

[54] **METHOD AND SYSTEM FOR DRYING WOOD EMPLOYING PAPER-REINFORCED, THERMOSETTING RESIN LAMINATE AND METHOD OF MAKING SUCH**

[75] Inventors: **Kenneth J. Denton**, Vancouver, Wash.; **John C. Groot**, Gladstone, Oreg.

[73] Assignee: **Simpson Timber Company**, Seattle, Wash.

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[51] **Int. Cl.²** **F26B 3/02; F26B 7/00**

[58] **Field of Search** **34/9.5, 13.8, 13.4, DIG. 19, 34/DIG. 21, 16.5, 94; 156/335; 161/263, 264; 21/7, 61, 62; 117/136**

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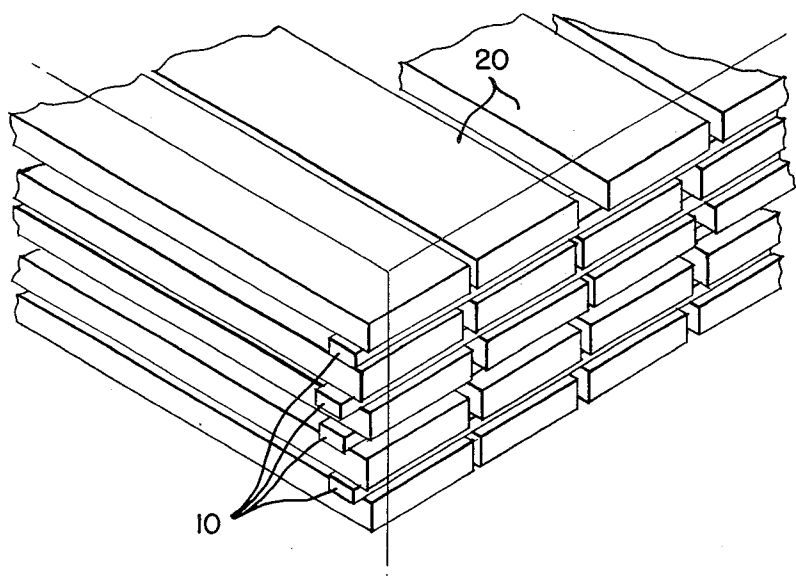
Primary Examiner—John J. Camby
Assistant Examiner—Henry C. Yuen
Attorney, Agent, or Firm—Seed, Berry, Vernon & Baynham

[57] **ABSTRACT**

An improved method and system of kiln-drying wood is disclosed wherein the courses of wood in a conventional drying kiln are separated by strong, dimensionally stable, re-usable kiln stickers made of paper-reinforced, thermosetting resin laminae having a thickness ranging from ¼ inch to 1 inch. Use of the laminated stickers enables increased kiln capacity, more uniform drying, and faster drying schedules. The laminated stickers have a longer production life compared with conventional wood stickers.

The laminate is made by saturating a resin-saturating paper with thermosetting resin, such as a phenol-formaldehyde resin or lignin-phenol-formaldehyde resin. A series of the resin impregnated sheets are stacked to provide the requisite thickness and heated under pressure of from 150–250 psi to 250°–350°F. to cure the resin.

2 Claims, 3 Drawing Figures



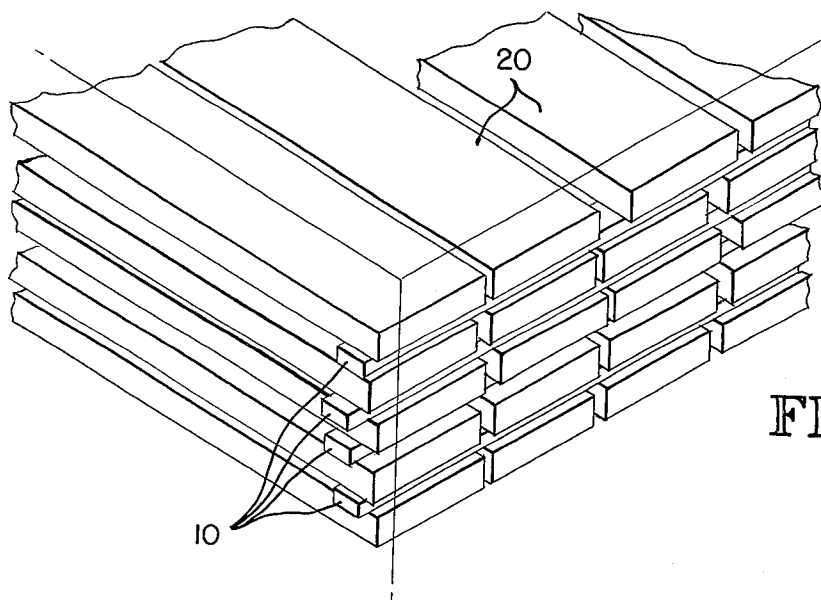


FIG. 1

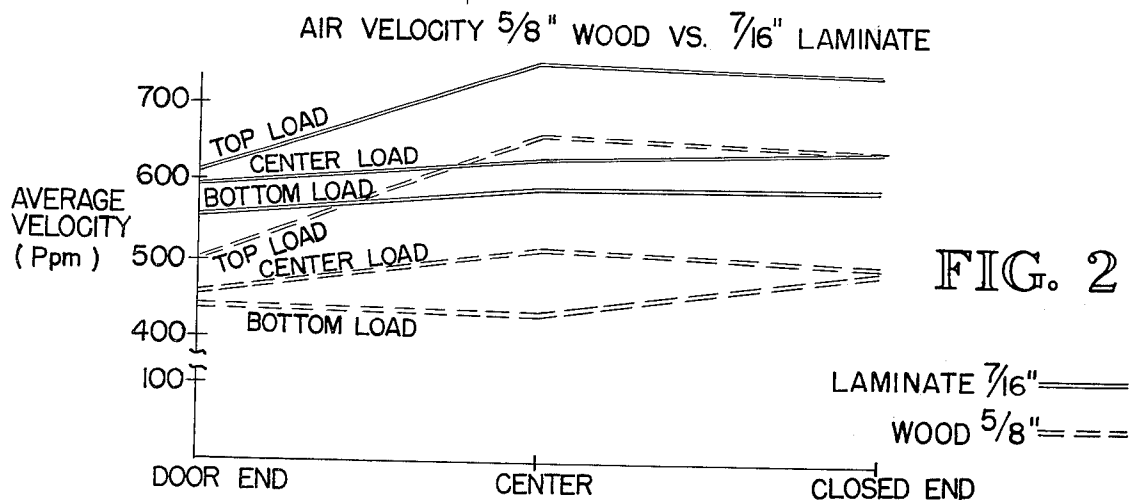


FIG. 2

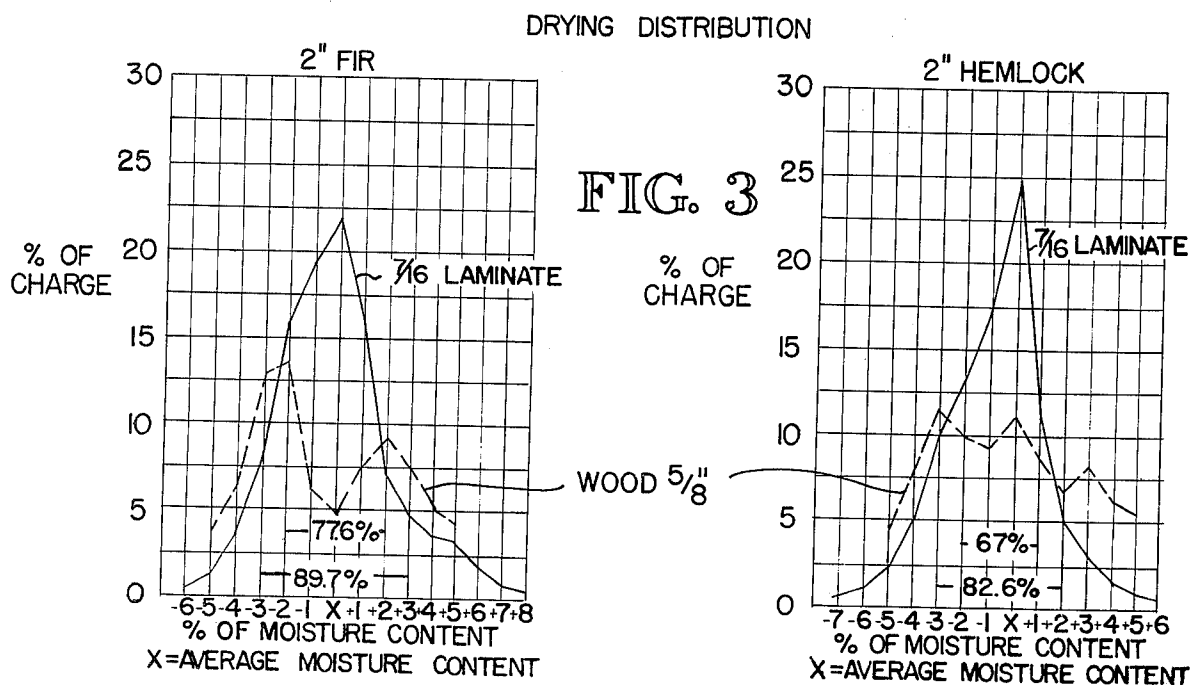


FIG. 3

METHOD AND SYSTEM FOR DRYING WOOD EMPLOYING PAPER-REINFORCED, THERMOSETTING RESIN LAMINATE AND METHOD OF MAKING SUCH

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to the method of making dimensionally stable, paper-reinforced, thermosetting resin laminates and their use in a system of kiln drying of green wood.

2. Prior Art Relating to the Disclosure

Traditionally, wood drying operations in wood drying kilns have utilized wood kiln stickers normally about three-fourths inch thick by 1½ inches wide and as long as necessary. The species of wood used for application as stickers varies according to type of mill and the geographical location. It is desirable to provide the straightest kiln sticker and, to do so, knot-free straight grain lumber having a large amount of sap is desired. This type of lumber has the highest cost raw material price of any grade lumber in any given sawmill. Such high grade lumber is required to resist warpage, twist, compression and deflection of the wood stickers when subjected to the extreme weight and environmental conditions that exist in normal kiln drying operations. Traditionally, most companies saw their own kiln stickers out of existing lumber stock. This disrupts normal production lines due to changeover for the specific purpose of manufacturing kiln stickers. The kiln stickers in the dry kiln environment are exposed first to an extremely wet condition and then, as the lumber in the kiln is dried, to a dry condition. This combination of wet and dry conditions plus the weight of the wood in the kiln reduces the strength of the wood kiln sticker by 30% to 40% and dries the sticker in a set condition. This results in warpage and compression. When the wood kiln stickers are subjected to subsequent cycles, this warped condition is accentuated and creates jam-ups in the automatic equipment used for loading and unloading the kilns. Re-use of wood kiln stickers also increases the compression set which occurs on the ends of each sticker and causes "domed" loads which reduce the size of the kiln charge that can be put into the kiln and can cause the kiln charge to overbalance and tumble. Further, re-use of wood kiln stickers reduces the efficiency of air passage through the spaces in the lumber load resulting in an increase of drying time to achieve standard dry conditions. Repeated drying cycles using wood kiln stickers eventually degrades the stickers to the point where they must be disposed of—normally a maximum of five to seven cycles.

Because of the problems associated with the use of wood kiln stickers, numerous attempts have been made to substitute different materials. Glass fiber-reinforced resin kiln stickers were tried but proved unsuitable.

SUMMARY OF THE INVENTION

The objects of this invention are to provide a method and system of drying wood using improved, dimensionally stable paper-reinforced thermosetting resin laminates as kiln stickers and to provide a method of making the same. Use of the laminates enable improvements in the drying process. The improved kiln stickers used in wood drying operations are not subject to compression or warpage when reused because of the density and water insolubility of the stickers. Virtually no

warpage of the laminated stickers occurs during the kiln drying operation because of the dimensional stability of the laminates. This results in dramatic reduced downtime caused by jamming of the automated equipment used for loading and unloading the dry kiln. Use of the laminated sticker enables clear and smooth air passage through the dry kiln over many cycles of use, thereby increasing the drying efficiency. The laminated stickers can be reduced in thickness compared to wood, because of their density and uniform strength. This enables more lumber per charge to be inserted into the dry kiln than previously possible.

The dimensionally stable paper-reinforced thermosetting phenolic laminates are made by (1) saturating a resin-saturating paper with a thermosetting resin such as a phenol-formaldehyde resin having a molar ratio of phenol to formaldehyde ranging from 1:1 to 1:3, a solids content of from 40% to 60% and a pH of from 9 to 11, or a ligninphenol-formaldehyde wherein the phenol in the phenol-formaldehyde resin is replaced by a sodium or ammonia type lignin (2) stacking a series of resin-impregnated sheets together until the desired thickness is obtained, and (3) pressing the stacked laminates together at a pressure of 150 to 250 psi at 250°–350°F. to cure the resin. The composition of the resin is such that an exothermic reaction is initiated during curing of the resin initially at or near the outer surfaces of the laminate and progressively inwardly which results in cure of the resin uniformly throughout the width of the product. Generally, paper-reinforced thermosetting laminates have been made rather thin and subjected to intensely high pressures at relatively high temperatures to insure adequate curing of the resin. In comparison, the resin utilized herein is one which undergoes an exothermic reaction when the outer surfaces of the laminate are heated to curing temperature to generate sufficient heat to trigger an exothermic reaction of the resin saturating the inner layers of resin-impregnated sheets. The resin in the laminate cures throughout the thickness thereof without the need of high pressures and temperatures.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial perspective view of the dimensionally stable paper-reinforced thermosetting phenolic laminated stickers separating courses of wood in a wood charge for insertion into a conventional dry kiln;

FIG. 2 is a graph illustrating improved air flow through a dry kiln using the kiln stickers of this invention compared to conventional wood stickers; and

FIG. 3 illustrates the improved drying distribution around average using the kiln stickers of this invention compared to wood stickers.

DETAILED DESCRIPTION OF THE INVENTION

inch, stickers of paper-reinforced thermosetting laminates may be made in any dimension as desired, but generally are from ¼ to 1 inch preferably three-eighths to seven-eighths inch thick, from 1 to 3 inches wide preferably 1½ inches and whatever length desired, generally 52 to 120 inches.

The kiln stickers of this invention are made by saturating paper of from 50 to 135 lb. basis weight with an essentially uncured, uncatalyzed phenol-formaldehyde or lignin-phenol-formaldehyde resin. The paper, such as a resin-saturating natural kraft paper, is immersed in a bath containing the resin, metered through squeeze

rolls to reduce the saturation to from 40%–60% wt. based on the weight of the paper, generally 47%–50%, and then partially cured by feeding it through an oven where high velocity heated air is impinging against the impregnated paper.

The resin used to impregnate the paper may be a phenol-formaldehyde or lignin-phenol-formaldehyde resin. The phenol-formaldehyde resin is made by reacting phenol with formaldehyde in a mole ratio of from 1:1 to 1:3 in the presence of an alkali such as sodium hydroxide at pH 9 to 11 until the viscosity ranges from 30 to 80 and generally 40 to 65 cps at 70°F. The resin is essentially water soluble and contains approximately 40%–60% resin solids. Surfactants such as tributyl-phosphate and others may be added in amounts ranging from 0.5% to 1.5% to the resin solution to obtain better impregnation of the resin into the paper.

Lignin compounds such as those marketed under the trade name "Orzan" by Crown Zellerbach Corporation may be substituted for the phenol content of the formaldehyde resin in amounts ranging from 0 to 90% lignin-to-phenol without significantly affecting the needed physical properties of the kiln stickers. This substitution enables a significant cost reduction in the kiln stickers.

After the resin-impregnated sheet is dried it is cut in lengths desired and stacked. A specific number of resin-impregnated sheets are required to produce a particular thickness of the final laminate. For example 85 sheets of 50 basis weight kraft paper impregnated to about 48% resin content are required to obtain a laminate having a thickness of seven-sixteenths inch. The required number of resin impregnated sheets are stacked and covered top and bottom with an impregnated paper designed for caul plates and placed in a conventional plywood hot press. The hot press is closed directly on the material and the laminate pressed at pressures ranging from 150 to 250 psi and 250°–350°F. for from 5 to 30 minutes. The pressing time and temperature depends on the thickness of the laminate. It is a distinct advantage of this invention to be able to make laminates of 1 inch or greater in thickness at relatively low pressures and temperatures in as little as 20 minutes. After pressing the laminate is removed from the press and cooled for about 12 minutes. A laminate seven-sixteenths inch thick can be pressed at 300°F. and 200 psi for 10 minutes following by a cooling cycle of 7 minutes. This is possible because of the resin system used wherein the heat from the press initiates an exothermic reaction in the resin impregnating the sheets of the laminate. This exothermic reaction generates sufficient heat to trigger an exothermic reaction of the resin in the middle and inner laminates sufficient to fully cure the resin throughout the thickness of the laminate at a relatively low temperature and pressure.

After cooling each laminate is sawed into strips of the required dimensions, generally 1½ inches wide and 50–52 inches long. The properties of a typical finished kiln sticker made as specified are as follows:

Specific Gravity	1.3 gm/cu cm
Modulus of elasticity	1,500,000 psi
Modulus of rupture	16,000 psi

Referring to FIG. 1 the kiln stickers 10 are utilized in conventional dry kilns wherein courses of lumber 20 to be dried are separated by the stickers laid crosswise to

the length dimension of the lumber. Tests conducted using the laminated kiln stickers have proved that the product has superior dimensional stability when compared to wood stickers resulting in fewer problems with the automatic stacking equipment, a key advantage in downtime. The high stiffness of the laminated stickers prevents warpage and permits thinner than normal stickers to be used thereby providing more courses in a charge and a greater amount of wood to be dried at one time. The constant thickness and dimensional stability of the laminated kiln stickers assures uniformly stacked wood. Air flow through the charge using the laminated kiln stickers is more uniform resulting in a more uniformly dried wood, and reduction in the number of pieces of wood which have to be redried. Reference to FIG. 2 illustrates the improved air flow through a dry kiln using 7/16 inch laminated kiln stickers compared to ½ inch wood stickers which have been subjected to about five cycles of operation.

Tests were conducted in Shelton, Washington, in dry kilns of the type manufactured by Moore, (double-track kiln, 107 feet long having separate internal motor-type kilns, which are run up to 210°F.). The dry kiln had been operated using 5/8×2½×52 inch stickers of Douglas fir placed in a modified Irvington sticker pattern. For the tests the laminated kiln stickers were placed using the same equipment in the same pattern. Moisture distributions were obtained by random sampling of boards from all kiln locations with a hand-held moisture detector. Using 7/16 inch thickness laminated kiln stickers rather than conventional ½ inch wood stickers the following increases in kiln capacity were realized:

2" × 4" lumber	9.1%
2" × 5" lumber	5.2%
1½" × 5" lumber	11.1%
1" × 4" lumber	12.5%

Normal drying schedules were maintained using the laminated kiln stickers even though more wood could be put in the kiln than with the conventional wood stickers. Laminated kiln stickers carried through 41 cycles showed no deterioration from the kiln environment. In no case were the laminated kiln stickers deteriorated by temperature, moisture, compression or uneven courses of lumber. Placement of the laminated stickers gave a remarkable improvement in reliability due to their dimension stability. Actual trial results showed a 91% reduction in jam-ups in the automatic equipment laying the stickers to separate the courses of lumber. Reference to FIG. 3 illustrates the improved drying uniformity obtained when drying 2 inches thick fir and 2 inches thick hemlock dimension lumber using 7/16 inch kiln stickers of this invention compared to ½ inch wood stickers.

A lignin-phenol-formaldehyde resin was prepared by heating together 668 lbs. phenol, 980 lbs. formaldehyde, 104 lbs. of a 50% NaOH solution, 100 lbs. water and 1684 lbs. of a sodium form of lignin (Orzan SL-50). The mixture was heated for about 1.5 hrs. at a temperature ranging from 90°C. to 180°C.

The kiln stickers were made using the lignin-phenol-formaldehyde resin and tested for the breaking strength, modulus of elasticity (MOE) and modulus of rupture (MOR) in comparison with kiln stickers made with paper-reinforced phenol-formaldehyde resin.

Kiln Stickers Using Phenol-formaldehyde			
Thickness	Breaking Strength	MOE	MOR
.487	365	1,528,846	24,467
.486	350	1,511,407	23,560
.486	400	2,210,000	22,250
.494	360	1,720,000	19,550

Kiln Stickers Using Lignin-phenol-formaldehyde			
Thickness	Breaking Strength	MOE	MOR
.488	360	1,342,000	20,050
.487	385	1,510,000	21,650
.485	365	1,540,000	20,595

The tests to date and the results demonstrate clearly that the laminated kiln stickers provide increased kiln capacity, highly uniform drying, extreme resistance to deterioration and measurable improvement in sticker placement.

The embodiments of the invention in which a particular property or privilege is claimed are defined as follows:

1. An improved method of kiln-drying wood comprising:
- providing a wood drying kiln,
 - separating courses of wood stacked in the kiln with kiln stickers of a dimensionally stable, paper-reinforced, thermosetting phenolic resin laminate which is resistant to deterioration under kiln conditions, has high resin content, a high modulus of

elasticity and upturn and a thickness ranging from ¼ to 1 inch, and

forcing controlled, heated air through the kiln to dry the wood therein, the kiln stickers increasing the drying efficiency and resulting in more uniformly dried wood.

2. A method of using a dimensionally stable, elongated, rectangular paper-reinforced thermosetting phenolic resin laminate of high resin content, high modulus of elasticity and rupture, a thickness ranging from ¼ to 1 inch and specific gravity greater than one gm./cu.cm. as a kiln sticker for separating courses of lumber stacked in a drying kiln, comprising:

- providing a first course of lumber to be dried,
- laying said elongated, rectangular, laminated kiln stickers crosswise to and at spaced intervals along the length dimension of the lumber, each kiln sticker having a length at least the width of the course of lumber,
- stacking a second course of lumber over the first course, said kiln stickers separating the two courses of lumber to allow air flow therebetween,
- repeating steps (2) and (3) until a charge of lumber to be dried is obtained,
- inserting the charge into a drying kiln, and
- forcing controlled drying air through the kiln and the lumber charge therein to dry the lumber, the kiln stickers, because of their dimensional stability under varying atmospheric moisture content and temperature conditions during the kiln drying cycle, resulting in a more uniform air flow through the kiln, reduction in the number of pieces of lumber to be redried and more uniformly dried lumber.

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