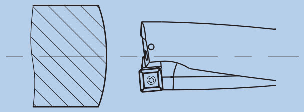
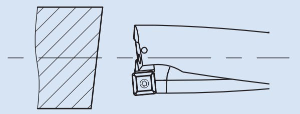
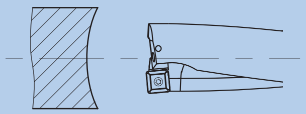
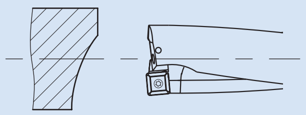
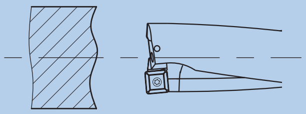
Initial drill penetration

Initial drill penetration is an important factor for successful drilling. One way of ensuring good hole quality is to make sure the penetration surface of the workpiece is vertical to the drill centre axis. In addition, an indexable drill can carry out initial penetration of convex, concave, inclined and irregular surfaces by adjusting feed rates.

Workpiece surface	Countermeasures
	For a convex surface, the conditions are relatively good and the centre of the drill ideally makes contact with the workpiece first, thus normal feed can be adopted.
	When penetrating an inclined surface, the cutting edges will be unevenly loaded, which may result in the premature drill abrasion. If the angle of the inclined surface is larger than 2°, the feed should be reduced to 1/3 of the value recommended for the drill.
	When drilling into concave surface, drill center axis normally tends to go off-center, the feed should be reduced to 1/3 of the value recommended for the drill.
	When drilling into non-symmetric curved surfaces, the drill tends to deviate from the centre because it is penetrating an inclined surface. The feed should be reduced to lower than the value recommended for the initial penetration of concave surfaces.
	When drilling into irregular surface, the insert faces the risk of chipping, which may also occur when drilling through the workpiece. Therefore, the feed rate should be reduced.

Calculations for shallow drilling

Cutting speed(Vc)

$$V_c = \frac{D_c \times \pi \times n}{1000}$$

V_c (m/min): cutting speed
D_c(mm): drill diameter
n (rev/min): rotating speed

◆ Example

Spindle speed is1600 rev/min，drill diameter is 20mm，thus cutting speed is：

$$V_c = \frac{D_c \times \pi \times n}{1000} = \frac{20 \times 3.14 \times 1600}{1000} = 100\ (m/min)$$

Feed speed

$$V_f = f_r \times n\ (mm/min)$$

V_f (mm/min): feed speed
f_r (mm/rev): feed rate per revolution
n (rev/min): spindle speed

◆ Example

Spindle speed is1500 rev/min，feed rate per revolution is 0.1mm/rev，thus feed speed is：

$$V_f = f_r \times n = 0.1 \times 1500 = 150\ (mm/min)$$

Machining time

$$T_c = \frac{I_d \times i}{n \times f}$$

T_c (min): machining time
f_r (mm/rev): feed rate per revolution
i: number of holes Id (mm): drilling depth
n (rev/min): spindle speed

◆ Example

Drilling a hole with a diameter of 20mm and a depth of 40mm, cutting speed is 100m/min and feed rate per revolution is 0.1mm/rev. Calculate the drilling time.

$$n = \frac{V_c \times 1000}{D_c \times \pi} = \frac{100 \times 1000}{20 \times 3.14} = 1600\ (rev/min)$$

$$T_c = \frac{I_d \times i}{n \times f_r} = \frac{40 \times 1}{1600 \times 0.1} = 0.25\ (min)$$

Metal removal rate

$$Q = \frac{V_f \times \pi \times D_c^2}{4 \times 1000}$$

Q (cm^3/min): metal removal rate
D_c(mm): drill diameter
V_f (mm/min): feed speed

◆ Example

Drill diameter is 20mm, feed speed is 160mm/rev, thus metal removal rate is:

$$Q = \frac{V_f \times \pi \times D_c^2}{4 \times 1000} = \frac{160 \times 3.14 \times 20^2}{4 \times 1000} = 50.24\ (cm^3/min)$$

Recommended cutting parameters for ZSD

ISO	Materials	Hardness HB	Diameter Dc mm	Feed rate fn mm/r	Cutting speed Vc m/min
P	Carbon steel	80-200	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.09 0.06-0.10 0.07-0.11	200(170-240)
	Low alloy steel	150-260	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.12 0.06-0.14 0.08-0.16	170(140-220)
	Hign alloy steel	150-320	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.12 0.06-0.16 0.08-0.18	150(120-180)
	Cast steel	180-250	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.08 0.05-0.08 0.06-0.10 0.07-0.11	140(120-170)
M	Stainless steel Ferrite Martensite	150-270	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.12 0.06-0.16 0.08-0.18	160(110-230)
	Austenite	150-275	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.11 0.06-0.13 0.08-0.14	140(110-220)
K	Malleable cast iron	150-230	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.10 0.05-0.14 0.08-0.16 0.10-0.20	160(120-220)
	Gray cast iron	150-220	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.10 0.05-0.14 0.08-0.16 0.10-0.20	200(170-240)
	Nodular cast iron	160-250	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.09 0.05-0.12 0.06-0.14 0.08-0.16	160(130-200)
N	Non ferrous meatals	60-110	12.0-21.5 22.0-33.5 34.0-41.5 42.0-50.0	0.04-0.10 0.05-0.14 0.08-0.16 0.10-0.20	300(250-350)

Recommended cutting parameters for ZTD

ISO	Materials	Hardness HB	Diameter Dc mm	Feed rate fn mm/r	Cutting speed Vc m/min
P	Carbon steel	80-200	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.09 0.06-0.10 0.07-0.11 0.08-0.12	200(170-240)
	Low alloy steel	150-260	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.12 0.06-0.14 0.08-0.16 0.10-0.20	170(140-220)
	Hign alloy steel	150-320	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.12 0.06-0.16 0.08-0.18 0.10-0.22	150(120-180)
	Cast steel	180-250	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.08 0.05-0.08 0.06-0.10 0.07-0.11 0.07-0.12	140(120-170)
M	Stainless steel Ferrite Martensite	150-270	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.12 0.06-0.16 0.08-0.18 0.10-0.22	160(110-230)
	Austenite	150-275	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.11 0.06-0.13 0.08-0.14 0.10-0.16	140(110-220)
K	Malleable cast iron	150-230	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.10 0.05-0.14 0.08-0.16 0.10-0.20 0.12-0.24	160(120-220)
	Gray cast iron	150-220	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.10 0.05-0.14 0.08-0.16 0.10-0.20 0.12-0.24	200(170-240)
	Nodular cast iron	160-250	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.09 0.05-0.12 0.06-0.14 0.08-0.16 0.10-0.20	160(130-200)
N	Non ferrous meatals	60-110	13.0-21.0 22.0-33.0 34.0-41.0 42.0-50.0 51.0-58.0	0.05-0.10 0.05-0.14 0.08-0.16 0.10-0.20 0.12-0.24	300(250-350)