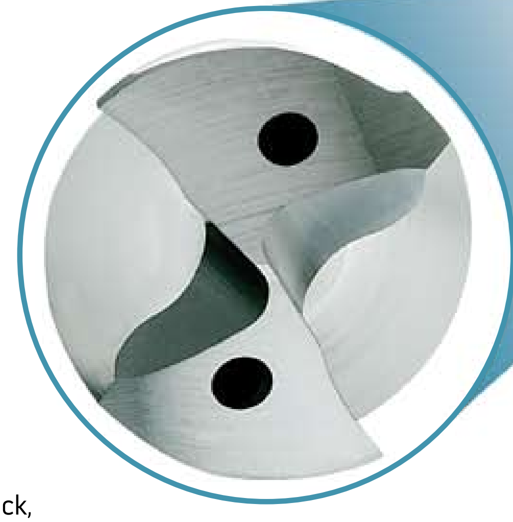
JANUARY 2009 / VOLUME 61 / ISSUE 1



By Herbert Kauper and Allen Poponick,
Kennametal Inc.

Walk On By

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Figure 1: Kennametal's Y-Tech drill has two flutes and three margins.

A carbide drill designed with two asymmetrically angled cutting edges and three margins reportedly minimizes walking while extending tool life.

All drills walk. Although this adverse condition is typically associated with HSS drills, out-of-roundness, deflection and poor cylindricality also result, to a lesser degree, when using a solid-carbide drill. The same forces that cause a drill to walk or push-off also shorten tool life, especially when drilling difficult-to-machine, exotic and expensive workpiece materials such as Inconel, Waspaloy and duplex stainless steel, commonly used for aerospace- and energy-industry parts. Wear quickly accelerates into tool chipping and then catastrophic drill failure within one or two holes of chipping occurrence, causing machine downtime and longer lead time for critical parts.

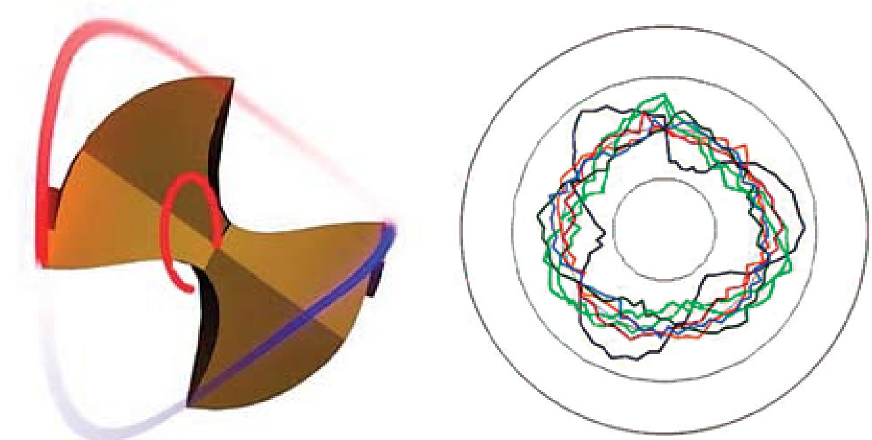
Because of high material, labor and machine costs, the aerospace, energy and other major industries are demanding drills that guarantee process security, consistent life for new and reconditioned drills and excellent hole quality. One tool addressing these demands is the new Y-Tech drill from Kennametal Inc., which "rebalances" traditional technical assumptions about drilling with a solid-carbide drill due to its unique design. The drill has asymmetrically angled cutting edges and three margins (Figure 1).

Drill, Don't Walk

The new drill's basic concept acknowledges that drills with two symmetrical cutting edges and two margins walk to some extent upon entering the workpiece. Walking occurs even though the function of the chisel point is to center the drill. The primary geometric factors impacting a drill's ability to center properly are the chisel edge angle, web thinning and point angle, as well as the degree of grinding accuracy when finishing a tool.

Because the cutting speed is zero at the drill tip's center and low along the length of the chisel edge while drilling, the workpiece material is pushed away until the main cutting edges are engaged. Fine adjustments to the many geometrical combinations available can improve centering, but the trade-off is a weak chisel edge. Conversely, a robust chisel edge produces poor centering and high thrust but can tolerate high feed rates.

Recent studies by the Institut für Produktionsmanagement, Technologie und Werkzeugmaschinen Technische (PTW), Universität Darmstadt, Germany, showed that as the chisel edge enters a workpiece, it creates a concave oval. This causes the drill to "swing" in a motion similar to a pendulum (Figures 2a and 2b). For ease of description, the drill creates a triangular hole; the corners of the drill form the triangle's points as the drill continues the pendulum motion created by the chisel edge.



PTW

Figures 2a and 2b: These illustrations show the pendulum motion and its impact on hole roundness caused by the concave oval that's created as a conventional drill's chisel edge enters a workpiece.

Coupled with the 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 result is an out-of-round hole with poor cylindricality and, at times, notable deflection from the centerline.

Cutting forces are not equal per cutting edge, so each cutting edge is at a slightly different plane as it follows 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 Matters

High-tensile-strength workpiece materials compound the issues previously noted. However, the aerospace, energy, food processing and medical industries desire parts made of those materials.

When machining these materials, machine operators must lower feed rates, extending the time a drill's chisel edge is pushing material away before the main cutting edges engage the workpiece. Such extreme wear on the chisel edge further

Walk On By *(continued)*

reduces a drill's ability to center for subsequent holes, thereby increasing the pendulum motion.

Workhardening and elasticity increase cutting forces and therefore the risk of drill push-off when drilling high-tensile-strength materials. As a result, hole-roundness errors become more pronounced in these materials.

Typical tool wear when drilling these materials includes chipping of the chisel edge, cutting edge (often caused as the drill is retracted) and the margin below the cutting edge. All contribute to reducing the number of times a drill can be reground, reducing drill life and the tool's overall value.

Other 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

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A chipped margin land, such as the one shown on this conventional solid-carbide drill, reduces the number of times a solid-carbide drill can be reground.

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 new drill's design is not symmetrical. One of the two cutting edges is asymmetrically angled above the drill's centerline. 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 is directed against the guiding margin counterforce,

Glossary

THE FOLLOWING TERMS were extracted from ANSI B94.11-M-1979, "Twist Drills—Straight Shank and Taper Shank, Combined Drills and Countersinks."

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

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

lips
Cutting edges of a 2-flute drill that extend from the chisel edge to the periphery. On core drills, the lips are the cutting edges that extend from the bottom of the chamfer to the periphery.

margin
Cylindrical portion of the land that is not cut away to provide clearance.

point
Cutting end of the drill, comprised of the ends of the lands, the web and the lips. It resembles a cone, but it departs from a true cone to furnish clearance behind the cutting lips.

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

web thinning
Operation of reducing the web thickness at the point to reduce drilling thrust.

Comparison of drill performance when drilling duplex stainless steel in a laboratory test.

	Y-Tech drill	Conventional solid-carbide drill
Roundness	13µm	52µm
Cylindricality	19µm	117µm
Straightness	20µm	23µm
Parallelism	20µm	36µm
Inclination	4µm	33µm

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ensuring the drill maintains the tool's diameter throughout the cut. Any latent side-to-side forces are supported by two traditionally placed margins.

To minimize the walking and pendulum motion, the new drill has a chisel edge that enables effective self-centering and a relatively short transition time from the chisel to the cutting edges. In addition, the drill is suited for the low feed rates generally used in drilling high-temperature alloys because the cutting edges have a light or medium hone that ensures the drill is cutting without work-hardening.

Eliminating the pendulum motion not only improves hole quality but also reduces wear 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 X210Cr12) material reported a 60 percent improvement in tool life and elimination of retraction damage caused by hole shape errors, such as spirals and corner chipping.

Drills want to walk when entering a workpiece, but drills that rebalance traditional technical assumptions can provide improved hole quality required for critical parts. CTE

About the Authors: *Herbert Kauper is senior product engineer, solid-carbide drills, and Allen Poponick is manager, global machine technology-holemaking for Kennametal GmbH & Co. KG, Fürth, Germany. For more information about the company's cutting tools, call Kennametal Inc., Latrobe, Pa., at (800) 446-7738 or visit www.kennametal.com.*

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