HOSOI DRILLING TECHNOLOGY

Section I

Drilling operation account for a large percentage of normal machining processes. Twist drills are most commonly used but they are low both in drilling capacity and precision. Also, cutting efficiency is bad due to the difficulty in disposing of chips.

1. CUTTING CAPACITY

The big limitation with twist drills is that it must cut the material "in the material", which is different from other cutting tools. It is also very difficult to use coolant efficiently. Another problem is that the channel for removing the chips must be part of the drill. The volume of chips is directly proportional to the amount of metal removal, so if the area of the chip channel is too small, then drilling becomes impossible. Increasing the chip channel area reduces the rigidity of the drill. A practical solution of this problem has not been found.

The attempt has been made to increase drilling capacity by using carbide edges but, carbide is apt to break at low cutting speeds. The chisel problem at the drill point was not solved and breakage of this chisel point has made the manufacture of carbide tipped twist drills extremely difficult.

Newly developed throw away carbide tipped drills cannot applied to small diameter drilling (below 20mm), and the chisel point problem is still not solved. It can be used for shallow hole drilling but, It cannot substitute for a twist drill and should really be called a center cutting end mill.

2. MACHINING ACCURACY

With the conventional twist drill, the cutting condition in which the cone-spiral chips are produced are ideal as shown below;

Smooth transport of chips in this case is not possible unless the chip channel is large in cross sectional area. In addition to the above, the fundamental trend to minimize the chisel problem is to thin the web thickness, In other words, poor regidity, hence;

-uniform dimentions of the drilled hole are unobtainable...

-considerable expantion of the drilled hole versus the drill diameter...

-expansion rate is infinity by the cutting/feed rates...
-bad chamfer, in order to obtain accurate positioning, centering or guide bushing are needed...
-bad vertical accuracy...

3. OPERATION EFFICIENCY

Cone spiral chips which are through to be recommendable for twist drills quickly becomes obstacles once outside the drilledhole. They tend to coil around the drill and make continuous machining difficult. So the operator has to stop feeding the drill periodically to break the chip, further redusing drilling efficiency. The disposal of these long coiled chips are also troublesome.

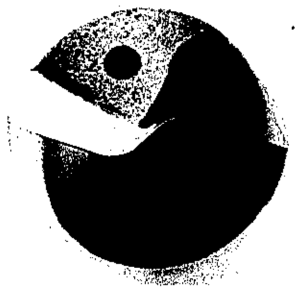
Section II

Carbide Drills with Hosoi Geometry

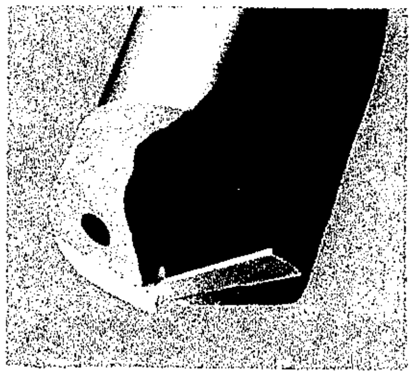
Ref: Sandvic Delta Drills
Dijet-Hosoi Drills

Conventional carbide tipped drills only replaced the cutting edge of high speed twist drills with carbide. There were no improvements made in tool nose geometry. These drills were efficient cutting cast iron but not steel.
One of the outstanding features of Hosoi ground carbide drills is that because of Hosoi's patented geometry the chips produced are intentionaly broken.

ref:2 Cutting edge of Hosoi Drill

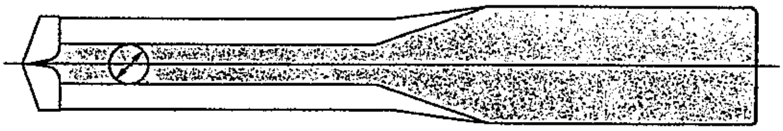


ref:3 Rake face and exhaust groove of Hosoi Drill



With the conventional twist drills, the exhaust groove is formed with the rake face with no clear division between them.
With Hosoi drills, the chip exhaust groove(channel) and the cutting edge rake face are clearly separated. With the Hosoi drills there is no web on the carbide tip and the shape at the center of the tip is special spiral shape completely eliminating the problems caused by the standard chisel point as shown in Reference#4:

ref:4 Cross section of Hosoi Drill with carbide tip. (oil hole is excepted)

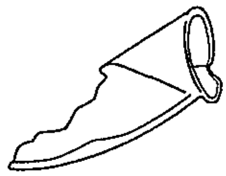


Conventional twist drills have the additional problem of weakness caused by the thin webs that have been utilized trying to minimize the chisel problem. Because the Hosoi geometry has completely solved this chisel point problem, Hosoi ground drills can cut efficiently with drills having webs up to 1/3 thickness of the drill diameter, enabling much heavier feed rates. Also, by generating an intentionally differnt level between the rake face and chip exhaust groove as well as the special shape of the cutting edge enables the drill to generate the chip shorn-torn phenomena.

Chips are shorn, torn, and exhaused...Cutting operation and chip disposal efficiency are increased, for example:

Drilling holes in S50C material with 20mm diameter drill

Feed rate;	300~600 mm/min
Accuracy	± 0.02mm
Face accuracy	6μ R max
Tool life	over 50m between re-grinding



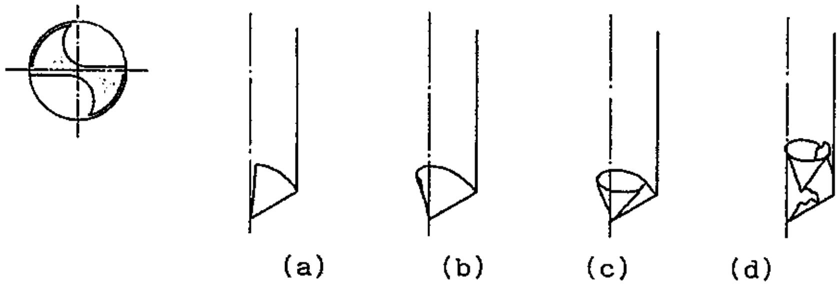
ref:5

Section III

Shorn-torn shape chips

It has been said that the drills producing chips illustrated right (REF.5) is not feasible as the cutting resistance and heat increase and the vibration caused by the change of resistance result in short life and poor accuracy. Cone spiral chips were said to be proof of good drilling.

The following sketches show how such shorn-torn chips are produced;



ref:6 Explanation of forming shorn-torn shape chips by conventional drills.

(a) Chips start growing, pressed onto the flat face of the exhaust groove to the perpendicular direction of the cutting edge but, at the cutting volume increases, starting from the central part of the cutting edge toward the outer edge while the feed rate is constant across the entire width of the cutting edge, chips grow on the rake face in fan form.

(b) Conforming to the concave part of the cross-sectional of the exhause groove, the chips form cone-shape.

(c) With this cone-shape the edge of the chip at the largest circle is touching the inside wall of the hole being cut. If this plastic deformation is easily made, the contact pressure produces the component of force to push the chips upward aided by the spiral angle of the exhaust groove and the rotation of the drill. The chips become cone-spiral shape.

(d) If the feed rate is too high, producing thick chips and the plastic deformation is not easily made, the flow of the cone-shape chip between the exhaust groove and the wall of the hole is not longer smooth. Thus, the growth of the chip stops, is conpressed on the rake face, the chip thickness grows and cutting resistance greatly increases. The stress on the chip is bigger on the outer diameter than in the center. If the stress exceeds a certain amount, chips start being torn from the center to the outer diameter. The chip becames a long pitch shape for a short period. Because the ductility of the chips decrease, it is shorn on the bottom and the whole chip generation process being again.

The sketch below shows the development of the chip and the distribution of thickness produced in the above mentioned procedure. The distribution of thickness of the cone shaped portion is almost constant. The straight portion thickness, on the outer side has increased by 70%, indicating that the cutting resistance has greatly increased.

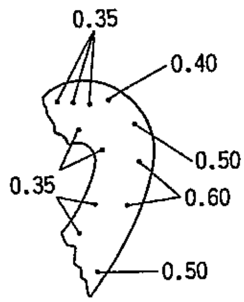


fig:7 Development of shorn-torn shape chip and the distribution of the thickness

Shorn-torn chips produced by Hosoi geometry.

Hosoi ground drills are designed to attain 3~5 times faster drilling than with conventional drill geometry. Such high volume cutting is impossible with drills producing cone-spiral chips. The chip strings whip and coil around the drill and prohibit continuous machining. To obtain higher cutting efficiency the feed rate must be increased meaning that the chips will be thicker and will become shorn-torn shaped.

However if you adapt high feed rate without changing the drill geometry the cutting edge will break down irrespective of the geometry of the drill point.

The fundamental design difference between Hosoi geometry and all other is that it encourage the generation of shorn-torn chips before interference between the chip top and the wall of the hole being drilled.

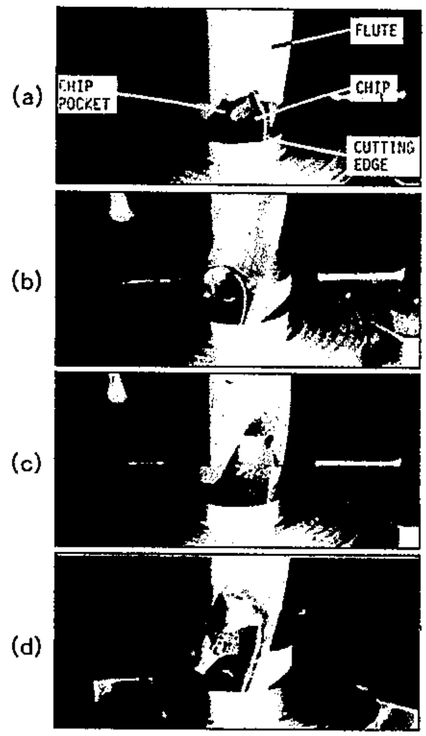
REF.8 shows the process in which the chips being to grown, are torn and exhausted with Hosoi Drills.

(a) The process in which the chip grow fan-shaped on the rake face is the same as with conventional drills. The Hosoi drill top angle is 140 deg.(carbide) Instead of the conventional 118 deg. to create a slightly different shaped chip.

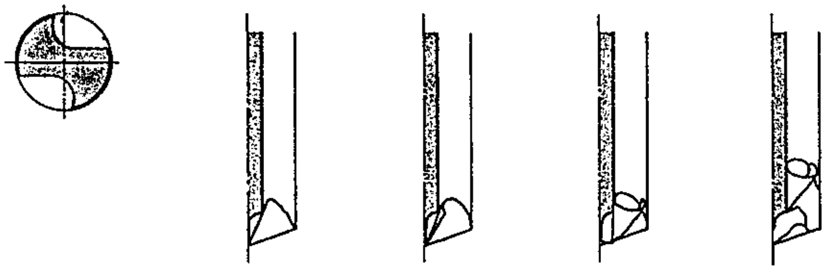
(b) The chips grow and meet the level difference point between the carbide cutting edge and the exhaust groove. Chips at the outer edge are thick and are not easily deformed, hence the chips are pressed on the concave wall of the exhaust groove. They form a cone shape.

(c) The top edge of the reverse cone shape moves its position and chips at the drill top are torn from the center to the outer edge. This action is enhanced because the center of the cutting edge is spiral shaped and pushes the chip generated at the point toward the outer edge.

(d) The chips on the outer side become long pitch shaped and are exhaused in the shorn-torn shape like conventional twist drills.

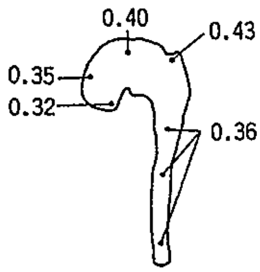


Thus, with Hosoi Drills, thickness of the chips and cutting power on the cutting edge is kept constant, the shorn-torn chips are generated before they contact and interfare with the drilled hole wall. See REF:9 - next page.



ref:9 The process of growth of short-torn shaped chips with Hosoi Drills

REF:10 - shows the distribution of Hosoi generated shorn-torn chips. If you compare the thickness distribution of the short-torn chips generated by conventional drills (See REF:7) It is apparent that the Hosoi geometry creates the chip thickness consistancy that is vital for efficient operation.



ref:10 Divelopment of shorn-torn shaped chips and the distribution of thickness with Hosoi Drills.

Section IV

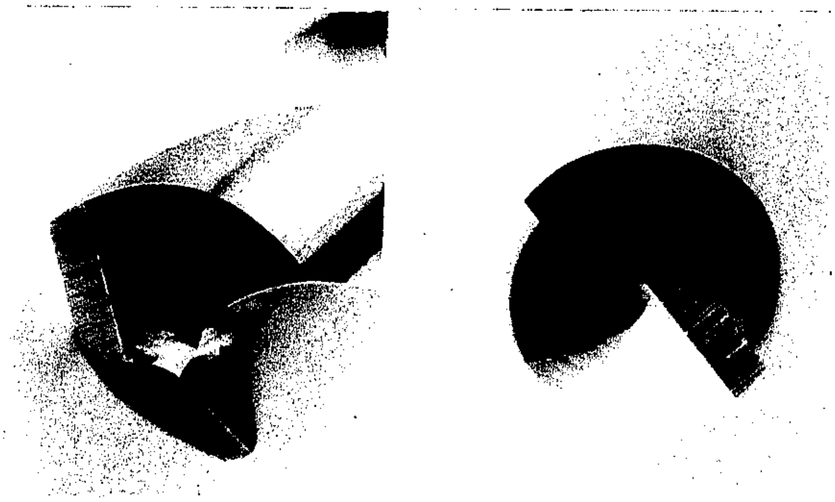
H.S.S.Drills with Hosoi Geometry

Ref: OSG Ex-Gold Drills

Carbide tipped drills with Hosoi geometry are extremely efficient when compared to conventional H.S.S.drills. In order to gain this efficiency, extremely rigid and high-powered machine tools are required. Our goal was to produce a high efficiency drill geometry that could be utilized on a wide range of machine tools and application.

As already explained, the chip shape must be torn- shorn in order to drill most efficiently but the H.S.S. drill differs from the carbide-tipped drill because the rake face and the exhaust groove is integral, not a two-piece construction. Web thinning to create shorn-torn chips by conventional methods does not work. It only creates a cutting edge on the chisel.

Hosoi ground H.S.S. drills are disigned , as are the carbide-tipped drills., to be extreamly rigid by making the web thickness 1/3 of the drill diameter. The chisel point is made into a special spiral by thinning and the mating line of rake face and the concave face of the exhaust groove can be located accurately from the center of the drill. By this grinding method we can create the same shorn-torn chips that are efficiently produced by Hosoi carbide drills.



ref:11 The top of Hosoi H.S.S.drills

Section V

<u>Hosoi u-nice Drill Grinder</u>

With H.S.S drills, there is a big difference between tool life between re-grind and that of carbide tipped drills. With the Hosoi Grinder we can apply the same high efficiency geometry on H.S.S. drills without any special technique as we do on carbide tipped drills . For example:

Drill Material - H.S.S.
Part Material - S50C
Drill Diameter - 8mm
Spindle Speed - 18 m/min

With a conventionally ground drill we get shorn-torn chips at feed rate of 0.3mm/rev., but if we re-grind the same drill and apply the Hosoi geometry, we can create this shorn-torn chip at only 0.16mm/rev..

REF.12 is a comparison of drill life between conventional and Hosoi geometry when applied to the same drill.

Spindle speed - 18m/min
Feed rate - 0.3mm/min
Cutting depth - 20mm
Coolant - Water soluble oil

ref:12

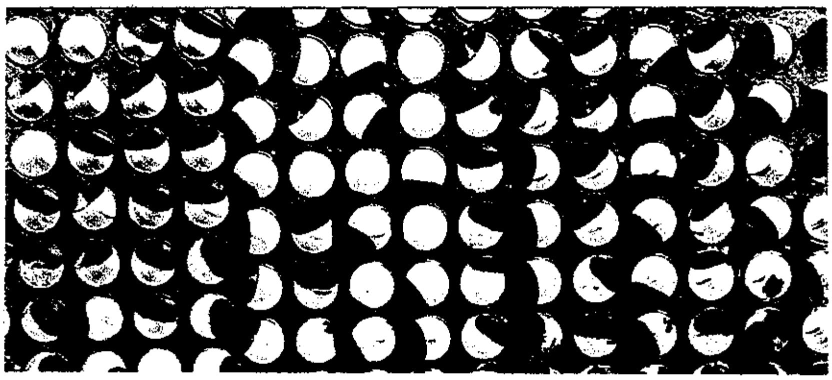
Life / Drill	5 — 10 — 15 length(m) 250 — 500 — 750 number of holes	%
conventional drill		100%
drill ground by u-nice drill grinder		150%

It is obvious that the Hosoi geometry greatly increases cutting efficiency and tool life.

When cutting through holes with a conventional geometry drill, break through occurs from the drill point outward. After break-through, the coolant flows through this hole and the outer edge of the drill is cutting dry. This wears and limits the life of the outer edge of the drill and margin.

With the Hosoi geometry, the breakthrough is delayed, utilizing the plasticity of the material, untill full diameter has been reached. See REF:13 .

ref:13 . Hosoi drills cut the hole through at the outer diameter portion, and the coolant oil works efficientry till the last moment, preventing harmful phenomena.



Combined with the above features, the special spiral point geometry as well as the 130 deg. top angle all contribute to much longer tool life when the Hosoi geometry is used.

By re-grinding H.S.S. drills with the Hosoi Model u-nice drill grinder, the following rates can be achieved:

Material: S50C (1050)

Drill: 6 mm (1/4″)

RPM: 1000

Feedrate: 0.3 mm/rev (12 IPM)

The actual recommended feed rate would be 0.3 mm/rev to insure good tool life. It is also recommended to shorten the standard jobber's length drill by 1/3 to 1/2 to increase the rigidity of the drill.

Recommended cutting conditions for H.S.S. drills ground on Hosoi u-nice drill grinder, based upon drilling S50C material.

Drill Diameter(mm)	RPM	Feed/Rev	Feed/min
1	6,000	0.05	300
2	3,000	0.1	300
3	2,000	0.15	300
4	1,500	0.2	300
6	1,000	0.3	300
8	750	0.3	225
10	600	0.3	180
12	500	0.4	200
20	300	0.6	180
25	240	0.7	168
30	200	0.8	160