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THE USE OF SAW-DRY-RIP TO PRODUCE SOUTHERN RED OAK, SWEETGUM, AND BLACKGUM SQUARES

By

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Abstract

The use of two new technologies for the manufacture of turning squares resulted in less warp in a much shorter time than current practice provides. The technologies were Saw-Dry-Rip (SDR) and vacuum-dehumidification drying. The species evaluated were southern red oak, blackgum, tupelo, and sweetgum.

SDR reduced the amount of warp in the turning squares by 67% for crook, 58% for twist, and 44% for bow. On the basis of reduced warp, the number of usable squares was increased from 64% for southern red oak to 81% for sweetgum, compared to conventional processing. The basis for acceptable squares was arbitrarily set.

Drying was excellent for blackgum and sweetgum sapwood. For all southern red oak and some sweetgum heartwood, severe honeycomb and collapse occurred. Further research will be necessary to develop drying schedules for this material.

Introduction

The manufacture of turning squares can be a less than profitable venture if not managed properly. When you consider all the possible problems in the recovery of usable squares, it may even seem impossible. There is the problem of log geometry and size. If a log is too small, you may not get much solid

wood yield and incur a lot of waney edgings. If the log is large enough to get a fair amount of solid wood squares, you may still have a lot of side lumber to deal with. If your primary product is squares, side lumber may be a real burden. To deal with this problem of matching bolt or log size to maximum square recovery, we recommend the use of the program developed by Anderson and Reynolds (1981).

Other problems that plague squares manufacturers are warp and drying degrade. Among the types of warp are bow and twist in the length of the squares and diamonding in the cross section. These types of warp cost dearly in wood volume, especially in usable wood volume. Bow and sometimes twist cause loss in the volume of longer pieces. Because of the deviation from end to end in the pieces, they must be cut in length to get material straight enough to be useful. This often results in an overabundance of short squares but a dearth of longer squares. Diamonding on the other hand requires the upsizing of the cross-sectional dimensions to compensate for the dimension lost when the piece warps to the diamond shape. This can be as much as 1/4 inch or more in green dimension. For example, if the desired square size is 3 inches, you may have to oversize to 3-1/4 inches to compensate for diamonding. The additional 1/4 inch on each piece could be the difference between profit and loss in the operation.

Other problems beset the manufacturers of turning squares, such as checks, honeycomb, and collapse that just cannot be tolerated. Because of the extra thickness of squares, drying is more difficult. It is possible to laminate lumber to the desired dimensions, but this is expensive in itself and does not make the same quality of turning that solid wood does. In trying to minimize the drying time for squares, many a manufacturer has ruined a load of fine hardwood by causing severe checking and internal honeycomb.

The question is, can solid wood turning squares be manufactured in such a way as to minimize the defects and drying time while maximizing the yield of usable squares?

Research at the Forest Products Laboratory (FPL) and elsewhere, has shown that it is possible to reduce the amount of warp in lumber by using the Saw-Dry-Rip (SDR) method (Huber et al. 1984; Larson et al. 1984; Layton et al. 1984; Maeglin and Boone 1983; Maeglin and Boone 1985; Trachsel 1982). However, the method has not been used on thick stock such as that required for squares. It has been shown that wide flitches required in the SDR process take longer to dry in steam kilns than sized lumber. If one were to cut 3-inch-thick stock and dry it under normal conditions, it might take up to 100 days, depending on species and moisture conditions going into the kiln (McMillen and Wengert 1978). This is an awfully long time to wait for usable stock to emerge from the kiln, to say nothing of the expense in fuel and inventory.

Another area of research at FPL is the study of vacuum-dehumidification drying (Simpson 1986). This technology has proven to be very fast and quite good for a wide range of lumber types and thicknesses. It, however, has not been studied for the thicknesses involved in squares 3 or more inches thick. The earlier results on materials up to 2-1/2 inches thick were very encouraging.

The study reported here investigates the use of SDR in combination with vacuum-dehumidification drying to produce turning squares. Conventionally produced squares were compared to the SDR squares.

Materials and Methods

Study Design

A 2 x 1 factorial design was used, with two sawing methods and one drying method. Approximately 1,600 board feet of each of three species were sawed for the study. About half, or 800 board feet, was cut as squares and 800 feet as SDR flitches for drying (table 1).

Table 1.--The distribution of materials in the study of SDR for turning squares

Species	Squares	Flitches
	Bd. ft.[1]	Bd. ft.[1]
Sweetgum	800	800
Blackgum	800	800
Southern red oak	800	800

[1]Approximate scaled volumes of logs.

Materials

The logs were obtained from a South Carolina company that manufactures turning squares and were shipped to FPL for processing.

The species used (table 1) were sweetgum (*Liquidambar styraciflua* L.), tupelo (*Nyssa aquatica* L.), Blackgum (*Nyssa sylvatica* Marsh.) and southern red oak (*Quercus falcata* Michx.). Blackgum and tupelo were grouped together and designated blackgum.

The small end diameter of the logs varied from 10 to 30 inches.

Sawing

All of the logs were end trimmed to 100 inches in length and then livesawn. Every other flitch from a log was processed as squares or flitches. Flitches sawn-from each log were numbered consecutively as they were sawn. The even numbered pieces went to one treatment and the odd numbered to the other treatment. For the next batch of logs of the same species, the treatments were reversed, i.e., odd and even numbered pieces were assigned to the opposite treatments as before. By processing the flitches this way, the treatments were approximately balanced in the amount of material cut.

After cutting on the headsaw, the flitches designated for squares were straight-line ripped into squares. The pieces designated as SDR flitches were edged lightly, before drying, for a compact kiln load.

Sawing on the headrig was done using full taper sawing, cutting parallel to one side of the log. The target size for the gum logs was 3-1/4 inches thick, and for the oak logs 3 inches. All squares and SDR flitches were numbered for log and piece.

Drying

The drying of both squares and flitches was done in a Wood Mizer vacuum-dehumidification dry kiln with 1000-bd.-ft. capacity.[1] The target moisture content was 8 ± 2%. Each kiln load consisted of 300 to 400 bd. ft. each of squares and flitches mixed uniformly throughout the load. There were six kiln loads, two for southern red oak, and four for mixed gums. A mild schedule was used for all species. The schedule began with a drying temperature of 110 °F. As drying progressed, the temperature rose in the kiln, which is both desirable and necessary. Schedule variations were used in the study to regulate the time of heating and dehumidifying operation. The temperature was kept relatively low early in the drying cycle, limiting the maximum temperature to 150 °F. Dead periods were used during each 100-minute cycle when neither heat nor dehumidification were applied. This dead period allowed some moisture and stress equalization to occur and reduced drying defects. The water extracted from the wood was collected and weighed periodically to develop a drying curve and estimate moisture content. Internal and surface temperatures of the wood were also measured and recorded.

Prior to conducting this study, about 300 bd. ft. of 10/4 northern red oak (Quercus rubra L.) was dried to evaluate a general drying schedule and the quality of material. This test seemed quite reasonable, taking 13 days and producing no honeycomb or surface checking. Approximately the same schedule was used in this study.

Sample Processing

After all materials were dried, the SDR flitches were ripped to final dimension for each species, 2-3/4 inches for southern red oak and 3 inches for the gums. All materials were then measured for warp, defects, and moisture content. Warp measurements included bow and twist (fig 1). Bow is a deviation, flatwise, from a line drawn between ends of a piece. Twist is a deviation from a plane surface in the form of a spiral or curl.

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[1]Mention of commercial names does not constitute endorsement of the product by the U.S. Forest Service.

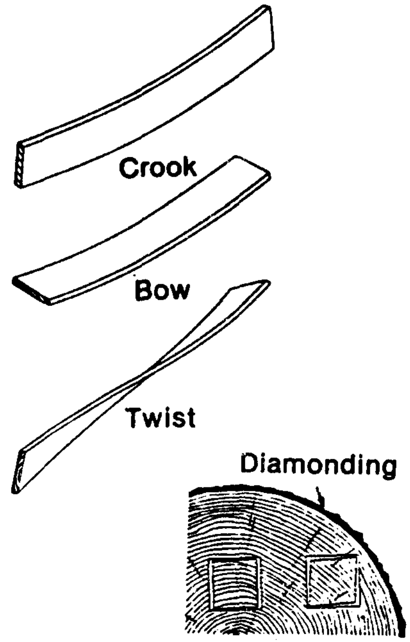


Figure 1. --Three longitudinal types of warp: Crook, bow and twist, and diamonding.

Measurements were made on a flat table using a calibrated wedge to gauge the deflection from a straight line. Deflections were measured to the nearest 1/100 inch.

After measurements for warp were made, the squares, both conventionally processed and SDR, were examined for collapse, honeycomb, ring failure, diamonding (Rasmussen 1961), and surface checks. To evaluate honeycomb, ring failure and diamonding, a 10% sample of the squares was crosscut at midlength to observe the defects on the exposed internal surfaces. Collapse and surface checks were subjectively evaluated on the surface of the squares.

For moisture content evaluation, a single reading was taken from the approximate center of each finished turning square. Sampling was done using a resistance moisture meter with pins driven to approximately a l-1/2-inch depth.

Analysis

Simple statistics are presented without determination of significance in a statistical sense. The evaluations of means and ranges are given for crook, bow, and twist and means only for moisture content.

Diamonding, collapse, and honeycomb were evaluated on a subjective basis because of the difficulty in defining the quantitative nature of these defects. Considering warp only, an evaluation of the number of useful pieces was also made.

Results and Discussion

Nearly 383 cu. ft. of turning squares were produced in this study: 131 cu. ft. of blackgum, 108 cu. ft. of sweetgum, and 142 cu. ft. of southern red oak (table 2).

Bow

Average bow for the combined SDR squares was 0.21 inch. For the combined Conventional squares, the average was 0.37 inch. The reduction using SDR was 42.5% (figs. 2-4).

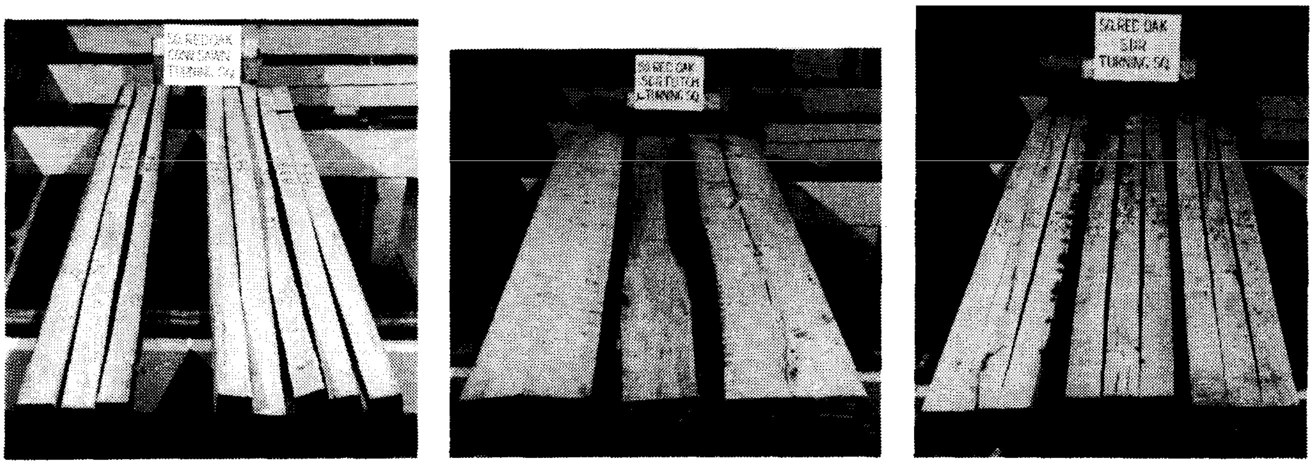


Figure 2. --Examples of southern red oak turning squares. a. Conventionally sawn squares cut green and dried. (M86 0088-3) b. SDR flitches before ripping. (M86 0088-6) c. SDR squares after ripping. (M86 0089-2)

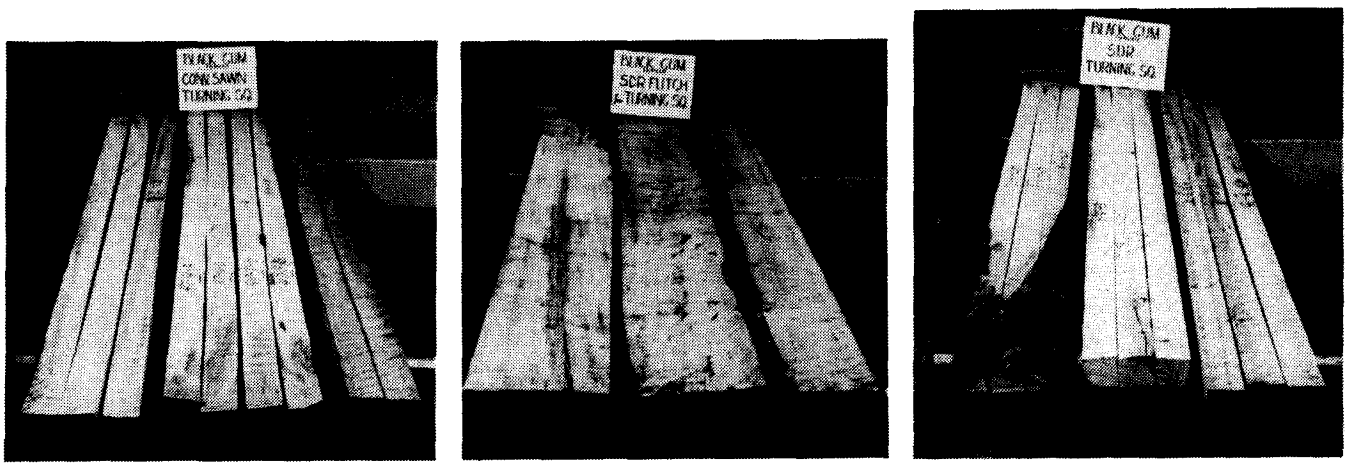


Figure 3. --Examples of blackgum turning squares. a. Conventionally sawn squares cut green and dried. (M86 0099-3) b. SDR flitches before ripping. (M86 0099-4) c. SDR squares after ripping. (M86 0099-7)

Figure 4.--Examples of sweetgum turning squares. a. Conventionally sawn squares cut green and dried. (M86 0097-5) b. SDR flitches before ripping. (M86 0099-5) c. SDR squares after ripping. (M86 0099-6)

On a species by species basis, southern red oak bow was reduced 44.4%, blackgum 42.5%, and sweetgum 40.8% (table 2). All of these reductions are of practical significance.

Table 2.--Averages and ranges of bow and twist and averages of moisture content for southern red oak, blackgum, and sweetgum[1]

Species	Treatment	N	Average bow	Average twist	High bow	Low bow	High twist	Low twist	Average moisture content
			In	In	In	In	In	In	In
Blackgum	SDR	139	0.22	0.24	0.90	0.03	1.00	0.00	5.8
Blackgum	Conventional	113	.38	.47	1.12	.06	1.97	0.00	5.4
Sweetgum	SDR	99	.18	.18	.66	0.00	1.38	0.00	6.2
Sweetgum	Conventional	108	.31	.44	1.44	0.00	1.94	0.00	5.6
Southern red oak	SDR	132	.22	.14	.66	0.00	.53	0.00	9.1
Southern red oak	Conventional	140	.40	.18	2.00	0.00	1.12	0.00	5.8

[1]Both blackgum (*Nyssa sylvatica*) and tupelo (*Nyssa aquatica*) are combined as blackgum.

The ranges of bow for individual SDR pieces were 0 to 0.66 inch for sweetgum, 0 to 0.66 for southern red oak, and 0.03 to 0.91 for blackgum. For the conventional treatments the ranges were 0.06 to 1.12 inches for blackgum, 0 to 1.44 for sweetgum, and 0 to 2.00 for southern red oak.

Twist

Average twist for the combined SDR squares was 0.19 inch, while the average for the combined conventional squares was 0.35 inch. The reduction gained by using SDR was 46.3% (figs. 2-4).

Both sweetgum and blackgum are known for their tendency to twist. This is largely due to the interlocked grain that both species have. The results of this study point up the differences between the gums and oak. The conventionally processed gums had twists of 0.47 and 0.44 inch respectively for blackgum and sweetgum. The Conventional oak had an average twist of 0.18 inch, a 60% difference in twist between the gums and oak.

For SDR, the average twists were 0.18 inch for sweetgum, 0.24 for blackgum, and 0.14 for southern red oak. This is a 35% difference between the gums and oak.

On a species by species basis, sweetgum twist was reduced 57.6%, blackgum 50.1%, and southern red oak 23.8% by using SDR (table 2). The reductions of twist for the gums are of practical significance. Those for southern red oak may be, but the results are marginal.

Yield of Useful Squares

Just considering warp, the number of reject pieces was substantially decreased using SDR (table 3). Acceptable limits for an 8-foot turning square were set at 0.25 inch for bow. For twist the limits were set at 0.125, 0.1875 inch and no limit. If bow is within limits, it would seem that twist should not effect the quality of the turning.

These limits were based on getting a suitable turning of 48 inches length and assuming a uniform curvature in the warped piece. The limits are quite conservative and could possibly be greater, especially for twist; that is why we used three twist categories. If a shorter turning length were used, the limits could also be set much higher. It is possible that many of the pieces listed here as rejects could be fully utilized in lengths of 12 to 18 inches.

For the conventional treatment, with limits of 0.25 inch for bow and 0.125 inch for twist, the highest recovery was 24.3% for southern red oak. For SDR, southern red oak and sweetgum had the same recovery, 42.4%. For the conventional treatment with the 0.1875-inch twist limit, the highest recovery was 32.1% for southern red oak. For SDR, the highest recovery was 56.6% for sweetgum. For the Conventional treatment with no limit on twist, the highest recovery was 51.8% for sweetgum and 80.8% for SDR, also for sweetgum.

Rejects

Reductions in the number of rejected pieces due to SDR ranged from 100% for sweetgum crook to 9.7% for blackgum twist when using the 0.125-inch limit. With the 0.1875-inch twist limit the reduction due to SDR ranged from 100% for sweetgum crook to 22.9% for blackgum twist. With no limit on twist the reduction ranged from 100% for sweetgum crook to 40.8% for blackgum bow.

The number of reject pieces by warp type is listed in table 3. These data show that twist, with the lower limits, is responsible for most of the rejects. Only with southern red oak is twist less important than other warp. For the gums, twist resulted in more rejects than bow by as much as 60%.

Table 3.--Number of rejects[1] by treatment and species, southern red oak, sweetgum, and blackgum[2]

Treatment	Limits[3]		Species					
	Bow	Twist	Southern red oak		Sweetgum		Blackgum	
			Bow	Twist	Bow	Twist	Bow	Twist
Conventional	0.25	0.125	79	68	71	93	46	87
Conventional	.25	.1875	79	47	71	87	46	75
SDR	.25	.125	43	56	42	84	19	47
SDR	.25	.1875	43	32	42	67	19	33

[1]Total number of squares is found in table 2.
[2]Both blackgum and tupelo are combined as blackgum.
[3]With no limit for twist, all twist values go to zero.

While it appears that SDR has done a commendable job of improving the yield of turning squares, the picture is not complete. We have-only discussed the sawing process and its effects. Drying is a key ingredient in the success of the process. As mentioned in the introduction, a lot of squares have been destroyed in the drying phase.

Drying

As noted in table 2, the drying exceeded the target of 8 ± 2% in most cases. Actually, the moisture contents were on the average lower than shown because meter readings of less than 5% were tabulated as 5%.

The drying of thick stock, such as turning squares, can be very difficult. Though our drying schedule was based on a successful trial with northern red oak (fig. 5) the schedule did not work well with southern red oak. Most of the squares. whether conventional or SDR, honeycombed badly. Essentially none of them were usable due to honeycomb. Along with the honeycomb there was a lot of surface checking and collapse (fig. 6).

The drying time for all of the charges was between 12 and 14 days from green. It is possible to slow the schedule for the southern red oak to reduce or eliminate the defects (fig. 6).

Sweetgum had some honeycomb in the heartwood, especially where there were yellowish discolorations (probably bacterial wetwood) (Ward and Pong 1980). There was some collapse and surface checking along with the honeycomb in the sweetgum (fig. 7).

Figure 5--Samples of northern red oak turning squares dried in the vacuum-dehumidification kiln. (M 86 0116)

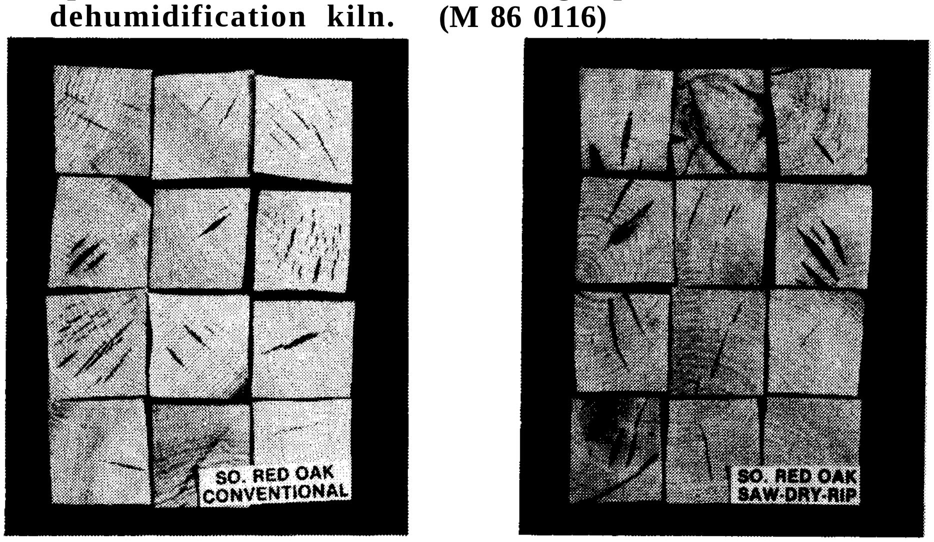
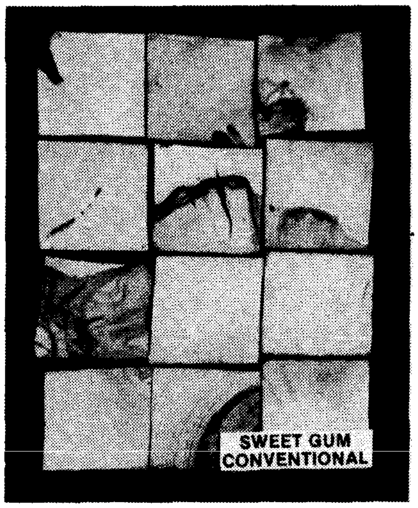


Figure 6. --Cross sections of sample southern red oak turning squares manufactured by conventional and SDR processes and dried in a vacuum-dehumidification kiln. (M 86 0121-22)

Blackgum performed quite well on the schedule used. Only minor checking was noted in a few isolated pieces (fig. 8).

It is obvious from figures 6-9 that poor drying, especially collapse, results in distortion, loss of wood, and rejection of squares. Figure 2c also shows the effects of casehardening on warp, where the pieces bow due to drying stress. Good drying is a must to achieve the quality and yield desired.

One of the features of using the SDR process is the reduction of diamonding in the squares. Because the material is dried in flitch form, the shrinkage is spread across the whole piece. The flitches are also better balanced relative to shrinkage. The dried flitches do not change when ripped into squares, so distortion such as diamonding is eliminated (fig. 9). If, however, as shown in the red oak, there is collapse the effectiveness of SDR is greatly diminished.



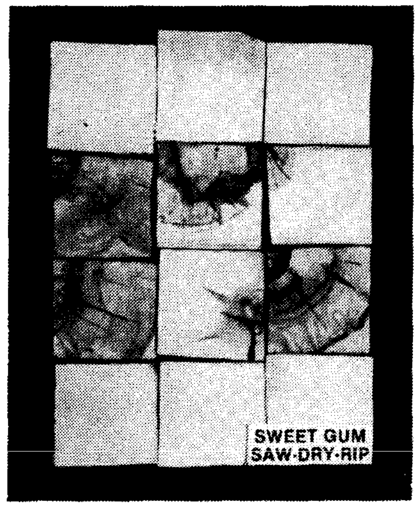


Figure 7.--Samples of sweetgum turning squares manufactured by conventional and SDR processes and dried in a vacuum-dehumidification kiln. (M 86 0117-18)

Figure 8.--Samples of blackgum turning squares manufactured by conventional and SDR processes and dried in a vacuum-dehumidification kiln. (M 86 0119-20)

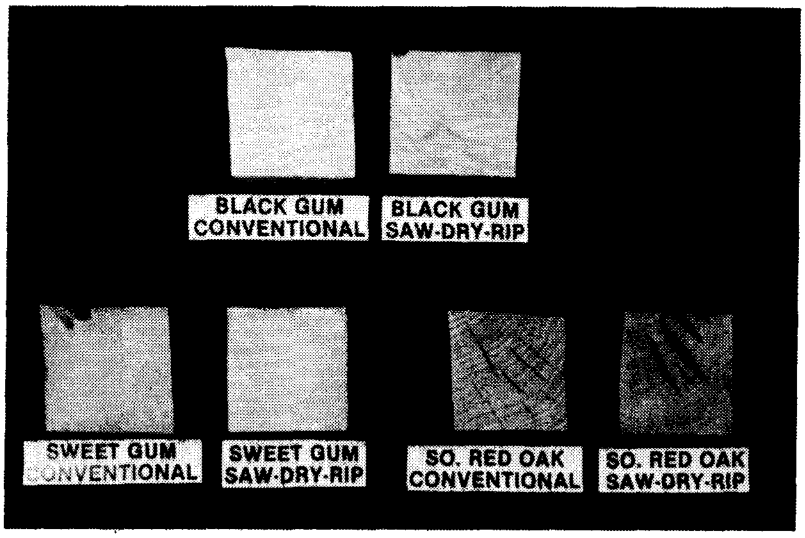


Figure 9. --Comparison of turning squares dried in square form and flitch form. Squares cut green and dried respond to shrinkage by taking on a diamond shape. Squares cut from dried flitches are more square because shrinkage is restricted. Once the flitch is dried, the squares can be ripped without distortion. (M 86 0115)

The use of the vacuum-dehumidification kiln can be advantageous with a proper schedule. As noted with the blackgum, full 3-1/4-inch-thick stock was dried from green to an average moisture content of 5.4 to 5.8% in about 12 days. This kind of turnaround saves inventory, energy, and capital. The sweetgum schedule would have to be adjusted a bit to minimize defects. The elimination of heartwood would permit the use of the study schedule, for there were no apparent defects in the sapwood. The oak schedule would need complete change.

Two problems were evident in drying, cupping (fig. 2b) and casehardening of the flitches. Cupping prevented quality ripping of the squares. In figures 3c and 4c, the separations between the SDR squares are the result of cupping.

Casehardening resulted in a pinched saw in several cases when the flitches were being ripped. This is evident in figure 2c for SDR red oak, where the squares warped from the drying stress.

Summary and Conclusions

In this study we tried to demonstrate some new technology that would offer an opportunity for doing business in a new way. We believe that we have accomplished that, at least in part. We tried to combine the SDR technology with drying in a vacuum-dehumidification kiln. The SDR technology is that of livesawing logs into flitches which are dried and then ripped to the desired width after drying. The vacuum-dehumidification drying was done in a l,000-bd.-ft.-capacity kiln that is automated by microprocessors to follow a preset schedule. The schedule in this case followed a trial schedule developed for northern red oak. Twelve to 14 days of drying were required using the schedule.

SDR

The SDR process is definitely a possibility for improving the yield of suitable turning squares. In all instances SDR resulted in lower warp and straighter squares. SDR also reduced the diamonding effect by drying the larger flitches. The results show reductions of bow up to 44% and twist up to nearly 58%.

For warp only (bow and twist) and using arbitrarily set limits of warp, there were 56% acceptable pieces for sweetgum, 54% for southern red oak, and 34% for blackgum. With no limit on twist, southern red oak had 64.4% acceptable pieces, blackgum 66.9%, and sweetgum 80.8%. The evaluations were made on 8-foot squares. The use of shorter length pieces for evaluation would increase the yields notably.

Drying

The use of the vacuum-dehumidification kiln is also promising. Even though the schedule used in this study was not optimum for all three species, it did perform well with blackgum and sweetgum sapwood. The ability to dry thick squares from green to 6% or less in less than 2 weeks is remarkable. The major problem was with the southern red oak. This material honeycombed, collapsed, and surface checked badly. A completely different and slower schedule would be necessary for the oak. The potential for developing a suitable drying schedule for the oak is great but will require further research.

Two other problems were cupping of the flitches and casehardening. The cupping problem is a feature of the particular kiln that was used and also needs further research to solve. The casehardening could probably be resolved through schedule modification.

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