THE APPLICATION AND PROPERTIES OF IMPREG

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The dimensional stabilization of wood by impregnation with phenolic resins as developed by the Forest Products Laboratory has been described rather extensively in many reports, magazines, and technical journals during the past two decades. However, because of the recent application of resin-impregnated wood (impreg) (*4, 8, 9, 11, 12*) for patterns and die models by the Ford Motor Company, this method of dimensionally stabilizing wood has been given considerable publicity in newspapers and trade journals during the past several months.

The results of the investigation by the Forest Products Laboratory and the Ford Motor Company of the suitability of impreg for patterns and die models was first given in a paper (*7*) presented at the annual meeting of the Forest Products Research Society, May 5, 6, and 7, 1954, at Grand Rapids, Mich.

At present resin-treated wood has been chiefly used in its compressed form. This stable form of resin-treated compressed wood (impreg) (*4, 5, 6, 10, 11, 13*) is sold under various trade names by the manufacturers of this product. Compreg is being currently used for cutlery handles, musical instruments, strain insulators (and other applications in the electrical field where a high-strength, high-dielecrtic material is required), electrical transformer parts, spar and connector plates, tooling jigs and forming dies, sporting goods, decorative applications, and for many applications in the textile industry.

Impreg is uncompressed, resin-impregnated wood. Impreg is made by impregnating the wood with an aqueous solution of phenolic resin, followed by drying and curing of the resin within the cell walls of the wood. This process has been chiefly limited to the treatment of thin sections of wood such as veneer, or to wood in short lengths, because of the difficulty encountered in obtaining uniform impregnation and in the subsequent drying of the treated wood in lumber-size dimensions. Of course, laminated panels of any desired thickness can be built up from the treated veneer.

This process involves the impregnation of veneer by an aqueous solution of phenolic resin, then first drying the veneer at approximately 175°F. to remove most of the water, and then curing the resin in the wood by heating for approximately 30 minutes at 300°F. In commercial practice the drying and curing of the treated veneer is generally done in a veneer roller drier. The treated veneer can then be glued into the panels by the conventional methods used in making plywood.

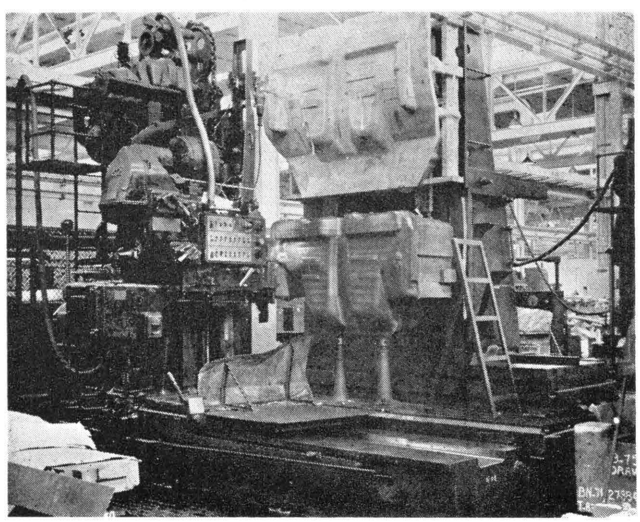
Advantages of Resin Impregnation

The chief properties imparted to wood by resin impregnation are:

1. Reduced shrinking and swelling and moisture absorption.
2. Increased resistance to heat.
3. Increased electrical resistance.
4. Increased resistance to chemicals.
5. Increased resistance to decay.

Except in hardness and compressive strength, which are slightly increased, the mechanical properties (2) of wood are not improved by this treatment. Toughness and impact strength are materially reduced.

Industry has taken advantage of some of the properties of impreg, including its high chemical resistant property, in the construction of



Keller duplicating machine.

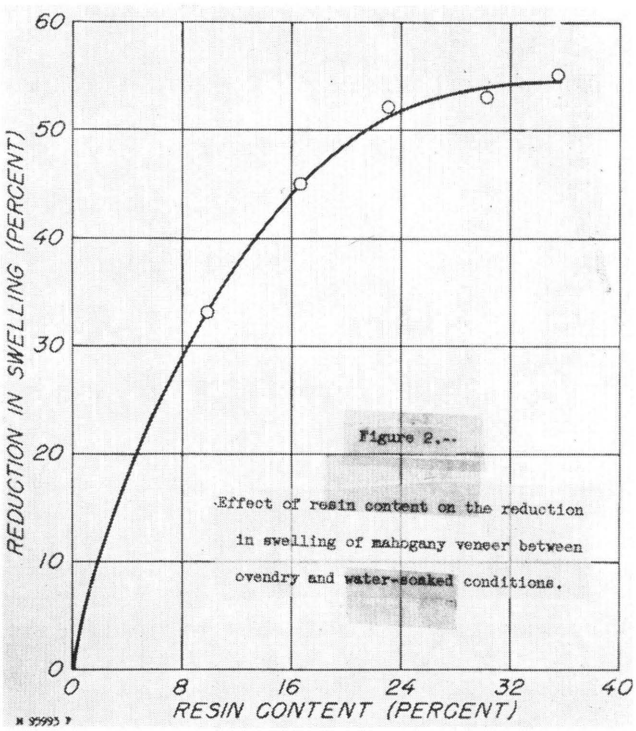


Figure 2.--

Effect of resin content on the reduction in swelling of mahogany veneer between ovendry and water-soaked conditions.

chemical storage tanks and filter frames from this material. Impreg also shows promise as a superior chemical-resistant material for fillers in Jordan refining machines used in the pulp and paper industry. The electrical-resistant properties (*14*) of this material have been utilized in its use for housings for electrical control equipment. Until recently, however, industry has been slow to take advantage of the most improved property, dimensional stability, imparted to wood by resin impregnation. In many applications where the lack of dimensional stability of the untreated wood has been a problem of major importance, the increased cost of impreg over that of untreated wood could be readily justified.

One of these applications is the use of impreg for die models in the automobile industry. Since the beginning of mass production of cars, the body parts have been stamped out of steel dies. In order to make the steel dies, models of the correct size and shape must be first made of wood, and from these wooden models the surfaces are duplicated in steel by Keller machines (fig 1). Since the wooden models determine the shape of the steel dies, it is highly important that these models do not change dimensions appreciably from the time the models are made until the steel dies have been completed. Changes in dimensions in the wood models, unless corrected, would be reflected in the dimensions of the steel dies with the result that the final products (car body parts) would not fit together exactly as designed. Frequently these changes may be of sufficient magnitude to require reworking of the entire surface of the models. Since each step in the engineering and tooling for production of a new model is closely timed, any delay is costly from a time and monetary standpoint. The fact that wood changes in dimensions with changes in moisture content therefore represents a serious problem, and one which has been faced with difficulty for the last 40 or more years in the automobile industry.

Most of the efforts that have been made to eliminate or reduce this difficulty involve attempting to prevent mechanically the entrance and exit of moisture with surface coatings (*1*, *3*) such as paint, varnish, water repellents, and related products. These treatments have proved effective in retarding the rate of moisture changes, and are therefore effective in reducing changes in moisture content and dimensional changes when exposure to high or low moisture conditions is for short periods of time. Since surface coatings affect only the rate of moisture absorption and do not significantly change the amount of moisture that wood can absorb, this type of treatment is not effective in reducing changes in moisture content or dimensional changes of wood when exposed to long humidity-change cycles such as seasonal changes.

Impreg in the Automobile Industry

Because of the difficulty encountered in trying to maintain accurate dimensions of the die models, the Ford Motor Company sponsored a research project at the Forest Products Laboratory to determine the suitability of impreg for making die models and patterns.

The properties of impreg in general had been well established. However, the effect of phenolic resin on mahogany for this application had yet to be determined. This research project was therefore chiefly devoted to determining the effectiveness of resin impregnation on the reduction of dimensional changes of die models, the gluing and carving properties of this material, and the technique of manufacturing impreg panels for this application.

The effect of varying amounts of resin on reduction in swelling of mahogany veneer from ovendry to water-soaked conditions is shown in figure 2. The resin content was based on the weight of the untreated ovendry wood. The dimensional stability increases with increase in resin content up to approximately 30 percent. Additional amounts of resin do not significantly increase stabilization. Bakelite resin, BR15100, was the impregnating resin used in making impreg for these tests and for the impreg die models discussed in this paper.

In order to determine the dimensional stability of die models made from this material, two die models were made from impreg. Comparable models were made from conventional mahogany lumber. All four models were then subjected to high and low moisture conditions, and their relative dimensional changes were determined.

Since the standard die models are built up from mahogany boards, this practice was followed in the fabrication of impreg die models; that is, the treated veneer was first made into boards or panels of comparable thickness and width of mahogany lumber. A conventional hot-press phenol resin glue was used in the gluing of the veneer into panels. Impreg die models were then built up from these panels by using a room-temperature-setting resorcinol or epoxy resin as the bonding agent.

Honduras mahogany (Swietenia) has been used for making die models because of the low dimensional-change properties and the good working qualities of this species. With the increased stability and superior working quality imparted to wood by resin impregnation, other species of wood may be suitable for making impreg for this application.

The first batch of impreg for this application was made at the Forest Products Laboratory. This batch consisted of approximately 300 board feet of laminated panels (approximately 1 x 12 x 48 inches). Each panel was laminated from 17 plies of one-sixteenth-inch sliced Honduras mahogany (Swietenia) veneer. Later tests have shown that either well-cut sliced or rotary-cut veneer in thicknesses up to one-tenth inch is suitable for this application.

From this material, the first impreg die model with its comparable model from mahogany (upper back panels) was made by Deutsch and Sons Pattern and Machine Works, Milwaukee, Wis. Both models (fig. 3) were subjected to 90 percent relative humidity at 80°F. for a month and then to 30 percent relative humidity for the same length of time. The dimensional changes were determined periodically. The comparative dimensional changes of the two die models when subjected to 90 percent relative humidity are shown in figure 4. Each value represents the average measurements made at 24 different positions in each model. The results show that a 65 percent reduction in swelling was obtained for the impreg model. Similar values for reduction in shrinkage were obtained when the models were subjected to 30 percent relative humidity.

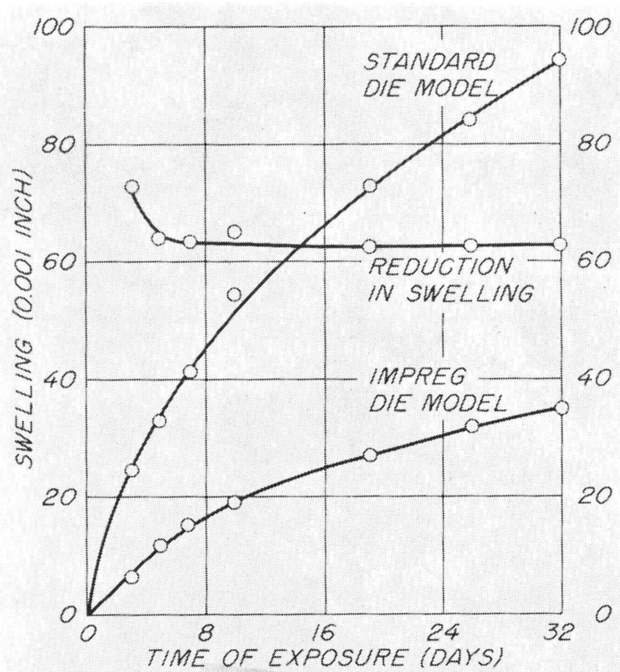
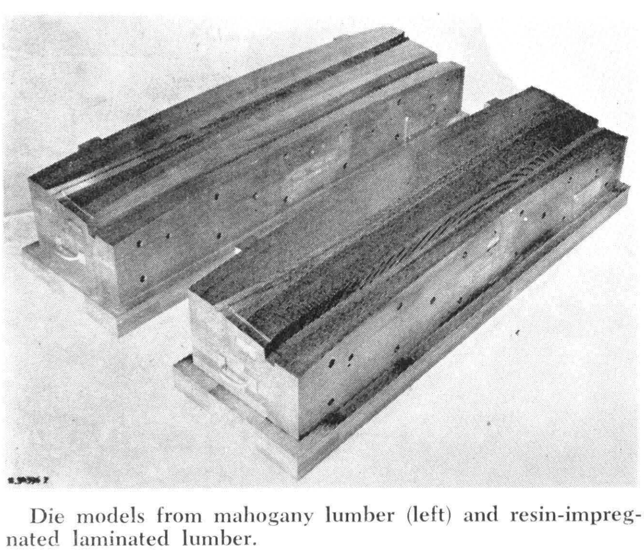


Figure 4.--

-Comparative dimensional changes of a die model made from mahogany lumber and one made from resin-impregnated laminated lumber. Data represent average of 24 measurements.



Die models from mahogany lumber (left) and resin-impregnated laminated lumber.

In the fabrication of models from untreated mahogany lumber, polyvinyl resin glues are currently being used for gluing the boards together. This type of glue depends on the partial loss of moisture to the wood; that is, the partial drying of the glue to give a good initial bond. Such a glue appears to be satisfactory for gluing untreated wood that will absorb moisture during the desired pressure period. This type of glue, however, was found to be unsatisfactory for the bonding of impreg panels, since the absorption of water by the treated wood is too slow and incomplete to give a good bond during the period of time that the material is clamped together. It has therefore been necessary to use a glue that does not depend primarily on the absorption of moisture by the wood to give a good glue bond. The various thermosetting resin glues, which harden or cure by undergoing a chemical reaction, naturally suggest themselves for such an application. Such glues, which are capable of reaction at normal room temperatures, are most desirable. Resorcinol resins or epoxy resins that set up at a room temperature of 70°F. or higher have proven satisfactory for this purpose when properly used.

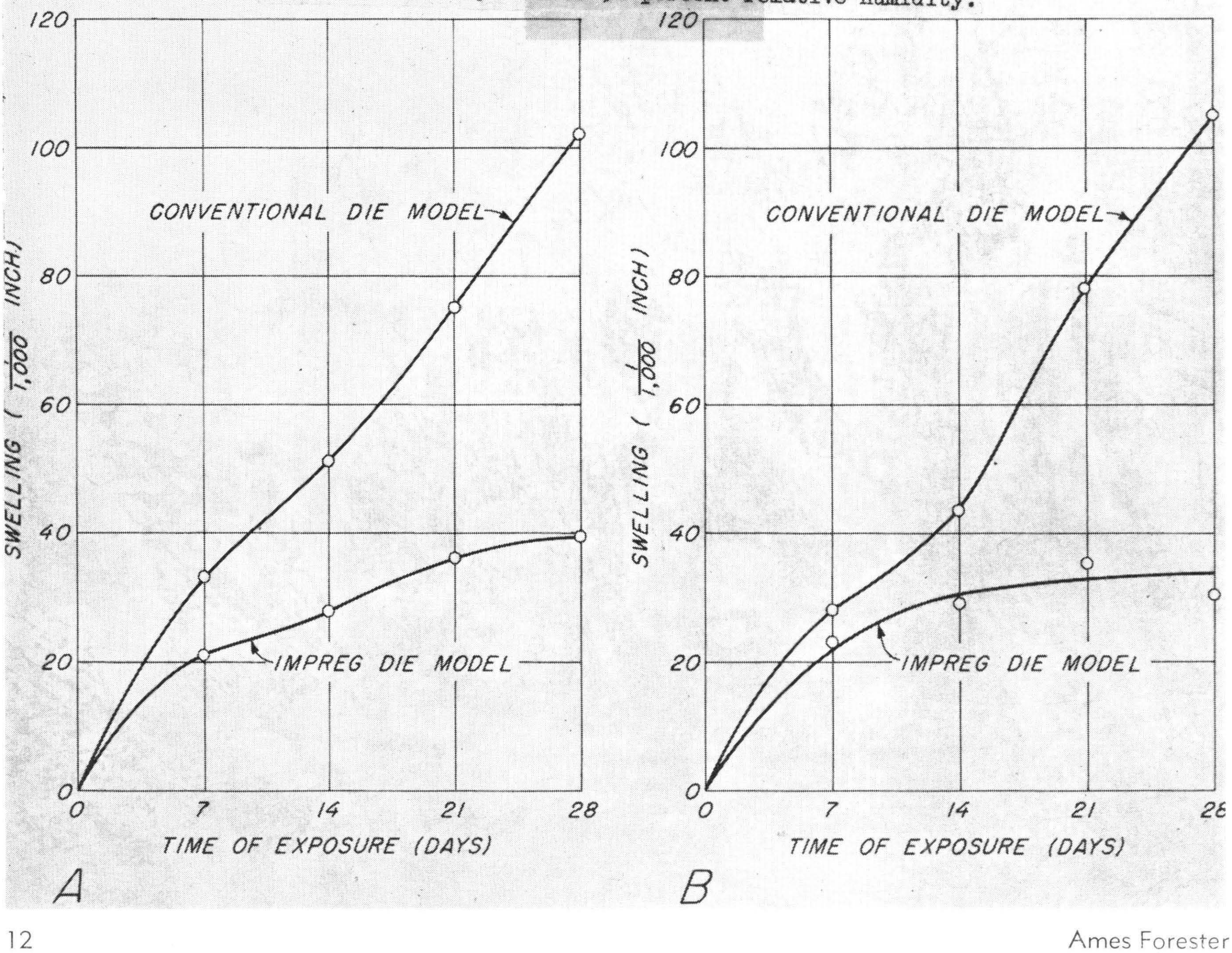
Tests conducted on the impreg die model made from the original 200 board feet of mahogany impreg and on the conventional die model made from mahogany lumber, showed that impreg is far superior to normal wood for this application. It was therefore desirable to further test the suitability of this material in larger die models. Consequently, two roof die models were made, one from impreg (fig. 5), and one from mahogany lumber. A roof model was chosen because it is one of the largest die models made, and also because experience has shown that it will change dimensions extensively due to moisture changes.

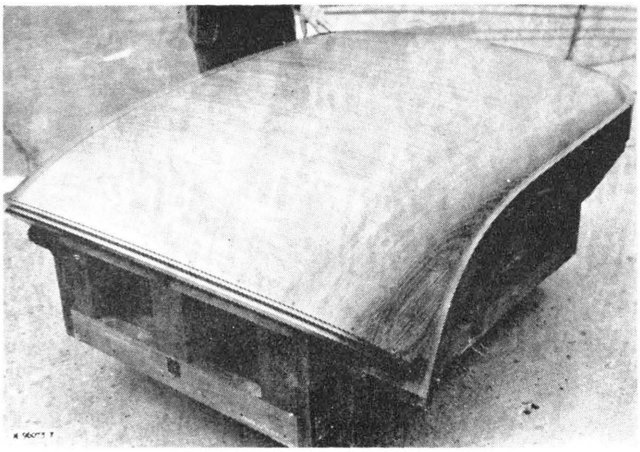
Comparative exposure tests at 90 percent relative humidity and at 80°F. were made at the Forest Products Laboratory on the two models. Dimensional changes were determined after each week of exposure for a period of 4 weeks. Comparable dimensional changes in the width and length directions of the two models are shown in figure 6. The reduction in swelling of the impreg die model as compared to that of the conventional die model is in close agreement with the results obtained on the smaller die models (upper back panels) previously tested.

Production Begins

For the construction of the roof die model and for various other tests, approximately 5,000 board feet of impreg panels were produced by Haskelite Corporation, Grand Rapids, Mich., and by Nickey Brothers, Memphis, Tenn., in cooperation with Koppers Company Wood Preserving Division, Orrville, Ohio. A second batch of 30,000 board feet of this material has been produced by these firms for the Ford Motor Company and manufactured under specifications set up by the Forest Products Laboratory. Plans are already being made for additional material. From this supply of material, each die-model shop and pattern shop in the Chicago, Milwaukee, and Detroit areas that makes models for the Ford Motor Company made experimental models. From their experience, there is no indication that it is any more difficult to make a model from impreg than from conventional mahogany lumber. In fact, there is

Figure 6.-- Comparative dimensional changes in, A, width, and, B, length of a roof die model made from mahogany lumber and one made from resin-impregnated laminated lumber when subjected to 90 percent relative humidity.





Roof die model of mahogany impreg.

every indication that it will be easier. Generally, no increased dulling of the tools was experienced while working with this new material, and the surface of the models made from impreg is easier to sand to a smooth finish than the surface of the models made from conventional mahogany.

Several die models for the 1956-model cars have been made from this material, and they are now at the various tool and die shops, where the hard dies are being Kellered from them. It is expected that no difficulty will be experienced. The use of models made from this material will enable the tool manufacturers to take from the die model as many plaster or plastic casts as desired without experiencing any changes of dimensions or extortion of the original model. Also, from a practical usage standpoint, the model will be dimensionally stable throughout its life.

The Ford Motor Company has made from impreg, wood crankshaft patterns that were used to make experimental shell-molded crankshafts. In this application advantage is taken both of the dimensional-stability and heat-resistant properties of this material, inasmuch as the pattern is heated for the duration of an hour to 400°F. before the mixture is set and resin is applied. No apparent disintegration of the impreg occurred after over 50 cycles of heating at these conditions, which will readily char and disintegrate untreated wood.

From the results of tests on patterns and die models made from impreg, and from the performance of die models currently being used, it is reasonable to expect that this dimensionally stable material will possible replace the six million board feet of conventional mahogany lumber that is used annually for pattern and die models that require a high degree of dimensional stability. The application of impreg for patterns and die models is an extremely important technological advance that promises to effect substantial reduction of cost and improvement in product quality.

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ABOUT THE AUTHOR . . .

Mr. Seborg graduated from Montana State College in 1928 with a B.S. degree. He came to the Forest Products Laboratory directly after graduating, and has been there since, except for a period of six months in 1945 when he was a member of the Technical Industrial Intelligence Committee which investigated the technical developments in the various branches of science in Germany.

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