562

Determining the impact of sorting capacity on rip-first rough mill yield

Edward Thomas
John Brown

Abstract

The problem of increasing gang-rip-first rough mill yield often amounts to little more than optimizing the fit of needed parts into strips. However, it is rare when a part or combination of parts fits precisely in the area between two defects. Intuition tells us that the more lengths we have to choose from, the greater the chance of completely filling such an area. Because of the many interrelated processing dependencies in a rough mill, it is difficult to estimate the potential yield increase due to cutting more lengths simultaneously by conventional methods. Using the ROMI-RIP simulator, we analyzed the impact of sorting capacity (i.e., the number of lengths and widths cut simultaneously) on yield for various lumber grade mixes and typical industrial cutting bill combinations. Using an analysis of variance, significant yield increases were observed as a result of increasing sorting capacities. However, a plateau is reached around 18 to 20 part sizes, where additional sorting capacity increases result in negligible yield gains. Knowing the necessary number of lengths for maximum yield provides the opportunity for rough mill operators to determine the most economical sorting capacity for a rough mill.

The difficulty of increasing gang-rip-first rough mill yield involves optimizing the fit of needed parts into the clear areas between defects on strips. Rarely will a part or combination of parts fit precisely into the clear area, but the more unique the part lengths, the more possibilities exist to completely fill such a space. By unique lengths we refer to lengths that are not multiples of shorter lengths within the shortest and longest lengths of a cutting bill. Cutting more lengths simultaneously increases the choices for optimizing yield. However, the number of different part sizes a rough mill can cut at once is dictated by three factors: 1) the number of part sizes in the cutting bill; 2) the sorting capacity, i.e., the physical number of different part sizes that can be sorted and stacked at the same time; and 3) the number of lengths that can be processed or kept track of at the chopsaw.

With the advent of automatic, computer-controlled chopsaws, an almost infinite number of unique part sizes can be cut and tallied. However, sorting capacities have not grown as quickly. Automated chopsaws often are not operated with more part sizes than manual saws. This could be due, in part, to the complexity of estimating the economic merit of an increased sorting capacity since potential yield gains are difficult to estimate. This uncertainty makes it difficult for rough mill operators to justify adding employees and equipment to increase sorting capacity.

Optimization theory informs us that the greater the number of different part sizes that can be processed together, the better the overall yield, due to increased optimization choices. However, the extent of yield improvement from increased sorting capacity is not well documented due to difficulties in studying this problem in rough mills. This paper examines the impact of the number of part sizes processed simultaneously on rip-first rough dimension part yield using the ROMI-RIP 2.1 simulator (Thomas 1996, 1999a; Thomas and Buehlmann 2001).

This paper does not examine part scheduling and replacement methods. However, an understanding of these methods is necessary for studying the impact of sorting capacity on rough mill yield. This is because, in most cases, the sorting capacity is less than the number of parts required by a cutting bill and decisions must be made concerning which parts to process together. The rough mill operator also must decide which parts should replace other parts as quantity requirements are met during processing. This task usually is referred to as part scheduling and replacement. Scheduling and replacement methods seek to

The authors are, respectively, Research Scientist and Statistician, USDA Forest Service, Forestry Sciences Laboratory, 241 Mercer Springs Road, Princeton, WV 24740. This paper was received for publication in February 2002. Article No. 9436.

Forest Prod. J. 53(7/8):

group together parts that have the widest possible range of length and width requirements and are not multiples of shorter parts. By allowing the gang ripsaw and chopsaw optimizers a wide range of part sizes to choose from, better cut-up solutions are realized and yield is improved. For example, yield usually suffers when fewer unique lengths, or when only longer lengths, are required by the cutting bill. The ideal solution is to simultaneously process a mix of long, medium, and short length parts.

Methods

It would be difficult to perform this study in an actual rough mill because of the disruption of normal operations and required modifications. Extra chopsaw capabilities and sorting capacity would be needed to determine the potential, if any, of additional yield. This difficulty and the potential variability of the lumber used for each test leads us to conclude that simulation is the best approach. The ROMI-RIP 2.1 (RR2) rip-first rough mill simulator (Thomas 1996, 1999a, 1999b; Thomas and Buehlmann 2001) was used in this study because of its support for a variety of rough mill operations, including algorithms for part scheduling and replacement.

Simulation design

We examined nine cutting bills (**Table 1**) from actual rough mill operations. These cutting bills represent a wide variety of products and range from 17 to 29 part sizes. We did not select cutting bills based on their composition of panel parts. Our only goal was to select cutting bills such that a range of difficulties and part size requirements could be examined. The maximum percentage of any cutting bill composed of panels was approximately 60 percent. Panels usually make cutting bill requirements less difficult because of their random-width nature. This observation is usually evident when examining the yield from different cutting bills.

Cutting bills can generally be classified into one of three categories: easy, moderate, and difficult (Thomas 1996). Easy cutting bills have an evenly balanced distribution of part size requirements and need few, if any, wide and long part sizes. Moderate cutting bills also have an evenly balanced part requirement distribution but require more difficult-to-obtain, wider, and longer part sizes. Difficult cutting bills contain an unbalanced part-size requirement distribution and require relatively larger part sizes. Of the nine cutting bills selected, two were classified as easy, four as medium, and three as difficult.

For each cutting bill, we used a standard set of processing options that were held constant over all simulations. The options used included: fixed-blade-best-feed arbor, 1/8-inch ripsaw and chopsaw kerf sizes, no endtrim allowance, and dynamic part prioritization. Fixed-blade-best-feed gang-ripsaws have a set of fixed blades where the distances between the blades are the primary part widths. Boards are fed through the arbor according to their width and defect placement such that an optimal yield in strips, and later during chopsawing, dimension parts are produced. This method of processing is similar to that of advanced systems that use vision technology. The kerf sizes are the thicknesses of the blades used during processing. The end trim allowance refers to the length cut from each end of a board before processing begins. This is usually done to remove end-checks or splits in the end of the board.

Dynamic part prioritization prioritizes cutting bill parts based on their current required quantity and size (Thomas 1996). As processing continues and

Table 1. — Description of cutting bills used.

Cutting bill no.	Width count	Width information (in.)	Length count	Length information (in.)	Total part count	Comments
1	6	1.25 to 3.875	12	14.75 to 43.00	17	8 panel parts. Very few lengths per part, but no difficult part sizes. A medium cutting bill.
2	7	1.00 to 3.75	14	11.125 to 40.75	16	4 panel parts. Most widths have only one or two lengths - makes optimization very challenging. A difficult cutting bill.
3	5	1.75 to 4.5	21	9.875 to 43.75	21	8 panel parts. No long parts, good balance of part sizes. Easy to medium cutting bill.
4	5	1.5 to 4.25	15	14.625 to 78.875	16	6 panel parts. Requires primarily medium-length and narrow parts. An easy to medium cutting bill.
5	3	2.5 to 4.25	18	14.25 to 64.50	20	2 panel parts. Requires few shorts and panels. A medium difficulty cutting bill.
6	3	1.625 to 3.125	18	13.00 to 80.50	29	3 panel parts. Well balanced requirements. An easy to medium difficultly cutting bill.
7	6	2.25 to 4.125	14	19.5 to 87.75	16	2 panel parts. No short lengths. Very few (maximum of 4) lengths per width. A difficult cutting bill.
8	3	1.75 to 3.5	16	18.25 to 67.00	26	No panel parts. Good distribution of part sizes. Requires few longer and wider parts. A medium cutting bill.
9	3	1.75 to 3.5	15	19.5 to 70.25	29	No panel parts. Good part size distribution. Requires few 1.75-in.-wide parts as well as fewer longer and wider parts. A medium cutting bill.

parts are obtained, the priorities of the parts are updated. The goal of dynamic prioritization is to emphasize larger part sizes and part sizes that have higher required numbers of parts. The arbor for each cutting bill was designed according to the width distribution of the incoming lumber and the width demands of the cutting bill, according to the method developed by Gatchell (1996).

We examined sorting capacity sizes of 10, 12, 14, and up to the total number of part sizes in the cutting bill in two part size increments. The starting sort capacity size of 10 was chosen as any smaller size would not normally be encountered except in the instance of some specialty products. For any cutting bill there is nearly an infinite number of ways to schedule and replace part sizes. A simple strategy was developed to group cutting bill parts so that a complementary group of parts could be selected for initial processing. This strategy treats solid and panel parts differently such that they are grouped and selected separately.

First, the distribution of solid parts versus panels in each cutting bill was established. For a sorting capacity of n, the maximum number of panel parts that are scheduled at once is $n/5$ rounded up to the nearest integer. This procedure, based on past experience, was conducted to reduce the number of panels processed at one time and to balance panel processing over the life of the cutting bill. As stated earlier, the random-width requirements of panels make them easier to obtain and improves overall yield.

Second, individual solid parts and panels were assigned to each cutting bill. Once the number of solid and panel parts to be processed concurrently is known, the part sizes are grouped together. The goal of selection is to choose an initial scheduling of parts whose sizes and quantities complement each other. The selection strategy works by calculating priorities for each part size. Three different prioritizing methods were used to avoid the possibility of examining only poor or extremely good scheduling choices. The three methods of calculating priorities are listed below. **Table 2** presents the prioritized values calculated for cutting bill 6.

Method 1: Part Width × Part Length
Method 2: Part Width × Part Length × Part Quantity
Method 3: Part Length × Part Quantity

Consider a cutting bill with 26 solid part sizes, 3 panels (as shown in **Table 2**

Table 2. — Part sizes and prioritized part values for cutting bill 6.

Width	Length	Quantity	Priority Method 1	Priority Method 2	Priority Method 3
------------ (in.) ------------					
Panel parts					
7.000	21.500	50	151	7525	1075
5.000	14.000	50	70	3500	700
9.250	30.500	50	282	14106	1525
Solid parts					
1.625	13.000	500	21	10563	6500
1.625	15.500	1000	25	25188	15500
1.625	19.750	600	32	19256	11850
1.625	21.500	500	35	17469	10750
1.625	24.500	500	40	19906	12250
1.625	27.500	1250	45	55859	34375
1.625	31.000	3000	50	151125	93000
1.625	33.500	650	54	35384	21775
1.625	36.500	100	59	5931	3650
1.625	39.500	150	64	9628	5925
1.625	45.500	150	74	11091	6825
1.625	80.500	100	131	13081	8050
2.000	27.500	100	55	5500	2750
2.250	14.000	1000	32	31500	14000
2.250	16.750	750	38	28266	12563
2.250	19.750	1000	44	44438	19750
2.250	23.750	1750	53	93516	41563
2.250	28.750	2000	65	129375	57500
2.250	31.000	250	70	17438	7750
2.250	36.750	100	83	8269	3675
2.250	40.750	100	92	9169	4075
3.125	16.250	300	51	15234	4875
3.125	21.500	300	67	20156	6450
3.125	28.000	450	88	39375	12600
3.125	39.500	100	123	12344	3950
3.125	80.500	100	252	25156	8050

Table 3. — Grouping table and initial parts scheduling for cutting bill 6 using Method 2.

Part type	Part no.	Grouping 1			Part no.	Grouping 2			Part no.	Grouping 3		
		Width	Length	Priority		Width	Length	Priority		Width	Length	Priority
		------ (in.) ------				------ (in.) ------				------ (in.) ------		
Panels	1	5.0000	14.0000	3500								
	2	7.0000	21.5000	7525								
	3	9.2500	30.5000	14105								
Solids	1	2.0000	27.5000	5500	12	1.6250	21.5000	17469	23	1.6250	27.5000	55859
	2	1.6250	36.5000	5931	13	1.6250	19.7500	19256	24	2.2500	23.7500	93516
	3	2.2500	36.7500	8269	14	1.6250	24.5000	19906	25	2.2500	28.7500	129375
	4	2.2500	40.7500	9169	15	3.1250	21.5000	20156	26	1.6250	31.0000	151125
	5	1.6250	39.5000	9628	16	3.1250	80.5000	25156				
	6	1.6250	13.0000	10563	17	1.6250	15.5000	25188				
	7	1.6250	45.5000	11091	18	2.2500	16.7500	28266				
	8	3.1250	39.5000	12344	19	2.2500	14.0000	31500				
	9	1.6250	80.5000	13081	20	1.6250	33.5000	35384				
	10	3.1250	16.2500	15234	21	3.1250	28.0000	39375				
	11	2.2500	31.0000	17438	22	2.2500	19.7500	44438				

for cutting bill 6), and a total sorting capacity of 14. For a sorting capacity of this size, all 3 panels and 11 solids would be processed at once. The grouping method begins with a blank spreadsheet. Parts are then placed into the spreadsheet starting at the leftmost column starting with the lowest priority value and moving down the column in ascending order of priority value. As the cells are filled, parts are placed in columns to the right. When viewing the completed part priority table (**Table 3**), the reader will notice that the panel and solid areas of the table are simply filled with part sizes in order by their prioritized value. **Table 3** presents a grouping spreadsheet based on the second method (Priority = Width Length Quantity) of calculating priorities. The part number columns indicate the sequence in which parts were added to the table. The highlighted parts are those in the initial cutting schedule. Although the strategy generated initial cutting bill schedules with a good mix of selected part lengths, we did not endeavor to determine if the strategy generated an optimal solution. The only concern was whether the three prioritization methods used with the selection methodology produced different, reasonable solutions where a mix of part lengths were selected for initial processing. Further research is needed to develop an algorithm for selecting an optimal initial part selection from a cutting bill.

As part requirements are met during processing, parts are replaced by a static strategy that replaces parts with the next closest part length within the same width. If there are no remaining parts in that width, then the scheduler selects a part from the next closest width and length. This is RR2's default part scheduling operation and is similar to methods used in the secondary wood products industry.

Each cutting bill, sorting capacity, and scheduling method was processed using four different grade mixes: 50 percent FAS and 50 percent 1 Common, 100 percent 1 Common, 50 percent 1 Common and 50 percent 2A Common, and 100 percent 2A Common. These grade mixes were randomly sampled from the 1998 Databank for Kiln-Dried Red Oak Lumber (Buehlmann et al. 1998) using the Makefile random sampling program (Thomas 1999). The red oak lumber databank is graded to 1998 National Hardwood Lumber Association (NHLA) rules (NHLA 1998). Three random lumber samples from each grade mix were generated and used in the analysis. Each cutting bill, sorting capacity, and scheduling method was run three times each on each grade mix. For each of the runs, the datafile was randomly sorted such that a different sequence of lumber would be processed each time. A total of 1,945 simulations using the RR2 program were performed. While most of the analyses required more than 1,000 boards, the minimum number of boards used by any of the cutting bills was 304. With samples of these sizes, we avoided potential bias due to small lumber samples as discussed in Buehlmann et. al. (1997).

Statistical analysis

The initial analysis of the simulation data began as a four-way analysis of variance (ANOVA). Model selection was conducted using the Proc GLM procedure in SAS (SAS 2000). The four factors under consideration were cutting bill, sorting capacity size (the number of part sizes simultaneously processed), grade mix, and part scheduling method. Although there are identical sorting capacity sizes for the cutting bills, they are not intrinsically the same. This is due to the fact that the sorting capacity sizes are drawn from different cutting bills that have different numbers of parts. As an example, consider two cutting bills, one with 30 parts and one with 15 parts, and a sorting capacity size of 12 part sizes. The cutting bill with 30 part sizes will always have more potential initial part selections than the one with 15 part sizes. Because of this relationship, sort capacity size was nested within cutting bill for the analysis.[1]

Results and discussion

To examine the effect of grade mix on cutting bill yield, let us consider the yields when the sorting capacity is

[1] For significant effects, Tukey's test for pairwise comparisons was conducted to examine differences in factor levels.

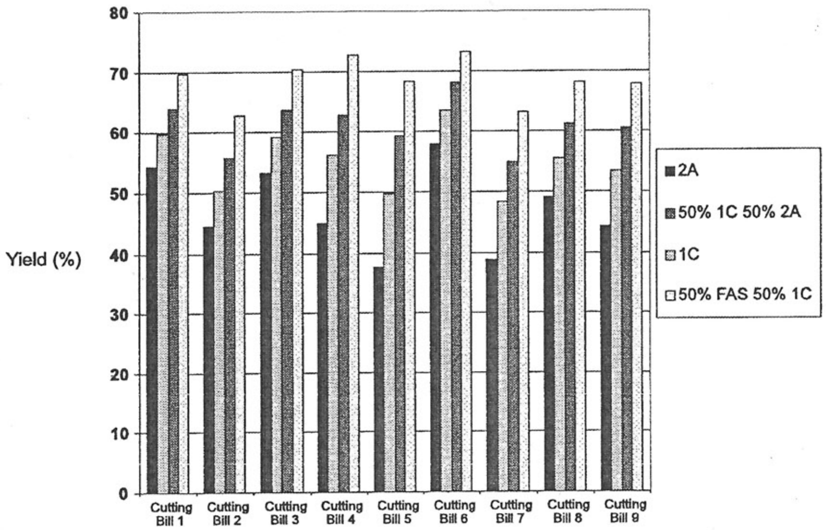

Figure 1. — Mean cutting bill yields by lumber grade mix.

equal to the number of cutting bill parts (**Fig. 1**). A consistent yield improvement occurred when progressing from the lowest to the highest quality grade mix. The lowest yield was 37.7 percent with cutting bill 5 using the 100 percent 2A Common lumber sample. The highest yield observed was 73.2 percent with cutting bill 6 using a sample of 50 percent 1 Common and 50 percent FAS lumber. The requirements of cutting bill 6 were less difficult compared to the other cutting bills. In addition, cutting bill 6 consistently achieved the highest yields of all cutting bills for all grade mix groups. **Table 2** lists the part requirements of cutting bill 6. No cutting bill consistently obtained the lowest yields for all grade mixes.

During model selection, the part scheduling methodology, the process by which parts were prioritized and selected for scheduling, proved to be non-

Cutting Bill 1

	10	12	14	16	17
10	*				
12		*			
14			*	*	*
16			*	*	*
17			*	*	*

Cutting Bill 2

	10	12	14	16
10	*	*	*	*
12	*	*	*	*
14	*	*	*	*
16	*	*	*	*

Cutting Bill 3

	10	12	14	16	18	20	21
10	*						
12		*					
14			*	*			
16			*	*	*		
18				*	*	*	*
20					*	*	*
21					*	*	*

Cutting Bill 4

	10	12	14	16
10	*	*		
12	*	*		
14			*	
16				*

Cutting Bill 5

	10	12	14	16	18	20
10	*					
12		*				
14			*			
16				*	*	*
18				*	*	*
20				*	*	*

Cutting Bill 6

	10	12	14	16	18	20	22	24	26	28	29
10	*										
12		*									
14			*								
16				*							
18					*	*	*				
20					*	*	*	*	*	*	
22					*	*	*	*	*	*	*
24						*	*	*	*	*	*
26						*	*	*	*	*	*
28						*	*	*	*	*	*
29							*	*	*	*	*

Cutting Bill 7

	10	12	14	16
10	*			
12		*		*
14			*	*
16		*	*	*

Cutting Bill 8

	10	12	14	16	18	20	22	24	26
10	*								
12		*							
14			*						
16				*	*				
18				*	*	*			
20					*	*	*	*	
22						*	*	*	*
24						*	*	*	*
26							*	*	*

Cutting Bill 9

	10	12	14	16	18	20	22	24	26	28	29
10	*										
12		*									
14			*								
16				*	*						
18				*	*	*					
20					*	*	*	*			
22						*	*	*	*	*	*
24						*	*	*	*	*	*
26							*	*	*	*	*
28							*	*	*	*	*
29							*	*	*	*	*

Figure 2. — Statistically similar sorting capacity means for each cutting bill.

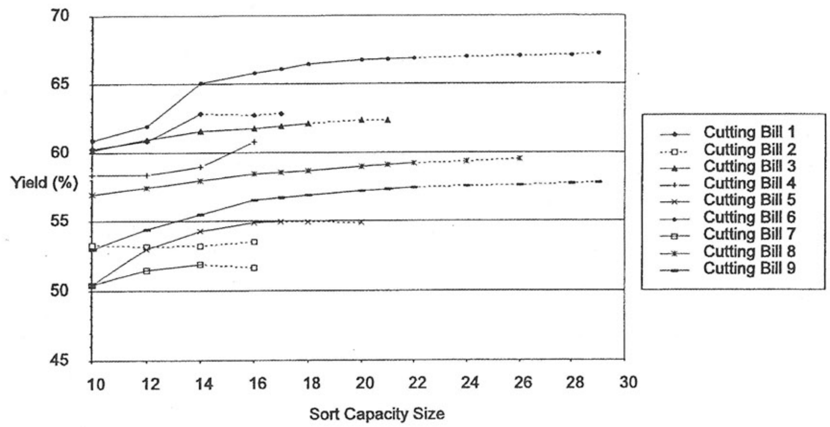

Figure 3. — Cutting bill yield improvement by sorting capacity size.

significant (p<82) and was removed from the model. The final model was:

Part yield = f (cutting bill, sorting capacity (cutting bill), grade mix, cutting bill grade mix)

Thus, the earlier stated goal of using neutral part scheduling methods (i.e., ones that did not perform exceptionally bad or good) was achieved. Thus, the results of the study are primarily focused on sort capacity.

This model explained a substantial portion of the data variation ($r^2 = 0.99$). As expected, the interaction term of cutting bill * grade mix was significant at p < 0001. Since this interaction term was significant, the main effects of grade mix and cutting bill were not considered separately. Thus, for the cutting bills in this study, the potential yield gains must be examined within the context of a selected lumber grade mix. This is logical when you consider the difference in processing a high-quality lumber grade such as FAS and a lower quality grade like 2A Common. Consider a cutting bill primarily composed of large (wide and long) part sizes. This type of cutting bill would benefit more from being processed with a high-quality lumber grade such as FAS rather than a lower quality grade like 2A Common, as compared to a cutting bill composed of many small parts.

The nested effect of sorting capacity within a cutting bill was significant. Within at least one cutting bill, one or more sorting capacities led to significantly different mean yield. The tables in **Figure 2** indicate statistically similar mean yields by sorting capacity size for each cutting bill ($p < 0.05$). In the case of cutting bill 2, all four sorting capacity sizes resulted in statistically similar part yields. In the case of cutting bill 1, yields from sorting capacity sizes of 10 and 12 were not similar to those from other capacity sizes (e.g., 14, 16, or 17). This means that for a cutting bill like number 2, yield is not influenced by the fact that 10, 12, 14, or all 16 part sizes are cut at once. It must be noted that the yield of a sorting capacity size for one cutting bill is not directly comparable to that of another cutting bill for the same sorting capacity size due to the wide variety in cutting bill requirements.

Figure 3 shows the mean yields by sorting capacity size for the nine cutting bills. Solid lines connect sorting capacity sizes where a significant yield improvement was realized from one level to the next. Dashed lines connect sorting capacity sizes with no statistically significant yield change. With the exception of cutting bills 2 and 4, statistically significant higher yields were realized as sorting capacity sizes increased to 14 parts. In the case of cutting bill 4, the sorting capacities of 10 and 12 were statistically similar. However, as sorting capacity was increased to 14 and 16 sizes, the yields were significantly higher. Increasing the sorting capacity size from 10 to 14 resulted in average yield gains of 1.9 percent over all nine cutting bills. For five of the nine cutting bills, significantly higher yields were experienced as the sorting capacity increased to 16 part sizes. Here the average yield gain was 2.6 percent compared to the 10 part size sorting capacity. In most cases, significant higher yields were not discerned when the sorting capacity size was increased beyond 18 to 20 part sizes. For the 18 and 20 part sorting capacity sizes, the average yield gains leveled off to 2.8 and 2.9 percent, respectively, compared to the 10 part capacity.

However, the three cutting bills with the greatest number of different part sizes, cutting bills 6, 8, and 9, had significant yield improvements as the sorting capacity size increased to 22 part sizes. The average yield improvement for these three cutting bills was 0.5 percent, comparing the sorting capacity yields of 22 to 18 part sizes (significant at the 0.95% level). Because these cutting bills have a balanced distribution of part requirements, this improvement can most likely be attributed to the greater number of different part sizes (optimization choices) available.

The influence of grouping different solid and panel parts to individual cutting bills was not addressed in this paper. The hypothesis was: can yield be increased by more efficient initial part selection and replacement algorithms without adding sorting capacity to a rough mill? Theoretically, no scheduling system can completely offset the benefit of increased choice (e.g., increased number of sorting bins) for yield optimization. However, smart-grouping algorithms could potentially mimic an increased number of sorting bins by decomposing individual part requirements into several batches. The goal of a smart-grouping strategy would be to select an initial group of parts that have the greatest range possible of lengths for each width processed. During processing, the algorithm would actively manage the part sizes available for cutting such that as wide a range as possible of part sizes was always being processed at the same time.

Six of the cutting bills examined in this study achieved their optimum yield when 18 or fewer part sizes were processed at once (cutting bills 1, 2, 3, 4, 5, 7). This is not to say that yield decreased when sorting capacity was increased above 18 sizes. Rather, no significant yield improvement was observed due to the increased sorting capacity. Three cutting bills produced an additional 0.39 to 0.52 percent using a sorting capacity of 22 part sizes (bills 6, 8, 9) (significant at the 0.95% level). Most cutting bills classified as difficult or medium-difficult to process (cutting bills 4, 5, 7) and those bills with larger numbers of part sizes (cutting bills 6, 8, 9) showed the greatest yield improvement as sorting capacities increased to 16 or more part sizes. Clearly, above a certain level, the benefit of additional sorting capacity diminishes until no significant yield increase is detectable. In most cases, this point of diminishing return is around 18 to 20 part sizes, slightly less if the cutting bills processed are considered easy to process.

Sorting capacity size has a significant impact on rough mill yield. For each rough mill, one would assume that the question of how many sorting bins to install is governed by economics. As this study demonstrates, yield gains of up to 5 percent are achievable by expanding the sorting capacity of an existing rough mill from 10 to 16 bins. Kline et al. (1998) estimates a savings of up to $300,000 for every 1 percent yield increase achieved in the rough mill. Consequently, mill operators may want to revisit their sorting bin capacity decision to ensure that their rough mill operates with the most economical number of sorting bins. ROMI-RIP 2.1 will allow rough mill operators to assess this question by inputting their system capabilities and their typical cutting bills for analysis.

The ROMI-RIP 2.1 Rough Mill Simulator used in this study is available free upon request. To obtain a copy contact: Ed Thomas, USDA Forest Service, Forestry Sciences Lab., 241 Mercer Springs Road, Princeton, WV 24740; ethomas@fs.fed.us ; 304-431-2324; Fax 304-431-2772.

Literature cited

Buehlmann, U., J.K. Wiedenbeck, and D.E. Kline. 1997. Character-marked furniture: Potential of lumber yield increase in rip-first rough mills. Forest Prod. J. 48(4):43-50.

__________, R.E. Thomas, and E.S. Walker. 1998. 1998 databank for kiln-dried red oak lumber. Gen. Tech. Rept. NE-245. USDA Forest Serv. Northeastern Forest Expt. Station, Radnor, PA. 60 pp.

Gatchell, C.J. 1996. Designing a fixed-blade gang-ripsaw arbor with a pencil. Forest Prod. J. 46(6):37-40.

Kline, D.E., A. Widoyoko, J.K. Wiedenbeck, and P.A. Araman. 1998. Performance of color camera-based machine vision in automated furniture rough mill systems. Forest Prod. J. 48(3):38-45.

National Hardwood Lumber Association (NHLA). 1998. Rules for the measurement and inspection of hardwood and cypress lumber. NHLA, Memphis, TN.

Statistical Analysis Software (SAS). 2000. SAS V8.01. SAS Institute Inc., Cary, NC.

Thomas, R.E. 1996. Prioritizing parts from cutting bills when gang-ripping first. Forest Prod. J. 46(10):61-66.

__________ 1999a. A guide for using ROMI-RIP 2.00, a Rough Mill RIP-First Simulator. Gen. Tech. Rept. NE-259. USDA Forest Serv., Northeastern Forest Expt. Sta., Radnor, PA. 64 pp.

__________ 1999b. A new analysis tool for rip-first rough mill operations. Forest Prod. J. 49(5):35-40.

__________ and U. Buehlmann. 2002. Validation of the ROMI-RIP Rough Mill Simulator in an actual rough mill. Forest Prod. J. 52(2):23-29.

9436 P & P: An important factor that contributes to the efficiency of processing dimension parts is the size of the sorting capacity, i.e., the number of different part sizes that can be processed at once. Intuition tells us that the more lengths we have to choose from the greater the chance of completely filling the area between defects and strip ends. However, the question remains, how much sorting capacity is needed to obtain near optimal yields. This paper answers this question and examines the impact different sized sorting capacities have on yield for four grade mixes and nine cutting bills from industry using the ROMI-RIP 2.0 Rough Mill Simulator.