Bending Wood the Wright Way

Cold bending is a whole lot easier with this flexible clamping fixture.

In my mind, there are three classifications of woodworking techniques. There are many that I classify as "useful," a smaller number that I think of as "indispensable," and then a very few that represent a true breakthrough in woodworking technology. Bending wood is one of the latter.

The ability to alter the grain direction as our imagination dictates while preserving the strength inherent in a straight piece of wood allows us to create the elegant beauty of a continuous-arm Windsor chair and the inspiring sweep of a vaulted ceiling. We first explored our world in sailing ships with bent wood hulls, then left it in airplanes with bent wood wings. Our world would be much less beautiful and much less exciting without this simple woodworking technique.

I'm currently engaged in a woodworking project designed to create a little excitement, and bending wood is at the very heart of it. I'm part of a group of historians and aviators who are recreating the six experimental airplanes of the Wright brothers, beginning with their model glider of 1899 and ending with the 1905 Wright Flyer 3, the first practical airplane. The frames of these primitive aircraft are a collection of bent wood parts — ribs, wing ends, braces and skids — ingeniously arranged to catch the wind and lift a man into the air.

Photos by Chris Schwarz

True Geniuses Prefer Cold Bending

When most of us hear the words "bending wood," we think of steam bending. The wood is heated briefly in low-pressure steam to soften the lignin (a glue-like protein that holds the cellulose fibers together). While the wood is still hot, it's clamped into a bending form. The cellulose fibers telescope to conform to the curve, and the lignin cools to hold them in place. Or almost. In actual practice, the fibers never quite conform, and when you remove the wood from the bending form, there is a great deal of springback — the wood loses some of its curve. If the wood is not attached to the other parts in the project so as to hold the curve, it may continue to relax and it will spring back even more. This problem plagued the Wright brothers while they were doing their glider experiments — they calculated precise curves for the ribs to fly as efficiently as possible, only to have the ribs relax and lose a good deal of curvature before they could get their gliders in the air.

To solve this problem, they eventually abandoned steam bending for an early form of cold bending. They arranged the parts of the ribs for their Flyers in a bending form, then nailed them together with brads. They could not use glue — the adhesives 100 years ago were not weatherproof. A good rain and the wings would have come apart.

Fortunately, we have a much larger and more reliable selection of adhesives to choose from than the Wrights. We decided to make the bent wood ribs of our replica Wright gliders by laminating the parts with a water-resistant aliphatic resin (yellow) glue. You could also use Resorcinol, epoxy or polyurethane glue for an application like ours. If your project won't be exposed to the weather, you can use almost any good wood glue.

To cold-bend wood, first resaw your

stock into thin strips and plane it so the thickness is even. The thickness of the strips depends to a large extent on the radius of the curve. The tighter the radius, the thinner the strips. I use this chart as a jumping-off point:

- 2" to 4" radius — 3/32" thick
- 4" to 8" radius — 1/8" thick
- 8" to 12" radius — 3/16" thick
- 12" radius or larger — 1/4" thick

There are other factors to consider: the species of wood, the slope of the grain (as it runs between the faces of the strips), the strength you want, and the amount of springback you can tolerate. For maximum strength and minimum springback, we decided to glue up the ribs from 1/8"-thick strips, although the radius of the curve was nowhere near 8".

Stack the strips as you will glue them together. If you use strips that were all resawn from the same board, flip every other strip end for end to reverse the grain slope. Spread a thin layer of glue on the face of one strip, lay the next strip on top of it, spread more glue and repeat. If you're laminating a large number of strips, you may want to choose an adhesive with an extended working time.

Before the glue sets, clamp the laminated strip in the bending form. Let the glue set up for its full clamp time. If you're not sure of the clamp time, wait a full day before you remove the assembly from the bending form. As you release the clamps, there will be a small amount of springback. If the curve is critical (as it was for our glider ribs) make the curves in the bending form slightly tighter to compensate.

Making a Cold Bending Form

Pretty simple, huh? The only real trick to cold bending is in making a form that will apply an even clamping pressure all along the laminated assembly. Traditional bending forms consist of two parts, the form (the positive shape) and the press (the negative shape). Both of these parts are normally cut from the same stock. Begin by drawing the curve you want on the face of the stock. Cut the curve with a band saw, separating the stock into two parts. On the negative part, mark the thickness of the bent wood part. (Tip: Use a compass like a calipers, set it to the desired thickness. Follow the curve with the point of the compass, marking the thickness with the scribe.) Cut away the thickness on the band saw — this will create the press.

The trouble with this traditional bending form is that the press doesn't compensate for small variations in the thickness of the laminated stock or a band saw blade

Help Kids Build a Wright Flyer

The most exciting woodworking project in 100 years.

The year 2003 will mark the 100th anniversary of the first controlled, sustained flight. On Dec. 17, 1903, Wilbur and Orville Wright flew their first powered aircraft, called simply the Flyer, 852 feet across the sands of Kitty Hawk, North Carolina. This coming anniversary presents a unique opportunity to get young people all across America excited about aviation — and woodworking!

A replica of the Wright Brothers' 1900 Glider that Nick Engler built and got airborne at Kitty Hawk, N.C., in late October.

The Wright brothers built the gliders and airplanes in their workshop in Dayton, Ohio. These machines were largely made of wood: spruce for the straight parts, ash for the bent parts and a little boxwood for the pulleys. The end result of these labors was that the Wrights, by virtue of their ingenuity and craftsmanship, achieved the age-old dream of flight. The story of their woodworking projects has become one of the most inspiring stories in American history.

That said, it is becoming harder and harder for young people to acquire the woodworking skills that gave us the airplane and a thousand other useful and beautiful innovations. High school shop programs are becoming a thing of the past. Vocational schools train students for industry, which relies more and more on computer-aided manufacturing. The old manual machine setups — what we use every time we make a cut or drill a hole — are no longer being taught on a wide scale, and our craft will suffer if we don't find other ways to introduce young people to the joys of woodworking.

***Popular Woodworking* has lent its support to a unique program of the Wright Brothers Aeroplane Company (WBAC) of Dayton, Ohio, that addresses these concerns directly. The WBAC is a non-profit educational organization of craftsmen, historians and aviators who are building replicas of Wright aircraft, including the 1903 Wright Flyer. They will build the Flyer with the involvement of young people across America!**

Here's how it works: The WBAC has scripted a learning experience for kids ages 10 to 18 during which they learn a little aviation, a little history and a little woodworking. During this experience, which takes just a few hours of a morning or an afternoon, the kids build 1/4-scale ribs of the Flyer that they can take home. Then the whole class comes together to build a full-scale rib. The kids sign it and send it to the WBAC in Dayton, Ohio. There, more kids under the supervision of accomplished craftsmen, will assemble the ribs in a replica Flyer, that's 40 feet from wingtip to wingtip.

And that's not all. Each of the kids who works on a rib gets to sign it. The WBAC also invites each young person to make a prediction about what the next 100 years of aviation will bring. All the signatures will be preserved on the replica Flyer, and the predictions will be edited and assembled into a large book. The completed kid-built Flyer and the book will be unveiled at the Dayton International Airport on December 17, 2002 (a year before the centennial anniversary), where it will serve as a milepost in both aviation and craftsmanship, pointing 100 years back and looking 100 years forward.

We're looking for woodworkers to serve as teachers and mentors to help conduct these learning experiences and to communicate the thrill of building something wonderful to children. The WBAC will send you information on these experiences if you'll just raise your hand and say "I'll do it." You can contact them through the Internet a www.wright-brothers.org, or write Wright Brothers Aeroplane Company, Kids Build a Flyer!, P.O. Box 204, West Milton, OH 45383.

Meanwhile, we'll continue to report on this exciting woodworking project as it progresses. PW

Spread the glue on the surface of each strip with a 3/8"-32 threaded rod to draw the adhesive out as evenly as possible. Note that I've placed the strip on a long scrap to elevate it above the bench. This allows the extra glue to drip over the edge.

Clamp the laminated strips in the bending form, spacing the clamps every 3" — dead center in the middle of each segment of the press. I drilled 1 1/4"-diameter holes in the form to hold the top face of the clamps and automatically space them.

Before you tighten the clamps, just snug them up to hold the stock against the form. With a scrap of wood and a hammer, tap the top edges of the strips to even them up. Then tighten the clamps until the gaps disappear between the laminations.

that wanders a hair off the line. Consequently when you apply the clamps, the clamping pressure may not be completely even all along the form. This may result in weak laminations or even gaps between the laminations when the glue dries.

To ensure that this didn't happen to our glider ribs, I designed a compensating press. After cutting away the thickness of the bent wood part, use the compass to mark yet another curve on the negative part, this one 1" larger in radius than the curve you just cut. Saw this curve then cut the 1"-thick piece into 3"-long segments. Adhere the segments back to the negative part temporarily with double-face carpet tape. Glue a strip of canvas to the inside curve of the segments and cover the canvas with 6-mil plastic.

When you separate the segments from the negative part and discard the tape, they should be held together by the canvas like the tambours of a rolltop desk. This is your press. When you squeeze the laminated stock to the form, arrange the clamps in the middle of each segment; this will compensate for any variation in stock thickness or inaccuracies in the bending form and keep the clamping pressure relatively even.

Note: The plastic on the press will keep any glue that squeezes out from between the laminations from sticking to the canvas. To prevent the squeeze-out from sticking to the form, apply paste wax to the form before each glue-up.

Spreading the Glue

Just as uneven clamping pressure will reduce the strength of the lamination, so will an uneven application of glue. You must spread it as evenly as possible, and I've got just the ticket. This little trick was shown to me by the good folks at Franklin International (makers of Titebond glue). Get rid of your glue brushes and spread the glue with the teeth of a 3/8" x 32 threaded rod. The threads spread the glue to just the right thickness (about 0.005") for a strong joint with a minimum of squeeze-out. For this particular project, I mounted a short length of threaded rod in a wooden handle. Between glue-ups, I keep the rod submersed in water to prevent the glue from drying on the threads. **PW**

Nick Engler is a craftsman, pilot and the author of 52 books on woodworking. He's also the director of the Wright Brothers Aeroplane Co. — you can find out more about the Wright aircraft he's helping to build at www.wright-brothers.org.