PRINCIPLES FOR GLUING

Ross Roepke, 23 January, 2003

An article in Modern Woodworking, January 2003, inspired me to present some factors in the gluing process that deserve attention by wood-workers to make joints that are less likely to fail. The goal is to provide a better understanding of the gluing process as a means toward more consistent and reliable results.

In previous discussions members have presented some of the design and fabrication issues. This discussion will not review the details about the effects of proper wood preparation so the joint mates properly, the age of the glue, clamping pressures, clamp spacing, etc. These may be useful topics for another presentation.

The above article references five interfaces in the glue joint; each interface is like a link in a chain where the chain is only as strong as the weakest link. The outside links in this chain are the two wood surfaces to be joined. The next links are the contact between the glue and the wood. The last link is the cured glue film in its fully developed state of cohesive strength. In the ideal glue joint, the wood itself should be the weakest link. Following some of the procedures recommended will cause this to be so.

The primary links in the chain discussed in this article will be the interface between the glue and the wood. It is where we can influence the quality of the bond by good procedures.

Wood is comprised of parallel fibers that are like a bundle of straws held together in a cellulose matrix. The glue must penetrate into this matrix to establish a good fusion in order to form a strong bond. Penetration of the glue is the mechanical portion of this process. But, to get penetration, the glue must wet the surfaces of the wood. Wetting is a chemical phenomenon between the liquid and the surface in which the glue creates thorough contact with the wood at the molecular level.

To determine wettability, put a drop of water on the wood surface. If it beads up, like on a waxed car, it is not wetting the surface. If, on the other hand, it flattens out so the drop spreads out, and the edge contact angle is small, the wood is in a condition where the glue will wet the surface. The flatter the drop becomes and the smaller the contact angle, the better. The adhesive must wet and penetrate into both of the glue surfaces to make a strong bond.

Common causes of glazed surfaces that do not accept glue are dull planer or jointer blades. The ideal glue surface is probably a freshly planed or scraped surface prepared with sharp tools. It is recommended that any glue surface be freshly scraped or sanded to remove oxidized wood and contaminants to assure good wetting and penetration of the adhesive.

The optimum glue joint, using PVA type glues, needs to have both surfaces coated with glue prior to clamping to be sure both have been wetted over the entire contact area. If clamping is delayed, for example, an uncoated surface may not be sufficiently wetted from the other glued surface to form a strong bond. Makers of the new polyurethane glues contend that only one surface needs to be coated, thereby making their glues more cost competitive.

Penetration is less often a problem on end grain where the fibers will tend to siphon up the glue. End grain joints tend to be quite weak because of the linkage between the glue and the grain. One way to increase the strength of end grain or scarf joints is to apply an abundant coat of thinned glue to the end grain and let it soak in for several minutes, then recoating as necessary, before clamping. Tests have shown such joints to be 50% stronger because of the improved interface link.

Moisture content of the wood affects the depth of glue penetration. Very dry wood absorbs moisture from the glue, making it viscous and unable to penetrate the wood properly. Very wet wood affects the drying time of the joint. Gluing wood above about 15% moisture content is not recommended with water based adhesives, like PVA, because the bond will not harden properly. And, if dimensional changes occur in the wood during drying, stresses build up and weaken the joint. This can occur especially if the adjoining wood in the joint is at much different moisture content.

The harder the wood, in general, the less permeable it is because the denser wood has thicker cell walls and smaller cells. These denser woods are also stronger so it is more important to achieve the ideal joint where the failure occurs in the wood. Denser woods also tend to have greater dimensional changes with changes in moisture content and induce stresses in the joint.

Another characteristic of some woods that affect bond performance is the concentration of extractives in the wood. Some oily woods do not permit the glue to wet the surface and thereby restrict glue penetration. The oil can be removed from the glue surface with lacquer thinner to permit better permeability. In other cases, tannin in the woods are acidic and affect the adhesive chemistry and strength. This is not usually a problem with our normally used woods because the adhesives are formulated to accommodate the tannins.

The glue must harden into a solid with little or no internal stresses to develop its full strength. Glues harden in one of three ways: by cooling (hot glues), by evaporation (PVAs), by chemical reaction (epoxies). The times required for curing a glue joint depend on the type adhesive used and the temperature of the wood. PVA glues should ideally be used above 60 degrees. At low temperatures, below 40 degrees, glues tend to form different crystalline structures that are weak. The times needed are often posted on the container. We have a tendency to remove clamps too quickly.

I plan to add to this article later as I have a chance to investigate further. So keep posted. Your comments and suggestions are invited.

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