Creation of a Styrofoam Boat for Modified 3HP & Zephyr Events

By Mark Suter

Prior to the 2002 boating season, Elaine Suter was competing in AOMC Modified 3HP and Modified Zephyr events with a J-class racing utility. While that boat proved to be reasonably fast in the straight-aways, its tendency to slip off plane in the corners rendered the boat uncompetitive in these events. It was noted that the most successful hulls in these events (thin plywood hulls on minimal spruce framing) had much more surface area and were only marginally slower in the corners than in the straight-aways. It was also noted that without much internal structure (for weight savings), they tend to have somewhat flexible bottom surfaces and thereby promote more water surface contact and thus more drag. As such, a project was undertaken by Tom Squicciarini and the author to create a unique boat that had the following features:

- Rigid Styrofoam core for light weight, to enhance flotation, and reduce drag.
- Thin fiberglass skin for structure and water-proofing (1 ounce cloth on the topside and 2 ounce cloth on the sides and bottom).
- Localized usage of Kevlar and carbon fiber cloth in high-stress areas (on transom, dashboard, and bottom fin mount) to provide required strength and help distribute stresses.
- Minimal usage of marine plywood (2mm thick outer layers on either side of transom, 2mm floorboard, 8mm thick dashboard, 8mm thick throttle mount, and 37.5mm thick plate at top of transom to carry motor clamp loads).
- Metal-reinforced joints for all bolting of hardware (T-nuts on dash and throttle mount plate and ½-inch diameter aluminum columns through the core to mount bottom fin and motor thrust socket).
- Substantial after-planes to enhance flotation, especially when using heavier motors.
- Powdered graphite in bottom resin which, when sanded, reduces surface tension and drag.

Not being able to find thick layers of Styrofoam, the desired 12-inch thickness was created by laminating six 2-inch layers together with epoxy resin. Styrofoam comes in several densities all denoted by color. The least dense is white and the second lowest density grade is blue. For this project, the blue grade was chosen based primarily on successful applications in prior projects. Toothpicks were used to keep layers aligned while the resin cured. Good alignment would reduce sanding required in later steps of the construction. Slow curing resins were chosen to minimize heat generation during set-up and thereby avoiding any melting of the Styrofoam. Many manufacturers of resins will recommend NOT using epoxy on Styrofoam for this very reason. MAS resins were used exclusively with "Low Viscosity" resin used on horizontal surfaces and "Flag" resin used on non-horizontal surfaces. Two different catalysts were used ("Slow" and "Medium" hardeners) depending on how much time each step of the process would take. Care was taken to minimize getting any resin on outer surfaces of the structure to minimize future sanding requirements. All gaps between layers at the outer surface were filled with resin containing about 20% Microlite filler that is easy to sand when cured. Care had to be taken when sanding to avoid severe abrasion of the Styrofoam.

Before the laminating was done, each sheet was saw-cut to rough form the cockpit, transom, and bow shape. This eliminated the need for any further saw-cutting once the 12-inch thick slab was created. Once laminated, the Styrofoam hull was then finish-shaped with Stanley Shur-Form files and sandpaper. The sanding was primarily to rough up any resin on the outer surface such that the outer fiberglass layer would adhere to it. Once the entire core was finish-shaped, all holes and gouges were filled with resin containing Microlite filler and these areas were then sanded. We were now ready to start applying the few necessary pieces of marine plywood.

A 1.5-inch thick block of plywood was cemented into the top center portion of the transom with epoxy to take the motor clamp loads. Then the stern side of the transom had layers of Kevlar and carbon fiber cloths applied with epoxy across the entire width of the boat. A 2mm layer of plywood was then laminated over the two layers of cloth. Another 2mm layer of plywood was applied on the front side of the transom, but only inside the cockpit. The dashboard was made by laminating four 2mm layers of plywood together. T-nuts were strategically located on the backside of the dash panel to mount a steering wheel and eyes for steering cable pulleys. Each T-nut was filled with a threaded piece of bamboo and sealed with RTV to prevent any intrusion of epoxy resin. The dash area was reinforced with layers of Kevlar and carbon fiber cloth before the dash panel was laminated in place. A recess for a throttle mounting plate was routed into the side of the cockpit. A ½-inch thick plywood plate was made to fit the recess. T-nuts were located to mount the throttle and filled and sealed similar to those on the dash. The plate was then laminated into the recess. A 2mm plywood floorboard was then laminated to the floor of the cockpit. The afterplanes were then laminated on the outside of the transom with outside edges flush with the sides of the boat. The last preparation before applying the fiberglass skin was to create generous fillets at all sharp corners of the cockpit and the insides of the afterplanes. This was done using a putty made from Flag resin and colloidal silica filler. Care must be taken when mixing or sanding this putty (wear a mask) to avoid the inhalation of the silica…this is nasty stuff. Fillet radii were created using the curvature of a "junk" CD that we received in the mail (we finally found a good use for those things). Extra care was taken in creating the fillets because sanding this putty is very difficult when it is cured.

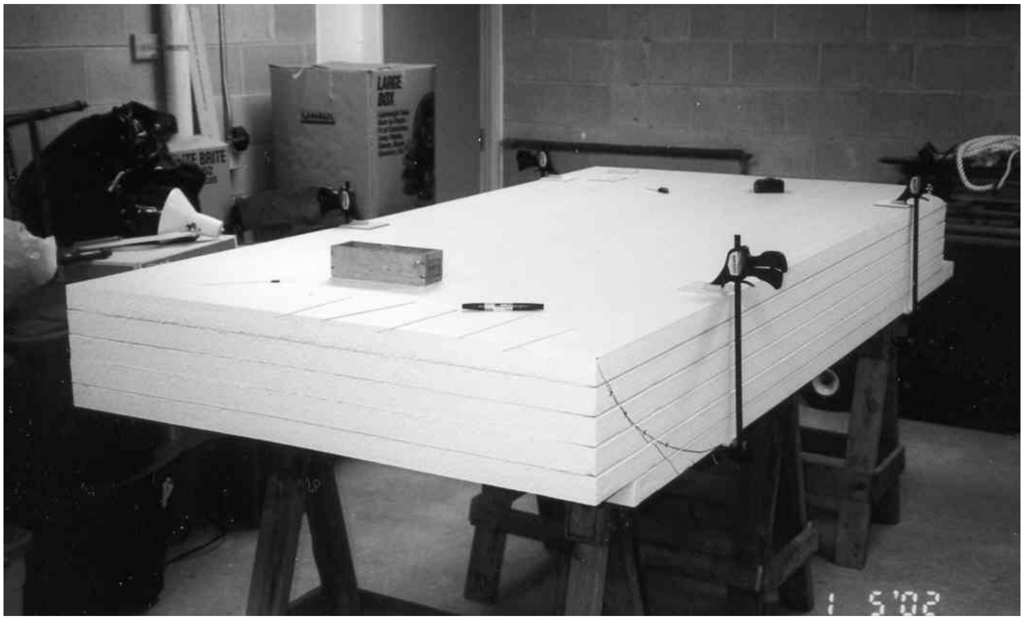
We decided to apply the 2-ounce fiberglass cloth to the bottom first. There are two possible approaches to applying a layer of fiberglass: apply the resin and then lay the fiberglass over it, or put the glass in place and then apply the resin over it. Since it is tricky to get the glass to fit over a compound shape, we chose to cut and secure the glass in place with push-pins and then put the resin on over it. The push-pins were pulled out once the resin was in place. Several layers of resin were required (with sanding between each layer to eliminate any "runs" and assure adhesion of the succeeding layer) before the desired smooth surface was obtained. Each time we accidentally sanded through the glass layer, a glass cloth patch was locally added to ensure the existence of "skin" over 100% of the outer surface area. All small holes and gouges were filled with resin containing Microlite filler. The last layer of resin on the bottom and sides contained about 20% carbon graphite powder. This outer layer was then sanded to bare carbon particles that have less surface drag in water. Graphite powder is also nasty stuff so wear a mask when mixing and sanding.

Once the bottom was done, we turned the boat over and worked on the topside. The first item on the agenda was to break the sharp external corners on the transom using a Shur-Form file and sanding, and then make sure there were generous fillets on the internal corners by filling with a unique batch of "putty". To preclude sagging, we tried using a faster set-up resin and wound up burning holes in our core (which had to be filled by injecting resin into the "pockets"). Once our fillets were in place and the pockets were filled, we put a 3-inch strip of fiberglass tape across the entire top of the transom to help ensure that our "sandwich" would not come apart. Now we were ready to apply the 1-ounce fiberglass skin to the entire topside. The procedure was identical to that for the bottom except there was no glass applied over the floorboard and there was no graphite applied in the finish coat of resin. A minimum overlap of one inch was maintained between the top and bottom fiberglass layers to avoid any splitting at this joint.

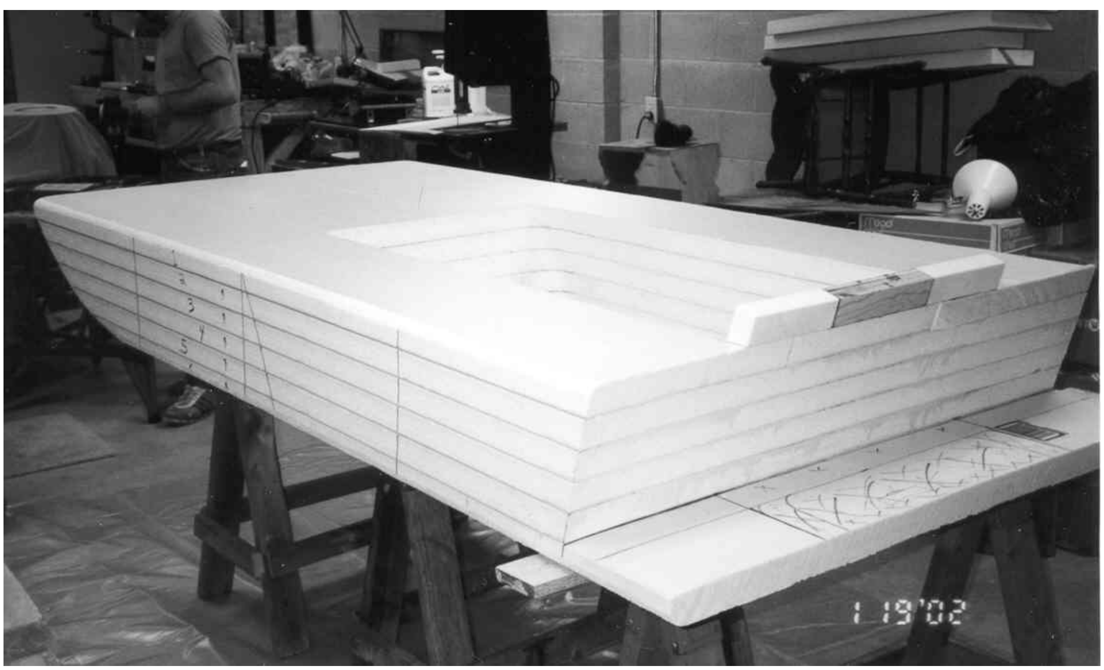
Once the glassing was done, the bamboo was removed from each of the T-nuts and the steering wheel, pulleys, and throttle were installed. One-half-inch diameter holes were drilled in the bottom and the transom for fin and thrust socket mounting. Each hole was fit with a knurled aluminum column to support the compressive load and the columns were then cemented into place with epoxy resin. A 1/8-inch aluminum plate was drilled to match the fin mounting pattern and stainless steel fender washers were used to cover the cockpit side of the thrust-socket mounting holes. One-half inch marine plywood and a block of oak were used to fabricate a simple thrust socket. The thrust of the motor is absorbed at the very bottom of the transom. With this design, a different thickness oak block would be required for each different tilt angle and a unique set of blocks would be required for each different motor. An adjustable thrust socket will be designed at a later date. Both the aluminum fin and the thrust socket were then bolted into place with stainless steel screws and locknuts and sealed with latex caulk.

The boat came in heavier than we had hoped…fully dressed it weighs about 75 pounds. We had hoped for a dressed weight around 50 pounds but that target was obviously unrealistic. The actual weight is quite similar to those of the successful plywood boats. Participation in the events of the 2002 season proved several things. The boat planes very easily, corners like a dream, can easily handle heavier powerplants (like a 3HP motor based on an Elto Ruddertwin), and is durable (there are no signs of stress cracks). The skin is somewhat vulnerable to damage as there have been numerous punctures related to careless handling. This is being addressed by more care in handling. The top of the boat is also vulnerable to damage from UV rays in sunlight (i.e., deterioration over time or actual blistering as occurred on one of the carbon-filled surfaces). This will be addressed by applying a coat of acrylic enamel paint at a later date.

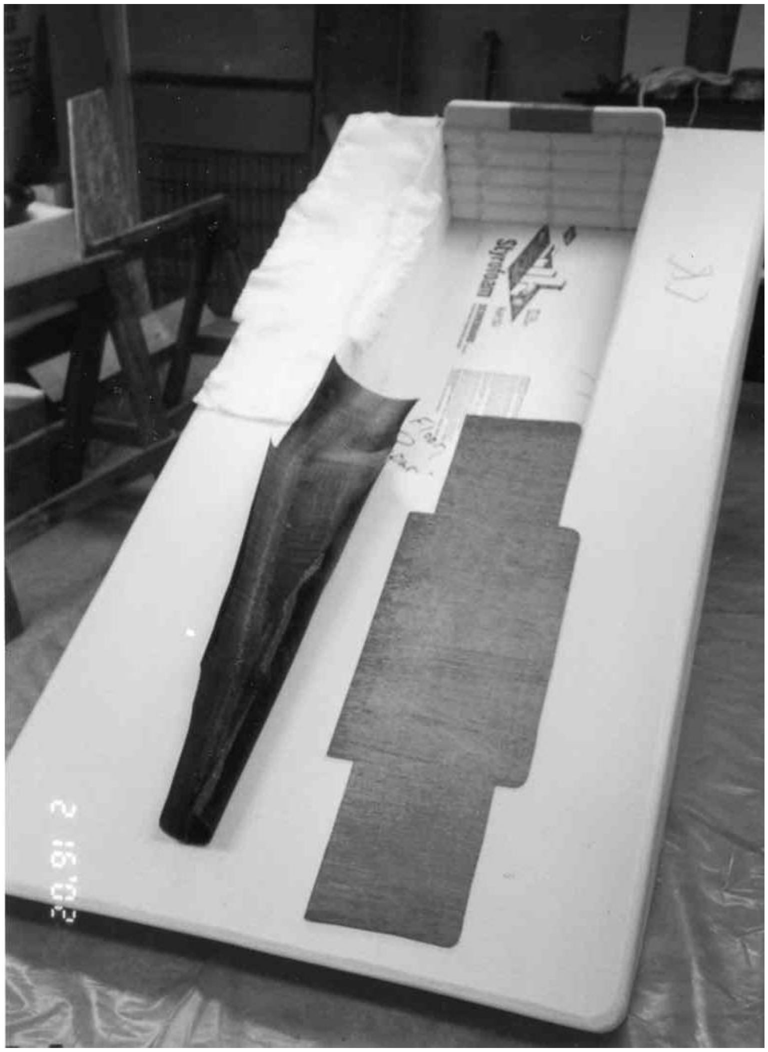
The speed of the boat was been somewhat disappointing but this was largely attributable to poor motor performance (I'm sure you can easily guess what the author's winter projects included). Although the project was somewhat costly, the boat appears to be quite competitive. Prospects for success in 2003 events at Constantine and Tomahawk are good assuming the author did his homework properly on Elaine's modified 3HP and Zephyr motors.



Styrofoam core before cutout of cockpit and laminating process



Styrofoam core after lamination; note bow shape, cockpit cutout, and wooden core for motor clamp load.



Kevlar and carbon fiber cloth and plywood for exterior of transom.

View of transom after lamination of cloth and plywood; note bottoms of afterplanes.

View after addition of afterplanes, fiberglass tape over top of transom, dashboard, and throttle-mount.

View showing carbon fiber resin on bottom of boat.

View showing all hardware installed (except for torque thrust socket) and modified Zephyr motor mounted.

Elaine planing out the boat at Tomahawk with the modified 3HP motor.