

Bent Laminations and Turnings

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Bent Laminations

- Process of creating curved shapes by gluing up thin strips of wood and bending them, typically over a form.

How/why I got started

- It is a better technique to use for several shapes I was turning—Suspended vessels
- Allows for shapes that cannot be turned
- Allowed me to branch into wall art
- Allows for adding highly figured wood with turnings, without the high expense

How learned

- Class from Marc Adams School of woodworking—www.marcadams.com
- Michael Cooper— artist, sculptor, hot rodder—www.michaelcooper.us
- Michael Fortune— furniture maker—www.michaelfortune.com

Why laminations

- Bending solid stock wood is tough—requires special techniques, has limitations
- Steam/heat bending—requires air-dried wood, need special chamber, limited on shapes
- Kerf bending—only works in special cases where can hide kerfs
- Cut shapes out of board stock—wood waste, grain pattern can create weak areas

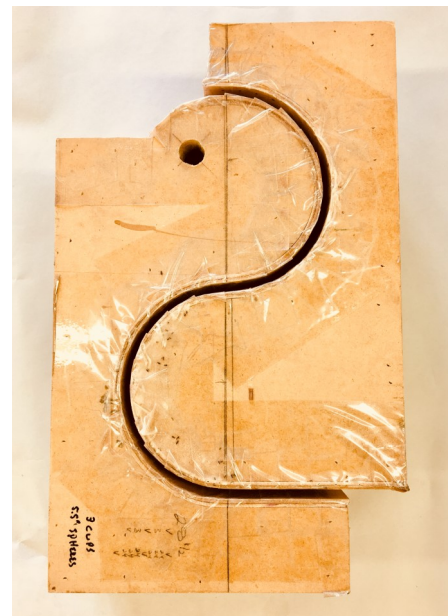
Getting Started

- Sketch ideas—unlike turning, you need a plan
- Enlarge to full size
- Quite often you find that sketches don't scale or things don't fit when you go full scale—sketches are not perfect, but full size drawing has to be as you'll be making a form from it
- Some drawing aids for those of us who can't draw
- Circle templates, compass, French curves
- Drawing bows— symmetrical, asymmetrical—www.leevalley.com
- Blending curves, flexible curves —lee valley
- Curve templates—www.woodcraft.com

Picking a form/clamping style for the bends

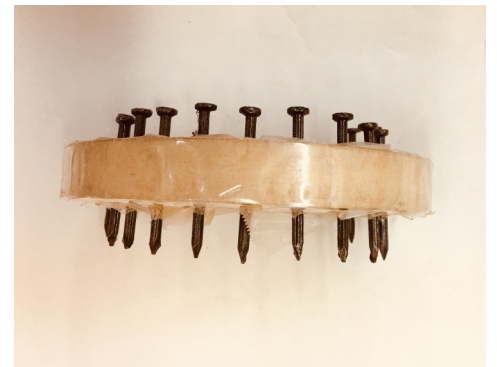
A/B , male/female, positive/negative—two sided form that sandwiches the laminations being bent

- Pros: Works well for tighter double curves, narrow strips where clamping is easier
- Cheapest—just MDF (or scrap wood) and clamps (but you need numerous clamps)
- Cons: Harder to use with wider laminations as the form clamping becomes harder
- Each side of form must be perfectly shaped and allow for the exact thickness of lamination—have to have a different form for each lamination thickness



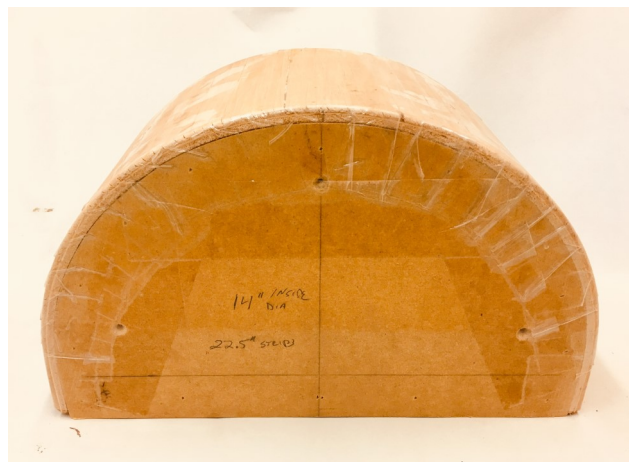
Wrap around—one piece that the laminations are bent on. Only clamps hold the laminations to the form.

- Pros: Simple. Works well for single curve, narrow strips
- Simple rope/concrete nails as clamping device—space the nails roughly 3/4—1” apart and no closer than 3/4” from edge. Typically cannot use regular clamps with these—not enough room for them
- Cons: Need something like a vice to be able to hold the form as you need two hands for clamping



Vacuum press—One-sided form placed in vacuum bag. Vacuum pump sucks all the air from the bag and the bag becomes the clamp.

- Pros: Easiest way to clamp a piece.
- Works well with wider pieces as clamping pressure is uniform
- Cons: Expensive—good bags and pump are not cheap
- Double curves are harder to get clamped—must make sure bag gets into coves
- Also need to watch for bag getting under ends of lamination as air is removed



Free form—bends done without a form

- Pros: No form
- Clamping easy, wrap with rope or pallet wrap
- Useful for creative art projects
- Cons: Really only useful for free form pieces where exact radii is not needed
- Must be creative with clamping, ends need to be clamped in vice or to work table



Making forms

- Bent laminations will follow a form exactly, defect in form results in defect in product
- Visualizing the form is sometimes one of the more difficult things
- Typically use MDF for forms as it is easy to cut and sand, and it is totally smooth
- Useful to have—bandsaw, drum sanders (oscillating preferred), belt sanders
- Forms take a lot of pressure—build them strong
- A/B forms need to be roughly 2" thick at narrowest point
- Vacuum bags can exert roughly 1800 lbs per sq foot of pressure.
- **For vacuum bag forms**
- Must be wider and longer than laminations being pressed as the bag will pucker at the edge of the form and will not clamp strongly there—I typically allow at least 1/2" extra width on each side.
- They also need to be taller than needed for same reason. For example, when I press an arch form, the form is typically 1" taller than the arch allow for bag pucker at the base of the form.
- Form must NOT have any sharp corners as these will reduce the life of the bag

- Make forms wider and longer than pieces being bent
- Need to be prepared for the wood to shift as it is clamped
- Bottom strips always extend out past the layers on top of stack
- Side to side movement almost impossible to prevent as well
- For wider forms you can save time by making spar pieces (usually three is enough) and then cover with wiggly wood (bendable plywood). I use for 1/8" and 1/4" thicknesses.
- NOTE: the spars must take into account the thickness of the plywood being added, otherwise curve radius will be incorrect
- Bendable plywood available at high quality wood suppliers, e.g. Fine Lumber in Austin



- Mark key points on the form with a thin, permanent marker or pen. Do this on top and sides of forms. These reference points will be transferred to the bent piece when done and marking the form is the easiest way to do that.
- All radius center lines
- Any specific mounting points it attaching to something else
- Sometimes boundary lines where strips will start are useful
- Cover any surface that might come in contact with the glue in heavy duty, plastic packing tape—the main surface and at least 1" down the sides. The veneer glue does not stick to the tape.
- Label the form with:
 - its purpose,
 - length/width of veneer used
 - Number of veneer pieces, thickness of pieces, and color order
 - Amount of glue used (done after first press)

Veneer

- You can get veneer in almost any species and figure you can think of
- Typical thickness is 1/42", but you can get some species in thicker sizes such as 1/24, 1/16, and 1/8 (I've also seen 1/28, 1/20 1/10, but these are less common)
- My preference is to use 1/24 as much as I can and only the outer veneer is 1/42
- Bulk of the lamination is never seen, so no need to waste it on the highly figured veneer
- Have used some 1/16, but doesn't bend as well
- The thicker veneer saves time (less to cut) and usually money too

Veneer thickness/width affect the bend

- The tighter the bend, the narrower or thinner the veneer needs to be.
- Can bend pieces that are 1" wide tighter (smaller radius) than a piece 2" wide
- Can bend pieces that are 1/42" thick tighter than pieces 1/24" thick

Other veneer notes

- Non-figured wood bends easier than figured wood
- You will see veneer listed as flat cut and quarter cut
- I have not found a lot of difference in bendability, but some save quarter cut will bend easier. Depends on width needed and grain pattern. Flat cut can have knots.
- Use cheap veneer on interior laminations, save the expensive stuff for the top/bottom layer
- If you are going to round over the final, glued up piece, don't waste any money on fancy veneers as you will not see enough of it in the final product.

Cutting veneer

- Always cut veneer larger than the desired finished size
- Simple laminations 1/2" longer, ones with double curves may be 1-2" longer
- Add at least 1/4" to the width, veneer always slides side to side at least 1/8" in both directions
- Strips always shift a little when clamping, almost impossible to keep straight, especially on longer ones
- For small amounts, I just use a hand veneer saw
- Waste board under veneer, use long metal ruler with sandpaper on back as straight edge. Sandpaper on bottom of ruler helps to hold it in place
- For large amounts, use bandsaw with fine blade and zero clearance insert.
- Very hard to cut straight, any ideas let me know
- Have also tried (unsuccessfully) to cut multiple layers at the same time

Glue

- Use veneer glue
- Yellow glue (PVA glue) doesn't dry hard, always stays a bit flexible, short work time.
- Might work for simple curves , and flat things, but generally not recommended
- I use a PPR glue—precatalyzed, powdered resin also called a plastic resin glue
- Dries very hard, helps hold shape of bend
- Glue is powdered, mix with water, water to cleanup
- Dark brown in color, but there are lighteners you can use if don't want a dark glue line
- Can only be used when temp is 70 degrees or hotter
- Package says must be clamped for minimum 6 hours, that is not long enough for bent lamination. I like 12 hours.
- NOTE: It contains formaldehyde, wear a mask when mixing/sanding
- Must use a glue that doesn't stick to plastic or polyurethane (vacuum bag material)
- There are other veneer glues, I haven't tried them. www.joewoodworker.com/veneering/glues.htm is great article on various veneering glues.

Clamping

A/B forms— I typically use traditional bar clamps

- I prefer clamps that you turn some handle to crank as I think it give best pressure, the quick release squeeze handle ones don't work as well IMHO.

Wrap around forms—I use concrete nails and clothes line.

- Drill holds for nails along outer edge of form, not more than 1" apart
- Insert concrete nails into the holes. Concrete nails don't bend easily
- Wrap the rope (clothesline) back and forth, across the form, from nail to nail to clamp the piece
- I use a single clamp at the end to hold the rope in place.
- Some glue will stick to the rope, but it is easily cleaned by rubbing it across the edge of a bench or tool

Free bends—use the clothes line without the nails

- Clamp one end of the piece in a vice and just wrap the rope in a spiral around the strips
- Similar thing can be done with pallet wrap, but can't always get it as tight.

Vacuum bagging/clamping

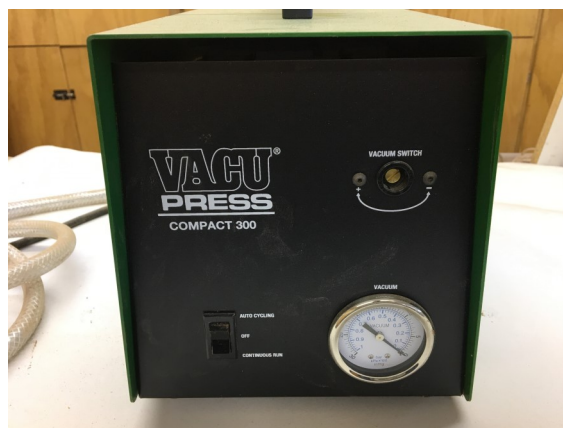
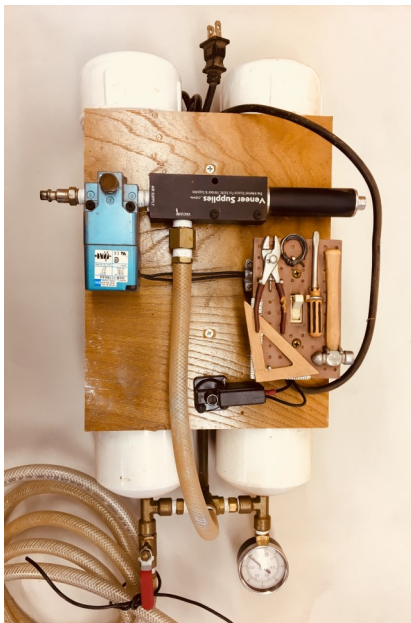
- My favorite clamping method

Bags

- Buy the best bag you can afford, typically three different levels
- 30 mil vinyl—avoid if possible, they don't stretch as well, they definitely will get holes (can be fixed)
- Approximate price for 2' x 4' - \$70
- 20 mil polyurethane—good choice, hold up well
- Approximate price for 2' x 4' - \$140 (seen on sale for \$100)
- 30 mil polyurethane—best choice if you can afford them, have yet to put a hold in one
- Approximate price for 2' x 4' - \$190 (seen on sale for \$140)
- Don't over size, get a size for what you need. Oversized bags work, just take longer to pull out all the air
- If get more than one, buy from same vendor as connectors vary

Pumps

- Best if pump is one made for vacuum bagging
- Typically come in CFM rating 1-5, higher the number the faster it will pull the air out, but doesn't affect pressure applied. Need higher CFM for larger bags.
- Want something that can pull 25" Hg of pressure, but should pull at least 18"
- Highly recommend one that auto-cycles, i.e. cycles on and off, only runs when pressure drops below a certain amount
- Two types I've used: venturi and electric:



Vacuum bagging continued

- Auto-cycling Venturi pump—uses your air compressor and a venturi to pull a vacuum
 - Less expensive, build from kit for \$270-\$380
 - Must have a decent air compressor, but large one not needed (5 CFM at 80 psi good for most pumps)
- Auto-cycling electric pump
 - More expensive—Start at \$500 and goes up
 - Portable
 - Typically more quiet
- My venturi kit came from—www.veneersupplies.com. Lots of great articles here on sizing systems and using different types of pumps— important to read if want to use an existing pump like one you use for stabilization.
- My electric came from—www.vacupress.com

Vacuum bag platen

- Inside the vacuum bag it is best to have a platen—piece of melamine with groves in it
 - Gives a flat surface to lay the work on
 - Platen contain groves to allow the air to flow
- Can also use a platen in conjunction with breather mesh. The mesh also allow air to flow. I use this when vacuum bagging flat work.
- See veneersupplies.com for more information

General process

- Once I have the veneer cut I will test the form with a dry clamp of the pieces
- Stack you veneer in the order it will appear in the final piece, number them if needed
- Mark a reference line on the top piece that matches a reference line on your form
- This helps you align it, and is most important if vacuum bagging. For me it is quite often a center line.
- If the bends are severe, I may keep the veneer clamped dry in the form for a day so it will clamp easier.
- Dry clamping will also give you an idea how much the piece will want to slide in the form as you clamp it.
- All laminations will move some as you apply pressure and make the wood bend into the curves.
- You quite often have to start the clamping with the wood positioned past the starting point to allow it to settle into the correct place as it is clamped. This varies with the form and severity of the bends.
- If you see any gaps between the veneer strips you must figure out why. Do you need more clamps? Is the form bad (A/B forms are the worst for this)?

Glue Process

- Prep your glue table by laying down some scrap paper
- Newspaper works or all veneer ships rolled up with brown craft paper that makes great table cover
- Unstack your veneers in order on your table, but remove the top and bottom veneers. Glue up is messy. You want to keep the top and bottom veneers as clean as you can so there is less sanding
- Mix the glue
- Think runny cake batter consistency, too thin-won't bond, too thick-hard to spread
- The plastic resin glue has a fairly long open time, roughly 45 minutes or more
- Roll on the glue
- I use an old bread pan like a paint tray for the glue
- I use a veneer glue roller to apply, but a short, hard paint roller will work
- Roll on the glue onto one side of the veneer. You can roll multiple pieces at a time, side by side
- Leave a clean area on your work surface for when you do the top/bottom veneers
- Stack the strips in the correct order, making sure the edges all align
- Move the stack to a clean area and apply glue to the top and add the top veneer, flip over and do same for bottom veneer
- Tape the ends of the stack with blue tape. This will help you keep things aligned as you clamp the piece.
- Clean up with water (warm, water works best) - do this AFTER you clamp the piece

Clamp Process

- Place the stack in/on the form and apply your clamping pressure

A/B form (this depends on the style, but for the basic one, here's some steps)

- Place the two forms on your clamps, with clamps open wide enough to let the straight stack go between the forms
- I use Pony bar clamps where I can first slide the stop in before cranking. I slide all clamps in as far as I can and then start cranking the clamps from left to right.
- The pieces will start to slide as pressure is applied. You need to make sure everything doesn't slide past where you want it to start. If it does, back off the clamps and re-adjust.
- The individual veneers may also slide side to side. The blue tape should prevent most of that, but if not, you may need to back off the pressure and adjust.
- Take your time. The glue isn't going to set instantly. I've clamped/unclamped pieces more than five times to get it right.
- Make sure the stack stays straight in the form
- Work your way down the line applying pressure, you want to make sure the clamps are tight. If you see any gaps in the laminations, apply more clamps.

Wrap-around forms

- Clamp the form into a vice
- Clamp one end of the stack to the form
- Start wrapping the rope back and forth between the nails
- As you wrap around a nail, make sure you are pulling the rope as tight as you can.
- NOTE: It is best to wear leather work gloves, otherwise you will get rope burns
- Keep the piece aligned straight with the form, trying to avoid any side to side slippage of the veneers
- When you are done, tie off the rope or clamp it to the form
- My wrap around forms are built to have a place to initially clamp the veneer stack to the form and a place to clamp the end of the rope.



Clamp Process continues

Vacuum bag

- Put form into bag about midway down the bag
- Put the veneer stack on the form, trying to align it to the form with the reference line
- Seal the bag and start the pump
- As the air is pulled from the bag, keep the piece aligned and square to the form
- If things go awry, stop the pump, release the seal and re-align and start again
- Watch for places where the bag might be puckering incorrectly or getting under the lamination instead of on top. If this happens, stop the pump, release the seal and try again
- Tips
- If you are bending a large curve, manually bend the laminations as the air is pulled out to help the bag correctly press on the form.
- If you have a cove in the form, manually press the bag into the cove as the air is pulled out to help the bag correctly press on the form.
- I often need three hands to vacuum press a piece. I often will use my knee to hold the bag into the form while my hands are bending the lamination around other curves. This is why I always test the press with no glue to see where the issues will be.
- Special Note: Once the piece is dried and out of the bag, clean **ALL** glue drops/residue out of the bag. These small pieces of glue are very sharp and can puncture your bag if left in the bag and you press again.

After the glue dries

- Take your piece out of the form
- NOTE: the dried glue is very hard and had sharp edges!
- Sand/form the piece as needed.
- I find it takes 80 grit minimum to cut through the glue. I purchased a big 6x48 oscillating belt sander just for this job.
- NOTE: This is a dusty operation. Use good respirator and use a dust collector and air cleaner

Issues

- This is not a fool-proof process. Sometimes things just don't come out looking like they should.
- Wood is porous. Just be aware that woods like birdseye maple and burls can have small holes in them. The glue is going to come through these! Usually not too big of a problem, just more sanding. Bigger problem with these is if you use a different glue that might stick to bags/forms, hence my recommendation for the PPR glues.
- Spring back. Depending on the thickness of the final stack, wood varieties, grain patterns, you can get some spring back. The PPR glue helps, but not always. Sometimes I will keep a complex piece in the form for as long as I can to limit the spring back. Sometimes you have to design a tighter curve, expecting a little spring back to occur.
- Twisting. I hate this one the most. I can't predict this one at all. Sometime a piece will develop a twist after taking it out of the form. Could be the grain, I don't know. I need to take better notes on it. Perhaps this is a place where if I only use quarter cut wood it wouldn't happen. More investigation is needed. If you have any ideas let me know.
- NOTE: When I do flat laminations, they are typically short enough that I can cross the grain of one or two inner veneers (like plywood) so that the resulting piece never has a twist.

Combining with Woodturning

- You need to have a plan ahead of time to know how you are going to attach the bent lamination to your turning.
- Where will it attach, how will it attach.
- If you have to drill something, how are you going to do that. The Oneway Drill Wizard is a must for drilling holes in the sides of turnings. You almost certainly will need an indexing capability on the lathe.
- Plan ahead for how you will drill the bent lamination pieces too. For some, having horizontal boring capabilities is very useful (one of the reasons I still have my Shopsmith).
- The woodturnings have curves in all directions, the bent lamination does not. When they are paired together, there is always a gap. I solve this by putting a small flat on the turning so that it matches up with the lamination.
- Sometime the fix is to put a recess into the lamination where the two come together.

Bent Lamination References

Veneer

VeneerSupplies.com

Only carries true veneer, no special thicknesses. Great place for small batch orders. Great selection, all different grades. Pictures have been true to product shipped. Often has specials. Online ordering. Also site for all kinds of supplies including vacuum bags/pumps/glue. Associated site, www.joewoodworker.com, has tons of informational articles.

Certainlywood.com

Carries all kinds of veneer and thicker versions of many common woods. My go to place for thicker veneers (1/24, 1/16). Also my source for inexpensive black veneer. Can order in small quantities or great deals on larger orders. Must submit email inquiry first, then call to complete order.

Marwoodveneer.com (812) 288-8344

Lots of different veneers, different thicknesses. NOT for small lot orders. Used them when Certainly Wood did not have the 1/24 veneer I wanted, but had to order a huge bundle. Email/call to order.

Vacuum pressing

VeneerSupplies.com

Full line of pumps, pump kits, bags, glues, and accessories (e.g. veneer saw, glue rollers, etc). I use a venturi kit from here as well as my bags, and the UltraCat glue. Great customer service. Joe will answer any question you have.

Vacupress.com

Has line of bags and pumps and other supplies. My electric pump is from here (Compact 300). Probably a little more geared to the professional cabinet shop, but good stuff here. They have some veneering DVDs too.

Useful things

Leevalley.com

Lots of neat tools here. My source for the drawing bows and blending curves.

Woodcraft.com

Curve template they sell can be useful, but it is a bit cumbersome.

Marcadams.com

Lots of woodworking classes. Also woodturning classes.

Michaelcooper.us

One of my original instructors. Lots of inspirational stuff here. Site is FLASH based so doesn't work on ipad.