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American Association of Woodturners

Glue, Grain, and Joints

Keeping It Together

By Jim Rodgers

Joinery is one of the great challenges in woodworking, whether you're building cabinets or a segmented vessel. Although cabinetmakers can employ a wide variety of worked joints as well as hardware, we woodturners have more limited choices. As a result, turners need to pay careful attention to all of the details to achieve joints that are tight and long-lasting.

5 key considerations

Material movement and joint strength are the two interrelated concerns. The more the wood moves, the greater the problem; if neighboring pieces move in different directions, it becomes even more of a problem.

Here are five key challenges:

1. Joining woods that move at different rates.
2. Using joinery to aid fastening.
3. Joining woods that move in different directions.
4. Improving the quality of the fastened surfaces.
5. Selecting the best glue types for the application.

Our solutions lie in:

- Minimizing the differential in movement between wood surfaces being joined.
- Increasing the joined surface area to improve the joint strength.
- Using adhesives suitable to the specific task.
- Wise species selection.

Special challenges for segmented turners

In segmented turning, woodturners usually deal with more different species of wood in a single project than other turners do. In designing a project, then, we must consider the relative rates of movement of the adjacent species. If each wood species is moving at approximately the same rate, the joint will be less stressed.

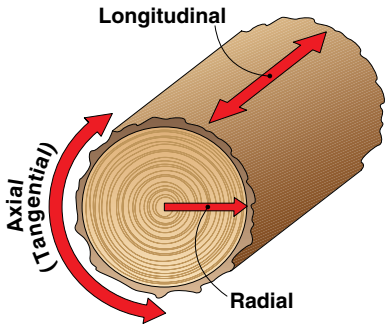
We also need to consider the relative density of the species being joined so that the turning task is more manageable. This is important because moving our tool from soft to hard wood while turning may cause tool control and tear-out issues.

How wood moves

There are a number of possible variations of grain alignment between joined pieces. The strengths of those you're likely to use are listed in the sidebar "Wood Orientation and Joint Strength," *opposite*, prepared with the technical assistance of Dr. Roman Rabiej, a scientist formerly at Franklin International (manufacturer of Titebond glues) and now a professor at Western Michigan University. But before diving into the three most common configurations, let's briefly review wood movement.

Wood moves in three dimensions: radial, longitudinal and axial (sometimes called tangential). The rates of movement differ dramatically in

each dimension and from species to species. Typically, **longitudinal** movement (along the grain) is near zero, but **axial** movement can be as much as 8 percent and **radial** movement about half of that.



Radial grain to axial grain

While the two presentations of the wood are moving at different rates, the relative movement to each other is all that is important. The concern here is that even though no end grain is involved, the movement between the two faces can still be substantial. Large glue-ups (even single species) may fail over time due to continued flexing if the species' axial and radial movements differ greatly. Solutions include:

- Be sure that the surfaces to be glued are as flat as possible, thus increasing the bonding surface area.
- Always seal all exposed surfaces to reduce the movement due to moisture gain or loss.
- Work with species that have minimal movements.
- Assure that wood grain is aligned in the same plane before cutting the segments for a ring.
- Use glue with elasticity (creep) such as polyvinyl acetate (PVA) glues. More about that later.

End grain to radial or axial grain

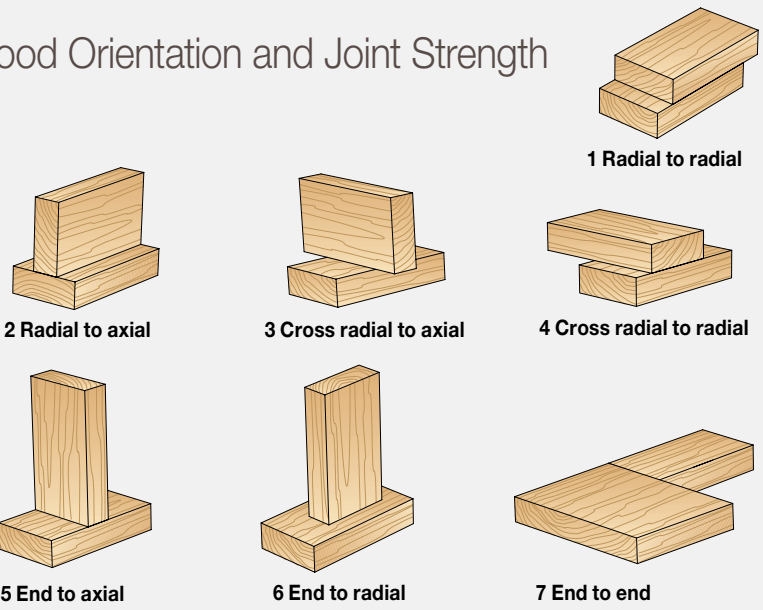
This glue joint has a significant problem because the side-grain timber is moving in two planes at different rates. Additionally, the end grain adsorbs the glue into the long cell structure of the timber, reducing the bonding strength.

Cabinetmakers address this issue by choosing joints that present stronger grain orientation and sometimes even add mechanical strength as well. For example, box joints increase the side-grain surface area, reducing reliance on the end-grain bond. Although dovetail joints do the same thing, this joinery introduces mechanical strength. Panel doors, tabletops, and other tongue-and-groove connections eliminate the glue in troublesome areas and allow the larger wood surface to "float."

Neck rings, disc feet, and other cross-grain segmented design elements create situations similar to those faced by cabinetmakers, but turners have fewer possible solutions. Here are a few suggestions:

- Preseal the end grain with thinned glue (1:1 mixed with water). Allow the glue to dry and then reglue the joint as usual. The initial sizing coat will close the open cell structure, thus increasing the glue surface area. The joint will be a glue-to-glue joint (joining glue rather than wood).

Wood Orientation and Joint Strength



Wood Orientation	Glue Joint Strength
1 Radial grain to radial grain (flat sawn to flat sawn)	100%
2 Radial grain to axial grain (flat sawn to flat sawn)	65–70%
3 Cross radial grain to axial grain	50%
4 Cross radial grain to radial grain	50%
5 End grain to axial grain	15–20%
6 End grain to radial grain	15%
7 End grain to end grain (sized joint, see text for details)	30%

Dr. Roman Rabiej, professor of Engineering and Applied Sciences at Western Michigan University, provided technical information for this chart on the relative strength of various orientations of glued wood joints. Dr. Rabiej is a recognized expert on wood technology.

Analysis of a simple ring-segmented vessel

All segments are arranged with horizontal running grain. This means that each ring was glued up end grain to end grain. Each ring was brick laid to add strength by gluing side grain to side grain. All joints were overlapped to add more strength.

Veneer added here was made from a single sheet of veneer, cut into a circle and glued between the rings. At only two side locations is the grain of the veneer running parallel with the grain of the adjoining rings.

The veneer acts with the adjacent woods and not as a separate wood element.

Spacers in the feature ring were too wide (⅛") to act as veneers and were cut so that their grain runs parallel with the stabilized/dyed box elder burl feature wood.

The vessel was finished both inside and out to further reduce uneven expansion/contraction possibilities.

The solid wood foot attached with a veneer spacer layer has both parallel-grain and cross-grain attachments to the first ring. Good surface preparation, gluing, and its small size (under 4") minimizes problems.

This vessel is 10×8". The base is black acacia with a body of redheart. The feature ring is built from stabilized and dyed box elder burl and yellowheart banded on either side with a narrow ebony ring. The neck is ebony.

Is your glue good to go?

To assist in building the strongest joints in vessels, our glue must also be in prime condition. Glue degrades over time, and poor storage conditions shorten that period even further.

According to Franklin International, Titebond guarantees its polyvinyl acetate (PVA) glues for a one-year shelf life because the company does not know and cannot control the conditions under which the glue is stored.

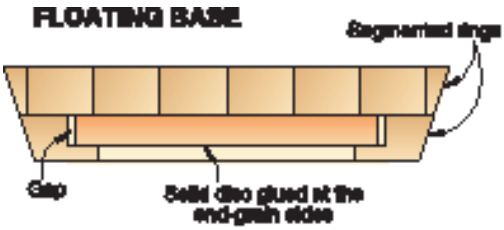
Photo: John Hetherington

However, Titebond II can enjoy a shelf life of up to four years when stored under optimal conditions (moderate temperature and dim lighting). Other Titebond products have shelf lives of two to three years.

Titebond products can stand up to six freeze/thaw cycles with some decrease of strength with each cycle. After being frozen, the glue may need to be stirred to homogenize it. If the glue is stringy, however, discard it. Similar degrading problems occur with extreme heat cycles. If your shop area isn't climate controlled, store your glue in a living area of your home.

To determine the manufacturing date of your Titebond product, check the date code stamped on each bottle. The date code can be found in the batch stamp on each bottle indicating the year (number) followed by the month (alpha code) of manufacture. The additional digits encode other batch information.

—Jim Rodgers



• Consider increasing the glue area by using a tongue-and-groove construction for a foot or neck ring. In *The Art of Segmented Woodturning*, Malcolm Tibbetts suggests a great bowl foot idea that is exactly like the cabinetmaker's floating panel. As shown *above*, a rabbet captures the "foot" between the first and second base rings of a vessel. The base is cut slightly smaller than the rabbet and allowed to float.
• Avoid this construction.

End grain to end grain

These are the weakest possible joints. The amount of surface area to be glued is minimal and the glue is wicked away from the available surface by capillary action.
These are your options:
• Don't do it.
• Overlap an end-grain joint with another side-grain joint (brick-laid joinery), thus providing more face-grain strength.
• Size the joint first with a 1:1 solution of glue and water; allow it to dry and then glue. This will create a joint where the sizing seals the end grain and creates a glue-friendly surface, although the bond is actually glue-to-glue.

Joint quality

Wood that is being glued must be flat and clean, free of inhibiting burrs and debris. A poorly prepared joint may fail when all else is fine.
• Oily species should be glued immediately after cutting or wiped down with acetone, naphtha, or other solvent to remove accumulated extractives, such as terpenes and oils, immediately before gluing.
• Crosscuts should be made with a sharp finish-cut blade. A 10"- dia. blade should have 60 or more teeth.
• Wood should be held firmly while cutting to eliminate accidental movement and vibrations that would reduce the cut surface quality.
• Burrs and surface tear-out should be sanded away to prevent capture in the glue joint.
• The face of the cut should also be sanded to improve the surface quality, especially on soft (western soft maples) or open-grain woods (walnut, wenge) as well as brittle species (purpleheart).

Choosing appropriate glues

Some glues permit movement and some don't. Other adhesives expand and fill while many don't.

For example, when cyanoacrylate (CA) glue is catalyzed, it becomes a solid acrylic material incapable of moving. Thus, CA glue can't expand or contract with the wood movement. Therefore it is not appropriate for segmented turning.

Polyvinyl acetate (PVA) glues (white glues) and modified PVAs (Titebond I & II are two examples) creep and will allow for some relatively slow movement in the joint. Some epoxy glues are also formulated to allow constant movement and twisting (West System epoxy and System 3 are two examples).

5 strategies for segmented woodturners

Here are five key guidelines to help ensure gluing success:
1. Use PVA glues.
2. Prepare joints that are clear of obstructions.
3. Increase the glue area.
4. Wipe down oily exotic woods before applying glue.
5. Never align glue joints in adjacent layers. Always overlap to add more strength to the joint.

Final thoughts

Here are some general considerations that will also aid in reducing the number of potential joint failures in your next segmented project:
• When using a solid hardwood as a bowl foot, keep the size small so that it is less affected by movement. Less than 5" in diameter is best.
• Use burl woods that have totally dried to ambient conditions. (This will vary depending on your climate.) Burls are stable and don't move much because of their interlocked grain structure.
• When inserting a veneer between layers of a vessel, maintain clamping pressure until the joints are completely dry. Veneers tend to absorb moisture from glue and will swell and crinkle, causing the joint to open if unclamped prematurely.
• Other than appearance, the movement in cross-grain veneers is not a concern. The thinness of the wood when bonded to a solid wood causes it to move with the wood to which it is attached (not as a separate element).
• All turnings should be sealed inside and outside to minimize uneven movement due to uneven absorption of moisture.

Jim Rodgers (jlrodgers@aol.com) has written several journal articles about segmented turning. He is a former president of the Bay Area Woodturners and lives in Martinez, CA.