PEAK OF FLIGHT NEWSLETTER

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IN THIS ISSUE

British Helicopter Technology

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PEAK OF FLIGHT

British Helicopter Technology

By Tim Van Milligan

Last fall, in one of our Advanced Construction Videos (www.apogeerockets.com/Advanced_Construction_Videos/Rocketry_Video_154) we did an interview with John Jacomb, one of the modelers on the British International Team. In that video, we got a sneak peak at the gyrocopter that has several features that are state of the art. In this newsletter, I'd like to discuss that rocket that John showed in the video, and present some detailed photos of the rocket. The hope is to spark some ideas for further enhancements of helicopter duration models.

Figure 1: John Jacomb prepping his rocket for competition.

The first thing that caught my eye about the British helicopter is that it didn't contain any balsa wood. Everything was composite or plastic. The reason for this is because humidity plays havoc with balsa wood. It warps the wood in unpredictable ways. I'm sure you've experienced this issue if you ever received warped plywood fins in a kit.

In competition rocketry, this warping can be extremely detrimental to the flight of the rocket. I noticed this myself this past summer when my daughters were trying out for the USA team. The helicopter models we built (see Newsletter #398 at (https://www.apogeerockets.com/education/downloads/newsletter 398) had twisted rotor blades. The portion of the blade closest to the hub was angled down, and the tip part of the blade had zero degrees angle of attack. The amount of twist is critical, and all three blades on the helicopter must be identical. Unfortunately, when we got to the contest, we found that the blades had warped due to the humidity change, and the rocket failed to rotate properly.

Figure 2: Composite blade tip.

An all-composite blade doesn't suffer from this issue, because the material doesn't absorb enough moisture to warp. The disadvantage of a composite blade is that it weighs more than a balsa wood blade. Composite blades are made from fiberglass or carbon fiber cloth, epoxy resin, and a Rohacell® foam core. Any of the parts has a higher density than good contest grade balsa wood. There is a trade-off that has to be made if you decide to use a composite rotor blade. The airfoil shape and the precision of the blade has to provide a significant advantage over the extra amount of weight that it will gain by using composite materials.

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 Continued on page 3

British Helicopter Technology

Continued from page 2

Figure 3: Shark fin shaped composite fins.

Even the fins of the model were made from composite material in order to get rid of balsa wood that can warp with changes in humidity. They also sport a shape that resembles a shark fin, which is supposed to have lower induced drag than an elliptical fin shape.

You can see from ***Figure 4*** that the blade has a tip extension on it to increase the diameter of the blades. The purpose of this is to increase the blade area and rotor diameter, which increases the descent time of the rocket - which is the whole goal of the event. A larger rotor diameter is more efficient than a smaller one. This is the reason that electrical power generation windmills are getting larger and larger in diameter.

Figure 4: Blade extensions.

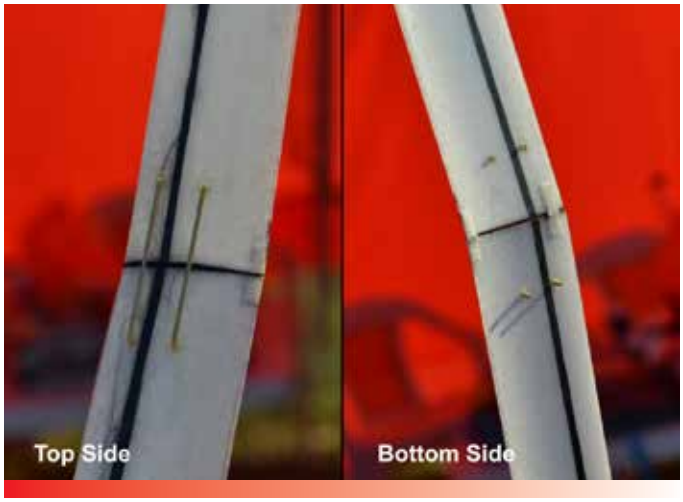

Figure 5: Close-up of blade joints.

The joint where the two panels of the blade come together are shown in ***Figure 5***. This is a critical part of the blade design, as it must hold the dihedral of the blade. The way the British go about pulling the blade open with elastic is interesting. They drill holes in the blades and glue two pieces of elastic into the holes. I'm not sure why they use two pieces, other than it gives some redundancy in the system. Replacing those pieces of elastic must be pretty time consuming, as you'd have to drill out the holes in the blades.

The hinge material is shown on the bottom of the blades (the right side shown in ***Figure 5***). To me, it appears to be a small portion of a model airplane hinge.

There is some debate on whether or not a multi-part long blade is better than a single-piece

Continued on page 4

British Helicopter Technology

Continued from page 3

short blade. The philosophy of most American modelers is that a single piece is going to be lighter weight, and therefore the model will boost higher. That is the philosophy that I personally take in my own designs too. I'd rather boost higher and have more chances of the model entering a thermal on the way down.

The yellow rotor hub shown in ***Figure 6*** is one of the more interesting parts of the rocket design to me. It is also the most critical piece of the design.

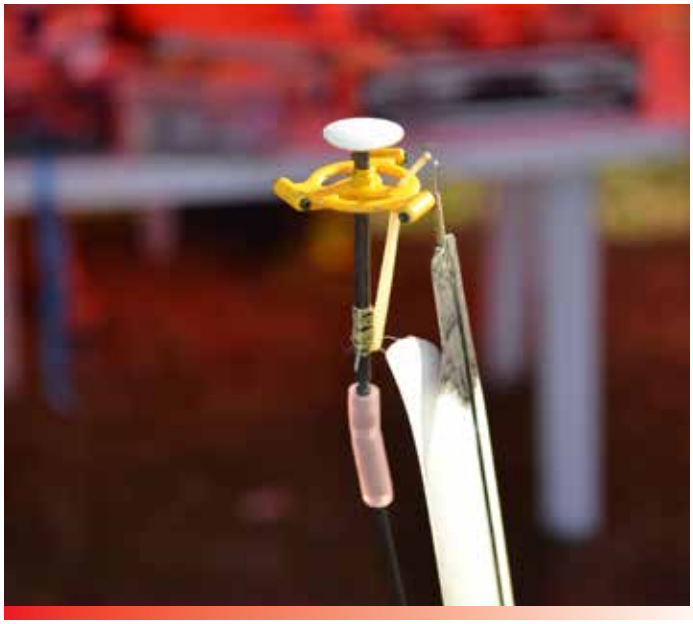

Figure 6: Close-up of rotor hub.

This piece, according to John, was originally created on a 3D printer. To make the part lighter weight, they created a mold of the design and use cast-resin mixed with micro-balloons to lower the density.

What I like about the hub is the way the blades are pulled open. In my own personal helicopter models I attach the rubber bands to the shaft, but above the rotor blades. As you can see in ***Figure 7***, where the rubber band attaches to the rotor shaft on the British model is actually below the hub disk.

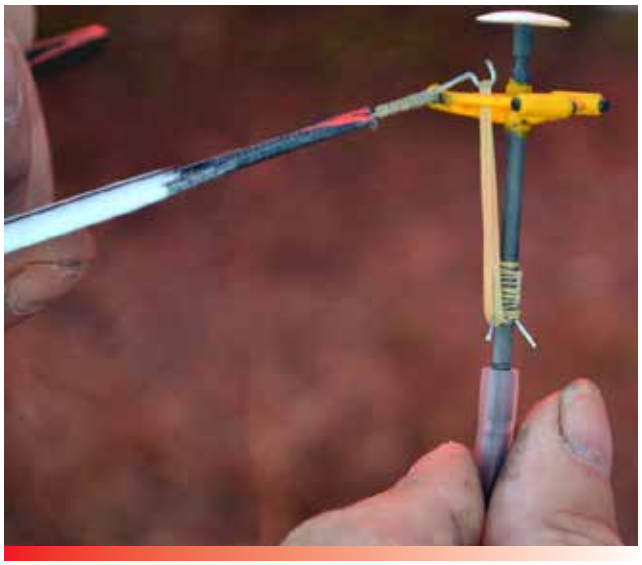

Figure 7: Rubber bands below the hub disk.

I'm guessing that the reason they do this is to lower the center of gravity of the model. By doing so, it makes the model orient itself in a vertical position. They even eject the nose cone and have it fall below the body of the rocket in order to move the CG of the rocket even lower, just to make sure the rocket orients vertically.

The blades are attached to the hub through a post made from stiff music wire. If you look closely (***Figure 8*** *on page 5*), you'll see that the post is actually two pieces of music wire that

 Continued on page 5

British Helicopter Technology

Continued from page 4

are bound together by several wraps of Kevlar thread. They make a T shape. The trunk of the T is the pin that is inserted in the pivot hole on the yellow hub. The cross-member of the T shaped music wire extends out from the core of the rotor blade, and makes a U-shaped loop on the other end. The U-shaped part is where the rubber band is hooked on (see ***Figure 8***).

Figure 8: Close-up of music wire on and off hub disk.

The music wire assembly is the part that gives me the shivers. While it is very simple looking, my experience with working with music wire is that it is hard to get precise bend-angles. If you bend incorrectly any one of the three pieces used on the model, the model will have one of the blades at a higher or lower dihedral angle that the others.

But it greatly simplifies the way the rotors are attached to the hub, and allows the blades to be completely removed from the rocket as seen in the left image in ***Figure 8***. And in this design, because of the folding blade, you want to remove the blades so that the elastic glued to the blades at the hinge section aren't stretched out. The blades need to be stored and transported in an open position

Figure 9: Pivot point made from a part of a Ping-Pong ball.

Another advantage of the removable blades is that if one blade should break during a flight, you can swap it out with a replacement in just a couple of seconds.

That white hemisphere above the yellow hub is a section of Ping-Pong ball. It is a pivot point so that the nose cone can easily rotate off the rocket at ejection. The inside of the nose cone (see ***Figure 9***) also contains a section of Ping-Pong ball. The two sections of Ping-Pong ball butt against each other when the nose is on the rocket. When the ejection charge pushes out the nose cone, it rotates and easily falls away from the rocket.

There is one other feature near the rotor hub

 Continued on page 6

British Helicopter Technology

Continued from page 5

that is worth mentioning. The graphite rod is split into two sections, As seen in ***Figure 6*** (on page 4), there is a piece of surgical tubing that joins the two pieces of graphite rod together.

This surgical tubing does two things. First, it acts like a rubber shock cord, and stretches slightly when the rotors are deployed. That little bit of stretch absorbs some of the shock of ejection and protects the rocket from being ripped apart.

But the main reason of the surgical tubing is that it acts as a pivot in the shaft. The purpose is to keep the rotor hub level as the rocket is spinning down to the ground. The hub is most efficient when it is parallel to the ground. But sometimes a gust of wind hits the bottom part of the rocket near the fins, and that wants to tilt the rocket sideways. With the pivot in the system, the rotor hub can stay parallel to the ground even if the body of the rocket is tilted to one side because of the wind.

Figure 10: Blades inside the rocket.

Figure 11: Piston head is specially shaped to hold the composite blades into place.

Figure 10 shows how the blades are stowed inside the piston part of the rocket for launch. The central graphite shaft is connected to a foam piston. This slides upward when the gases from the ejection charge pressurize the inside of the body tube. The piston head is restrained from exiting the tube by a Kevlar shock cord that is anchored near the bottom of the rocket.

The piston head is unique in that it has a cup shape that conforms to the shape of the blades (see ***Figure 11***). The purpose of this is to keep

 Continued on page 7

British Helicopter Technology

Continued from page 6

the blades from springing open inside the rocket and then rubbing on the inside of the tube. Remember, the blades want to open because of the rubber bands pulling on them near the hub.

The Kevlar cord that prevents the piston from exiting the tube is anchored to a ring at the base of the rocket (shown in ***Figure 12***).

Conclusion

I enjoyed writing this article, because I appreciate how much thought and engineering went into the design. They are on the cutting edge of technology.

Overall, this is a very complex rocket because it has a lot of parts to it. I'm not sure I'd personally fly anything this complex, but the British fliers on their international team are quite proud of the design. They even have a version of the rocket that has a dethermalizer system built into it. They swear that the rocket works so well that the only way to get one back from a flight is to purposely bring it down quickly by having one of the blades over-rotate after 3 minutes.

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.

Figure 12: The Kevlar cord is anchored to the ring at the base of the tube.