WITHIN-GRADE QUALITY DIFFERENCES FOR 1 AND 2A COMMON LUMBER AFFECT PROCESSING AND YIELDS WHEN GANG-RIPPING RED OAK LUMBER

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ABSTRACT

Using a new computer grading program (UGRS), 1 and 2A Common lumber was sorted based on the percentage of board surface measure found in the maximum allowable number of grading cuttings. For 1 Common, 46.0 percent of921 boards had percentages in the FAS range (83-1/3% and above). For 2A Common, 54.7 percent of 825 boards had percentages in the 1 Common range. When gang-ripped first, these quality sorts produced important differences in the number of rips, crosscuts, and parts produced for primary and salvage operations when processed to easy and difficult cutting bills. In addition, important differences emerged in the cost and amount of lumber required for each of the quality sorts.

What are the important factors that influence gang-rip-first yields from 1 and 2A Common lumber? In earlier work, we studied the effects on yield of lumber grade (1,2,7), crook or sidebend (3,4), within-board quality differences (6,7,14), and gang ripsaw arbor design (4,5). We found that there is a relatively small yield difference (10% or less) between 1 and 2A Common primary yields (pieces cut to length from full-width strips) when these two grades are treated alike.

The similarity between yields from 1 and 2A Common requires further examination. NO.1 Common lumber must have at least 66-2/3 percent of its surface area in fewer (usually) grading cuttings than 2A Common, which starts with 50 percent of its surface area in grading cuttings (15). That suggests at least a 16 percent yield difference. Further, 1 Common lumber contains all of those boards that would otherwise be FAS, FIF, or Selects except for violations of rules for the higher grades. Boards that are too short or too narrow, even though clear, would be 1 Common. Other rule violations include grading cuttings that are too short or narrow, defects that are too large, or cuttings with too much pith or wane. Except for grading cuttings that are too short or narrow, the only 1 Common rule violation that can cause a downgrade to 2A Common is pith that exceeds one half the length of the board.

One answer to the puzzle of similarity of yields was found in an analysis of the quality characteristics of Appalachian red oak lumber (14). An analysis of 198 FAS, 591 1 Common, and 580 2A Common boards in the "1992 Data Bank for Red Oak Lumber" (14) showed that the average percent of board surface area occupied by defects was 6.8 percent for 1 Common and 9.8 percent for 2A Common. While statistically different, these are similar when compared to FAS at 1.2 percent. For 1 and 2A Common lumber, area of defects alone is not a sufficient explanation. It is the number, size, and distribution of defects that are the important factors in determining the Common grades.

The National Hardwood Lumber Association (NHLA) lumber grades (15) are somewhat open ended. Minimum requirements are well stated and lumber graders do not concern themselves with whether a board exceeds the minimums. Graders look for the highest grade and determine only whether a board meets the minimum requirements. The grades are written in such a way that percentages of surface measure (SM) typical of the higher grades can be found in the lower grades. We wondered whether the effects of within-grade quality differences were important when processing to specific cutting bills. In this study, we found that within-grade quality differences can have important yield and production control implications when gang-ripping first.

THE STUDY

To evaluate the effects of within-grade quality differences on gang-rip-first yields, two new analytical tools were used: UGRS (9,10) and ROMI-RIP (11-13). UGRS is a new computer program that closely simulates procedures used by humans to determine the grade of a hardwood board according to NHLA rules (] 5). Once the grade of the board is determined, UGRS has an option that determines the maximum grading surface area of the board in the maximum allowable number of grading

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TABLE 1. - Cutting bill 1 (easy).

Part length	Part width (in.)			
	1.5	2.0	2.25	2.75
(in.)	- - - - - - - - (No. of parts) - - - - - - - -			
12.0	1,000			
13.75				1,000
16.5	5,000			
19.75		500		
27.0	260	125		
28.75				800
29.25			500	
44.0				1,000
48		400		

TABLE 2. - Cutting bill 2 (difficult).

Part length	Part width (in.)						
	1.5	2.25	2.75	3.0	3.25	4.0	4.25
(in.)	- - - - - - - - (No. of parts) - - - - - - - -						
19.5			156				
21.0							183
22.75		100					
23.25						617	
28.25				43			
30.0	605	203	203	203	405		
33.25				120			281
48.25	480	240	240		120		
56.0					617		
64.5		67					
80.5		67					
87.75		135					

cuttings. This option was used to separate 921 1 Common and 825 2A Common boards from our 1997 databank (8) into low and high quality board sorts. With these sorts as input, the gang-rip-first roughmill simulator (ROMI-RIP) was used to process two cutting bills of different size and complexity. The effects of these sorts on yields and processing factors were then evaluated.

The low quality sort contained all boards in what might be considered the normal range of the grade. That is, the percentage of each board's SM contained in the grading cuttings for low quality 2A Common (2A-Low) was 50 to 66-2/3 percent and for low quality 1 Common (IC-Low) it was 66-2/3 to 83-1/3 percent. The high quality sorts (2A-High and IC-High) contained all the boards in those grades with percentages above these ranges.

When grading lumber, the NHLA rules specify the maximum number and the minimum sizes of grading cuttings that can be used to determine the percentage of the SM in these grading cuttings. The number of grading cuttings is determined by dividing the SM by a factor and dropping all fractions. For FAS, it is SM/4; for 1 Common, it is (SM + 1)/3; and for 2A Common, it is SM/2.

There also are special rules. An extra grading cutting can be used for 1 Common for boards with 3 through 10 feet of SM, provided the percentage of SM in the grading cuttings is at least 75 percent. For 2A Common, the extra cutting is allowed for boards with 2 through 7 feet of SM, provided the percentage of SM is at least 66-2/3 percent (the entry level for I Common). Human graders use the extra cutting only when it is needed to establish the grade. We used it to determine the maximum percentage of SM in the grading cuttings.

Because a grader has only to find 50 percent of a 2A Common board's SM in grading cuttings and will use the largest grading cuttings first, there will often be smaller areas that could be used but are ignored. Using the extra cutting rule allows some of these areas to be counted. In the larger boards as many as three additional cuttings could be used. For example, a board that is 12 feet long and 6 inches wide contains 6 feet of SM (72 cutting units). If half of the board is clear, the grader will see 50 percent in one cutting (36 cutting units) and move on. But, for 6 feet of SM, three cuttings are allowed for 2A Common (SM/2) and four when the extra cutting is used. The 2A Common grading cutting's minimum size is 3 inches by 2 feet (6 cutting units). It might be possible to fit three of these in the remaining 6 feet of board length. That is an additional 18 cutting units which, when added to the 36 cutting units of the clear half, give a final percentage of SM in the grading cuttings of 75 percent. The important question is what effect, if any, does all of this have on processing.

While this study shows some of the features of UGRS and ROMI-RIP, it is not intended as an in-depth simulation of an actual gang-rip-first roughmill. For example, we do not end trim strips before crosscutting out parts. We use II4-inch sawkerfs because that is what is allowed by the current version of ROMI-RIP. Narrower kerfs are meaningless unless an extra strip is generated. We do not use boards with crook for two reasons. The least important is that UGRS grades with the edges of the grading cuttings parallel to the X-axis rather than the edge of the board. The most important reason for not using boards with crook is that our earlier work (3,4,7) showed that the effects of crook on gang-rip-first yields are so negative that crook amounts of 1/2 inch or greater should be removed by cross-cutting before gang-ripping. We do, however, treat all boards the same and believe that the comparisons made and the results obtained are valid as guides for what can be expected in practice.

We chose two cutting bills that we judged easy and difficult to meet, owing to the number and size of parts. Cutting bill I (easy) (**Table 1**) was made up mostly of short and narrow pieces that should be easy to produce from 1 and 2A Common lumber. Cutting bill 2 (difficult) (**Table 2**), with some long and wide parts, had the greatest number of parts in the 30- to 48-inch range and emphasized widths from 2.25 through 4.25 inches. We expected some difficulty in achieving these and longer part sizes from 1 and 2A Common lumber. Because of this anticipated difficulty, we also ran cutting bill 2 with FAS lumber.

To evaluate gang-ripping with the cutting bills shown in **Tables 1** and **2**, it was necessary to determine a saw space sequence for a fixed arbor. We used the procedures outlined in Gatchell (5) and produced the following sequences (all values in inches with 114-in. sawkerfs between spacings):

Arbor 1 - for cutting bill 1 (easy):
-2.75-2.75-2.25-2.0-1.5-1.5-1.5
-1.5-2.75-2.0

Arbor 2 - for cutting bill 2 (difficult):
-4.25-2.25-2.25-2.75-1.5-4.0-3.0
-3.25-4.0-1.5

TABLE 3. - Within-grade quality sorts for 1 and 2A Common lumber based on the maximum number of allowable /grading cutting.

Grade	No. of boards	Average surface measure	Grading cuttings surface area	Percent of overall grade
		(ft.)	(%)	
I Common High (lC-High)	424	5.64	83-113 and above	46.0
1 Common Low (IC-Low)	497	6.17	66-2/3 to 83-113	54.0
2A Common High (2A-High)	451	5.15	66-2/3 and above	54.7
2A Common Low (2A-Low)	374	5.44	50 to 66-2/3	45.3

PROCESSING TO MEET CUTTING BILL REQUIREMENTS

When processing to meet the needs of a cutting bill, the interaction between a part's size and its required quantity must be considered with a prioritizing procedure. ROMI-RIP does this by generating a weighted value for each part size in the cutting bill based on its size and required quantity (13). The crosscut operation used to generate parts from the ripped strips is tied directly to the gang-ripping operation so that the weighted values are continually updated. This ensures that the most needed and/or the parts that are hardest to get will be taken from each board. As parts are cut, the weighted values are adjusted to reflect a reduced requirement. For cutting bill analyses, ROMI-RIP operates by maximizing the total value of parts for each board.

ROM I-RIP examines each gangripped strip and produces as many as four kinds of yield in the following sequence: 1) primary; 2) primary from salvage ("smart salvage"); 3) excess primary; and 4) salvage. First, all the needed primary parts are removed from a full-width strip by crosscutting the strip to the lengths specified in the cutting bill. Next, the remainder of the strip is examined to determine whether narrower parts that are required by the cutting bill can be found. These parts will be taken even if they extend into full-width remaining sections of the strip. These parts are called "smart salvage" (11,12). When operated to produce smart salvage, ROMI-RIP also looks for additional yields in the lengths given in the cutting bills. The assumption here is that panels could be glued up to the needed lengths and ripped to cutting bill parts at a later time. These additional yields are excess primary and salvage.

An excess primary part is a strip-wide (full-width) piece for which the requirements have been met. It also can be a wider or narrower piece that is not required by the cutting bill. In this case, it must be a full-width piece cut to a cutting bill length. Salvage parts are ripped and crosscut to lengths and widths listed in the cutting bill table but for which there are no specified parts requirements. If no use is to be made of the excess primary or salvage, then these yields are considered to be waste.

ROMI-RIP was operated to simulate the industrial practice of finding the best place to feed each board into the fixed spacings on an arbor. The decision was based on maximum prioritized part values for a given board. This means that if a board would fit equally well at two different locations on an arbor, the location chosen might give a lower total yield based on the area of cuttings but a higher yield based on total prioritized value. It also means that a 10-inch-wide board with 2 inches of wane along much of one edge would be fed through spacings better suited for an 8-inch-wide board without wane.

Boards were processed in sequence until all of the cutting bill requirements were met. Processed this way, the sequence of boards in a sample can be important. Wide, high quality boards in the beginning of a run could yield the longest and widest of the most needed parts and could result in less total input lumber being required. We randomized the board sequence in each quality sort three times to account for this. Finding only trivial differences, we present average values for the three runs in this paper.

When running ROMI-RIP to meet the needs of a cutting bill, the program will continue to call for lumber until the needs of the cutting bill are met. To ensure enough lumber to complete the analysis, the following procedure was used. The boards in a sort were randomized by length and width. They were then flipped edge for edge and this sequence was appended to the original randomized sort. For fixed arbors, this will almost always produce different strips for crosscutting into parts. ROMI-RIP keeps track of parts produced and adjusts part priorities as we go along. Thus, even if the same strip is produced several hundred boards later, the parts required from that strip will almost certainly be different. We then repeated this combined sort and appended it to the original to assure an adequate number of boards for each cutting bill run.

ROMI-RIP provides processing information. We focused on the primary yields and report the average number of crosscuts per primary part and the average number of crosscuts and rips for each smart-salvage part. The range of numbers of average crosscuts per part is 1 through 2. Parts that are cut from the ends of strips require one crosscut. Initial end trims were not made for this study. Single parts cut from between two defects require two crosscuts. The average crosscuts per part include these extremes and reflect the ease of manufacture where several adjacent parts may be crosscut in sequence. For example, four parts cut in succession from between two defects would require five crosscuts with an average of 1.25 crosscuts per part. For this discussion, we consider that three of the four required one crosscut and the fourth required two (rather than two adjacent parts sharing a single crosscut). With this reasoning, a crosscut per part value of 1.5 means as many parts required one crosscut to produce as required two.

Similar reasoning is applied to the average number of salvage rips. Most salvage pieces will be obtained with a single salvage rip.

RESULTS

Please recall that humans look for the highest grade possible and stop grading with the first solution that satisfies the specifications for the grade in question. When operated this way, UGRS found that 79.4 percent of the I Common boards had grading cuttings surface areas in the normal range for the grade (662/3% to 83-l/3%). The remaining 21.6 percent had grading cuttings surface areas in the FAS range (83-l/3% and above). For 2A Common, the percentage found in the normal range for 2A Common (50% to 66-2/3%) was 89.2 percent.

When operated to find the maximum possible grading cuttings surface area used in this study, UGRS found only 54.0 percent of the 1 Common boards (**Table 3**) had grading cuttings surface area in the range of 66-2/3 percent to 83-1/3 percent. The remaining 46.0 percent of the boards (424 of 921) had maximum grading cuttings surface areas in the FAS range (83-l/3% and above). This was not surprising because of the severe restrictions in the amount or size of defects in the FAS grade, which cause an automatic downgrade of boards that otherwise qualify for FAS. For example, the total lineal inches of pith (boxed or showing) cannot exceed the number of feet of SM. Total wane on either edge of the board cannot exceed one-half the length. There are special quality restrictions for the first and last lineal feet of an FAS board. Also, the average diameter of any hole or knot cannot exceed in inches one-third the number of feet of SM. No.1 Common lumber also contains all of those boards that otherwise would be FAS except that they or their grading cuttings are too short and/or too narrow.

The quality sort results for 2A were surprising. The high quality sort, which begins at 66-2/3 percent, contained 54.7 percent of the 2A boards (451 of 825). We believe our databank is typical of the quality of red oak lumber available in the Appalachian region. This means that more than half of all 2A Common has maximum grading surface areas in the 1 Common quality range. We believe there are three factors that, in combination, account for most of this high percentage. These are the amount of the surface area that is actually defective and the number and size of the 2A Common grading cuttings. Recall that the amount of the surface area that is actually defective in the average 2A Common board is only 9.8 percent versus 6.8 percent for 1 Common (14). The defects that make up this 9.8 percent are considered to be scattered about the board surface. Because the grader has only to find 50 percent of the SM in the grading cutting(s), many small areas that could be used for 2A grading are normally ignored. With our maximized approach, most of these are now counted.

CUTTING BILL YIELD RESULTS

When viewing cutting bill results, it is important to remember that ROMI-RIP will continue to call for boards until all cutting bill requirements are met. If we change the required volumes in the cutting bill, we change the amount of wood that is processed in this simulation.

TABLE 4. - Yields and processing\factors for 1 and 2A Common quality sorts for cutting bill 1 (easy).

								Processing factors				
				Yield (% of lumber input)								
Board quality	Lumber	Lumber costs[a]	Primary	Smart salvage	Excess primary	Salvage	Total	No. of primary parts	No. of crosscuts per primary part	No. of smart-salvage parts	No. of crosscuts per smart-salvage part	No. of rips per smart-salvage part
	(BF)	($)										
IC-High	4,598	4,368	70.4	1.0	1.5	0.6	73.5	10,362	1.16	238	1.13	1.24
IC-Low	5,019	4,768	64.1	1.3	2.0	1.1	68.5	10,229	1.28	367	1.27	1.22
2A-High	5,245	3,278	61.1	1.4	1.9	1.0	65.4	10,154	1.38	438	1.25	1.24
2A-Low	5,874	3,671	54.1	1.8	3.3	2.2	61.4	10,001	1.46	587	1.38	1.24

[a]Prices per MBF for kiln-dried 4/4 Appalachian red oak as listed in the *Weekly Hardwood Review* (16) were: FAS-$1,375; 1 Common-$950; and 2A Common-$625.

TABLE 5. - Yields and processing factors for FAS and1 and 2A Common quality sorts for cutting bill 2 (difficult).

								Processing factors				
				Yield (% of lumber input)								
Board quality	Lumber	Lumber costs"	Primary	Smart salvage	Excess primary	Salvage	Total	No. of primary parts	No. of crosscuts per primary part	No. of smart - salvage parts	No. of crosscuts per smart-salvage part	No. of rips per smart-salvage part
	(BF)	($)										
FAS	4,952	6,809	73.6	1.1	5.2	1.2	81.1	4,960	1.08	156	1.07	1.17
1C-High	5,411	5,140	67.0	1.2	2.6	1.4	72.2	4,930	1.29	173	1.20	1.22
1C-Low	6,267	5,954	57.3	1.5	3.8	3.1	65.7	4,850	1.47	234	1.34	1.24
2A-High	7,141	4,463	50.1	1.4	4.7	5.0	61.2	4,848	1.61	237	1.42	1.28
2A-Low	8,579	5,362	41.5	1.4	5.7	7.2	55.8	4,802	1.70	284	1.54	1.27

[a] Prices per MBF for kiln-dried 4/4 Appalachian red oak as listed in the *Weekly Hardwood Review* (16) were: FAS-$1,375; 1 Common-$950; and 2A Common-$625.

TABLE 6. - Accumulated width of excess primary and salvage parts for cutting bill 2.

Lumber quality sort input	BF of lumber	Percent of lumber input In excess primary and salvage yields	Length class (in.)			
			19.5 to 23.25	28.25 to 33.25	48.25 to 64.5	80.5 to 87.75
			- - - - - - - - - - (Accumulated width (in.)) - - - - - - -			
IC-High	5,411	4.0	938	191	58	42
IC-Law	6,267	6.9	1,941	353	113	50
2A-High	7,141	97	3,019	743	150	34
2A-Low	8,579	12.4	4,756	1,267	230	57

Therefore, the cutting bills must be viewed separately for detailed results and compared only in general terms.

The goal of cutting bill 1 (easy)(**Table 1**) is to produce 10,585 parts, most of which are short and narrow. The totals of primary and smart-salvage parts will be about this amount. The goal of cutting bill 2 (difficult) (**Table 2**) is to produce 5,085 parts, many of which are long or wide.

The yield trends within the 1 or 2A Common quality sorts were, in general, similar for the two cutting bills (**Tables 4** and 5). As expected, primary yield decreased with a decrease in lumber quality. But the way it decreased was dependent on the cutting bill.

For cutting bill I (easy), the primary yields ranged from 70.4 percent for 1C High to 54.1 percent for 2A-Low (**Table 4**). The difference in primary yields between the IC-High and Low sorts at 6.3 percent was about the same as that between the 2A High and Low sorts (7.0%). Throughput considerations favored the higher quality material with about 1,300 fewer board feet (BF) of IC-High being required than 2A-Low. The cost of lumber favored 2A Common, but processing costs, as reflected in the number of crosscuts and rips to produce this cutting bill, would be higher for the 2A-Low material. With an average number of crosscuts per primary part of 1.46 for 2A-Low, about as many primary parts required two crosscuts to produce as required only one.

The yields for the IC-Low and 2A High were very similar for cutting bill I (easy), with IC-Low having a 3 percent greater primary yield. Everything else was very similar except that the lumber cost advantage clearly belonged to the 2A-High lumber sample.

For cutting bill 2 (difficult), the long and wide part requirements caused much greater differences in yields and processing factors from the various lumber quality sorts (**Table 5**). The range in primary yields from 67.0 percent for IC-High to only 41.5 percent for 2A -Low reflected the increase in lumber requirements from 5,411 BF (lC-High) to 8,579 BF (2ALow). For the easy cutting bill, the lumber cost advantage was always in favor of 2A Common (**Table 4**). For the difficult cutting bill, this was not the case. The IC-High lumber costs were about $814 less than IC-Low with 9.7 percent more primary yield. The IC-High lumber costs were $222 less than 2A-Low with 25.5 percent more primary yield. As with the easy cutting bill, the 2A-High lumber costs were the lowest for the difficult cutting bill.

The similarities of yields and processing factors between IC-Low and 2AHigh that were so apparent for the easy cutting bill (**Table 4**) are not as pronounced for the difficult cutting bill (**Table 5**). The IC-Low produced 7.2 percent more primary yield and required 874 fewer BF of lumber than the 2A-High. The cost of lumber was still an advantage for the 2A-High sort. The 2A Common salvage yields echoed the FAS need for glue-up and re-rip procedures. Excess primary and salvage yields were 9.7 percent for 2A-High and 12.9 percent for 2ALow.

With crosscuts per primary part above 1.5 (1.61 for 2A-High and 1.70 for 2A-Low), more 2A Common primary parts required two chops per part than one. For primary parts from smart salvage, there were about as many requiring two chops as one. Smart-salvage rip averages were about 1.25, which means three parts were produced with only one salvage rip for every part that required two salvage rips.

When we compared what would happen if FAS were used for the difficult cutting bill, the results were somewhat surprising and clearly indicated the need for glue-up and re-ripping when processing to difficult cutting bills. The FAS primary yields were only 6.6 percent higher than the 1C-High yields but there was twice as much excess primary (5.2% versus 2.6%) from the FAS. The processing advantages of FAS lumber are clearly shown in **Table 5**. With crosscuts per part of about one, processing FAS is little more than cutting clear strips to length. But, with a difference of primary yield of only 6.6 percent over the IC-High, one must question whether the processing benefits justify the additional lumber costs of $1,669.

The distribution of excess primary and salvage yields for cutting bill 2 is shown in **Table 6**. Recall that excess primary parts are cut to the lengths specified in the cutting bill, but for which there are no initial parts requirements or for which the initial requirements have been met. Salvage parts are ripped and crosscut to the lengths and widths listed in the cutting bill table, but for which there are no parts requirements. The accumulated width of these parts indicates the amount of glued-up panels that might be produced. Most of the accumulated width was in the short lengths (19.5 through 33.25 in.) and the lower the lumber input quality, the larger the amount in the short lengths. Without a demand for parts or panels in these lengths, this material would be hogged for fuel or considered as waste.

DISCUSSION

When evaluating the potential of a lumber grade for particular cutting bills, we should remember a basic building block upon which the grades are based: the minimum size of the grading cutting. For I Common, the minimum sizes are 3 inches by 3 feet and 4 inches by 2 feet. For 2A Common, the minimum size is 3 inches by 2 feet. If the reader will review part sizes for cutting bill I (easy), it will be found that over 40 percent of all required parts will fit into the minimum size of the 2A Common grading cutting for length and 100 percent for width. On the other hand, almost none of cutting bill 2 (difficult) does so. At the outset, then, we should not expect the performance of 2A lumber relative to I Common to be as good for cutting bill 2.

The importance of the interaction between lumber quality and cutting bills must be emphasized. Consider the results for the IC-High and the 2A-Low quality sorts. For the IC-High, the decrease in primary yields between the cutting bills was only 3.4 percent. The decrease was 12.6 percent for the 2A-Low. This indicates that the lower quality lumber within an NHLA grade is much more sensitive to changes in cutting bills than is the higher quality lumber. It does not mean that the lower quality lumber should not be used. It means that more careful planning in its use may be necessary.

Consider the quality extremes of this study: FAS and 2A-Low for cutting bill 2. Because the 2A-Low boards were smaller and yields were less, 3,627 more BF of 2A-Low were required. To get the primary part yields, more than 2,800 additional crosscuts of gang-ripped strips were necessary to achieve the primary parts from 2A-Low. If we ignore the higher yields from 2A-High and make the 2A-Low carry the entire price, then 2A lumber costs were $5,362. For FAS, the lumber costs were $6,809. The question left unanswered is whether the ease of production with FAS is worth $1,447 for cutting bill 2.

Management has several options if greater use of the lower grades is desired. One is arbor adjustment. The results in this study are only for the arbors shown. That we can satisfy cutting bill 2 requirements with No. 2A Common may be considered surprising. However, what would happen if we adjust cutting bill 2 by deleting 4.0- and 4.25-inch parts? Perhaps these scenarios will be evaluated in a separate operation with a small sample of FAS lumber. Details of such an exercise are beyond the scope of this paper. Suffice it to say that the arbor design and part priorities would be different.

Preprocessing of lumber before gang-ripping, particularly in the lower quality sorts within each grade, will have beneficial effects on production. We know that as much as 5 percent of the area of all low-grade lumber will have no yield in it and board-wide defective areas can be removed before gang-ripping (7). We also know that crosscutting the better sections from the worse sections in boards with 10 percent or more end-to-end yield differences (about half of all red oak boards) also will have a beneficial effect on production efficiency (6,7). Removing crook by crosscutting long boards to shorter lengths has been mentioned earlier. Research is currently underway to quantify the effects of remanufacturing and preprocessing of lumber on gang-rip-first yields.

This study shows that the NHLA 1 and 2A Common lumber grades describe a wide range of quality. With half or so of each grade having a maximum grading surface area that falls into the next higher grade, this range of quality has important cost and processing implications when gang-ripping to difficult cutting bills. Inputs of thousands of board feet and costs in the thousands of dollars with a concomitant reduction in ease of processing can be involved. Without the processing precision of ROMI-RIP, differences among sorts are expected to be greater than reported here.

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