Influence of sawing solution and pith location on warp in 2 by 4 lumber sawn from small-diameter loblolly pine stems

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Abstract

Pith location in loblolly pine 2 by 4's sawn from small-diameter stems was investigated as a contributing factor toward warp and lumber degrade. Mean bow values were significantly higher, and mean lumber grade based on bow was significantly worse for lumber that did not contain pith and lumber that contained pith along one wide face than for lumber that contained pith in the center. Mean twist values were significantly higher, and mean lumber grade based on twist was significantly worse for lumber that contained pith, either at the center or centered along one wide face. Overall lumber grade, based on warp, was not significantly different among the three pith location categories investigated herein.

Background

As part of plantation pine forestry in the southern region of the United States, forest stands are often thinned at approximately 10 to 12 years of age. This forest management scheme helps trees concentrate on height growth while they are young; then after thinning, the trees continue to grow in height and rapidly increase in diameter. Ultimately, the stands of trees are harvested as chip-n-saw timber, sawlogs, poles, or similar. The small-diameter pine thinnings have traditionally been utilized as pulp chips. Another use for the small stems is as lumber. Rapid and efficient conversion of the woody stems is possible through high-speed, optimized sawing equipment facilities. Much of the high-speed sawing equipment was developed in Canada to convert small-diameter spruce, pine, and fir trees to lumber. These sawing systems operate at line speeds on the order of 2.3 m per second[1]. They focus on high stem-per-minute counts and aggressive interpretation of wane rules in order to increase production; because each single stem contains less given wood fiber, more stems must be processed per unit time. **Figure 1** illustrates three sawing solutions and their respective impacts on pith location in lumber. **Figure 2** illustrates a package of the lumber at the sawmill.

Geometrically, southern pine thinnings are similar in form to the small-diameter Canadian trees. As such, the pine thinnings are readily processed through the high-speed optimized sawing equipment. The southern pine trees however have significantly faster rates of growth and greater proportions of juvenile wood, often up to 100 percent, based on the fact that the transition from juvenile to mature wood typically occurs through approximately age 20[2]. Juvenile wood exhibits erratic and excessive differential shrinkage, which leads to warp and distortion. Thus, lumber sawn from the southern pine thinnings is highly susceptible to warp.

Objective Statement

The objective of this study was to investigate the influence of pith location on warp in lumber sawn from small-diameter loblolly pine trees.

Procedure

A cooperating mill was selected in central Mississippi. The mill converts loblolly pine thinnings into lumber. Because their tree diameters are small, 3.5 inches small end, and they

[1] Bowyer, J.L., R. Shmulsky, and J.G. Haygreen. 2002. Forest Products and Wood Science and Introduction, 5th ed. Blackwell Publishing, Ames, Iowa. pp. 343.

[2] Bowyer, J.L., R. Shmulsky, and J.G. Haygreen. 2002. Forest Products and Wood Science and Introduction, 5th ed. Blackwell Publishing, Ames, Iowa. pp 118-119.

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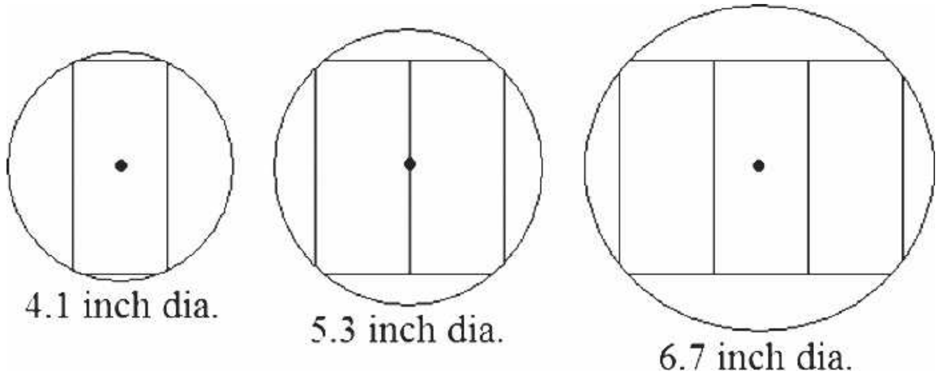

Figure 1. — Example of three sawing solutions, and their associated pith locations, for 2 by 4's from small-diameter trees.

Figure 2. — Photograph of green 2 by 4 lumber sawn from small-diameter loblolly pine thinnings (photo courtesy D.L. Buckner).

only produce 1 by 4-, 2 by 3-, and 2 by 4-inch lumber, they have a small number of sawing solutions. In general, these solutions produce 2 by 4's with either 1) pith centered in the cross section of the board, 2) pith at the edge of the cross section of the board (whereby it runs lengthwise along the center of one wide face), or 3) no pith in the cross section (but otherwise closely associated thereto), see **Figure 1** and **Figure 2**.

Lumber for three charges of 2 by 4-inch, 8-foot long freshly sawn (within 24 h) pine was delivered to Starkville, Mississippi. Each charge was 11 courses high with 10 pieces per course for a total of 586 board feet (BF) per charge. Lumber for charges 2 and 3 was dead packed and sprinkled with water to prevent drying during staging. All lumber was dried within 8 days of receipt. The mill suggested a schedule of: 4 hours ramp time to 220 °F, followed by 20 hours of drying. The wet-bulb temperature was not controlled, and airflow was approximately 1000 feet per minute of airflow. After drying, the first charge appeared over dried, as compared to the target average moisture content (MC) of 14 to 15 percent, so the total times on the second and third charges were cut back to 16 and 14 hours, respectively.

After kiln-drying, each piece of wood was reweighed, and dry MC was taken with a capacitance-type meter that was calibrated for southern pine lumber. To that end, dry pieces

Table 1. — Summary statistics (mean) for individual board weights (kg) and MCs (percent).

	Initial weight (kg)	Final weight (kg)	Initial MC (%)	Final MC (%)
Charge 1	10.2 (1.07)[a]	5.1 (0.54)	124 (26.6)	11.2 (3.79)
Charge 2	10.5 (0.78)	5.0 (0.62)	133 (25.5)	10.3 (2.99)
Charge 3	10.2 (0.94)	5.1 (0.48)	122 (22.3)	11.4 (2.11)
Total	10.3 (0.95)	5.1 (0.55)	126 (25.2)	11.0 (3.07)

[a]Values in parentheses reflect the mean SD.

were measured for maximum crook, bow, and twist on a flat and true warp table. Care was taken to be as fair and consistent as possible in the measurement technique from board to board. The following procedure was used for warp measurement: 1) Each piece was positioned on a warp table to examine the extent of each warp type. 2) If the amount of warp appeared so small that a meaningful determination seemed implausible, a judgment of "no warp" was assigned. 3) When a measurement was judged to be required it was made via insertion of a calibrated inclined plane wedge. With the wedge inserted to the point of mild refusal, the reading was read off the calibrated vertical face of the wedge. This measurement scheme was developed previously and has been used with success[3,4]. As each board was measured for warp, pith location was noted as center, edge, or none. These data were then analyzed with a general linear model to determine if pith location (a function of sawing solution) influenced warp. Lumber was then graded as No. 1, 2, 3, or 4 based on its straightness characteristics for crook, bow, and twist, and then the worst grade was selected as the overall grade of the board.

Results

Summary statistics for weights and MCs are shown in **Table 1**. The average MC value of the lumber was 11 percent. Analysis of variance indicated that average MC values among the three different locations of pith were not statistically different, p-value: 0.4811. Analysis of variance indicated that average MC values among kiln charges were statistically different, p-value: 0.0229. Average green MC of lumber was 126 percent, with a standard deviation of 25.2 percent. **Table 2** shows summary statistics by pith location for each charge. Pith location was statistically significant with respect to the

[3] Shmulsky, R. and D. Butler. 2005. Shrinkage and grade retention in restraint dried thick dimension loblolly pine. Forest Prod. J. 55(11):34-36.

[4] Shmulsky, R., R.W. Erickson, P.H. Steele, and D.L. Buckner. 2005. Warp reduction of SYP lumber by restraint drying. Forest Prod. J. 55(9):37-41.

mean level of bow, p-value: 0.0294. Boards with no pith or pith at the edge of the board were not significantly different, but both had significantly greater mean bow than boards with pith in the center. Pith location was also statistically significant with respect to the mean level of twist, p-value: 0.0001. Boards with pith located at either the center or the edge were not significantly different but both had significantly greater mean twist than boards with no pith. Pith location was not statistically significantly with respect to mean crook, p-value: 0.4506. **Table 3** shows the mean separation among pith locations by warp type as crook, bow and twist.

Pith location was statistically significant with respect to lumber grade based on bow, p-value: 0.0241. There again, boards with no pith or boards with pith at the edge were not significantly different, but both were of significantly lower grade than lumber with boards with center pith. Pith location was also statistically significant with respect to lumber grade based on twist, p-value: 0.005. There again, boards with pith located at either the center or the edge were not significantly different, but both were of significantly lower grade than lumber with no pith. Pith location was not statistically significant with respect to mean lumber grade based on crook, p-value: 0.5803. Pith location did not significantly affect mean overall grade, p-value: 0.9044. **Table 4** shows the mean separation among pith locations with respect to mean grade of crook, bow, twist, as well as the overall grade. **Figure 3** illustrates the overall grade distribution with respect to pith location for the lumber in the three charges.

In summary, lumber with pith in the center had significantly less mean bow than lumber that contained pith on the edge or lumber that contained no pith, p-value: 0.0294. This sawing difference significantly reduced grade, based on bow, for lumber that contained no pith (mean grade: 1.47) or lumber that contained pith on the edge (mean grade: 1.39) as compared to lumber with pith in the center (mean grade: 1.17), p-value = 0.0241. Lumber with no pith had significantly less mean twist than lumber that contained pith, either center or edge, p-value: 0.0001. This difference significantly reduced grade, based on twist, for lumber that contained pith mean grades based on twist 1.66 and 1.49) as compared to lumber that did not contain pith (mean grade based on twist: 1.24), p-value = 0.0005. With respect to pith location, mean crook, grade based on crook, and overall grade were not statistically different. This finding suggests that sawing solution has no impact on grade recovery based on warp. All lumber produced from these small trees is more-or-less equally prone to warp.

Table 2. — Summary statistics, number of pieces and (percent), by pith location for each charge.

	Pith in center	Pith at edge	No pith
		(%)	
Charge 1	11 (10%)	48 (44%)	51 (44%)
Charge 2	32 (29%)	19 (17%)	59 (54%)
Charge 3	28 (25%)	26 (24%)	56 (51%)
Total	71 (22%)	93 (28%)	166 (50%)

Table 3. — Influence of pith location on mean warp measurement.

	Crook[a]	Bow[a]	Twist[a]
Pith at center	0.23 (A)	0.24 (B)	0.31 (D)
Pith at edge	0.23 (A)	0.34 (C)	0.26 (D)
No pith	0.25 (A)	0.35 (C)	0.16 (E)

[a]Within each column, T-groupings for mean with the same letter are not statistically different at the $\alpha = 0.05$ level

Table 4. — Influence of pith location on mean individual board grade based on warp.

	Crook grade[a]	Bow grade[a]	Twist grade[a]	Mean[a]
Pith at center	1.56 (A)	1.17 (B)	1.66 (D)	2.14 (F)
Pith at edge	1.63 (A)	1.39 (C)	1.49 (D)	2.16 (F)
No pith	1.69 (A)	1.47 (C)	1.24 (E)	2.16 (F)

[a]Within each column, T-groupings for mean with the same letter are not statistically different at the $\alpha = 0.05$ level.

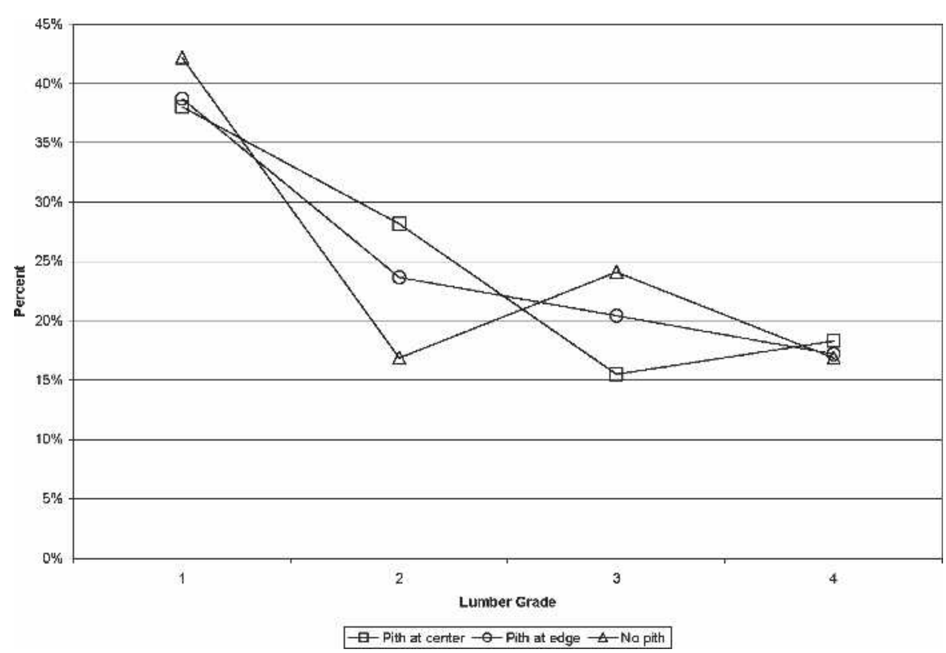

Figure 3. — Grade distribution of lumber within each pith-location category, following drying.