Yield comparisons from floating blade and fixed arbor gang ripsaws when processing boards before and after crook removal

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Abstract

Gang-ripping technology that uses a movable (floating) outer blade to eliminate unusable edgings is described, including new terminology for identifying preferred and minimally acceptable strip widths. Because of the large amount of salvage required to achieve total yields, floating blade gang ripping is not recommended for boards with crook. With crook removed by crosscutting to shorter, straight pieces, fixed arbor and floating blade procedures gave similar yield results. The yields from several hundred straight boards were also similar to those for the boards with crook removed. No. 1 Common had more yield in the longest lengths than did No. 2 Common, but the amount of No. 2 Common lengths had been shown earlier to be more than sufficient to meet the needs of the furniture and cabinet industries.

This paper is a companion article to "The effect of crook on yields when processing narrow lumber with a fixed arbor gang ripsaw" (5). The lumber and procedures used are identical except for the variation of gang ripsaw technology. Therefore, the results presented here for the floating blade simulations are directly comparable to those from the earlier fixed arbor simulations.

With fixed arbor gang ripping, a predetermined sequence of saw spacings is set on a single arbor. Boards are fed through whichever subgroup of spacings gives the highest yield in strips. A major objective is to minimize the amount of unusable edgings. All strip widths are predetermined.

With floating blade gang ripping, the range of acceptable strip widths is specified but all of these strip widths are not preset. Most of the floating blade technology now available allows the sawblade nearest the fence and/or the sawblade farthest from the fence to be moved toward or away from a fixed set of saw spacings. No unusable edgings are generated. Strips generated by movable blades will usually be of random widths. This should have little negative effect where panels are routinely glued up but may be cause for concern when only a few fixed widths are needed.

The purpose of this report is to describe the floating blade gang ripsaw process and evaluate the effects of crook when this type of process is used on narrow lumber. Narrow, crooked boards are a worst-case roughmill scenario for optimizing yield with gang-ripping technology. There is not much wood to work with and board edges are at continuously varying angles and distances from the saw guide fence.

Included in this study are comparisons of floating blade and fixed arbor gang ripping. Also included are comparisons between boards with crook removed and full-length lumber that was initially straight. Not included is the wasteful practice of using the floating blade(s) to simply edge off the crook. Instead, crook is removed by crosscutting before gang ripping as described in detail earlier (5).

This report is the fifth in a series exploring the potential of gang ripping. Earlier work includes considerations of roughmill design (2); a discussion of the interactions among lumber grading rules, gang-ripping technology, and industry needs on the potential value of No. 2 Common (3); a tool for setting up gang ripsaw arbors (4); and fixed arbor gang ripping of narrow boards with crook (5).

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Forest Prod. J. 41(5):9-17.

TABLE 1. — *Strip-width probabilities for the 2.0*2.0 float.*[a]

Gross board width	Strip width (in.)												
	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5	4.75	5.0
(in.)													
4.75	2/2												
5.00	1/2	1/2											
5.25	1/2		1/2										
5.50	1/2			1/2									
5.75	1/2				1/2								
6.00	1/2					1/2							
6.25	1/2						1/2						
6.50	1/2							1/2					
6.75	1/2								1/2				
7.00	3/3												
7.25	2/3	1/3											
7.50	2/3		1/3										
7.75	2/3			1/3									
8.00	2/3				1/3								
8.25	2/3					1/3							

[a] For each gross board width (board width plus crook), the sum of the probabilities is 1.

Floating blade procedure

The floating blade gang-ripping simulation was modeled as a set of predetermined and uniform saw spacings followed by a single movable blade that was moved to the outside edge (away from the fence) of each board. The predetermined spacings could have been nonuniform as in normal fixed arbor gang ripping, but this was found to unnecessarily complicate the presentation of results. By repeating a saw spacing until the outside blade is floated, all primary cutting widths that are different from the repeated width must be the result of the float. Primary cuttings have the width of the gang-ripped strip and are produced by simply crosscutting the strips to length (longest possible specified length first). Salvage cuttings follow crosscutting the strips to length and result from a salvage rip and, rarely, an additional crosscut.

Floating blade simulations were run on 29 No. 1 Common and 32 No. 2A Common,[1] 4/4 red oak crooked boards that were graded after kiln-drying using the Special Kiln-Dried Rule (6). All defects on both faces were recorded to an accuracy of 1/4 inch. The average board width in each grade was 5-3/4 inches and each board had at least 1/2 inch of crook. The average clear-face grading surface area for the No. 1 Common sample was 77 percent and for the No. 2A Common sample was 62 percent.

Simulations were run on full-length boards (10 to 16 ft.) with crook and on these same boards after crook was removed or reduced to 1/4 inch by crosscutting the full-length boards to shorter and straighter pieces. For full-length boards with up to 1-1/2 inches of crook (three-fourths of each sample), only one crosscut was normally made. The position of the crosscut along the length was usually at a large defect that occurred somewhere between the first and last quarter of the full-board length. If a significant defect was not found in this center half of the board length, the crosscut was made at the point of maximum crook. After crosscutting, the position of each defect was remeasured relative to the x-axis before the simulations were repeated.

When specifying the setup of the floating blade gang rip arbor, it is necessary to identify two widths. The first is the preferred strip width that is to be repeated. The second width is the minimum acceptable strip width. In this study, 2.0, 2.5, or 3.0 inches are the preferred widths. The minimum acceptable width is 2.0 inches. For brevity, the preferred and minimum widths are paired with an asterisk between them. For example, 2.5*2.0 means that the preferred strip width is 2.5 inches and the minimum acceptable strip width is 2.0 inches. The range of strip widths that will result from these specifications is easily determined. The narrowest is the number following the asterisk and the widest is the sum of the two numbers. The widest salvage piece width will be 1/4 inch less than the widest strip width. The minimum piece width from salvage was specified at 1.0 inch. All sawkerfs are 1/4 inch wide.

In practice, all saws will be preset before the board is gang-ripped. In describing the procedure for setting the saws, it is useful to discuss the saws in sequence starting at the fence. First, a 1/4-inch edge cleanup rip is made on the inner board edge next to the fence. Then, a single, preferred saw spacing is repeated. As the outer edge of the board is approached, the computer analyzes what would happen if the next preferred saw spacing is ripped. If the remainder (after sawkerf and outside edging are factored in) is equal to or wider than the specified minimum spacing, then the preferred spacing is sawed and the outside blade is floated out to take a 1/4-inch cleanup rip on the outer edge of the board. When less than the minimum specified strip width remains, the last preferred saw spacing is not ripped. Instead, the outside sawblade is floated to the outer board edge where the 1/4-inch edge cleanup rip is made.

The study of the floating blade procedure was simpler than the earlier conventional fixed arbor gang ripping. Repeating a preferred width until the outer edge was approached made the procedure the same whether or not boards contained crook. With a fixed

[1] Effective Jan. 1, 1990, the National Hardwood Lumber Association (6) changed the No. 2 Common grade of earlier work to No. 2A Common.

arbor, adjacent spacings normally differ and the order of saw space sequencing is very important to the amount of primary yields. While in practice the floated outer blade will yield random width strips, our computer simulation program floated the outer blade in 1/4-inch increments. Therefore, strip widths could be predicted according to strip-width probabilities (Tables 1, 2, and 3) and the amount of lumber in each board width according to procedures developed earlier (4).

Potential distribution of yields

It is important to understand the implications of the various floats on possible yields. Because the preferred strip width is repeated until it is necessary to float the outer blade, the highest amount of yield should normally be in the preferred width. However, consider the 3.0*2.0 float strip-width probabilities found in Table 3 and recall that a 1/4-inch cleanup occurs on each edge and that 1/4-inch kerfs are used. Boards that are 4.75 inches wide (the narrowest in the study) through 5.5 inches wide will only be edged and will produce cuttings that are 4.25 through 5.0 inches wide. For boards that are 5.75 inches wide, a 3.0- and a 2.0-inch strip are sawn (add .75 in. for one kerf and two edge cleanups to total 5.75 in.). For boards 6.0 through 6.5 inches wide, one 3.0-inch strip and one strip from 2.25 through 2.75 inches wide are produced. Boards that are 6.75 inches wide are sawn to two 3.0-inch-wide strips. From 7 inches through 8.25 inches, a single 3.0-inch-wide strip and a strip wider than 3.0 inches would be produced.

The distribution of board widths after removal of crook is given in Table 4. Forty percent of the No. 1 Common and 27 percent of the No. 2A Common boards were between 4.75 and 5.5 inches wide and would therefore yield only one wide (from 4.25 through 5.0 in. wide) strip from the 3.0*2.0 float. Note that this strip is wider than the preferred spacing of 3.0 inches specified in the float. And, for this study of narrow boards, 56 percent of No. 1 Common and 37 percent of the No. 2A Common input raw material will yield strips greater than 3.0 inches in width overall from the 3.0*2.0 float.

On the other hand, the 2.0*2.0 float presents less opportunity for wide cuttings (Table 1). The widest cutting can only be 4 inches. The 4.75-inch narrowest board width will yield two 2-inch-wide strips. Every larger width increment will also yield a 2.0-inch-wide strip. Boards that are 7.0 inches wide will yield three 2.0-inch-wide strips. For study boards wider than 7.0 inches, two 2-inch-wide strips and one strip wider than 2.0 inches will be sawn.

Selected comparisons between fixed arbor and floating blade gang ripping were made for boards with

TABLE 2. — *Strip-width probabilities for the 2.5*2.0 float.*[a]

Gross board	Strip width (in.)												
width	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5	4.75	5.0
(in.)													
4.75										1/1			
5.00											1/1		
5.25	1/2		1/2										
5.50		1/2	1/2										
5.75			2/2										
6.00			1/2	1/2									
6.25			1/2		1/2								
6.50			1/2			1/2							
6.75			1/2				1/2						
7.00			1/2					1/2					
7.25			1/2						1/2				
7.50			1/2							1/2			
7.75			1/2								1/2		
8.00	1/3		2/3										
8.25		1/3	2/3										

[a] For each gross board width (board width plus crook), the sum of the probabilities is 1.

TABLE 3. — *Strip-width probabilities for the 3.0*2.0 float.*[a]

Gross board	Strip width (in.)												
width	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25	4.5	4.75	5.0
(in.)													
4.75										1/1			
5.00											1/1		
5.25												1/1	
5.50													1/1
5.75	1/2				1/2								
6.00		1/2			1/2								
6.25			1/2		1/2								
6.50				1/2	1/2								
6.75					2/2								
7.00					1/2	1/2							
7.25					1/2		1/2						
7.50					1/2			1/2					
7.75					1/2				1/2				
8.00					1/2					1/2			
8.25					1/2						1/2		

[a] For each gross board width (board width plus crook), the sum of the probabilities is 1.

crook and with crook removed. A comparison between boards with crook removed and several hundred straight boards from 4 to 16 feet long and widths to 14 inches were also made.

Results

Width yields

Floating blade width yields for boards with crook and with crook removed are given in Tables 5 and 6.

TABLE 4. — *Distributions by width of the total board surface area of pieces after crosscutting to remove crook from No. 1 and No. 2A Common red oak lumber.*

Piece width	No. 1 Common	No. 2A Common
(in.)	(% of total sample surface area)	
4.75	2.6	--
5.00	3.8	2.2
5.25	11.2	4.9
5.50	23.0	19.6
5.75	17.7	31.0
6.00	12.3	17.3
6.25	6.6	13.0
6.50	--	--
6.75	6.6	2.5
7.00	3.2	4.0
7.25	--	2.4
7.50	1.6	--
7.75	5.5	3.1
8.00	5.9	--

For boards with crook, the total amount of yield within each grade was about the same regardless of the preferred strip width used (Table 5). However, large amounts of salvage work were necessary to achieve these totals. Half or more of all yield from the 2.5*2.0 and 3.0*2.0 floats came from salvage. The lowest yield from salvage was 27.5 percent from the No. 1 Common crooked boards and 30.0 percent for No. 2A Common yield (for the 2.0*2.0 floats). The highest salvage yields were 40.8 percent from the No. 1 Common crooked boards and 39.4 percent from the No. 2A Common yield (for the 3.0*2.0 float). The computer finds the maximum salvage possible and always places the sawkerf in the defect. It is unlikely that human operators will do as well. These large salvage yields strongly suggest that the floating blade procedure used here should not be used on boards with crook.

Primary width distributions follow predictions for boards with crook removed (Table 6). The range of floats provided a wide range of predicted and, therefore, actual yields. While yields were predicted to be principally in the preferred strip width, the No. 1 Common 3.0*2.0 float actually had a higher prediction for the 4.75 inch and wider width grouping than for the 3.0 widths. This was caused by the distribution of the narrow board widths used (Table 4) in combination with the strip-width probabilities (Table 3).

TABLE 5. — *Width yields from boards with crook using 2.0*2.0,[a] 2.5*2.0,[b] and 3.0*2.0[c] floating blade setups.*

	Width (in.)													
Grade	1.0 and 1.25	1.5 and 1.75	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25 and 4.50	4.75+	Total
	(%)													
No. 1C, 2.0*2.0														
Primary	--	--	24.7	1.8	1.4	0.4	2.5	3.8	3.9	4.0	0.9	--	--	43.4
Salvage	9.2	6.8	1.2	1.6	2.6	2.3	1.8	2.0	--	--	--	--	--	27.5
Total	9.2	6.8	25.9	3.4	4.0	2.7	4.3	5.8	3.9	4.0	0.9	--	--	70.9
No. 1C, 2.5*2.0														
Primary	--	--	1.5	1.2	17.6	1.9	2.5	3.5	0.8	2.8	3.3	1.5	--	36.6
Salvage	4.4	9.8	6.5	3.4	2.1	4.5	1.2	--	1.1	0.5	1.5	--	--	35.0
Total	4.4	9.8	8.0	4.6	19.7	6.4	3.7	3.5	1.9	3.3	4.8	1.5	--	71.6
No. 1C, 3.0*2.0														
Primary	--	--	0.8	1.6	2.1	3.1	11.1	2.4	2.9	0.8	0.6	4.0	1.1	30.5
Salvage	3.7	7.6	6.0	7.5	6.4	2.9	1.0	1.2	1.6	1.1	1.0	0.8	--	40.8
Total	3.7	7.6	6.8	9.1	8.5	6.0	12.1	3.6	4.5	1.9	1.6	4.8	1.1	71.3
No. 2AC, 2.0*2.0														
Primary	--	--	19.2	0.8	0.5	1.1	1.6	5.2	1.9	4.2	1.2	--	--	35.7
Salvage	8.4	8.6	1.9	1.8	1.3	1.6	3.1	1.8	1.5	--	--	--	--	30.0
Total	8.4	8.6	21.1	2.6	1.8	2.7	4.7	7.0	3.4	4.2	1.2	--	--	65.7
No. 2AC, 2.5*2.0														
Primary	--	--	1.1	--	13.8	4.4	1.3	4.1	1.1	1.7	1.3	2.2	--	31.0
Salvage	4.7	9.4	4.7	5.0	4.0	3.8	2.5	0.3	0.3	0.3	0.9	--	--	35.9
Total	4.7	9.4	5.8	5.0	17.8	8.2	3.8	4.4	1.4	2.0	2.2	2.2	--	66.9
No. 2AC, 3.0*2.0														
Primary	--	--	0.3	3.8	1.4	3.6	11.8	1.5	1.1	0.4	1.6	1.7	0.4	27.6
Salvage	4.7	5.4	6.8	8.6	5.8	3.8	1.6	0.6	0.8	0.2	0.5	0.6	--	39.4
Total	4.7	5.4	7.1	12.4	7.2	7.4	13.4	2.1	1.9	0.6	2.1	2.3	0.4	67.0

[a] Preferred strip width is 2.0 inches with no saw spacing less than 2.0 inches.
[b] Preferred strip width is 2.5 inches with no saw spacing less than 2.0 inches.
[c] Preferred strip width is 3.0 inches with no saw spacing less than 2.0 inches.

TABLE 6. — *Width yields from boards with crook using 2.0*2.0,[a] 2.5*2.0,[b] and 3.0*2.0[c] floating blade setups.*

	Width (in.)													
Grade	1.0 and 1.25	1.5 and 1.75	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.25 and 4.50	4.75+	Total
	(%)													
No. 1C, 2.0*2.0														
Predicted	--	--	55.0	1.9	6.1	13.3	10.9	6.2	3.3	--	3.3	--	--	100.0
Primary	--	--	32.4	1.5	4.9	10.1	7.9	6.1	1.7	--	2.9	--	--	67.5
Salvage	1.5	2.0	0.1	1.0	0.8	0.4	--	0.6	--	0.2	--	--	--	6.6
Total	1.5	2.0	32.5	2.5	5.7	10.5	7.9	6.7	1.7	0.2	2.9	--	--	74.1
No. 1C, 2.5*2.0														
Predicted	--	--	7.6	11.5	56.7	6.1	3.3	--	3.3	1.6	--	9.9	--	100.0
Primary	--	--	4.3	8.3	37.3	4.3	2.4	--	3.1	1.4	--	7.1	--	68.2
Salvage	1.6	2.2	1.0	1.9	--	--	0.2	--	--	--	--	--	--	6.9
Total	1.6	2.2	5.3	10.2	37.3	4.3	2.6	--	3.1	1.4	--	7.1	--	75.1
No. 1C, 3.0*2.0														
Predicted	--	--	8.9	6.1	3.3	--	33.0	1.6	--	0.8	2.8	9.3	34.2	100.0
Primary	--	--	4.8	3.5	2.0	--	23.5	1.2	--	--	2.4	6.4	20.7	64.5
Salvage	1.0	1.5	0.4	1.1	0.8	0.7	0.7	0.6	--	0.4	1.1	0.3	1.7	10.3
Total	1.0	1.5	5.2	4.6	2.8	0.7	24.2	1.8	--	0.4	3.5	6.7	22.4	74.8
No. 2AC, 2.0*2.0														
Predicted	--	--	52.9	1.9	2.5	9.8	15.9	9.3	6.5	--	1.2	--	--	100.0
Primary	--	--	27.6	0.9	1.4	7.4	10.7	4.0	3.4	--	0.9	--	--	56.3
Salvage	2.8	3.1	0.8	1.1	0.8	1.5	1.4	0.2	--	--	--	--	--	11.7
Total	2.8	3.1	28.4	2.0	2.2	8.9	12.1	4.2	3.4	--	0.9	--	--	68.0
No. 2AC, 2.5*2.0														
Predicted	--	--	2.8	10.5	65.0	8.6	6.5	--	1.2	2.0	1.2	2.2	--	100.0
Primary	--	--	1.6	7.0	38.3	3.2	3.2	--	0.8	1.7	--	1.3	--	57.1
Salvage	2.8	2.9	1.2	2.2	1.0	0.2	--	--	0.5	--	--	0.4	--	11.2
Total	2.8	2.9	2.8	9.2	39.3	3.4	3.2	--	1.3	1.7	--	1.7	--	68.3
No. 2AC, 3.0*2.0														
Predicted	--	--	15.5	8.7	6.5	--	37.9	2.0	1.2	--	--	3.7	24.5	100.0
Primary	--	--	7.4	2.7	2.7	--	23.2	1.4	--	--	--	2.8	13.6	53.8
Salvage	3.0	4.0	2.0	1.3	0.7	2.0	0.2	0.6	--	--	--	0.3	--	14.1
Total	3.0	4.0	9.4	4.0	3.4	2.0	23.4	2.0	--	--	--	3.1	13.6	67.9

[a] Preferred strip width is 2.0 inches with no saw spacing less than 2.0 inches.
[b] Preferred strip width is 2.5 inches with no saw spacing less than 2.0 inches.
[c] Preferred strip width is 3.0 inches with no saw spacing less than 2.0 inches.

Length yields

Floating blade length yields for boards with crook and for the same boards after crook was removed are given in Tables 7 and 8. The lengths shown are those most often needed by the furniture and kitchen cabinet industries (1). For the full-length boards with crook (Table 7), total length yields within a grade were not affected by the float that was used. However, for each length increment in No. 1 Common, the amount of salvage work to achieve these totals generally increased as the float changed from 2.0*2.0 to 3.0*2.0. For No. 2A Common, salvage yields were generally high in each length increment and made up most of the 75-inch yield for the 2.5*2.0 and 3.0*2.0 floats. As mentioned earlier in the discussion of width yields, the large amount of salvage work required to achieve the total makes our floating blade procedure of questionable value when processing full-length boards with crook.

Crook removal had a positive effect on length yields (Table 8). Most of the yield was primary (crosscutting the gang-ripped strips to length). At worst (3.0*2.0 float), total salvage yields were only 10.3 percent for No. 1 Common and 14.1 percent for No. 2A Common. In comparison with full-length boards with crook, boards with crook removed had important increases in the primary yields for lengths above 29 inches. Total yields did not increase much (from about 71% to about 75% for No. 1 Common and from 67% to 68% for No. 2A Common).

Length comparisons: fixed arbor gang ripping

Earlier work (5) on fixed arbor gang ripping used saw spacings from 1-1/2 to 3 inches. The floating blade procedure produced strip widths from 2 through 5 inches. This means that, when comparing length yields, there will be a bias against the floating blade procedure. The bias occurs because the wider strips generally encounter defects sooner in a cut-to-length operation. To make comparisons as realistic as possible, the fixed arbor results were compared to the 2.0*2.0 float (spacings from 2.0 to 4.0 in.). Table 9 details this comparison. The narrow spacing was always first on the fixed arbor (optimum fixed arbor conditions).

For boards with crook, the wider spacings of the 2.0*2.0 float caused important reductions in the primary yield totals for both No. 1 Common (10.3 percentage points) and No. 2A Common (8.6 percentage points)

TABLE 7. — *Length yields from boards with crook using 2.0*2.0,[a] 2.5*2.0,[b] and 3.0*2.0[c] floating blade arbor setups.*

Grade	Length (in.) 15	18	25	29	33	38	45	50	60	75	Total
	(%)										
No. 1C, 2.0*2.0											
Primary	1.4	2.8	1.7	2.5	2.5	4.0	3.5	5.7	9.5	9.8	43.4
Salvage	1.5	2.0	2.7	1.3	2.5	3.5	2.2	3.0	4.6	4.2	27.5
Total	2.9	4.8	4.4	3.8	5.0	7.5	5.7	8.7	14.1	14.0	70.9
No. 1C, 2.5*2.0											
Primary	1.2	3.4	2.5	1.7	2.4	3.5	3.2	6.3	6.5	5.9	36.6
Salvage	1.2	3.3	3.2	1.2	3.5	3.5	2.8	2.3	5.8	8.2	35.0
Total	2.4	6.7	5.7	2.9	5.9	7.0	6.0	8.6	12.3	14.1	71.6
No. 1C, 3.0*2.0											
Primary	1.5	3.5	2.6	1.2	3.3	3.1	2.5	5.0	5.7	2.1	30.5
Salvage	2.0	3.9	2.7	1.9	2.9	4.4	1.8	3.4	6.3	11.5	40.8
Total	3.5	7.4	5.3	3.1	6.2	7.5	4.3	8.4	12.0	13.6	71.3
No. 2AC, 2.0*2.0											
Primary	2.2	4.0	2.7	4.5	2.3	2.1	2.0	4.7	5.1	6.1	35.7
Salvage	2.1	4.2	2.4	2.0	3.9	4.0	2.0	2.1	2.6	4.7	30.0
Total	4.3	8.2	5.1	6.5	6.2	6.1	4.0	6.8	7.7	10.8	65.7
No. 2AC, 2.5*2.0											
Primary	2.2	3.1	3.2	4.1	2.3	2.3	2.4	4.6	4.2	2.6	31.0
Salvage	1.9	4.5	2.4	2.8	4.7	5.1	2.0	3.6	2.6	6.3	35.9
Total	4.1	7.6	5.6	6.9	7.0	7.4	4.4	8.2	6.8	8.9	66.9
No. 2AC, 3.0*2.0											
Primary	2.2	3.1	3.0	4.2	2.0	2.4	1.8	3.2	3.8	1.9	27.6
Salvage	2.6	4.4	2.3	3.0	4.5	5.4	1.9	4.0	3.9	7.4	39.4
Total	4.8	7.5	5.3	7.2	6.5	7.8	3.7	7.2	7.7	9.3	67.0

[a] Preferred strip width is 2.0 inches with no saw spacing less than 2.0 inches.
[b] Preferred strip width is 2.5 inches with no saw spacing less than 2.0 inches.
[c] Preferred strip width is 3.0 inches with no saw spacing less than 2.0 inches.

TABLE 8. — *Length yields from boards with crook removed when processed using 2.0*2.0,[a] 2.5*2.0,[b] and 3.0*2.0[c] floating blade arbor setups.*

Grade	Length (in.) 15	18	25	29	33	38	45	50	60	75	Total
	(%)										
No. 1C, 2.0*2.0											
Primary	1.7	2.7	3.7	2.2	4.7	7.0	5.3	9.5	10.6	20.2	67.6
Salvage	1.8	1.3	0.8	- -	0.6	0.2	0.3	0.7	0.8	- -	6.5
Total	3.5	4.0	4.5	2.2	5.3	7.2	5.6	10.2	11.4	20.2	74.1
No. 1C, 2.5*2.0											
Primary	1.8	3.0	3.3	2.5	3.7	7.7	4.4	9.3	12.5	20.0	68.2
Salvage	1.5	1.4	1.2	- -	0.9	0.1	0.2	1.1	0.5	- -	6.9
Total	3.3	4.4	4.5	2.5	4.6	7.8	4.6	10.4	13.0	20.0	75.1
No. 1C, 3.0*2.0											
Primary	1.8	4.5	3.5	2.5	5.7	6.2	4.6	9.6	10.2	15.9	64.5
Salvage	2.1	2.3	1.3	0.5	0.4	0.2	0.9	0.6	2.0	- -	10.3
Total	3.9	6.8	4.8	3.0	6.1	6.4	5.5	10.2	12.2	15.9	74.8
No. 2AC, 2.0*2.0											
Primary	1.7	4.7	4.4	3.4	5.6	5.9	4.0	11.5	9.0	6.1	56.3
Salvage	2.4	2.5	1.2	2.2	0.7	0.7	0.2	1.0	0.5	0.3	11.7
Total	4.1	7.2	5.6	5.6	6.3	6.6	4.2	12.5	9.5	6.4	68.0
No. 2AC, 2.5*2.0											
Primary	2.1	4.6	5.4	2.9	6.4	4.6	4.8	10.7	9.4	6.2	57.1
Salvage	2.1	2.7	1.9	1.2	0.5	0.8	- -	1.1	0.5	0.4	11.2
Total	4.2	7.3	7.3	4.1	6.9	5.4	4.8	11.8	9.9	6.6	68.3
No. 2AC, 3.0*2.0											
Primary	1.3	5.8	4.2	4.0	5.8	3.8	5.6	8.4	9.8	5.1	53.8
Salvage	2.7	2.8	2.2	1.7	1.3	1.0	- -	1.2	0.3	0.9	14.1
Total	4.0	8.6	6.4	5.7	7.1	4.8	5.6	9.6	10.1	6.0	67.9

[a] Preferred strip width is 2.0 inches with no saw spacing less than 2.0 inches.
[b] Preferred strip width is 2.5 inches with no saw spacing less than 2.0 inches.
[c] Preferred strip width is 3.0 inches with no saw spacing less than 2.0 inches.

TABLE 9. — *Length yields from certain fixed arbor and floating blade gang rip simulations of narrow boards with crook and with crook removed.*

Grade	Length (in.)										Total
	15	18	25	29	33	38	45	50	60	75	
	(%)										
Boards with crook, No. 1C											
Fixed arbor (1.5- to 3-in. spacings — narrow spacing first)											
Primary yield	1.4	3.7	2.1	3.2	2.9	4.1	2.6	5.3	9.3	19.1	53.7
Salvage yield	1.5	2.2	1.6	1.2	1.3	2.3	1.0	2.1	2.2	1.0	16.4
Total	2.9	5.9	3.7	4.4	4.2	6.4	3.6	7.4	11.5	20.1	70.1
Floating blade (2.0*2.0)[a]											
Primary yield	1.4	2.8	1.7	2.5	2.5	4.0	3.5	5.7	9.5	9.8	43.4
Salvage yield	1.5	2.0	2.7	1.3	2.5	3.5	2.2	3.0	4.6	4.2	27.5
Total	2.9	4.8	4.4	3.8	5.0	7.5	5.7	8.7	14.1	14.0	70.9
Boards with crook, No. 2AC											
Fixed arbor (1.5- to 3-in. spacings — narrow spacing first)											
Primary yield	2.1	3.5	3.1	3.1	2.4	2.9	2.4	8.2	7.2	9.4	44.3
Salvage yield	2.3	4.0	1.0	1.7	2.4	2.8	1.4	1.1	1.5	1.9	20.1
Total	4.4	7.5	4.1	4.8	4.8	5.7	3.8	9.3	8.7	11.3	64.4
Floating blade (2.0*2.0)[a]											
Primary yield	2.2	4.0	2.7	4.5	2.3	2.1	2.0	4.7	5.1	6.1	35.7
Salvage yield	2.1	4.2	2.4	2.0	3.9	4.0	2.0	2.1	2.6	4.7	30.0
Total	4.3	8.2	5.1	6.5	6.2	6.1	4.0	6.8	7.7	10.8	65.7
Boards with crook removed, No. 1C											
Fixed arbor (1.5- to 3-in. spacings — narrow spacing first)											
Primary yield	1.7	3.3	3.3	3.2	3.5	7.3	5.0	10.0	10.2	21.4	68.9
Salvage yield	1.8	1.1	1.6	0.0	0.4	0.0	0.0	0.6	0.3	0.0	5.8
Total	3.5	4.4	4.9	3.2	3.9	7.3	5.0	10.6	10.5	21.4	74.7
Floating blade (2.0*2.0)[a]											
Primary yield	1.7	2.7	3.7	2.2	4.7	7.0	5.3	9.5	10.6	20.2	67.6
Salvage yield	1.8	1.3	0.8	0.0	0.6	0.2	0.3	0.7	0.8	0.0	6.5
Total	3.5	4.0	4.5	2.2	5.3	7.2	5.6	10.2	11.4	20.2	74.1
Boards with crook removed, No. 2AC											
Fixed arbor (1.5- to 3-in. spacings — narrow spacing first)											
Primary yield	1.7	4.7	4.1	3.4	4.1	6.1	4.1	11.8	9.7	7.1	56.8
Salvage yield	2.2	2.9	1.0	1.3	0.3	1.0	0.0	1.2	0.5	0.3	10.7
Total	3.9	7.6	5.1	4.7	4.4	7.1	4.1	13.0	10.2	7.4	67.5
Floating blade (2.0*2.0)[a]											
Primary yield	1.7	4.7	4.4	3.4	5.6	5.9	4.0	11.5	9.0	6.1	56.3
Salvage yield	2.4	2.5	1.2	2.2	0.7	0.7	0.2	1.0	0.5	0.3	11.7
Total	4.1	7.2	5.6	5.6	6.3	6.6	4.2	12.5	9.5	6.4	68.0

[a] Preferred strip width is 2.0 inches with no saw spacing less than 2.0 inches.

TABLE 10. — *2.0*2.0[a] floating blade gang ripping yields from 639 No. 1 Common and 626 No. 2 Common straight boards compared to 29 No. 1 Common and 32 No. 2 Common boards after crook removal.*

Grade	Length (in.)										Total
	15	18	25	29	33	38	45	50	60	75	
	(%)										
No. 1C, straight boards											
Primary yield	1.3	3.6	2.6	2.6	3.5	5.4	4.2	7.2	12.9	22.6	65.9
Salvage yield	1.1	1.5	0.9	0.7	0.6	0.7	0.3	0.4	0.5	0.4	7.1
Total	2.4	5.1	3.5	3.3	4.1	6.1	4.5	7.6	13.4	23.0	73.0
No. 1C, crook removed											
Primary yield	1.7	2.7	3.7	2.2	4.7	7.0	5.3	9.5	10.6	20.2	67.6
Salvage yield	1.8	1.3	0.8	0.0	0.6	0.2	0.3	0.7	0.8	0.0	6.5
Total	3.5	4.0	4.5	2.2	5.3	7.2	5.6	10.2	11.4	20.2	74.1
No. 2AC, straight boards											
Primary yield	2.5	6.0	4.0	3.7	4.7	6.1	4.7	6.7	8.7	11.4	58.5
Salvage yield	1.6	2.1	1.1	0.7	0.6	0.9	0.4	0.6	0.4	0.5	8.9
Total	4.1	8.1	5.1	4.4	5.3	7.0	5.1	7.3	9.1	11.9	67.4
No. 2AC, crook removed											
Primary yield	1.7	4.7	4.4	3.4	5.6	5.9	4.0	11.5	9.0	6.1	56.3
Salvage yield	2.4	2.5	1.2	2.2	0.7	0.7	0.2	1.0	0.5	0.3	11.7
Total	3.1	7.2	5.6	5.6	6.3	6.6	4.2	12.5	9.5	6.4	68.0

[a] Preferred strip width is 2.0 inches with no strip width less than 2.0 inches.

compared to the fixed arbor, even though overall totals were similar. For the No. 1 Common crooked boards, there was also an important reduction in the amount of 75-inch primary yield for the 2.0*2.0 float. For No. 2A Common crooked boards, there was a consistent though small decrease in the primary yields of the longest lengths (50, 60, and 75 in.). Again, the high salvage yields from ripping crooked boards with the floating blade make this procedure undesirable even though the total of the No. 2A Common primary and salvage yields for each length were about the same for the fixed arbor and floating blade procedures.

For boards with crook removed, the yields for the two ripping procedures were remarkably similar. Totals for all specified lengths, totals for each specified length, and amounts of primary and salvage yields were quite uniform within either grade.

Length comparisons: straight lumber

The crook study boards were narrow (4.75 to 8.0 in. wide) and ranged from 10 to 16 feet long. With the crook removed, gang ripping was done on shorter, straight board segments. How do these length results compare when full-length, full-width straight boards in the two grades are gang ripped? To find out, the 2.0*2.0 float was simulated on more than 600 boards in each grade. These straight boards ranged in width from 4 to 14 inches and in length from 4 to 16 feet. They represented the full range of grade quality.

The results of the 2.0*2.0 float simulation on the large, straight, full-length lumber sample are given in Table 10. Compared to the boards with crook removed, the total results were about the same. Individual length comparisons between boards with crook removed and straight boards were also quite similar for No. 1 Common lumber. For No. 2A Common, the totals for the 50-, 60-, and 75-inch lengths were the same, although there was less 50-inch yield and more 75-inch yield from the straight boards (about 5% in each case). Otherwise, the No. 2A Common length distributions were similar whether from straight boards or boards with crook removed.

Discussion of results

The floating blade gang ripping procedure simulated in this study requires the specification of a preferred strip width and a minimum strip width. It further requires that no unusable edgings will be produced. Any potential strip that is narrower than the minimum strip width is added to the previous preferred strip width. One result of this procedure is that strips wider than the preferred width are often produced (Tables 1, 2, and 3). A benefit of this procedure is that the effects of the float on the primary yields can be easily identified.

However, it is hoped that the reader will visualize other arbor setups and yield distributions. Consider, for example, the 3.0*2.0 values for No. 1 Common in Table 6 and the strip-width probabilities in Tables 1 and 3. If cuttings 4 inches and wider are not desired, then boards could be sorted for two different arbor setups. All board widths from 4.75 through 5.5 inches and 7.75 inches and wider could be run through the 2.0*2.0 arbor. This would shift the 45 percent or so predicted yields for 4.0-inch and wider strips for the 3.0*2.0 float to 2.0 to 3.0-inch widths. Or, an arbor with variable saw spacings and floating outer blade could be designed. Gang ripping is a flexible process.

The computer program looks for the longest full-width clear piece it can find between two defects. Increasing the strip width increases the likelihood that a defect will be encountered in a cut-to-length operation. When a board contains crook, the outside edges are not parallel to the fence. Yield from strips containing the crook is mostly from salvage. As a consequence, much of the yield from narrow crooked boards comes from salvage operations (Tables 5 and 7). So much so, in fact, that processing narrow boards with crook with the floating blade procedure is not recommended and will not be discussed further.

In contrast, when c[illegible] removed, the floating blade technology is an effective processing technique. Most of the yield is in primary parts and there is relatively little yield in the narrowest salvage widths (Table 6). Primary width yields follow the predicted yield patterns. Further, the floating blade procedure has a large production control potential when processing narrow straight boards. Floats ranging from 2.0*2.0 to 3.0*2.0 allow emphasis to be placed on narrow or wide strip-width distributions without any important increase in salvage work or decrease in total yield. A large percentage of the yield will be wider than the preferred spacing specified in the float.

The length distributions for the boards with crook removed and boards that were initially straight reflected the longest length first cut-to-length procedure (Tables 8, 9, and 10) with the highest yields generally occurring in the longest lengths or groups of lengths. No. 1 Common had more yield in the 75-inch length than did No. 2A Common but the No. 2A Common yields were shown earlier to be more than sufficient to meet the needs of the furniture and cabinet industries (3). There were 10 lengths in the study. The amount of yield in each short length was generally less than 10 percent of the total.

Comparisons of fixed arbor and floating blade length yields after crook removal showed a remarkable similarity within each grade (Table 9). And comparison between the grades showed remarkable similarity in length yields for all but the 75-inch lengths. These results have important production control implications and suggest that managers have a wide latitude in operating procedures when manufacturing dimension parts from 15 to 60 inches long and from 1.5 to 5 inches wide provided the boards are straight.

Comparisons of yields from boards after crook removal to yields from straight boards (Table 10) suggest a new and important production control implication for the potential use of short lumber. There appears to be no need to feed boards over 12 feet long through a gang ripsaw to obtain sufficient long part lengths (through 75 in. for No. 1 Common and 60 in. for No. 2A Common). The procedure used to remove crook was to make a crosscut somewhere after the first quarter and before the last quarter of the board length. Thus, the longest length after crook removal from a 16-foot board was 12 feet. Generally, it was less. This implication will be tested more fully in a future study.

Conclusions

Gang ripping narrow boards with 1/2 inch or more of crook should not be done. To maximize yield from crooked boards, a great amount of expensive salvage work will be required. Much of the salvage will be in long, narrow pieces that will be hard to get and hard to work with. Removal of crook puts most of the yield in easy-to-get primary pieces.

Rather than use the wasteful practice of edging off the crook during gang ripping, crook should be removed by crosscutting before gang ripping. Our procedure calls for crosscutting somewhere in the center half of the board at a large defect or at the point of maximum crook. This is not as efficient as crosscutting at the end of a specified cutting length or a combination of cutting lengths. Even so, our procedure with No. 2A Common lumber produced more long lengths than are required by the furniture and cabinet industries.

With crook removed by crosscutting, fixed arbor and floating blade procedures give similar yield distributions. The distribution of yields from No. 1 and No. 2A Common lumber with crook removed is similar up to the 75-inch length, where No. 1 Common was superior. This may be a moot point for the furniture and cabinet industries as the lesser yield from No. 2A Common is still adequate for their needs. Of greater importance, perhaps, is that length distributions are not weighted toward the short lengths.

Those who may still be concerned that crosscutting out crook will reduce the amount in the longer lengths should be reassured by the limited comparison with full-length straight boards. From 15 through 75 inches, the length distributions for the crosscut and straight boards were the same for No. 1 Common. They were also the same for No. 2A Common when the 50-, 60-, and 75-inch lengths were grouped together.

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