PEAK OF FLIGHT NEWSLETTER

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PEAK OF FLIGHT

Fixing Broken Fins

By Tim Van Milligan

Every time I take my daughters to a rocket competition, we come home with a box of beat-up and broken rockets. The typical damage is that a fin has broken off the tube of the model. I'm sure that this has happened to you too, probably at least once for each rocket you own, right?

I'm not saying it is flight damage that is causing the fins to break off. I'm thinking it is the way the rockets are transported to and from the launch field. To be honest, we don't have a fancy system to protect the rockets as they are being transported. We use a simple cardboard box.

The rockets that are most prone to breaking are those that have very thin fins. This describes almost all of the competition rockets, which use thin fins to lower the drag of the model. The lower the drag, the higher the rocket will fly in the air, which is what you want for competition models.

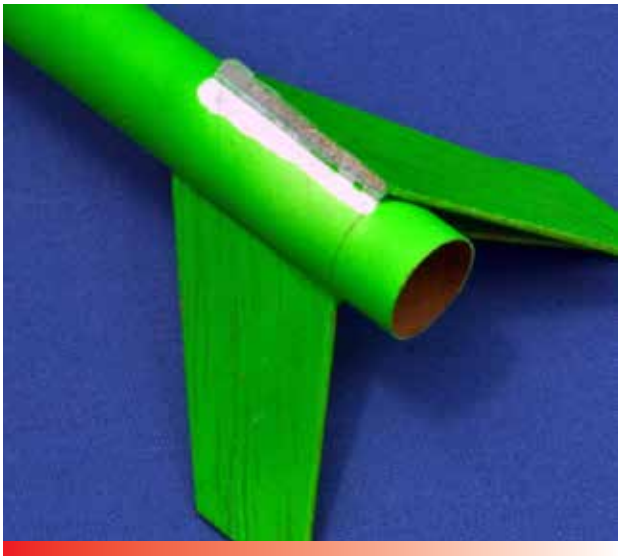

Figure 1: Fin breaking off of the paper body tube.

To make matters worse, if the fins are simply surface-mounted to the tube, they are even easier to knock off. Again, competition models are usually minimum diameter, so it is more likely that they use surface mount fins. Sanding an airfoil into the balsa fins makes the situation worse, because there is less surface area on the root edge of the fin to bond to the tube.

Even though they are harder to construct, I've since started to make through-the-wall fins for my competition-style minimum diameter rockets too (see Peak-of-Flight Newsletter #386 at: www.apogeerockets.com/education/downloads/newsletter386.pdf). It is worth the effort if you plan on keeping the rocket for a while.

Figure 1 shows the typical break of the fin. If you notice closely, it isn't the fin or the glue that breaks. The glue is actually probably the strongest part of the rocket, followed by the balsa wood fins. It is the paper tube that is the weak part of the system. Paper tubes delaminate, which means the fibers in the paper can separate.

The only thing weaker than the paper is paint. You never want to glue to paint, because is has virtually zero strength.

The first thing I do in the process of fixing the fin is to use water-thin super glue to saturate the paper under the fin (see ***Figure 2***). I don't want the fin coming off in the future.

If the glue on the paper helps keep the fins on, then why not saturate the tubes when building the rocket originally? That is a great

Figure 2: Using water-thin super glue to saturate the paper under the fin.

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question. The reason is that it is impossible to get the glue to saturate all the fibers in the paper tube. If you don't get glue to penetrate all the paper, the paper that is not saturated is still weak.

Remember that most paper tubes in model rocketry are covered with a thin and glossy layer of paper called glassine. The thin super glue doesn't wick through the glassine. If you wanted to pre-saturate the paper, you can scuff the outer layer of the tube to expose the fibers under the glassine layer of the tube. An alternative is to score through the glassine layer to get the thin glue to penetrate to the paper fibers below. If you cut all the way through the tube, you essentially have a slot, which can be used for through-the-wall fins.

The problem with trying to saturate from the inside of the tube is that the glue will harden before it gets all the way to the outer surface. And it still wouldn't penetrate through the glassine layer.

And finally, stiffening the tube will add weight to the rocket. And that is something I don't want to do on the rockets I fly in competition. So I'm willing to live with the risk that a fin will break off the tube. Fixing them takes some time, but it isn't too hard to do.

In ***Figure 3***, I tried to show that I applied too much glue to the paper under the fin. I do this because I want to make sure that all the paper is saturated, and the excess glue is going to be used to glue the bottom of the fin too. Once the fin is pressed into the glue, the excess will be forced out.

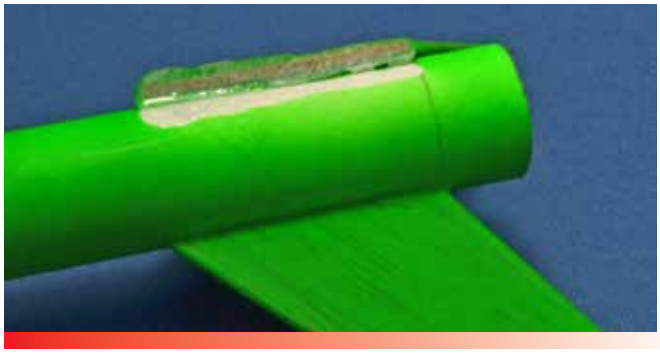

Figure 3: Excess glue used to saturate area of tube.

I try to wipe off this glue quickly, as shown in ***Figure 4***. When wiping, don't dab. Keep the paper towel moving quickly across the surface, or the glue will bond to the paper towel too. Now you'll have the paper towel stuck to the tube — been there, done that.

Figure 4: Wipe glue quickly.

It is important to press the fin hard against the paper tube and maintain the pressure until the glue has hardened. If the fin lifts off the paper before the glue has hardened, you'll have an air pocket below the fin. That's even weaker than

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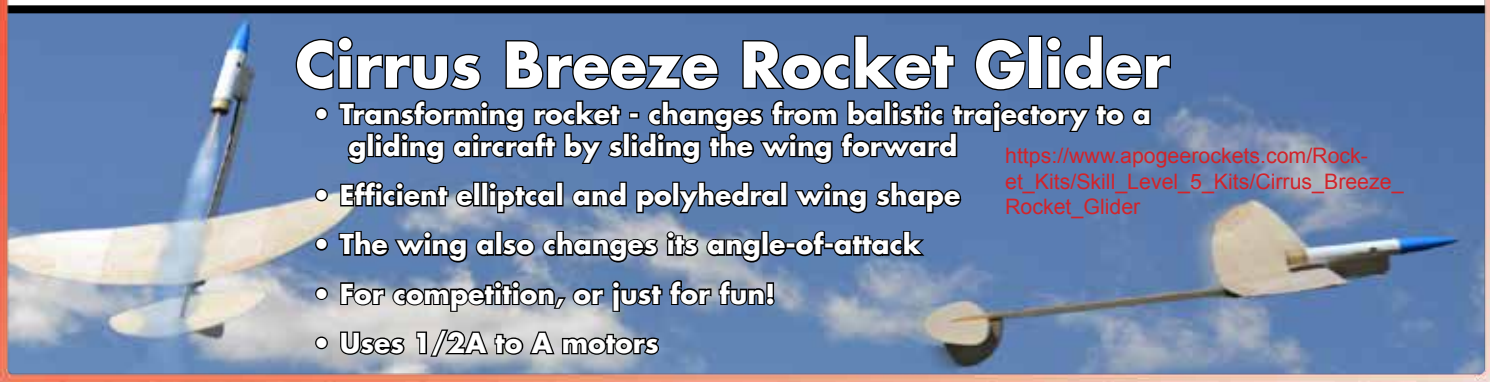

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unsaturated paper, so you have to prevent this from happening.

Because I don't like holding the fin in place for long periods of time, I like to kick off the chemical curing reaction with some super-glue accelerator. You can pick this up at the hobby store where you purchased your super glue. It goes under a couple of brand names, like Insta-Set and Kicker.

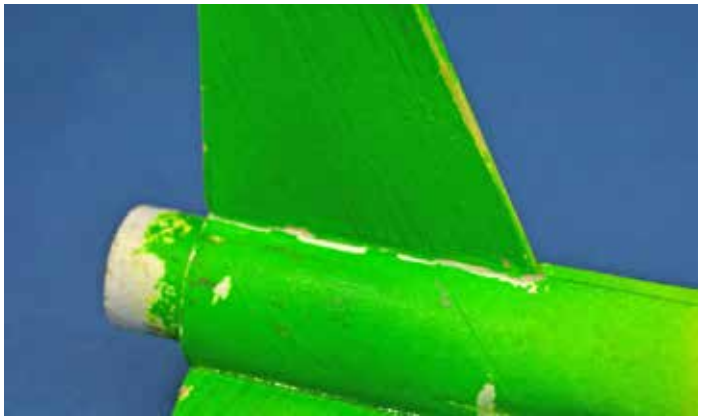

Figure 5: Gaps in the previous fin fillets.

It may be hard to notice that you don't have good contact between the root edge of the fin and the paper tube until the fin snaps off a second time (been there, done that too). So if you're gluing the same fin a second time to the tube, you'll need to switch to thicker glue. This will fill the gaps better.

But I don't like to use thick glue the first time a fin snaps off, because almost all of it will ooze out when the fin is pressed against the tube. When you wipe if off, you end up leaving more glue on the surface of the rocket.

If you're lucky, when you get the fin glued down to the tube, you'll end up with a clean joint. And at this point, you're done and the rocket is ready to fly. Unfortunately, I'm never that lucky…

On the fins that I am usually bonding to the rocket, they had previous fin fillets, and the crack is right through the fillet. The edges of the fillet chip off. So when the fin is bonded back against the tube, there are gaps in the previous fin fillets, as shown in ***Figure 5***. Note, the pictures I'm using show old rockets that are really dinged up, so just ignore the rest of the damage and concentrate your gaze on the fin joint.

My typical field-repair process involves laying another glue fillet over the top of the old one to try to smooth out the surface. I like using thick super glue for this because of its strength and that it hardens very quickly. Figure 6 shows a typical repair fillet applied along the joint. But notice how lumpy it is.

Figure 6: Lumpy repair fillet.

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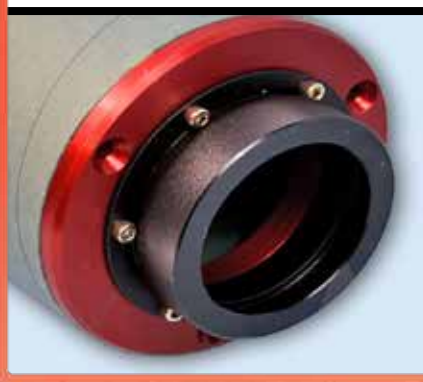

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Putting super glue fillets on the rocket like this doesn't really increase the strength of the fin. Remember, you're putting glue on top of paint, which has no strength at all. So the purpose of this layer of glue is only to smooth out the surface. If you want to increase the strength of the joint, you have to sand away the paint so that the glue comes in contact with the paper tube and the wood of the fin.

Figure 7: Using a jeweler's needle file.

The problem with super glue fillets are they are very hard, and difficult to sand smooth. This is compounded on small rockets where the radius of the fillet is small. I find that a jeweler's needle file is pretty much the only thing that cuts down on the time it takes to smooth them out. See ***Figure 7***.

Personally, I think that a set of small files is a necessary part of your range box. They work so much easier and quicker than sand paper because you can apply pressure in some very unique ways. If you don't have a set of small files, I highly recommend you take a trip to your local hobby store and pick up some. If you don't have a store near you, search the Internet for them. It is worth it.

Figure 8: Fin after sanding.

You do always have the option of ignoring the lumpiness of the new fillet and flying the rocket as is. And when you're making a field repair, this is probably the tactic I'd take too. The rocket doesn't have to be perfectly smooth for it to work well. Just know that the performance is going to be diminished by a small percentage. For the rockets shown in the photos of this article, I'd probably not spend the effort on making the fillets smooth. Just look at the back edge of the fins in the rocket shown in ***Figure 7***. That is going to cause more drag than the lumpy fin fillets.

When you get back home, you may decide it is worth it to make the rocket nice-looking again. ***Figure 8*** shows the results of what the fin from ***Figure 7*** looks like after I sanded down the lumpy super glue with a round needle file. It ain't pretty at this point, but it is actually better than before sanding it.

The little arrow shows a seam where the glue was extra lumpy and difficult to sand the edge smooth.

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If you want to make the fin joint smoother, I'd recommend using the Elmer's Carpenter's Wood Filler as seen in ***Figure 9***. You can find this stuff down at any hardware or building supply store. I use this stuff all the time because it is so easy to work with. It is water soluble, so you can thin it out with just a few drops of water and paint it on the rocket. I use it all the time for sealing the wood fins (see Video # 5 at: https://www.apogeerockets.com/How-To/Getting_Started_How_to_Build_a_Rocket).

The newest product from Elmer's is the color-changing putty. It is purple when wet, and white when dry and ready to sand. I really like this feature, because I get impatient and want to sand before the filler has a chance to dry. Now I can see by the purple color that I have to wait until the water dries out of it.

Figure 9: Recommended Wood Filler.

The other reason I like it is that it is very lightweight. It hardly adds any mass to the rocket when you put it on.

Figure 10 shows how I apply it. I just put a dab of the filler putty on my fingertip, and run it along the joint between the fin and the body tube.

Figure 10: How to apply the Wood Filler.

Note that this filler doesn't have much strength, so it is purely for smoothing out the surface of the fillet. You can put it over paint, although you'd want to scuff up any glossy paint so that it sticks to the surface better.

When it is dry, it will look similar to what is seen in ***Figure 11***.

You want to apply as thin a film of the wood filler as possible. If you put it on too thick, you'll notice little cracks and crevices in the surface, similar to that in ***Figure 11***. This occurs because the filler shrinks as the water evaporates out of it. It would be just like leaving a ribbon of toothpaste on your bathroom counter to dry. It would be lumpy and bumpy too.

But the nice thing about the carpenter's wood filler is that it sticks well to the surface of the rocket, and it sands really easily. When you sand it, you'll notice how dusty it is, and that it never clogs the surface of the sand paper.

Figure 11: Dried Wood Filler.

When you've done

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Figure 12: Wood Filler after sanding

some sanding, you'll end up with something similar to ***Figure 12***.

While it looks awful, the actual surface of the fillet is very smooth. Run the tip of your finger along the joint to feel for any lumps or edges. Either sand more, or lay another coat of the wood filler along the joint to repeat the process.

For a rocket like this one, where the fins are pretty beat up, I'd probably not use a second coat of the wood filler. But you may decide it is worth it on your particular model.

Figure 13: Finished product.

At this point, I called it good enough, and simply put a final coat of paint over the rocket to make it look a little nicer and to give the surface a uniform texture. ***Figure 13*** is the finished product.

While you'll notice that there are a couple of blemishes in the fillet near the leading and the trailing edges, the middle portion of the fillet is pretty nice. It is so uniform that it was difficult to take this picture. The camera needs hard edges to auto-focus, and the fillet smoothens them out too much. I actually had to focus on the hard edges in the blemishes in order to take the photo.

I know you've probably repaired a lot of rockets, so I hoped that this article provided a little bit of new information on how to fix broken fins. If you have other techniques or tips on fixing rockets, please send them in to me here at Apogee. I'd love to learn some new tricks too.

About the Author

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. Before he started writing articles and books about rocketry, he worked on the Delta II rocket that launched satellites into orbit.

He has a B.S. in Aeronautical Engineering from Embry- Riddle Aeronautical University in Daytona Beach, Florida, and has worked toward a M.S. in Space Technology from the Florida Institute of Technology in Melbourne, Florida. Currently, he is the owner of Apogee Components (http:// www.apogeerockets.com) and the curator of the rocketry education web site: http://www.apogeerockets.com/educa- tion/. He is also the author of the books: "Model Rocket Design and Construction," "69 Simple Science Fair Projects with Model Rockets: Aeronautics" and publisher of a FREE e-zine newsletter about model rockets.

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