INITIAL LOOK AT OPPORTUNITIES FOR OPTIMIZING LUMBER VOLUME USING BOF DECISIONS FOR HARDWOOD SAWING

Philip H. Steele

Graduate Research Assistant
Mississippi Forest Products Utilization Laboratory
Mississippi State University
Mississippi State, MS 39762

and

Eugene M. Wengert

Professor
Department of Forest Products
Virginia Polytechnic and State University
Blacksburg, VA 24061

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ABSTRACT

Considerable information is available on lumber yields from the use of best opening face (BOF) decisions in softwood sawmills. No such information is available for hardwood sawmills. This study was designed to supply an initial look at the magnitude of lumber volume-yield increase possible through use of BOF decisions for hardwood sawing. The simulated sawing of a wide distribution of study log lengths, widths, and tapers was carried out using a computer model of the hardwood sawing process. Yields for 15 incremental opening-face positions per log were determined. Percentage increases were calculated based on these yields by two methods. The first method followed past research procedure for softwood sawing and calculated percentage increase of maximum above minimum lumber yield for 15 opening face positions. The second method provided a more conservative estimate by calculating percentage increase of maximum above average yield for the same 15 positions. Percentage lumber yield increases were 6.3 and 2.8%, respectively, for the two methods. Statistical tests were performed which demonstrated that these yields were based on an actual increase in fiber yield rather than on an increase due to manipulation of lumber widths.

Keywords: Hardwoods, sawmilling, sawing, BOF, computer decisions, lumber yield.

INTRODUCTION

Use of best opening face (BOF) decisions to obtain maximum lumber volume yield is common in softwood sawmills. In hardwood sawmills, BOF technology is not used. One reason may be that information on potential yields from the use of BOF decisions in hardwood sawmills has not been available. The objective of this study was to provide an initial look at potential lumber yield increases from use of BOF decisions in hardwood sawmills. It was recognized that it was only after publication of research results on theoretical use of BOF decisions for softwood sawing that use of BOF technology began to be used in softwood sawmills (Hallock and Lewis 1971; Hallock et al. 1976; Hallock et al. 1979).

The BOF concept is based on the fact that placement of the initial sawline is critical in determining lumber volume sawn from each log. Precise placement of this sawline allows optimal yield from the respective sawing pattern used.

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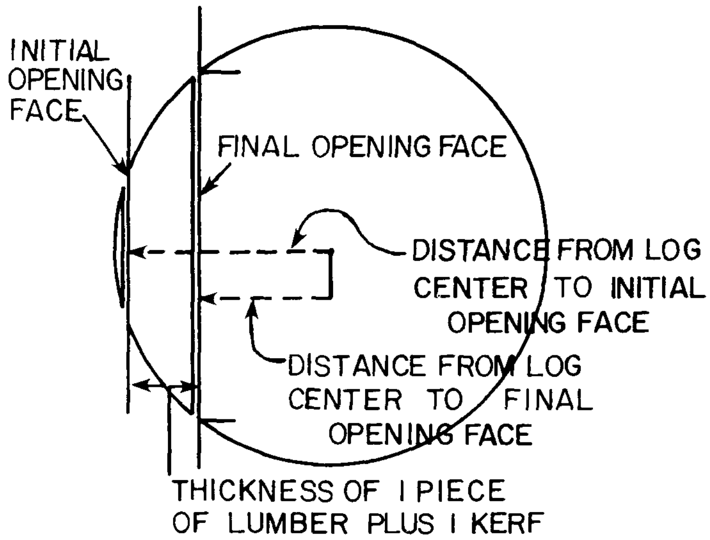

FIG. 1. Representation of the small end of a log showing the initial and final opening face positions and the thickness of 1 piece of lumber plus kerf. Other opening face positions were at 0.1-inch increments across the thickness of the piece of lumber plus kerf.

Reliable information on yields from BOF sawing of hardwood sawlogs required that all reasonable log diameters, lengths, and tapers be analyzed. To perform the simulated sawing of these logs, a sawing model that produced random width lumber trimmed to one-foot increments of length and that simulated the live-sawn, split-taper sawing method was used. This model was considered adequate to provide information on the magnitude of lumber yield increases possible from use of BOF decisions.

PROCEDURE

The approach used in this study was similar to that used in past research to determine the volume consequences of using softwood BOF (Hallock and Lewis 1971). A computer simulation of the sawing process was developed and lumber volume yields for various opening face positions were determined. The computer simulation was adapted from one developed to model the hardwood sawing process (Adkins et al. 1979; Richards et al. 1979). The sawing parameters used for the sawing simulation were chosen to be as close to current hardwood sawmill practice as possible. Minimum board width was 3.0 inches at board midlength. Hardwood sawmills frequently salvage lumber under 8.0 feet in length, but few purposely produce such lumber in their sawing patterns. For this reason minimum lumber length of 8.0 feet was used to simulate current hardwood sawmill practice in this study. The computer simulation sawed only 4/4 lumber with a thickness of 1.125 inches. Kerf width used was 0.250 inch. Total thickness of one piece of lumber plus kerf was, therefore, 1.375 inches.

For this study, 15 opening face positions were tested for each log. Each subsequent opening face after the first was moved 0.1 inch nearer to the center of the log. (Figure 1 is a diagram illustrating initial opening face location as well as

TABLE 1. *Distance from log center and board-foot yields (BF) for 15 incremental positions tested for an 11.2-inch diameter log, 12-feet-long with 2 inches taper in 16 feet of length. Maximum board-foot yields are bracketed.*

Sawline position number	Distance from log center (in.)	BF yield
1	5.715	71
2	5.615	71
3	5.515	[74]
4	5.415	[74]
5	5.315	[74]
6	5.215	[74]
7	5.115	71
8	5.015	68
9	4.915	69
10	4.815	69
11	4.715	68
12	4.615	69
13	4.515	69
14	4.415	69
15	4.315	68

Mean board foot yield = 70.5, all positions.

other terms described below.) The number of opening face positions was determined by following a procedure used in past research on softwood BOF of incrementing sawline position across the thickness of one piece of lumber plus kerf. The model followed the National Hardwood Lumber Association (NHLA) scaling process by measuring all boards at midlength (National Hardwood Lumber Association 1982). The NHLA rules for FAS lumber were applied to all lumber cut. These rules restrict length of wane to less than 50% along each edge of a piece. The rules also specify that within one lineal foot from the ends of boards of standard lengths, there shall be not less than 50% clear face in not more than two pieces of any shape. In addition, there shall not be less than 25% of sound wood in the aggregate. This rule was modeled by requiring that all boards have at least 2.5 inches sound wood at the small end of the board and 3.0 inches sound wood at board midlength with wane not wider than 2.0 inches on each edge.

Each study log was entirely sawn at each of the 15 opening face positions. Table 1 gives an example of board-foot yields for an 11.2-inch log for the 15 positions. For the first position, a board of minimum dimension was sawn from the log with an opening-face sawline 5.715 inches from log center. The resultant yield was 71 board feet. The log was then sawn again after moving the sawline 0.1 inch toward log center to a distance of 5.615 inches from log center. Again, the yield was 71 board feet. This process was repeated until all 15 sawline positions had been tested.

A wide distribution of log diameters, lengths, and tapers was analyzed in 14 diameter classes. Diameters ranged from 7.6 inches to 21.4 inches in 0.2-inch increments for a total of 70 logs per diameter class. Each diameter class included 5 lengths (8, 10, 12, 14, and 16 feet) and 5 taper classes (0, 1, 2, 3, and 4 inches per 16 feet of log length). The total number of logs analyzed was, therefore, 1,750 (70 diameters × 5 lengths × 5 tapers = 1,750).

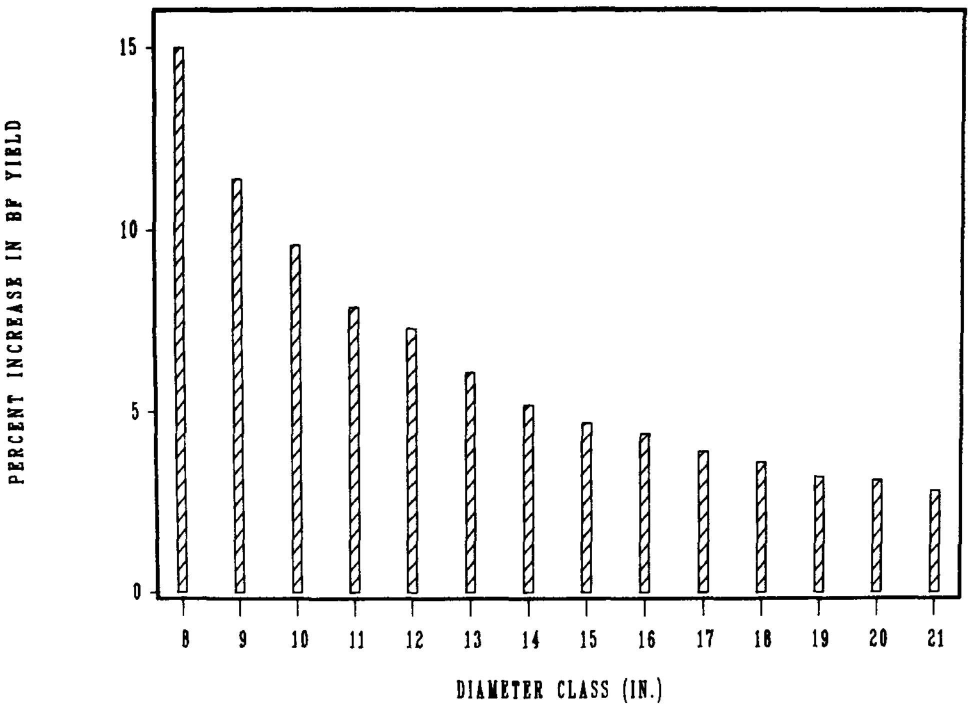

FIG. 2. Percentage yield increase by diameter class. Based on maximum above minimum board-foot yields from those obtained by sawing each study log at 15 initial sawline positions.

Research on the influence of BOF decisions on softwood yields has estimated the percentage increase of maximum yield above minimum yield from the sawlines tested for each log (Hallock and Lewis 1971). This procedure was followed for this part of the study. This meant that from the 15 board-foot-yield estimates for each log the maximum and minimum yield were selected. The example data in Table 1 for the 11.2-inch-diameter log show the minimum yield to be 68 board feet for the eighth, eleventh, and fifteenth sawline positions tested; maximum yield was 74 board feet for sawline positions 3 to 6. Percent increase of maximum above minimum was, therefore, 8.8% for this example $[((74 \div 68) - 1) \times 100 = 8.8\%]$.

Use of maximum above minimum percentage yield may overestimate the potential yield increase possible from use of BOF decisions in hardwood sawmills. The information desired is the increase in yield that BOF decisions would give versus the performance of the average sawyer. This would require information on sawline placement by the average sawyer and unfortunately this information is not available. The maximum above minimum percentage yield gives an estimate of increase in yield based on an assumption that the average sawyer would always place the sawline so as to achieve minimum yield in the 1.4-inch distance across which sawline placement was tested. A more conservative estimate of potential yield increase would be to estimate the yield increase of maximum BOF position

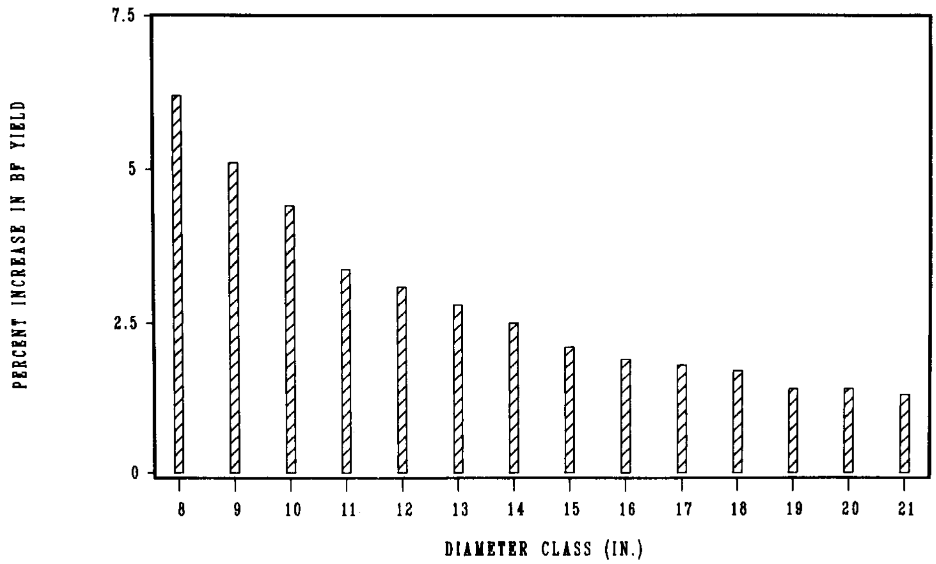

FIG. 3. Percentage yield increases by diameter class. Based on maximum above average board-foot yields from those obtained by sawing each study log at 15 initial sawline positions.

above the average yield for all 15 sawlines tested. This assumes random placement of the sawline in the 1.4-inch distance by the sawyer and is probably a more realistic assumption.

For the data on the 11.2-inch-diameter log in Table 1, mean yield for all positions was 70.5 board feet. Maximum percentage yield above average yield would, therefore, be 5.0% [((74 ÷ 70.5) − 1) × 100 = 5.0%].

RESULTS

Increases in percentage lumber yield from the use of BOF decisions based on maximum above minimum board-foot yield obtained from each diameter class are shown in Fig. 2. Yield increases ranged from 15.0% for the 8-inch-diameter class to 2.8% for the 20-inch-diameter class. Average percentage increase for all diameter classes tested was 6.3%.

Note that estimated percentage yield increase is highest for the 8-inch-diameter class and decreases steadily for all following diameter classes. These results are similar to those from research on BOF decisions for softwood sawing (Hallock and Lewis 1971). BOF decisions are recognized to be much more important for small-diameter logs. Failure to accurately place the opening face sawline causes a much greater loss of total lumber volume yield for small-diameter logs than for large-diameter logs.

Increase of percentage yield from use of BOF decisions based on maximum above average yield for each diameter class is shown in Fig. 3. Yield increases ranged from 6.2% for the 8-inch-diameter class to 1.3% for the 21-inch-diameter class. The average percentage increase for all diameter classes was 2.8%. Again, potential percentage yield estimates decrease steadily as log diameter increases.

There has been some concern that board-foot yields may only be increased from use of BOF decisions for hardwoods by producing lumber that measures consistently under the 0.5-inch marks on a lumber rule. This would increase lumber volume in a technical way without a corresponding net increase in actual fiber yield. Such an outcome could conceivably pose marketing problems for the hardwood sawmill using such a BOF system since the buyer has the right to expect a uniform distribution of widths that guarantees he fairly obtains the wood fiber for which he is paying. The hypothesis that lumber widths were sawn consistently below the 0.5-inch mark by the simulation model used in this study was statistically tested. Two of the five taper classes of logs, the 0- and 2-inch taper classes, were selected as representative to perform the tests. All diameter and length classes of logs within these groups were tested, resulting in a test based on 700 logs. All boards from each maximum position for each log were used for the test. The boards were divided into two groups based on whether their width fell above or below the 0.5-inch mark. Boards that fell exactly on the 0.5-inch mark were alternately placed into one of the two groups.

Of the 644 total boards tested from the 0-inch taper group of logs, 322 fell below the 0.5-inch mark and 322 above. Of the 1062 boards in the 2-inch taper group of logs, 517 fell below the 0.5-inch mark and 555 above. A chi-square test at the $\alpha = 0.05$ level for goodness of fit was performed on the two groups to determine if this distribution was significantly different from that expected for a uniform or random distribution of widths. This test showed that board widths were not distributed differently than a uniform distribution. Therefore, hardwood BOF did not maximize yield in this study through a manipulation of board widths to technically increase board-foot yields. Rather, hardwood BOF maximizes yield by determining a sawing solution that increases total fiber yield.

SUMMARY

Percentage estimates of increased board-foot yields from use of BOF decisions in hardwood sawmills were made by two methods. The first method calculated percentage increases based on maximum above minimum board-foot yield for the 15 sawline positions tested per log. The second method calculated percentage increase based on maximum above average yield for the 15 sawline positions tested per log. Percentage estimates based on these methods were 6.3 and 2.8%, respectively.

The hypothesis that lumber widths produced by a hardwood BOF system would be unevenly distributed such that a disproportionate percentage would be below the 0.5-inch mark on a lumber rule was statistically tested. It was found that the number of widths below the 0.5-inch mark was not significantly different from the number above. This indicates that hardwood BOF maximizes yield by determining a sawing solution that increases total fiber yield rather than through manipulation of lumber widths.

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REFERENCES

Adkins, W. K., D. B. Richards, D. W. Lewis, and E. H. Bulgrin. 1979. Programs for computer simulation of hardwood log sawing. USDA Forest Serv. Res. Pap. FPL 357. Forest Prod. Lab., Madison, WI.

Hallock, H., and D. W. Lewis. 1971. Increasing softwood dimension yield from small logs. USDA Forest Serv. Res. Pap. FPL 166. Forest Prod. Lab., Madison, WI.

———, A. R. Stern, and D. W. Lewis. 1976. Is there a "best" sawing method. USDA Forest Serv. Res. Pap. FPL 280. Forest Prod. Lab., Madison, WI.

———, ———, and ———. 1979. A look at centered vs. offset sawing. USDA Forest Serv. Res. Pap. FPL 321. Forest Prod. Lab., Madison, WI.

National Hardwood Lumber Association. 1982. Rules for the measurement and inspection of hardwood and cypress lumber. NHLA, Memphis, TN.

Richards, D. B., W. K. Adkins, H. Hallock, and E. H. Bulgrin. 1979. Simulation of hardwood log sawing. USDA Forest Serv. Res. Pap. FPL 355. Forest Prod. Lab., Madison, WI.