U. S. Department of Agriculture, Forest Service

FOREST PRODUCTS LABORATORY

In cooperation with the University of Wisconsin

MADISON, WISCONSIN

MINIMIZING SHRINKING AND SWELLING

By

A. J. STAMM, Senior Chemist,
and
R. M. SEBORG, Assistant Chemist

Published in

FURNITURE INDEX,
November 1937

MINIMIZING SHRINKING AND SWELLING

By

A. J. STAMM, Senior Chemist,

and

R. M. SEBORG, Assistant Chemist

The furniture manufacturer has to a large extent overcome the difficulties due to the shrinkage and swelling of wood by the use of properly seasoned wood, and special structural design to balance or relieve stresses. These, however, furnish only a partial solution of the problem. For this reason a treatment of the wood was sought at the Forest Products Laboratory that would actually cut down the affinity of wood for water and the subsequent changes in dimensions, and thus permanently reduce the moisture absorption and make possible the cutting, nailing, and abrasion of the wood without loss of moisture-excluding efficiency. Preliminary studies showed that depositing of waxes and resins within the cell wall materially reduces the initial shrinkage after treatment, but does not prevent moisture from ultimately being absorbed and swelling occurring beyond the green dimensions of the wood. Even though the waxes and resins in themselves are highly water-resistant, water works its way between the internal wax films and the wood. Although the treatment appreciably reduces the rate of take-up of water, the amount finally taken up is not affected. It was therefore obvious that a treating material would have to be used that would actually bond to the wood. Materials that have an affinity for wood, unfortunately, also have an affinity for water so that they would be of no value in excluding moisture. It thus is necessary in using such a wood-bonding material to convert it to a water-insoluble material after it has bonded to the wood. This is exactly what is done in the process of forming synthetic resins within the wood structure, which was recently developed by the Forest Products Laboratory.

The wood is treated with a mixture of phenol and formaldehyde together with a catalyst, dissolved either in water or wood alcohol. This solution has a great affinity for wood, as is shown by the fact that wood swells more in it than in the solvent alone. The treatment consists in soaking green wood in the solution at room temperature sufficiently long for the solution to diffuse into the fine structure of the wood or impregnating the seasoned wood with the solution by a pressure treating process. The wood is then slowly dried at only a slightly elevated temperature in order that further diffusion of the resin-forming materials into the cell walls may accompany the removal of solvent. This is followed by heating the

wood to about 200° F. for a period of time depending upon its thickness in order to cause the phenol and the formaldehyde to react to form a resin that is water-insoluble. The shrinking and swelling of the wood can be reduced to one-quarter of normal in this way by forming 30 to 50 percent of the weight of the wood of synthetic resin in the structure. The dimension changes can be reduced to one-half of normal when the increase in weight of the wood caused by the resin is as little as 15 percent. The reduction in the dimension changes appears to be permanent and the wood can be cut and nailed without affecting the effect of the treatment.

Not only is the swelling and shrinking of wood permanently reduced by this treatment, but some of the mechanical properties are improved as well. The hardness and the compressive strength at the proportional limit perpendicular to the grain are increased greatly. Maple containing about 20 percent of its weight of synthetic resin gave increases of over 50 percent in each of these properties. Compressive strength parallel to the grain was increased much less, while in static bending, the modulus of rupture and modulus of elasticity were but little affected. There are indications that the shock resistance may be actually decreased. It thus appears that it is the across the grain properties that show the significant increases as a result of the treatment.

Gluing tests showed that the treated wood can be glued with animal or casein glues. Excellent results were obtained with the phenolic-resin type of glues, using the hot-press, but not the cold-press technic. Plywood glued with phenol-resin film or with casein glue was successfully treated with the synthetic resin without affecting the glue joints.

The present limitations of this process are the size of specimen and species that can be treated and the cost of treatment. Not all woods can be successfully treated in appreciable sizes because of the difficulty of getting the treating material distributed throughout the structure. A number of softwoods, the sapwood of a number of hardwoods, and the heartwood of the softer hardwoods have been successfully treated in specimens 14 by 4 by 1 inch in size. The largest specimen successfully treated to date is 30 inches long by 5 by 5 inches. Larger specimens of the more readily treated species could undoubtedly be treated, but the treatment would take prohibitive lengths of time.

On the basis of the complete treatment of the wood the cost would be about 40 cents per board foot. This figure is at least ten times the cost that could economically be added to general millwork to minimize the dimension changes. Even at present costs the treatment might, however, be economically applied to such specialties as lithograph backings, shoe lasts, shuttles, wood bearings, small handles, athletic goods, and the more valuable veneers and plywoods.

Of special interest to the furniture manufacturer is the application of this treating process to the manufacture of plywood which is now being studied. The results look promising. One-eighth inch Douglas

fir and birch veneers have been treated successfully with synthetic-resin forming solutions. These have been successfully assembled into plywood with glue film and other types of phenolic glues, using the normal hot-press technic. The best results are obtained if the resin in the treated plies has only been partially resinfied prior to the assembly in the press, as in this case there are still active groups in the treated wood to bond with the active groups of the glue. Joints have been obtained under these conditions that show 100 percent wood failure on shearing tests in spite of the fact that the strength of the wood has been appreciably increased. In the case of Douglas fir it was found possible to assemble the veneer plies without the use of a glue, the treating material acting as the bond. In this case the drying of the plies prior to assembly must be more carefully controlled to cut down preresinification and higher assembly pressures must be used in the press to obtain adequate contact between the meagerly filmed surfaces. Further research will be required to perfect this technic.

In all cases the wood is but slightly darkened by the treatment. A considerably improved surface is obtained which probably would require little or no filler in finishing. Specimens immersed in water for two months took up approximately 25 percent of water compared with over 100 percent in the case of similar untreated plywood. On drying the treated specimens practically no degrade in the form of warping or checking occurred. Tests of vapor transfusion through plywood show that water vapor passes about 15 times as fast through the untreated plywood as through the treated plywood.

These tests all indicate that a desirable product can be obtained. In the case of 3/8-inch Douglas fir plywood it is estimated that treated plywood could be produced for two to three times the cost of the untreated synthetic-resin glued plywood. With the more expensive woods, the proportional increased cost for the treated material would be less. It thus appears that the cost of the treatment would by no means be excessive for high-grade furniture plywoods and veneers. The treatment might be of considerable value in the case of matched figured veneers that contain appreciable amounts of cross grain and should largely eliminate the detrimental surface checking that is often encountered in these veneers.

Research is being continued on the application of their treating process. With the aid of the fundamental information and background gained to date, it is hoped that further efforts will yield results of more widespread usefulness.