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APOGEE PEAK OF FLIGHT NEWSLETTER

Feature Article:

Common Misconceptions About Centering Rings

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APOGEE

PEAK OF FLIGHT

Common Misconceptions About Centering Rings

Building Tough Rings To Withstand The Pounding Of High Thrust Motors

By Tim Van Milligan

People often tell me of their plans to upscale a favorite rocket, or modify an existing kit to accept high power motors. The question that often comes up is what to do about the centering rings?

There is a misconception that the rings have to be replaced with some exotic material like fiberglass rings, or heavy guage plywood. This is not true; which I'll explain in the rest of this article.

Over the years, I've been trying to get across the point to modelers that they need to keep the weight of their rockets down. This is a major safety issue. The common perception is that if the rocket is able to survive a crash, then it must be a safe model. This is completely wrong! If your rocket is built to withstand a ballistic impact, it is UNSAFE. As yourself: "how safe would I feel if I was standing at the impact point?"

Actually, this article is a continuation of a previous one. *Paper Centering Rings for High Power Rockets* found at: http://www.apogeerockets.com/education/newsletter63.asp. The reason I'm writing about it again is that modelers continue to ignore this important safety issue. So this time, I'll try to show you the concepts with pictures. I hope that modelers will change their design philosophies.

As preparation for this article, I did some research into how to calculate the strength of centering rings. It is possible to calculate, but it is beyond the scope of this article. However, there is one thing that is important to know. The amount of deflection the ring can withstand is proportional to the thickness of the ring to the fourth power. In other words, if you double the thickness of the ring, the deflection will be 1/16th the original amount.

This is important, because it give us a way to strengthen simple "cardboard" centering rings. We DON'T need to use heavy rings made out of plywood, nor exotic materials like fiberglass. You CAN make them out of paper and other lightweight materials such as foam-board. These rings can be very strong, and they are safer to put into a rocket becuase they will give way in the event of a ballistic impact. And from a practical perspective, they are "cheap" - so you can save money on your rockets.

How to Make Rings

The first step is to draw them at 100% scale on a piece of paper. If you are a RockSim user, printing out ring patterns is a piece-of-cake.

If you don't have RockSim, then next best thing is a drawing (not a PAINTing) program for your computer. Most computers come with a drawing program that can be used to draw

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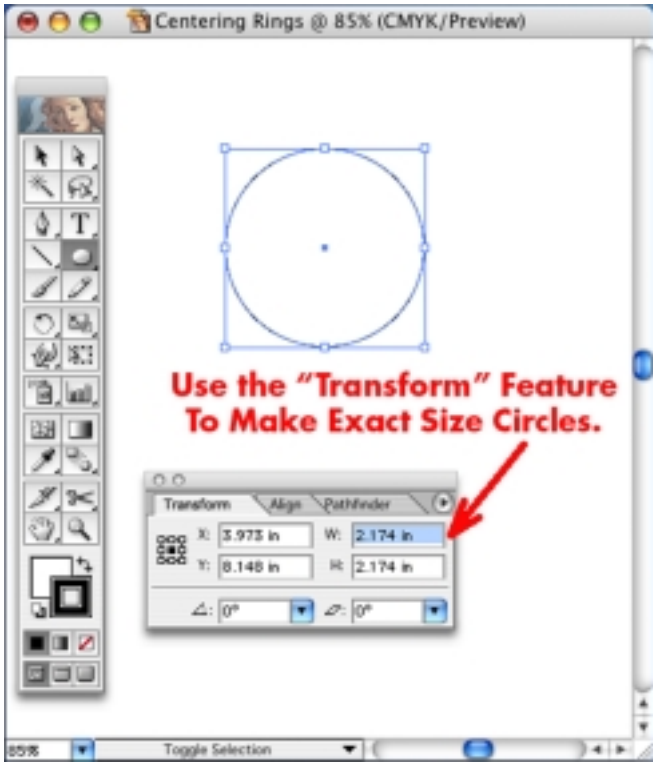

Figure 1: The first key to great rings is drawing them to exact size. Here, I use a drawing program to get the right size rings.

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highly accurate rings.

The key to getting an exact size ring is to use the transform feature to tweak the circles to the measurement you want. For example, you'll start by drawing a circle. Find the transform pallette in the drawing program. Figure 1 shows the transform options in Adobe Illustrator software. By typing in a value in the fields, you can get an exact measured circle.

By the way, what size do you make the rings to get a correct fit. If you make them the same size as the tube that they fit into, I can assure you, they won't go in very easily. The outside diameter of the ring has to be slightly smaller than the inside diameter of the tube that it fits inside of. As a rule of thumb, subtract 0.006 inches to make a nice slip fit. For example, a BT-70 size tube has a inside diameter is 2.180 inches. Subtracting .006 inches from that makes the outside diameter 2.174 inches.

You'll do the same for the inner circle of the ring. For the example I used in this article, I have the ring slipping over a BT-50 (24mm) tube. The O.D. on that tube is .976. The inside diameter of the ring will then be 0.976 + .006 = .982 inches.

Figure 2: Aligning the centers of the rings both horizontally and vertically assures they are perfectly cocentric.

Making sure the rings are concentric is done with the alignment function of the drawing program. Highlite both rings, and click "Align horizontal centers," and "align vertical centers" as shown in Figure 2. This makes the rings aligned perfectly concentric.

When you print out the rings, set the line thickness in the drawing program at 1/2 point. This is thin enough to make an accurate circle.

Once you've printed out the rings on a sheet of paper, how do you transfer it to the cardstock? That's easy: use 3M's Spray Mount adhesive. It is a low-tack adhesive, sort of like rubber cement. Just spray a very light coat of the Spray Mount on the back, and press it down against the cardboard. It will stick, and it won't let go while you cut it out with a hobby knife (see Figure 3).

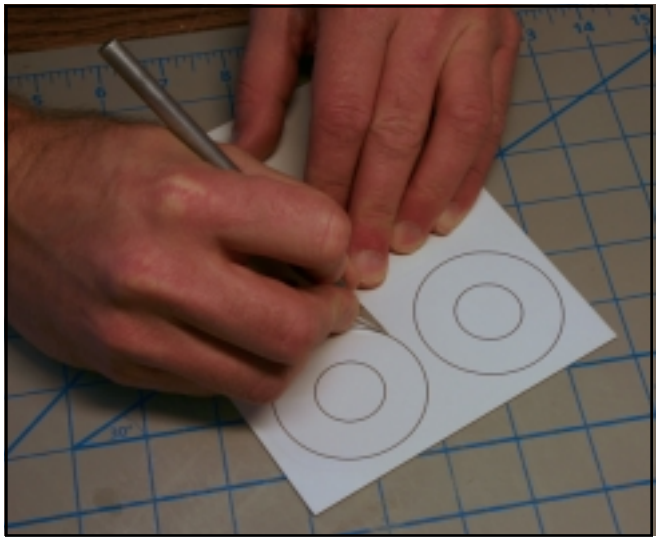

Figure 3: Cut out the rings using a sharp hobby knife. Work slowly, and don't forget to wear safety glasses in case the tip snaps off.

No matter how close you think you've cut out your ring, you can never achieve a perfect ring. What I do is sand it down to make it fit properly.

Start by sanding the inside of the ring. Here is what I do: I take a old spent engine casing, and glue some sandpaper to it. This can then be inserted into the inside circle to sand it smooth (see Figure 4). As you sand, you'll need to check the fit by sliding the engine mount tube inside of it.

The outside can be done the same way. But it never seems to end up circular. It always seems to be loose in one area of

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Figure 4: Sand the inside first, so it slides smoothly over the engine mount tube.

the tube, and too tight in another. Here is how to solve that problem: tack-glue the ring to a tube coupler, and then sand it. I put three small drops of wood glue equally spaced around the perimeter of the couple edge. Then press the ring on and hold it securely.

Before you start sanding, make sure the glue is dry. You don't want it coming loose off the coupler.

When you sand, always draw the sandpaper toward the coupler, like shown in figure 5. This does a few things. First, it keeps the paper on the ring from delaminating. In other words, the edges of the ring don't become all fuzzy. It's hard to sand fuzzy things, isn't it?

Second, the couple is used to guide the sanding block, so you get a perfect circle when you notice you're sanding into the paper of the coupler tube. Finally, by working toward the coupler, you prevent the ring from popping off the coupler.

Figure 5: Tack-glue the ring onto a coupler, and sand the outside edge. Always work the sandpaper towards the tube.

When you are done, it should be easy to break the glue joints and pop the completed ring off the coupler.

You're probably thinking: why go through all the trouble to make a perfect circle on the ring? Can't you just fill in any gaps with a thick-old fillet of glue?

The answer is that you can fillet the ring heavily. *HOWEVER:* glue is heavy, and it would be stronger if the ring was perfectly round. Trust me, it is well worth the effort to make a perfect ring. Besides, when you show your rocket to your friends, they'll be able to tell if you've made a perfect ring compared to one with gaps. The tell-tale sign is the thickness of the fillets. Big fillets are used to hide poor workmanship. You want to prove to your friends that you are a great rocket builder, don't you?

Where / Why do Rings Fail?

In my experience with low and mid-power rocketry, I can't ever recall seeing a ring fail. What fails is one of the glue joints along the edge of the ring, where it is glued to the inner or outer tubes.

In other words, the ring doesn't fail, it is the "attachment" that fails.

What does this tell us? Think about it for a second.

We don't need bullet-proof rings. We can use thin rings made out of cardstock, but we need a stronger way of attaching them to the components!

Since the rings aren't the weak point, why bother using heavier plywood rings or ones made out of fiberglass? Even if you used those materials, it is still the glue joint that fails. So all the effort using those materials results in only one thing: a heavier rocket. What's worse is that it is heavier at the tail end, which is destabilizing. I've seen it again and again that people must add more nose weight to tail heavy rockets to counteract the weight of the heavy-duty rings. It is self defeat-

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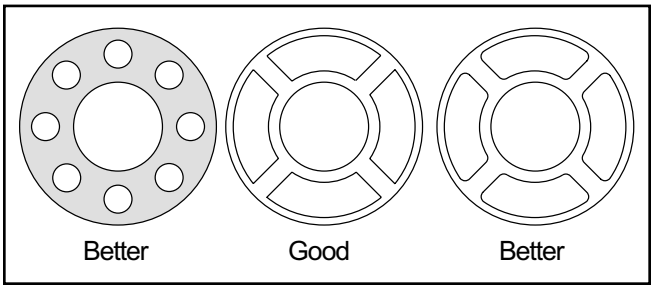

Figure 6: Examples of lightening holes. Sharp corners should be avoided, but can be used.

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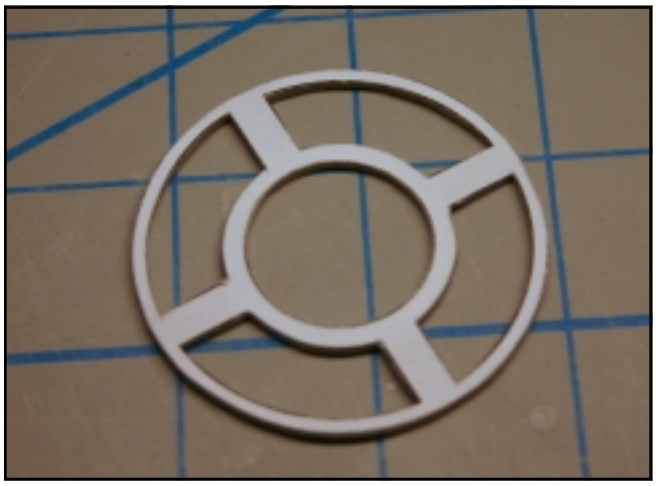

Figure 7: Here the lightening holes have be cut out to make an ultra-light weight centering ring.

ing. You make the rocket less safe to fly because it is heavier.

Since the paper ring is more than adequate, we can even reduce its weight further. As seen in Figure 6, you can cut holes in the ring to reduce weight. There is actually a term for these holes. They are called "Lightening Holes," because they make the ring lighter in weight.

The real key to strengthening rings though, is to make them stiffer by using radial beams, like those shown in figure 8. They are simply glued from the engine mount tube to the

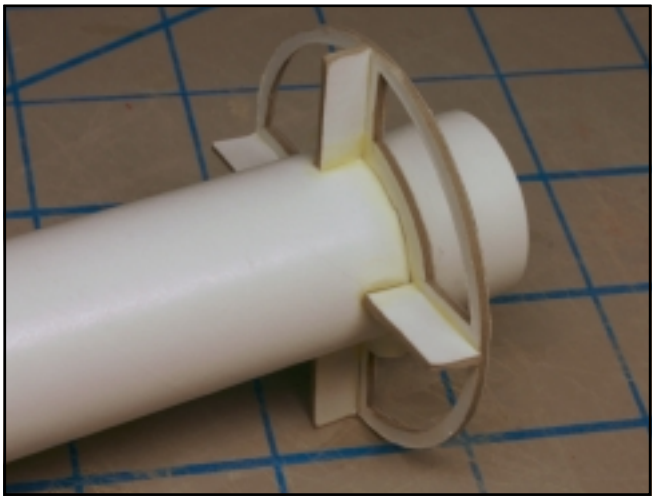

Figure 8: The ring is now stiffened with radial beams of cardboard. This makes it much stronger than even a extra thick solid ring.

inside wall of the outer tube. These add very little weight, and increase the surface area touching for the glue to grab hold of.

In fact, you can take it so far as to leave the ring completely off, and just use thse radial stiffener to hold the engine mount tube.

A lot of modelers will use through-the-wall (TTW) fins, which a portion of the fin (the tab) extends through a slot in the body tube, so that it touches the engine mount tube. This not only stiffens the rings, but also makes for a much stronger fin joint. This is a great technique to use, and it worth the effort!

Figure 10 shows a ultra-light engine mount that consists of two rings with lightening holes cut out of them. The aft

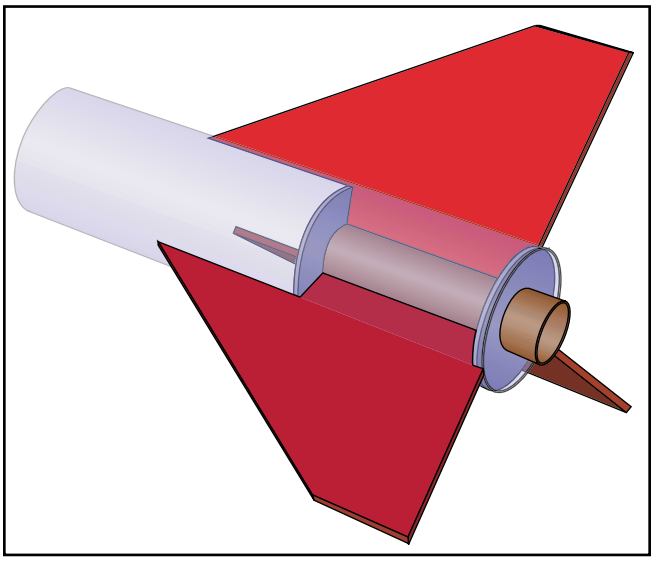

Figure 9: Through-the-Wall fins, which butt up against the rings, not only stiffen the fins, but they also make the rings very strong.

ring has the radial stiffeners to increase the strength of the ring and increase the glue surface area to prevent tearout. You'll notice that on the forward ring, I placed a thin paper cap over the lightening holes. The reason for this is to seal off the tube, so that when the ejection charge fires, it can pressurize the tube and pop out the parachute.

Here are a couple of other simple ways to strengthen the centering rings without adding a lot of mass. Remember, it is really the glue joint holding the rings in that we need to strengthen. If you are using through the wall fins, you won't need these extra strengthening methods. It would be redundant.

1. Put a short (only 1/4 inch) length of tube coupler inside the tube, just in front of the front centering ring on the engine

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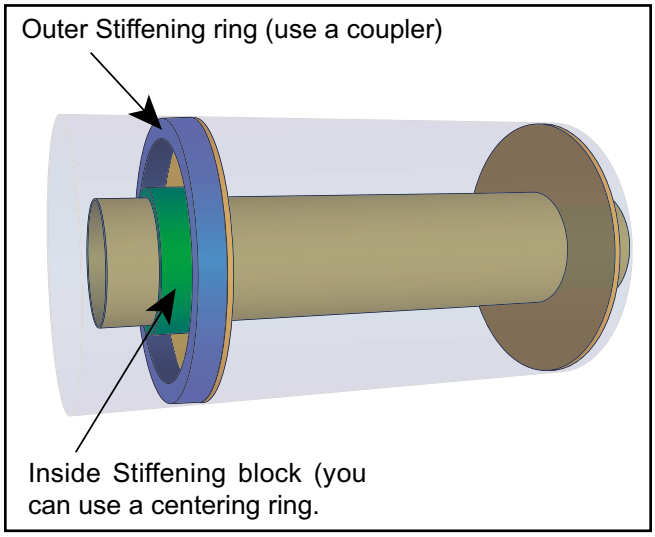

Figure 10: Reinforcing the edges of the glue joints holding the ring greatly increases the strength of the centering ring.

mount. This gives the ring something to butt up against and prevents it from sliding forward in case the glue joint fails.

2. Similarly, put a ring over the engine mount tube - again positioned just in front of the forward ring so that it can't slide forward if the glue joint fails.

Conclusion

Building strong centering rings is possible without using expensive plywood rings or ones made out of fiberglass. You just need to remember that it is usually the glue joint that lets go, and not the ring that fails. So spend more time making sure the glue joint is sufficient.

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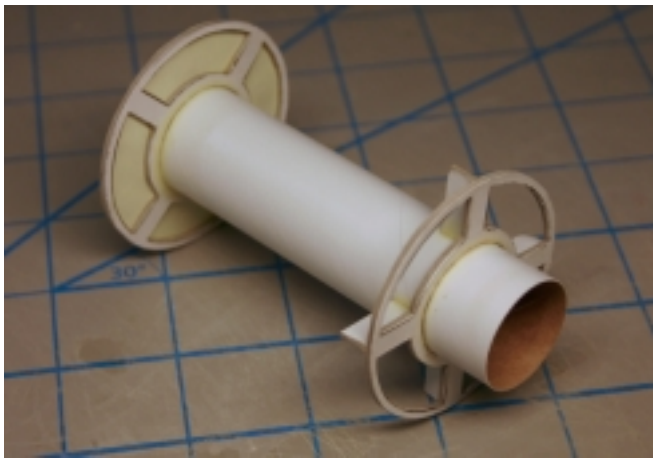

Figure 10: An ultra-light weight engine mount. Note the paper disk on the front that seals the tube so the parachute is ejected properly.

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