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PEAK OF FLIGHT

NEWSLETTER

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How To Make Advanced Composite Fins Part 1

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Advanced Composite Fin Build Part 1

By Daniel Cavender

As you develop in the hobby of high power rocket building, you reach a point where making further advancements in building techniques plateau. That is where I have found myself for some time. I got a little spoiled having the resources of a university engineering department machine shop to mill precision components and casting ABS plastic covered aluminum fins. It felt like going backwards to build rockets the way I used to. So, I spent some time trying to develop advanced composite techniques that anybody could do. The easy surface mounting fiberglass fin is one of those techniques.

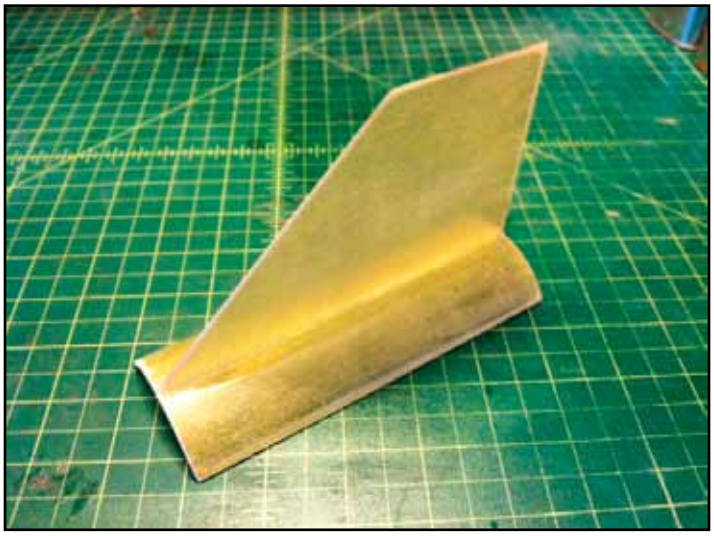

Figure 1: The completed surface mount fiberglass fin.

This surface mounting fin is self-aligning, with no need for fin slotting. It's up to you how you shape the fin, and you can fit any number of them around your airframe. It's a very cool concept, and while my first set of fins was made for the Madcow Rocketry's 2.6" fiberglass airframe, I can't wait to try this on larger rockets.

The three part mold shapes the fin's root so that it can be bonded to an airframe. The two side molds are made of *medium density fiberboard* (MDF) and the third part is a short section of airframe. These steps and images will show you how to build surface mounting fiberglass fins for small rockets (<3" diameter airframe), but the techniques can be applied to build larger rocket fins too. So, let's get started on how I did it.

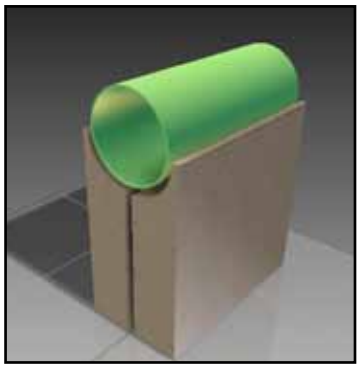

Figure 2: The side molds.

Building the Side Molds

This part of the project took a while to do. It involved a lot of table saw time and a lot of sanding. You will need:

- >12" wide by >24" MDF board, 1" thick
- Gorilla wood glue
- 120/220/330 Grit sand paper
- Bar clamps
- Table saw
- Airframe tube of desired diameter

First, I cut the MDF board up into four 6" x 6" pieces. I sanded off any frayed edges around the corners to prepare them for gluing. The mold will be four MDF pieces thick. Each side is made of two pieces of the MDF pieces glued together. I spread a thin layer of Gorilla glue across the entire surface of the faces to be bonded. It's very important that the two halves *not* be glued together. I flushed up the edges and used two bar clamps to compress the MDF parts while the glue dried. The gorilla glue expands and some will squeeze out the sides. Once it was dried, I released the clamps and cleaned up the dried Gorilla

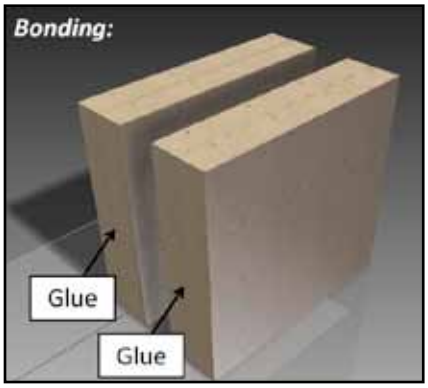

Figure 3: The mold is four pieces thick. But only the outer edges are glued together.

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glue from the sides.

I flushed up the edges again, especially the side that will be the bottom, and clamped the MDF parts back together on the bottom edge. This bottom side was my reference for alignment of the curved surface at the top. So, those edges are now flush and the parts are clamped together tightly. I placed the edge of the airframe tube on one side of the mold, centered it up, and sketched the curve of the airframe. This is the curve that you are going to cut out on the table saw. I left the MDF parts clamped together to notch out the curve.

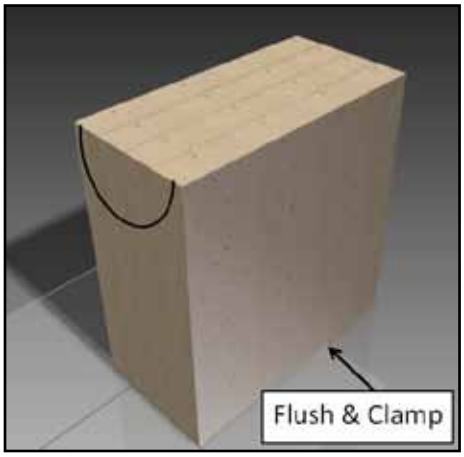

Figure 4: The sides are clamped together, and a body tube curve is drawn on one side.

I flipped the clamped block of MDF upside down and rested it on the table saw deck. I adjusted the blade height and the fence position to let the saw blade notch out the profile of the airframe curve that I drew on earlier. I carefully pushed the MDF blocks across the blade notching out the curve. It will help the next part of the mold build go easier the closer the notches are to the curve, but take care not to cross over the curve.

Once the curve is notched out, I clamped the MDF blocks to the side of my work bench having flushed up the edges once again. I wrapped a sheet of 150 grit sand paper around the airframe tube and started working the airframe back and forth evenly to sand the inside of the mold smooth. It took about 15 minutes to get all the notches worked down. I then switched from 150 grit to 220 grit and then 320 grit sand paper and sanded to make the surface smoother.

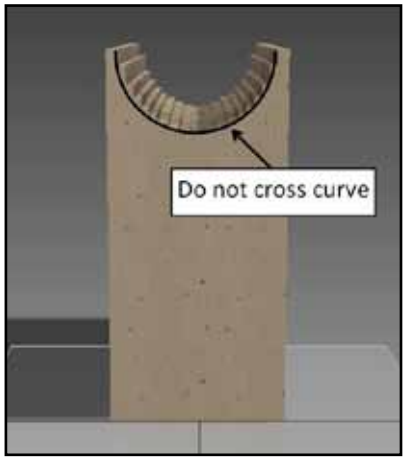

Figure 5: Using a table saw, notch out most of the material on the inside of the curve.

I unclamped the MDF blocks and sanded a 1/8" radius fillet on the inside edge of the mold to leave a nice fillet on the fin root once it is laid up. I lightly sanded all the corners and brushed off the MDF blocks. That completed the mold building, so now it's time to make some fins.

Figure 6: The blocks are clamped to the table so the curved surface can be sanded smooth.

Mold Prep

Mold preparation is very easy thanks to *Dura-Lar.* Dura-Lar is

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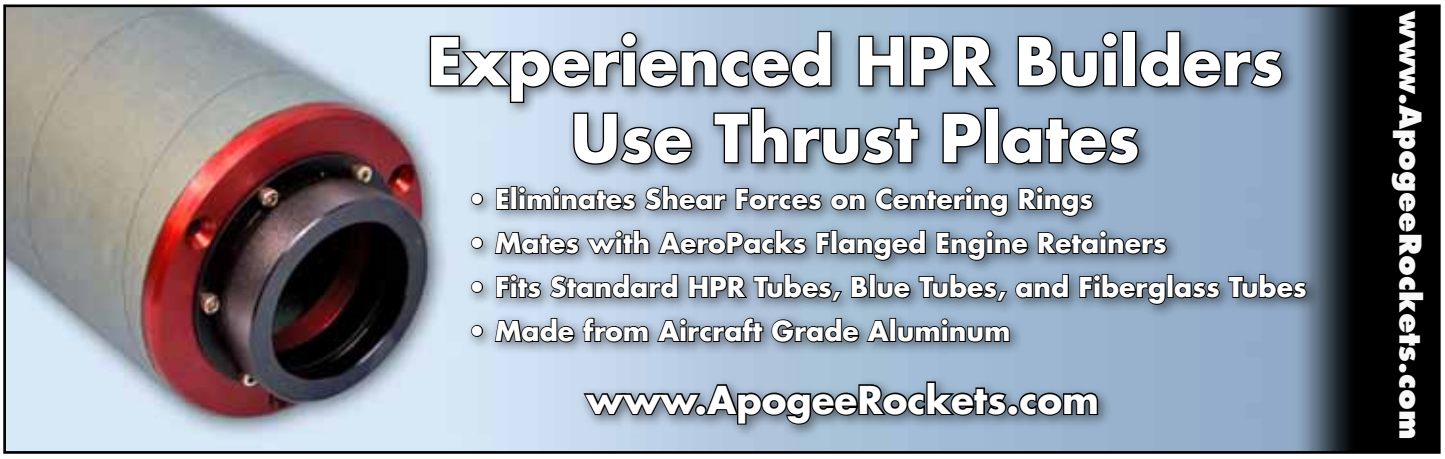

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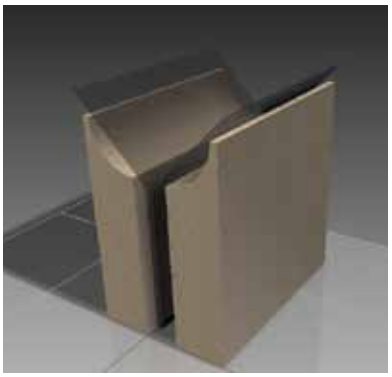

Figure 7: Dura-Lar is placed between the two mold parts.

a clear polyester film that combines the best features of Mylar and Acetate to provide a highly versatile material. Dura-Lar will not tear, absorb moisture or discolor with age. It is heat resistant, lies flat, and is dimensionally stable. You will need:

- Cutting mat
- Razor knife or scissors
- Straight edge
- Roll of 19” wide Dura-Lar
- Clear Scotch tape

First, I cut a piece of Dura-Lar long enough to drape from the top edge of both side molds down to the bottom (roughly 6” wide and 15” long). Next, I cut a piece of Dura-Lar to wrap around the airframe segment (roughly 6” wide and 8” long). I wrapped this piece around the airframe and secured it with a few pieces of Scotch tape. Done! It’s that easy.

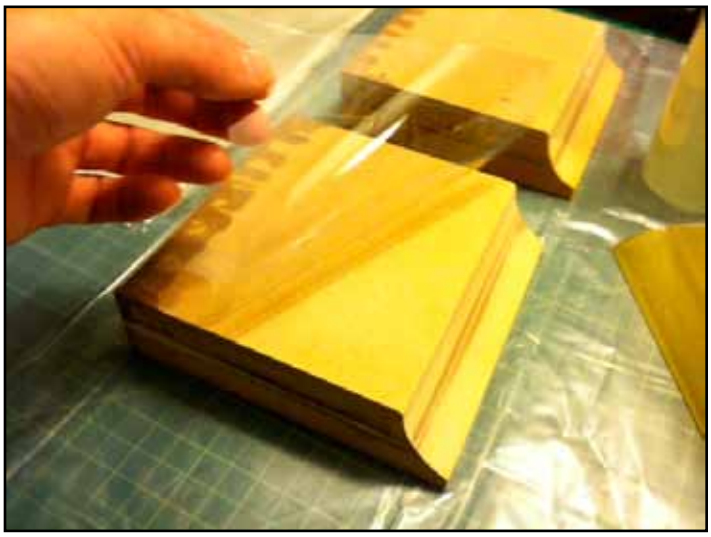

Figure 8: Dura-Lar is a clear plastic sheet.

Fiberglass Prep and Layup

This is the easy part. To make one fin, you will need:

- Two-part epoxy resin system
- Digital scale
- Mixing cups & stir stick
- Latex/Nitrile gloves
- Five 8 oz fiberglass sheets (6” wide, 10” long)

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Figure 9: Fiberglass layup for making a fin sheet.

- Plastic drop cloth to cover work area

I covered my work area with two layers of plastic drop cloth and laid out the work supplies. First I weighed the 5 fiberglass sheets on the digital scale. I used a fiberglass-resin ratio of 1:1 by weight. The sheets weighed 1.5 oz., so I mixed just over 1.5 oz. of epoxy. I fully wetted one sheet at a time, using a short round wooden dowel to work out as much of the resin as I could, stacking the next sheet on top of the wetted ones as I went. When finished, I had an ideally wetted fiberglass sheet ready for the next part of the build. I folded the wetted fiberglass in half, matching the ends and pressing them flat as I worked my way to the crease. Be careful not to press the crease flat. This part will be pressed into a curve surface that matches the airframe.

Molding the Fin

This part is worth taking the time to get right. It will take practice to perfect so you might not get it right the first time. It wasn't until my third fin that it started looking pretty good. Position the fiberglass between the two side molds draped in Dura-Lar with the creased end protruding out in the middle. Press the two side molds together sandwiching the fiberglass in the middle and clamp them together loosely.

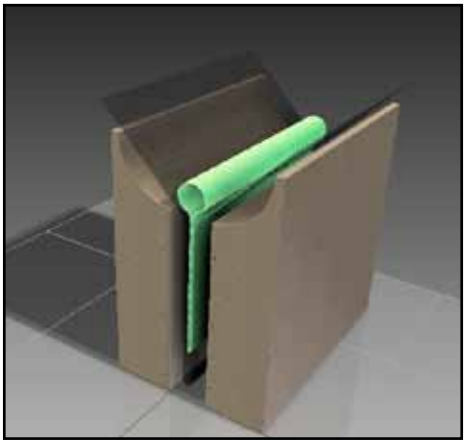

Figure 10: The folded over fiberglass will conform to the curvature of the tube.

Figure 11: The tube is taped down to the mold to create a fiberglass sandwhich.

The crease will be pressed flat against the curved surface, so make sure that the crease when pressed flat will yield a symmetric surface. Imagine that the crease is a tube, and you want the tube to be the same diameter on both ends. If it is not, the flattened surface will not be symmetric.

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Tighten the clamps to secure the fiberglass from moving. Press the Dura-Lar wrapped airframe segment down onto the crease, pressing it flat. The fiberglass should be evenly split left and right of the centerline. Rotating the airframe tube slightly can achieve the necessary symmetry. Once the fiberglass was laid out the way I wanted it, I used some duct tape to hold the airframe tube down in place. The layup is finished.

Curing Oven

I built a very simple curing oven for small composite jobs. It measures 36" tall, 18" wide, and 18" deep. It uses a single 75 watt incandescent light bulb to heat the parts and has a maximum temperature of 120°F. I sat the parts inside of the oven and left it on overnight (roughly 8 hours). Then, I removed the molds from the oven and let the parts cool down before de-molding.

Cutting the fins

To demonstrate the technique, I only wanted to cut a simple fin shape. The fin won't lay flat on the deck of the table saw so I used a scrap piece of MDF as a standoff so the fin laid flat. First I wanted to cut a flush trailing edge at 90 degrees from the root chord. I used my miter saw set at a 90 degree cut and carefully trimmed one of the sides of the fin. Now I have a straight edge to gauge the rest of the cuts by. I measured and marked the desired fin span (about 4" for this fin) and with the straight trailing edge firmly pressed against the miter saw's fence, I carefully cut the fin's tip chord.

I want my fin to have a 45 degree leading edge sweep so I set my miter saw to 45 degrees. I measured and marked the desired tip chord length, and with the tip chord pressed firmly against the miter saw's fence I carefully cut the leading edge. I cleaned up the edges with some 120 grit sand paper and VOILA! I had a surface mountable fin that can be epoxy bonded to a 2.6" diameter airframe (see Figure 1 on page 2). I made a simple fin shape to develop this technique. It took a few tries to get a fin that I considered flight quality.

Lessons Learned from Fin Molding

1. Getting the two sides to line up perfectly was a bit of a challenge but not impossible. On a second mold set, I added alignment pins on one side to match the two sides perfectly and easily.

2. I learned that it would be easier & faster with much less variability between fins if I made four at once. So, I made the second mold 24" long. I laid up a full 24" length fin stock that I could then cut up with my miter saw. I could make four fins in the same time it took me to make one before. All the fins made with the longer 24" mold set were much more similar with regards to bonding surface size, cloth-resin ratio, and fiber orientation.

3. I sealed the second mold set with Shellac finish and sealer spray which helped protect the MDF from moisture and epoxy.

4. There was not enough fiberglass or resin to fill a small void along fin root fillet where the internal volume was increased. On subsequent fins, I pulled some filaments of fiberglass off of the edge of a sheet and bundled them up to the size of a coffee stir straw. I wet the fibers and passed them through the open crease of the fiberglass before pressing it flat. I worked the fibers against the saddle where the two filleted edges meet to fill the void when the crease is flattened.

Coming In Part 2

In part 2, Daniel expands on the lessons learned from

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his first attempts at building the mold, how to make the curing oven, and how to bond the fins to the rocket airframe. So don't start building your molds until you read the next issue of Peak-of-Flight Newsletter.

About the Author

Daniel Cavender is a leading researcher in nuclear thermal propulsion at NASA's Marshall Space Flight Center, and subject matter expert in the realm of amateur rocketry. He is president of the Huntsville Area Rocketry Association (HARA) and has contracted with the Alabama Space Grant Consortium (ASGC) to conduct advanced rocketry workshops for NASA student launch initiative program. Daniel holds a level three certification with both NAR and TRA, and is a member of the TRA Technical Advisor Panel. Daniel encourages students to pursue science-oriented careers through hands-on experience, and promotes sport rocketry for all ages.

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