CARBONICS

Advanced Composite Engineering & Manufacturing for Marine & Industrial Applications — GMT

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Photo: Billy Black

Tim Kent's Everest Horizontal finished a solid second in the Open 50 ft. Class of this year's Around Alone. GMT spars and rigging powered Tim to a strong performance. See "GMT NEWS" for more on Tim's race.

MEGA YACHT PARTS PUT GMT INTO "BIG TIME"

Since the founding of GMT in 1984, we've been building high strength parts for yachts of all descriptions. Whether it's a 35 ft. spinnaker pole for a 100 footer, a rudder for a Volvo 60 or masts for an 82 ft. world cruising yawl, the same GMT pedigree can be found in all three. Years of experience engineering and building critical structural elements for high load applications was a natural fit for use in constructing parts for the burgeoning mega yacht market.

In 1996 GMT manufactured the first carbon fiber headstay chainplate for the 125 ft. Antonisa, built by Hodgdon Yachts. The immense part, measuring 5 ft. x 3 ft. and weighing 195 lbs. was engineered and built to handle a 115,000 lb. headstay load. Six years later, GMT won the opportunity to construct a similar part for Scheherazade, 154 ft. of hand crafted beauty set to be launched late this summer. This time the part was built to handle loads commensurate with a headstay of -195 rod (breaking strength = 195,000 lbs.)! (For photos, see Carbonics #18) In 1998, we were selected to build a daggerboard for a Bill Dixon 120 footer and a rudder for an Ed Dubois 143 ft. sloop both under way at Holland's Vitters Shipyard. We currently are building

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COMPACTING CARBON LAMINATES OR DEBUNKING THE AUTOCLAVE MYTH

By David Schwartz, Chief Engineer & President, GMT Composites

Ever since GMT began building prepreg carbon spars, we have touted the benefits of carbon spars in general and our manufacturing process specifically. In recent years, the sailing public has been bombarded by claims that carbon fiber construction is best carried out with the use of an autoclave. The fact that GMT has the lowest failure rate in the industry is the first indication that those claims are false. To better understand GMT's construction process, we present the following description of not only our process, but a thorough look at the years of experience that led us to it.

GMT manufactures spars by applying uni-directional, pre-pregs to either a male or female tool.

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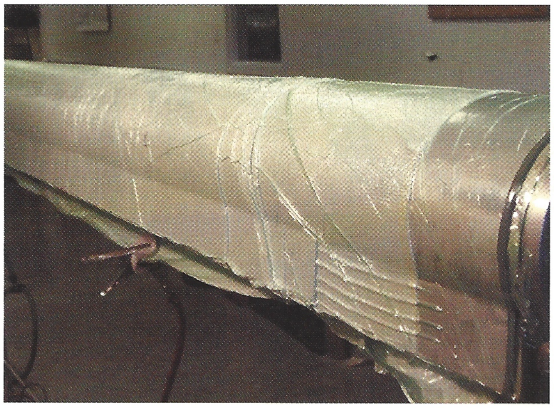
AUTOCLAVE MYTH *cont.*

The pre-preg material that we use is manufactured by Newport Composites. After evaluating materials from seven manufacturers, we selected this material in 1990. Over the years, we have evaluated new resin systems, but find that the Newport product still yields superior laminates. The resin system in the pre-preg is tailored specifically for a vacuum bag cure at 250 F. This means that the viscosity profile with temperature and the cure rate were designed so that the resin would exhibit excellent flow and fiber wet out under one atmosphere prior to curing. The result will be a uniform laminate with very low void content.

Good results also depend on laying down the uni-directional carbon properly. The plies must be applied smoothly in the correct orientation. Fibers must be kept straight as no amount of compaction pressure will straighten out kinked fibers. Debulking under full vacuum is carried out numerous times during the laminating process. Tape wrapping is added in select areas to aid uniformity and compaction. A similar process is carried out before the final cure. At this time, the temperature of the part is ramped up to an elevated temperature in our instrumented oven. The part is allowed to dwell at this temperature to allow the partially softened resin to flow. After the dwell, the oven temperature is raised to the cure temperature. The resin viscosity decreases farther and completely wets out the fiber. After an hour the resin solidifies. Final resin content of the part is controlled by a perforated film which allows a small amount of excess resin to flow out of the part as it compacts and cures. This flow helps remove any gases that may be in the laminate.



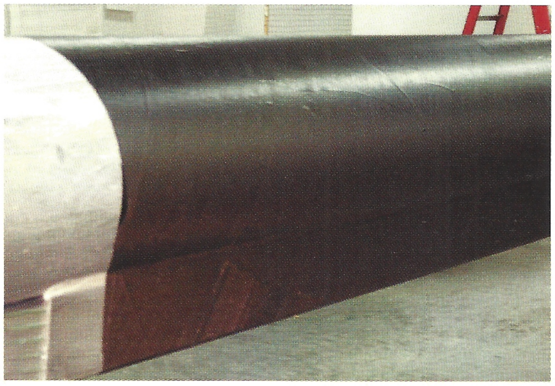


Photo: Cathy Antone

Debulking under full vacuum is carried out numerous times during the laminating process (top). With vacuum bag and other laminate consolidation materials removed, the carbon laminate is compacted and ready for additional plies of uni-directional carbon (bottom).

GMT perfected this process early in its history. It is a process that was originally developed in the aerospace industry. They used it to make many parts with vacuum bag cure epoxy. As the defense industry expanded their use of composite parts, they found that they needed laminates that would stand up better in what they call a "hot-wet environment." This is an environment where liquids such as jet fuel or exhaust at temperatures exceeding 180 degrees come into contact with the composite. A 250 degree cure epoxy laminate loses too much of its strength under exposure to these conditions. The aerospace industry was forced to switch to 350 degree cure systems using epoxy, bismalemeimide or other resin systems which are much higher in viscosity than the 250 degree cure epoxies. To increase the resin flow, manufacturers were forced to use autoclaves to help squeeze the resin into the fiber and eliminate voids. This switch created its own set of problems. Increased cost, leaks from vacuum bags, and failure due to excess compaction of the laminate in corner areas were just some of the new areas of concern.

> ***However, when you compare the weight, stiffness, or safety history of masts produced by both methods, you can't find any real difference.***

GMT has investigated the benefits of using autoclave compaction and found them to be minimal. We started this investigation back in 1993 with the help of aerospace companies who made parts by both vacuum bagging and autoclaving. Test panels were made from the same number of plies of the same pre-preg. They were compacted using both processes. These panels were then tested at independent labs. A typical test result shows that the autoclaved part has a bit lower resin content and is thinner. Mechanical properties are about the same. The autoclaved part is at most 3% stronger in tension and compression while the vacuum bagged part is stronger in shear. The void content of the vacuum bagged parts is very low. Although we have never void tested an autoclaved part, voids measured in our parts are typically around 1/2 per cent.

These small differences in properties are insignificant when it comes to the structural integrity of a mast. The main design parameter for a mast is the compressive stiffness in column. This is because a mast will fail globally by buckling under the compressive loads from the rigging. Resistance to buckling

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Photo: Peter MacKay

Photo: Andrew Sims/Wavelength

GMT REFIT DEP.: GAYLARK (top), a 1974 Swan 38 saved nearly 200 lbs converting to GMT carbon and is noticeably faster and more comfortable. DUE II (left), a 1960's Hinckley Pilot, received her carbon rig ten years ago and is now gracing the waterways and dusting the competition in St. John, New Brunswick.

GMT NEWS

From the racecourse, GMT sparred EVEREST HORIZONTAL, skipped by Tim Kent finished second in the Class II Open 50 footers, in the recently completed Around Alone race. Tim's finish was not without its trials. Writing from the Southern Atlantic in February, Tim reported,"On the bright side, I just lost my headstay and kept my rig. This is HUGE! The rig in this boat, built by GMT Composites, is sturdy beyond belief."

Earlier in the single handed season, Nick Maloney, sailing his GMT sparred Open 50, won the monohull division of the Route du Rhum. This was especially noteworthy as none fewer than 10 boats lost their rigs in one of the toughest races in recent history.

GMT Composites has signed on as a sponsor of the Cruising Rally Association's calendar of blue water sailing events. GMT Sales Manager Will Rogers said of the move, "Sponsorship of an organization dedicated to the enjoyment of offshore passagemaking is an ideal fit for GMT, as we excel in making this type of pursuit safer and more enjoyable."

NEW PROJECTS

In what will undoubtedly be one of the largest carbon spar refits ever, GMT Composites was awarded the contract to supply a new mast and rigging for TOTO, an Alden designed 108 ft. motorsailor (pictured). Built in 1982 by Palmer Johnson, TOTO's 21 year old aluminum Stoway mast has suffered the ravages of time and metal fatigue and requires immediate replacement. Commenting on the news, David Schwartz said, "We are delighted to be building their new rig. GMT's the best company for the job, having built more carbon Stoway masts than anyone else." The new mast is scheduled for installation at a Rhode Island yard later this summer.

Photo: John G. Alden Yacht Design

S/V Toto, pictured under power, will be fitted with a new GMT carbon Stoway mast.

After Simone Bianchetti's remarkable finish in his Open 60 TISCALI (with the top third of his mast dangling by halyards), GMT was called in to effect the repair. The mast was transported to GMT. Repairs were made within two weeks of the partial dismasting. The boat sailed back to Europe where she is being prepared for coming events.

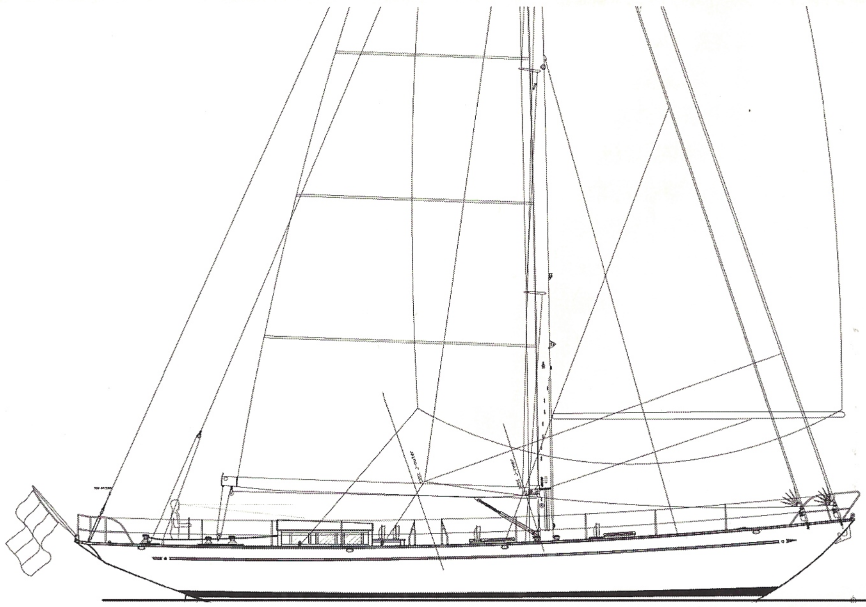
Also under construction in GMT's 12,000 square foot purpose-built facility are spars for the new Morris 51, Morris 48-02 and a Bruce King designed 40 footer underway at Brion Rief Boatbuilders.

AUTOCLAVE MYTH *cont.*

is proportional to stiffness, (E compressive modulus x I moment of inertia). The compressive modulus of an autoclaved laminate is 1 to 3% higher than for a vacuum bagged laminate, however the mast wall is thinner giving a lower moment of inertia. When the higher E is multiplied by the lower I, the resulting overall mast stiffness from quality laminates manufactured by either method is essentially the same.

Masts can not only fail from global buckling but also from local failure of the tube. Local failures are often traceable to splices between tube sections or to changes in wall thickness. Most masts are built from two or more tube sections as the length of the tool or oven/autoclave limits the length of a section. GMT splices sections together by using a pre-preg scarf splice. This splice is constructed and cured using the same techniques that were used to build the sections. The result is a joint that is the same stiffness and strength as the rest of the mast. No hard spots or stress concentrations are produced with this type of splice. Manufacturers who autoclave their tube sections can not construct the splice in the autoclave. They can either use a vacuum bag cured scarf splice or a sleeve splice. However, when a splice like this is used in an autoclaved part, the argument that autoclaves must be used to produce superior masts is shown to be spurious. A second area of concern with autoclaved parts is that the aft corners of the section can be thinned out. As compacting pressure is applied through the bag, it tends to be concentrated at any outside corner. The higher the pressure, the greater the chance that the fibers will be pushed away from the corners during cure. Manufacturers using autoclaves need to be careful that this does not become a problem.

There has been a lot hype about how autoclave cured spars are superior. Some builders have published undocumented claims saying that their process yields masts that are 50% stronger than masts cured with a vacuum bag. However, when you compare the weight, stiffness, or safety history of masts produced by both methods, you can't find any real difference. Comparing test data also shows that any differences are trivial. Once you separate the facts from the marketing buzz, it is clear that a mast of equally high quality can be built by either method. All it takes is a company that knows what they are doing and the proper raw materials designed for the chosen process. As is most often the case, taking a good look at a company's track record is the best way to find out the truth.



Gerard Dijkstra & Partners

GMT spars and rigging are soon to be completed for this Gerry Dijkstra designed 21 m sloop being built by a west coast client.

MEGA YACHTS *cont.*

a sister rudder for another Dubois 143 footer. Recently, GMT won the contract to supply a new 122 ft. Stoway spar for S/V Toto, a John G. Alden Design 108 ft. motor sailor. The massive spar section measures 24" x 11" to handle furling of the 1900 plus square foot mainsail. (For more on this exciting project see NEW PROJECTS).

Projects of this magnitude underscore GMT Composites' talents in engineering and construction of structural parts for large yachts. Whatever the application, GMT is the company to call when solutions to high load problems are needed.

GMT

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