EFFECT OF WETTING AGENT ON DRYING CHARACTERISTICS OF 4/4 SUGAR MAPLE

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INTRODUCTION

The newly formed sapwood in trees is extremely permeable and, therefore, easy to dry. However, as sapwood becomes physiologically dead heartwood, extractives are deposited in the cell lumens and on the pit membranes and, in some species, tyloses are formed in the vessels (4). These extractives and tyloses tend to block the flow of fluids in wood, thus slowing the drying rate of heartwood.

One potential way to increase the permeability of heartwood and reduce drying time is pre-soaking green lumber in a wetting agent solution before kiln drying. Wetting agents, such as common detergents, can lower the surface tension of wood sap, and also may dissolve and remove the water-soluble extractives from the pit membranes. Chen and Simpson (2) found that soaking sugar maple and black walnut heartwood blocks (2"x2"x1") in a wetting agent for 1 week increased the subsequent drying rates in a controlled temperature and humidity chamber as moisture content was reduced to near and below the fiber saturation point (fsp).

This paper describes the effect of a wetting agent (common liquid detergent) on drying characteristics of 4/4 sugar maple lumber in a steam-heated dry kiln.

MATERIALS

Wood Samples

Five sugar maple (Acer saccharum Marsh.) trees (10 to 12 inches in dbh) from Crab Orchard National Wildlife Refuge near Carterville, Illinois, were selected for this study. A total of 20 boards (10 soaked and 10 controls) cut from the first log of each of the 5 trees were used in this study. Additional boards were cut from the second or third log of each tree to make a 600 board-foot stack for the dry kiln run.

Wetting Agent

The wetting agent solution was prepared by diluting 1 gallon of common liquid detergent (Cheer[1]) with tap water to make 40 gallons of solution (2).

EXPERIMENTAL PROCEDURES

1. One 4-inch board and one 6-inch board (boards 1 and 2) from one side of the first log of each tree were cut and soaked in a common detergent for 1 week before kiln drying. The other half of the log was saved to be cut after 1 week (Fig. 1). Green moisture content (MC) and dimension (thickness and width) were measured immediately after sawing and before soaking.

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[1]The use of trade names does not constitute endorsement by the USDA Forest Service.

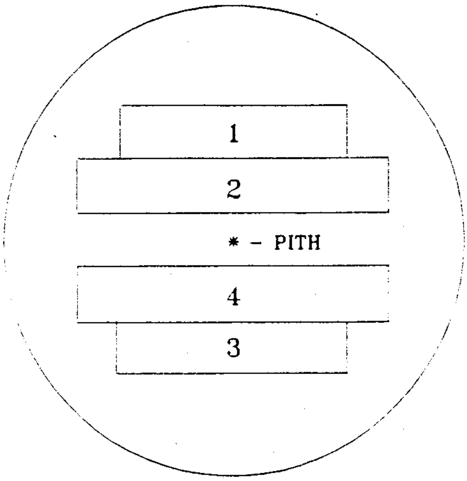

Figure 1. Location of boards: Boards 1 and 3 are 4 inches wide, and boards 2 and 4 are 6 inches wide.

2. Thickness and width measurements were taken 1 foot from one end and at midlength of each board.

3. After 1 week of soaking, boards were removed from the tank and left to drip dry for 2 hours before the moisture content was determined again.

4. On the same day the soaked boards were removed from the wetting agent solution, another 4-inch board and another 6-inch board (boards 3 and 4) from the other side of each first log were cut for controls (Fig. 1) . Green MC and dimension (thickness and width) were determined immediately after sawing.

5. Boards from the same log were stacked on the same row in the kiln; dummy boards were placed in between soaked boards and their matched controls.

6. The standard drying schedule T8-C3 (5) for 4/4 sugar maple was used to dry the lumber. Kiln fans were reversed every 2 hours throughout drying and conditioning.

7. The 10 soaked boards and 10 control boards (all 8 feet in length) were weighed every day (24 hours) until the end of drying.

8. At the end of drying and conditioning, the warpage (cup, twist, bow, and crook) of each board was also measured.

9. A series of paired t-tests was performed for the MC, shrinkage, and warpage measurements, and a split-plot ANOVA was performed for the daily drying rates throughout the entire drying.

RESULTS AND DISCUSSION

Effect on Initial Moisture Content

Soaking 4/4 sugar maple lumber in a wetting agent solution for 1 week increased the average initial moisture content (AIMC) less than 1% (Table 1). This is quite a contrast to the more than 21% increase in AIMC that Chen and Simpson (2) found in a previous study after soaking sugar maple blocks (2"x2"x1") in the same wetting agent.

Table 1. Average initial moisture contents (%) for 4/4 sugar maple lumber

Soaked		Control
Green	After soaking	Green
74.2	75.1^{ns}	78.0

NS - non-significant

We believe the reasons for the great difference in the two studies are: (1) In the previous study, trees were cut during the dry summer and only heartwood (with MC of 55.3%) was used (2); in the present study, trees were cut during spring when the sap began to rise, and both heartwood and sapwood were used. (2) When the soaked boards were removed from the wetting agent solution, they were left in the storage area to drip dry for 2 hours before the MC was determined. The delay in determining MC would definitely lower the AIMC for the soaked boards, which would explain the nearly 3% difference in AIMC between the soaked boards and the controls (Table 1).

Effect On Drying Rate

Contrary to what Chen and Simpson (2) found earlier, soaking 8-foot-long 4/4 boards in the same wetting agent solution for 1 week failed to produce a significant increase in the subsequent drying rate (% MC/hour) over that of controls (Table 2). We believe two reasons caused the results of the two studies to differ: (1) Surface area to volume ratio (SA/VOL) was at least 70% greater in the previous study than in the present one. The SA/VOL for the earlier study was 4, whereas the SA/VOL for the present study was 2.26 and 2.35 for 4-inch and 6-inch boards, respectively. The greater SA/VOL would facilitate the diffusion of wetting agent into wood. (2) The green MC in the present study was much higher (74.2%) than in the previous study (55.3%). The minor differences in moisture content between soaked and control lumber suggest that there was no mass absorption of wetting agent solution by the soaked sample boards in the present study (Table 1). Therefore, the wetting agent must have relied solely on the diffusion process to get into the 4/4 lumber. However, in the previous study, the 21% increase in MC due to soaking showed that both mass absorption and diffusion were present. More thorough displacement of wood sap by the wetting agent solution with lower surface tension would increase the subsequent drying rate. Chen (1) found that reduced polarity and surface tension in wood sap significantly reduced shrinkage and drying time in drying solvent-displaced red oak and cottonwood.

Table 2. Average daily moisture contents and drying rates for 4/4 sugar maple lumber.

Day of drying	Moisture content (%) Soaked	Moisture content (%) Control	Drying rate (% MC/hr) Soaked	Drying rate (% MC/hr) Control	% of soaked boards showing greater drying rate
1	48.0	48.3	1.1313	1.2410	30
2	37.8	38.3	0.4225	0.4138	50
3	31.0	32.1	0.2851	0.2588	80
4	23.6	24.9	0.3073	0.3019	80
5	16.3	18.0	0.3033	0.2866	80
6	14.5	16.1	0.0771	0.0795	10
7	6.7	8.3	0.3242	0.3238	50

Effect On Shrinkage

Soaking in a wetting agent solution at room temperature for 1 week before kiln drying significantly increased the thickness shrinkage and volumetric shrinkage of 4/4 sugar maple lumber, but not the width shrinkage (Table 3). The soaking removed a portion of water-soluble extractives, as evidenced by the darker color of the soaking solution at the end of the week. It appeared that these water-soluble extractives acted as bulking agents when sugar maple lumber was kiln dried at temperatures between 130 and 180°F. Demaree and Erickson (3) found that when redwood heartwood samples were dried at room temperature and 110°F, the quantity of extractives in wood was inversely related to volumetric shrinkage. They concluded that at low drying temperature the extractives act primarily as bulking agents. In our study, apparently, the extractives acted as bulking agents for sugar maple lumber even at relatively higher drying temperatures. The removal of these extractives by soaking caused a significant increase in volumetric shrinkage during subsequent drying.

In their previous study, Chen and Simpson (2) found that soaking hardwood blocks in a wetting agent solution for 1 week significantly increased the thickness and width shrinkage. Blocks in that study were dried in a controlled temperature-humidity chamber without any restraint from any direction. However, in the present study, the lumber was dried in a stack, which restrained some width shrinkage but increased thickness shrinkage somewhat.

Table 3. Summary shrinkage data for 4/4 sugar maple lumber.

	Thickness shrinkage	Width shrinkage	Volumetric shrinkage
		%	
Soaked	5.60**	8.24^{NS}	13.38**
Controls	3.88	8.54	12.10
5% LSD	1.06	0.38	0.87
1% LSD	1.53	0.55	1.26

** - significant at 1% level.
NS - non-significant.
LSD - least-significant difference.

Table 4. Summary warpage data for 4/4 sugar maple lumber.

	Cup	Twist	Bow	Crook
	- - - - - - - - - inch - - - - - - - - -			
Soaked	0.068^{NS}	0.207^{NS}	0.234^{NS}	0.377^{NS}
Controls	0.057	0.185	0.168	0.434
5% LSD	0.042	0.111	0.110	0.135

NS - non-significant.
LSD - least-significant difference.

CONCLUSIONS

Sugar maple lumber soaked in a wetting agent solution for 1 week did not dry faster than matched controls during subsequent kiln drying.

Soaking in a wetting agent solution for 1 week significantly increased the thickness and volumetric shrinkage, but did not alter the warpage properties of 4/4 sugar maple lumber during subsequent kiln drying.

RECOMMENDATIONS FOR FUTURE WORK

Our preliminary results indicate that soaking in a common detergent solution may be an effective means to increase drying rates of some refractory hardwood species. Therefore, we recommend that additional research be conducted to investigate effects of various wetting agent concentrations, soaking durations, and soaking temperatures on drying characteristics of refractory hardwood lumber.

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