PEAK OF FLIGHT NEWSLETTER

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TIP-TO-TIP FIBERGLASS YOUR ROCKET

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PEAK OF FLIGHT

Tip-to-Tip Fiberglass

By Martin Jay Mckee

Tip-to-tip fiberglassing of a rocket is where you run a continuous layer of fiberglass cloth from the tip of one fin to the tip of the adjacent fin. Doing this on both sides of the fins can lead to many benefits. There are two primary reasons that one might choose to do tip-to-tip fiberglassing of a rocket however: increasing strength, and improving surface finish. For a minimum diameter mach-buster, it's not unusual to have fully surface mounted fins. Even if the fins are fiberglass themselves, there will be a weak point at the root of the fin. Running a layer or two of fiberglass over the fins after building up a nice epoxy fillet can go a long way toward making a bulletproof fin attachment that will remain solid despite punching through supersonic shock waves. Even in the case of through-the-wall fins, however, the strength benefits of tip-to-tip fiberglassing can be beneficial. This is the case I'll be presenting with the rocket in this article. Similarly, a thin coat of fiberglass can provide a smooth, hard, surface that is excellent for finishing. The fiberglass cloth and epoxy fills the wood grain and small surface imperfections as well as produces an exceptionally smooth surface when sanded. In the case of fiberglassing for a smooth finish, it is possvible to use just a single coat of a very lightweight cloth and then sand to a glass-smooth finish. The process effectively adds no weight to a rocket above what a solely paint finish might.

FIGURE 1 - THIS IS A PICTURE OF THE FINISHED ROCKET THAT'S RECEIVING TIP-TO-TIP FIBERGLASS. HERE IT'S STILL WAITING FOR A SET OF DECALS.

Before you can apply tip-to-tip fiberglass to a rocket, however, you need to decide on what the goal is. For strength, multiple layers are typically going to be needed. That means more weight as well. To simply improve surface finish very little is required if the tube, fins, and fillets were good to begin with. This article isn't going to go in depth into choosing a layup, which is the number, orientation, and types of layers. For further ideas on layup, the articles in Peak of Flight #370 (https://www.apogeerockets.com/education/downloads/Newsletter370.pdf) and #371 (https://www.apogeerockets.com/education/downloads/Newsletter371.pdf) ("Fabricating Carbon Fiber Airframes") are an excellent read. There are also endless references online regarding the physical properties of composites for the more technically minded.

For the purpose of this article I will be applying two layers of cloth to the fins of a small high-power rocket. The finished product (sans decals) is shown in Figure 1. It's a 3" diameter rocket that I built to make it easy to practice dual-deployment flights and test different electronic payloads. The rocket is built out of thin-wall cardboard tubing to make inexpensive flights possible. In any case, I'm not expecting this rocket to ever go all that fast. Since I decided to make it look a bit like a Black Brant VB though, it has fins that stick down well below the tube. Given that the whole point of the rocket is for it to be a robust rocket that will be flown over and over, I wanted to strengthen the fins enough that I shouldn't have to worry about a fin snapping on landing even in those cases where things don't go completely right (nothing can save a rocket when things go completely wrong!). With two layers, I am doing more than just a thin coat for aesthetics but it won't make for a mach-buster either. The result is noticeably stiffer than the uncoated fins and the weight increase was minimal.

It should be said, before digging in, that almost every material that is used in this process is bad for you. Epoxy is toxic. Fiberglass cloth sheds small particles of glass fiber that are a skin irritant and glass dust (such as from sanding) can cause respiratory issues. There are potential dangers to the use of different fillers and of isopropyl alcohol. When doing tip-to-tip fiberglassing (or any composites work for that matter) it is important to be mindful of safety and to wear appropriate PPE (Personal Protective Equipment). The basics are gloves, eye glasses, long sleeves, and a respirator. And that's generally plenty. Still, the damage from some of these materials can be permanent, so it's worth taking the dangers seriously.

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Fiberglass Composite Introduction

There are many different types of fiberglass fabric. There are different weaves, different weights, S-glass and E-glass, biaxial/triaxial/quadraxial/unidirectional weaves, chopped mat, and many other esoteric options. Luckily, for tip-to-tip fiberglassing the requirements are very simple. S-Glass is an expensive grade of glass fiber that is often used in aerospace. It's overkill for anything other than a competition rocket or record attempt. Even then, it's likely easier to just use Kevlar or Carbon Fiber. Likewise, the unidirectional, triaxial, and quadraxial forms are woven to ensure that more fibers are aligned in particular directions. This can be important for maximum strength, but it's not likely to be of much benefit when doing a composite layup by hand (as will be demonstrated here) and without the assistance of vacuum bagging. All that matters for our purposes here are the fabric weight and the fabric weave.

FIGURE 2 - THE 2 OZ/YD² FIBERGLASS ON THE LEFT HAS A MUCH FINER WEAVE THAN THE 6.5 OZ/YD² CLOTH ON THE RIGHT AND WILL LEAD TO A MUCH BETTER SURFACE FINISH WHEN THE EPOXY CURES.

Fiberglass cloth can be purchased with weights that range from 0.5 oz/yd² all the way up to 25 oz/yd² and more. Very light cloths, especially those under 1 oz/yd² can be difficult to work with because they deform so easily. If the fabric gets caught on a tool during layup, it can easily damage the surface finish. Such light fabrics will also lift in response to static electricity. Very heavy cloths lead to poor surface finish due to simply being bumpy as a result of the large yarns that make up the weave. They also struggle to drape over even simple curves unless the curve is very gentle. The range that I have found most useful for rockets of L2 size and smaller is roughly 2 oz/yd2 to 8 oz/yd2. Figure 2 shows three fiberglasses of differing weights. The lightest (on the far left) is 2 oz/yd², the middle 4 oz/yd², and the heaviest 6.5 oz/yd². It is quite apparent how the size of the yarn changes between the different weights and it is not at all difficult to imagine that as the cloth becomes heavier, it will make it progressively more difficult to achieve a smooth surface finish.

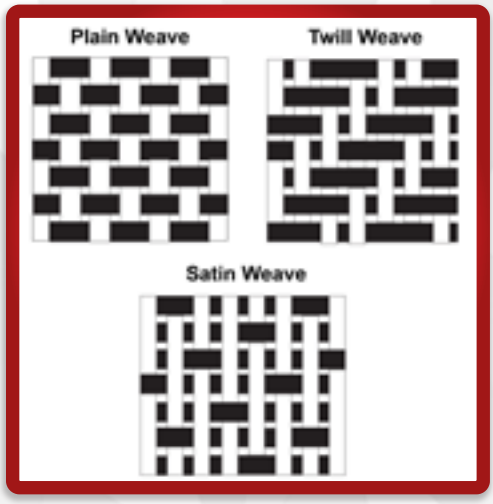

FIGURE 3 - WHILE THERE ARE DOZENS OF SPECIFIC PATTERNS, THERE ARE REALLY ONLY A FEW MAIN CLASSES OF WEAVES FOUND IN REINFORCING CLOTHS.

The weave of the cloth refers to the pattern of how the individual strands of fiberglass (the warp and weft) are interlaced with each other. Figure 3 shows three main types of weave that are available in fiberglass cloth. A plain weave is one where the fibers alternately cross above and below each other in both the warp (the strands along the length of the fabric) and weft (the strands that run across

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the width of the fabric). It is typically used where molding over compound curves is not required. A plain weave has the advantage of being less likely than other weaves to fray at the edges and it also has uniform strength in both directions. A twill weave is one in which the strands jump two or more threads in at least one direction. Twills drape over compound curves better than a plain weave, but they do not drape as well as a satin. If forming around tight compound curves is required, a satin weave is ideal. A satin weave is one in which the strands in one direction jump a minimum of four strands. Satin weaves have minimal utility in most surface finishing and reinforcement applications that one might find in rocketry. They are very useful for molding of nose cones and the like, however. Also, because the strands in a satin weave jump so far, the cloth will fray quite a bit when cut.

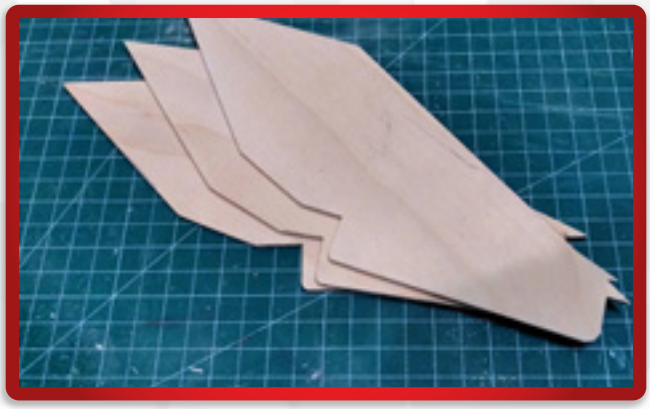

FIGURE 4 - THE FINS WERE CUT OUT OF ⅛" BIRCH PLYWOOD AND MOUNTED THROUGH THE WALL. THEY WERE SANDED PRIOR TO MOUNTING TO REDUCE THE WORK THAT WOULD BE NEEDED LATER.

The demo rocket had a total of two layers of fiberglass applied on each surface. The first (inner) layer is the 6.5 oz/yd^2 cloth that was shown in Figure 2. This cloth provides quite a bit of strength quickly, but it is coarse and leads to a poor finish. To minimize surface roughness issues, a layer of the 4 oz/yd^2 was added on top. This is far from an ideal solution as the 4 oz/yd^2 cloth results in a fairly rough surface as well. However, I got the fabric at a good deal, compared to the lighter (and finer) 2 oz/yd^2 cloth I have. So, since the rocket is meant more as a beater rocket than a show rocket, I'm willing to take a bit of time to work for a "good enough" surface finish. Honestly, with very little work, the results were excellent. For best surface finish, however, it would be preferable to use two layers of the 2 oz/yd^2 cloth in place of the 4 oz/yd^2. The first of these 2 oz/yd^2 layers would provide a smooth base and the second layer the sandable outer surface.

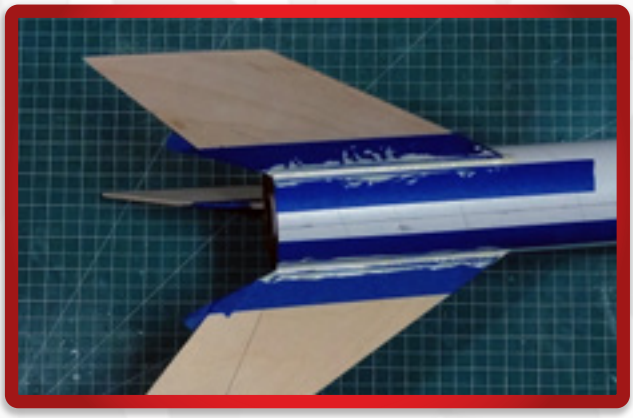

FIGURE 5 - WITH A THICK ENOUGH SLURRY OF EPOXY AND MICROBALLOONS, ALL OF THE FILLETS CAN BE APPLIED AT THE SAME TIME.

Preparation of the Base

Applying layers of fiberglass will never rescue a poorly built rocket. To achieve a good result when doing tip-to-tip fiberglassing, you need a good base. As was mentioned

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before, I am not fiberglassing this rocket in an attempt to reach high speeds. Rather, the goal is to have a rocket that is robust to landing loads. As such, the fins are constructed of 1/8" plywood and are mounted through the wall (shown in Figure 4). Internal fillets are applied and the aft centering ring glued into place with fillets against the fin tabs as well as the body tube. Upon this base, a generous epoxy fillet is formed on each of the fin roots using epoxy thickened with glass microballoons. I used masking tape to improve my chances at clean fillets since this mixture has a tendency to flow a bit. This is a place that a filled epoxy like RocketPoxy (https://www.apogeerockets.com/Building-Supplies/Adhesives/G5000-RocketPoxy-8-oz-Package) excels. However, on a rocket like this with through the wall fins, it can also be done with something like wood filler and spackling. These fillets are not primarily structural. On a rocket with surface mounted fins, epoxy fillets here are certainly preferable. The main purpose of the fillets is to provide a smooth root transition upon which to apply the fiberglass. By applying the fiberglass over a fillet (even one made of lower strength materials) the fiberglass is able to provide much more rigidity to the root of the fin than it would with a sharp joint. It also makes the actual application of the laminate much easier as it minimizes the tight bends which need to be made.

Once the fins are mounted and have fillets, the entire area of the rocket that will be covered in fiberglass should be sanded smooth. Figure 6 shows the preparation for sanding the fillets and fin surfaces. I used a rod to help maintain a uniform radius on the fillets, and 400 grit sandpaper as there was very little actual material removal that was necessary. This sanding step does two things. First, despite the thickness of the laminate, medium and large surface imperfections will transfer through the layers of fiberglass. The final surface will be no better than the surface you are beginning with. It is also important to roughen the surface to ensure that the epoxy bonds as well as possible with the fins, fillets and body tube. Once everything is sanded, it should be well cleaned to remove any dust. Additionally, after being blown or brushed off, all of the surfaces should be wiped with a paper towel (or lint-free wipe) that is lightly wetted with isopropyl alcohol. Unlike water, the isopropyl will have only a limited effect on a hygroscopic body tube. The alcohol also dries more quickly, so it doesn't slow down a build. Neither alcohol nor water do a great job cleaning off grease, however. If there is contamination by grease or oils on the surface, something like Acetone should be used to remove it. Oils from your hands will be no problem however. In any case, the surface should be fully dry before beginning layup.

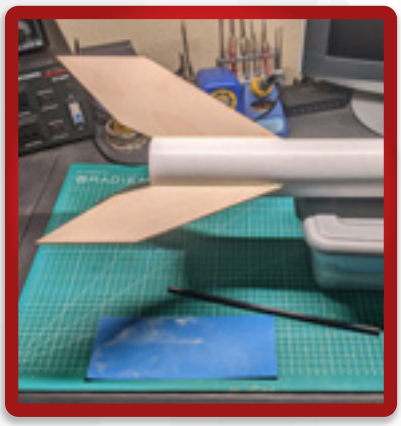

FIGURE 6 - PREPARED TO SAND BASE.

Patterns, and Cutting Cloth

Prior to applying the laminate, everything needs to be prepared. The first step is to create patterns for the fiberglass segments. I wanted to avoid making the fins on my rocket any thicker at the leading and trailing edge than I had to, so I decided to make the first lamination slightly inset from the edges. I simply folded a piece of paper in half and traced from the centerline between the fins and around the edges. I then drew a line approximately 1/2" within the fin outline for the inner layer. I cut out patterns for both the inner layer and the outer layer.

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The patterns were then traced onto the fiberglass cloth in preparation for cutting out the laminates. The inner pattern was traced exactly to the edge. The outer pattern, however, was traced with excess around the edges. This is to allow the cloth to hang over the edge when the layup is done. It is exceptionally difficult to do a "wet" hand layup (one done with liquid epoxy) without distorting the cloth at least a little. Cutting the cloth exactly the size needed is simply asking for frustration later. I often add a border of around 1/2", and do not measure it but eyeball it. Clearly, the additional border can simply be added to the pattern if desired.

Cutting the fiberglass is certainly a time where protective gear is important. The cloth will generally not produce any particles that are likely to get in your lungs. It will, however, shed small glass fibers that will stick to your clothes and irritate your skin. It is important to wear gloves and long sleeves when working with fiberglass to avoid the irritation. To cut the cloth I just use a sharp pair of scissors.

FIGURE 7 - VERY LITTLE IS REQUIRED TO ACTUALLY CUT THE PIECES OF THE FIBERGLASS CLOTH BEYOND PATTERNS, SCISSORS, AND THE CLOTH ITSELF.

This works fine with fiberglass (other fiber types require specific types of shears), though it will dull the cutting surfaces over time. It is sometimes difficult to handle the cloth and cut odd shapes without distortion however. As a result,

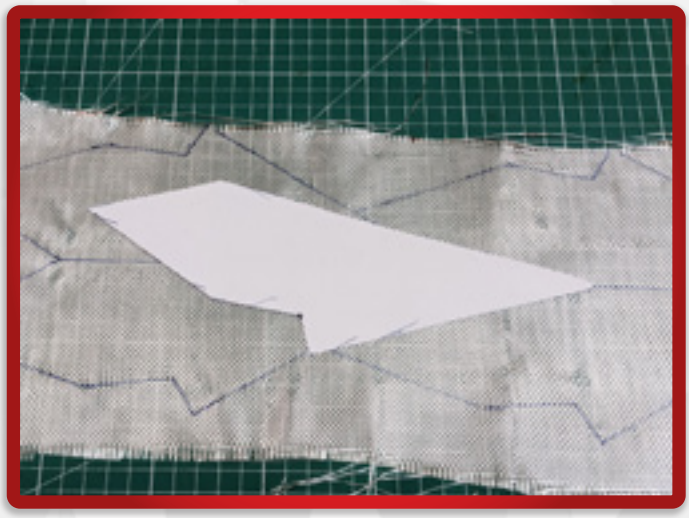

FIGURE 8 - I TYPICALLY USE A SHARPIE TO TRACE PATTERNS DUE TO THEIR HIGH CONTRAST. THE MARKING DOES REMAIN IN THE FABRIC, HOWEVER, AND IS VISIBLE IN LATER STEPS.

many people prefer rolling style cutters. In any case, all of the segments that are to be laid up in each step must be cut before mixing the first batch of epoxy. Figure 9 shows the two layers worth of cloth cut. Given the through-the-wall fins and epoxy fillets, I chose to only go fully tip-to-tip with the outer layer on this rocket. As such, there are three pieces of 4 oz/yd^2 cloth and six pieces of the 6.5 oz/yd^2 cloth.

Epoxy and Hand Layup

What is needed for layup of a fiberglass composite is a laminating resin. There are many types of resins that

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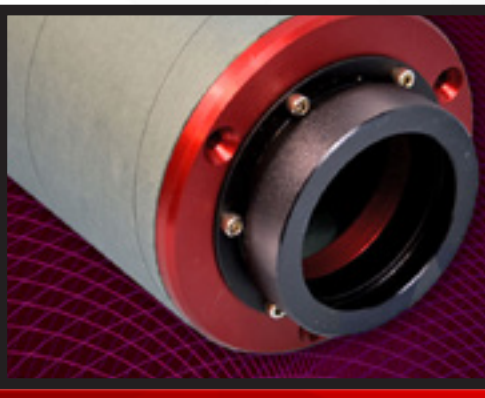

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can be used. There are Vinyl ester resin, Polyester resin, and Epoxy resin. As well as many different variations on each. Generally, for rocketry projects, an epoxy resin is the best choice. Automotive and marine applications are often done with a polyester resin. If you're familiar with the smell of Bondo, that's the smell of polyester resins. Such resins are hardened using toxic chemicals like MEK (Methyl ethyl ketone) and MEKP (Methyl ethyl ketone peroxide). Polyester resins also have the least strength of the typically available resins. They would be strong enough for rocketry, but there's really no reason to buy them if you don't have them on hand. Their main advantage when used in large quantities is their low cost. In the quantities that are used in rocketry it hardly makes any difference. Vinyl ester resins are basically a polyester resin that is modified with some epoxy components. They are more expensive than polyester resin and have many of the same undesirable characteristics of polyester resins, but they are much stronger and more durable. They also have better chemical resistance than epoxy resins.

FIGURE 9 - EVEN SHORTLY AFTER CUTTING, THE EDGES OF THE CLOTH WILL BEGIN TO FRAY, SO CAREFUL HANDLING IS PREFERABLE.

That leaves epoxy resin as the best option for applying tip-to-tip fiberglassing on a model rocket. The high-strength bond that epoxy produces along with a less brittle hardened resin means that epoxy is - by far - the most rugged option overall. In addition, epoxy tends to be somewhat less objectionable than other options. It should be noted, however, that while epoxy is less toxic (and smelly) than the options, it is still a dangerous chemical that is prone to causing chemical sensitivities with repeated exposure. It is not unusual for people to become so sensitive to epoxy that they are no longer able to work anywhere near it (at least it avoids the extreme flammability of MEK!). As such, full PPE should be used at all times when working with epoxy. Gloves, long sleeves, safety glasses, and a VOC (Volatile Organic Compound) rated respirator should be considered the minimum when working with epoxy. Moreover, it is preferable to work in an area such as a workshop or garage where the project can be left while the epoxy cures to minimize exposure duration.

FIGURE 10 - READILY AVAILABLE 1:1 EPOXY

The small bottles of epoxy such as the Bob Smith Industries Mid-Cure 15-Minute Epoxy (https://www.apogeerockets.com/Building-Supplies/Adhesives/Mid-Cure-15-min-Epoxy-4-5-oz) that Apogee sells is are not what you want when you're doing composites layup. These quick setting epoxies are great for many applications, but there are multiple problems when it comes to fiberglassing fins. First, there are inert additives mixed with the epoxy so that a 1:1 mixing ratio can be achieved. This makes the epoxy much easier to use but it means that the bond is weaker than it would otherwise be with pure epoxy. It also ends up heavier, due to the inert content. Additionally, the bonding

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epoxies of this sort are thickened. Again, this makes their typical use much easier, but it does make it very difficult to "wet out" a fabric in a composite layup. Finally, these epoxy blends cure much too quickly to grant time for applying the multiple layers typically used.

A proper laminating resin will have a very low viscosity. It will not be as thin as water but it should be no thicker than syrup. For this demo project, I'm using up an old 5:1 epoxy that was marketed for boat work. I doubt it is as strong as a high-quality aerospace grade epoxy, but at the time I got it, it was less than half the price of the well known brands. It has served me well. Some of the well known manufacturers of appropriate laminating resins are West Systems (Resin 105), Fiberglast (System 2000), and Aeropoxy (Resin PR2032). All of these companies provide a selection of hardeners that will give a variety of working time. Generally a slower hardening time will result in a stronger composite but, again, it won't matter in this application. As tempting as it is to get a 20 minute hardening system, however, it makes sense to get something with a working time of at least 1 hour. Between properly mixing the epoxy, placing the cloth, wetting it out, and ensuring there are no bubbles, folds or lifting, 30 minutes pass very quickly. Giving yourself just a bit more time can greatly reduce the stress of completing the layup process.

FIGURE 11 - MOST OF THE TOOLS REQUIRED FOR LAYUP ARE DISPLAYED HERE. NOTABLY MISSING IS THE RESPIRATOR AND OTHER PPE.

The actual mixing ratio of the epoxy will depend upon which epoxy you purchase. As I mentioned earlier, I am using a 5:1 epoxy. That is an epoxy that uses 5 parts of the resin and 1 part hardener. The amount of epoxy required is based upon the amount of fiberglass to be used. An ideal resin percentage is around 45% (by weight). That is, if a finished part weighs 100g, then 45g of that would be resin and 55g glass fiber.

FIGURE 12 - THE BEST WAY TO DETERMINE THE AMOUNT OF EPOXY REQUIRED IS TO CALCULATE IT FROM THE WEIGHT OF THE CLOTH THAT IS GOING TO BE APPLIED.

Additional resin only adds weight, not strength, so the goal is to make the resin percentage as low as possible. A resin percentage under 50% is difficult to achieve in a hand layup, but is entirely achievable with other methods. The target for this layup was a resin percentage of 55%. In preparing the epoxy, the first step is to weigh the fiberglass. As shown in Figure 12, I had 31 grams of cloth. I also mix about 10% more than is needed to account for waste in mixing and application. As such, I needed to mix about $1.1 * (^{55}/_{45}) * 31 = 42$ grams. This calculation comes from fairly basic mathematics. The ratio of the resin and fiberglass should be the same the ratio of their fractions: $^{P_r}/_{P_f} = ^{W_r}/_{W_f}$. A bit of rearranging

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gives the target resin weight: $w_r=w_f(\rho_r/\rho_f)$. Finally, that target value is increased by 10%. This gives the total mixed weight of resin, however. Since the final mix is made of six equal parts (5 of resin and 1 of hardener), I divided the total by six and measured 7g of hardener then topped it up with 35g of the resin. It really pays to either use a scale or measuring pumps to ensure that the mixture is correct. The resin was thoroughly mixed for several minutes. In fact, one advantage of using a slower epoxy is that it is much easier to mix it for a long time and be sure that it is fully blended without fear of the epoxy setting up while you are working.

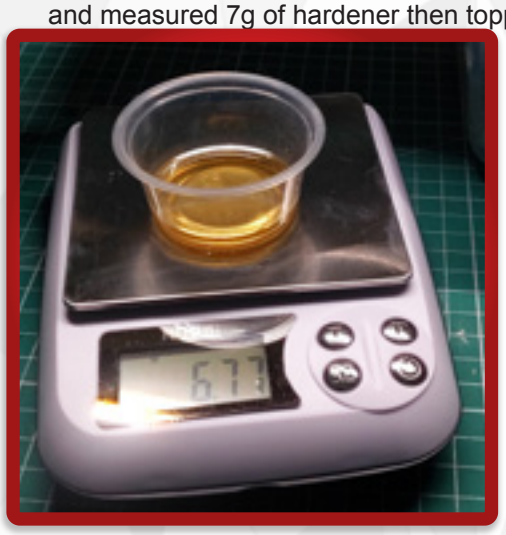

FIGURE 13 - SOME EPOXY SYSTEMS COME WITH METERED PUMPS. IF THEY DON'T OR IF SMALLER QUANTITIES ARE TO BE MIXED, THE COMPONENTS CAN BE WEIGHED DIRECTLY.

Since I chose to apply the cloth to all three segments at the same time, I needed to find a simple way to rotate the fin-can as I worked. I selected a plastic bin that was tall enough for the fins to be held above the work surface and I used rolls of solder to hold the fin can in place. The layup process is simple from here. First, apply a layer of epoxy to the surface using a chip brush or foam brush (don't use a good brush, it will be ruined!). Figure 15 shows that there need only be enough epoxy to hold the cloth in place. Position the cloth in the desired location and apply just enough epoxy on the outside to fully "wet out" the cloth.

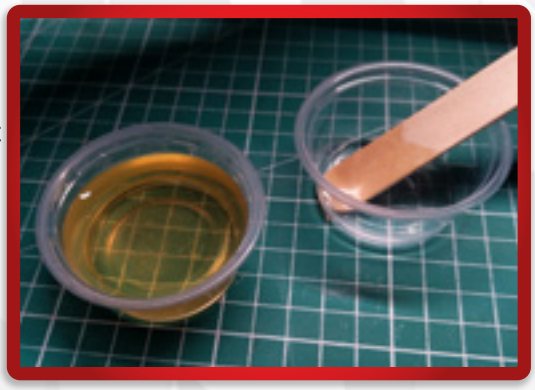

FIGURE 14 - IN A HAND LAYUP, AIR BUBBLES IN THE FULLY MIXED EPOXY WILL CAUSE NO PROBLEMS SO IT IS ALWAYS BEST TO ERR ON THE SIDE OF MIXING LONGER.

Fiberglass is an excellent place to start working with composites because it is so easy to see when it has been wet out as it will go clear. Other composite materials such as carbon fiber will not have as much of a visual change. If the laminate is not fully wet out, it will not have full strength and will be prone to delamination and bubbles. As such, continue smoothing and dabbing the cloth until it lays down and is uniformly saturated (as shown in Figure 16). Continue this process for all the cloth on the first layer.

The second layer is applied in exactly the same manner with a small amount of epoxy applied under the

FIGURE 15 - HERE THE FIRST LAYER OF CLOTH HAS BEEN PLACED ON A THIN LAYER OF EPOXY. THE CLOTH HAS NOT YET BEEN WET OUT, HOWEVER, AND IT IS STILL WHITE.

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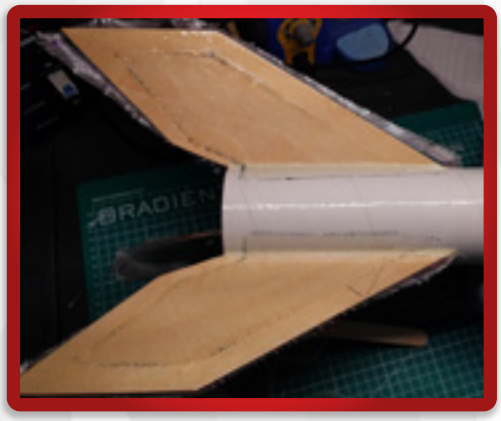

FIGURE 16 - BY APPLYING EPOXY AND WORKING IT INTO THE CLOTH, THE LAMINATE BECOMES "WET OUT". WHEN THIS HAPPENS, IT HAS ABSORBED EPOXY INTO ALL THE AIR GAPS AND IT TURNS CLEAR.

cloth, then the cloth is applied, smoothed, and wet out. If a layer covers the same area as the previous layer, no additional epoxy is required before placing the cloth. In my case, I had to add some epoxy around the edges. Also, rather than wet out the second layer using pure epoxy, I added some micro-balloons to improve the filling capability and minimize the amount of sanding and filling I would have to do later. This resulted in an only slightly thicker epoxy. If using a nice light fiberglass as the outer layer, this step is unnecessary. Be sure that during the final wet out, the epoxy continues right off the edge (as shown in Figure 18) so that there is no area that delamination can begin once the layup is complete. Once all the layers are applied, do a final pass to ensure that the laminate is as smooth as possible and that the surface has a uniform sheen. If any area looks particularly matte (or dry) add a little epoxy and remove epoxy from areas that have puddles. Any excess epoxy left in place will have to be sanded off later and areas that are not properly wet out will delaminate. Again, it is beneficial to spend a bit of extra time at this point to avoid problems later.

FIGURE 17 - THE AMOUNT OF MICROBALLOONS THAT I ADDED WAS NEVER MEASURED. THIS IS ONE OF THOSE THINGS THAT ARE DONE BY "FEEL". I WAS AIMING FOR THE CONSISTENCY OF GRAVY.

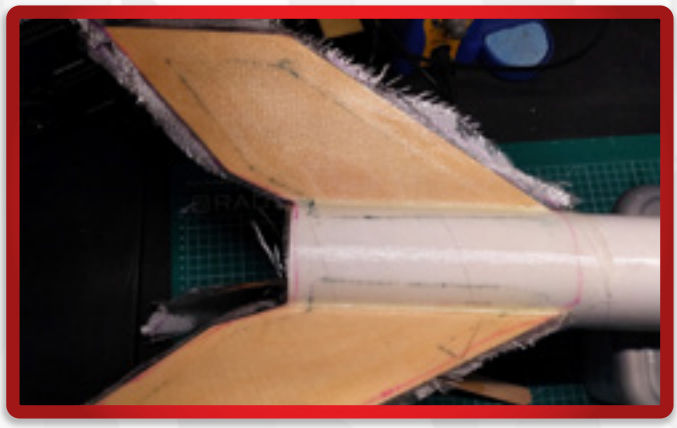

FIGURE 18 - HAVING APPLIED THE SECOND LAYER OF CLOTH, IT TOO IS WET OUT, MAKING SURE TO GO ALL THE WAY OFF THE EDGE.

Trimming, Sanding, Filling, and Finishing

Once the resin has set to the point that it is no longer tacky, but before it is fully hardened, the excess fiberglass should be trimmed off. The actual time is going to depend upon the epoxy resin you selected, but for a resin with a 1 hour cure time, the best time to trim is likely to be between 2-3 hours after mixing. Too early, and the fabric will create

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a mess and pull up from the surface, too late and it simply becomes difficult to cut the composite with a blade. Figure 19 shows the demo rocket partially trimmed. To trim, use a sharp single-edged razor blade or hobby knife, and run it along the edges of the fins. Cut as close to flush with the edge as possible to minimize the amount of edge sanding required. After trimming, the epoxy should be allowed to set entirely before any other finishing is attempted. For a 1 hour resin, that is generally going to be at least 24 hours. If a slower resin is used, or the work environment is particularly cool, it will take even longer for the resin to reach full hardness. It is important for the resin to reach a full cure, however, as it will not sand well until it does.

FIGURE 19 - ONCE THE EPOXY HAS CURED TO THE POINT THAT IT IS RUBBERY, THE CLOTH THAT HANGS OFF THE EDGE IS TRIMMED.

Once fully cured, the laminate will need to be sanded – even with an outer layer that has a tight weave. A hand layup as shown will not produce the glass-smooth surface that is representative of molded fiberglass parts. Rather, such a surface must be achieved by filling and sanding. If it is desired to see the cloth, a clear resin can be used for filling. For this project (and when using fiberglass in general) I was planning on painting. So, any filling was to be done with automotive spot/glazing putty. Since I knew the surface was going to be somewhat rough, I had planned on using a combination of filling and sanding to reach the smooth surface I desired. Figure 20 shows the results of sanding. It went well, for the most part. Figure 21 shows a closeup of the one bubble that was in the laminate. Its location right on one of the fillets and in an area that is multiple layers thick is unsurprising. Tight bends as well as multiple layers make it much more likely that bubbles happen. Bubbles will show up as a white area and if they are severe, they will delaminate and leave a hole. This was very minor and required nothing more than light filling (which I was going to do anyway).

FIGURE 20 - AFTER A LIGHT SANDING, ANY MAJOR SURFACE IMPERFECTIONS ARE REMOVED AND THE FIN CAN IS READY FOR FILLING.

With a surface as rough as this one ended up, the simplest approach to filling is one of brute force. Using a plastic card as a squeegee, I applied spot putty to the entire laminate area as well as to the edges of the

FIGURE 21 - THE ONE REAL ISSUE WITH THE LAYUP WAS A SMALL BUBBLE ALONG ONE OF THE FILLETS. NOTHING NEEDS TO BE DONE TO FIX SOMETHING THIS SIZE SINCE IT DIDN'T COMPLETELY DELAMINATE.

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FIGURE 22 - WHILE IT SEEMS LIKE THE FILLER WAS ABSOLUTELY CAKED ON HERE, IT'S ACTUALLY A VERY THIN COAT IN MOST PLACES.

cloth on the tube. Thin as it is, there is a step at the edge of the cloth and so filler is required to form a smooth transition between the tube and the tip-to-tip fiberglassing. After sanding, most of the filler is gone and the fin-can is ready to be primed (filled again, if any surface imperfections were missed) and painted. What can be noticed in Figure 23 is that the filler is noticeably thicker in the areas where there are edges in the laminate. This is unavoidable. It is, however, an extremely small step that can be filled without trouble. Figure 24 shows a closeup of the final paint and the "step" on the fin is only barely visible as a ghost. Had I desired it, I could have done another filling pass and even gotten rid of that. But again… it's just intended as a beater rocket. I think it came out well, given the short-cuts in finishing.

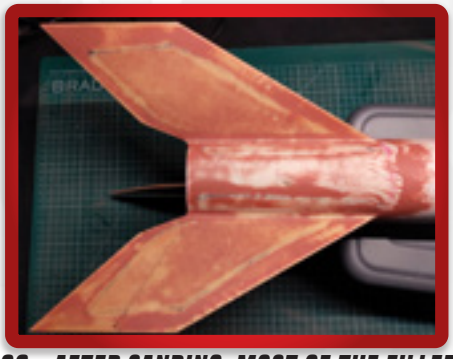

FIGURE 23 - AFTER SANDING, MOST OF THE FILLER IS GONE AND THE SURFACE IS EXTREMELY FLAT.

FIGURE 24 - AFTER A COAT OF PRIMER AND SOME FINAL PAINT, THE FIN CAN IS SMOOTH AND SHOWS NO SIGNS OF THE STEP ON THE BODY TUBE WHILE ONLY THE MEREST HINT OF THE STEP IS VISIBLE ON THE FINS.

Beyond a simple Tip-To-Tip

Fiberglass has a couple of real advantages for an article like this. First, it's the cheapest reinforcing fabric on the market. Secondly, it is widely available. The heavy fabric I used is Bondo brand and was found in the automotive section of Walmart. Finally, it is very easy to tell when it is properly wet out, as it changes color from white to clear. Still, all the procedures described in this article work just the same with other reinforcing fabrics. It is no different to do tip-to-tip with a carbon fiber cloth, or a Kevlar cloth. Also, while I only applied two layers, it is no more difficult to apply many layers for greater strength.

Also, there are many possibilities for other applications of epoxy composites in model rockets. Whether that be improving surface finish, strengthening the bond between

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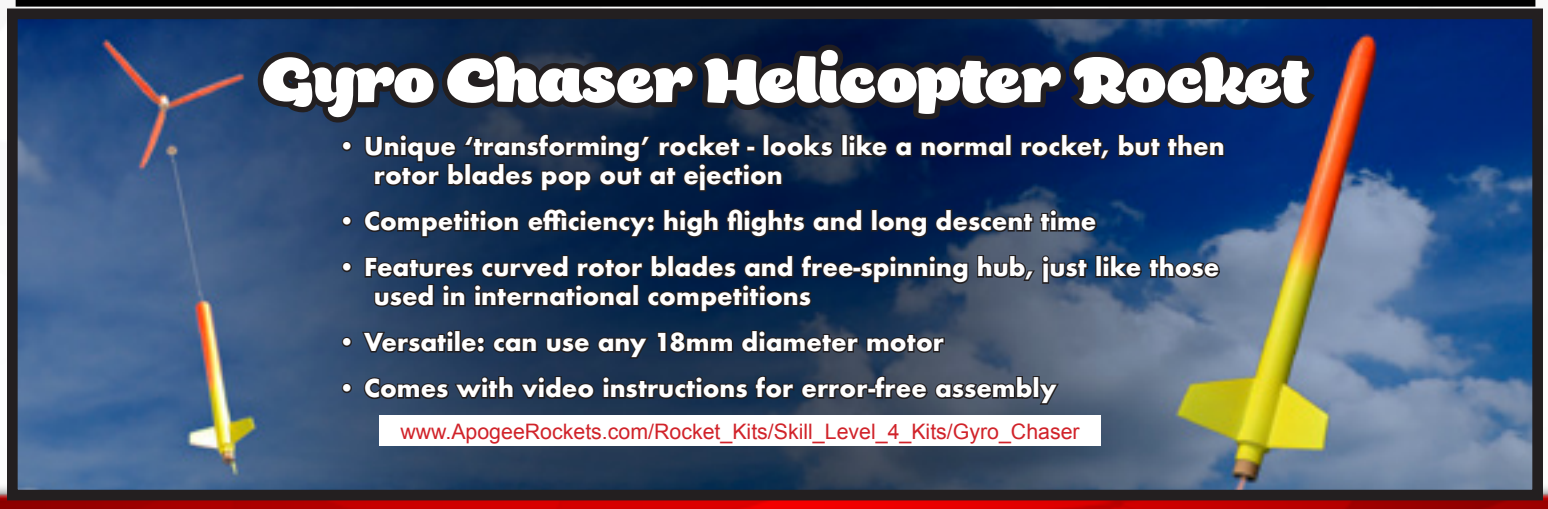
components, or increasing rigidity with a minimal increase in weight. There have been many articles in the Peak of Flight that have touched on different uses of composites in model rockets. Recently there was an article in Peak of Flight about using a 3D mold to create a nose cone (#581 https://www.apogeerockets.com/Peak-of-Flight/Newsletter581). There have also been articles about making ultra-light glider booms (#479 https://www.apogeerockets.com/Peak-of-Flight/Newsletter479), reinforcing helicopter blades (#478 https://www.apogeerockets.com/Peak-of-Flight/Newsletter478), and making light weight body tubes (#430 https://www.apogeerockets.com/education/downloads/Newsletter430.pdf, #431 https://www.apogeerockets.com/education/downloads/Newsletter431.pdf, #432 https://www.apogeerockets.com/education/downloads/Newsletter432.pdf, #434 https://www.apogeerockets.com/education/downloads/Newsletter434.pdf) and many other things. The basic materials and processes are very similar in all of these, so starting out with a quick tip-to-tip fin job is a great way to ease yourself into working with composites.

MARTIN JAY MCKEE

Martin has been designing and building rockets for as long as he can remember. After originally toying with the idea of pursuing a career in Aerospace Engineering, he did a double major in Computer Science and Fine Art then spent a decade working in K-12 math and science education. Only recently did he land at Apogee Components as the Product Designer.