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Getting the most out of your diamond-drill operation.

CORE COMPETENCY

Successful metalcutting operations often are a combination of art and science. That's certainly true when producing holes with bonded diamond core drills and solid drills.

The science part can be mastered through proper understanding of drilling speed and pressure, coolant usage and tool accessories. Experience hones the artisan.

Nonetheless, even first-time users of bonded diamond drills can quickly become proficient by learning and applying some basic principles. The following suggestions can help you drill advanced materials, such as highly metallic alloys, composites, glass and ceramics, faster and easier, while obtaining a smoother surface finish, minimizing workpiece damage and extending tool life.

Predrill Procedures

Before beginning, visually examine the diamond drill for cracks and other damage. Then check for drill runout, which will cause excess vibration during the operation.

Check for runout with an indicator specifically designed for this purpose. Slowly bring the indicator toward the drill until the indicator's spring just touches the tool's diamond tip. The indicator dial should read zero.

Next, turn on the drilling machine while holding the indicator firmly in place. The indicator dial should remain at zero while the drill is running. If it doesn't, the drill is experiencing runout. Turn off the machine and remount the drill.

Another effective way to check for runout is with a water swivel adapter, which directs water, coolant or air through the center of core drills (shown). Rotate the adapter assembly by hand. The water swivel adapter stem, which is placed into the drilling machine chuck, will indicate the runout of the drill's diamond section—the cutting edge. Wobble the head of the adapter manually. If too much vibration exists, there's runout. The greater the runout of the adapter, the greater the drill runout will be.

A. Richter

You should also ensure that the drill is held properly in the chuck. If the drill is not running true, loosen the chuck, turn the drill 90° and run the drill again. If this does not correct the problem, examine the equipment's condition or mount the drill on another machine to determine whether the machine, rather than the drill, is the problem.

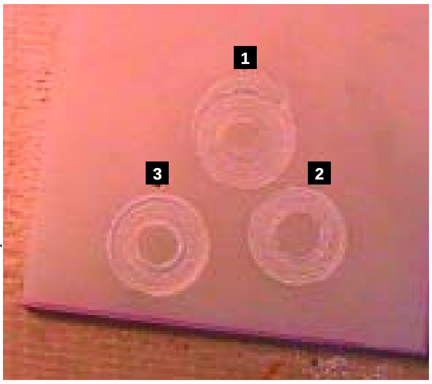
Make sure all equipment is in proper condition to accomplish your objectives. No matter how precise the drill, parts will be out of tolerance if the shaft or chuck are misaligned or vibrate excessively.

Starting a Hole

Once you're sure the drill and machine are set up properly, you're ready to start drilling. Clearly mark the insertion point on the workpiece and line up the drill with this mark. Drill by quickly pressing and lifting the drill head. Frequent raising and lowering of the drill during machining allows the metalcutting fluid to cool the tool and flush out chips and debris.

It is extremely important to hold the workpiece firmly in place with a clamp throughout the operation. Any workpiece movement can cause the tool's diamond section to break, possibly resulting in scrapped parts or operator injury.

When drilling thin materials, consider holding the workpiece with heavy-duty, double-sided tape or other adhesive product.



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Hole No. 1 shows significant runout, indicating the diamond drill was not dressed before use. The hole is out of round and shows signs of the drill hammering the surface of the material before making an indentation. Hole No. 2 shows the drill was properly mounted and checked for concentricity. However, it was still not dressed before use. Hole No. 3 indicates all proper diamond drilling procedures were followed. The tool was properly dressed and runs concentric.

To maximize drill life and minimize workpiece damage, drill at the manufacturer-recommended speed and pressure. The appropriate spindle speed depends on the drill diameter, diamond mesh size, type and amount of coolant, workpiece hardness, and bond type and hardness.

Small-diameter diamond drills must be applied at high speeds to impart a fine surface finish and perform efficiently. For example, speeds for solid diamond drills from 0.001" to 0.100" in diameter range from 350,000 to 9,000 rpm, respectively.

High-speed air spindles, hand-held drills and other specialty microdrilling equipment must be used. Air spindles typically run at up to 350,000 rpm, hand-held machines drill at up to 35,000 rpm and specialty microdrilling equipment speeds reach 25,000 rpm. At the other end of the spectrum is a 48"-dia. core drill. It's run at speeds as low as 3 rpm.

Soft, abrasive materials also require higher speeds, while hard, dense materials are machined at lower speeds. When diamond drills are used to cut hard materials—a common application—they typically run at very slow speeds.

Higher speeds would seem to increase productivity, but the tradeoff is a significant increase in friction and heat, which considerably reduces drill life and increases the risk of workpiece heat fractures and breakage.

It is critical to apply the right amount of pressure during drilling. Never force a diamond drill. Apply even pressure until the drill and material just touch. Since the drill and material surfaces are not perfectly symmetric to each other, this will allow the drill to adjust to the workpiece surface.

Applying light-to-medium pressure, gradually feed the drill into the material until it begins to progress on its own. Increasing pressure on the drill will do little to reduce the time it takes to complete a hole, but it can cause the tool to overload and overheat. This leads to excessive drill wear and defective parts.

When producing a through-hole, reduce drill pressure considerably as the tool is about to break through the material. This will minimize material chipping.

If a diamond core drill develops dark "burn" marks at the diamond section, the drill speed is probably too high or the amount of pressure is too great.

Coolant Considerations

The most frequent cause of diamond-drill damage is drilling without enough coolant. Never run a diamond drill dry—coolant should always be used to cool and lubricate the drill and to flush out debris.

Water is frequently used because it removes heat exceptionally well, is cheap and is compatible with most materials. Synthetic water-soluble coolants, mineral oils and other oils are sometimes applied. If coolant cannot be applied, another option is high-pressure air. Submerging the workpiece in coolant is another option.

If you plan to use water as a coolant, check with the drill manufacturer to find out what pressure is required and if any additives are recommended. (Note: Using additives will require a circulating system to ensure that the right coolant-to-additive ratio is maintained.)

The amount of coolant required generally increases as workpiece hardness does. Sparks flying while drilling indicate that insufficient coolant is reaching the drilling zone or the type of coolant is ineffective for that application. A generous flow of coolant increases holemaking efficiency and reduces heat buildup, thereby reducing the material cracking and deformation associated with overheating.

High-pressure coolant also washes out any debris that might stick in the

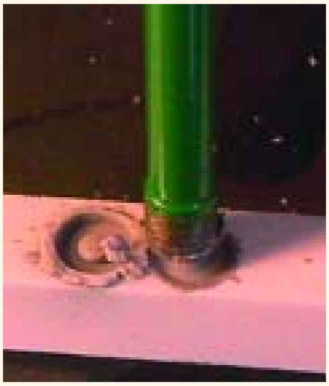
Drill dressing

Most bonded diamond can be dressed, or retrued, several times. The wear usually occurs on the drill core, diamond section and drill wall.

A diamond drill can be dressed by running the diamond section (diamond tip) against a dressing stick or silicon-carbide wheel until the wall thickness is uniform.

While dressing can improve the drill's accuracy, it can also pull particles from the diamond section. You can re-expose the diamonds by drilling into an Al_2O_3 stick a few times after dressing.

—*B. Farberov*



Drilling into an Al_2O_3 stick re-exposes diamonds after dressing.

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The best way to check for runout is with an indicator specifically designed for this purpose. The indicator dial should remain at zero while the drill (shown here mounted to a water swivel adapter) is running to ensure concentricity.

center of the drill. Periodically check the inside of the drill for material buildup. If you see that the core is becoming clogged, flush out the debris.

Center plugs restrict coolant flow and prevent coolant from reaching the diamond section. As a result, you will start to drill dry, significantly reducing tool life and damaging surface finish. Center plugs cause 90 percent of all drill wrecks.

To ensure proper cooling of the drill and workpiece, the coolant flow should be directed at the tool/workpiece interface. Coolant also should flow in the same direction as the rotation of the drill.

When drilling into a vertical surface, which is not recommend for advanced materials, continuously pour water onto the drilling zone with a squirt bottle or small cup.

Most diamond drills for advanced-material applications are applied on a horizontal surface, and coolant flows through the drill's center. If your equipment does not have a center-feed capability, consider using a water swivel adapter, which is also called a drill-head assembly. This device provides a constant, controllable flow of coolant through the center of the drill and is designed to efficiently cool both the drill and workpiece. Water swivel adapters have been shown to increase drill life by 40 to 75 percent, on average.

When selecting a water swivel adapter, make sure it is designed for the speed of your operation. Adapters with stainless steel ball bearings that offer adjustable water flow generally last longer and are easier to use than brass adapters with no bearings.

Swivel adapters are typically used with sintered (metal-bond) and other types of bonded drills that are mounted on a collet with a female or male thread. Solid drills and most electroplated (nickel-bond) drills have a straight shank and are not designed to have coolant run through their centers. When using these types of drills, submerge the workpiece in coolant or apply high-pressure coolant.

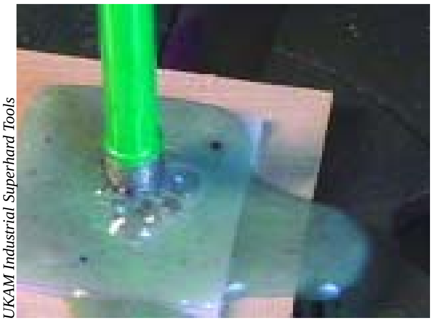
Drilling Depth

Most advanced-material applications require a drilling depth of no more than 1". When hole depth exceeds 1", coolant should be applied from multiple directions. For these applications, run coolant through the drill's center and from the side of the drill or, if needed, submerge the workpiece in coolant. This ensures the maximum amount of coolant reaches the drilling zone.

Apply more pressure and reduce the speed as the drill penetrates deeper into the workpiece. Lift the drill up after every inch of drill depth, letting the drill cool and fluid reach deeper into the hole. Visually examine the condition of the diamond tip, making sure it is round.

Proper care and maintenance are key to ensuring optimal drilling performance. If the results are unsatisfactory, ensure that:

- The drill is not damaged or misaligned.
- The workpiece is held securely.
- You're drilling at the right speed and applying the proper pressure.
- Sufficient coolant is being applied and necessary accessories are in place.



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Coolant, such as water, water-soluble coolant and mineral oil, needs to be applied during all diamond drilling operations.

Finally, check the drill regularly for debris buildup and dress the tool as needed to extend its useful life (see sidebar, page 40). Following these basic suggestions will help ensure efficient, problem-free drilling.

About the Author

Brian Farberov is vice president of UKAM Industrial Superhard Tools, Valencia, Calif. For more information about the company's diamond drills and other tools for cutting advanced materials, call (661) 257-2288 or visit www.ukam.com.