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➤ BY JASON WELLS

To the POINT

Understanding how a drill point's geometric features work together helps users optimize their drilling operations.

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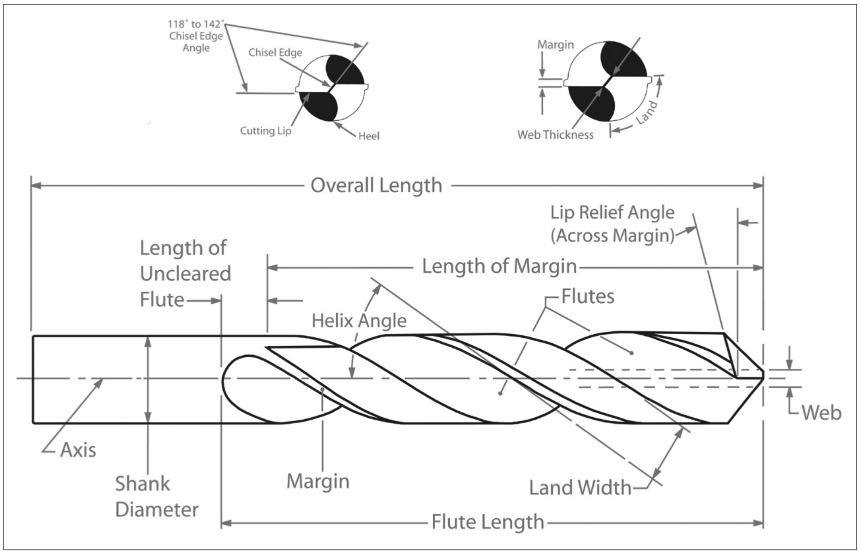
In operation, a drill's point does all the cutting. It should come as no surprise, then, that the drill point is where a majority of the tool's cutting geometry is located.

The drill point is crammed with a complex array of lands and edges, clearances and margins that all must work in unison in order to optimize a drilling operation. The first step in this process is for users to learn what the drill point's geometric features are and how they function.



Darex

Twist drill nomenclature.

Angle of Attack

Drills are available with a variety of point angles. The most common point, the standard 118°, balances the drill's ability to penetrate mild steels and control the forces that arise when drilling those materials. (For many years, mild steel was the base material used for developing drill designs.) However, today's users tackle a variety of materials, requiring them to apply more than a one-size-fits-all point angle.

Softer metals, as well as many plastics, are easier to penetrate than harder materials. This improves tool performance, due to the reduced forces encountered when drilling. The downside, though, is the drill is also more prone to wander (or walk). The reason is because when resistance to penetration is low, a drill tends to push instead of shear material, causing it to walk.

A possible solution to the problem is to apply a drill with a steeper point angle, such as 90°. It enters soft materials more quickly and moves through them more efficiently than a 118° point.

A steeper point also has a longer cutting edge, or lip length, than a shallow-angle point. This means cutting forces are distributed across a greater area on a steep point. Conversely, the larger area means more of the drill contacts the workpiece, increasing the torque exerted on the tool.

Shallower point angles—say, 140°—have proven more successful in difficult-to-drill materials than the 118° point. The 140° cuts a thicker chip than a narrow point. Thick chips carry more heat away from the work zone than thin chips.

Another benefit of the 140° point is it minimizes drill walking in harder materials. The shallow angle allows the corners of the drill to contact the surface of the workpiece quicker; this allows the drill to stabilize much sooner in difficult-to-penetrate materials. Not only does this shallow angle help on entry, it also allows the drill to exit a hole more quickly and efficiently, which, in turn reduces burr development on breakthrough.

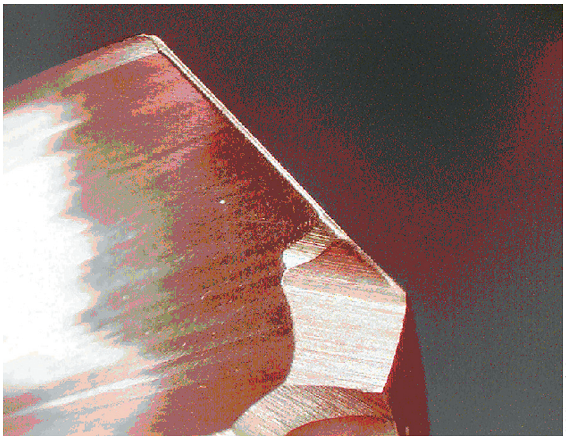
Geometry Lesson

Too much clearance also causes problems. A drill with an abundance of clearance cuts freely, but, because of the excessive amount of material removed from behind the cutting edge, it is weaker. This can lead to edge chipping, cratering and catastrophic failure.

Clearance angles can be adjusted and optimized for specific materials and applications. Angles vary according to tool diameter. Because small-diameter drills are much more fragile than large-diameter tools, they require a higher relief angle in order for the drill to be free-cutting.

In addition to the actual clearance angles, there also are three major types of relief applied to drills:

■ Cam relief. This common grind is an axial-eccentric relief that runs from the cutting edge to the back of the land. A convex form, it follows the natural shape of the point angle. With cam relief, more material is left behind the cutting edge, which creates a stronger edge. However, it does not give the drill a satisfactory centering capability compared to other forms of point relief, which can foster additional torque and thrust.



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A common feature of high-performance carbide drills is the hone. It is a manufactured wear pattern ground on the cutting lip of the drill that adds strength and protects the sharp edges.

■ Faceted relief. This is a flat grind that forms a pyramid at the center of the tool. The relief is constant along the cutting lip; it provides the drill with an excellent self-centering capability. Not reducing the amount of material in the center of the tool with this type of relief may result in excessive torque and thrust.

■ Helical relief. A much less common relief than the first two, it is a specialized grind that features an "S" shape with a crown at the center. Although it reduces torque and thrust and forms a curled chip, some strength is sacrificed with this design.

The Right Balance

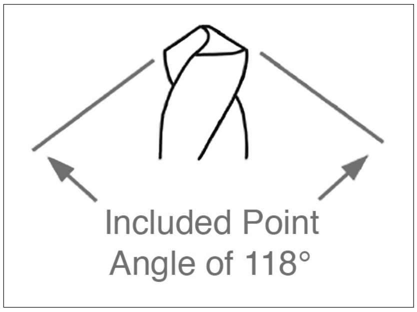
At the end of the web—the section of the drill formed at the pinnacle of the drill point—is the chisel edge. The chisel edge, which connects the cutting lips, is ground at an angle and handles more than half of the axial thrust that develops during drilling. Its length (along with the thickness of the web) plays a major role in determining penetration rates and controlling the level of thrust.

Many drill producers grind away as much of this area as possible. The reason they do this is to reduce thrust and improve penetration rates. The process, called web thinning, also aids in tool life and hole quality.

There are limits to how thin the web can be, though. As an analogy, think about driving nails into a piece of soft wood. Less force and energy is needed to drive a finishing nail into the wood than to pound in a large framing nail. In hard wood, conversely, the finishing nail is more susceptible to bending than the framing nail. Similarly, a drill manufacturer must balance factors such as the workpiece material, hole size and performance requirements when deciding how much to thin a drill's web.

Besides drill performance in a specific material, users are concerned about hole quality. A drill must produce a straight, round hole while meeting the finished-hole-size tolerance. This starts with, and is heavily dependent on, applying a tool whose geometric features are in balance.

The drill point's geometry must ensure that the pressure and load on each cutting lip is equal and that chip formation is balanced. This "symmetry" is critical to a successful drilling application. An unsymmetrical drill will produce out-of-round, out-of-tolerance holes; location accuracy and hole finish will be unsatisfactory; and tool pressure will be excessive, thereby shortening wear life.



Darex

The standard 118° included point angle balances the drill's ability to penetrate mild steels and control the forces that arise when drilling those materials.

Enhancing Performance

A common misperception among drill users is that little can be done to a drill point's geometry to enhance tool performance. That is patently untrue. Drill manufacturers continually find new ways to improve their products.

Many material- and application-specific drill-point configurations have been introduced in the past several years, spawning a whole group of high-performance drills.

A common feature of high-performance carbide drills is the hone. This is a manufactured wear pattern ground on the cutting lip of the drill. It adds strength and protects the sharp edges typically applied to drills. By varying the hone width and angle, the drillmaker can optimize performance for a specific application. But, like other features, too much of a good thing can be bad. If the hone is too large, it can cause the drill to plow instead of shear.

Another feature that can be ground on a drill is a dub. Dubbing is the act of placing a flat grind across the flute faces from the outermost diameter to the chisel edge. This alters the rake angle of the tool to 0° or just slightly positive. Dubbing strengthens the cutting edge but increases the plowing effect. A dub can be useful in materials that tend to "grab" the drill or when additional strength is needed to prevent chipping.

Many drills have a straight cutting lip, which gives the tool a strong neutral cutting edge and is less of a challenge to produce. A curved cutting lip also can be applied. A concave lip, wherein a hook is ground from the tool's center to its outer corner, helps curl the chip. However, this feature may result in weak, sharp corners at the outermost diameters.

A slightly convex shape, or rounded edge, also can be added. With it, the outer corner falls away from the center of the cutting lip. This creates a strong edge and offers greater corner protection, but, again, it tends to make the drill plow instead of shear and lessens the holemaking tool's self-centering capability.

Sharp corners can easily chip or break. Conversely, a dull corner can cause a drill to wander or produce inaccurate holes.

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Adding certain geometric features can diminish or even eliminate these problems.

An example is the addition of either a small radius or chamfer to corners. Either of these is recommended for abrasive workpiece materials, because the frictive force that develops is dispersed across the width of the chamfer or radius instead of being localized at the sharp intersection.

Plenty of other features can be added to a drill point's geometry, as well as other sections of the tool, to enhance performance. There are too many to discuss here. But, hopefully, readers will use this article as a base for learning more about tool geometry and as a jumping-off point to optimizing their drilling operations. △

About the Author

Jason Wells is a journeyman toolmaker who works as director of product development and marketing for a manufacturer of solid-carbide round tools.