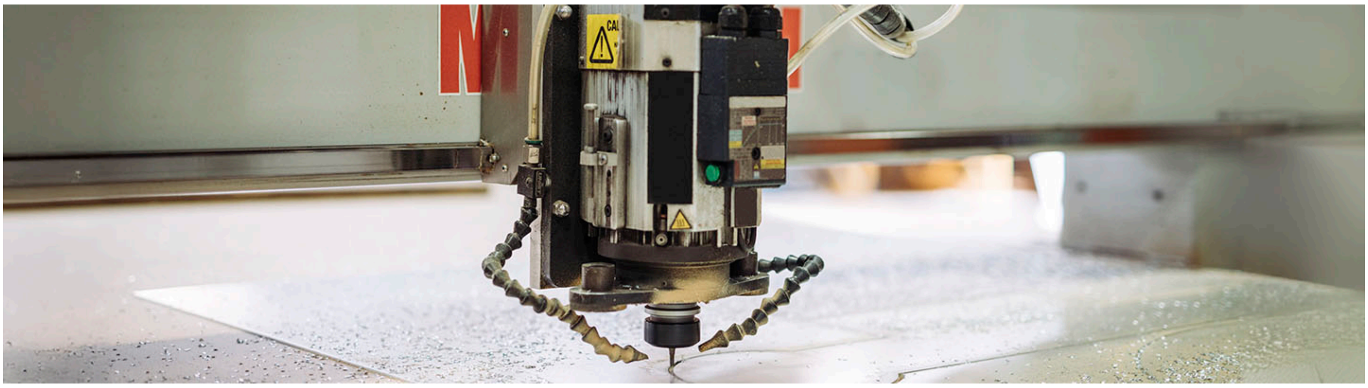


Metalworking

Machining Composites: Smarter Tools, Better Results

Kip Hanson | May 13, 2025

From automotive body panels and tires to canoes, tennis rackets and abrasion-resistant work gloves, composite materials are all around us.

The lion's share of these are glass fiber-reinforced polymers (GFRP) that, due to their lower cost, are used to make many of the products just listed. Carbon fiber-reinforced polymers (CFRP) and aramid fiber composites, aka Kevlar, on the other hand, exhibit superior strength and lighter weight (albeit at a higher price tag), making them the darlings of the ***aerospace industry***.

The applications are too numerous to list, but one well-known example comes from aerospace giant Boeing. Its Dreamliner 787 contains just over 70,000 pounds (32,000 kilograms) of CFRP, built from roughly 23 metric tons (50,700 pounds) of raw carbon fiber. These can be found in the fuselage, wings, tail, doors and interior structures, most manufactured by automated fiber placement (AFP) and automated tape laying (ATL) heads that layer carbon-fiber "prepreg" onto contoured molds.

Though highly sophisticated and able to produce extremely complex shapes, this is, in many ways, the easier part of the manufacturing process. That's because practically all composite parts require trimming of the outer periphery after layup, as well as operations like cutting out windows and drilling mounting holes. And as anyone who's machined it can attest, CFRP and GFRP are both highly abrasive, while their older cousin phenolic tends to melt when tools get too hot. Furthermore, all three of these materials are prone to splintering, fiber pull-out, and delamination, failure modes that become even more prevalent as tools grow dull.

> **"The interface between coating and tool is extremely important."**
> William Sebring
> Kyocera SGS Precision Tools

Manufacturers looking to machine them learn very quickly that the drills and end mills used on aluminum and steel don't last. Cutting fluid is typically a no-no, so heat builds up quickly. Tool wear skyrockets, fibers pull out, layers begin to separate. Simply put, a ***better solution is needed***.

The good news is that cutting tool manufacturers like Kyocera SGS Precision Tools of Cuyahoga Falls, Ohio, have developed a lineup of drills, end mills and routers specifically designed to handle the unique challenges of composites while delivering longer tool life and "cleaner" parts.

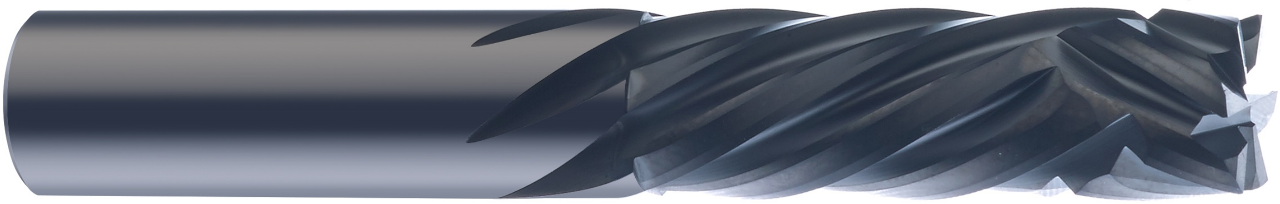
Read more: What is a Composite Technician?

The Right Balance

William Sebring, vice president of the company's Technical Center for Research and Development, says coatings are the first line of defense. His team uses and recommends chemical vapor deposition (CVD) diamond coatings on their solid carbide drills, routers and end mills. "The interface between coating and tool is extremely important," he says. "This is why we recommend a fine grain carbide substrate with 6 percent cobalt, which provides for improved adhesion following the pre-treatment process."

Compared with physical vapor deposition (PVD) coatings, CVD is many times thicker—12 to 20 microns, as opposed to PVD's 2 to 4—and harder. That increased thickness and hardness helps tools survive the abrasive punishment of composites, but unfortunately, it also rounds the cutting edge somewhat. As with any machining process, however, sharpness matters, especially when it comes to avoiding fiber pull-out and delamination, although these are more likely if tools wear prematurely. Put the two together, and composite machining is a balancing act between tool life and workpiece quality.

Compression-style endmills help solve the problem of fiber pull-out and delamination. Since the flutes are ground in opposite directions—upcut helix at the bottom and downcut helix at the top—the cutting forces push the composite layers together during machining, keeping the material intact.



Compression-style endmills have an upcut helix at the bottom and downcut helix at the top. These serve to push the composite layers together during machining and keep the material intact. (Photo courtesy of Kyocera)

Yet part thickness also plays a role here. Standard compression routers work well for most applications, but when panels are much thicker or thinner than usual, Kyocera SGS Precision Tools can adjust the transition point between the upcut and downcut flutes. "Through the special-order process, we can change that transition point to accommodate different material thicknesses," Sebring says.

Layup direction also matters. Sebring explained that composite layers can run in different directions—zero degrees, 90 degrees, 45 degrees—and every change affects how the tool cuts. "As you start to build up these different layers, a tool that handles one section cleanly might struggle a few millimeters deeper. This is why it's important to work with the cutting tool supplier to optimize the geometry and coating thickness, especially on longer-running jobs."

Some facilities turn to brazed polycrystalline diamond (PCD) tools in situations like these. While these are very hard and wear-resistant, you can't grind complex shapes into them the way you can with solid carbide. Kyocera SGS's solid carbide CVD diamond-coated tools, on the other hand, are said to allow for finely tuned geometries—compression, burr and special tip shapes—that cut cleaner and last longer than non-PCD tools and give manufacturers the geometries needed for complex, composite aerospace parts.

Solid carbide and CVD diamond-coated tools are available in compression, burr and special tip shapes, giving manufacturers the geometries needed for complex, composite parts. (Photo courtesy of Kyocera)

Speed Matters

Somewhat surprisingly, the cutting parameters used in composite machining aren't extreme. Cutting speeds usually range from 400 to 500 surface feet per minute—fast enough to remain productive but slow enough to avoid increased rates of wear due to abrasion and cutting temperatures.

Dust control is another consideration. Unlike metal machining, which produces chips that fall to the machine bottom and is typically performed with cutting fluid, composites produce a fine dust. Many CNC machines use negative pressure systems to pull the dust away before it can settle into toolholders, motors and, more importantly, an operator's lungs. If such environmental controls are unavailable, however, it's crucial that the machine is equipped with an appropriately sized dust collector.

Toolholder selection is similarly important. Shrink-fit holders are recommended for composite machining because they provide strong clamping, rigidity and low runout. ER collets, by comparison, are prone to dust contamination if not carefully cleaned. "If you're using any kind of collet, the dust can get up inside the collet and create problems if not thoroughly cleaned with each tool change," Sebring says.

Read more: Cutting Challenges: Mixed-Matrix Composites and Fiber-Reinforced Composites

Cutting Costs

Price is always a factor in any cutting tool discussion, especially where diamond and diamond-coated tools are concerned. It's for this reason that some shops choose lower-cost PVD-coated tools or even uncoated carbide for short runs. But as Sebring points out, this might be a case of saving pennies and throwing dollars away—a CVD-coated tool can last 15 to 20 times longer than an uncoated one when cutting graphite and composites, meaning fewer stops to change tools, longer unattended runs, and cleaner parts at the end of the shift.

Composite development isn't standing still. New resins, new fibers and new layup techniques are hitting the market every year. That makes cutting composites more like chasing a moving target than following a playbook.

"Every day is a learning experience with these materials," Sebring says. "Success means staying flexible, finding the optimal balance of tool life and part quality, and working closely with suppliers who understand this application. Doing so can save manufacturers a lot of money."

What challenges with cutting composites have you encountered at your facility? Tell us in the comments below.

