EFFECTS OF PREPROCESSING 1 COMMON AND 2A COMMON RED OAK LUMBER ON GANG-RIP-FIRST ROUGH-MILL DIMENSION PART YIELDS

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ABSTRACT

Using the ROMI-RIP simulator we examined the implications of preprocessing for gang-rip-first rough mills. Rip-first rough mills can improve yield and throughput by preprocessing 1 Common and 2A Common hardwood lumber. This can be achieved by using a chopsaw to separate poorer quality board segments from better ones and remove waste areas with little or no yield. This preprocessing is in addition to major production benefits from crosscutting out crook or sidebend.

For greatest efficiency, a gang-rip-first rough mill should process straight lumber. Unfortunately, much of today's hardwood lumber resource is not straight. In a current study of lumber used in 14 mills, about 25 percent of more than 4,000 boards contain 1/2 inch or more of crook or sidebend in them[1]. If we consider only boards longer than 8 feet, the percentage exceeds 28. These numbers are consistent with the percentages we obtained while developing the 3,487-board 1998 red oak lumber data bank (6).

The removal of crook is the major reason for placing a crosscut-saw preprocessing station ahead of the main production line gang ripsaw. In earlier studies of fixed-arbor gang-ripping (1,2), it was shown that removing crook in amounts of 1/2 inch or more will: 1) greatly increase the amount of primary yields (rough-dimension parts cut to length from full-width strips); 2) greatly decrease the amount of salvage yield and work; 3) limit salvage to short, narrow pieces; 4) decrease the importance of saw-space sequencing for fixed-arbor gang ripsaws; and 5) produce part-length yield distributions similar to those for full-length straight boards. For these reasons, we considered only boards with 1/4 inch or less of crook in this study.

Other research has shown that most red oak boards have one end that is distinctly better than the other (7). When processed in gang-rip-first rough mills, the better ends will produce better overall yield, more primary yield, less salvage yield, and more yield in longer and wider cuttings.

Additional research has shown that 1 Common and 2A Common lumber has a wider range of quality than might be surmised by a casual review of grading requirements (5). When grading hardwood lumber, the fewest possible grading cuttings are used to establish the grade (10). When we graded the boards in the 1998 red oak lumber data bank, we found that 80 percent of 1 Common and 90 percent of 2A Common had percentages of their surface measures in the normal range for their grades: 66.7 to 83.3 percent for 1 Common and 50 to 66.7 percent for 2A Common. Further, the grades did not change when as many as possible of the maximum number of grading cuttings were used. However, we did find that approximately 50 percent of the 1 Common and 2A Common boards had percentages of surface measure in the range of the next higher grade (1 Common to FAS, and 2A Common to 1 Common).

While our research has shown the increased potential of 2A Common (1), some manufacturers are reluctant to use this grade even though costs and yields may seem favorable. The reason given is that the increased machine time required to obtain the yields from 2A Common prevents sufficient parts from being produced per shift (throughput). In an earlier study, we suggested that expanded use of the crook-removing crosscut saw might

[1] Hoff, K.G., N.D. Bennett, E.D. Rast, and J.K. Wiedenbeck. Size and quality distribution of the Appalachian lumber resource currently processed by secondary manufacturers. In preparation.

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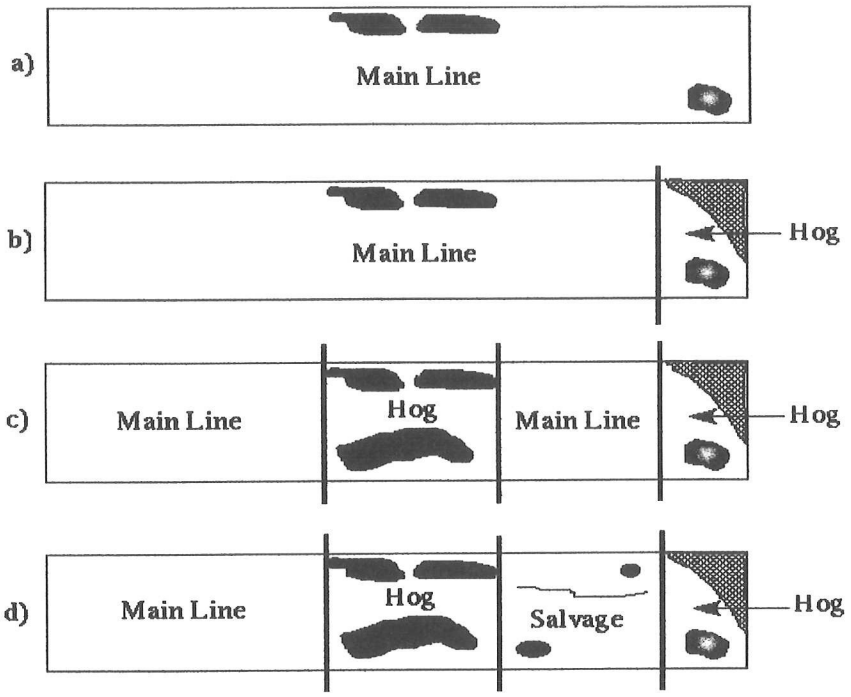

Figure 1.—As boards become more defective, several preprocessing options occur, including: a. none; b and c. hog defective areas leaving main line segments; and d. hog defective areas and sort to main line and salvage segments depending on quality.

remove this objection (5). In another study, Gatchell at al. further examined the preprocessing of lumber (8). Here, several pre-processing strategies and their impact on cutting length distributions were examined.

However, these earlier studies did not adequately examine the impact preprocessing has on cutting bill requirements, processing, and throughput. In this study, we examined the impact of a simple, but agressive preprocessing strategy on two industrial cutting bills. In addition to crook removal, lumber was preprocessed to remove defective areas containing no yields and to separate obviously better segments from obviously poorer segments. In addition, no concern was given to cutting bill part sizes during preprocessing. The better material went to the gang ripsaw in the main production line. The poorer material went to a separate salvage line. Did this scheme improve the throughput of the main line? The answers to this question are not straightforward because of the interactions among such factors as cutting bills, gang-ripsaw arbors, and lumber grades or grade mixes.

Procedure

Program ChopOR (Chop Or Rip)[2] was used with all of the 6-foot and longer 1 Common and 2A Common boards from our 1998 4/4 red oak lumber data bank graded to 1998 NHLA rules (6,10). This data bank contains only straight boards and boards with 1/4 inch of crook that will be edged off during gang-ripping. We simulated a preprocessing crosscut station ahead of the rough mill. The instructions were simple:

1. Examine both board faces.

2. Crosscut out and hog defective areas from which little or no yield can be obtained.

3. Examine board remainder and use additional crosscuts to separate better from worse segments.

4. Place the better segments in a main line sort that also contains boards that are of sufficient quality that no crosscutting is necessary.

5. Place the poorer segments in a salvage sort for a separate salvage processing line. Also include full-length boards that have defects so scattered that no "better" sections can be found, and that will require substantial processing to obtain any parts.

This was a subjective procedure. Each board was evaluated in about 10 seconds to determine whether or where the crosscuts would be made. The idea was to minimize the amount of processing required to obtain yield from the main production line. No reference to a cutting bill was considered. If such a procedure is adopted, there is considerable flexibility as more or less material could be hogged or sent to the salvage operation. If only a small salvage operation is to be used, more material will be sent through the main line and/or hogged. This would reduce the positive effects of preprocessing but might make more sense from the point of view of costs.

This procedure allowed several possibilities from each board (**Fig. 1**). A board could be untrimmed, trimmed on one or both ends to a single board segment, or crosscut to remove defective areas into two or more segments. Two or more segments from a single board could be judged as all main line or a mixture of main line and salvage line. If the result would be only salvage segments, the board would be passed directly to the salvage line without preprocessing.

In examining the effects of preprocessing, our assumption is that meeting cutting-bill requirements with less lumber represents an increase in production line efficiency, particularly if the same or less work is required at the crosscut saws. We assume that a manufacturer is gang-ripping to meet the needs of an "easy" and a "hard" cutting bill. Easy and hard are relative terms that refer to the ease with which rough-dimension parts can be produced. An easy bill has lots of short lengths and narrow widths and panels that can absorb extra parts. The easy cutting bill (**Table 1**) has 15 part lengths, 9 of which are shorter than 40 inches. The shortest length is 11.875 inches. The easy bill has five different part widths, two of these are under 2.0 inches. Further, the easy bill has five panels, four of which can absorb extra parts (one panel part is longer than any solid part.) The use of 2A

[2] Walker, E.S. ChopOR: a chop or rip-first preprocessing program. In preparation.

Common should prove effective for much of the easy cutting bill.

The hard cutting bill (**Table 2**) has 12 lengths, 7 of which are shorter than 40 inches. The shortest length is 19.5 inches. The hard bill has two lengths that exceed 80 inches. The narrowest of six part widths is 2.25 inches. Further, the hard bill has only two panel sizes. It would be difficult to meet this cutting bill with 2A Common.

Two types of gang-ripsaw operations were simulated. The first used an arbor with the saw spacings in a fixed sequence. Each board could be fed at the location that would give the greatest yield of primary parts (parts crosscut to length from full-width strips). This arbor, called fixed-spacing-best-feed, is commonly used by the industry. Because the part widths of the easy and hard cutting bills differ, it was necessary to design a saw-spacing sequence for each cutting bill following procedures in Gatchell (4) to optimize yields.

The easy cutting-bill arbor sequence, in inches, was:

4.25-2.625-1.875-1.875-1.5-
1.5-1.5-2.625-1.5-3.875-2.625

The hard cutting-bill sequence, in inches, was:

4.25-3.25-2.75-2.25-
4.25-3.25-2.25-2.25-3.0

The spacing sequences were designed for a 31-inch-wide arbor. The total width of the easy cutting bill arbor was 27.625 inches. The hard cutting bill arbor was 29 inches wide. The results from using this arbor size can be viewed as a conservative estimate of switching between two different spacing sequences on a 24-inch-wide arbor, as is the case when presorting lumber by width.

We also used an arbor that allowed all blades to move so long as the resulting spacing sequence was a combination of the specified widths in the cutting bills. This was an all-spacings-movable arbor that maximized yield from each board. This provided an upper limit of gang-ripping yields. More detailed descriptions of these arbor types are found in Thomas (11).

ROUGH-MILL SIMULATIONS WITH ROMI-RIP

In this study, a preprocessing station containing a crosscut saw was independent of the rough mill. It was used to remove crook, hog waste or defective areas, and separate the better sections from the poorer ones. Because the negative effects of crook have been demonstrated in earlier work (2,3), we restricted our attention to input lumber that was straight or had no more than 1/4 inch of crook. ROMI-RIP cleans up 1/4 inch from each edge and therefore removes such crook. With this approach, we could focus on preprocessing benefits in addition to crook removal. After the lumber was preprocessed, it was fed to a rough mill containing main and salvage processing lines. Each contained a gang ripsaw and several chopsaws that cut strips to specified lengths. In practice, the salvage line probably would use a straight-line ripsaw.

The better boards from either grade that do not need preprocessing along with the better segments passed directly to the main rough-mill line. Boards in the low end of the grades that cannot be preprocessed and the poorer segments went to the salvage line.

We used three classifications for 1 Common and 2A Common boards and segments: standard, improved, or salvage. Standard 1 Common contained all of the 1 Common data-bank boards before preprocessing that are 6 feet or longer. Improved 1 Common contained a copy of all boards from the standard 1 Common data set that were judged to give high yields and would not benefit from preprocessing. Improved 1 Common also contained the better 1 Common segments resulting from preprocessing. Salvage 1 Common contained the poorer segments from preprocessing as well as a copy of standard 1 Common boards judged difficult to process because of defect placements. Salvage 1 Common went to the salvage processing line. Standard, improved, and salvage 2A Common had similar definitions.

The simulations were run with continuously updated part prioritization. ROMI-RIP prioritized all cutting-bill parts so that the parts that are hardest to get are cut first (11). Continuous updating meant that the relative priorities among all parts were changed as each part was cut.

To obtain a feel for the yield possibilities from standard lumber, we ran each cutting bill and arbor using the standard FAS and 6-foot and longer 1 Common and 2A Common boards from the data bank. We then processed a mix of standard 1 Common and standard 2A Common lumber (53.1 percent 1 Common and 46.9 percent 2A Common) that represented the percentage distribution of these grades in the data bank. Next, we examined the effects on yields of preprocessing the 1 Common and 2A Common boards. We also combined the poorer segments and boards from 1 Common and 2A Common preprocess-

TABLE 1. — Part sizes and required quantities for the easy cutting bill.

Part width	Part length	Quantity required
-------- (in.) --------		
Solid parts		
4.250	32.000	44
4.250	15.875	125
3.875	61.750	135
3.875	14.625	105
2.625	57.375	215
2.625	22.875	100
1.875	44.625	300
1.500	55.375	250
1.500	23.000	1550
1.500	15.000	240
Panels		
20.625	19.875	125
17.625	54.000	26
6.250	28.375	30
4.500	78.875	30
4.500	11.875	110

TABLE 2. — Part sizes and required quantities for the hard cutting bill.

Part width	Part length	Quantity required
-------- (in.) --------		
Solid parts		
4.250	33.125	105
4.250	23.500	230
4.250	21.000	69
3.250	56.000	230
3.250	30.000	60
3.250	19.500	38
3.000	64.375	50
3.000	28.250	30
2.750	33.125	38
2.750	19.500	60
2.250	87.750	50
2.250	80.375	50
2.250	64.375	50
2.250	22.750	38
Panels		
20.000	48.250	45
19.000	30.000	75

ing even though there was no expectation that the needs of the cutting bills could be met with this mix because of its relatively low volume, low quality, and generally short lengths.

RESULTS

PREPROCESSING

In all, 459 of 883 1 Common boards and 559 of 785 2A Common boards were processed (**Table 3**). Based on the input lumber surface area, 55.8 percent of the 1 Common and 75.2 percent of the 2A Common were improved by preprocessing. This means that about half of the 1 Common lumber input went directly to the main gang-rip-first production line versus only one 2A Common board in four. Although there was 20 percent more preprocessing of the 2A Common input surface area, there was only a 5 percent increase in the amount of main-line segments produced. There was twice as much salvage and nearly twice as much hogged material from 2A Common.

Another way to view the data in **Table 3** is that preprocessing removes about 30 percent (salvage plus hogged) of the 2A Common input that otherwise would impede the rapid production of dimension parts. While this is twice the salvage and hogged material of 1 Common, it does not mean that preprocessing 1 Common is of little value. Removing 15 percent of the 1 Common input that contains little or no yield should also benefit the output of the main production line.

The length distributions of the preprocessed segments are shown in **Table 4**. The 459 preprocessed 1 Common boards were separated into 515 main-line segments and 182 salvage segments. The 559 2A Common boards were separated into 579 main-line and 321 salvage segments. The length distributions for the 1 Common and 2A Common main-line segments or salvage segments were fairly similar in both length and amount, particularly when several adjacent length groups were combined before comparisons were made. There were a few percent more main-line segments from 2A Common in lengths from 3 to 7 feet. From 7 feet on, there were slightly more 1 Common segments in each length class.

ROMI-RIP SIMULATIONS

The reader should keep in mind three factors that affect the results. First, the easy and hard cutting bills specified different quantities of different part sizes with the hard bill requiring less total output. Second, each grade mix was made up of different percentages of components. The primary and salvage yields from each component were given, but an average was not. Instead, a net yield was calculated that takes into account the different component amounts. Third, the data sets were established and randomized prior to any runs and used repeatedly. ROMI-RIP continues to draw boards from each data set until the cutting-bill requirements are met. Thus, a simulation that requires more input from a given grade or grade mix than another will contain all the boards found in the latter's data set plus additional material.

The fixed-spacings-best-feed arbor (**Table 5**) produced less yield than the all-spacings-movable arbor (**Table 6**) primarily because of a lack of flexibility in the saw-space sequencing. There is no flexibility in sequencing with the fixed arbor, but for saw-space sequences narrower than a board's width, the board can be fed for maximum yield. The all-spacings-moveable arbor selects both saw spacings and sequences to maximize the prioritized part yield from each board. Even for boards that call for the same saw spacings, the all-spacings-moveable arbor uses a different sequence if that sequence produces a higher primary yield.

The comparisons of the fixed-spacings-best-feed and all-spacings-moveable arbors produced somewhat surprising results. There was a greater yield difference between these arbors for all standard grades and grade mixes when the easy cutting bill (about 3% to 5%) was used compared to the hard cutting bill (less than 2%). We believe the major reason for this apparent anomaly can be explained by comparing the cutting-bill part widths and the data-bank board widths. Most of the data-bank boards are 5 to 7 inches wide. The narrower dimension part widths (two under 2 in.) of the easy cutting bill give more chances for the all-spacings-movable arbor to arrange spacings for maximum yield for a given board. This would allow the all-spacings-movable arbor to produce higher yields on average. However, the wider widths of the hard cutting bill (minimum width: 2.25 in.) greatly restrict the number of spacings for most of the boards. The fixed arbor and the hard cutting bill results are improved by the ability to feed a board anywhere across its width to maximize yield.

While the absolute amounts differ, the trends in the results between the fixed-spacings-best-feed arbor and the all-spacings-movable arbor remained the same. In every case, there was a greater yield from the all-spacings-movable arbor. The salvage yields in all cases were so small that discussion of differences are moot. We will limit the following discussion to the primary yields from the all-blades-movable arbor (**Table 6**).

The FAS, 1 Common, and 2A Common all-spacings-movable benchmark yields are shown at the top of **Table 6**. FAS lumber produced primary yields of 81.1 percent from the easy cutting bill and 76.7 percent from the hard bill. The chops (or crosscuts) per part were 1.1 for both bills. Chops per part is a measure of the ease of manufacture; each part requires one or two chops to produce. A value of 1.1 means most parts were obtained with 1 chop, as would be the case with long strips of clear material. A value of 1.5 means that for every part obtained with one chop, another part required two chops.

As expected, the yields were reduced and the work to produce parts as measured by the chops per primary part increased as the grade of lumber was lowered. When only 2A Common was used, the primary yields were only 50.4 per-

TABLE 3. — Preprocessing data.

Grade	No. of BF	No. of boards	No. preprocessed	Lumber input surface area			
				Preprocessed	Main line	Salvage	Hogged
				(%)			
1C	5466	883	459	55.8	40.1	11.9	3.9
2AC	4450	785	559	75.2	45.1	23.2	6.9

TABLE 4. — Frequency distribution by segment length.

Grade	Sort	Total no. of segments	Segment length (ft.) < 2	2 to 2.99	3 to 3.99	4 to 4.99	5 to 5.99	6 to 6.99	7 to 7.99	8 to 8.99	9 to 9.99	10 to 10.99	11 to 11.99	12 to 12.99	13 +
									(%)						
1C[a]	Main line	515	0.19	2.72	7.38	12.82	17.48	12.04	13.79	10.10	8.35	5.44	3.88	2.14	3.69
	Salvage	182	6.59	24.73	18.68	9.89	10.99	6.59	6.04	3.30	3.85	1.10	1.65	1.10	5.49
2AC[b]	Main line	579	0.17	2.25	12.61	15.03	16.58	16.75	12.61	9.33	6.91	3.28	2.59	1.38	0.52
	Salvage	321	5.61	24.92	16.20	14.95	7.17	5.92	6.54	2.49	4.05	1.56	2.80	1.25	6.54

[a] 459 boards.
[b] 559 boards.

TABLE 5. — Yields from the fixed-spacings-best-feed arbor cutting bill.

Grade	Input type	Easy cutting bill: Percent of mix	No. of BF	Yield: Primary	Yield: Salvage	No. chops/ primary part	Hard cutting bill: Percent of mix	No. of BF	Yield: Primary	Yield: Salvage	No. chops/ primary part
		(%)		---------- (%) ----------			(%)		---------- (%) ----------		
FAS	FAS	100.0	2,742	78.1	1.2	1.1	100.0	2,118	75.0	0.4	1.1
1C	1 Common	100.0	3,271	64.5	1.4	1.4	100.0	2,683	58.6	0.7	1.5
2A	2A Common	100.0	4,419	47.7	1.0	1.6	100.0	3,867	40.5	0.4	1.7
Standard 1C&2AC	1 Common	53.1	1,988	61.5	1.4	1.4	54.9	1,709	56.7	0.5	1.5
	2A Common	46.9	1,754	50.2	1.6	1.6	45.1	1,406	42.5	0.5	1.7
			3,742	56.2(net)	1.5(net)	1.5(net)		3,115	50.3(net)	0.5(net)	1.6(net)
Improved 1C&2AC	Better 1C	29.9	976	66.5	1.3	1.3	29.5	804	60.9	0.6	1.3
	Better 2AC	14.6	476	59.5	2.0	1.5	14.5	395	46.2	0.9	1.6
	Better 1C+2A segments	55.4	1,807	65.4	1.1	1.3	56.0	1,524	58.6	0.4	1.4
			3,259	64.8(net)	1.3(net)	1.4(net)		2,723	57.5(net)	0.5(net)	1.4(net)
Improved 1C	Better 1C boards	51.7	1,614	66.9	1.5	1.3	52.5	1,305	62.3	0.5	1.4
	Better 1C segments	48.4	1,511	68.2	1.7	1.3	47.5	1,183	64.1	0.5	1.3
			3,125	67.5(net)	1.6(net)	1.3(net)		2,487	63.2(net)	0.5(net)	1.3(net)
Improved 2AC	Better 2A boards	34.9	1,230	58.7	1.4	1.5	34.7	1,077	46.4	0.7	1.7
	Better 2A segments	65.1	2,297	60.9	0.9	1.4	65.3	2,029	52.6	0.3	1.5
			3,527	60.0(net)	1.1(net)	1.5(net)		3,106	50.4(net)	0.4(net)	1.6(net)
Salvage 1C&2AC	Salvage segments and boards	100.0	1,688	(50.9)	(1.5)	(1.6)	100.0	1,688	(39.2)	(0.3)	(1.6)
				Insufficient input to fully meet cutting bill requirements					Insufficient input to fully meet cutting bill requirements		

TABLE 6. — Yields from the all-spacings-movable arbor cutting bill.

Grade	Input type	Easy cutting bill: Percent of mix	Easy cutting bill: No. of BF	Easy cutting bill: Yield Primary	Easy cutting bill: Yield Salvage	Easy cutting bill: No. chops/ primary part	Hard cutting bill: Percent of mix	Hard cutting bill: No. of BF	Hard cutting bill: Yield Primary	Hard cutting bill: Yield Salvage	Hard cutting bill: No. chops/ primary part
		(%)		----------(%)----------			(%)		----------(%)----------		
FAS	FAS	100.0	2,692	81.1	0.4	1.1	100.0	2,042	76.7	0.4	1.1
1C	1 Common	100.0	3,111	68.4	1.0	1.4	100.0	2,680	59.1	0.4	1.5
2A	2A Common	100.0	4,206	50.4	0.9	1.6	100.0	3,795	41.3	0.4	1.7
Standard 1C&2AC	1 Common	54.0	1,879	65.3	1.1	1.4	55.0	1,641	58.5	0.7	1.5
	2A Common	46.0	1,601	55.4	1.2	1.6	45.0	1,341	44.3	0.7	1.7
			3,480	60.8(net)	1.1(net)	1.5(net)		2,982	52.1(net)	0.7(net)	1.6(net)
Improved 1C&2AC	Better 1C	29.0	912	70.0	0.9	1.3	29.0	763	62.8	0.4	1.4
	Better 2AC	14.8	459	63.0	1.4	1.5	14.7	387	47.7	1.1	1.6
	Better 1C+2A segments	55.9	1,736	69.2	0.7	1.3	56.4	1,484	60.6	0.3	1.4
			3,107	68.5(net)	0.9(net)	1.3(net)		2,634	59.4(net)	0.4(net)	1.4(net)
Improved 1C	Better 1C boards	51.0	1,513	71.0	1.0	1.3	52.4	1,272	63.2	0.5	1.4
	Better 1C segments	49.0	1,451	73.1	0.6	1.3	47.6	1,155	66.1	0.5	1.3
			2,964	72.0(net)	0.8(net)	1.3(net)		2,427	64.5(net)	0.5(net)	1.3(net)
Improved 2AC	Better 2A boards	35.0	1,218	59.2	1.0	1.5	34.7	1,084	45.5	0.7	1.7
	Better 2A segments	65.1	2,266	62.1	0.5	1.4	65.3	2,042	52.1	0.3	1.7
			3,484	61.1(net)	0.7(net)	1.5(net)		3,126	49.8(net)	0.4(net)	1.7(net)
Salvage 1C&2AC	Salvage segments and boards	100.0	1,688	(53.1)	(1.2)	(1.6)	100.0	1,688	(40.1)	(0.3)	(1.6)
				Insufficient input to fully meet cutting bill requirements					Insufficient input to fully meet cutting bill requirements		

cent for the easy cutting bill and 41.3 percent for the hard bill. The long lengths and wide widths of the hard bill were difficult to obtain from 2A Common alone. The chops per part for 2A Common, at 1.6 and 1.7 for the easy and hard bills, respectively, means that most of the parts were produced individually (two crosscuts) from between two defects.

When we mixed the 1 Common and 2A Common standard lumber, the yield from 1 Common decreased and the yield from 2A Common increased. This result is attributed primarily to the prioritization of parts when each board in a mix is processed in turn. The long, wide pieces were obtained more easily from the 1 Common boards. This allowed 2A Common to be used for more of the shorter pieces. In turn, the amount of short pieces that were produced from the 1 Common boards was reduced. The end result was better utility for 2A Common and somewhat poorer utilization of 1 Common.

The net yield for the mixture of standard 1 Common and 2A Common boards was 60.8 percent for the easy cutting bill and 52.1 percent for the hard bill. Net chops per part were 1.5 for the easy bill and 1.6 for the hard bill. For the easy cutting bill, yields by grade of the mix were 65.3 percent for 1 Common and 55.4 percent for 2A Common. For the hard bill, yields were 58.5 and 44.3 percent. Note that there was divergence in yield between grades as we moved from easy to hard cutting bills. The difference between 1 Common and 2A Common in the easy bill was 9.9 percent primary yield. The difference was 14.2 percent for the hard bill. As measured by chops per part, it also was more difficult to obtain parts from the lower grade with the harder bill. Again, it was more difficult to find long and wide parts in 2A Common than in 1 Common.

Recall that the improved 1 Common and 2A Common data set contained standard boards that were at the high end of the grade and would not benefit from preprocessing. This was half of the 1 Common and one-fourth of the 2A Common. The improved 1 Common and 2A Common data set also included the better segments from all of the other 1 Common and 2A Common boards. This improved grade mix had a 7.7 percent net increase in primary yield for the easy cutting bill and a 7.3 percent net increase for the hard bill. Note that the improved 1 Common and 2A Common segments of this mix gave yields (69.2%) that were similar to the better 1 Common boards (70.0%).

Looking at the improved 2A Common mix, we see that the better segments resulting from preprocessing made up about two-thirds of the mix in the percentage of input surface area. The net yield from the improved 2A Common was about the same as the net yield from the standard 1 Common and 2A Common mix for the easy cutting bill. The net yield was slightly less (2.3%) than the standard mix for the hard cutting bill. While the improved 2A Common net yield fell off significantly between the easy and hard cutting bills, the improved 2A Common netted 5.7 percent more yield than the standard 2A Common in the standard 1 Common and 2A Common mix.

Yields from the Salvage 1 Common and 2A Common were poor. The initial data set of 1,688 board feet was flipped edge for edge, and this new data set was appended to the initial data set. Still, there was not sufficient raw material. This was not surprising as there was little opportunity to obtain the longest cuttings from this raw material mix of essentially what is left after the better boards and segments are removed. The low yields shown in parentheses would continue to decrease as additional salvage is used in an attempt to obtain the longer and wider dimension parts after the requirements for the shorter parts have been met (**Tables 5** and **6**).

Discussion

Important improvements can be made to the throughput of the main rough-mill production line when only the better boards and the better segments of the lower grade boards are passed through. Improved 2A Common (better 2A standard boards and better 2A segments) gave yields that were better than or equal to the mix of standard 1 Common and 2A Common, regardless of whether the cutting bill was easy or hard or the arbor had all movable blades or fixed-blade spacings. When we also improved the 1 Common lumber, there was an increase of around 7 to 8 percent from the mix of better boards and better segments over the standard 1 Common and 2A Common mix.

About half of 1 Common and about 75 percent of 2A Common boards benefited from preprocessing (**Table 4**). About 4 percent of the 1 Common volume and about 7 percent of the 2A Common was hogged. This is waste that would not have to be removed in the main production line. Comparisons of the 1 Common better segments to the 2A Common better segments sorted for the main-line showed similar length distributions, as did the salvage segments.

The absolute values of the yields reported in this study are not important. Recall that this was a subjective study of preprocessing where a quick visual inspection formed the basis for crosscutting decisions. Decisions based on multiples of cutting-bill lengths would improve primary yields. Being less precise than we were or leaving more defective areas attached to the better segments would reduce primary yields. In future studies, preprocessing to specific cutting bills to maximize yield will be explored. Also, if ROMI-RIP is run with periodic rather than continuous part priority updating, primary yields will drop and excess primary parts will be produced. But in simulations not included in this paper, we found that the trends among grade mixes were the same as reported here.

When preprocessing is used, an efficient salvage operation is critical to overall plant efficiency. About one-fourth of the 2A Common input and one-eighth of the 1 Common can be shunted to this line in the form of segments and low-end boards. One way to improve the efficiency of this station is to modify or change the cutting bill to exclude long and wide cuttings and to make panels from random-width parts. Another way is to adjust the amount of material going to the salvage operation by accepting a reduced improvement in main-line efficiency.

Most of the yield improvements discussed here can be achieved with relatively little extra effort at the preprocessing crosscut saw. Recall that about 25 percent of all input lumber will have crook that should be removed. The crosscuts that remove crook probably can be combined with quality improvement efforts. This process should be flexible. Depending on the interactions of costs and value, more or less of the poorer material can be converted to parts or fuel or waste. Thus, a minimum salvage operation can be initiated and expanded as results permit.

The reader may be concerned with the subjective nature of this paper. We invite requests for our data bank and the programs used to allow readers to develop their own criteria for evaluation. Copies of the 1998 red oak data bank and the ROMI-RIP gang-rip computer program along with supporting documentation are available free of charge from the Northeastern Research Station, Forestry Sciences Laboratory, 241 Mercer Springs Road, Princeton, WV 24740, phone: 304-431-2700, fax: 304-431-2772. An unsupported copy of the ChopOR program also is available.

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