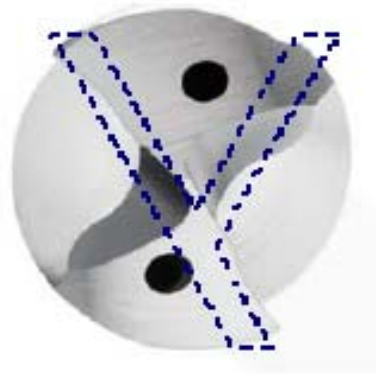


## **Straight Round**

By Herbert Kauper & Allen Poponick  
Kennametal Inc.

All drills walk. Although this condition is typically associated with applications using HSS drills, out-of-round holes, deflection, and poor cylindricity are, to a lesser degree, also the result of drilling with a solid-carbide drill. The same forces that cause the drill to “walk” or “push off” also reduce drill life. This is particularly true when drilling tough, exotic, and expensive aerospace and energy materials such as Inconel, Waspalloy, and duplex stainless steel workpieces. Wear quickly accelerates into chipping and then catastrophic drill failure within one or two holes of occurrence, resulting in machine downtime and longer lead time for critical aerospace or energy parts.

Due to high material, labor, and machine costs, aerospace, energy, and other major industries are demanding drills that guarantee process security, consistent new and reconditioned drill life, and excellent hole quality. Addressing these market demands is the new Y-TECH drill from Kennametal that “rebalances” traditional technical assumptions of drilling with a solid-carbide drill due to its unique design that features two asymmetrically angled cutting edges and three margins.

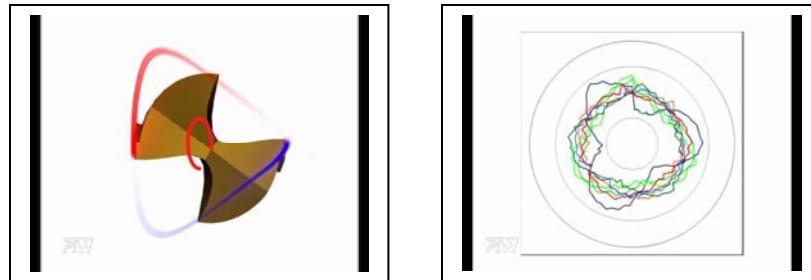


**New Y-TECH drill with two flutes and three margin lands**

## **Background**

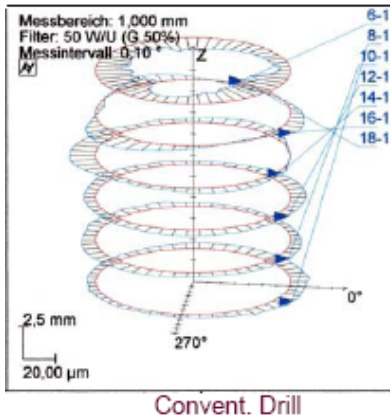
The basic concept of the Y-TECH drill acknowledges that all symmetrical two-cutting-edge, two-margin drills “walk” to some extent upon entering the workpiece. The function of the chisel point is to center the drill. Primary geometrical factors affecting the ability of the drill to center properly are the chisel angle, web thinning, and point angle, as well as the degree of grinding accuracy used in the drill’s finishing process. Due to the zero cutting speed at the drill tip’s center and low cutting speed along the length of the chisel edge while drilling, the workpiece material is pushed out of the way until the main cutting edges are engaged. Fine adjustments to the many geometrical combinations available can produce better centering, but at the cost of a weak chisel edge. Conversely, a robust chisel edge can tolerate high feed rates, but produces high thrust and poor centering.

Recent studies by the Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen Technische (PTW), Universität Darmstadt, Germany, shows that as the chisel edge enters the workpiece, it creates a concave oval, causing the drill to “swing” in a motion similar to a pendulum. Figures 1b and 1c show the effects of the pendulum motion on the roundness of the hole. For ease of description, the drill creates a triangular hole; the cutting edge corner forms the points of the triangle as the drill continues the pendulum motion created by the chisel edge.



Pics from PTW. Courtesy of PTW

Coupled with feed rate, the cutting action is slightly comparable to helical interpolation, with the drill margins typically riding the lead of the chisel edge throughout the hole. The end result is an out of round hole, with poor cylindricity and, at times, notable deflection from centerline.



Cutting forces are not equal per cutting edge, so the cutting edges are at slightly different planes as they follow the pendulum. Geometric deviations found in the drill grinding process, such as unequal hones on the cutting edges and symmetry errors, also contribute to creating asymmetric cutting forces.

## Material

Exotic materials with high tensile strength essential to the aerospace, energy, food processing, and medical industries, compound the issues noted above. With such high toughness materials, machine operators are forced to use low feed rates, extending the time that the drill's chisel edge is pushing material out of the way for the cutting edges to engage. Such extreme wear on the chisel edge further reduces the ability of the drill to center for subsequent holes, also increasing the pendulum motion.

Work hardening and elasticity are factors that increase the risk of drill push-off, due to increased cutting forces. Errors in hole roundness and shape become more pronounced in these materials.

Typical drill wear criteria in these materials are chipping on the chisel edge, chipping on the cutting edge (often caused as the drill is retracted), and chipping of the margin below the cutting edge. All contribute to reducing the number of times the drill can be reground, significantly reducing drill life and overall value.



Conventional SC-Drill:  
Chipping on margin  
land

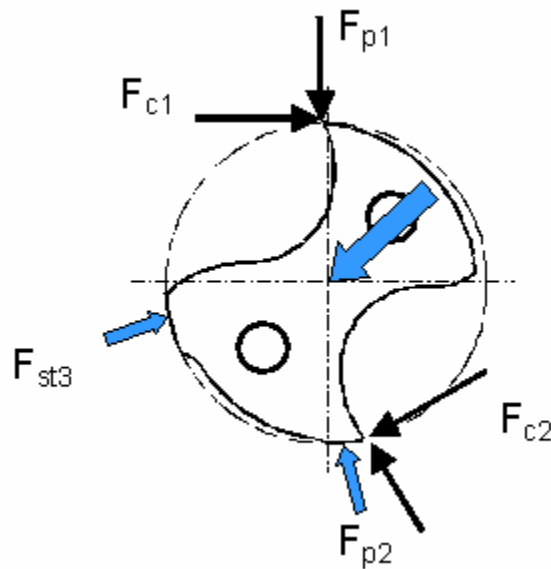
Other critical factors affecting hole quality are toolholding, machine rigidity, and fixturing. However, these factors can rarely rectify errors starting at the chisel edge.

### **Reconsidering Balance**

Balance is a state of equilibrium. Although symmetrically designed, conventional drills tend to create and perpetuate unbalanced cutting forces in the cut that

cannot be controlled. The Y-TECH drill redefines balance from an aesthetic design to a controlled function of the drilling process.

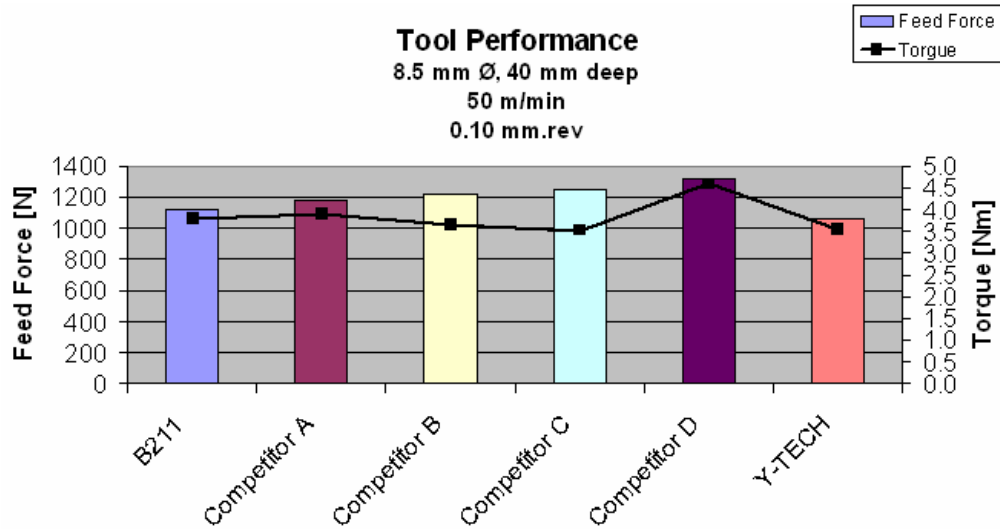
The design of the Y-TECH drill is not symmetrical. With one of the two cutting edges asymmetrically angled above the centerline of the drill, this slightly leading edge creates an overriding, one-directional force.



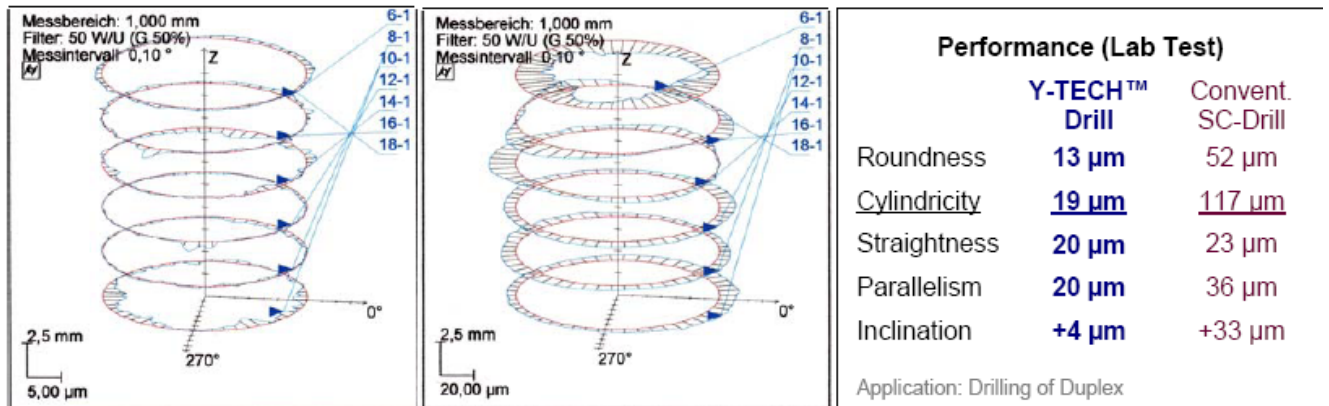
Counteracting this force is a guiding margin behind the lead cutting edge. This controlled cutting force directed against the guiding margin counterforce, guaranteeing that the drill will maintain the diameter throughout the cut. Any latent forces are supported by two traditionally placed margins.

To minimize the walking and pendulum motion, the Y-TECH features a chisel edge that allows good self-centering and a relatively short transition time from chisel to cutting edges. Although small, it is robust enough to center the drill and

is ideally suited to the low feed rates generally used in drilling high temperature alloys. The following chart shows the thrust and torque results in Duplex Stainless Steel (DIN 1.4462) material.



Substantial hole quality improvements are noted in the following test. Hole quality is consistent throughout the life of the drill.



Eliminating the pendulum motion not only improves the hole quality, but also reduces the wear and tear on the chisel edge, cutting lips, and the corner of the drill, substantially improving tool life. A producer of power turbines made from ASTM A 681 D3 (DIN X210Cr 12) material noted a 60% improvement in tool life. Retraction damage caused by hole shape errors such as spirals and corner chipping have been eliminated. Tool life improvements in secondary hole finishing operations such as tapping and reaming due to a constant chip load per tooth are obvious.

New in 2008, Kennametal's Holmaking Catalog is a great source for complete holmaking and hole-finishing tool and tool-system selection. It is available in print or in PDF format from [www.kennametal.com](http://www.kennametal.com). The 700-plus-page publication contains information on special tooling, and technical sections for the most informed choices in holmaking designed to increase accuracy and performance.

# # #

## **Glossary**

The following terminology is extracted from ANSI B94. 11-M-1979, "Twist Drills—Straight Shank and Taper Shank, Combined Drills and Countersinks," Many of these terms also apply to other types of drills,

**axis** The imaginary straight line which forms the longitudinal centerline of the drill.

**back taper** A slight decrease in diameter from point to back in the body of the drill.

**body** The portion of the drill extending from the shank or neck to the outer corners of the cutting lips.

**body-diameter clearance** That portion of the land that has been cut away so it will not rub against hole walls.

**chisel edge** The edge at the end of the web that connects the cutting lips.

**chisel edge angle** The angle included between the chisel edge and the cutting lip as viewed from the end of the drill.

**clearance diameter** The diameter over the cutaway portion of the drill lands.

**drill diameter** The diameter over the margins of the drill measured at the point.

**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.

**flute length** The length from the outer corners of the cutting lip to the extreme back end of the flutes. It includes the sweep of the tool used to generate the flutes and therefore does not indicate the useable length of the flutes.

**helix angle** The angle made by the leading edge of the land with a plane containing the axis of the drill.

**land** The peripheral portion of the drill body between adjacent flutes.

**land width** The distance between the leading edge and the heel of the land measured at a right angle to the leading edge.

**lips** The cutting edges of a two-flute drill extending from the chisel edge to the periphery. On core drills, the lips are the cutting edges extending from the bottom of the chamfer to the periphery.

**lip relief** The axial relief on the drill point.

**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. Lip relief angle is usually measured across the margin of the twist drill.

**margin** The cylindrical portion of the land which is not cut away to provide clearance.

**neck** The section of reduced diameter between the body and the shank of a drill.

**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.

**point** The cutting end of the drill, made up of the ends of the lands, the web, and the lips. In form, it resembles a cone, but it departs from a true cone to furnish clearance behind the cutting lips.

**point angle** The angle included between the lips projected upon a plane parallel to the drill axis and parallel to the cutting lips.

**shank** The part of the drill by which it is held and driven.

**tang** The flattened end of a taper shank, intended to fit into a driving slot in the socket.

**tang drive** Two opposite and parallel driving flats on the extreme end of a straight shank.

**web** The central portion of the body that joins the lands. The extreme end of the web forms the chisel edge on a two-flute drill.

**web thickness** The thickness of the web at the point unless another specific location is indicated.

**web thinning** The operation of reducing the web thickness at the point to reduce drilling thrust.