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A Comparison of Four Techniques For Producing High-Grade Furniture Core Material From Low-Grade Yellow-Poplar

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Abstract

Four methods of converting low-grade yellow-poplar lumber into high-grade furniture core material (lumber core) were compared. High-grade core material is used in tops, shelves, doors, and drawer fronts and only minor defects are allowed. Three gang-rip first and the conventional crosscut-first manufacturing sequences were evaluated in combination with 1 Common, 2A Common, and 2B Common lumber. Results based on costs and yields indicate that 2A and 2B Common lumber and either of two gang-rip first techniques would be the most effective choices.

INTRODUCTION

IN RECENT YEARS, yellow-poplar lumber has become abundant, especially in the lower grades. Because of this increase in availability and current lumber costs, the continued use of yellow-poplar as furniture core material would be assured if the current cost of lumber core could be maintained or lowered.

Achieving this goal requires the use of low-grade lumber in combination with an efficient low-cost manufacturing technique. Failure to do this would result in the loss of the furniture core market to particleboard, fiberboard, and other substitute materials.

Core panels are used as center fill material for laminated products. High-grade lumber core cuttings—such as those used in tops, shelves, doors, and drawer fronts—can contain only minor defects such as stain, small bird pecks, small burls, pin knots, and pinworm holes.

In this study, I attempted to determine the most efficient techniques for producing furniture core from low grades of yellow-poplar.

In actual cutup tests or through computer simulation, I compared the following manufacturing sequences:

Ž Crosscut-rip
• Gang-rip crosscut
• Gang-rip longest length
• Gang-rip finger joint.

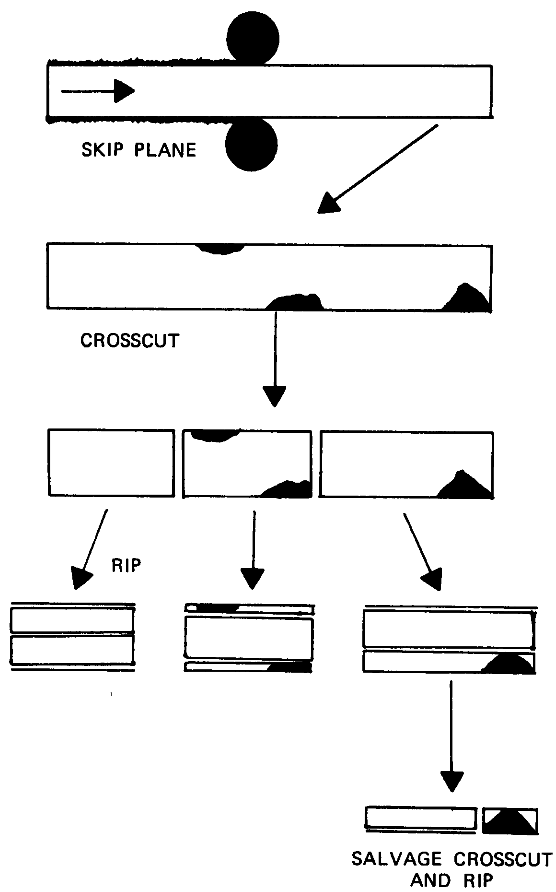
In all tests I used kiln-dried 4/4 yellow-poplar lumber in grades 1 Common (l C), 2A Common (2AC), and 2B Common (2BC). In making the comparisons, I also considered the:

• Optimum ripping width when gang ripping
• Costs for lumber, transportation, drying, handling, rough milling, and overhead
• Ease of manufacture and the frequency of operator error.

Crosscut-rip

In this traditional method, the lumber is skip planed and then crosscut to required lengths (Fig. 1). The crosscut saw operator uses a back-gage in deciding where to cut a board to the required length while maximizing usable material. Random-width cuttings are ripped from the cut-to-length boards. Pieces containing defects are sent

Figure I.-Crosscut-rip manufacturing sequence.



to a salvage crosscut and rip operation where smaller cuttings are produced.

Each of the following gang-ripping methods included the following steps:

- Crosscut warped lumber to shorter lengths to remove bow or crook (maximum allowable deflection of 5/16 inch)
- Rough plane the lumber
- Gang rip the lumber into strips of equal width (Fig. 2).

Gang-rip crosscut

In this method, strips from the gang-ripping operation are crosscut to specified lengths. The crosscut saw operator used a back-gage to maximize recovery from the strips. Cutting bills usually include five lengths (one primary and four secondary). The primary length represents the longest length of the five cuttings and is the most difficult to obtain. The secondary cuttings provide a range of cutting lengths.

Gang-rip longest length

In this method, strips from the gang-ripping operation are sent to a defecting station where objectionable defects are removed by crosscutting. Each random-length piece is then crosscut to the longest length needed.

Gang-rip finger joint

As with the longest length method, strips are sent to a defecting station for removal of objectionable defects by crosscutting. The resulting random-length pieces (minimum of 8 inches) are sent to a finger jointing station where the ends are machined and glued together in a continuous strip. This strip. is then cut to each of the required lengths. Finger jointing results in a loss in usable length of 7/8 inch per joint (Fig. 3), and in a loss in width of 1/8 inch.

MATERIALS AND METHODS

Ripping width simulation

I used computer simulation to determine the effect of ripping width on the yield in strips and edgings for use in the gang ripping sequences. For samples of lC, 2AC, and 2BC yellow-poplar lumber, the computer simulation included 9 ripping widths ranging from 1.0 to 3.0 inches (Table 1).

All salvage edgings were evaluated as though they had been processed to random widths (minimum of 1 inch). The yields were added to those from the strips. The simulation also included a 7/ 16-inch hogging head cut on the leading edge of each board to produce a glueline edge; a 3/ 16-inch kerf was used for all other saws.

Figure 2.-Gang ripping a board into strips and an edging.

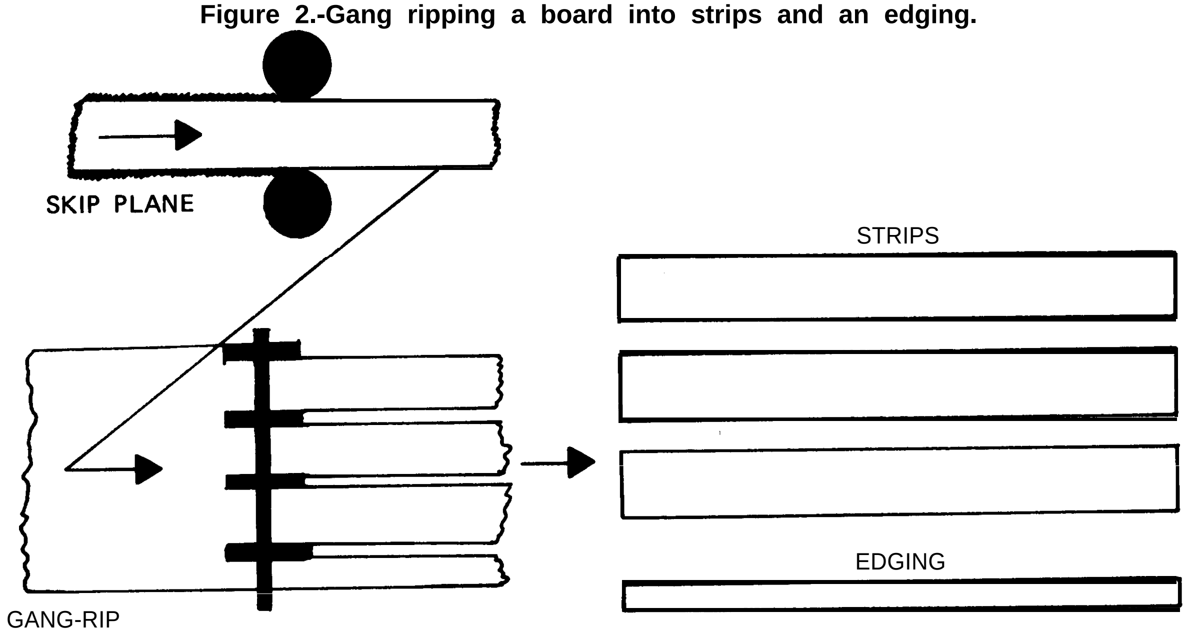
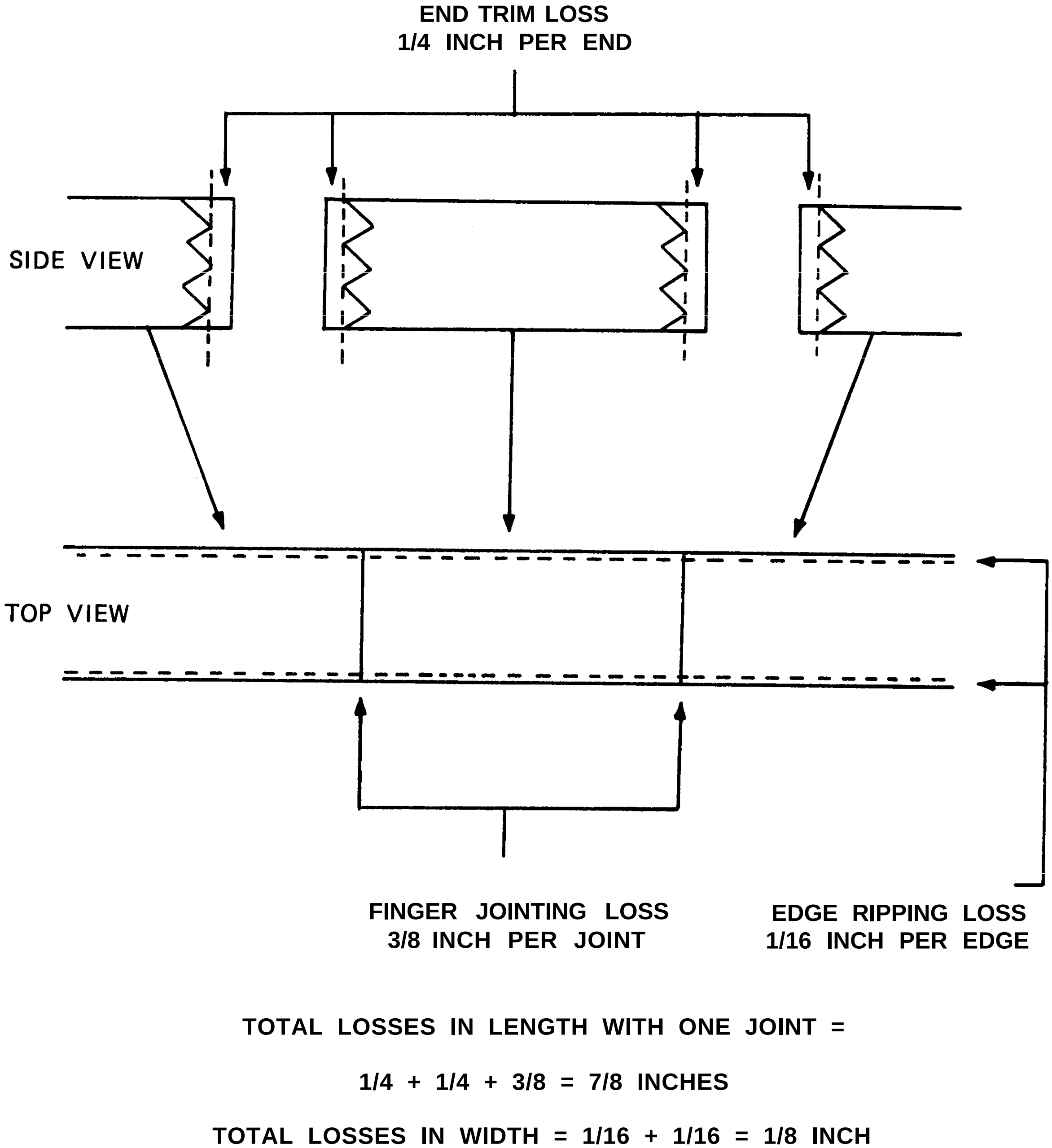


Figure 3.—Losses from finger jointing pieces of wood to be used in core panels.



The total yield in undefeated strips and undefected edgings (wider than 1 inch) ranged from 75 to 88 percent (Table 1). The yields differed slightly between the lumber grades for a given ripping width. As the strip width increased, the yield in edgings along with the total yield increased. These results are important in considering a gang-ripping operation because edgings are difficult to handle and are costly to process.

I selected two widths for further testing: the 3-inch ripping width because it produced the highest total yield and the 2.25-inch width because the total yield was high and few edgings would require processing.

Table 1. Simulated gang= ripping yields in undefeated strips and edgings (wider than 1 inch) by lumber grade and strip width

Strip width (inches)	1C		Total	2AC		Total	2BC		Total
	Strips	Edgings		Strips	Edgings		Strips	Edgings	
	- -percent- -								
3.00	68	18	86	71	15	86	72	16	88
2.75	69	18	87	72	13	85	72	15	87
2.50	72	12	84	72	13	85	72	14	86
2.25	75	9	84	75	10	85	77	7	84
2.00	75	7	82	75	8	83	76	7	83
1.75	75	6	81	76	5	81	79	4	83
1.50	76	4	80	76	3	79	77	2	79
1.25	77	0	77	77	0	77	77	0	77
1.00	76	0	76	75	0	75	76	0	76

Table 2. A typical distribution of furniture core requirements in a cutting order

Cutting No.	Length of glued panel (inches)	Percent of total output
1	81	3
2	70	2
3	65	2
4	58	8
5	45¼	10
6	40	22
7	32½	9
8	26	18
9	21	20
10	16¼	6

Rough mill tests

The production of a list of required cuttings was simulated for the gang-ripping tests and physically processed for the crosscut-rip tests. The cutting order approximated that of a typical furniture manufacturer (Table 2). The cutting order required glued panels ranging in length from 16 1/4 to 81 inches. Required quantities were expressed as a percentage of total output.

The computer simulated the gang-rip sequences in the following manner:

Gang-rip crosscut. The initial cutting bill included cuttings 1, 3, 5, 7, and 9 from the list of cuttings (Table 2). The primary length is the longest of the five because it is hardest to obtain. The secondary cuttings are selected to provide a range of cutting lengths. When the requirements for one of the five lengths were satisfied, it was replaced by the next longest cutting. This procedure was repeated until the total required cuttings for the 10 lengths are sawed.

Gang-rip longest length. All 10 lengths in the list of cuttings are initially set up at the crosscut station. As the requirement of any length cutting was satisfied, that length was simply removed from the setup.

Gang-rip finger joint. After finger joining, the continuous usable strips were cut-one at a time—to each of the required lengths. The cuttings were then re-edged for gluing into panels.

For all three gang-ripping methods, edgings were manufactured into random-width cuttings by simulation. The edgings were first cut to required lengths by the longest length method. The pieces were then ripped to random-width cuttings (1 inch minimum) by removing the rough edge. Results were then added to the cutting yields from the strips.

Crosscut-rip. In a physical yield test, the lumber was crosscut to one of five lengths in a cutting bill with one primary and four secondary cuttings (cuttings 1,3,5,7, and 9 from the list of cuttings). As the cutting requirements for a length were satisfied, the requirements for the next longest cutting were added to the cutting bill. This procedure was repeated until the requirements of the 10 lengths were sawed.

RESULTS

In the gang-ripping tests, the average yield in core material for lC, 2AC, and 2BC lumber was 66 percent for the 2.25-inch strips and 61 percent for the 3-inch strips. Individual yields by lumber grade and manufacturing method ranged from 43 to 73 percent (Table 3). The lower yields for the 3-inch strips probably were caused by the greater loss of wood (volume) when a defect had been removed and by the greater probability that objectionable defects would be found. Because of the higher average yield, the gang-rip methods using the 2.25-inch strip width were used in further cornparisons with the crosscut-rip method.

The yield in core material from lC lumber for the crosscut-rip method was 78 percent (Table 3). Yields from lC lumber for the 2.25-inch strip width were 72 percent each for the gang-rip crosscut and gang-rip finger joint sequences and 70 percent for the gang-rip longest length method.

Yields in core material for 2AC lumber were similar for all four manufacturing methods (Table 3). For 2BC lumber, the yield for the crosscut-rip method was 53 percent, 1 percent higher than that for the gang-rip crosscut method. Yields from 2BC lumber for the gang-rip longest length and gang-rip finger joint methods were 59 and 63 percent, respectively.

However, the average yield when all lumber grades were combined was similar for all manufacturing methods (Table 3).

Table 3. Yield in core material from the rough mill tests

Manufacturing sequence	Lumber grade			Average
	lC	2AC	2BC	
	- - - *percent* - - -			
3 .0-INCH STRIP WIDTH				
Gang-rip finger joint	72	65	59	65
Gang-rip crosscut	70	60	43	58
Gang-rip longest length	69	61	49	60
Average	70	62	50	61
2.25-INCH STRIP WIDTH				
Gang-rip finger joint	72	73	63	69
Gang-rip crosscut	72	68	52	64
Gang-rip longest length	70	69	59	66
Average	71	70	58	66
Crosscut-rip	78	72	53	68

DETERMINING COSTS

The yield by grade of lumber is only one of several factors that must be considered in determining the most efficient method of converting low-grade yellow-poplar lumber into furniture core material. One also must consider the cost of lumber by grade, transportation from the mill, handling, air drying, kiln drying, rough milling, and overhead expenses. In determining the most economical combinations of lumber grade and manufacturing method, I calculated the total cost per 1,000 board feet (MBF) of core material for each combination by the following equation:

$$TC = \frac{(LC + AOC)}{\%\ \text{yield}}$$

where

- TC = total cost/MBF of core material
- LC = lumber cost/MBF
- AOC = all other costs/MBF
- % yield = yield in core material for a given grade of lumber processed by a given manufacturing method.

Lumber costs per MBF for 4/4 Appalachian yellow-poplar lumber were obtained from the Hardwood Market Report of November 1977 (lC: $220; 2AC: $135; 2BC: $110). A fixed charge of $160 was assigned for all other costs (AOC). This figure was obtained from a cooperator with a modern conventional rough mill.

It might seem that lumping all costs other than that for lumber is a gross simplification. But consider the effect of an increase of or decrease of $20 in AOC cost on the total cost per MBF of core material (Table 4). For 1 C lumber, an AOC of $160 resulted in a total cost of $521 per MBF of core material when the lumber cost was $220 and the average yield for all four manufacturing methods was 73 percent. An increase or decrease in the AOC of 12.5 percent changed the total cost of the core material by only $28 (plus or minus).

Thus a change in AOC of 12.5 percent resulted in a change in total costs of only 5 percent. For 2BC lumber, a similar change in AOC had a slightly greater effect on the total cost—7 percent (Table 4).

Of greater importance than the effect of changes in AOC is the effect of the combination of lumber cost and yield by grade of lumber. Table 4 shows that compared to 2AC lumber, lC is high in price and produces only a slightly higher yield, and that 2BC is low in price and produces a

lower yield. Given a choice of only one grade to use, 2AC would be preferred because of its relatively high yield and low price and the corresponding lower total cost per MBF of core material.

When 2AC and 2BC yellow-poplar were considered individually by manufacturing method, the total cost of core material ranged from $404 to $519 per MBF (Table 5). When these grades were combined in a 50-50 mix, the gang-rip finger joint and longest length methods produced lower total costs—$0.42 and $0.44 per square foot, respectively.

DISCUSSION

Gang-rip crosscut

This method was the most expensive, $0.48 per square foot, and yielded less core material than the other gang ripping methods when 2AC and 2BC were combined (Table 5), even though the use of material between defects was maximized with the aid of a back-gage. Also, decisions required by the crosscut saw operator would make it difficult to achieve the yields obtained for this method in the laboratory.

Table 4. Effect of variation of AOC on total costs/MBF of core material by lumber grade (2.25=inch strip width)

Lumber grade	Average yield for all methods	Lumber/ MBF	Total cost when--		
			AOC = $140	AOC = $160	AOC = $180
	percent		*dollars*		
1C	73	220	493	521	548
2AC	71	135	387	415	444
2BC	57	110	439	474	509

Table 5. Total cost/MBF of core material, by manufacturing sequence and lumber grade

Manufacturing sequences	Lumber grade	Percent yield	Total costs/ MBF[a]	Average total costs/MBF[b]	Average total costs/BF
			dollars		
Gang-rip crosscut	2AC	68	434	477	0.48
	2BC	52	519		
Gang-rip longest length	2AC	69	428	443	.44
	2BC	59	458		
Gang-rip finger joint	2AC	73	404	417	.42
	2BC	63	429		
Crosscut-rip	2AC	72	410	460	.46
	2BC	53	509		

[a] AOC = $160
[b] 50-50 mix of 2AC and 2BC lumber

Gang-rip longest length

For this method, the cost of core material was $0.44 per square foot when grades 2AC and 2BC were combined. This method is simple and yields are easily obtained. This method also can be highly automated and there is little chance of operator error.

Gang-rip finger joint

This method had the lowest average cost—$0.42 per square foot (Table 5). However, the costs of this method may be greater than estimated because of the additional costs for finger jointing. This method is simple and can use material as small as 8 inches long. There also is little chance of operator error with the finger joint method because decisions are required only when objectionable defects are removed.

Crosscut-rip

The average total cost for this method was $0.46 per square foot (Table 5). This cutup technique is by far the most susceptible to operator error of all methods studied, so it would be difficult to achieve the laboratory yields in actual production. However, a well-run, efficient conventional rough mill using only 2AC lumber would be an acceptable but not the best choice for producing high-grade core material.

Using only 2BC lumber would cause serious problems because decisions required of a crosscut saw operator are overwhelming when attempting to find long cuttings in 2BC lumber. Also, the back-gage was not helpful in tests with 2BC lumber. The number and location of objectionable defects in 2BC boards would make crosscutting difficult. By contrast, defects are easier to locate and remove in gang-ripping operations.

CONCLUSION

The results of this study indicate that 2AC is the most economical grade in converting low-grade yellow-poplar lumber into furniture core material. Ideally, a combination of 2AC and 2BC lumber should be used. The more highly automated and error free gang-rip finger joint and gang-rip longest length manufacturing methods were the most efficient in processing these grades.

* U.S. GOVERNMENT PRINTING OFFICE: 1979– 603011:68

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