What you need to know about cutting holes

In the first of a new series, **Kurt Hertzog** covers the subject of drilling on the lathe

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Cutting and drilling holes in wood, plastic, or other commonly turned material may seem like a 'no-brainer'. Even so, I am surprised at the poor quality of some of the holes I see in woodturning projects. A wonderfully turned coat and umbrella stand is really less than optimal if the pegs aren't at the same angle and equally spaced. I've seen many stools with legs at slightly different angles. They may sit, but certainly are obvious in their shoddy workmanship. Don't limit your thinking to only the turning. What about the rest of the project? I've seen many otherwise stellar Windsor chairs with chip out evidence on the seat where the spindles are inserted. Usually repaired, but still evident to the critical eye. Some holes are cut with a lathe tool but many are cut with other cutters, either on the lathe or on other pieces of equipment before, after turning, or on other component pieces of the final product. In woodturning, two of the key rules for success are sharp tools and knowing your material. Using sharp tools with a light touch is always a winning strategy. I can't think of an instance when following that will let you down. Knowing your material is also always important. Be aware of and plan for any limitations of your material, its orientation and the best methods to work with it. Far too many turners will drill or cut into wood, oblivious to the characteristics of that species or particular material. Even knowing, they may pay no attention to the grain orientation. For the opening topic of this new series, we'll touch on both of those key points again as we generically explore cutting holes in turnings. We'll include drilled holes and cut holes of regular shape. Down the road, we'll deal with carved pockets, shapes, piercing, and irregularly shaped holes. While I won't be covering a lot about our turning tools and the methods you'd use with those, I'll be covering other things that will certainly get you thinking about cutting and drilling holes in general regardless of the tool and piece of equipment.

SAFETY

Throughout the discussion on creating holes, the use of safety glasses or a face shield as appropriate along with dust extraction and filter masks as needed is assumed. The appropriate personal protective equipment should always be the first thing you don before you begin to work

PHOTOGRAPHS BY KURT HERTZOG

On the lathe, it is so easy to make a diameter hole with any wall taper provided it is on the centreline. Off the centreline becomes a bit more difficult

Think first, cut second

I am not being facetious. Depending on your hole's end use, size, orientation with respect to the grain, equipment available to be used, stage of completion of the project, size and shape criticality, function, positional accuracy required and more, you'll be directed to different tools and methods. For example, the perch hole and bird entry hole in the side of a turned birdhouse. Properly located and drilled into the blank using a drill press before turning is far

safer and more effective than after turning and hollowing. Drilling into end grain lends itself to different cutters than those used when cutting into face grain or cross grain. Of course, wet wood drills and cuts far differently than drier wood. One of the most important considerations is the size and criticality of the hole. A 2mm hole is far easier to accomplish well than a 30mm hole. Thinking first about these various considerations will help you be successful. Plan on the various holes you'll need in your turning and when it is optimal to create them. On occasion, the best time is a bit out of the usual sequence but it is when you can get the best grip on the material for the process you'll be using. Sometimes additional fixturing is needed to perform a safe and top quality job. I have found the time spent creating the proper fixturing when needed is far shorter than the time redoing the project because you've messed it up. Believe me, I do speak from experience. Thinking through the entire project, knowing when and where the various holes are needed and planning for the best time to execute them is worth the time and effort. There are times certain holes can be best done prior to turning, during turning, or when the turning has been completed. Perform them at the various times as needed for the best final result.

TIPS FOR THINK FIRST, CUT SECOND

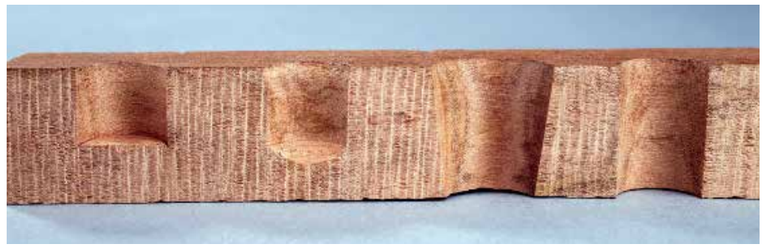
1. Does the material lend itself to the holes needed or will it be troublesome?
2. When is the best time and what is the safest, most secure workholding method for the particular cutting process?
3. Is the size, shape, position, fit, direction, depth critical and planned for?
4. Will the grain orientation cause me problems with any of the above needs?
5. Is it a through hole or a blind hole? Can I properly back up a through hole for a clean breakout?
6. Do I have the ideal tool and equipment for the job?
7. If not, can I borrow, rent, or buy the proper tool or equipment for the task?

Think grain

This was a topic in the past, so you may want to review that to refresh your memory – see issue 255, July 2013. We'll hit just some of the highlights here. One of the first things you'll need to consider is the orientation of the grain. Are you cutting into face grain, end grain, or some cross grain condition? Depending on the grain orientation, you may be better served with a drill, sawtooth bit or rotary hand tool with a cutter. In a perfect world with the assumption you have the proper size in either tool, you will usually use the standard twist drill for end grain and the sawtooth – Forstner – bit for face grain, regularly shaped round holes. With a cross grain situation, you can select one or the other based on the degree of angle of the grain and the material. How dense is the material? Will it cut cleanly or be soft, mushy and produce a ragged edge regardless? Does the hole need to be a finished hole or is it an in-process hole? Is it a through hole or a blind hole? If it is a blind hole, is the depth critical? What about the geometry of the bottom of the hole? Can it be the commonly available twist drill configuration of 118° or 135° or does it need to be 'square' at the bottom? Grain will have a tremendous effect on all of these issues. Depending on the grain orientation, hole diameter and hole depth, the drill can be misdirected along the intended path. Deep drillings with small diameter drill sizes are very susceptible to following the grain direction or just plain wandering.
A great example might be drilling a hole for the brass tube used in pen kits. It is a through hole, but susceptible to blowout at the exit end depending on material. For the most part, it is an end grain drilling but there is occasion where a face grain or cross grain orientation is selected for unique appearance. The size, while not especially critical, does have importance. The amount of space between the outer diameter of the tube and the inner diameter of the hole will be important for how much space there is for glue. Too tight and you risk squeegeeing the adhesive off as you press in the tube. Too loose and you have a large gap to fill. Drill too far ahead of the actual tube gluing process and you risk having the hole change shape with moisture changes causing difficulties with tube insertion later on. Another example would be the implications with chair rung drillings or other holes that will require adhesives, controlled fit and perhaps the hole bottom geometry. Too loose is sloppy with a visible perimeter line and potential glue visibility. Being too tight can become a piston when trying to glue.

When drilling larger sized holes, it is often better to start small and do progressively larger drilling rather than attempt a single large hole in one pass

Even the most modest priced countersink will do a better job of a chamfer than attempting to use a twist drill as this turner did



Depending on your final use, you may need a bottoming twist drill hole, a through hole, a tapered through hole, or a 'flat' bottomed hole

Very effective for clean entry in face grain, the outer perimeter scoring cutters engage after the pilot point and just before the peeling cutters

With the scoring cutters leading the way, the peeling cutters can act just like a bench plane when drilling into face grain

A thickness of packing tape on the top and bottom surfaces seems to help minimise damage as does always having a sacrificial breakout backing block. The piece is clamped down to prevent spinning if jamming of the blade occurs

TIPS FOR THINKING GRAIN

1. For face grain drillings, a sawtooth bit is usually best suited because of the scoring process performed by the cutter outer diameter
2. For end grain drilling, a standard twist drill bit will most often work well provided the hole size is not too large
3. For larger end grain hole drilling, drills are not available or extremely expensive so a sawtooth bit is brought to bear. Drill slowly and clear the debris
4. For twist drills, it is usually better to 'step up' the hole size by using progressively larger bits than to drill a single, large hole immediately
5. Proper support for the workpiece is critical for location, size and quality
6. Finished surface holes require special care both at entrance and exit surfaces

Sharp cutters are key

Sharp tools and light touch are keys to success. Dull cutters of any type will do a poor job. Without sharp tools, everything becomes a scraper. You'll use too much force, generate excessive heat and create an end result that is far less than optimal. There are so many different cutters you'll need in your workshop that it will be impractical to cover all sharpening, but let me touch on a couple.

There is a more in depth sharpening discussion in issue 261. You should have developed your skills at sharpening your lathe tools, but don't be afraid to touch up whatever you are using before you begin cutting your hole. Take the opportunity to refresh that edge often should the hole involve extended cutting. This is particularly true when doing deep drillings with a sawtooth bit in end grain. The only reason to use a sawtooth bit in end grain is the high cost of twist drills in larger sizes. That along with the difficulty in chucking larger drill sizes.

Sawtooth bits are very modest in price for larger sizes by comparison. The advantages of sawtooth bit operation is lost when drilling end grain. In end grain, the peeling cutters of the sawtooth bit are continually cutting short little stubs of wood rather than peeling the layers of face grain. That works the cutters extremely hard. Stop and touch up the tool with your hone rather than continually pushing harder. Letting the bit cool and refreshing the peeling cutter edges is worth the effort. You'll have less degradation of the tool, less smoke and far better results.

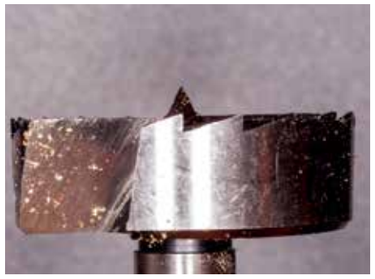
I know there are a few rare exceptions, but for our purposes here I don't believe you'll run into any problems with using a tool that is too sharp. For sharpening, let's focus on the two most commonly used drill bits that woodturners use; these are standard twist drills and sawtooth bits. Drills of any sort as purchased aren't necessarily sharpened properly or well. I don't possess the skills to freehand sharpen drills on a grinder as some do. Years ago, I purchased a Drill Doctor to sharpen my drills. That drill sharpening machine, equivalent, or other fixturing devices for a grinder can aid in sharpening twist drills. The model that I own will not only do very small drills, but also rather large diameters. It is capable of both 118° and 135° drill nose angles. It can't deal with many of the speciality, stepped nose grinds or brad point bits, but it accomplishes what I need quickly with accuracy and repeatability well beyond my freehand skills.

Sawtooth bits are usually a turner's downfall. They are often marginal quality and used improperly. Because they often come in sets at a bargain price, they are economy steel and not always as sharp as they need to be. Beyond that, the end user will run them far too fast, overheating the bit and dulling it quickly. Even sawtooth bits of moderate quality can easily be sharpened using a diamond hone. The skills and equipment needed are minimal. The key is using the correct technique and sharpening often. If a sawtooth bit becomes dull, you'll have great difficulty sharpening it. If it is touched up often to maintain sharpness, you'll be able

My drill sharpening machine sharpens 118° and 135° drills from 2.38mm to 19mm quickly and repeatably

Discounters often have replacement drill sets for a modest price. Depending on your needs, it may be a lower cost alternative to a sharpening machine

Sawtooth bit sets are available at very modest cost. Larger or speciality sizes are usually quite expensive



A sawtooth bit does three functions in sequence: the centre point provides guidance; the scoring perimeter slices the face grain and peeling cutters slice the material out

to touch it up quickly and provide quality cut holes. The outer perimeter of the sawtooth bit should never be sharpened by the home user. These are scoring knives and will last the usable life of the cutter provided it isn't abused. Messing with the scoring knives on the outer diameter of a sawtooth bit changes the hole dimension, alters the effectiveness of the scoring function and more often than not, ruins the cutter. Don't ever touch the outer diameter scoring knives! If you do manage to use – or abuse – the bit to where the scoring cutters aren't effective any longer, it is time to replace the bit. If it is a costly bit worth resharpening, let a professional touch up the scoring knives.

It is similar to sharpening a fine hand saw and is usually best left to the experts. The only place you'll need to sharpen is the peeling cutters inside the outer diameter. Sharpen those peeling cutters with your diamond hone – never hone on the angled top surfaces of the cutting edge. Always hone on the long flats leading to the peeling cutter edge. You'll be able to refresh the edge by honing this flat surface. In order to keep from rolling the cutting edge, keep the hone flat to this surface as you sharpen. That will keep the peeling cutter edges at their original relief angle and coplanar. It is the same concept and method used when sharpening spade bits. On the topic of spade bits, they have little to no use in woodturning holes. Even with their scoring cutters, they are brutal in their entry and exit holes and function much like a scraper. Spade bits are ugly in face grain and useless in end grain. They may be cost attractive, but are best left to creating holes in floor joists for passing water pipes or electric lines.

TIPS FOR SHARPENING

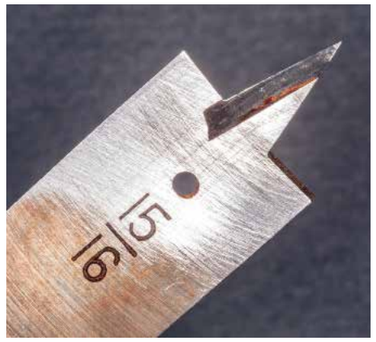
1. Always touch up your tool sharpness before it begins to cut poorly
2. Keeping your cutters sharp by touching them up often is far easier than sharpening a dull cutter
3. Grinding cutting tools should be a cool process without discolouration or need for quenching
4. Most twist drills, spade bits and sawtooth bits are carbon steel so overheating whether from sharpening or abuse can cause permanent damage
5. A set of diamond hones is one of the handiest sharpening touch up tools in the workshop
6. A drill sharpening tool or fixture can be a good investment over the long haul

Handy to have in the workshop at a very reasonable cost, a set of diamond hones will aid sharpening everything from your skew chisels to sawtooth bits

The outer perimeter scoring cutters perform valuable work on face grain. Most turners should never attempt to sharpen them

A diamond hone held flat to the front surface leading to the peeling cutter edge while sliding the hone back and forth will help keep your sawtooth bits sharp

A diamond hone can sharpen a spade bit nicely, used in the same fashion as for a sawtooth bit: flat on the surface leading to the cutting edge on both sides



Even with the OD edge of the blade engaging first, a spade bit is a scraper and is brutal on the entry and exit hole surface finishes. Avoid using them in woodturning

Speeds and feeds

Much like setting the speed on your lathe based on the size, shape, weight, tool being used and finish desired, the speeds and feeds of your cutter creating your hole are extremely important. Too fast and you'll overheat things while muscling your way through. It dulls cutters, burns material and often blows out on the far side. Too slow and it doesn't always make the optimal cut. It rips and tears more than cuts. Exactly like the size of your blank being turned appropriately, the surface speed of your cutter needs to be considered. Like all cutting, the surface finish and effectiveness of the cut is based on the surface feet per minute of the cutter past the material being cut. This is true whether you are rotating the cutter or rotating the work. RPM really isn't the issue to be concerned with, it is surface feet per minute. The SFPM of the cutting edges is all important. Cutting a hole with a 6mm sawtooth bit can be run at a far faster RPM than using a 100mm bit. Of course, this is all tempered with the material, orientation, workmounting and desired finish surface.

Slower isn't always the answer. When drilling, feeds are just as important. I always recommend including the process of 'breaking the chip'. The drilling process I use is to advance with steady yet reasonable force, then relax the force and retract the cutter slightly; this will allow the chip to break and the cutter to exhaust the debris. Without the flutes being clear, the debris can plug them and cause burning at the cutter edges. The quality and finished size of the hole are at risk. If needed, retracting your cutter and clearing the flutes is always worth the time. Even with good backing support when cutting a through hole, good practice is to relax the drilling force when nearing the breakthrough point. This will improve the exit hole finish regardless of the backing support provided. If you are ever in doubt of the proper speed and feed, take a piece of scrap of the same material and test out your best guess. Cutting a few holes in the same material and the same orientation will usually give you the best answer. A quick view of those holes can tell you almost everything needed. Burnished on the inside, RPM too high; rough and torn up on the inside, RPM too slow. Breakout on the bottom, too much force approaching the exit and/or insufficient backing support. Surface entry torn up, use a sacrificial top board or tape to keep fibres in place and use slower feed and lower entry force.

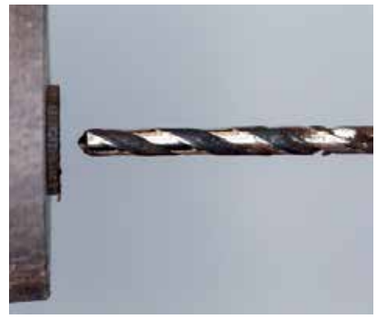
TIPS FOR SPEEDS AND FEEDS

1. When in doubt, practice on a scrap of the same material and orientation
2. Breaking the chip and clearing the exhaust mechanism is worth the time.
3. Smoke is rarely a good sign!
4. Don't worry about RPM, surface feet per minute of the actual cutter surfaces is the important factor
5. Material, depth, diameter, cutter type, and work-holding all impact proper speed and feed
6. If you are to err, err on the side of slower than needed rather than faster

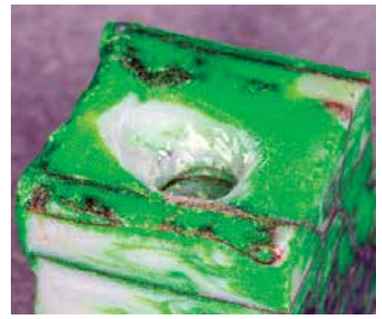
The surface feet per minute of the cutting edges at the same RPM is quite evident between a 6mm and 80mm sawtooth bits

The exit hole in softwood shows the tape used to assist with the process. Force reduction just prior to breakout will allow for the breakout to be a clean 'plug'

Drills are available in a myriad of forms including centre drills, standard twist drills, short fluted long drills and full length fluted long drills



Dense, wet, or oily woods are troublesome with plugging the flutes. For the best results, it is wise to stop, clear the flutes and then continue the drilling



Rare in woods, blow out at the exit is common in brittle plastics. The easiest solution is to leave sufficient stock for cutoff to the unaffected area

Finished size accuracy and position

When you select a drill from an index or a sawtooth bit from the box, you'll take it based on the size of the hole you desire and the marked size of that bit. If the size of the hole is approximate or you'll be turning a piece to fit that hole, all is good. If the hole needs to mate with something of a precise size, check your cutter carefully with an accurate measuring tool. Even if you are using high-quality drills or sawtooth bits from one of the quality producers, your dimensions are likely to be off a bit. Not only will the material and method have an impact on your final hole size, but certainly the manufacturing variation from the marked size can also cause a problem. Not usually a radical difference from the indicated size, there is always a tolerance from the best quality to the lowest quality. Usually the less expensive the cutter, the larger the variance from the indicated size often is. Not always but if size is important, select the proper drill or bit based on your measurement of the actual cutter tip rather than the shank. Better yet, measure the size of the finished hole using that bit in a test block. It isn't often that a woodturner needs a precisely dimensioned hole, but accept that most cutters aren't always as they say. Also, the material itself will impact the final dimension. Regardless of the drill size, measure the finished hole if size is that important to you. If the position is important, using a centre drill to locate the starting point is very important. A set of machinist's centre drills is inexpensive and a valuable addition to your kit. By design, they will create a small starting location precisely where you locate it and provide the drill or bit a starting point to prevent wandering on the start. I always use them on the lathe and

often in my drill press. Whether face grain, end grain or in between, the time and effort involved in providing a good start location is worth doing. I keep a medium-sized centre drill mounted in a spare drill chuck with a Morse taper at the lathe for quick use. When a different size centre drill is needed, I will take the time to retrieve it and mount it for use.

Depending on your need for positional accuracy, you may be laying out the position(s) with layout tools or patterns. Your layout tools might be as simple as a ruler, compass and a pencil or as complex as a furniture maker's layout tools. For large radius curves, such as the radius of the spindle holes for a Windsor chair seat, I've used a push pin, string and golf score pencil. In order to precisely locate the centre of a hole, a centre punch or scratch awl may locate the exact location prior to the centre drill. You may be able to use the centre punch mark to begin your drilling or use it to locate the centre drill. Either way, the goal is to create a mechanical start point for your subsequent drilling. This is especially key when creating any geometric or repeating pattern. The human eye has the ability to detect minor variations in size or position in repetitive patterns. Turning the finest set of Shaker pegs for a hallway coat rack will certainly be lost if they aren't all mounted on the exact same line, angle and spacing.

"Either way, the goal is to create a mechanical start point for your subsequent drilling"

TOP TIPS FOR SIZING AND POSITIONING

1. Virtually all cutters have some small manufacturing variance from the indicated size
2. When measuring cutters, the absolute accuracy of the measuring instrument isn't important if you use the same instrument to measure all of the items involved in the fit
3. The material and method can have an impact on the finished size
4. When the finished size is critical, measure a test hole created in a scrap of the same material
5. Your headstock indexing system can be a valuable tool for rotational position holes
6. A set of centre drills is a wise and modestly priced investment

The true size of a drill is the measurement across the cutting flutes. It isn't the stamped size or the shank measurement. When important, measure a drilled test hole

Very rigid and short, especially the drill portion, machinist centre drills are used to create the starting point for your subsequent drillings. It prevents wandering

Using a centre drill to create the starting point, even a long, slender drill, such as this 3 × 150mm will start exactly where desired

When drilling round stock in a drill press, always use a 'V' block to safely hold the work and a centre drill to spot your starting location

A chair spread hole being drilled with a sawtooth bit. Notice the starter drill hole and the depth indicator with the blue tape 'flapper'

Handy for drilling holes on a lathe, a drilling fixture provides angle setting, depth control, and rotational position when used with the lathe indexing lock

Conclusion

In anticipation of the emails to the Editor asking 'what on earth does an article on cutting holes have to do with woodturning?' My answer is 'everything'! The most accomplished turner with poorly executed holes, a finish with runs in it, or sanding scratch marks under a superb finish hasn't accomplished their best result. Every process you do in the creation of your work, whether a bowl, lidded box, ornament, pen, chair spreader, stairwell baluster, or any other turning, is important to the end result. Bragging about turning your ornament with your skew chisel really isn't impressive if your hole for the hanger is off centre or holes for your chair back spindles are chipped out on the perimeter edges, is it? Attention to detail is what separates the truly accomplished turners from the 'wannabees'. Everything you do from the selection of the project and material to the presentation of the finished work is an important aspect of woodturning. As said in the intro, it may seem like a 'no brainer' but it really isn't. With just a little attention to detail, you can be certain that these necessary functions add value to your end result rather than being a detraction. ●

Lots of effort creating a unique blank. Far too little effort in layout and drilling the holes. Attention to detail isn't that difficult and it pays dividends