Effect of hardwood sawmill edging and trimming practices on furniture part production

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Abstract

In a recent edging and trimming study at three hardwood sawmills, it was observed that the lumber volume produced was approximately 10 percent less than would be necessary to make the most valuable lumber. Furthermore, the excess portion of wood that was removed from the edging and trimming process contained a large percentage of clearwood. In light of rising costs and increasing environmental concerns, the option of producing furniture parts from unedged and untrimmed boards is explored. This research investigates the potential furniture part yields from unedged and untrimmed boards compared to both optimal and actual edging and trimming practices. The resulting volume of cuttings from unedged and untrimmed boards was found to be 25 percent higher than from the actual edged and trimmed lumber produced at the mills. Also, the volume of long cuttings (84 in.) was found to be 22 percent higher from the unedged and untrimmed boards. In addition to more efficiently utilizing our timber resources, the overall cost of furniture cuttings from unedged and untrimmed boards was found to be 8 percent less even when considering the additional costs of drying, handling, and processing.

Edging and trimming optimization discussed in a previous study investigated the potential for improving lumber value through optimization of edging and trimming (5). In the mills studied, the lumber value actually manufactured was about 32 percent less (on average) than optimal. Furthermore, the lumber volume actually produced was about 10 percent less than optimal value edging and trimming. Optimization was based on prices of National Hardwood Lumber Assoc. (NHLA) lumber grades, not on actual furniture cutting yield.

In the manufacture of dimension components, logs are first manufactured into lumber, which must meet the requirements of specific NHLA grades and the traditional market expectation of minimal wane. Lumber lengths commonly range from 8 to 16 feet in even-numbered foot increments. Odd-numbered foot lengths are allowed but are not common. Lumber is then dried and cut into parts of specified dimensions, eliminating objectionable characteristics in the lumber such as knots, splits, checks, stain, and warp.

Typically, the ratio of the volume of lumber to the volume of logs is less than 55 percent and the ratio of the volume of parts to the volume of lumber is less than 60 percent. Many techniques have been suggested to improve the overall part yield from logs, including back-gages, thin kerf saws, and computer automation. However, as the price of the wood raw material increases and as environmental constraints limit the volume of logs that can be harvested, all available options for better utilizing these raw materials need to be explored.

The objective of this study is to determine the effect of different edging and trimming practices on furniture

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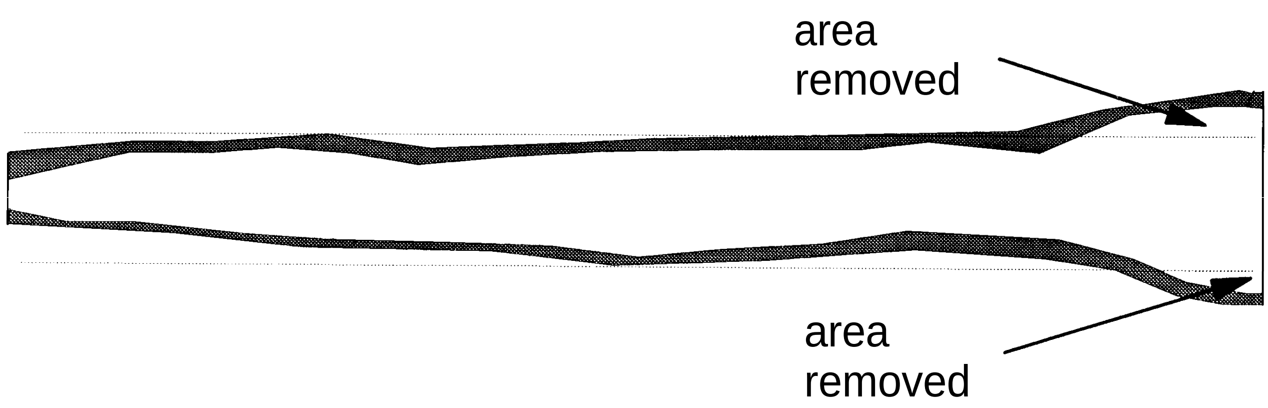

Figure 1. — Removal of protruding edges from unedged and untrimmed boards.

part production to assist in developing practical and useful methods for more efficient wood utilization. Using various levels of edging and trimming on boards, furniture part production will be evaluated in terms of yield, length, and cost.

Methods and materials

The data used in this study consisted of 120 green unedged/untrimmed 4/4 red oak boards obtained from 3 hardwood sawmills (5). Only boards that had at least one waney edge and required end trimming were selected. Board lengths ranged from 6 to 13 feet. A wide variety of board quality was selected, including pieces with sweep and taper.

The image of each unedged/untrimmed board was traced onto full-size transparent plastic sheets immediately after manufacturing at the headsaw. All defect types were marked and coded on the plastic sheet. Defects included wane, sound and unsound knots, stain, decay, pith, holes, checks, and splits. After the images of both sides were traced, the board was returned to production to be edged and trimmed. The resulting edged and trimmed board was retrieved and actual edging and trimming locations were marked on the plastic sheet containing the original unedged/untrimmed image data.

From the image on each plastic sheet, data were digitized and entered into a computer. Using 1/4-inch resolution, the coordinates of the lower left and upper right corners of the rectangle enclosing each defect and the type of defect were recorded. Several contiguous rectangles were used for large and irregular defects to better approximate their true shape. Also, the coordinates defining the board geometry and the shape of the waney edges were digitized. For each unedged/untrimmed board, an edging and trimming optimization procedure was used to find the coordinates of the edging and trimming lines such that lumber value was maximized based on NHLA grading rules (5). Finally, the coordinates of the actual edging and trimming lines as observed at the mills were recorded. A more detailed description of the data collection and optimization procedures is described elsewhere (5,6).

TABLE 1. – *Lumber grade distribution (number of pieces) for optimum and observed edging and trimming solutions for 120 boards sampled.*

	FAS	FAS 1 Face	No. 1 Common	No. 2A Common	No. 3A Common	Below grade
Optimum	5	49	41	18[a]	11[a]	--
Observed	6	16	46	39[a]	13	1

[a]Includes extra pieces produced when ripping two pieces of lumber from one board.

The data were processed so that each board could be represented in three different forms: 1) unedged and untrimmed lumber (i.e., the waney-edged board), 2) optimally edged and trimmed lumber, and 3) actual edged and trimmed lumber.

Unedged/untrimmed lumber

Of the 120 boards, 18 pieces had 1 straight edge, i.e., wane on 1 edge had been removed during log sawing. Many boards contained irregularities such as sweep, taper, and nonsquare ends because they had not been edged or trimmed. The 1/4-inch resolution achieved an adequate representation of an unedged/untrimmed board with all its irregularities.

A special procedure was performed on unedged/untrimmed boards with protruding edges, e.g., wide-butted boards. The procedure is illustrated in Figure 1. Protruding areas were removed because it was believed that the extra cutting that could be obtained from these areas did not compensate for the added problem in material handling. Only 5 of 120 specimens fell under this category.

Optimally edged and trimmed lumber

The procedure for finding the optimum placement of edging and trimming kerf lines to maximize lumber value is discussed in more detail elsewhere (5,6). In general, the procedure consisted of the following steps: 1) iterative variation of the coordinates of edging and trimming kerf lines, 2) evaluation of lumber grade, volume, and value for each edge/trim combination, and 3) selection of the solution(s) that give the maximum lumber value. All these steps were performed by

TABLE 2. – *Comparison of yields from four edging and trimming practices.*

	Unedged/ untrimmed boards	Widest optimum solution	Narrowest optimum solution	Actual solution
Lumber volume (BF)	--	853	853	769
Lumber value ($)[a]	--	566	566	385
Number of cuttings	1,157	830	810	808
Volume of cuttings (BF)	714	614	606	573

[a]Lumber prices are: FAS, $990/MBF; FAS 1 Face, $980/MBF; No. 1 Common, $520/ MBF; No. 2A Common, $255/MBF; and No. 3A Common, $195/MBF.

computer, using geometry and defect data from the unedged/untrimmed boards as input. For lumber grade evaluation, Klinkhachorn's (4) grading program was incorporated into the lumber value optimization program. The lumber grade distribution of the sample of 120 boards, if edged and trimmed according to the optimum solution, is detailed in Table 1.

For many boards, a maximum value solution was not unique. Different placements of edging and trimming kerf lines produced the same grade and volume. For example, specimens with different widths (or lengths) may have the same surface measure due to the practice of rounding off to the nearest foot in calculating this value. For this yield study, it was decided to further subdivide the optimum edging and trimming solutions into two categories, the narrowest width solution and the widest width solution. The narrowest width solution typically represents the optimum solution with the least wane. The widest width solution typically represents the optimum solution with the maximum allowable wane. Further, if a board had several maximum value solutions all with the same width, the solution with the longest lumber length was selected.

Actual edged and trimmed lumber

The actual edged and trimmed lumber as observed in the sawmills established a reference point for the volume of furniture cuttings that would be produced. Table 1 shows the grade distribution of the actual lumber produced at the mills. Note that the optimum edge/trim solution would have produced over 77 percent No. 1 Common and better lumber (Table 1). The actual results produced only 57 percent No. 1 Common and better. As noted in Regalado et al. (5), the major factor that contributed to loss in lumber grade was overedging. It was also observed that of the 120 boards processed, 15 specimens had an overlength greater than 2 inches (average overlength of these specimens was 6.25 in.).

Calculation of furniture cuttings

Using the various representations of boards as previously described, four different edging and trimming practices or scenarios and their effect on furniture part cuttings were investigated: 1) unedged and untrimmed boards; 2) wide-width optimum edging and trimming; 3) narrow-width optimum edging and trimming; and 4) actual edging and trimming.

A computer program for cutting yield optimization, Computer Optimization of Recoverable Yield (CORY) (1,2), was used in calculating the cutting yield from each of the four edging/trimming scenarios. The CORY version used was the three-stage version for simulating the sawing of random-width, fixed-length cuttings. One stage in this three-stage process is the same operation, either rip or crosscut. A sawing process enters a new stage when the operation changes from crosscut to rip or vice versa. The computed yields from a 3-stage processing sequence are usually less than from infinite-stage processes used in other cutting yield optimization programs such as the traditionally used YIELD (8) and the original version of CORY (1,2).

The crosscut-first model of CORY was used because it is typical of most roughmills. A random-width cutting was specified ranging from a minimum width of 1.0 inch to a maximum of 4.5 inches. The fixed cutting lengths used were the following: 12, 18, 24, 30, 36, 42, 48, 54, 60, 72, and 84 inches. A l/4-inch kerf was assumed for cross-cutting and a 3/16-inch kerf for ripping. All cuttings were clear twoface (i.e. no defects were allowed on either face of each cutting).

In choosing between two possible cuttings, the program selected the cutting with the greatest L^2W product (length squared times width) (1,2,8). This product reflects a higher priority placed on longer cuttings.

Results and discussion

Cutting yield

Both in terms of number of cuttings and total cutting volume, the greatest yield was from the unedged/untrimmed boards (Table 2). The volume of cuttings from the unedged/ untrimmed boards was 25 percent higher than actual edging and trimming, 18 percent higher than the narrowest optimum solution, and 16 percent higher than the widest optimum solution.

The results (Table 2) are comparable to the findings in a study on hard maple (3). That study included a comparison among yields from unedged, optimum (NHLA-based) edging, and severe edging practices observed in some Canadian mills. Unedged boards had a 25 percent greater yield than severe edging and 11 percent greater than optimum edging for No. 1 Common lumber (comprising 64% of the sample). For No.2 Common lumber (comprising 36% of the sample), the difference was a 28 percent greater yield from unedged than from severe edging, and 21 percent more than optimum edging. If averaged for the entire sample, the figures from Flann and Lamb's study represent a 26 percent difference between unedged and severe edging practices (compared to a 25% difference between unedged/untrimmed and actual mill edging and trimming in this study), and a 15 percent difference between unedged and optimum (compared to a 16% difference between unedged/un-

TABLE 3. – *Volume of cuttings by cutting length.*

Cutting length	Unedged/ untrimmed boards	Widest optimum solution	Narrowest optimum solution	Actual solution
(In.)	(B F)			
12	28	15	15	20
18	29	15	15	16
24	26	17	14	17
30	35	29	28	25
36	35	32	35	31
42	36	21	22	16
48	38	31	32	20
54	26	35	26	25
60	77	61	60	67
72	67	74	73	76
84	317	284	286	260
Total	714	614	606	573

TABLE 4. – *Roughmill manufacturing costs for unedged/untrimmed lumber versus optimum and actual lumber.*

	Unedged/untrimmed lumber		Optimum lumber	Actual lumber
	(B F)			
Volume	--		853	769
Cutting yield	714		614	573
	Case 1	Case 2		
	($)			
Price	566	385	566	385
Drying/stacking cost	144	144	128	115
Processing cost	528	528	454	424
Total cost	1,238	1,057	1,148	924
Part cost ($/BF)	1.73	1.48	1.87	1.61

trimmed and optimum edging and trimming in this study).

This study confirms that a significant volume of potential cuttings are lost when edging and trimming. In the effort to remove wane, some clear areas where cuttings could be made are sacrificed. Although it may be argued that the cutting yields are computer optimized and it is possible that a human roughmill operator may not achieve the same level of cutting volume recovery in one or more of the edging/trimming scenarios discussed, the relative differences in cutting volume for each scenario show that the amount of useable wood being lost through either conventional or optimal edging and trimming can be substantial.

Cutting lengths

The volume of cuttings by cutting length is shown in Table 3. The volume of 84-inch cuttings from the unedged/untrimmed boards was found to be 22 percent higher than the actual, 11 percent higher than the narrowest optimum solution, and 12 percent higher than the widest optimum solution. Because it is generally accepted that longer cuttings have a higher value per unit volume than the shorter cutting lengths, this increase has the potential to further raise the ultimate value of unedged/untrimmed boards. In all cutting-length categories, the greatest yield was from the unedged/untrimmed boards, with the exception of the 72-inch cuttings. This was most likely because with unedged/untrimmed boards, more clear areas are available to satisfy the dimensional requirements of the 84-inch cuttings, leaving less areas for the 72-inch cuttings, which were given less priority. This trend applies in comparing cuttings from the optimum and actual edge/trim. Compared to the actual, optimum edging and trimming yielded 9.6 percent more 84-inch cuttings on average but produced slightly less yield in the 60- and 72-inch cutting lengths.

In summary, boards from the unedged/untrimmed and optimum practices produce more available clear area than boards from the actual practice. This greater clear area increases the likelihood that longer cuttings can be obtained.

Cutting costs

As previously shown, unedged/untrimmed boards have the potential to increase the volume of cuttings by 25 percent over that of actual edged and trimmed lumber. To investigate if the benefit of additional volume is not exceeded by additional costs due to drying, handling, and processing, the roughmill manufacturing costs for unedged/ untrimmed, optimum, and actual lumber were estimated (Table 4). The widest optimum solution was used for the optimum lumber cutting yield in Table 4. The following assumptions were made: 1) the purchase prices for the optimum and actual green lumber were $566 and $385, respectively (Table 2); 2) drying, stacking, sorting, and any regrading loss was $150 per thousand board feet (MBF) of green lumber; and 3) the roughmill processing cost was $740 per MBF of parts produced (7). Because unedged/untrimmed boards would occupy up to 25 percent more space in the dry kiln, it was also assumed that drying, stacking, and other associated costs for this material were 25 percent higher than actual edged and trimmed lumber costs.

Note that the price of unedged/untrimmed boards would be substantially less than the price of actual lumber because they would be lower in grade.[1] However, to be conservative in the overall cost estimates for unedged/untrimmed boards, the highest potential prices were used. Therefore, two price scenarios were used in estimating the cost of parts for the unedged/untrimmed lumber: $566, representing the potential price for the optimum lumber that could be produced (Case 1), and $385, representing the potential price for the lumber that was actually produced (Case 2).

The cost of parts per board foot produced from the unedged/ untrimmed (Case 1) and optimum boards are $1.73 and $1.87, respectively (Table 4). This

[1]According to the wane restrictions specified in the NHLA grading rules, nearly all unedged and untrimmed lumber would be graded No.1 Common or less. To assess the true potential grade of unedged and untrimmed lumber, a new procedure could be established for grading called "pencil grading." Using the same grading rules, pencil grading involves marking the desired edging and trimming locations and then estimating the grade and footage of the lumber based on what would happen if the piece had been properly edged and trimmed.

difference is a 7 percent reduction in the overall cost for unedged/untrimmed boards assuming they are purchased at the same price as the optimum edged and trimmed lumber. Similarly, the cost of parts per board foot produced from unedged/ untrimmed (Case 2) and actual boards are $1.48 and $1.61, respectively (Table 4). This difference is an 8 percent reduction in the overall cost for unedged/untrimmed boards assuming they are purchased at the same price as the actual edged and trimmed lumber.

The large price differential between optimum lumber and actual lumber in Table 4 ($566 vs. $385) is because the optimum lumber set contains a greater volume of lumber that grades higher than No. 1 Common (Table 1). Therefore, part costs for optimum lumber are substantially higher than for actual lumber. Although utilizing lumber that grades higher than No. 1 Common for producing furniture parts may not reflect a most cost-effective use, the scenarios in Table 4 illustrate that overall costs can be reduced even when considering the additional cost of drying, handling, and processing unedged/untrimmed boards. If the price of lumber continues to increase at a greater rate than the other roughmill manufacturing costs, overall cost savings with unedged/untrimmed boards will grow even higher.

Summary and conclusions

As the price of wood raw material increases and as environmental constraints limit the volume of logs that can be harvested, options for better utilizing these raw materials need to be explored. To better utilize our wood resources, this research evaluated the potential of using unedged and untrimmed boards for manufacturing random-width cuttings. The potential production from unedged and untrimmed boards is compared with that of optimally edged and trimmed lumber, and actual edged and trimmed lumber. A computer program for furniture cutting optimization calculated the volume of random-width cuttings for each of the edging and trimming scenarios using a crosscut first option.

The results of this study indicated that the potential furniture cutting yield from unedged and untrimmed boards could have been up to 25 percent greater than yields from the actual edged and trimmed lumber. Up to 18 percent greater yield for unedged and untrimmed boards would have resulted if the same set of boards were optimally edged and trimmed. The volume of long cuttings (84 in.) was found to be 22 percent higher from the unedged and untrimmed boards than that from the actual lumber. Even when considering the cost of drying, handling, and processing the unedged and untrimmed boards, the overall cost of furniture cuttings could be reduced by 8 percent. Therefore, opportunities with unedged/untrimmed lumber exist in furniture part production to substantially reduce the cost of furniture cuttings while more efficiently utilizing our solid wood resources. These results call attention to a more efficient and economical use of wood resource that would have otherwise been converted to less valuable material.

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