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Increased STUD Grade Yield of Plantation Southern Pine by Saw-Dry-Rip

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Abstract

Saw-Dry-Rip (SDR) is a simple process. Small, 8- to 12-inch logs are live sawn (through and through on the same plane) into 7/4 thick flitches, dried, and then ripped to the desired widths. In this study, SDR is compared with conventional cant sawing, the industry norm, in regard to type and amount of warp of processed studs. The capacity of SDR to process more than one species simultaneously is also discussed.

SDR significantly increased the production of STUD grade lumber from plantation-grown loblolly pine. SDR caused an increase of 11 to 16 percent in graded yields compared to conventional cant sawing. After 120 or more days of storage, the SDR material yielded 8 to 10 percent more STUD grade pieces compared to conventionally sawn studs. Conventional drying (maximum temperature 190 °F) resulted in higher STUD grade yields than high temperature drying (maximum temperature 240 °F). Conventional drying yielded 4 to 5 percent more STUD grade pieces compared to high temperature drying initially, but only 1 percent more after storage.

Keywords: Southern pine, loblolly, *Pinus taeda,* studs, warp, SDR, sawing, kiln drying, high temperature drying

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Increased STUD Grade Yield of Plantation Southern Pine by Saw-Dry-Rip

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Introduction

Southern pine has long been a mainstay construction material in the eastern and southern United States. It is recognized for its superior strength characteristics. However, if improperly manufactured, southern pine is prone to warp. After World War II the southern pine industry made a great effort to increase the quality of lumber through the establishment of strict grading rules (Southern Lumberman 1985a). Since that time the timber resource has changed to mostly second or third growth, much of which is plantation grown. The current resource is being harvested at an earlier age than it had been in the past, and therefore contains a higher percentage of juvenile wood (Senft et al. 1985). The problems that accompany juvenile wood, such as warp, have renewed the southern pine industry's concern about lumber quality (Donnell 1985, Random Lengths 1985, Southern Lumberman 1985b). Poor manufacturing quality and lack of lumber stability of southern pine have in some cases resulted in the loss of southern pine lumber markets to other species.

Considerable research has been conducted on southern pine to try to reduce warp and increase the yield of STUD grade material. Hallock (1965) tried to reduce warp in second-growth loblolly pine by the improved FPL Scragg method of sawing. Koch (1971, 1974) tried several different approaches to overcome warp and instability in southern pine, which included oversizing the 2 by 4 blanks in both width and thickness, and using heavy top weights on kiln packages, serrated kiln sticks, and high temperature drying. While Hallock's and Koch's efforts resulted in better quality studs and structural lumber, the processes did not yield amounts of lumber equivalent to that produced by conventional processing.

Since the Saw-Dry-Rip (SDR) process (fig. 1) has successfully produced straight, stable lumber from low- to medium-density hardwoods, we hypothesized that this method would increase the quality of southern pine lumber. In ponderosa pine, SDR successfully increased the yield of STUD grade material over that produced by conventional cant sawing (fig. 2) (Maeglin and Boone 1983). Moreover, SDR has the capacity to process hardwoods and softwoods simultaneously. This report details the results of research using SDR on plantation-grown loblolly pine (*Pinus taeda* L.) from eastern Texas.

Methods and Materials

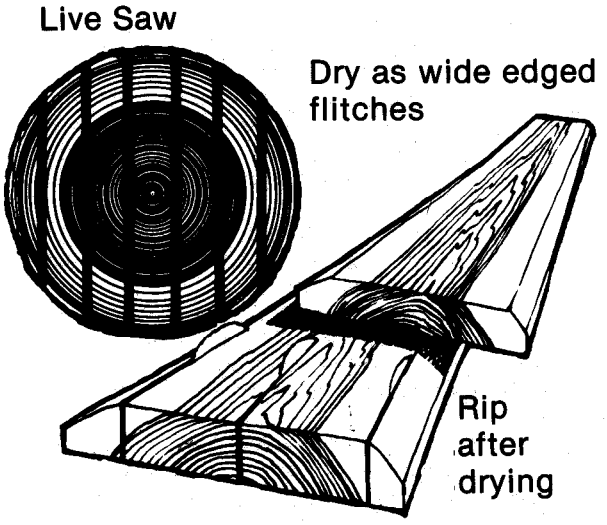

Figure 1—The SDR process: small logs are live sawn into 7/4 flitches; flitches are lightly edged for a compact kiln load, dried, and ripped to desired final length. (M146 219)

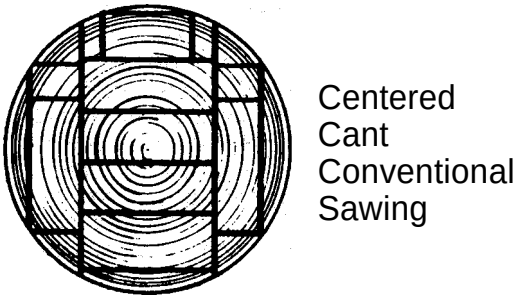

Figure 2—Conventional centered cant sawing pattern. (ML86 5279)

We compared conventionally sawn and SDR processed southern pine studs dried at conventional and high temperatures. Studs were measured for warp (crook, bow, and twist) immediately after processing and 120 or more days after storage.

Design

The study design was a 2 by 2 factorial: two sawing and two drying methods (table 1). The sawing methods were centered cant sawing, designated "conventional," and live sawing (through and through on the same plane), designated "SDR." The drying methods were conventional (temperature not above 190 °F) and high temperature (240 °F) drying. Two runs of each sample combination were used to avoid data loss in case of kiln malfunction.

Codes used for treatment combinations were: conventional sawing-conventional drying = CC, conventional sawing-high temperature drying = CH, SDR live sawing-conventional drying = SC, and SDR live sawing-high temperature drying = SH.

The sample size for study was determined statistically from previous studies of both hardwoods and ponderosa pine. The desired limit for sampling was a detectable difference of 5 percent with a confidence of 95 percent. For this limitation the sample size is about 18 logs. Twenty logs for each of the four treatment combinations were selected for study, giving a probability of detecting a 5 percent difference in stud acceptance at slightly more than 95 percent.

Table l-Log distribution per treatment. Two by two factorial with 20 logs per treatment

Sawing method	Drying method			
	Conventional		High temperature	
	Run 1	Run 2	Run 1	Run 2
Conventional centered cant	10	10	10	10
SDR live sawn	10	10	10	10

Sample Material

Loblolly pine (*Pinus taeda* L.) logs were obtained from eastern Texas. These fairly fast-grown, second-growth logs were shipped to the Forest Products Laboratory (FPL) in Madison, WI, in 40-foot lengths. The logs were stored under water spray for nearly 1 year, and then bucked to 8-foot 4-inch lengths before further processing.

One hundred and twenty 8- to 12-inch-diameter logs were measured for large and small end diameter and numbered. Random numbers were used to select the 80 sample logs. First, 40 logs were selected and the average diameter determined for each 20-log group. Then, a second group of 40 logs was selected and individual logs were replaced to balance the average log diameters with the first two 20-log groups.

Sawing

The conventionally sawed studs were cut using the centered cant method and split taper sawing (fig. 2) (a 4-inch cant is located in the geometric center of the log). Side flitches were ripped into stud size while green.

Logs processed by SDR were live sawn (fig. 1) into nominal 2-inch-thick flitches (7/4), using full taper sawing with a minimum 4-inch opening face. The flitches were lightly edged for a compact kiln load.

All studs and flitches were numbered for log and piece, and end trimmed before drying.

Drying

Lumber or flitches for each kiln charge was stacked on 3/4-inch stickers spaced 2 feet apart forming a pile about 4 feet wide and 3 feet high. All loads were top weighted with 30 pounds per square foot (Ib/ft^2) of iron to minimize warp in the top courses.

High temperature drying was based on a schedule of about 20 hours at 240 °F dry bulb temperature (DBT) and 180 °F wet bulb temperature (WBT), with air speeds through the load of 800 feet per minute (ft/min). This was followed by an equalizing period of about 20 hours at 180 °F DBT/170 °F WBT. An average moisture content (MC) of 12 ± 3 percent was the goal. At least three sample boards were used to monitor drying in each kiln load.

The conventional drying schedule followed FPL T13-C6 (Rasmussen 1961), starting at 170 °F DBT/155 °F WBT and finishing at 190 °F DBT/145 °F WBT, with air speeds through the load of 400 ft/min. Our target MC of 12 ± 3 percent was reached after about 93 hours. An 8-hour equalizing period (180 °F DBT/ 170 °F WBT) followed, for a total drying time of 101 hours. Three sample boards were used to monitor drying in each kiln load.

Sample Processing

After drying, all 2 by 4 studs were finish planed to American Lumber Standards (ALS) dimensions.[1] All SDR flitches were ripped to the ALS widths plus 1/8-inch planing allowance; e.g. 3-5/8 inches, 2-5/8 inches, and 1-5/8 inches. Each dried flitch was ripped to obtain its maximum yield, with emphasis on 2 by 4's. Any flitch yielding a 2-by-3/2-by-2 combination was cut to 2 by 4 dimension sacrificing yield. As each piece was ripped it was renumbered on the ends before planing to ALS dimensions.

All materials in a sample group were measured for MC and warp after planing. Moisture content was measured using an electronic resistance moisture meter. The probes were driven into each stud to a depth of 3/8 inch. Measurements were taken at three locations on each piece: 12 to 18 inches from each end and about in the middle. All knots and general defects were avoided when measuring MC.

Warp measurements were crook, bow, and twist. Crook is a deviation, edgewise, from a straight line drawn between board ends. Bow is a deviation, flatwise, from a straight line drawn between board ends. Twist is a deviation flatwise, or flatwise and edgewise, in the form of a curl or spiral.

Warp was measured using a flat table and calibrated wedges, recording to the nearest 1/32 inch.

Remeasurement After Storage

The measured studs were close piled, metal strapped and stored in a covered shed, thus exposing the material to ambient outside air conditions. After 120 or more days of exposure, the studs were remeasured for warp to evaluate their stability.

Analysis

Nonparametric analysis of variance was used to evaluate the effect of treatment on average crook, bow, and twist, and on the number of rejects per treatment. The basis for rejection of studs was the STUD grade warp limits of the National Grading Rule (Southern Pine Inspection Bureau 1977, U.S. Department of Commerce 1970). Any piece not meeting the STUD grade warp requirements was rejected.

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[1]American Lumber Standards dimensions are 2 by 4 = 1.5 in by 3.5 in; 2 by 3 = 1.5 in by 2.5 in; 2 by 2 = 1.5 in by 1.5 in.

Results

A total of 506 pieces were cut from the 80 logs. The average small end diameter of the logs was 9.3 inches, ranging from 7.1 to 11.0 inches. The small end diameter of SDR-treated and conventionally sawn logs averaged 9.25 inches and 9.33 inches, respectively. The volume of SDR-treated and conventionally sawn logs was 172 and 176 cubic feet, respectively, and the volume yields of lumber were 1,278.2 and 1,259.3 board feet, respectively (table 2).

Crook

Treatment markedly affected the amount of crook in the lumber produced. For all stud sizes combined, the average crook per treatment was CC-7/32, CH-8/32, SC-about 3/32, and SH-3/32 inch (table 3). The average crook for 2 by 4's only was CC-7/32, CH-8/32, SC-about 3/32, and SH-about 3/32 inch (table 4).

At the initial measurement, the number of studs rejected because of crook varied from 25 percent for treatment CH to only 8 percent for SC. After storage, the rejects due to crook varied from 21 percent for CC to 11 percent for SH (fig. 3).

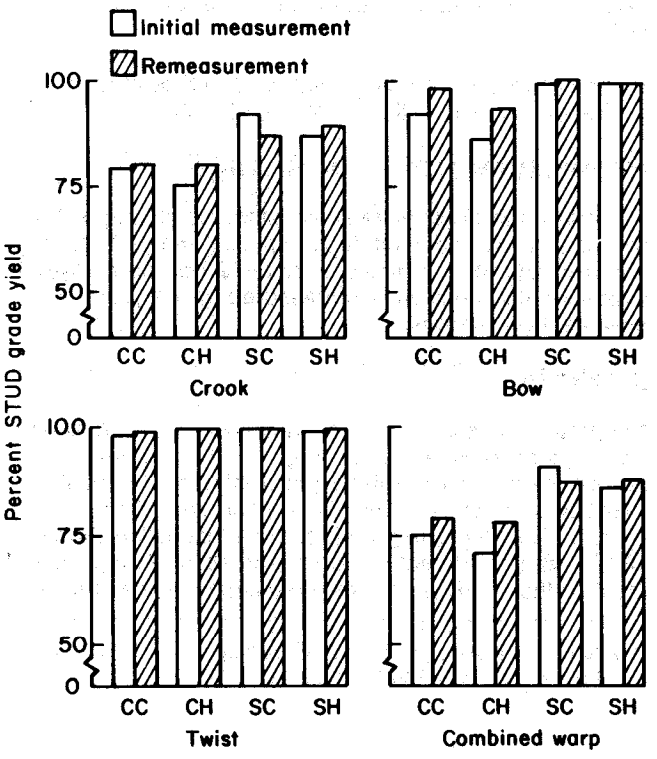

Figure 3—Percent yield of STUD-grade treated wood according to warp type and combined warp. Treatment abbreviations: CC, conventional sawing/conventional temperature drying; CH, conventional sawing/high temperature drying; SC, SDR/conventional temperature drying; SH, SDR/high temperature drying. (ML86 5214)

Bow

Bow was noticeably affected by treatment. The average bow for all stud sizes combined was CC-about 5/32, CH-about 7/32, SC-nearly 4/32, and SH-nearly 4/32 inch (table 3). Average bow for 2 by 4's only was CC-about 5/32, CH-about 8/32, SC-about 4/32, and SH-about 3/32 inch (table 4).

At the initial measurement, the number of studs rejected due to bow alone varied from 14 percent for CH to 1 percent for both SC and SH. After storage the rejects due to bow varied from 7 percent for CH to 0 percent for SC (fig. 3).

Twist

Like most species, loblolly pine is not prone to twist. Twist was only slightly affected by treatment. The average twist for all stud sizes combined was CC-about 2/32, CH-about 2/32, SC-about 2/32, and SH-1/32 inch (table 3). Average twist for 2 by 4's alone was CC-about 2/32, CH-about 2/32, SC-2/32, and SH-1/32 inch (table 4).

The percentage of studs rejected because of twist was very low. At the initial measurement, 2 percent of CC-treated studs and 1 percent of SH-treated studs were rejected. After storage, the only treatment group with rejects due to twist was CC, with 1 percent rejects (fig. 3).

Combined Warp Effects

Lumber is rejected for STUD-grade material according to the total amount of warp, i.e. the combination of crook, bow, and twist. There is usually no overlap between warp type in pieces that are rejected; for example, a piece rejected for crook most often will not be rejected for twist as well. Consequently, in our study there were more rejects because of combined warp than due to any individual warp type. The percentage of rejects for combined warp initially varied from 29 percent for CH to 9 percent for SC. After storage the rejects varied from 25 percent for CC to 12 percent for SH (fig. 3).

Drying Effects

The effects of drying were not as evident as the effects of sawing. With conventional sawing, high temperature drying (CH) initially resulted in higher levels of crook and bow, and a greater number of rejects for the combined stud sizes compared to conventional temperature drying (CC). The relationship of drying temperature to warp and percentage of rejects was the same after storage, except that CH had one less reject than CC. For the SDR live sawn material, there were only slight differences due to drying temperature and these were not consistent (table 3).

Table 2—Log and lumber data by treatment far loblolly pine

Treatment[1]	Average small end log diameter	Log volume		Total lumber volume	Volume by piece			Lumber recovery factor[2]	Average moisture content
		Average	Total		2 by 2	2 by 3	2 by 4		
	In	Ft^3		*Fbm*	*Pct*				*Pct*
CC	9.33	4.28	85.6	650.8	1.7	0.6	97.7	7.6	10.1
CH	9.33	4.39	87.8	608.5	1.8	3.3	94.9	6.9	9.5
SC	9.25	4.42	88.4	642.6	8.0	8.7	83.3	7.3	10.9
SH	9.26	4.31	86.2	635.6	4.7	9.4	85.9	7.4	10.1
Conventional sawing	9.33	4.40	176.0	1,259.3	1.7	1.9	96.4	7.1	9.8
Saw-Dry-Rip live sawing	9.25	4.30	172.0	1,278.2	6.3	9.1	84.6	7.4	10.5

[1]Treatment abbreviations: CC = conventional sawing–conventional drying, CH = conventional sawing-high temperature drying, SC = Saw-Dry-Rip live sawing-conventional drying, SH = live sawing-high temperature drying.

[2]Lumber recovery factor (LRF) = total lumber volume/total log volume.

Table 3—Warp average, range, and number of rejects by treatment for loblolly pine. All stud sizes combined (2 by 2, 2 by 3, 2 by 4)[1]

Warp	Conventional sawing						Saw-Dry-Rip live sawing					
	Conventional drying (CC)			High temperature drying (CH)			Conventional drying (SC)			High temperature drying (SH)		
	Average	Range[2]	Rejects	Average	Range[2]	Rejects	Average	Range*	Rejects	Average	Range[2]	Rejects
	[3]1/32 in		*No.*	*[3]1/32 in*		*No.*	*[3]1/32 in*		*No.*	*[3]1/32 in*		*No.*
					INITIAL MEASUREMENT							
Crook	7.0	68	26	7.9	98	30	3.3	46	11	3.0	22	17
Bow	5.3	45	10	7.3	52	16	3.7	19	1	3.8	25	1
Twist	2.2	23	2	1.6	10	0	1.5	10	0	1.1	17	1
					REMEASUREMENT AFTER STORAGE							
Crook	6.1	58	25	6.6	80	24	3.2	38	17	3.2	36	14
Bow	3.8	36	2	5.5	56	8	2.6	10	0	3.1	19	1
Twist	1.4	15	1	1.3	10	0	1.0	8	0	0.9	11	0

[1]Total number of samples per treatment: CC 125, CH 118, SC 134, SH 129.

[2]Range is from zero to value shown.

[3]Based on warp requirements for STUD grade.

Table 4—Warp average, range, and number of rejects by treatment for loblolly pine 2 by 4's[1]

Warp	Conventional sawing						Saw-Dry-Rip live sawing					
	Conventional drying (CC)			High temperature drying (CH)			Conventional drying (SC)			High temperature drying (SH)		
	Average	Range[2]	Rejects	Average	Range[2]	Rejects	Average	Range[2]	Rejects	Average	Range[2]	Rejects
	[3]1/32 in		*No.*	*[3]1/32 in*		*No.*	*[3]1/32 in*		*No.*	*[3]1//32 in*		*No.*
					INITIAL MEASUREMENT							
Crook	7.2	68	26	8.0	98	27	3.5	46	9	2.8	20	14
Bow	5.2	45	10	8.3	52	16	3.7	19	1	3.1	15	0
Twist	2.3	23	2	1.6	10	0	1.6	10	0	1.0	7	0
					REMEASUREMENT AFTER STORAGE							
Crook	6.3	58	25	6.8	80	23	3.6	38	15	3.0	24	12
Bow	3.8	36	2	5.6	56	8	2.6	10	0	2.9	19	1
Twist	1.4	15	1	1.4	10	0	1.2	8	0	0.9	4	0

[1]Total number of samples per treatment: CC 120, CH 109, SC 101, SH 103.

[2]Range is from zero to value shown.

[3]Based on warp requirements for STUD grade.

A similar relationship between drying temperature and warp was found for 2 by 4's alone. With conventional sawing, high temperature drying caused greater crook, bow, and rejects compared to conventional temperature both initially and after storage. The SDR studs had lower crook and bow when high temperature dried but also had more rejects due to crook. After storage the relationship of drying temperature to warp was not consistent (table 4).

Analysis of Variance

Using nonparametric tests, analyses of variance were made to test the significance of any changes in warp due to the factors evaluated in the study. The nonparametric tests were used because of unequal piece counts between treatments.

When all stud sizes were combined, statistical differences were found only in crook (table 5). The initial measurement showed a significant difference in crook between CH and SC; CH, CC, and SH. There was no significant difference between CH and CC, CC and SC, or SC and SH. Similarly, after storage differences were found only in crook. Treatments CH and CC were significantly different from SC and SH, but not different from one another (table 5).

When studs were considered by size, we found statistical differences only in the 2 by 4's (table 6). The 2 by 2 and 2 by 3 studs showed no differences either initially or after storage. Only crook differed significantly in the 2 by 4 studs. At the initial measurement, treatment SC was not significantly different from CC, CH, or SH, but SH was significantly different from CC and CH. After storage the SDR and conventional treatments were significantly different from each other (table 6).

Table 5—Nonparametric analysis of variance for warp by treatment.[1] All stud sizes (2 by 2, 2 by 3, 2 by 4)

Variable	Source	P<F	Equivalent treatments
	INITIAL MEASUREMENT		
Crook	Run (1)	0.0001	CH CC SC SH
	Treatment (2)	.0004	
	(1 by 2)	.1706	
Bow	Run (1)	.0004	CH CC SC SH
	Treatment (2)	.2176	
	(1 by 2)	.2862	
Twist	Run (1)	.0294	CH CC SC SH
	Treatment (2)	.2177	
	(1 by 2)	.1528	
	REMEASUREMENT AFTER STORAGE		
Crook	Run (1)	0.0001	CH CC SC SH
	Treatment (2)	.0001	
	(1 by 2)	.0129	
Bow	Run (1)	.0004	CH CC SC SH
	Treatment (2)	.1231	
	(1 by 2)	.2983	
Twist	Run (1)	.0705	CH CC SC SH
	Treatment (2)	.7141	
	(1 by 2)	.3347	

[1]Underlined treatments are not significantly different.
[2]See table 2 for treatment abbreviations.

Table 6—Nonparametric analysis of variance for crook by treatment and stud size[1]

Variable	Source	P<F	Equivalent treatments
	2 BY 4T		
Initial	Run (1)	0.0001	CH CC SC SH
	Treatment (2)	.0002	
	(1 by 2)	.2073	
After storage	Run (1)	.0001	CH CC SC SH
	Treatment (2)	.0001	
	(1 by 2)	.0847	
	2 BY 3		
Initial	Run (1)	0.2673	CH CC SC SH
	Treatment (2)	.7852	
	(1 by 2)	.8388	
After storage	Run (1)	.6386	CH CC SC SH
	Treatment (2)	.1856	
	(1 by 2)	.5518	
	2 BY 2		
Initial	Run (1)	0.0003	CH CC SC SH
	Treatment (2)	.1806	
	(1 by 2)	.0481	
After storage	Run (1)	.0907	CH CC SC SH
	Treatment (2)	.2902	
	(1 by 2)	.4600	

[1]Underlined treatments are not significantly different.
[2]See table 2 for treatment abbreviations.

Discussion

The original purpose of the SDR process was to reduce the amount of crook in lumber. Thus, it is not surprising that its greatest effects are on crook. SDR does not generally increase bow or twist. The bottom line for the producer is the percentage of pieces that make STUD grade, provided that the volume yield is adequate as well. As noted in figure 3, the SDR treatments were as good or better than the conventional treatments in the percent of pieces that made STUD grade. SDR reduced all warp, including bow and twist, although its greatest effects were on crook; SH reduced crook by 38 percent. The board foot volume in this study was almost identical for both the SDR and conventional treatments (1,278.2 fbm, SDR; 1,259.3 fbm, conventional). For our sample of southern pine, SDR treatments resulted in an 11-16 percent greater yield of STUD grade pieces compared to conventional treatments.

Although our previous studies with hardwoods showed that high temperature drying reduces warp (Maeglin and Boone 1963; Maeglin and Boone 1985) this effect was not as clearcut in the study reported here. Initial measurements showed that high temperature drying resulted in fewer STUD grade pieces compared to conventional temperature drying. After storage high-temperature dried lumber showed slightly less warp compared to lumber dried at conventional temperature.

It is important to note that the logs used in our study had been in storage for about a year. They were under water spray during the warm months and showed no sign of decay or blue stain. At the time of study, a microscopic examination of a sample of the wood indicated that the inter-cell pits were without tori. Lutz (1966) and Tschernitz[2] have demonstrated that even a relatively short storage period (2 to 3 months) can result in an enzymatic dissolution of the pit tori in southern pines. Although tori dissolution is not known to have deleterious effects on strength, warp, or other factors, it increases the permeability of the wood and therefore may hasten drying. Therefore, since it is likely that the stored logs dried faster than fresh logs would have, we plan to conduct another study using fresh logs.

Our results show that SDR significantly increased the production of STUD grade lumber from southern pine. Other studies have shown the effectiveness of SDR with low density hardwoods. Many areas within the range of the southern pines (including loblolly), especially the coastal and Piedmont areas, have a mixture of pine and hardwoods. Currently, manufacturers have difficulty dealing with the species that is the least abundant. For example, a pine stand may be scattered with yellow-poplar. What can the manufacturer do with the poplar? SDR allows both the pine and the poplar to be processed through the mill simultaneously and sold through the same channels. Drying times for the two species, though similar, are not exactly the same. Each mill needs to experiment with their own kilns to establish a drying schedule for combined species. The use of SDR could open new opportunities for mill operators for full use of species from a given area as well as high-yield production of STUD grade lumber.

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[2]High Yield Process Research Team. Feasibility of producing a high-yield laminated structural product. Appendix II–on press drying. Appendix IIA–press drying and associated effects. Office report, Aug. 1971. Forest Products Laboratory, Madison, WI.

Summary and Conclusions

We compared the effectiveness of SDR and conventional processing for the manufacture of studs from southern pine. Twenty logs were sawed into studs for each of four treatments. The sawing treatments were conventional cant sawing and SDR live sawing. The conventionally processed studs were cut to stud size from the log and then dried. The logs for SDR processing were sawed into 7/4 flitches and dried before ripping to stud width. For each sawing treatment, half of the logs were dried by conventional kiln drying (≤190 °F) and the other half by high temperature drying (240 °F). After all materials were dried and sized to nominal 2 by 2, 2 by 3, and 2 by 4 studs, they were planed to final ALS size and measured for warp (crook, bow, and twist) and moisture content.

The study results showed that SDR reduced the amount of actual crook, bow, and twist. SDR also resulted in fewer rejects due to combined warp, i.e. more acceptable STUD grade lumber.

The drying temperature did not have a major effect on the quality of studs.

The conclusions drawn from the study were:

1. SDR can raise the graded lumber recovery from southern pine (loblolly) by as much as 16 percent.

2. SDR has a significant effect on crook, reducing crook on the average by about 36 percent.

3. SDR has the capacity to mix certain hardwoods, such as yellow-poplar, with southern pine in the manufacturing process.

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