The “lost foam” method of composite fabrication

“Lost foam” composite fabrication uses Styrofoam™ as a male mold, over which composite materials are applied. The Styrofoam is then dissolved out of the cured part with acetone or lacquer thinner, leaving a hollowed out shell. (Other types of foam may not dissolve, so use styrenated foam exclusively for this process.) It is used to produce custom (one-off) parts with a molded interior cavity. Since the mold is destroyed after the part is built, this version of the lost foam method is not a production process. With this method, any shape that can be carved or molded out of Styrofoam can be turned into a fiberglass/epoxy composite. For example, this method can be used to fabricate air scoops and intake plenums for combustion engines, masthead fittings, and various types of nozzles or plumbing applications.

Brian Knight and J.R. Watson recently built small composite parts that required a specific hollow space. Both used the lost foam method to build the parts. These articles demonstrate two different approaches to a problem and how the method can be modified to suit individual needs.

1 Fabricating an air scoop

By Brian L. Knight

I used lost foam construction to fabricate a fiberglass air scoop for my son’s Formula Continental C race car. Our project started because a modification to the shape of the race car body necessitated the construction of a new air scoop. The air scoop is bolted to the car body so if either the air scoop or the body is damaged (a very likely scenario), the repair will be simpler. To fabricate the scoop, I made a Styrofoam male mold, surrounded the mold with fiberglass, and then dissolved the Styrofoam to leave a hollow part. I used Styrofoam to build the male mold for several reasons. It is readily available at most lumberyards, it is easy to shape with files and sandpaper, and it is easy to dissolve with lacquer thinner.

1—Viewed from behind, the finished Styrofoam mold carved to fit in place on the body where it will be installed.

2—The air scoop mold viewed from the front. The mold is in the process of being covered with clear packaging tape to prevent epoxy from bonding and to provide a smooth interior surface in the finished part.

Carve/shape a Styrofoam blank

The blank was built up of several layers of foam and then carved to shape. To build the blank, I used WEST SYSTEM® epoxy because it does not chemically attack the foam. However, the hard glue lines at each layer of foam can cause difficulties when shaping the part. Styrofoam has a density of about 2 pounds per cubic foot—very low. Unless the density of the glue line approximates the foam, the shaping process will remove foam much more quickly than the glue lines. This leaves unacceptable ridges at each joint in the foam. So to make shaping easier, I used epoxy thickened with 410 Microlight™ to glue the layers of Styrofoam together. Microlight has a very low density and does not make hard glue lines that other fillers might.

I used Surform™ tools, coarse files, and sandpaper to shape the mold. I made no attempt to get a good surface finish on the mold—I just concerned myself with the overall fairness. Since fiberglass will not conform to sharp corners, I used fillets of 410 Microlight on all inside corners.

I used clear packaging tape as a mold release *(Photos 1 and 2)*. One thing to pay attention to—epoxy does not adhere to the shiny side of the tape, but it will lock itself into wrinkles and gaps in the tape. So, do a neat job of applying the tape to avoid difficulty removing the tape from the cured part.

Apply the fabric

I applied a couple of layers of wet-out fiberglass cloth to the bottom of the foam and wrapped it up the sides a few inches. Then I allowed this to cure.

The next step involved sanding the cured edge of the fiberglass where the first application ended. There were lots of sharp "hairs" sticking up as well as several wrinkles in the glass. I carefully sanded this area smooth, taking care not to gouge into the Styrofoam immediately adjacent to the cured glass.

Then I applied several layers of fiberglass to the remainder of the part. These overlapped the previously applied cloth *(Photos 3 and 4)*.

When all the epoxy had cured, I sanded enough so that I could handle the part safely without getting cut on sharp edges and then cut a hole through the bottom fiberglass skin. This hole was sized to allow the carburetor and air cleaner to fit inside the air scoop. The hole also provided access to the inside of the scoop to make the job of removing the foam easier.

Dissolve the foam and clean up the inside

Lacquer thinner will effectively dissolve Styrofoam. Poured slowly over the foam, the lacquer thinner reduces the foam to a viscous blue liquid. When the lacquer thinner evaporates from the liquid, it leaves a small, hard plastic residue. For the air scoop, I used about a cup of lacquer thinner.

After dissolving the foam, reach in and remove the epoxy "ribs" that are left. The ribs are the epoxy layers (which are not attacked by the solvent) used to laminate the layers of foam. They need to be removed by hand.

The tape will generally remain with the part and will peel off after the foam is destroyed. This will also allow the removal of the fillets that are left after the foam is dissolved.

Finish the scoop

I wanted the air cleaner to fit precisely to the top of the car body. To accomplish this, I applied clear packaging tape to the body, applied a layer of 410 Microlight to the tape, and placed the air scoop in the putty. The 410 did not stick to the tape; it stuck to the bottom of the air scoop. This made a perfect fit between the two parts. Then I removed the tape from the body.

Because this part was built on a male mold, it required considerable fairing. I used epoxy thickened with 410 Microlight to make an easily sanded fairing compound. This was applied with a plastic spreader and allowed to cure. Lots of hand and block sanding later, the part was almost ready for paint *(Photos 5 and 6)*. To seal the sanded 410, I applied one last seal coat of neat epoxy.

The term lost foam is also used in metal casting. Similar to the lost wax method, the foam or wax is an exact pattern of the finished part within a sand or plaster mold, which is displaced by molten metal.

In lost foam composite fabrication, the foam is a core or male mold over which the finished part is built.

3—The fiberglass has cured over the Styrofoam mold before it is trimmed and sanded.

4—The cured part and mold from below before the foam was dissolved with lacquer thinner.

5—The cleaned up part after cleaning out the interior and fairing the exterior with epoxy/410 Microlight Filler.

410 fairing compound was also used to make a body-conforming base for the air scoop.

6—The finished air scoop viewed from the front. The lost foam method of composite fabrication was ideally suited for the scoop's aerodynamic shape.

7—Viewed from the top, the finished air scoop with two coats of white automotive paint and one clear coat.

After a final wet sanding of the seal coat, I sprayed several heavy applications of lacquer primer on the part. This was wet sanded and two coats of Omni™ automotive paint were applied. One more wet sanding followed by a coat of Omni Clear finished the job *(Photos 6 and 7)*. ■

2 Building a masthead fitting

By J.R.Watson

The masthead fitting had several design requirements:

- It must fit within an existing spar size and shape.
- It must have sufficient wall thickness to bear expected forces.
- It must house the sheave and provide adequate room to internally route the halyard.
- It must offer an attachment point for the topping lift.

Here's another use of the lost foam method to produce a custom part with a molded interior cavity. In this case, the part was a mast head fitting to hold an internal sheave and provide a route for the halyard to pass. This method can be adapted to a variety of other applications, as demonstrated in the previous article.

Making the foam mold

The first step was to make a full-size drawing of the fitting to use as a reference for manufacturing *(Photo 1)*. Using the drawing, I fashioned Styrofoam to represent the fitting's internal void. I bonded pieces of foam together to produce a billet of sufficient size, using the bond lines for a centerline to aid in measurements. (By using more layers of foam, you could use the additional glue lines each side of the centerline to produce contour lines for additional shaping guides.)

From the drawing, I made templates of the two side views. I taped them to the foam billet so I could rough-out the mold on a band saw *(Photo 2)*. Then I rounded over and smoothed the corners with sandpaper *(Photo 3)*. I bonded the sculpted foam blank to a temporary base to facilitate handling and applied paste wax to the mold to fill the porosity of the foam. This was done to produce a smoother surface and promote release of laminate later on.

Applying the fabric

Next, I applied a ⅛" thick layer of WEST SYSTEM® 105/205 epoxy (thickened to a grease-like consistency with 406 Colloidal Silica and 423 Graphite Power) over the entire part.

I wet out strips of woven graphite fiber reinforcement and pressed them into the thickened mixture until I achieved an estimated thickness of ¼". (Any more than this could have resulted in excessive exothermic temperatures.) While the laminate was still wet, I covered it with plastic (a freezer bag) and wrapped it with self amalgamated tape. This consolidated the laminate, extruding excess resin out the bottom. Reducing resin content to around 45% resin/55% fiber improves mechanical properties. Then I allowed it to cure.

I removed the cured part from the temporary base and dug out the foam with a carving chisel, hand-held rotary tool (Dremel™), file, and knife. As I approached the wax-covered exterior surface of the mold (now the interior surface of the masthead fitting), the foam fell off, revealing and replicating the sculpted surface.

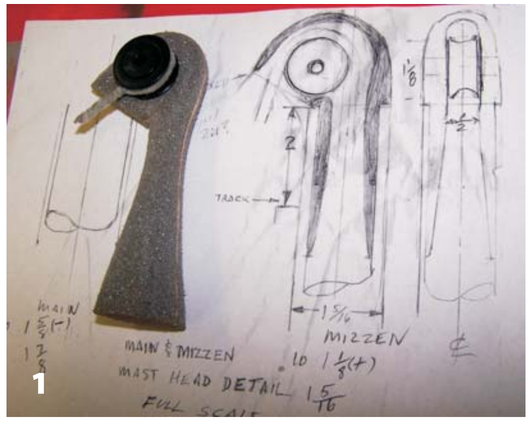
Then, I applied additional layers of fabric. I first applied another thickened epoxy/406/423 layer, which helped span minute surface irregularities. I used braided reinforcing material for these layers, taking care to overlap and align successive layers. Tape was produced by cutting braided sleeve material. With braid, fiber orientation can be adjusted simply by compressing or tensioning the material. I used templates made from the drawing to aid in establishing the finished shape/size. Round templates produced from paper towel core made for accurate sizing of round sections. After achieving the shape I wanted, I allowed the final layers of fabric to cure.

I located the sheave axle hole by measuring off the drawing with calipers. I first drilled undersize to check for accuracy with the real part and then drilled to axle size. You can make the topping lift of various materials; in this instance, I stitched nylon line together and wrapped it with thread for flexibility and light weight. I bonded the fiber part of the line to the crown of the fitting and covered it with fairing compound and a layer of braided tape *(Photo 4)*.

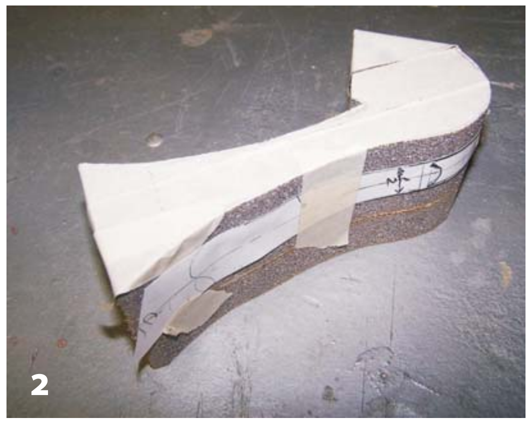
A tip for mounting the fitting to the mast

To prevent obstructing the passage with adhesive when the fitting is installed into the top of the mast, I inserted a common balloon covered with a thin layer of Vaseline™ down into the cavity. I inflated it after the fitting was inserted into the masthead, thereby pressing any invading excess adhesive against the spar and out of the way of the halyard. The balloon also exerted sufficient force to prevent any minute movement from the fitting's intended location until cure-up was achieved. The Vaseline made it easy to remove the deflated balloon after everything had cured.

Final blending and touch-up was done after cure-up, and a cover of carbon fiber braided sock was applied as further reinforcement. After a final coating and sanding, the fitting was primed and painted. ■



1—Make a full-size drawing of the part to make templates and use as a reference for manufacturing.



2—Make templates of the two side views and tape them to the foam billet. Use a band saw to cut out the rough shape of the mold.

3—Then round over and smooth the corners with sandpaper.

4—The nearly finished fitting with a duplicate of the foam mold. After the inside was cleaned out, additional fabric was applied to achieve the final exterior shape. The outside was faired and shaped before the topping lift and sheave were installed.