AN OVERVIEW ON DRILLS AND ITS GEOMETRY

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Abstract : Drilling is a machining process in which a hole is originated or enlarged by means of a multipoint, fluted, end cutting tool As the drill rotates and enters the workpiece, material is removed in the form of chips along the fluted shank of the drill The effectiveness and overall economy of drilling depend on the type of cutting tool, and way of use Simple geometrical modifications at the cutting edge can help achieve significant improvement in machinability, and hence its efficiency and economy In this paper, an overview is made on the advancement of drilling process and geometry of the drill bit

Keywords Drill Drill geometry, Tool material, Drill modification

1. Introduction

In manufacturing, large proportion of holes are produced by drilling Of all machining processes performed, drilling takes a share of about 25% Although drilling appears to be a simple process, it is accurately a complex process Cutting action is done inside the workpiece Friction between the margin and the hole wall causes its finishing The counter flow of chips through the flutes makes lubrication and cooling difficult There are four major actions taking place at the point of a drill

1 Chips are formed by the rotating lips
2 A small hole is formed by the web
3 Chips are removed from the hole by the screw action of the helical flutes
4 The drill is guided by lands or margins that rub against the walls of the hole

New drill-point geometries and new coatings have resulted in improved hole accuracy, longer tool life, self-centering, and increased feed-rate capabilities [1]

2. Drill Geometry

A drill is having the following portions and geometries

i) Axis The imaginary straight line which forms the longitudinal center line of the drill
ii) Overall length The length from the extreme end of the shank to the outer corners of the cutting lips, it does not include the conical shank end often used on straight shank drills, nor does it include the conical cutting point used on both straight and taper shank drills
iii) Body The portion of the drill extending from the shank or neck to the outer corners of the cutting lips
iv) Chisel edge The edge at the end of the web that connects the cutting lips
v) Chisel edge angle The angle included between the chisel edge and the cutting lip, as viewed from the end of the drill
vi) Flutes Helical or straight grooves cut or formed in the body of the drill to provide cutting lips, to permit removal of chips, and to allow cutting fluid to reach the cutting lips
vii) Flute length The length from the outer corners of the cutting lips to the extreme back end of the flutes
viii) Helix angle The angle made by the leading edge of the land with a plane containing the axis of the drill
ix) Land The peripheral portion of the body between adjacent flutes
x) Land width The distance between the leading edge and the heel of the land measured at a right angle to the leading edge

xi) Lips : Cutting edges of a two flute drill.
xii) Lip relief angle : The axial relief angle at the outer corner of the lip; it is measured by projection into a plane tangent to the periphery at the outer corner of the lip.
xiii) Point : The cutting end of a drill, that resembles a cone, but departs from a true cone to furnish clearance behind the cutting lips.
xiv) Point angle : The angle formed by the cutting edges of the drill. [2-5].

The shape of a conventional twist drill is of complex nature. But by analogy with a single point cutting tool, the angles of drill may be simulated as a combination of two turning edges twisted to meet at the chisel edge. Table 1 indicates the basic similarities between a conventional turning tool and a conventional twist drill [2].

Table 1 : Similarities between a turning tool and a drill

Conventional turning tool	Twist drill
Principal cutting edge angle (ϕ)	½ (Point angle),ρ
Inclination angle (λ)	$\lambda = -(\sin \varphi_n)(d_w/d)$
Back rake angle (γ_x)	Helix angle (θ)

3. Different Types of Drill

There are different kinds of drills used now a days. Few common type of drills are discussed in the following :

Twist drill : Twist drill is the most commonly used drill, at present. It drills holes in metal, plastic, and wood. The most common twist drill has a point angle of 118°. This is a suitable angle for a wide array of tasks. A more aggressive angle, such as 90°, is suited for very soft plastics and other materials. A shallow angle, such as 150°, is suited for drilling hard steels and other tougher materials. This bit requires a starter hole, but will not bind or suffer premature wear when a proper feed rate is used [6].

Gun drill : Gun drills are straight fluted drills which allow coolant (either compressed air or a suitable liquid) to be directed through the drill body, directly to the cutting face. They are used for deep drilling with depth to diameter ratio of 100:1 or more [6].

Centre drill : Centre drill is used in metal working to provide a starting hole for a larger-size drill bit or to make a conical impression at the end of a workpiece to be mounted on a lathe centre [6].

Spade drill : A spade drill is usually a two part drill, the cutting point being removable and usually made of high speed steel. Often spade drills will have coolant lines running through the body. Since the cutting point is removable, one drill can be used for a good range of hole sizes.

Trepan drill : A trepan drill, sometimes called a BTA Drill, is used to cut an annulus, and leaves a centre core. Trepans usually have multiple carbide inserts and rely on water to cool the cutting tips and to flush chips out of the hole. Trepans are often used to cut large diameters and deep holes. However, this drill is having only specific applications at present, due to its inherent problem for easy chip removal etc.

Ejector drill : Ejector drilling or two tube system is a process similar to the BTA process except that in this case, the drill tube consists of an inner and outer tube. Coolant is introduced at the spindle via a rotary connector, and passes between the inner and outer tube. Chips exit through the inner tube. Minimum diameter is limited to about 19 mm since there is less room for chip removal in the smaller diameter tube. The ejector system performs well in the case where the face of the part is irregular since the design of the rotary connector and drill head create a venturi effect to draw coolant, and chips flow through the inner tube without relying on a good seal between part and bushing [7].

4. Modifications on Drill

A number of methods is used for improvement of cutting performance, dimensional accuracy and production capacity of drills. Typical design features of few high-productivity drills are discussed below.

Double- cone drill : The point section is short and has a point angle of 70° to 75°, while the second or the longer section has the standard 116° to 118° point angle. This point style produces wider chips, but chips are thinner at the outer corner of the lip reducing the wear in this area and increasing drill life [2].

Thinned web drill : The thrust force can be appreciably reduced by thinning the web as shown in the Fig 1. This increases the active length of the cutting edge, and consequently reduces the specific pressure per unit length of the cutting edge.

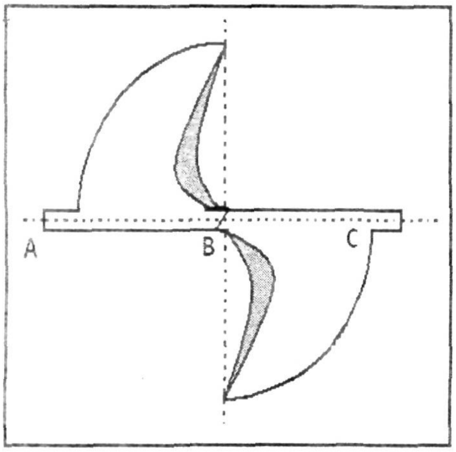

Fig 1 : Thinned web drill

Thinning the web also decreases the length of the chisel point, and lip angle at the web. Those factors lead to a reduction in thrust force, and increase the drill life [2,8].

Chip breaker drill : Handling of wide chips often becomes difficult when using large diameter drills. These chips can be conveniently broken by chip-breaking grooves placed at the cutting edge as shown in Fig 2 [2]. Oil tube chip breaker and oil hole chip breaker drills are also used in which coolant is fed through shank.

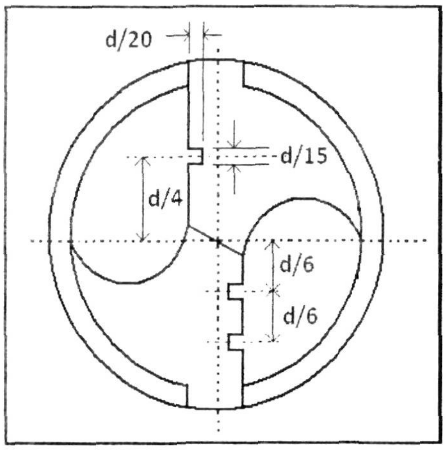

Fig 2 : Chip breaking drill

Crisp design chip breaker : Another type of chip breaker, known as crisp design chip breaker, shown in Fig 3, provides a helical rib on the heel side of the flute which extends for the entire length of the drill flute. This rib obstructs the normal chip flow and forces tighter chip curl, imposing additional strain which breaks the chip [2,9].

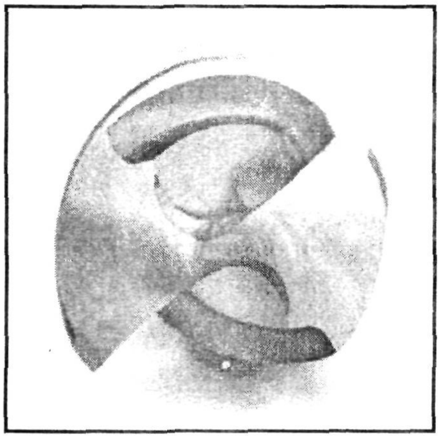

Fig. 3 : Crisp design chip breaker

Ernst and Haggerty's Spiral-Point Drill: Ernst and Haggersty devised a three dimensional spiral-point drill illustrated in Fig. 4. An analysis of the drill geometry shows that the straight chisel edge has a large negative rake angle and that the space ahead of the chisel edge is so restricted that the chip can not flow smoothly. The chisel edge action becomes extrusion as the velocity is very low. Changing the chisel edge design to a spiral-point reduces the normal rake angle, thus improving cutting action at low speed zone [2].

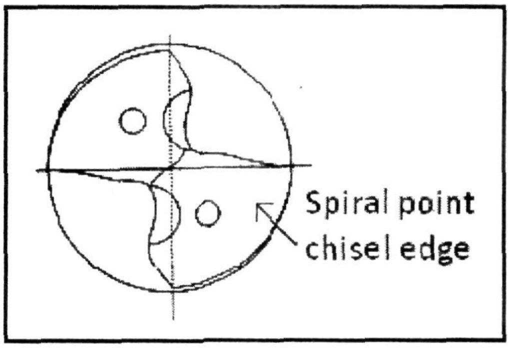

Fig 4 : Ernst and Haggerty's Spiral-Point Drill

Zhirov-Point Drill : Zhirov [2] has developed a high-production high-speed steel drill for drilling cast iron. The drill has a triple lip at each cutting edge, an extra rake ground on the face of the lip, and a split point. The shortest lip has an included angle of 55°, the intermediate lip has a point angle of 70°, and the largest lip has the standard point angle of 118°. The chisel edge has been reduced by a slot or groove. Therefore, extrusion action is replaced by cutting action. This design allows the thrust to reduce by one-third to one-fourth of that required for conventional drills

Chisel Edge Modification of Drills Thrust force causes wide dimensional deviation in drilling Excessively large drilling thrust force not only *demands high strength and rigidity of the drilling* machine but also shortens the life of drill and machine Some of chisel edge modification techniques which reduce drilling thrust dynamically by enabling the sharper chisel edge remove material by cutting action rather than indentation or extrusion [8-11]

The benefit of chisel edge modification, include

i) Sustainable reduction in the thrust force which economizes the design of the machine tool
ii) Increasing speed and feed, and hence productivity
iii) Dimensional accuracy like oversizing
iv) Smoother operation with much lesser noise and vibration
v) Drilling on even slightly curved surfaces is possible
vi) Lesser tool wear and longer tool life

Solid carbide drill Solid carbide drill provides maximum wear resistance while drilling various metals such as high carbon alloy and stainless steels, titanium, high temperature alloys, aluminum, bronze, cast and ductile iron Carbide is a compound composed of carbon and a less electronegative element These drills are known for its sturdy construction and dimensional accuracy Some types are solid carbide twist drill, solid carbide twist drill, step burnishing drill, step drill, etc [8] [11]

5. Concluding Discussion

In this paper an overview is made briefly on different aspects of drilling, and drill bits highlighting its types, material and geometrical modification Following comments can be made out of the discussion made

- Depending upon varying applications different types of drill have been developed in the past
- Modifications of suitable drill geometry have been made for enhancing productivity
- As new workpiece materials are being developed, there has to be continuous improvement regarding new drill materials and corresponding appropriate drill geometry

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Energy is eternal delight. – *William Blake*