a closer look

Not all carbide is created equal

THE HARDEST MAN-MADE MATERIAL HAS REVOLUTIONIZED WOODWORKING, BUT QUALITY VARIES

BY MARK SCHOFIELD

"Get used to honing your bits each time you use them, as dull ones tend to chip, splinter, and burn the work."

This advice, from the first issue of *Fine Woodworking*, is a reminder that some things have gotten a lot easier over the last 30 years.

The author was referring to steel router bits, and the reason this advice is no longer needed is summed up in one word: carbide. Invented in Germany in the 1920s, tungsten carbide is a dense, hard, wear-resistant material that now is everywhere from giant mining tools to the rolling ball of your pen. In woodworking, it has revolutionized sawblades and router bits, increasing exponentially the length of time between sharpening.

It's easy to take those carbide tips for granted, but after doing some research I've gained a new respect for them. There's a lot of technology in each tip.

Unfortunately, not all carbide is created equal, and there is no national or international standard for well over 5,000 different carbide grades. But there are ways to increase your chances of buying tools with premium-quality carbide. I also learned how to prolong the life of carbide-tipped blades and bits, and how to tell when they do need sharpening.

Carbide varies by quality and type

Tungsten carbide is the hardest man-made material known, with wear resistance about 100 times that of steel. In addition, it has 2½ times the rigidity of steel, is dimensionally stable, retains its hardness at high heat, and has an impact resistance similar to hard tool steels. In short, it is pretty amazing stuff.

You may have seen tool makers refer to their carbide as being C1, C2, etc. These grades, originally developed for classifying carbide by its ability to cut metal (they run from C1 to C19), are defined not by its chemical makeup, which can vary widely,

From fine powder to power tools

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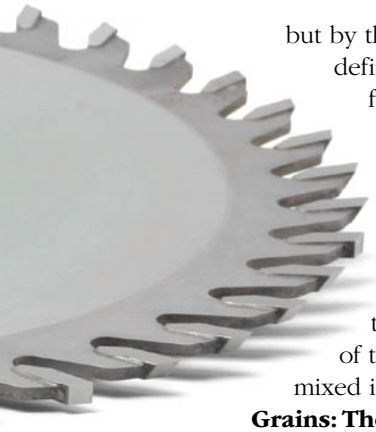
CARBIDE IS MADE IN THREE STAGES

Carbide begins as a mixture of very finely ground tungsten and carbon black (1). After a binder such as cobalt and some wax are added, the material is molded into its rough shape and given an initial baking. Known as green carbide, the material at this intermediate stage is soft and crumbly (2), which allows it to be machined easily. Finally, it is baked a second time at high temperature, which causes the material to shrink 18% to 24% to create the hard, dense carbide used on tools (3).

Molded under pressure. *Metal-injection molding (MIM) is used to form the powder/binder/wax mixture into more complex shapes. The equipment is similar to that used for injection molding of plastics.*

Attached as teeth. *Carbide tips are brazed onto the steel plate of a sawblade. Repairs to broken teeth are done in the same way.*

Photos: Multi-Metals (this page, bottom center); Case Western Reserve University (microscope images)



but by the style of work it can do. C3 is defined as finishing, C4 as precision, for example, but there is no agreement on what this means.

Like steel makers, carbide manufacturers face a trade-off between toughness (the ability to resist fracture), and hardness (wear resistance). There are two main ways to vary the properties of carbide: the size of the grain and the percentage of binder mixed in.

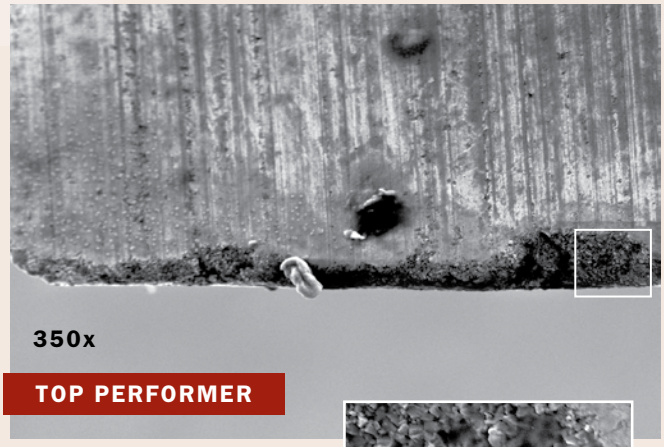
Grains: The trend is smaller—You'll often see carbide tools listed as having submicron carbide or micrograin carbide. This means the individual grains of carbide are less than 1 micron in diameter. Fine-grained carbide is listed as being 1–2 microns, medium as 2–5 microns, and coarse as over 5 microns. With the exception of fine-grained carbide found on "construction-grade" tools such as circular-saw blades or cheap router bits, most woodworking carbide is submicron because it gives greater wear resistance. Unfortunately, this also decreases the toughness of the carbide. To try and reach the sweet spot of greater longevity without excessive chipping or cracking, some manufacturers change the composition of their carbide by adding boron or titanium carbide.

Binder: the trade-off—The percentage of cobalt binder for most woodworking products ranges from 3% to 10%. As you increase the percentage, the hardness goes down, decreasing wear resistance, but strength goes up for better fracture resistance. Manufacturers use this to adjust the carbide's properties for different uses. Freud, alone among the woodworking tool makers, manufactures all of its own carbide and makes 22 grades. It might use an ultrafine grain (less than 0.5 micron), high-cobalt carbide for the exposed sawteeth on a high top-bevel blade,

Used in solid form. *While some bits and blades have carbide pieces attached to a steel plate or shaft, others, such as this spiral cutter, must be machined from solid carbide.*

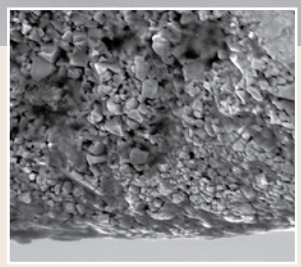
Tale of 2 bits: hard vs. tough

We were curious to see and compare the wear on two router bits tested in *FWW* #191 ("Tool Test: Router Bits"). David Matthiesen, a professor in the Department of Materials Science and Engineering at Case Western Reserve University, placed the winning and losing bits in a scanning electron microscope and looked at the damage to the straight edge on each, first at 350x resolution and then at 2,500x. We also noted the finer sharpening job on the better bit.



350x

TOP PERFORMER

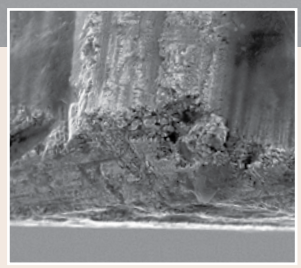


2,500x

Hard-wearing but brittle. *Some types of carbide emphasize hardness and wear-resistance, but they tend to be more brittle and can chip away. This bit was still cutting cleanly despite the microchips.*

350x

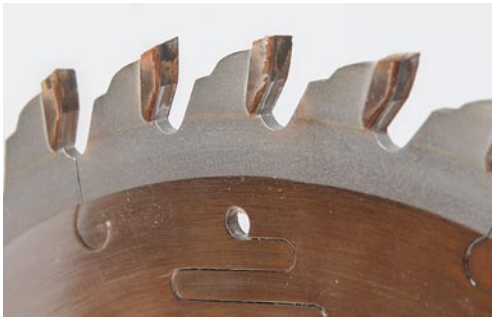
BACK OF THE PACK



2,500x

Tough but malleable. *This carbide resisted fracture better than the bit shown above but got blunt faster. The rounded-over edge made poor-quality cuts soon after the test started.*

Keep carbide clean



Brush your teeth regularly. *If pitch and residue are allowed to build up on the sawteeth, they will increase friction. This extra heat will shorten the life span of the carbide. Apply a mild household cleaner or blade-and-bit cleaner, allow it to sit for a few minutes, and then scrub the teeth with a brass- or nylon-bristle brush.*

but on a triple-chip grind blade designed to cut more abrasive melamine, more wear-resistant carbide is used.

What to look for

As one manufacturer of high-end blades ruefully explained, you can't tell good carbide from bad with the naked eye. You have to rely on the old saying "You get what you pay for." There is plenty of cheap carbide around, much of which contains recycled material, but most professional-quality tools use only virgin carbide.

What you can see with the naked eye is how finely ground the carbide is. A tooth or flute with visible coarse grind marks will be less sharp than one with a more polished appearance. A manufacturer trying to cut costs by using cheap carbide is unlikely to invest more than the bare minimum sharpening it. When comparing similar types of blades, choose the one with thicker carbide because it probably will be more durable and can be resharpened more often.

The way the teeth are brazed to the sawblade or router bit is also important. Steel's thermal expansion during brazing is two to three times that of carbide. So with conventional braze alloys, as the steel cools, it shrinks more than the carbide and wants to draw the latter into a bow shape, creating stresses.

If possible, choose a tool that claims to be made with tri-metal brazing shim using silver-copper-silver braze, as this reduces the joint stress caused by brazing. Last, go to a manufacturer's Web site and look around for information on the carbide it uses. If the site goes into detail about the carbide, there is a better chance the company is concerned about quality and matching the carbide specs to the tool's use.

How to make it last longer

High levels of pitch and residue buildup should be avoided because, as the residue is pulled away, it can take small microchips from the cutting edge with it. Eventually this will blunt the corners and cutting edges. Also, buildup increases friction and heat, shortening the life of the carbide. To overcome this problem, clean your carbide regularly.

There are many recommended dos and don'ts when it comes to cleaning sawblades and router bits. Freud recommends soaking the blade in kerosene and then removing the buildup with a bristle brush. Products the company has found that attack carbide are those very high or low on the pH scale. Forrest Manufacturing recommends cleaners such as Formula 409 or Fantastik in conjunction with a brass- or nylon-bristle brush such as an old toothbrush. Don't use a steel wire brush, as this will damage the carbide. Forrest doesn't recommend oven cleaner because it tarnishes the steel plate of the blade and removes any plastic film including the logo. Last, it is much easier to remove slight buildup on the blade or bit frequently than it is to wait until a thick layer of residue is baked on.

Materials that wear down carbide—Carbide is strong stuff, but there are one or two uses that will shorten its life. Any wood high in phenolic acid will corrode the cobalt binder. Fortunately, this is mostly found in green or wet wood, and in particular cedar—not something furniture makers are likely to encounter often.

Woods containing silica or salts, such as teak, also are more abrasive, as are man-made materials such as medium-density fiberboard and plywood. If you are going to be cutting large amounts of plywood or teak, put on an old carbide blade and save your best one for less-abrasive cuts.

When to sharpen—How can you tell when it's time to sharpen your carbide? Burnt cuts is one warning sign; increased pressure required to make the cut is another; deteriorating cut quality such as chipout when crosscutting plywood is a third.

Finally, should you sharpen your own carbide tools? In almost all cases, it is better to let a professional sharpening service do the job; after all, you no longer need to sharpen these tools each time you use them. □

Photos, except where noted: staff