

Drilling, Cutting, Machining Composite Materials and Structures

Dr. Scott W. Beckwith

SAMPE International Technical Director and President, BTG Composites Inc., Salt Lake City, UT
E-Mail: swbeckwith@aol.com

Composites, unlike metals, are not isotropic and consist of both unique resins and fibers. Hence drilling, cutting and machining composites in any post-processing operation to get to the final part shape/configuration, is indeed different. While this short column is not intended to cover “every” little trick of the trade, it is meant to offer some advice in areas pertaining to machining, cutting and other basic operations we need today to post-process composites. Understandably we do have water jet cutting equipment and other dry cutting equipment available. However, this short column is meant to address primarily those operations that are not quite as “automated” and often require a more “hands-on” personal approach.

Machining – one of the basic operations necessary to cut things to size and to finish off edges, dimensions and other aspect of a finished assembly part. Table 1 provides a few thoughts (some very obviously very basic and more typically fall into the “well duh?” regime). However, I’ve listed them here anyway.

Table 1. Machining composites – A few tricks of the trade to consider.

Topic	Best Practices or Reason
Tool Sharpness	<ul style="list-style-type: none"> • Keep all machining, drilling and cutting tools sharpened to reduce fuzzing, pitting, fraying and delamination
Coolant Use	<ul style="list-style-type: none"> • Reduces heat buildup in resin, controls dust and minimizes particulate damage
Backup Materials	<ul style="list-style-type: none"> • “Rigidize” thinner composite sections: <ul style="list-style-type: none"> ○ Masonite or aluminum stock ○ Plywood ○ Teflon or rigid plastics
Post-process Cleaning	<ul style="list-style-type: none"> • Rinse parts afterwards with water, solvents or appropriate materials
Overheating	<ul style="list-style-type: none"> • Overheating causes potential damage scenarios: <ul style="list-style-type: none"> ○ Fiber-resin microcracking ○ Delaminations at edges ○ Resin thermal degradation of mechanical properties ○ Unacceptable color changes (cosmetic loss)
Dust Collection	<ul style="list-style-type: none"> • Always use dust collectors for “dry” operations
Electrical Motor Protection	<ul style="list-style-type: none"> • Protect CNC electric motors, computer control systems, other electrical devices from carbon fiber dust: <ul style="list-style-type: none"> ○ Carbon fiber highly conductive – shorts out electrical systems ○ All reinforced fiber/resin dust unacceptable around secondary painting operations
Machining Speeds and Feed Rate	<ul style="list-style-type: none"> • Select machining speeds, drilling rates and feed rates appropriate for the materials used (note that aramid behaves very different from carbon and glass composites)

Conventional fluted steel cutters certainly exist and are used in fabricating final composite parts. These are the high-speed steel (HSS) and carbide cutters that are readily available and used quite often. Cemented carbide and preferably single-crystal tools are recommended for machining glass-fiber composites. However, polycrystalline diamond (PCD) tools are more preferred due to the fact they wear less than HSS cutting tools. Table 2 shows some of the desired parameters suggested for PCD tool use.

Finally, cutting composites may indeed produce more damage than desired if not done carefully or correctly. Table 3 points out some of the major concerns associated with “cutting composites”, particularly advanced composites.

Table 2. Recommended PCD tool parameters for glass- and carbon-fiber composites.

Tooling Parameter	Glass-Fiber Composites	Carbon- or Graphite-Fiber Composites
Nose Radius (inch)	0.030-0.090	0.020-0.040
Side Relief Angle (deg)	5-20	5-20
Positive Back Rake (deg)	0-5	0-5
Speed (sq. ft/min)	400-3600	500-2000
Depth of Cut (inch)	0.01 and greater	0.001 and greater
Feed Rate (inch/rad)	0.001-0.010	0.005-0.015

Table 3. Cutting advanced composites – Areas of concern.

Area of Concern	Considerations and Suggestions
Contamination	<ul style="list-style-type: none"> • Coolant contamination • Irreversible coolant solvent action • Contamination of secondary bonding areas • Particle residue contamination
Cut Quality	<ul style="list-style-type: none"> • Inability to obtain smooth surface finish • Minimization of fiber fraying and fuzzing • Minimization of delamination • Minimization of microcracking
Load or Stress on Composite Part	<ul style="list-style-type: none"> • Ply separations due to: <ul style="list-style-type: none"> ○ Holding or clamping forces ○ Excessive post-process induced operational loads
Heating Effects	<ul style="list-style-type: none"> • Heat distortion damage (warping) • Induced thermal overstresses • Excessive heat damage to composite, adhesives or resin
Radius Cutting	<ul style="list-style-type: none"> • Inability to cut small radii in composite structure
Post-Cut Operations	<ul style="list-style-type: none"> • Required “minimum” follow-up processing required • Increased processing costs to clean up/repair faulty operations or procedures
Tool Wear	<ul style="list-style-type: none"> • Excessive tool wear • Excessive tool wear not caught prior to finishing • Machine down-time from tool wear
Tool and Equipment Versatility	<ul style="list-style-type: none"> • Lack of ability to cut numerous materials and product types

And, for the interested reader, a few references for additional reading:

- | | |
|--|--|
| <p>1. DuPont Kevlar™ Aramid Fiber Processing Brochures:
 a. Cutting Aramid Fibers
 b. Machining: Special Cutting and Finishing
 c. Machining: Cutting, Drilling and Sawing</p> <p>2. Handbook of Composites (2nd Edition), S.T. Peters (Editor), Chapter 27 (Composites Machining), Kluwer Academic and Chapman & Hall, 1998, ISBN 0-412-54020-7.</p> | <p>3. Composites: Vol. 21, Introduction to Post-Processing and Assembly, F.C. Campbell, pp. 615-673, ASM International, 2001, ISBN 0-871-70703-9.</p> <p>4. Post Processing Treatment of Composites, M.M. Schwartz, SAMPE Publishing, 1996, ISBN 0-938-99475-1.</p> <p>5. Post-Processing FRP Composites: The Art of Drilling, Cutting, Machining and Getting Parts Ready to Ship, S.W. Beckwith, Composites Fabrication, pp. 52-64, October 2001.</p> |
|--|--|