When designing the machine, an allowance of 1.6 x Power Consumption and 1.4 x Thrust should be given.

■ Work Clamping

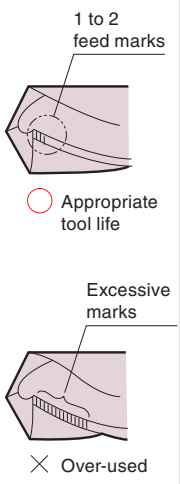
High thrust forces occur during high-efficiency drilling. Therefore, the workpiece must be supported to prevent fracture caused by bending. Also, large torques and horizontal cutting forces occur. Therefore, the workpiece must be clamped firmly enough to withstand them.



■ Drill Regrinding

- When to regrind
  When one or two feed marks (lines) appear on the margin, when corner wear reaches the margin width, or when small chipping occurs, it indicates that the drill needs to be sent for regrinding.
- How and where to regrind
  We recommend applying regrinding and recoating. Recoating is recommended to prevent shortening of tool life. Note, ask us or an approved vendor to recoat with our proprietary coating.
- Regrinding on your own
  Customers regrinding their own drills can obtain MultiDrill Regrinding Instructions from us directly or your vendor.

- Tool life determinant



■ Troubleshooting for Drilling

Failure		Cause	Basic Remedies	Remedy Examples
Drill Failure	Excessive Wear on Cutting Edge	· Inappropriate cutting conditions.	· Use higher cutting speeds.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
			· Increase feed rates.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
		· Unsuitable cutting fluid.	· Reduce pressure if using internal coolant.	· 1.5 MPa or below (external coolant if hole depth is L/D = 2 or less).
			· Use cutting fluid with more lubricity.	· Use JIS A1 grade No. 1 or its equivalent.
	Chisel Point Chipping	· Off-center starts.	· Reduce feed rate at entry point.	· f=0.08 to 0.12mm/rev
			· Pre-processing to ensure flat contact surface.	· Use endmill to produce flat surface.
		· Equipment and/or work material lacks rigidity.	· Change cutting conditions to reduce resistance.	· Increase v_c and decrease f (reduce thrust).
			· Improve work material clamp rigidity.	
		· Cutting edge is too weak.	· Increase size of chisel width.	· Set chisel width from 0.1 to 0.2 mm.
			· Increase amount of honing on cutting edge.	· Make thinning section of central area 1.5x current width.
	Chipping On Peripheral Cutting Edge	· Inappropriate drilling conditions.	· Decrease the cutting speed.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
			· Reduce feed rate.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
		· Unsuitable cutting fluid.	· Use cutting fluid with more lubricity.	· Use JIS A1 grade No. 1 or its equivalent.
		· Equipment and/or work material lacks rigidity.	· Improve work material clamp rigidity.	
		· Cutting edge is too weak.	· Increase amount of honing on cutting edge.	· Make peripheral cutting edge 1.5x current width.
			· Reduce the amount of front flank angle.	· Reduce the amount of front flank angle by 2° to 3°.
		· Peripheral cutting edge starts cutting first	· Increase margin width (W margin).	· Increase margin width by 2 to 3x current width.
		· Cutting interrupted when drilling through workpiece.	· Reduce feed rate.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
			· Increase amount of honing on cutting edge.	· Make peripheral cutting edge 1.5x current width.
			· Reduce the amount of front flank angle.	· Reduce the amount of front flank angle by 2° to 3°.
	Margin Wear	· Inappropriate drilling conditions.	· Decrease the cutting speed.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
		· Unsuitable cutting fluid.	· Use cutting fluid with more lubricity.	· Use JIS A1 grade No. 1 or its equivalent.
			· Increase coolant supply.	· If using external coolant, change to internal coolant supply.
		· Latent margin wear.	· Early regrind to ensure adequate back taper.	· Regrind margin damage to 1 mm or less.
		· Unsuitable tool design.	· Increase amount of back taper.	· Make back taper 0.5/100.
			· Reduce margin width.	· Decrease margin width to two-thirds of current width.
	Drill Breakage	· Chip build-up.	· Use optimal cutting conditions and tools.	· Refer to the table of recommended conditions in the Igetalloy Cutting Tools Catalogue.
			· Increase coolant supply.	· If using external coolant, change to internal coolant supply.
		· Collet clamp lacks strength.	· Use collet with strong grip force.	· Replace collet chuck if damaged. · Use collet holder one size bigger.
		· Equipment and/or work material lacks rigidity.	· Improve work material clamp rigidity.	
Unsatisfactory Hole Accuracy	Oversized Holes	· Off-center starts.	· Reduce feed rate at entry point.	· f=0.08 to 0.12mm/rev
			· Decrease the cutting speed.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
			· Pre-processing to ensure flat contact surface.	· Use endmill to produce flat surface.
		· Drill bit lacks rigidity.	· Use optimal drill type for hole depth.	· Refer to the Igetalloy Cutting Tools Catalogue.
			· Improve overall rigidity of drill.	· Large web with comparatively small flute.
		· Drill bit has run-out	· Improve drill clamp precision.	· Replace collet chuck if damaged.
			· Improve drill clamp rigidity.	· Use collet holder one size bigger.
		· Equipment and/or work material lacks rigidity.	· Improve work material clamp rigidity.	
	Poor Surface Finish	· Inappropriate cutting conditions.	· Increase cutting speeds.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
			· Reduce feed rate.	· Refer to the lower limit of recommended conditions listed in the Igetalloy Cutting Tools Catalogue.
		· Unsuitable cutting fluid.	· Use cutting fluid with more lubricity.	· Use JIS A1 grade No. 1 or its equivalent.
	Holes Are Not Straight	· Off-center starts.	· Increase feed rates.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
		· Drill is not mounted properly.	· Improve drill clamp precision.	· Replace collet chuck if damaged.
			· Improve drill clamp rigidity.	· Use collet holder one size bigger.
		· Equipment and/or work material lacks rigidity.	· Improve work material clamp rigidity.	
			· Select a double margin tool.	· Refer to the Igetalloy Cutting Tools Catalogue.
Unsatisfactory Chip Control	Packing Of Chips	· Inappropriate drilling conditions.	· Increase cutting speeds.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
			· Increase feed rates.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
		· Poor chip evacuation.	· Increase the amount or pressure of coolant applied if using internal coolant.	
	Long Stringy Chips	· Inappropriate drilling conditions.	· Increase feed rates.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
			· Increase cutting speeds.	· Refer to the upper limit of the recommended conditions listed the Igetalloy Cutting Tools Catalogue.
		· Cooling effect is too strong.	· Reduce pressure if using internal coolant.	· Keep pressure 1.5 MPa or lower if using internal coolant.
		· Dull cutting edge.	· Reduce amount of edge honing.	· Reduce to around two-thirds of current width.