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NEWSLETTER

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Build A Jig To Make It Easy To Sand Radial Taper Into Wood Fins

Cover Photo: MadCow Rocketry's Mozzie rocket kit. Get yours at: www.ApogeeRockets.com/Mozzie.asp

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ISSUE 271 OCTOBER 19, 2010

Build A Jig To Sand Radial Fin Taper

By Bart Hennin

A radial fin taper refers to the thickness of the fin, not the planform (flat surface) shape. In this regard, when we say "taper," we mean that the fin is slightly thicker where it meets the rocket's body tube and gets uniformly thinner moving towards the tip

This article will discuss when fin radial tapers are advantageous, and also when they should be avoided. We will also cover in detail how to construct and use a simple jig (made of 1/8" basswood or plywood) to give your fins precise, accurate, and perfectly symmetrical radial tapers.

Why Bother With A Radial Taper

Radial tapers are desirable for reducing aerodynamic drag on your rockets by keeping the fin's airfoil section contstant from root to the tip. As mentioned in Apogee's Technical Publication #16 about which fin shape is best for highest altitude flights, the tapered fin is desirable, but not as easy to make as a fin with constant thickness. Read Technical Publication #16 for free at: www.ApogeeRockets.com/technical_publication_16.asp

In addition to reducing drag, a taper can increase the efficiency of your rocket's dynamic stability response by reducing the radial moment of inertia of the rocket (see *Peak of Flight Newsletter* #196 at: www.ApogeeRockets.com/Education/Downloads/Newsletter196.pdf). In other words, your rockets will fly higher, faster and straighter!

Advantages to tapering your fins are...

- Faster, higher, longer duration flights
- Greater Dynamic Stability (fins return the rocket to vertical more efficiently and with less induced drag in less time)
- Reduced total rocket weight, particularly at the rear of the model where weight is most detrimental
- Less wear on rocket due to less severe aerodynamic forces (although the forces on the fin tips may be excessive - see the next section below)
- Better looking more accurately detailed scale models (even sports models will look vastly more professional!)

One of the biggest advantages to employing a radial fin taper is that it keeps the fin's airfoil scaled properly. An airfoil is most efficient when its maximum-thickness-to-fin-cord ratio remains constant across the entire fin span. In other words, if your fin tip cord is half as long as the root tip cord, the fin thickness at the tip should also be half as thick as at the root. If the fin tips are 1/4 the length of the fin's root edge, the tips should also be one-fourth the thickness of the root and so on.

That said, there are times when a radial taper is undesirable and even detrimental to your rocket design, such as:

- When your fins are already very thin (some competition model rockets have fins as thin as 1/64th of an inch! Such fins gain little from tapering).

- When you can get away with a thinner fin overall (tapering a 1/16" thick fin to 1/32" thick at the fin tip would reduce drag but not as much as replacing the entire 1/16" thick fin with 1/32" piece of balsa or basswood). If you want to know what thickness of wood you should you use for your rocket fins, it's in the *Model Rocket Design & Construction* book. www.ApogeeRockets.com/design_book.asp

- If fin FLUTTER is a danger or concern. Tapering fins weakens them toward the tips, where the aerodynamic forces are greater. This can cause the fin tips to "flutter" during boost, which not only generates a lot of induced drag but can also cause the fins to break in flight.

If your fin tips are getting quite thin you might be able to reduce the chance of fin tip flutter by stiffening the fin tips. Do this by applying a small amount of CYA glue to the thin tips to harden them (and re-sand smooth after the CYA has dried) and/or strengthen the whole fin structure by applying a paper skin to them as shown in this video. Do any fin shaping (radial taper, airfoil, rounded edges) BEFORE applying your paper skin. This video shows you how to easily apply a paper skin to your fins: www.ApogeeRockets.com/Rocketry_Videos/Rocketry_Video_16.asp

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How To Sand Fin Radial Taper

How To Apply A Proper Radial Taper:

An improperly applied radial taper can easily cancel out any aerodynamic advantages and be worse than no taper at all. Also, any asymmetry in the fin due to sanding a taper may cause the rocket to spin slightly. This spin (like drag) robs the rocket of energy that would otherwise go towards increasing its speed and altitude.

In creating fin radial tapers, "eyeballing" it isn't good enough. The only way to create tapers with the required accuracy and precision needed to gain a true aerodynamic advantage is to make and use a sanding jig. This eliminates "guesswork" and results in virtually perfect tapers every time!

A further vital advantage to using a jig is that every fin on your rocket ends up exactly IDENTICAL. This results in your model being more aerodynamically balanced, which reduces induced drag significantly!

Before we get into the actual construction of our jig (the example here uses 1/8" basswood) we'll first cover what (in principle) we need the jig to do for us.

Suppose we have a 1/8" thick fin with a 'clipped delta' plan form where the fin tip is half the length of the fin root. We want to sand a span-wise radial taper into the 1/8" thick fin, so that the tip is 1/16" thick (half the thickness).

To keep the taper symmetrical we must remove equal amounts of material from the top and bottom surfaces of the fin. In this case we reduce the thickness at the fin tip by 1/32" (1/4 of the fin's full thickness) on EACH side.

So we need a jig where the fin lays flat on a horizontal base resting between two vertical "walls" (the walls' top edges are lined with metal strips that can resist sanding) as shown in Figure 1.

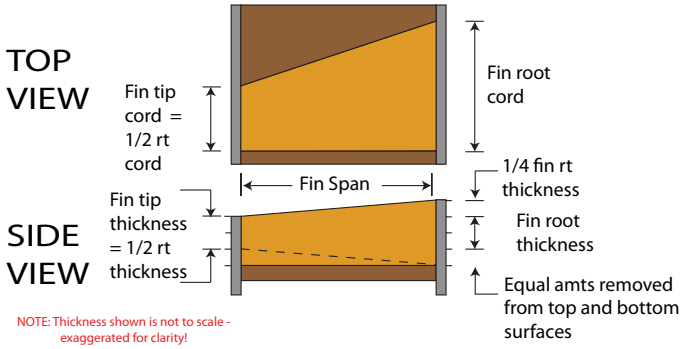

Figure 1: Jig Concept Illustration

Each wall abuts up against one fin edge. Specifically, one wall abuts up against the fin's root edge and its height above the base is equal to exactly the thickness of the fin material (1/8" in our example) so its top edge lies flush with the top surface of the fin. The second wall abuts up against the fin's tip edge and its height is 1/32" (1/4 the thickness) below the fin's top surface (i.e. 3/32" above the base).

Now, using a sanding block or sanding tee that is longer than the fin span, we sand parallel to the fin grain (fin grain is normally parallel to the fin's leading edge) span wise across the two walls until we get a smooth flat fin surface flush with the metal strips at both walls. Side one is done!

Now to do side 2 we can't just flip the fin over as the fin is no longer flat! We need to place a spacer or 'shim' under the fin when we flip it over to keep the second side at the right height for sanding. Fortunately there is a simple way to make an exact sized spacer.

Before you flip the fin over, rotate it 180 degrees (so the fin tip is now against the higher wall and the root tip is against the lower wall. Lay a strip of 1/16" thick balsa along the fin tip (now at the root wall) as shown in Figure 2. The

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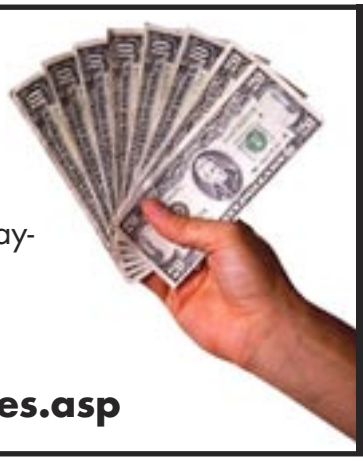

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strip's width should be only about 1/8" wide. On the side of the strip opposite the wall, place a strip of masking tape across the fin for protection.

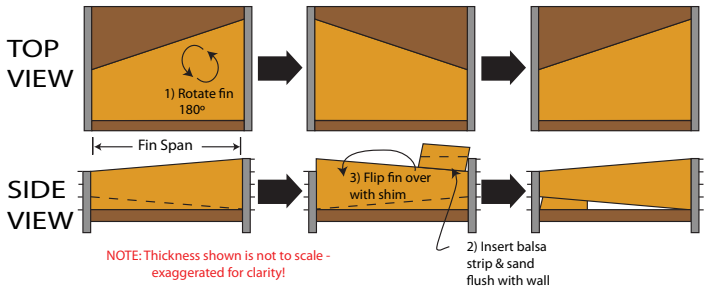

Figure 2: Making a shim

Now sand along the strip parallel to the vertical wall (keeping your sanding block or sanding tee flat) until the strip is flush with the wall.

Next, flip the fin with the shim and sand side 2. Repeat for your remaining fins and Voila! Perfect radial tapers!

Accuracy, & How To Increase It!

In practice it's difficult to measure off 1/32 of an inch (or less!) accurately. Plus, we can't be sure a 1/8" thick sheet stock IS exactly 1/8" thick (especially after sanding the sheet smooth!). Also, the method sited above depends on the two vertical walls as well as the base being exactly level to an incredible degree!

Wouldn't it be great if we could modify the above method so that...

- We could set our wall heights without having to "measure" the height?
- No matter what the thickness, we are still able to get a perfect taper?
- Even if the base/walls aren't perfectly level, we still get a perfect taper?

Well, believe it or not, with a few simple tricks we can! In order to greatly increase the accuracy and precision of our jig (and to avoid having to set precise heights to impossible fractions of fin thicknesses), we're going to do a special set up (see "Using Your Jig" later on in this article). In this set up, our horizontal wall separation is not ONE fin span but FOUR TIMES the fin span.

How does this increase our accuracy? First, at 4-times the fin span, errors in wall height only produce 25% the error that's produced at 1 fin span. Second, as we shall see, this special set up allows us to set wall heights to preset wood thicknesses without the need to "measure" anything!

First, we have to build a functional jig. If you can build a level 2 or 3 rocket, you can handle this jig construction. Once built, you can use it over and over for all your fins on all your rockets, so it's a productive investment of your time.

How To Build Yourself A Sturdy Versatile Jig:

We need our jig to match the size of our fins but obviously we don't want to have to build a DIFFERENT jig every time we switch fin sizes! We'd like our jig to be "adjustable" so we can taper different size fins with a wide range of fin thicknesses, fin spans and fin cord lengths!

To do this our jig needs to be adjustable in 2 directions.

First, our two vertical walls must be adjustable heightwise to accommodate different thicknesses of fins.

Second, the walls rest in "lock frames" that must be able to move closer together or farther apart to accommodate different fin spans.

Different fin cord lengths are handled simply by making the jig base long enough to handle a large range of fin sizes.

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How To Sand Fin Radial Taper

One design that meets these requirements is shown below. Basically, the jig consists of the following three components (refer to diagram below) as follows:

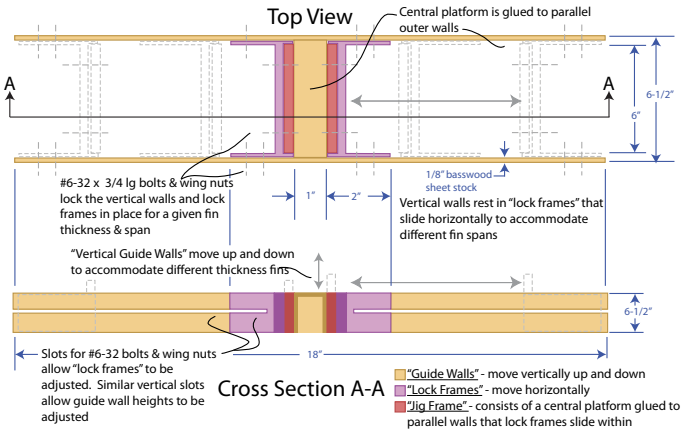

Figure 3: Radial Fin Taper Jig Layout

1) Two "guide walls" (shown in red) - These walls are adjustable vertically up and down and their top edge is lined with a metal strip. This is how the jig accommodates different fin thicknesses.

2) Two "lock frames" (shown in purple) - Each "vertical guide wall" rests in its own "lock frame". These lock frames slide back and forth horizontally to accommodate different fin spans.

3) "Jig Frame" (shown in beige) - This frame holds everything together and consists of a central platform (for the fin to rest on) glued to two parallel walls (that allow the lock frames to slide to and fro) .

Appropriate "slots" are made just wide enough to accommodate #6-32 bolts (with washers & wing nuts) so the walls and frames can be locked into any needed position for any specific fin size.

The overall dimensions of the jig are 1.5" tall by 6.5" wide by 18" long. (If you're wondering why so long, when we'd never have a fin span of 18", refer to *"Tricks To Greatly Increase The Accuracy Of Your Fin Tapering Jig"* below where we put this extra length to good use!)

NOTE: You may be wondering how we provide a wider platform for fins with longer spans. Simply make additional platform pieces identical to the central platform above (full construction details are shown below) and set them in the jig (unglued) to accommodate any additional width desired.

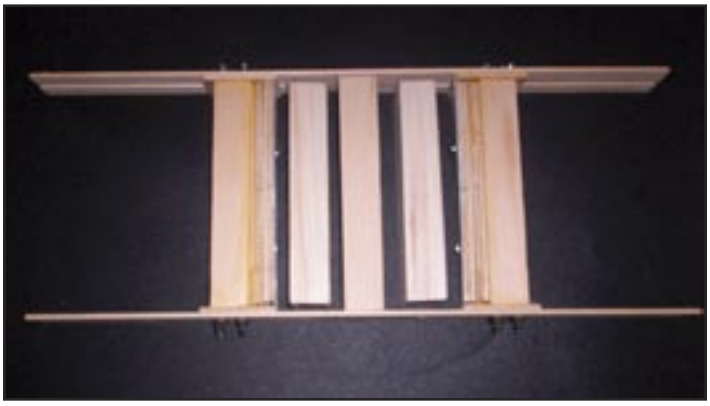

Photo 2: The assembled jig

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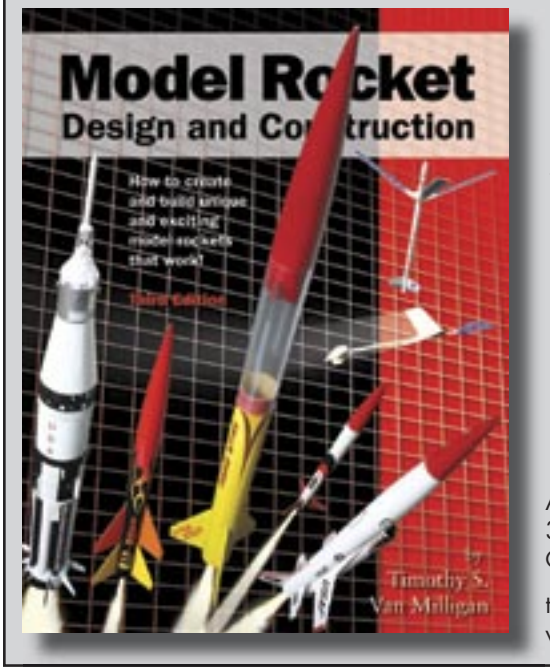

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Note that although ALL platforms must be sanded level and to the exact height, only ONE platform needs be of exact width (the center one you will be gluing to the frame); the others can be slightly narrower to make placement easier. IN FACT, in this example, only the center support is made of basswood (cut from 1/8" thick sheet stock), and the other two are made from 1/8" balsa sheet stock.

When using the jig, we will be laying a base plate (of 1/8" balsa or basswood sheet stock cut to size) across the platform pieces to create a solid level support platform.

The dimensions shown in the above design are just one example. When you make your own jig you can vary the dimensions to suit your own specific needs. However, the jig shown here handles anything up to 1/2 inch thick, with a span range of 1 to 5 inches with cord lengths up to 6" or more.

Photo 3: Tools & Materials Needed

To build this jig you'll need the following tools and materials: (Most of which you likely have on hand from your rocket building projects)

- 1/8" basswood sheet stock
- 1/8" balsa wood sheet stock
- 2 metal strips (in this example 6" long x 1/2" wide x 1/32" thick aluminum strips were used)
- 1 dozen #6-32 x 3/4" bolts with matching washers and wing nuts
- Wood glue
- Gorilla glue or similar (refer to gluing notes below)
- Sand paper in course and fine grits (for shaping and smoothing respectively)
- Hobby knife or similar (I found a case cutter worked better on the basswood)
- Metal ruler (metal square is optional)

Also, items nice to have but not essential are a razor saw, "pin vise" (if you don't have a drill), and a mini rasp file set. I improvised a "pin vise" using vice grips to grab hold of a 3/16" drill bit and used the same as a rasp file too where needed. With imagination, you can always improvise a tool you lack!

Gluing Tips: To get the best glue bonds, you'll want to pre-sand your basswood sheet(s) with a medium grit sand paper to even out any rough grain (and then dust them off

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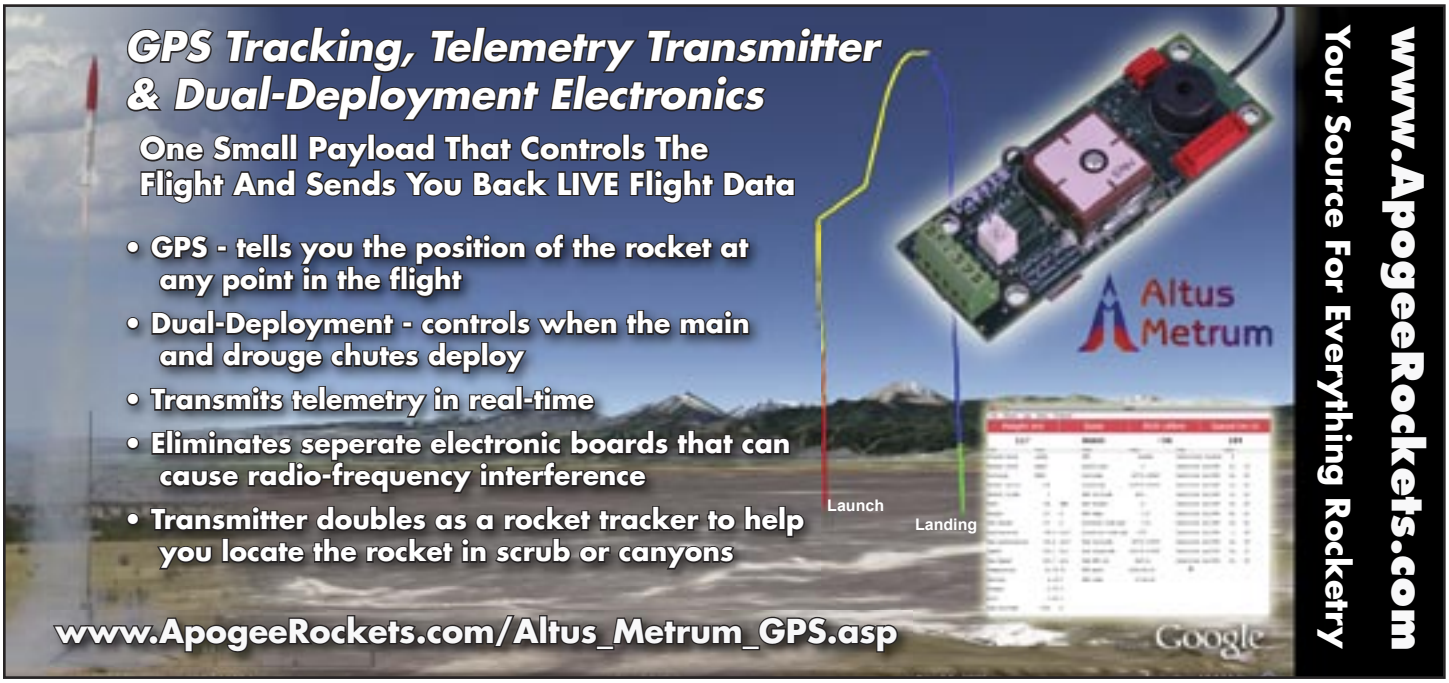

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thoroughly). This ensures a smooth clean surface to maximize glue joint strength. You don't need to sand the sheet much because, unlike your rocket, your jig won't be flying!

When gluing wood to wood, make sure each piece is dust free. Apply a thin layer of wood glue to each surface to be bonded, mate the parts together and then pull them immediately apart and smooth the glue flat. This lets the glue permeate the pores of the wood for a stronger bond. Let the glue dry for about 10 minutes, then reapply your glue (not excessive amounts) and press the parts back together. For parts glued at right angles apply small fillets of glue along the inside seams for strength. As well, add cross support pieces where appropriate for further stiffness and strength (see below).

To glue your metal strips to the basswood (or plywood) wood glue won't work. You have a number of options. You can use epoxy, super glue, no nails adhesive, or Gorilla glue.

Of these choices, the super glue is my LEAST favorite, as CYAs are very strong in tension but weak in shear (this is why if you accidentally glue your fingers together with super glue rubbing them back and forth and in a circle quickly gets them to come apart). Your metal strips will experience some shear forces and may not last as long with a CYA bond.

Epoxies can work well, especially the longer setting epoxies, but I don't like all the precise mixing! So I avoid epoxies except where they give a clear advantage such as constructing larger medium power rockets... but for my jigs? No epoxy for me (just a personal choice).

Gorilla glue is my personal choice as it's very strong and relatively easy to use.

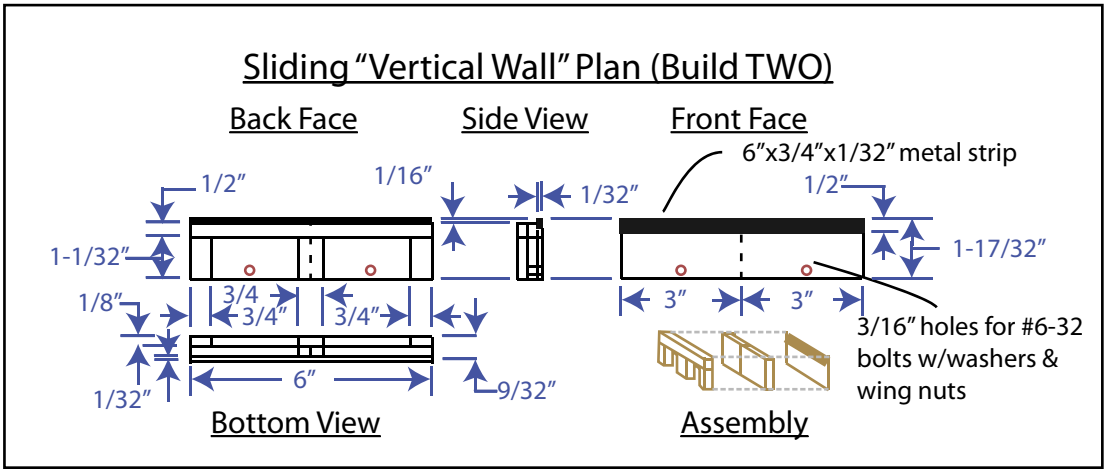
Before gluing your metal strips to the basswood (or plywood if you are using that), clean the surface of the metal with a clean rag and denatured alcohol to remove dirt and oil from the surface of the metal (oil will reduce glue bond strength). If you don't have denatured alcohol handy, at least wash the metal strips in hot soapy water, rinse thoroughly, and let air-dry.

Brush down the surface of the wood that is going to have the metal bonded to it with a dust brush (a clean 'natural animal hair' mineral make-up brush or similar is perfect for this). After gluing, wipe any excess adhesive that squeezes from underneath the metal with a paper towel.

Clamp the metal to the wood to press the bond together. Alternately you can use a heavy object such as a 5 gallon can of paint, a jug of water, or a stack of heavy books to apply pressure (cover the glued parts with plastic 'baggies' to avoid bonding your parts to your clamp or weights!).

Construction

Construction starts with the movable vertical guide



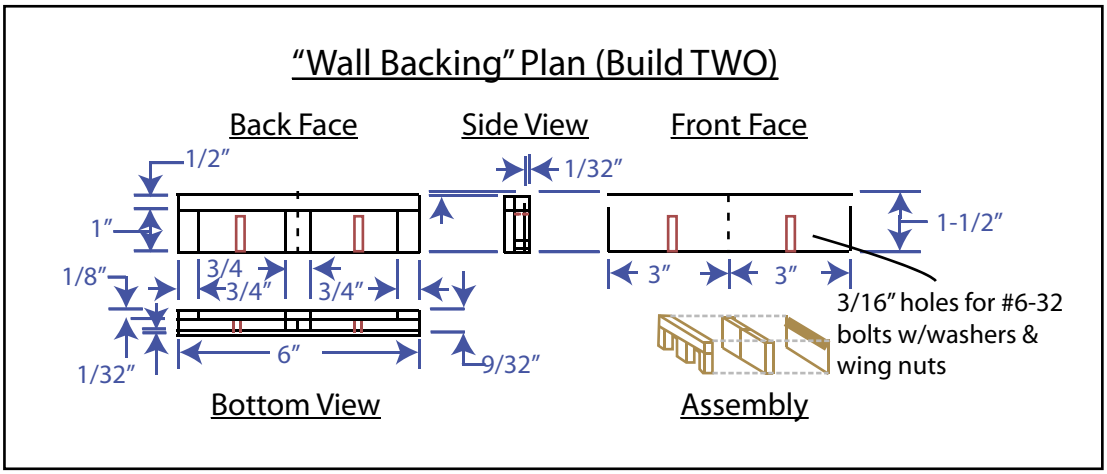


Figure 4: Guide Wall And Wall Backing Construction

Continued from page 7

How To Sand Fin Radial Taper

walls. These are the walls that will move up and down vertically to adjust your sanding slopes. They have the metal strips attached. They are shown in red in Figure 3 and in more detail in Figure 4.

In this case the width of the jig walls was dictated by the length of the aluminum metal strips acquired, which were 6” long (making the walls 6” wide). The walls in turn defined the width of the jig. Also, the walls were made 1.5” high as this allowed for vertical slots long enough to move the walls up and down with a range of 5/8” and still allow plenty of overlap between the walls and the lock frames they rest in.

The length of the parallel pieces of sheet stock that’s glued to the platform were set long enough to allow slots for span widths from 1” minimum to 5” maximum. The rest of the dimensions followed naturally from these sizes.

Steps To Building Your Jig:

Step 1: Construct your 2 vertical walls first (refer to “Vertical Wall” Diagram in Figure 4).

The width of the walls needs to match the width of the metal strips being used (in this example, 6” long x 1/2” Wide x 1/16” thick aluminum strips were used, but you can use any sufficiently stiff metal such as thin steel or copper strips depending what you find available).

IMPORTANT: When cutting the wall pieces from your basswood sheet, make sure the grain of the wood runs vertical, NOT horizontal! That is, the metal strips should end up glued “cross grain” (perpendicular to the wood grain) for greater strength.

TIP: When cutting out pieces, cut them slightly larger than the final dimensions to allow for sanding the edges even. Test fit connecting pieces to be sure they mate well. Sand parts to precisely matching sizes where appropriate.

If you want more detail on how to sand parts even to make them identical, go to www.ApogeeRockets.com/getting_started.asp and see the 2nd video (part 2). The technique shown here is for rocket fins but you can use the same technique to get exact matching parts for your jig.

Where pieces join at right angles, use a metal square (or the square end of your metal ruler) to ensure said pieces are truly perpendicular.

In this example, the basswood stock sheet acquired was only 4” wide (cut cross grain), not 6” so the walls were made by cutting TWO pieces, each 3” wide (by 1-1/2” tall) and gluing them together to make a single 6” strip. The piece was then reinforced with additional strips on the back as shown. After the glue dried the metal strip was added to the front along the top edge (fastened with Gorilla glue).

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Photo 4: Sliding vertical wall (front & back)

Finally, to bring the front wall face even with the metal strip, a 1/16" thick piece of basswood was glued to the wall front face and sanded flush with the metal strip.

Note that if you accidentally cut your wall(s) too wide, you can simply sand it down. If you make a mistake and it ends up too narrow, you can build up the width by applying "FIX-IT Epoxy Clay" (www.ApogeeRockets.com/epoxy-clay.asp) along the edges and sanding when dry.

KEY TIP: Since 1/8" basswood sheet is more difficult to cut precisely than the 1/32" basswood sheet, we can cheat a bit! The only wall piece that must be cut perfectly "squared" and to precise dimensions is the 1/32" face sheet. The 1/8" basswood can be considered reinforcement and need only be close but not exact in measurement.

Finally, drill a pair of 3/16" holes as shown (in red in the diagram below) to accommodate #6-32 bolts with washers and wing nuts. Bolt holes should be placed to 'match up' with the vertical slots in the "wall backings" (shown below) to allow the walls to be adjusted to various heights.

TIP: To "size" the bolt holes simply place a washer down on the wood and trace the inside diameter.

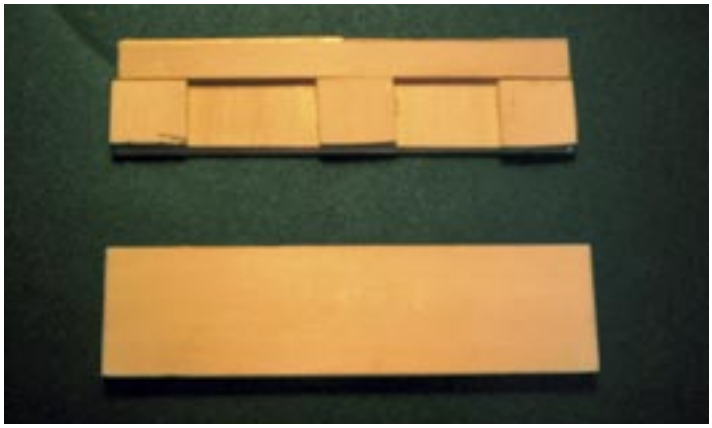

Photo 5: Wall backing (refer to "lock frames" in step 2. Shown front & back sides).

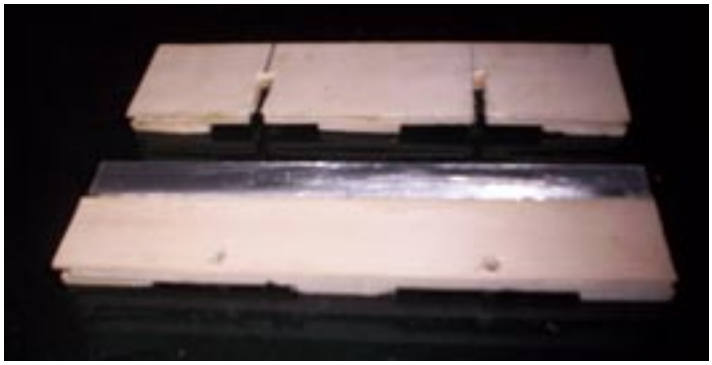

Photo 6 - Vertical Guide Wall (bottom) & Wall backing (top) with bolt holes & slots made.

Step 2: Construct your 2 "lock frames" next.

These are the frames (shown in purple in figure 3 above) that your vertical walls rest in and slide up and down in. These frames in turn slide back and forth within the jig frame to accommodate different length fin spans.

Each of the 2 lock frames are made of 3 main pieces each:

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- The "wall backing" (refer to "Wall Backing" in Figure 4 on page 7).
- Two 1-1/2" x 2" side sheets per wall backing (4 total).

For the wall backings, make them the same as your vertical walls sans the metal strips as shown in the diagram above.

Construct 2 wall backings (one for each lock frame) and sand the edges so their dimensions match the vertical guide wall in width and height exactly. Again in this example, the bass wood was only 4" wide so two 3 inch pieces were glued together and reinforced just like the guide walls. The added thickness, which adds strength doesn't hurt, as it's both stronger and easier to square up when attaching the side sheets. Cut out your side sheets and make bolt holes as shown in figure 5 below.

Before joining the "wall backings" to the "side sheets",

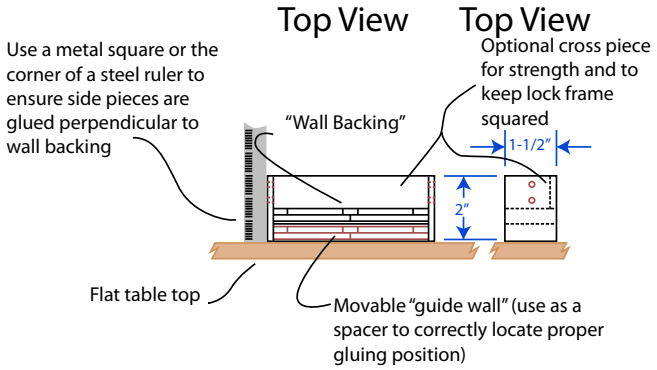

Figure 5: Lock Frame Construction

Photo 7: Marking glue line for lock frame

you need to make bolt holes in the side sheets (shown in red in Figure 5) to allow for horizontal movement of the lock frames within the jig frame.

Stack each wall backing on top of its corresponding guide wall so they are exactly lined up (you are using the guide wall as a 'spacer' so you can locate the proper gluing position of the wall backing to the lock frame side sheets). Mark pencil lines on the inside surfaces of the side sheets. These lines show you precisely where to glue the side sheets in place. After gluing, clamp the structure between two vertical surfaces (book ends or similar work great!) to keep everything properly "squared".

Optionally you can add a cross piece (as shown) for

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Photo 8: Use square end of metal ruler to ensure the joint is "squared"

greater strength and to ensure your side sheets are truly perpendicular to your wall backing piece.

Step 3: Construct your "jig frame" (with central platform base) next. Your "base" is what the fin will rest on.

You need to make several base "support" pieces. From your 1/8" basswood sheet stock, cut 2 pieces 1-3/8" wide by 6-1/4" long (vertical platform support pieces), and cut one 1" wide by 6-1/4" long (horizontal platform piece) and glue together as shown in Photos 9 and 10. Repeat 2x to make 3 total (more if you need). The duplicates can be made of bass OR balsa sheet stock depending what you have.

Photo 9: Central Platform Bases.

Sand so the height is the same as the lock frame height, and the width is the same as your lock frame width.

Photo 10 - Underside Central Platform Bases.

All of your support bases must be of *exactly* 1-1/2" in height to match the height of your vertical guide walls. However, of the three only ONE must be *exactly* 6-1/4" long. This is the piece to which you will glue your two parallel pieces of sheet stock. These two parallel pieces of sheet stock are what your "lock frames" (that you made previously in step 2) will slide back and forth in.

To make your parallel pieces of "jig frame" sheet stock, cut two strips 1.5" wide by 20" long (and sand even with the lock frame heights). Glue each end of your "central platform support piece" to the center of the parallel pieces of sheet stock and let dry. Fillet the glue joints for strength and again let dry (refer to beige color in Figure 3 on page 3).

TIP: Before gluing, do a mock up of the pieces with your lock frames in place to be sure everything is properly "squared up", parallel and of proper width.

Once glued, you now need to make slots in the sheet stock so your lock frames can slide along the jig frame. The

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easiest way of getting the slots positions on the parallel sheet stock to match the corresponding bolt positions on the lock frames is as follows...

1) Place your jig frame on a smooth, slippery, flat surface such as a polished tabletop (alternately, a glass surface is ideal).

2) Place your lock frames in their positions within the frame and against the center base piece.

3) Use a pencil through the bolt holes in the lock frame sides to trace circles on the inside surface of each of your parallel pieces of sheet stock (essentially marking the bolt height positions). The forward most bolt position marks the start of your "slot". Slide your lock frame(s) to several new positions and re-mark the bolt positions.

4) Use your metal ruler to mark horizontal lines across the tops and bottoms of your bolt marks (essentially marking the width of your slots). As a "check", drill out the 1st 2 bolt holes you marked and check that they match up with the holes in the lock frame (by actually putting bolts through and being sure they go through straight). If they don't quite fit, you may have to slightly file the holes a bit wider. Once happy with the fit, use the lines you marked as a guide to cut your slots.

5) After your slots are cut, run your bolts through (with washers on the inside and wing nuts on the outside), and test the fit by sliding the lock frames the full length of your slots (trim or sand where needed) to allow for a clear fit along the full length (your slots will likely end up a bit wider than needed but this is ok as the wing nuts are wide enough to be pretty forgiving and still grip the wood when tightened).

TIP: Since the bolt holes in your lock frame side pieces

Photo 11: Assembled jig showing wall bolts and wing nuts.

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may end up at slightly different heights, mark matching letters or symbols on each lock frame side wall and its matching jig frame wall/slot for easy future assembly. (I simply used “X”, “Y”, “Z”, & “R”.) Do a similar marking for each vertical guide wall and each lock frame too!

Using Your Fin Tapering Jig

1) Cut out the fins from the sheet stock and *stack sand* the fin edges to square them up and make them exactly same size. If you want more detail on how to do this, go to www.ApogeeRockets.com/getting_started.asp and see part 2 of the video series.

2) Cut out a rectangular piece of balsa at least as long as fin cord (preferably longer) and with exactly FOUR TIMES the width as the fin’s span. Sand the edges to match 4x the span exactly. (This piece is placed on top of your base support piece(s) in your jig and acts as a base support “floor” or “base plate”. For larger spans, add more support pieces as needed).

3) With your vertical guide walls raised higher than needed (don’t worry about precise heights right now), set your lock frame positions so they abut firmly against your “base plate”.

4) Cut out a rectangular piece of 1/16” thick basswood at least as long as the fin cord (preferably longer) and exactly the width as the fin’s span (sand edges to match the fin span exactly). Place on the base plate, under the fin. The fin root edge abuts against one of the vertical guide walls.

5) Cut out a second rectangular piece with the same dimensions as the basswood piece in step 5, but use 1/8” balsa this time (i.e. Cut to one span width. Place this so it abuts the fin tip/ 1/16” basswood piece.

6) Finally, cut out a rectangular piece of 1/16” thick basswood at least as long as the fin cord (preferably lon-

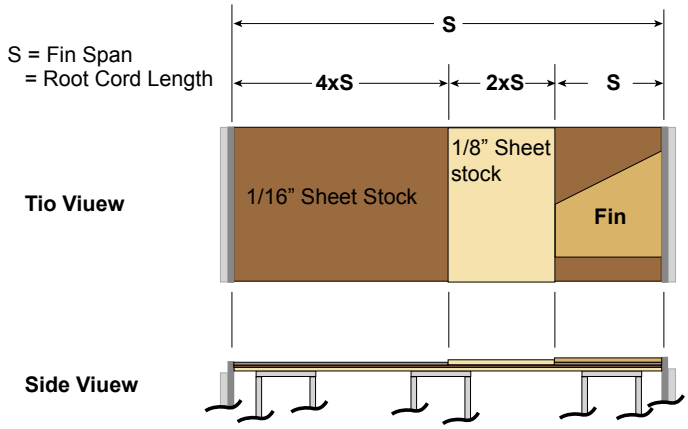

Fig. 6 Setting Up Your 4X’s Fin Span Layout

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ger) and exactly 2x the width of the fin's span (sand edges to match 2x the fins' span exactly). Place so it abuts up to the 1/8" thick piece made in step 5 and also abuts the second vertical guide wall.

7) Set your wall heights. Raise each wall height to be flush with the thickness of the piece(s) abutting it. DOUBLE CHECK your settings and ensure all your wing nuts are firmly locked in place!

SIDE NOTE - Why This Works: By setting the height of each wall flush with the respective balsa surfaces, you create a height difference of 1/8" over 4x the fin span length. That creates a sanding angle (taper angle) equal to 1/32" over ONE fin span (by similar triangles) but the wall height settings are much easier to set now!

It doesn't even matter if the 1/16" thickness sheet isn't exact as setting the fin tip guide wall flush with this height cancels it out no matter what the thickness. It's simply there to give the fin tip wall some height so it can abut the 1/8" 3x fin span piece, which in turn abuts the fin tip.

8) Finally, with a flat sanding block or sanding tee, sand the fin parallel to the balsa grain (i.e. parallel to the fin's leading edge) making sure that the flat sanding surface extends past both metal strips on the vertical walls at all times. Sand until the fin sanding tee or block is flush on the metal strips on both walls across the whole cord of the fin. Do all 3 fins on one side without moving any of the adjustments on the jig to ensure all fins come out precisely identical.

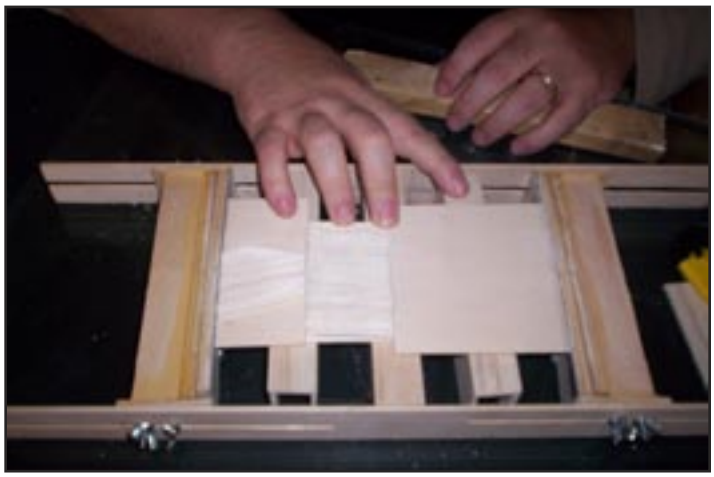

Photo 12: Layout showing fin (left) on 1/16" spacer sheet, 1/8" spacer sheet (middle), and 1/16" spacer sheet (right).

Making a shim:

BEFORE flipping the fins over to sand the second side, you need to (as previously mentioned) make a shim! As

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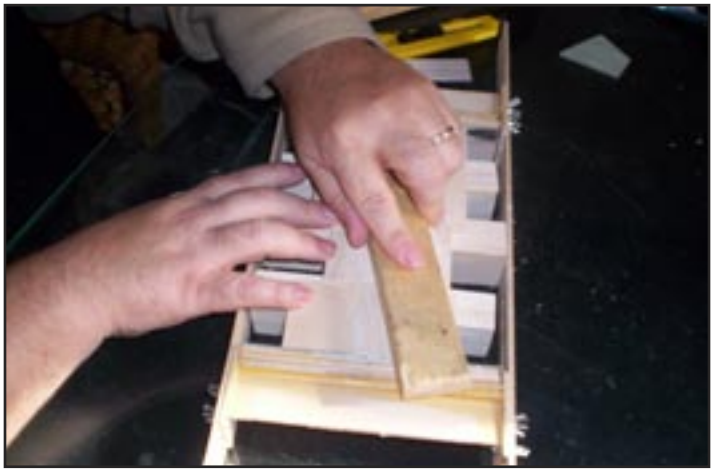

Photo 13: Using Sanding Jig (homemade "flat sanding block" is made by gluing sand paper to bottom side of any flat piece of wood.

said earlier, do this by simply rotating the last sanded fin 180 degrees so the tip now abuts against the higher height root wall. Insert a thin strip of balsa, which is about 1/8" wide and about as long as the fin tip cord.

Protect the fin with a piece of masking tape and sand the balsa shim to the same height as the wall using your sanding block or sanding tee (use the steel tipped wall as your guide). So now the fin tip thickness plus the balsa shim thickness precisely matches the height of the root edge wall, which by definition equals the original thickness of the fin before you sanded in the taper!

Photo 14: Fin Radial Taper (from full thickness to half thickness)

TIP: You can do your initial thinning of the shim piece by rubbing it between 2 flat sanding blocks.

NOW flip your fin (and shim) over so the shim is now on the bottom and the shim/fin tip is at the fin tip wall. Repeat the sanding procedure on the 2nd side of all your fins per the steps above (using the shim each time).

And there you have it! Perfectly tapered, perfectly symmetrical, exactly identical fins!

You can also use your jig to apply precise airfoils to your tapered fins!

Hopefully, in a future newsletter issue we'll go into how to do this in detail, but basically what you do is rotate your fin (with shim to keep it level) so you are sanding a taper front to back (leading edge to trailing edge) rather than from root to tip. Then reverse the fin to do the leading edge taper.

BUT it gets a bit more involved as you are no longer tapering the entire length of the fin. You must adjust your wall heights accordingly and with any luck, this is what a future newsletter will go into!

Meanwhile there is a great and simple semi-freehand method outlined in *Model Rocket Design & Construction* (http://www.apogeerockets.com/design_book.asp), which will give you great high-quality airfoils also!

Have fun and remember, "practice makes perfect!"

About the Author:

Bart Hennin graduated in 1984 with a BaSc in Mechanical Engineering from the University of Windsor, Ontario. His senior year thesis was "Optimization Of A Model Rocket For Highest Altitude" which earned a top of the class mark of A+. Following graduation, Bart worked for several years in auto manufacturing engineering, then migrated to technical sales, and eventually ended up in general sales and marketing.

Bart is currently married and is living in New York state. Bart says that his family consists of one obnoxious cat named Thor.