

► BY ALAN RICHTER, EDITOR

Index-A-Bore

Tools and techniques for boring small holes using indexable-insert boring bars.

Many shops look to replace solid-carbide tools with lower-cost indexable-insert tools whenever they can. In boring operations, it is now possible to apply indexable inserts for holes as small as 0.160". In this application, indexable inserts offer several advantages, including lower cost and ease of operation.

For example, Circle, Monrovia, Calif., a product of Kennametal Inc., makes a 0.156" inscribed-circle, 80° diamond-shaped insert with two cutting edges to access a 0.180" minimum bore. Therefore, indexable-insert boring bars can be used for boring small holes from around that dimension to less than 0.500", according to Kerry Cranford, Circle product manager.

While solid-carbide boring bars are still the tool of choice for boring smaller holes, indexable-insert tools offer a number of advantages.

"We hardly ever use something that's not indexable only because of the cost," said Greg Morgan, president of CNC Industries Inc., Fairmont, W.Va. The job shop typically applies steel boring bars from Iscar Metals Inc. tooled with Iscar inserts for boring diameters down to 5/16" in materials such as 1018 mild steel and 4140 alloy steel.

Many manufacturers use indexable-insert boring bars because it costs less to replace an indexable insert compared with a solid-carbide boring bar. However, Cranford emphasizes the time savings to index to a new cutting edge vs. setting up a solid-carbide boring bar once its edge is worn. "With solid carbide, you have to take the tool off the machine, go over to a grind-

ing machine, grind it and make sure it cuts," he said. "The indexable tool allows you to have the ultimate machining productivity off of a machine."

Gary Vanderpol, president of modular boring system manufacturer Criterion Machine Works, Costa Mesa, Calif., concurred. "As long as the repeatability of the insert is within the specifications of the bore, you can just index the insert or put a new insert in." That new insert can be identical to the previous one, or if the application requires, one with a different nose ra-

'As long as the repeatability of the insert is within the specifications of the bore, you can just index the insert or put a new insert in.'

dius, coating or chipbreaker configuration—what Vanderpol calls "the lumps and bumps."

In addition, regrinding a solid-carbide boring bar, if it is in salvageable condition, removes any coating and requires a vanishing skill set. "To find somebody who can grind a solid tool and put the right geometry on it, you probably can't find 10 guys in the country anymore who can do it," quipped Dennis King, director of engineering for Command Tooling Systems, Ramsey, Minn. The company makes MicroMax indexable-insert boring tools for holes as small as 0.228".

Geometries at Work

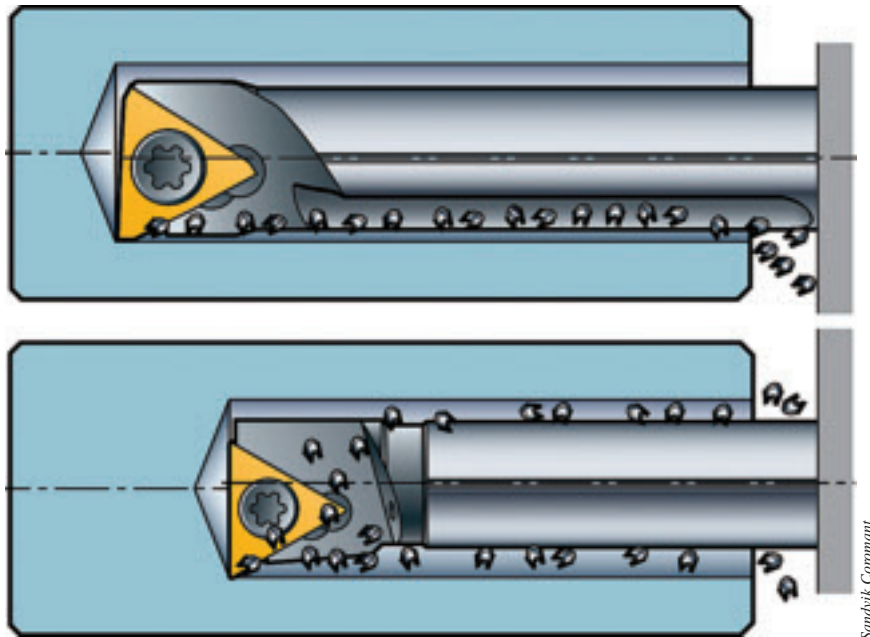
The insert's geometry is designed to break a chip when boring at low feed rates and a small DOC. The DOC

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ranges from 0.002" to 0.008" and the feed is up to 0.004 ipr but generally from 0.001 to 0.003 ipr, according to Bill Tisdall, turning products specialist for Sandvik Coromant Co., Fair Lawn, N.J.

Many of the toolmaker's inserts have a nose radius in the neighborhood of 0.032", but Tisdall noted that Sandvik Coromant's inserts for small-hole boring range from "dead sharp," or virtually no nose radius, to 0.008" to provide better shearing action and prevent chip control and vibration problems. "When machining small parts, you're going to need small radii because you don't want to put too much pressure on the workpiece," he said. "If you apply too large of a nose radius, typically, you're going to get some chatter. The smaller the nose radius, the easier it is to break the chip."

Surface finish, however, will suffer a bit with a small nose radius. Therefore, a wiper flat behind the nose radius



Sandvik Coromant mills a chip evacuation channel into its CoroTurn 107 boring bars (top) to better enable through-the-tool coolant to flush chips out of the hole and avoid recutting them compared to a standard ISO boring bar (bottom).

smooths the surface, enabling finishes as fine as 20 μ m. R_a , Tisdall explained.

The nose radius on the TPMT 321

coated insert from Iscar Metals Inc. that CNC Industries applies for small-hole boring is still relatively sharp at

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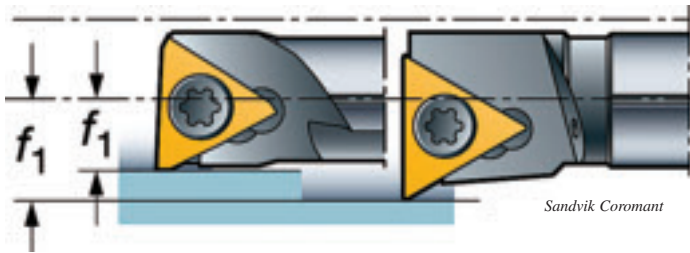
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Sandvik Coromant's CoroTurn 107 boring bars have a reduced F1 dimension compared to a standard ISO boring bar. This reduced dimension enables a larger diameter, more rigid bar to access a smaller diameter hole than previously possible.

0.015". Although Iscar recommends a 0.005 to 0.010 ipr, the shop reduced it to 0.003 ipr to achieve better chip control and produce the ideal C-shaped chip. "If we have a chip problem, it's pretty easy to define and then we modify our feed rate or spindle speed," Morgan said. "But we hardly ever modify the spindle speed because the insert is made to run at a specific surface footage."

Manufacturers can achieve more rigidity with their indexable-insert boring bars if the bars have reduced F1 dimensions. Tisdall said single-sided, positive-rake inserts with a 7° clearance angle are needed for Sandvik Coromant's CoroTurn 107 boring bars. The bars are available in four sizes: 5mm, 6mm, 8mm and 10mm. The bars feature a reduced F1 dimension, which is the dimension from the boring bar's centerline to the insert's theoretical tip. "The smaller the dimension, the smaller the bore you can access with the bar," he said.

An insert's geometries are designed to create and break a chip when boring, typically, at a low feed rate and small DOC.

This reduced F1 dimension allows a 6mm bar to bore a 7mm hole, for example, whereas a 5mm standard ISO boring bar was previously required to bore a 7mm hole. "Not only is the bar more rigid, but it allows more reach into the bore because the bar is larger," Tisdall noted. Therefore, when following the rule of thumb of a 4:1 length-to-diameter ratio for a steel bar, a 6mm bar can reach 24mm into the bore compared to 20mm for a 5mm bar.

To minimize deflection, Triad Tool-

ing Inc. adds a negative side rake on its boring bars to provide more strength under the insert pocket. "The bor-

ing bar has more material under the pocket," said Bob Vecchiarelli, president of the Wheat Ridge, Colo.-based

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toolmaker.

Vanderpol added that a boring bar made of heavy metal, which is similar to tungsten carbide but has a tungsten-nickel-copper-iron matrix, offers a length-to-diameter ratio up to 6:1 while a bar with a carbide shank and a brazed steel head offers a length-to-diameter ratio up to 8:1. Above an 8:1 ratio, a bar with some type of mechanical damping mechanism is needed, but bars for boring holes smaller than 1/2" are too small to accommodate such a mechanism.

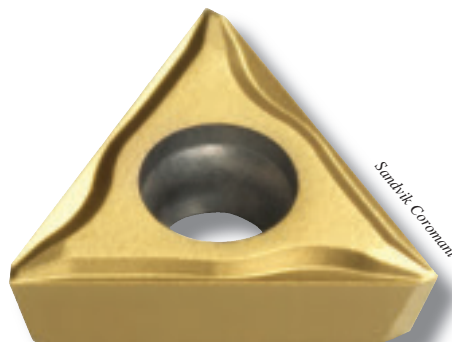
Pushing the limit isn't unheard of and Cranford recalled one customer who bored at a 15:1 ratio using a carbide bar. "But, you check back and find that he was only taking a 0.001" or 0.002" DOC in plastic or brass," he said. "As a tool company, we guarantee that if you fall within our recommendations, a tool will perform for you. It's when you go past those recommendations that the tool will not perform."

Out of the Hole

Once chips are created, they must be efficiently evacuated to prevent chip recutting, especially when boring blind-holes. To enhance chip evacuation, Triad Tooling Inc. includes a 2° to 5° lead angle for small-hole boring. "We always put a front lead on the bar," said Vecchiarelli. "We don't ever go flat into a blind-hole."

Effective chip evacuation is essential when boring smaller holes because 'those tools can't eat their chips.'

Triad also gundrills through-coolant holes into boring bars as small as 3/16" to direct the coolant to the tool/workpiece interface. "You don't even need high-pressure coolant, but if you can float those chips away from the cutting edge, you're going to have a better



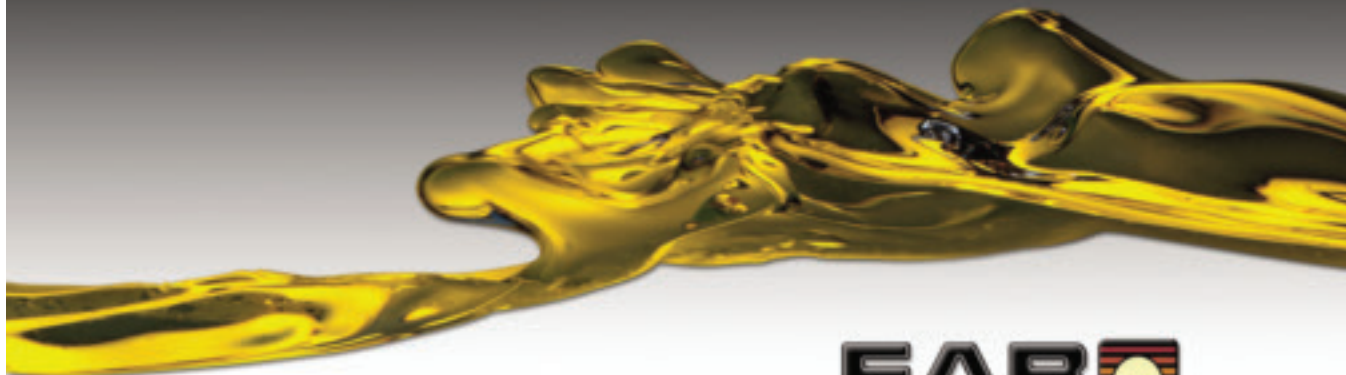
The chipbreaker geometry and wiper flats behind the nose radius on Sandvik Coromant's boring inserts help break chips and smooth finishes.

bore," Vecchiarelli said, adding that the 150- to 300-psi coolant pressure found on machine tools should be adequate.

To cut cooler and cleaner, skimming and filtering the coolant is important. "Even a paper filter on the chute entering the sump helps a lot," Vecchiarelli said.

When boring blind-holes, chips need to pass around the bar before exiting the hole. To enhance that action, Sandvik Coromant mills a

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chip evacuation channel into its Coro-Turn 107 boring bars. The slot allows through-the-tool coolant to flush chips through the channel.

Tisdall noted that boring bars can facilitate a coolant pressure of 70 bar (1,029 psi), which surpasses most machine tools' capabilities. Over that limit, the bar's fitting will likely start to leak and improper coolant flow may result.

Others take a different approach to coolant delivery to achieve the desired result. CNC Industries, for example, manually directs 80-psi coolant to the front of the hole being bored.

Applying less coolant when boring can be adequate but not desired. It's

better to apply some type of coolant, said Brian Schied, Urma product manager for Command, "but we can make it work without coolant or with a mist." When coolant is available, more is generally better. "But on smaller tools, too much pressure could sometimes be a hindrance because it could cause unnecessary tool pressure," he said. That, in turn, can cause chatter and hole tapering.

Whatever the method, effective chip evacuation is essential when boring smaller holes because "those tools can't eat their chips," said Command's King. "You have to get the chips out of the way because you'll lose size or finish or both."

To Coat or Not

The benefits that tool coatings provide during machining are well

The following companies contributed to this report:

Circle, a product of Kennametal Inc.
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www.circlemachine.com

CNC Industries Inc.
(304) 366-8262
www.cncindust.com

Command Tooling Systems
(800) 328-2197
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Kennametal Inc.
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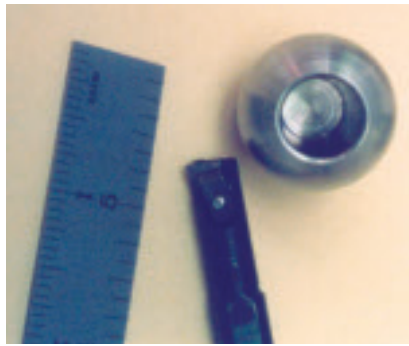
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documented, but coatings can be detrimental for small-hole boring because a coating smooths the edges. "Coated tools are never as sharp as uncoated tools," said King, "and the sharper the tool, the better the performance."

Sandvik Coromant's Tisdall agrees that applying an uncoated insert is an option, but usually recommends a PVD-coated grade. The PVD coating adheres to sharp edges with negligible alteration of the edge radius. "If you applied a thick CVD coating on a sharp edge, that coating will flake off the edge line," he said.

Circle's Cranford disagrees about a coating's impact. "The coating thickness is so minute it doesn't affect the nose radius or the cutting edges at all." However, he follows the rule of thumb that if a machine is not capable of running at high surface speeds, such as a manual lathe with a maximum



A cobalt-chrome cap for a hip implant is one example of a small-hole boring application using an indexable-insert boring bar at CNC Industries. The part starts with a 0.406" diameter and has a 1.5° taper.

CNC Industries

spindle speed of 3,000 rpm, apply uncoated inserts "because for coatings to work you have to really kick them up there," he said. "Circle's uncoated small-insert grades run best from 75 to 200 sfm. The grades with what we call a CG5 coating run best from 150 to 350 sfm."

Many shops use boring bars with flats clamped by setscrews because setup is easy. However, the drawback to clamping a boring bar in this manner is the bar is clamped at only two or three points. Tisdall recommends using a cylindrical sleeve with a cylindrical boring bar to achieve a stable

360° of holding contact. Finding the bar's center on a cylindrical bar isn't as easy as finding it on a bar with flats where everything lines up. To overcome that, Sandvik Coromant mills a small slot on the top of a cylindrical boring bar that interconnects with its Easy Fix Sleeve system. "The cylindrical sleeve has a spring plunger, and the ball that's attached to the plunger 'clicks' into the slot," he explained. "You can feel the bar come to center and then you clamp down on the sleeve so you know the bar is in the correct center position."

Because everything is magnified when boring small holes, a cutting force deflection, or dip, of about 0.010" will be much more significant on a 0.300" bore than on a 2.000" bore. "You have to remember that every time you bore a hole, your tool is going to dive," Triad's Vecchiarelli said, "so you have to establish centerline with reliability."

As smaller indexable-insert boring bars become more popular, the nature of small-hole boring becomes more evident, according to Cranford. "It's an art, just like making threads is an art." But with the proper tools and skills, manufacturers can create their small-hole boring art with consistent results. △



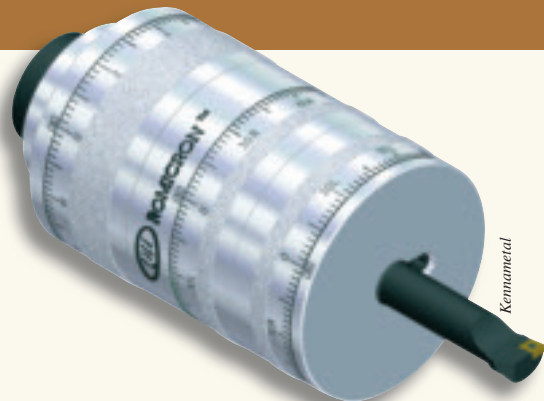
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For production boring applications that require statistical process control with CpK of 1.33 or greater, Kennametal Inc., Latrobe, Pa., offers the Romicron fine boring system made by Indústrias Romi S/A, Santa Bárbara d'Oeste, Brazil. The system permits 1.0µm adjustments of the tool tip on the tool radius without removing the tool from the machine. The various models provide a boring diameter range from 0.125" to 12.834", with the smallest diameter for an indexable-insert tool being 0.250". When using the modular units, the maximum boring diameter is limitless.

The clearly marked graduated dial makes it easy to see each adjustment, and the definite stop at each graduation allows the operator to feel and hear the click when making an adjustment with virtually no backlash, according to the company.

"The head design has a patented internal mechanism that doesn't require locking or unlocking," said Chet Parzick, Kennametal's senior product manager for holemaking. He added that other systems typically require a setscrew or thumbscrew to be locked and unlocked to move a mechanism when mak-



The Romicron fine boring system allows 1.0µm adjustments of the tool tip on the tool radius without removing the tool from the machine.

ing an adjustment. This process can cause some movement to the cutting edge once the final setting is established.

Built-in balancing allows the system to be balanced to G6.3 grade according to ISO standard 1940 even when through-coolant is used through the machine spindle. Allowable coolant pressures range from 284 to 1,000 psi.