Lamination Bending

Produce strong, tightly bent parts with minimal springback

BY LON SCHLEINING

Classic curve. *The graceful aprons on this maple table were curved using lamination-bending techniques.*

When it comes to making curved furniture parts, woodworkers have several options: They can cut or shape the curve from a single, thick piece of wood, or they can steam the part to make it pliable enough for bending. Some woodworkers cut a series of thin sawkerfs into the back of a piece of wood to make it bendable. And finally, there is lamination bending.

For many applications, I find that lamination bending—in which thin plies of wood are glued up on a curved form—is often the best method. It uses material efficiently and produces tight curves with little springback.

Lamination bending is very economical

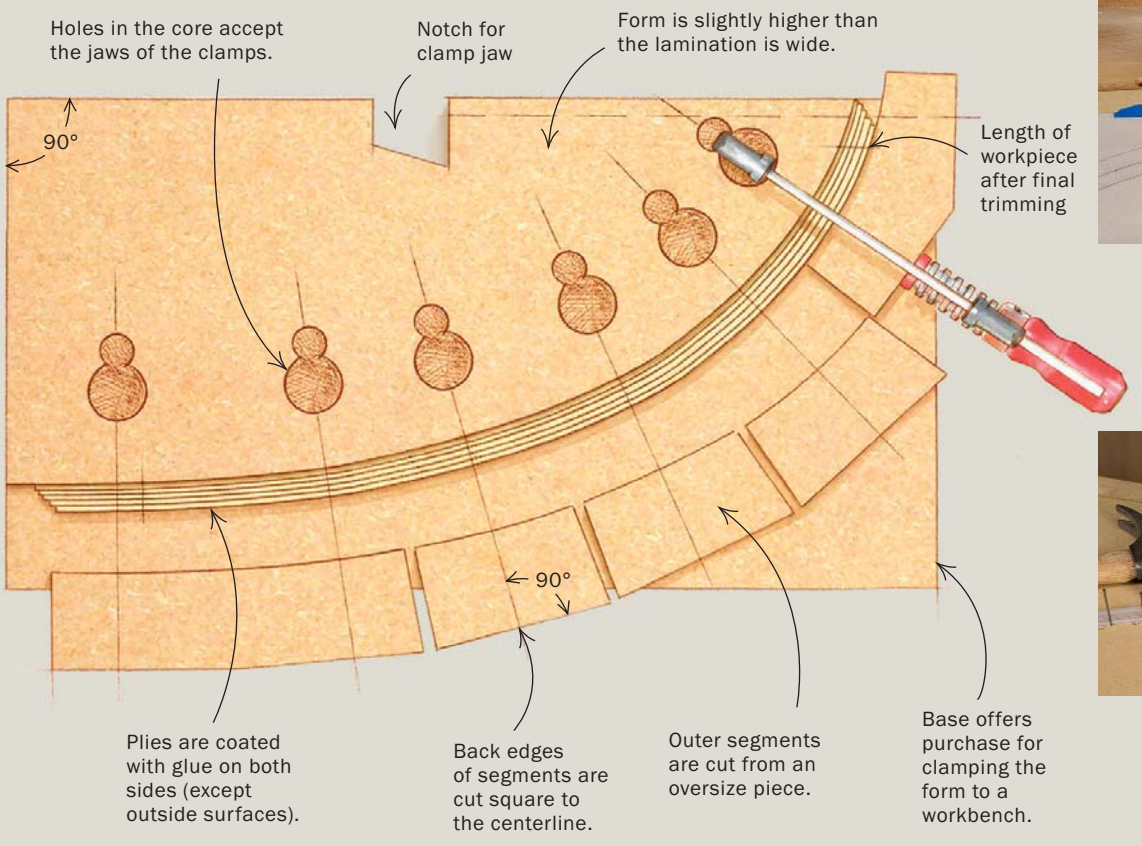
The procedure is simple. Glue is applied to all of the plies, then they are stacked and clamped around a curved form. The piece ends up with the same curve as the form.

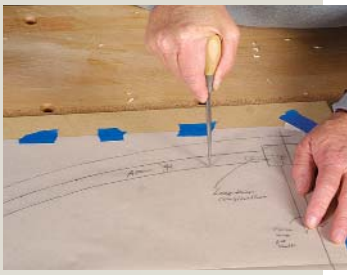
This technique is a good way to bend woods that feature interesting grain patterns, like curly or bird's-eye figure. You pay a premium for such wood, so cutting the curved piece from a single

Photos, except where noted: Tom Begnal

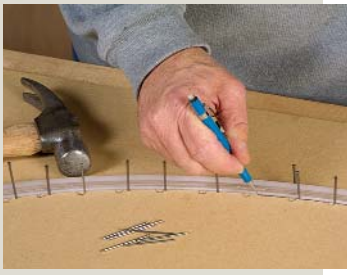
A FORM PRODUCES IDENTICAL CURVED PARTS

Mimicking the shape of the curve, the bending form consists of a core made from several layers of MDF, plus several outer segments that work like big clamp pads.





Start with a drawing. *With the full-size curve on paper, use an awl to transfer the curve to the first layer of the form.*



Connect the dots. *A series of nails holds a flexible ruler in place along the awl marks as Schleining scribes the curves.*

thick board can get rather expensive. And that fancy grain doesn't hold up well to the stresses of steam-bending. But by gluing up a stack of plies to make a curved piece, you need only use the figured wood for the show side of the workpiece. The inner plies can be any straight-grain wood. You end up with a strong part that looks like a solid piece of expensive wood.

A form supports the bend

To control the shape of a bend until the glue dries, you'll need a bending form. A typical form consists of a solid core with several outer segments. The core, often called the male form, matches the inside shape of the bend, while the outer segments, the female forms, match the outside shape of the bend. Particleboard, plywood and medium-density fiberboard (MDF) all are acceptable materials for making a form.

When clamped to the plies placed on the core, the outer segments serve as clamp pads, distributing the pressure evenly along the full length of the workpiece. With this method, all of the laminations end up squeezed tightly together, ensuring a good glue bond.

The height of the form should equal the width of the laminations, plus a bit extra. Generally, that means you'll need to face-glue several pieces of MDF.

But before making the form, two curves must be drawn full size on paper: One line represents the inside curve of the lamination; a second line parallel to the first represents the outside curve.

Once the curves have been drawn, tape the paper to a single piece of MDF that's a few inches wider and longer than the curve. Transfer the inside curve to the MDF using an awl. Punch a hole through the line on the paper and into the MDF every inch or so along the full length of both the inside and outside curves. Remove the paper and connect all of the holes to create a smooth curve.

A piece of thin plastic or wood batten comes in handy here as a flexible ruler. To make the process easier, use a few small nails to position the ruler exactly on the curve. Once everything looks okay, use a pencil to scribe a line along the full length of the curve. Then repeat the process for the outside curve.

Next, use the bandsaw to cut just slightly on the waste side of the two lines. You end up with three pieces: one for the core of the form, one for the segments and a waste piece from the middle.

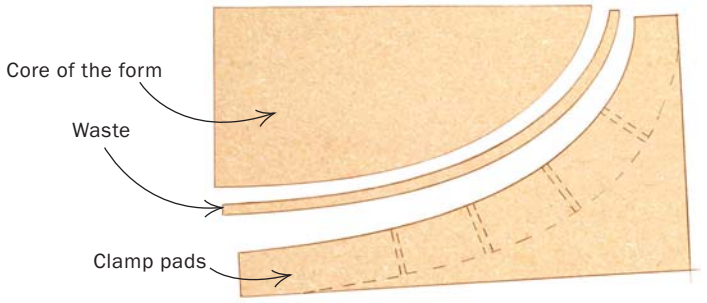
Now sand the curved edge of the core exactly to the line (I use a belt sander on edge). The inside curves on the segment piece are shaped to the line with a half-round file and then smoothed with sandpaper.

Use the first layer as a template to scribe the two curves on all of the remaining layers, then cut them out a bit on the waste side, just as you did on the first one. Now you're ready to trim the edge flush using a router and a flush-trimming bit. For applications like this, I like a bit with a shank-mounted bearing because it's easier to see

Drawings: Melanie Powell

THE FORM TAKES SHAPE

After cutting on the bandsaw, three parts are left. The large section is the core of the form, and the bottom piece is used for clamp pads. The middle section is discarded.



Smooth the curve. *With a belt sander on its side and secured in place, Schleining smooths the curve of the core of the form.*

Trim subsequent layers of the form flush to the first. *With the first layer of the core serving as a template, use a router and flush-trimming bit to bring the additional layers flush to the first.*

that the bearing is staying in contact with the template. Also, it vibrates less than a typical end-mounted flush-trimming bit.

Fasten the template to the first layer with a couple of screws. Then trim it flush using a router. Repeat the process for each layer, using the original template to guide the router.

Once all of the layers of the form have been cut out, glue and screw the pieces together, taking care to make sure the edges remain perfectly flush. When completed, you'll have two parts: the core and the segment piece.

Now use the bandsaw to cut the segment piece into several parts. On each segmented part, the edge opposite the curve is cut square to the centerline for better clamp alignment. Cut out about ¼ in. between each of the segments to provide adequate clearance.

Next, drill holes for the clamps in the core. Then add a base piece to the core, which will make it easier to clamp the form to a workbench. To complete work on the core, use wide cellophane tape to cover all of the surfaces that might see glue squeeze-out. Without the cellophane, the lamination would likely end up glued to the form.

For tight bends, use thinner plies

With the form completed, you need to determine the thickness of each ply. A general rule of thumb applies here: As the desired bend gets tighter, the plies must get thinner. When the plies are the correct thickness, springback becomes inconsequential, and failure due to splits or cracks is rare.

Fortunately, there's a foolproof test that can provide the correct ply thickness in short order. First, though, you need to cut a piece of stock to the same length and width as the lamination. Any thickness will do. Then plane one face flat.

As a starting point for determining the thickness, I usually set the bandsaw to make a resawing cut just slightly more than ⅛ in. thick. Then, with the planed face against the bandsaw fence, I cut a test piece.

The bandsaw leaves one side of the test piece with a rough surface. The test piece is too thin and flexible to run through the thickness planer without additional support. So I use double-sided tape to secure it temporarily, smooth side down, to a piece of melamine. Then, with the test piece attached and the planer set to make the lightest of cuts, run the melamine through the thickness planer to smooth the remaining side of the test piece to about ⅛ in. thick.

Next, place the test piece against the face of the core and try to bend the piece around the form using only a few fingers to apply moderate pressure. If the test piece bends, it is thin enough. However, if the test piece is hard to bend and feels like it might crack, it's too thick. In that case, remount it to the melamine and plane a little more off the thickness. Continue testing and planing until the test piece makes the bend.

At this point you'll need to determine how many plies you need to make the lamination. The process requires only a dial caliper and a little math. First measure the thickness of the test piece in decimals. Then divide the desired thickness of the lamination by the thickness of the test piece. For those like me who are numerically challenged, here's a numberless technique that also

THE PLIES TAKE SHAPE

HOW THICK? HOW MANY?

First, determine the proper thickness of the individual plies by bending a test piece around the core of the form. Plane the test piece until it can bend easily to the shape of the curve with only light finger pressure.

Second, determine how many plies you need. Measure the thickness of the test piece in decimals with a dial caliper. Then divide the desired thickness of the lamination (in decimals) by the thickness of the test piece. For example, a ¾-in.-thick lamination (0.750 in. in decimals) using a test piece 0.075 in. thick, divide 0.750 in. by 0.075 in. to get 10. The result: 10 plies to make a ¾-in.-thick lamination.

works. Simply bundle sample pieces together until you get the desired lamination thickness.

Milling the plies—Once the ply thickness is known, you can go ahead and cut all of the plies. First, rip stock to a little wider than the workpiece to allow for trimming after the part has been bent.

Next, crosscut the stock to length, keeping in mind that it's generally best to cut the plies several inches longer than the finished part. The lamination will be trimmed to final length after bending.

With all of the stock cut to rough length and width, it's ready to be resawn. Set the bandsaw fence to cut the stock just slightly thicker than the thickness of the test piece. Before starting, make sure the stock has both faces planed flat and parallel. Place the face of the stock against the bandsaw fence to cut the first piece. Before cutting the next ply, run the stock through the thickness planer to smooth the bandsawn face. Repeat the process until all of the plies have been resawn, each with one smooth face and one rough face.

To complete work on the plies, mount each one smooth side down to the melamine with double-sided tape. If the plies are narrow enough, two or more can be aligned side by side. Then, taking very light passes, plane each piece to the same thickness as the test piece. A drum sander also may be used to thickness stock.

You need to work quickly during glue-up

It's best to glue all of the plies in one operation. Apply glue to both sides of each one except, of course, for the two outside surfaces. The goal is to coat all of the surfaces completely. A pair of lightweight rubber gloves will help keep glue off your hands.

You'll want to work quickly because the glue has a very limited open time. To help speed up the process, I lay all of the plies on plastic wrap before spreading glue on one side of all of the layers at once. Then, except for the two outside pieces, I turn them over, glued side down on the plastic, and coat the other side. It's tempt-

Resaw thick stock for the plies. *With the ply stock cut to rough width and length, use a bandsaw to resaw each ply to a thickness that's slightly oversize.*

Plane the plies to thickness. *Use double-sided tape to secure several resawn surfaces, face up, to a piece of melamine. After a few light passes through a portable thickness planer, the resawn surface ends up smooth, and the plies are reduced to the correct thickness.*

Photo, this page (bottom left): Rodney Diaz

GLUE UP THE PLIES

Spread the glue. *Use a notched piece of credit-card size plastic or wood.*

Stack the plies. *With the glue applied, the plies are stacked with all of the edges flush.*

Add the first clamp. *After placing the stack of plies in the form, install the first clamp while making sure all edges of the plies stay reasonably flush.*

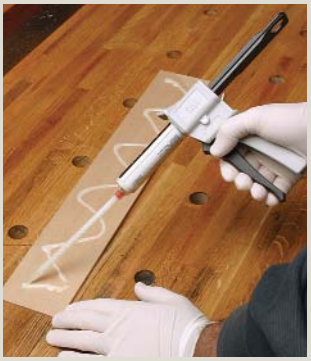
ing to glue the layers just a few at a time, but I always glue the entire oozing bundle at one time no matter how many pieces.

Once the surfaces have been coated with glue, the plies are placed one on top of the other to form a single stack. Make sure the two uncoated surfaces are facing the outside of the stack. Also, you want all of the edges of the stack to be reasonably flush.

Clamp the plies in the form—Now comes the part that's most exciting—bending the plies. First, though, place the stacked plies, on edge, on the core of the form. Then start adding the clamps and the segments.

You have a couple of options when determining the clamping sequence. You can apply the first clamp at the lengthwise midpoint of the lamination and then add clamps as you work toward each end. Or you can start at one end and work toward the opposite end (as shown above). The point is to avoid adding a clamp between two clamps already tightened. Doing so might encourage a bump in the curve.

Either way, get the first clamp secured. And as you do, keep the edges of the plies reasonably well aligned. Then add the remaining clamps in sequence. As I work my

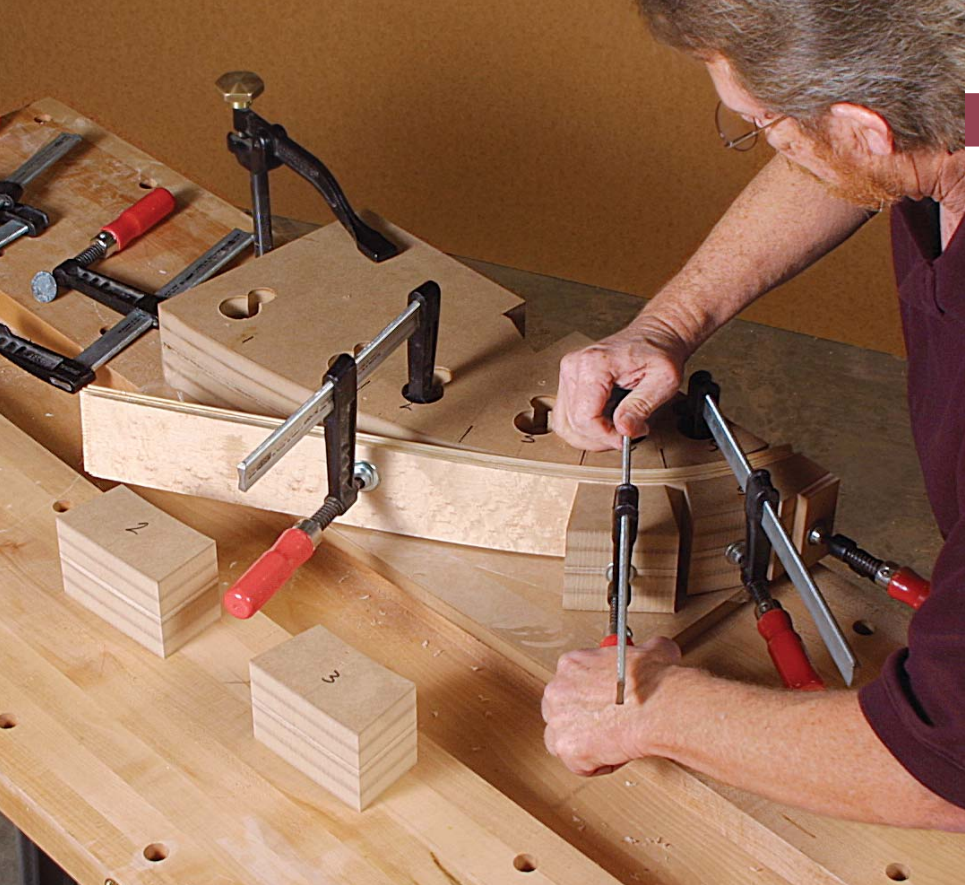


Easy applicator. *Teaming up a gun, glue cartridge and mixing nozzle, R.S. Hughes offers an easier way to apply epoxy.*

The right glue is everything

When lamination bending, I don't use either white or yellow woodworking glues because both of these glues remain slightly flexible, even when fully cured. That means, in time, they can allow the plies to slip a bit. Manufacturers call this "creep." The solution is to use glues that cure rock hard, so creep isn't a problem. Plastic resin glue is my first choice—although it takes longer to cure, it's less expensive than other creep-free glues. Vacuum Pressing Systems (800-382-4109) sells a two-part urea resin designed specifically for lamination bending. When pressed for time, I use an epoxy from West Systems (989-684-7286) that dries relatively quickly. And when convenience is a must, I use an epoxy system (left) from R.S. Hughes (877-774-8443) that includes an application gun and a long nozzle that mixes the glue as it travels to the tip.

Photos, this page (bottom left and right): Rodney Diaz



Once the first clamp is on, add the remaining clamps in sequence. *Schleining always leads with a loosely tightened temporary clamp to get the bend started.*

Tighten the clamps. *After adding the final clamp, give them all a final check for tightness.*

way along, adding and tightening clamps, I often keep an extra clamp on the plies. This loosely applied clamp, which is about a foot or so from the clamp being tightened, helps encourage the lamination to conform to the bend.

Once all of the clamps have been added, take a minute to make sure all of them are tight. When you're satisfied everything is snugged up properly, it's just a matter of letting the glue cure.

One last point. Big glue-ups like this always come with a certain amount of anxiety. But you can minimize the anxiety level by doing a dry run of the entire clamping process.

CLEAN UP THE EDGES

Smooth the edges—After the glue has dried, remove the workpiece from the form. Expect a fair amount of glue squeeze-out along the edges. Because the plies tend to shift a little during glue-up, the edges are going to be less than smooth. So the next step is to flatten, smooth and trim both edges to final width.

A handplane or belt sander makes short work of cleaning the glue, but they aren't the best tools for getting the two long edges of the workpiece straight and parallel. I get one surface as straight as possible and then send the workpiece on edge through my portable thickness planer. Depending on how much the workpiece is curved, it might have to be steered through the machine.

Take light cuts with the planer until the edge is clean, then turn over the piece and clean the other edge. Now keep taking cuts until you reach the final width. □

Lon Schleining (www.woodbender.com) is a contributing editor and author of The Complete Manual of Wood Bending *(Linden Publishing, 2002).*

One edge is handplaned. *When removed from the form, the edges of the workpiece are uneven and covered with glue.*

The other edge is smoothed by the thickness planer. *After the first edge has been handplaned reasonably smooth and flat, the opposite edge is planed using a thickness planer.*