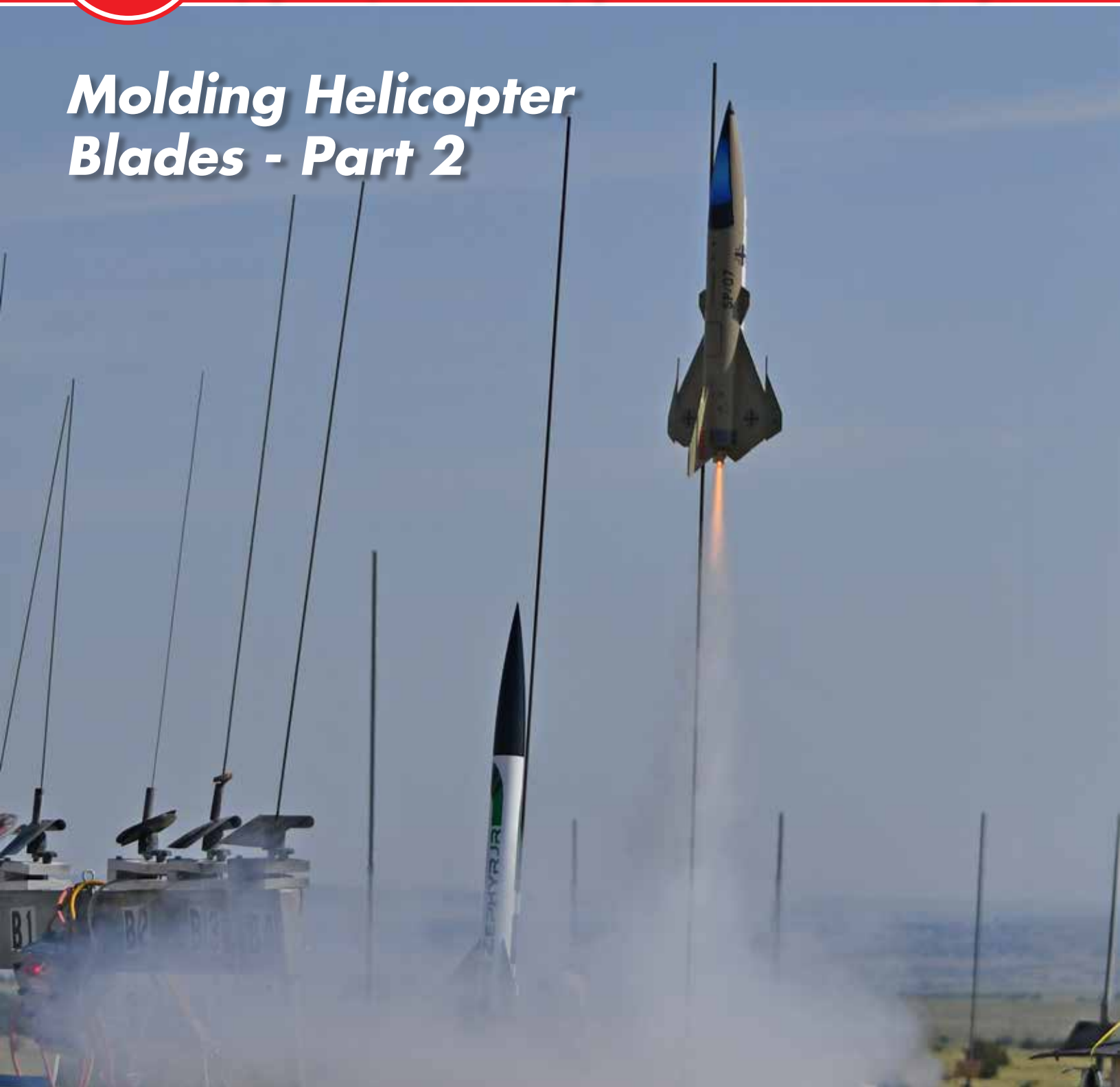
Issue 632 / August 13th, 2024

PEAK OF FLIGHT NEWSLETTER

Apogee Components, Inc. / ApogeeRockets.com / Colorado Springs, CO

Molding Helicopter Blades - Part 2



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COVER PHOTO

Apogee Skonk Wulf

This rocket-powered fighter is what might have been developed in a parallel universe where the NAZI's won World War II. It is a great example of retrofuturism from the creative mind of Shrox. The easy-to-build kit features through the wall fins, colorful self-adhesive vinyl decals, and a color plastic parachute. Flies on 24mm C, D, and E size rocket engines.

FEATURED ARTICLE

Molding Helicopter Blades - Part 2

by Tim Van Milligan

What does it take to make molded rotor blades for the competition rockets? And why would you even want to?

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About this Newsletter

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Editor-in-Chief: Tim Van Milligan
Managing Editor: Michelle Mason
Content Editor: Martin Jay McKee
Layout Design: Tim Van Milligan

DynaStar Amarok rocket rips skyward.

Would you like to see your launch photo featured in the *Peak-of-Flight* newsletter? Submit your photo at apogeerockets.com.

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Molding Helicopter Blades - Part 2

by Tim Van Milligan

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In the previous article in *Peak-of-Flight Newsletter #630* (**https://www.apogeerockets.com/education/downloads/Newsletter631.pdf**), I detailed the extensive research and experimentation that led to the development of a shaped helicopter blade design with excellent performance characteristics for use in model rocket recovery via gyrocopter. I also described the process of creating rigid resin molds that would be used to form these specialized blades. Now, in this second part, I will walk through the step-by-step process of actually molding the blades using the pre-fabricated molds. This involves carefully layering balsa wood for the core, carbon fiber tow for added stiffness, and a metallic foil outer layer to provide color and reflectivity to the final part. By following this meticulous molding procedure, you will be able to create high-quality helicopter blades that maximize the descent time and durability, and make the model much easier to find after the flight.

Molding the Helicopter Blades

Once the molds were made, I could begin the process of making up the balsa blades. First, the templates were cut out of the sheet of wood. I use my laser, because I have it available. But if you don't, you can cut them using a hobby knife. The process of hand cutting patterns from wood is shown in our Advanced Construction Video #287 (**https://www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_287**)

Figure 8 - The balsa blades are cut from a sheet of balsa wood.

After they are cut, they need to be curved. We'll warp the wood by spraying the surface with a water and household ammonia mixture. The ammonia softens the wood so it can be flexible enough to wrap around a tube. So I lay all my wood blades out on a table, and spray them with the water mix, as shown in Figure 9.

Figure 9 - The blades are soaked in ammonia water to make them pliable.

While the wood is still wet, they are taped down to the pvc pipe (at the 5° angle shown in Figure 3 of the previous newsletter). They are then spiral wrapped with a long strip of cloth to make sure they curve to the surface of the pvc pipe so they have the correct camber (curvature). This is shown in Figure 10.

When the water dries, the wood can be removed from the pvc pipe. I usually let it dry overnight, unless it is a really hot sunny day, in which case I put it outside to bake in the sun for about 4 hours.

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Figure 10 - The balsa blades are pre-curled by soaking the wood in ammonia-water, and holding them down to the pvc pipe using a long strip of cloth.

Once the blades are dried, the surface is sanded smooth. I wouldn't sand them before curving them, because adding water to the surface will make the wood fibers swell, and you'll still have to sand them after they are dry.

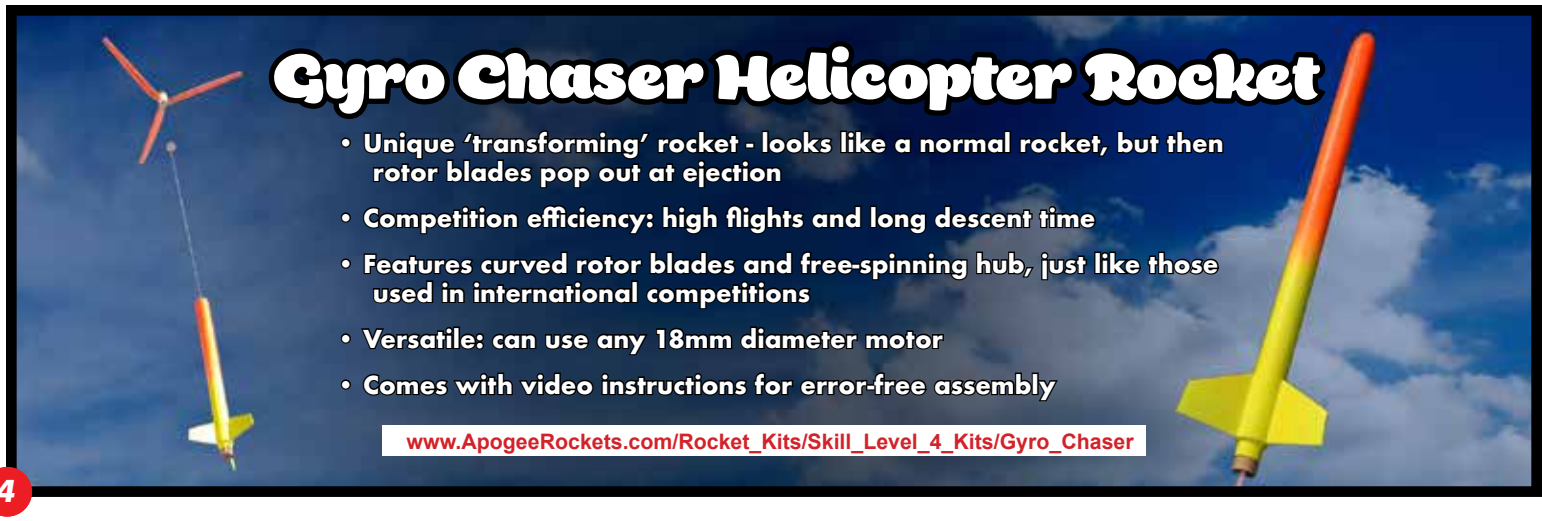
Next is adding the carbon fiber tow, which is done to increase the stiffness of the blades. The process again of separating the tow (flattening it out) and attaching it to the surface of the wood, is described in *Peak-of-Flight Newsletter #577* (**https://www.apogeerockets.com/Peak-of-Flight/Newsletter577**).

At this point, the carbon fiber tow is just loosely tacked to the surface of the balsa wood, and would easily come off. It needs to be bonded permanently using epoxy.

When I first started reinforcing balsa wood with carbon fiber (or fiberglass), I'd simply brush the epoxy on. But I found out that just brushing it on adds a lot of weight. My goal was to make these as lightweight as possible, and too much epoxy is used because you can't control how much is applied. So I've found that the BEST way to apply the epoxy is to spray it on. Now I know you don't believe me… because you've never sprayed one epoxy before. But it makes things so much more uniform, and you can control how much is applied.

You can see my video of the technique of spraying it on in Advanced Construction Video #415 at: **https://www.apogeerockets.com/Advanced_Construction_videos/Rocketry_Video_415**. When you're done, the part feels dry, but there is enough epoxy to bond the carbon fiber to the surface without adding much weight. The epoxy also provides a humidity barrier for the wood, which prevents the wood from warping on hot, humid days.

Figure 11 - The blades with the carbon-fiber tow are sprayed with a thin layer of epoxy.



Next, the blade with the carbon fiber tow is put into the resin mold. Of course, you need to put a mold release on the mold to keep the epoxy from sticking to it. But if you keep reading, you'll see that I was able to make another enhancement that got rid of the need for a mold release.

Once the blade is in the mold, it is simply clamped closed, and the epoxy is allowed to cure. When the mold is closed and clamped together really tight, it actually presses the carbon-fibers into the surface of the balsa. This makes it smooth and more efficient, without adding any additional weight. Gone were the speed bumps of carbon fiber tow on the surface of the blades. The carbon fiber was pressed into the wood so the outer surface was totally smooth.

When the epoxy is hard, the blade is removed and the edges are sanded. You want to round them off to reduce drag, and also some of the carbon fiber tow hangs over the edge and needs to be removed. It is just minor clean-up work.

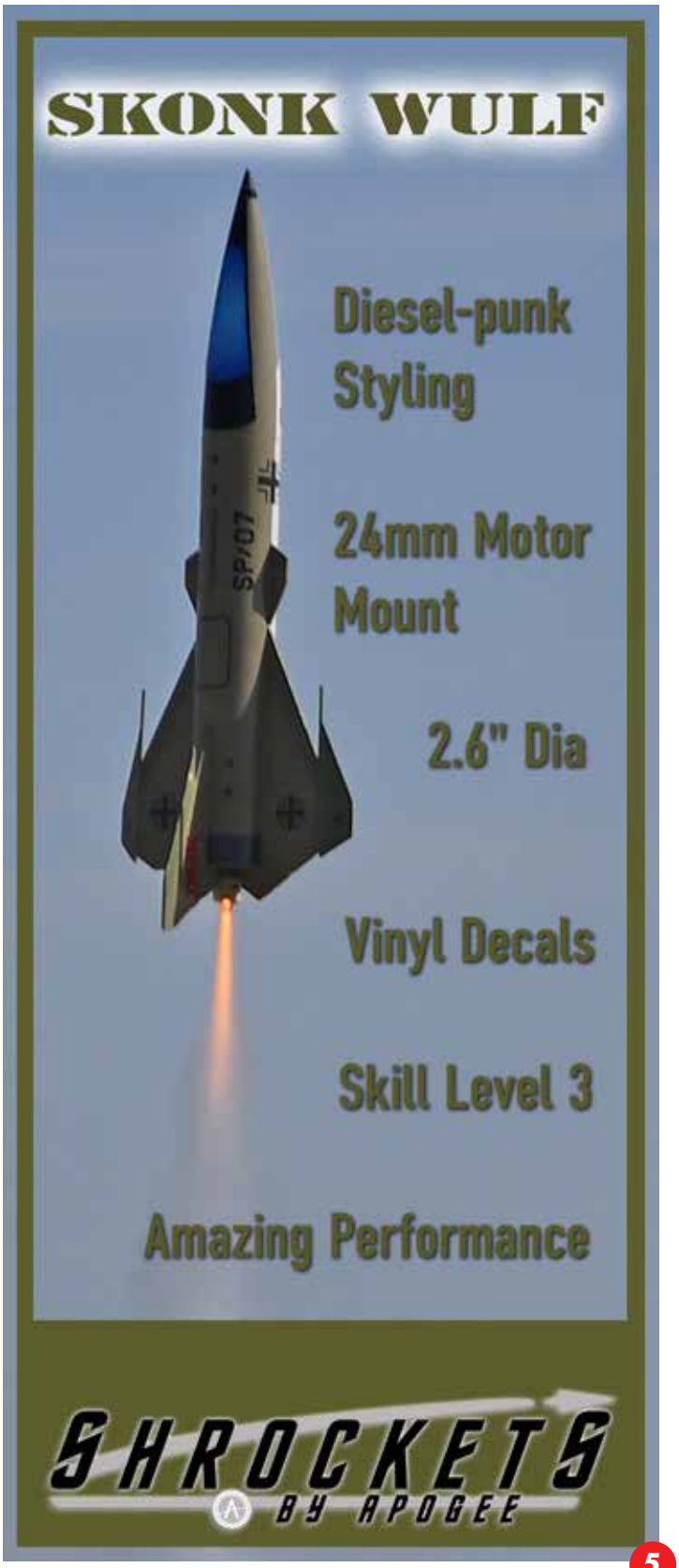
The molded blade at this point was coming out great. The surface was as smooth as the inside of the mold. And the carbon fiber tow was adhered permanently to the surface, so the blade was stiff and didn't flex much. I was very pleased with the result.

The first set of blades came out much smoother than I had made using a hand layup. But they still had one last issue. They were black colored. As I alluded to before, the outer color can make a huge difference when it comes to finding your rocket after a long flight. Black blades camouflage themselves into the environment because they look like any other dark shadow on the ground.

So I needed to add some color to them, but without adding any significant weight. I decided to play around and see if the toner reactive foil technique could be applied to the blades as I did with putting the foil on balsa wood fins. In *Peak-of-Flight Newsletter #571* (**https://www.apogeerockets.com/Peak-of-Flight/Newsletter571**), I showed my technique of applying chrome foil to balsa fins using the vacuum bag method.

It turns out that you can. Although the process is slightly different, and in my opinion, it is actually a little easier.

Toner reactive foil is a product that I've really come to love. It is super lightweight, it is opaque and covers up anything under it, and it is reflective and looks like metal. It sparkles



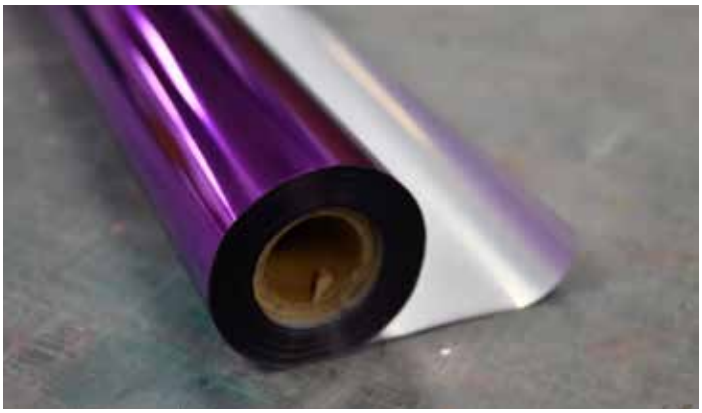


Figure 12 - Roll of toner reactive foil. I picked purple because it visibly stands out from dry grass and leaves.

in the sunlight and makes finding your rocket a lot easier. After buying and using several “sample” rolls, I ended up buying a large roll that should last me a lifetime (Figure 12).

There is, however, a process to using it. It is very thin, and even a small wisp of wind will blow it off your table. So I have to tack it down to a piece of cardboard just to keep it from rolling up or blowing off the table. (Figure 13).

The next step is to cut out the patterns that will completely cover both sides of the balsa blade. Since my blades are not symmetrical, I have to have a different pattern for each of the two sides. It is actually a mirror image of itself.

Again, you can cut these out with a hobby knife, but since I own a laser cutter, I just use that to cut out the patterns (Figure 14).

Figure 13 - Foil attached to cardboard with a little bit of spray adhesive to make it easier to cut.

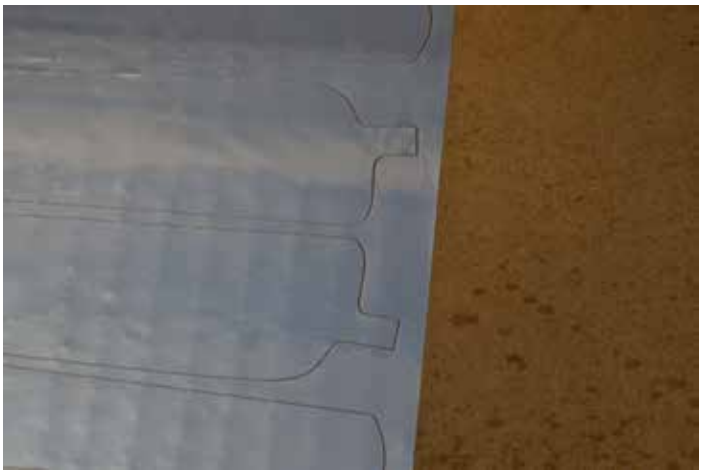


Figure 14 - Cut out the front and back-side patterns from the reactive foil.

At this point, I pull off the excess material, leaving the patterns on the cardboard (Figure 15).

To transfer the thin reflective foil to the balsa blade, you need to apply a thin coat of epoxy. Again, I spray it onto the bottom side of the foil using an airbrush. I do it at the same time that I spray the carbon fiber covered balsa wood.

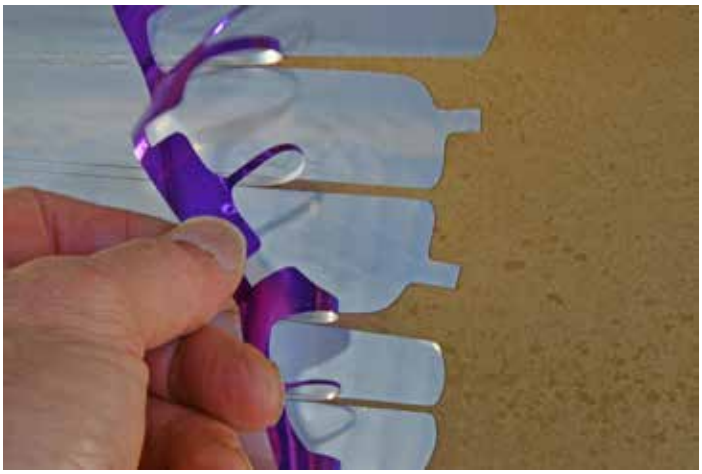
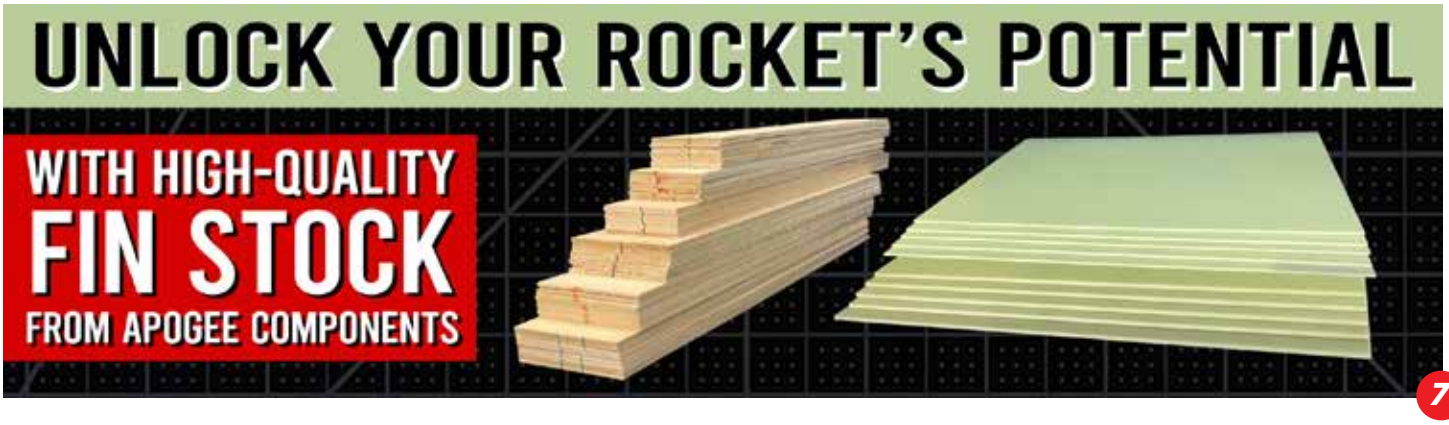


Figure 15: Removing the excess foil to leave the cut patterns.

Before putting the balsa into the mold, I'll take the foil and apply it to both sides of the wood, as shown in Figure 16. This part can be real tricky, because the foil will still want to roll up on itself as you lift it off the cardboard.

Figure 16 - The foil patterns are applied to both sides of the blade using a wisp of spray adhesive.

Additionally, if the epoxy touches anything, it will immediately lift off the foil from the clear plastic backer material. Don't touch it with your fingers. I pick it up very carefully using tweezers. It has to be flipped over and positioned over the balsa blade. You really only get one shot at placement, because if you try to lift it off, you'll leave the colored aluminum on the wrong area of the part. I usually make a few extra patterns of foil to have ready in case I ruin one by positioning it wrong on the blade. You can clean off the colored aluminum with a paper towel and some rubbing alcohol. But you'll have to respray the blade with epoxy and start over.



I have also found that if you put a little bit of spray adhesive on the epoxy, it will grab a little bit better to the surface of the balsa wood. This helps keep it attached, because there is so little epoxy on the surface of either the balsa or the surface of the foil.

The spray adhesive also helps keep the foil in place as you push out any air bubbles that get under the plastic.

My last step before placing the balsa into the mold, is to clean off the plastic surface of the foil with a rubbing alcohol. This is to remove any of the spray adhesive residue that was left on it when it was attached to the cardboard. See Figure 17.

The one additional thing that I like about the toner reactive foil is the plastic liner acts as a mold release. It keeps any epoxy from getting to the surface of the mold. It acts as a natural mold release, so the final parts simply pop out of the mold once the epoxy is cured. You don't need to use any mold release at all. The parts almost fall out of the mold as you remove the clamps (Figure 18).

Figure 17 - The blade is cleaned off to remove any adhesive residue that was used to hold the foil to the cardboard sheet during the epoxy application step.

Figure 18 - The mold is opened, and the blades are popped out.

When you look at the blades as the come out of the mold, they look really shiny. You think you're nearly done, but there is one last step to do. That is to remove the clear plastic liner that the foil was stuck to.

Getting it off is a matter of rubbing your finger over the edge of the part and catching an edge of the plastic so it starts lifting up (Figure 19). Once you get it started, it peels off quite easily. And the cool thing is that you remove a lot of the weight too. The actual metallic coloring is very thin, and hardly adds any mass to the blade.

After sanding the edges over to round them off, the blades are finally ready to use. Don't try to sand the surface, because the foil is so thin, you'll remove it from the blade even if you use 1000 grit ultra-fine sandpaper. If you have to sand anything, sand the inside of your mold to smooth it out so that the next blade you make doesn't need any

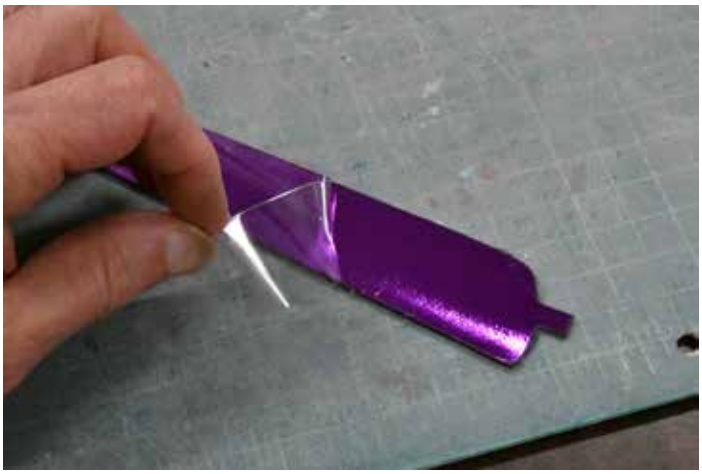


Figure 19 - Removing the clear plastic film from the toner reactive foil.

surface sanding at all.

Figure 20 below shows the incremental progression of my blades as I was developing this process.

Blade A is the 1/32 inch thick balsa blade that wasn't molded. It was just curved with the PVC pipe, and then had 12K spread tow on applied to both sides. *Blade B* uses carbon fiber tow that was cut into 3K strips, which were then spread and applied to both sides of the balsa. I also painted the blade orange for increased visibility. *Blade C* is the first one that is molded using the process described

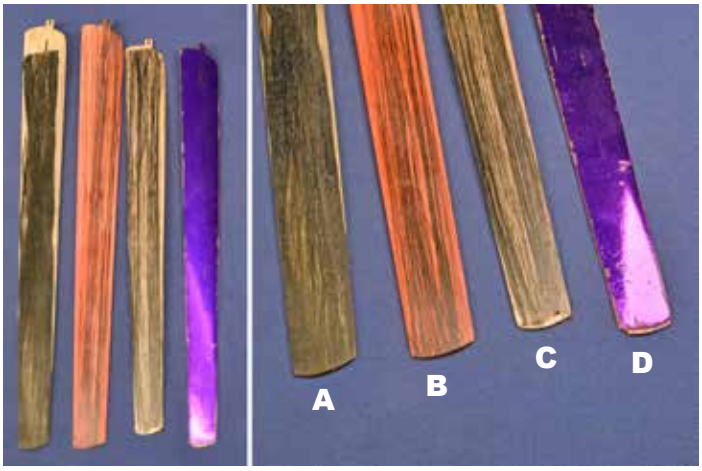


Figure 20 - Progression of blade development. A) thin blade with 6K spread tow on both sides. B) The spread tow was reduced to 3K on both sides, and painted orange for increased visibility. C) 3K spread tow on both sides, and molded to press the carbon fiber into the balsa so as to smooth the surface. D) 3K spread tow on both sides, with toner reactive foil on both sides, also molded to smooth the surface.

above. It has 3K spread carbon fiber tow on both sides. The surface is much smoother, and it is as shiny as the inside of my mold. If I'd polish up the mold, the surface would be even shinier. Finally, *Blade D* has 3K spread tow on both sides, with toner reactive foil also on both sides. Again, it was also molded to smooth the surface.

This technique of using a two part mold to make blades worked much better than I expected. Because of that, I decided to mold the rocket's fins as well. My previous way of making fins was described in *Peak-of-Flight Newsletter #571*, and it involved vacuum bagging the fins with the toner reactive foil. Using the method shown here, I didn't have to use a vacuum bag, I could just clamp the molds together while the epoxy cured. This was a big simplification and eliminates the need for any vacuum bagging equipment.

It does, however, require a mold for the fins. In this case, I simply 3D printed a mold instead of making the rubber ones (See Figure 21). I could do this, because they are much smaller and could easily fit into the platen of my 3D printer. On the other hand, the balsa helicopter

Figure 21 - Fins can also be molded. Here I used a 3D printed mold. Like the helicopter blades, they are made like a sandwich consisting of a balsa core covered by a layer of carbon fiber veil to give strength, and a surface layer of toner reactive foil to give a shiny metallic cover.

blades were much too long to be 3D printed with my own equipment. Maybe one day in the future I'll have a larger version, but I'm not quite there yet.

Like the balsa blades, the fins turned out much better than before - they were smooth, warp resistant from humidity,

shiny, perfectly flat and had a consistent thickness from one fin to the next. Furthermore, I could add carbon-fiber skins under the reactive foil, so I actually had fins that were significantly stronger and more rigid. This makes them less prone to fin flutter, which means the rocket has less drag and can stay attached when the rocket is flying at a higher speed. While adding the layer of carbon fiber increased the weight ever so slightly, it was definitely a good trade-off. A rocket that flies straighter usually flies higher.

Why Balsa Wood?

You might be asking a question that I also considered after I had perfected this process of molding helicopter blades and fins. Why use balsa wood? One of the problems I was trying to solve by using the process of molding the fins was to prevent the wood from warping. Couldn't I use a plastic foam core instead of wood. After all, since foam is a plastic, it doesn't warp at all.

I did an experiment with some Rohacell foam sheets instead of using balsa wood in the mold. The problem was that I couldn't find a foam that was as lightweight as super-light contest balsa. Believe it or not, balsa wood is really a miracle material. For its weight, it is incredibly strong. Only really exotic materials like graphene have a higher strength-to-weight ratio. So using foam as the core instead of balsa wood, would have resulted in a more flexible part. In order to get it as stiffness and strength as a balsa core blade, it would require more carbon fiber on the skins of the blades, which would add more weight. Balsa wood is still the material of choice for blades and fins on model rockets.

Conclusion

Molding balsawood parts like rotor blades and fins for competition rockets does take a bit of effort. It has the drawback that it takes a lot of planning on the front end in order to make the molds and cut the extra parts that make up the final assembled component. For the individual parts, you'll need a balsa core, two layers of carbon fiber to add strength, and the outer layers of reactive foil to give the piece a colorful metallic surface. Plus you'll be using sprayed-on epoxy to hold everything together.

They do take longer to assemble in the mold compared to simply sanding and sealing balsa wood fins in the traditional method. And they might be ever so slightly heavier

because of the extra layers of carbon fiber and epoxy. But in my opinion, the advantages are significant. The fins or blades are stiffer, have a beautiful surface finish that reduces drag, and they are colored in a reflective finish that makes them sparkle in the air and on the ground which makes them easier to find after the flight. Also, the parts are far more consistent in size and shape, which is important if you're making the same shape of fin for dozens of rockets. And the outer surface finish protects the balsa from humidity that can warp the wood and make the rocket fly in an unpredictable trajectory.

For most rockets, you wouldn't mold the fins or the helicopter blades. But in my case for FAI competition rockets, I was looking for a part that would solve the issues that could prevent the rocket from performing to its peak potential. And that is why I undertook this project, and am sharing my results with you. I hope you found it sparked some ideas for some of your own projects. If you extend this project further with your own experiments, please let me know. It probably would make a great follow-on article for this newsletter.

About The Author:

Tim Van Milligan (a.k.a. "Mr. Rocket") is a real rocket scientist who likes helping out other rocketeers. He is an avid rocketry competitor and is Level 3 high power certified. He is often asked what is the biggest rocket he's ever launched. His answer is that 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 an 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 also the author of the books: Model Rocket Design and Construction, 69 Simple Science Fair Projects with Model Rockets: Aeronautics and publisher of the "Peak-of-Flight" newsletter, a FREE ezine newsletter about model rockets. You can email him by using the contact form at https://www.apogeerockets.com/Contact.

PEAK OF FLIGHT NEWSLETTER
Article Submission Guidelines
Issue 632 / August 13th, 2024
www.ApogeeRockets.com

SUBMITTING ARTICLES TO APOGEE

We are always looking for quality articles to publish in the *Peak-of-Flight* newsletter. Please submit the "idea" first before you write your article. It will need to be approved first.

When you have an idea for an article you'd like to submit, please use our contact form at **https://www.apogeerockets.com/Contact**. After review, we will be able to tell you if your article idea will be appropriate for our publication.

Always include your name, address, and contact information with all submissions. Including best contact information allows us to conduct correspondence faster. If you have questions about the current disposition of a submission, contact the editor via email or phone.

CONTENT WE ARE LOOKING FOR

We prefer articles that have at least one photo or diagram for every 500 words of text. Total article length should be between 2000-4000 words and no shorter than 1750 words. Articles of a "how-to" nature are preferred (though other types of articles will be considered) and can be on any rocketry topic: design, construction, manufacture, decoration, contest organization, etc. Both model rocket and high-power rocket articles are accepted.

CONTENT WE ARE NOT LOOKING FOR

We don't publish articles like "launch reports." They are nice to read, but if you don't learn anything new from them, then they can get boring pretty quick... Example: "Bob flew a nice blue rocket on a H120 motor for his certification flight." As mentioned above, we're looking for articles that have an educational component to them, which is why we like "how-to" articles.

You can see what articles and topics we've published before at: **https://www.apogeerockets.com/Peak-of-Flight?pof_list=archives&m=education**. You might use this list to give you an idea or two for your topic.

Here are some of the more common articles that we reject all the time, because we've published on these topics before:

- How to get a L1 Cert
- How to get an L2 or L3 Cert
- Building cheap rockets
- How to 3D print parts
- Building Low Cost Launch Equipment (pads and controllers)
- Getting Back Into Rocketry After a Long Hiatus
- How to Build a Rocket Kit
- How to Build a Computer (too technical)

ARTICLE & IMAGES SUBMISSION

Articles may be submitted by emailing them to the editor. Article text can be provided in any standard word processor format (MS Word, Libre Office, etc.) or as plain-text. Graphics, meanwhile, should be provided in either a vector format (Adobe Illustrator, SVG, etc.) or a raster format (such as jpg or png) with a width of at least 600 pixels for single column images or a width of 1200 pixels for two-column images. If possible, it is generally preferable for images to be simple enough to be readable in a two-column layout, but special layouts can use the whole page width if required.

Send the images separately via email as well as showing where they go by placing them in the word processor document.

ACCEPTANCE

Submitted articles will be evaluated against a rubric (available here on our website). All articles will be evaluated and the results will be sent to the author. In the evaluation process, our goal is to ensure the quality of the content in *Peak-of-Flight*, but we want to publish your article! Resubmission of articles that do not meet the required standard are heavily encouraged.

ORIGINALITY

All articles submitted to Peak-of-Flight must not have been run in another publication before inclusion in the *Peak-of-Flight* newsletter, but it may be based on another work such as a prior article, R&D report, project report, etc. After we have published and paid for an article, you are free to submit them to other publications.

RATES

Apogee Components offers **$300** for a quality-written article over 2,000 words in length. Payment is pro-rated for shorter articles.

WHERE WILL IT APPEAR?

These articles will mainly be published in our free newsletter, *Peak-of-Flight*. Occasionally some of the higher-quality articles could potentially appear in one of Tim Van Milligan's books that he publishes from time to time.

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