THE CARBON FIBER SCENE

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After many years of hope and promise, carbon fiber finally seems to be coming of age. Once an expensive material used only for highly specialized parts, we now see a reduction in cost making it more affordable to the homebuilder.

The fiber that has been used on homebuilt aircraft is T300 (or a similar cloth) and it has been around for 20 years. Improved over the years, it is still very much the same as the original.

A fairly new development is a precured laminate which helps the homebuilder to achieve the properties carbon fiber is capable of. One of these is "Spar-Tuf," available from Gordon Plastics, 2872 S. Santa Fe Ave., San Marcos, CA, phone 619/727-2008. Spar Tuf is available in sheets up to about 12" wide and from .020" to .375" thick. The other one is a new arrival, "Graphlite," available from Neptco, Box 2323, Pawtucket, RI 02861-2323, 401/722-5500. This product comes in the form of round rods, .050" to .250" in diameter. It is the product that when bundled and encapsulated makes up the spars of the Bell VS-22 Tilt Rotor aircraft.

The feature which makes these precured laminates desirable is the fact that their process solves problems which all carbon fiber users share. These problems will cause a decrease in strength of the cured laminate. They might include: wavy or off-axis fibers where the yarn of the cloth is not straight, too much or too little resin, or problems in reduction in strength resulting from improper cure, etc.

Carbon fiber is used more in unidirectional layups of "yarn" than in woven fabric. The reason is that the inherent waviness of the fiber in woven fabric takes a terrible toll on the strength you can develop in the parts when compared to the straight fibers in yarns. The two products mentioned are not based on fabrics, but on straight and parallel fibers laid alongside each other in a minimum of resin.

One homebuilder who designed spar caps in carbon fiber had a friend test them in a commercial lab and was only developing 60,000 psi in either tension or compression; a quite disappointing result. Five years later he worked in a test lab himself and found he could make specimens that tested over 350,000 psi using the same fiber! The difference was all in the process controls applied to the materials, layup and cure of the parts. One way to cut through a lot of problems is to buy the spar cap material from the above shown sources rather than try to fabricate these yourself.

The Bell VS-22 was very weight sensitive, as most aircraft are. The designers were looking at ways to reach the theoretically possible 480,000 psi. The best their test specimens could do was about half that. By reducing the resin content to the laminate and by ensuring near perfect straightness of the fibers, they were able to reach a compressive strength of a little under 400,000 psi! The remarkable performance of this manufacturing method, shown in Figure 1, has been attributed as much to improved fiber straightness as to higher fiber volume content. It is probable that the exact amount of contribution made by each of these improvements will not ever be known, as they are both achieved at once by the same process.

Laminate materials having properties like those mentioned above require some of the "magic" of the new fibers, such as Hercules IM7 or IM8, or Toray T800 or T1000. All of these fibers are currently available and are in production at both the laminate producers mentioned above.

When we make our own laminates, the performance of the laminate may lie anywhere within a curve which probably looks like Material B in Figure 2. When we use a process like that employed in the plants making the materials noted above, the curve takes a shape much more like that of Material A in Figure 2, or possibly even better.

The problems in any composite material are so complex and devious that they are never really absent but usually range from poor to fair, good, or, hopefully, very good control. The difference in the measured strength of your parts can increase 100% or more, just by moving from "poor" to "fair" in this ranking. The improvement in some properties can be as much as 500 to 800 percent, if you go all the way to "very good."

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Editor's Note: One of the best sources for information on composites is the book Composite Basics by Andy Marshall. This book is available at $30 ppd from: Marshall Consulting, 720 Appaloosa Dr., Walnut Creek, CA 94596, phone/Fax 510/945-1461.

About the Author

Andy Marshall, BA, M.E., CA Registered Professional Engineer, is president of Marshall Consulting. He was employed by Hexel Corp. from 1950 to 1978; vice president of Orcon from 1984-1988; a former research engineer at the University of California; a UAL engineer, and publisher of numerous documents on composites. He is an internationally known expert in core materials, sandwich structures and composites in both aerospace and industrial fields.

FIGURE 1
COMPRESSIVE STRENGTH VS. WAVINESS

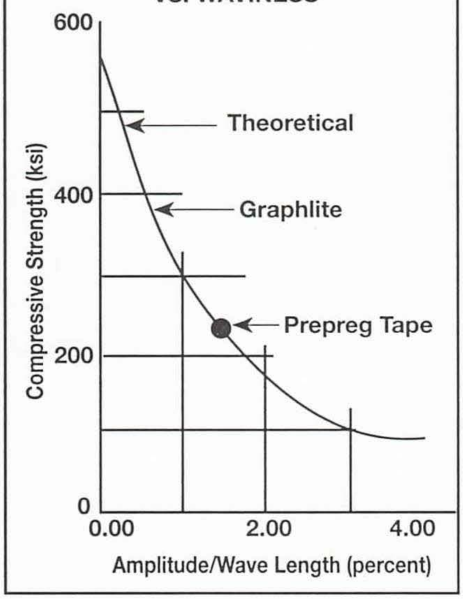

FIGURE 2