1991

Relative performance of hardwood sawing machines

P. H. Steele

M. W. Wade

Steven H. Bullard
Stephen F. Austin State University, Arthur Temple College of Forestry and Agriculture, bullardsh@sfasu.edu

P. Araman

RELATIVE PERFORMANCE OF HARDWOOD SAWING MACHINES

Philip H. Steele
Associate Professor
Mississippi Forest Products Laboratory
Mississippi State University
Mississippi State, MS 39762

Michael W. Wade
Graduate Research Assistant
and
Steven H. Bullard
Associate Professor
Department of Forestry
Mississippi State University
Mississippi State, MS 39762

Philip A. Araman
Project Leader
USDA Forest Service
Brooks Forest Products Center
Blacksburg, VA 24061

ABSTRACT

Only limited information has been available to hardwood sawmiller on the performance of their sawing machines. This study analyzes a large database of individual machine studies to provide detailed information on 6 machine types. These machine types were band headrig, circular headrig, band linebar resaw, vertical band splitter resaw, single arbor gang resaw and double arbor gang resaw. Kerf width and within-board, between-board and total sawing variation values are given with an analysis of their origin in individual machine characteristics. Feedworks and setworks type and sawblade thickness and type generally determined machine type performance.

INTRODUCTION

Individuals involved in the design, management, and maintenance of sawmills require up-to-date information on the performance of sawing machines. Initial choice of a sawing machine and its monitoring over time are both difficult if performance standards are not available.

The important variables that indicate relative performance are saw kerf width and sawing variation. For softwood sawing machines, a relative abundance of information on kerf width (1,2,4,6,9,17,18,20) and sawing variation values (4,5,8,16,17,19,20) is available.

Only limited information is available on the relative performance of hardwood sawing machines. Robichaud (14) compared the characteristics of horizontal and vertical bandsaws. He reported kerf and sawing precision values for four horizontal and four vertical bandsaws and found no significant difference between the machines.

The objective of this study was to provide information about the conversion characteristics of hardwood sawing machines and to determine statistical differences between them.

ANALYSIS PROCEDURES

Sawmill Improvement Program (SIP) studies on sawing machines in hardwood sawmills provided the data for this analysis. The SIP is a cooperative effort of the USDA Forest Services' State and Private Forestry, and state forestry organizations. These SIP studies represent results of 221 sawmill studies conducted on 266 individual machines in 26 states.

Random measurements of the width of at least 10 saw teeth from each sawblade were averaged to provide kerf width values. Although research on one machine type has shown that kerf width exceeds average measured sawtooth width by 7.0 percent (12) , an average sawtooth width was considered an adequate estimator of actual kerf width for the relative comparisons made in this analysis.

Maximum and minimum measurements were made on each of 100 randomly selected sample boards and sawing variation values were calculated based on these measurements. Conversion factors developed by Peterson and Ermer (12) were applied to the sawing variation values computed to make them comparable to those computed by the Brown analysis of variance method (3) which is the industry standard. The adjustments made to obtain values comparable to the Brown method assume four random measurements per board.

Sawing variation values for 4/4, 5/4, 6,4, and 8/4 National Hardwood Lumber Association thicknesses (11) were pooled to obtain mean values for within-board, between-board, and total sawing variation. This increased the sample size of sawing variation values available for each machine type.

The least significant difference (LSD) method at the 0.05 level, adjusted for unequal sample size (7,15) , was employed for comparison-of-means tests. Results of LSD tests are shown graphically with differences in means summarized by horizontal lines at the top of the graphs. For those means connected by a horizontal line, the LSD test showed no significant difference. The vertical bars in Figures 1 to 4 indicate ± 1-standard deviation values about the mean value for each machine type.

RESULTS

Kerf Width and Within-Board Sawing Variation

Saw wander during sawing is often a function of saw blade thickness and resultant kerf width. Within-board sawing variation is the combined measure of saw wander and feedworks accuracy (3). When comparing machine types, saw wander can sometimes be separated from feedworks performance if sawblade types and/or thicknesses are the same but feedworks differ. Differences in within-board sawing variation may then be assumed to be the result of feedworks performance. For machines with similar feedworks but different blade types, differences in within-board sawing variation may be attributed to blade type and/or blade thickness differences.

Despite the much thinner kerfs of band headrigs, most hardwood sawmills use circular headrigs because inserted-tooth circular saws are easier to maintain. Because the circular headrig can be maintained by the sawyer, a filing room and saw filer is unnecessary. Easy maintenance reduces overhead costs and results in savings that are important to small hardwood sawmills.

The circular headrig sawblade typically has a large diameter of 48 to 60 inches. The guidance system consists of a hardened block, usually of wood, of 1 to 1 1/2 inch diameter placed on both sides and near the outside edge of the blade. These blocks steady the blade and prevent dramatic blade wander, but the thickness, and resulting stiffness, of the blade is the main mechanical blade-stabilizing device.

Comparison of the kerf widths for circular and band headrigs are given in Table 1 and Figure 1. The average circular headrig kerf width was 0.282 inch compared to 0.162 inch for band headrigs. This amounted to 0.120-inch more wood required to produce a board from a circular compared to a band headrig. Figure 1 shows that these values were significantly different. The choice of circular over band headrig can be seen to result in considerable loss of fiber.

Within-board variation is a measure of the feedworks accuracy and saw wander of the sawblade in the cut (3). Band and circular headrigs employ similar feedworks so that differences in within-board sawing variation probably result from differences in blade performance. The within-board sawing variation values in Table 1 and Figure 2 show that while circular headrig within-board variation (0.026 inch) was higher than that of the band headrig (0.022 inch), the values were not significantly different. Apparently, the thick blade of the circular headrig allows within-board sawing accuracy equivalent to the band headrig.

Figure 1 and Table 1 shows average kerf width values for the single arbor gang resaw, double arbor gang saw, vertical band splitter resaw and band linebar resaw. These machines ranked in that order from highest to lowest kerf width. Mean kerf widths for these machines were 0.258, 0.232, 0.158, and 0.139 inch, respectively. The means of the band linebar resaw and vertical band splitter resaw did not differ significantly. The other two resaw types (single and double arbor gang resaws) differed significantly from these machine types and differed between themselves. Both double and single arbor gang resaw machines employ small-diameter circular saws that generally require a thicker blade than their bandsaw counterparts. The mean values for double and single arbor gang resaws shown in Table 1 and Figure 1 fit this generalization and had significantly higher kerf width values than the two band resaw machines.

The single arbor gang resaw had significantly wider kerf compared to the double arbor gang resaw. This result is the reverse of the finding for these resaws in softwood sawmills by Steele et al. (18). The fact that single arbor gang resaws had thinner kerf widths in softwood sawmills was attributed to the fact that single arbor gang resaws are often reserved for sawing narrower cants. In softwood sawmills, separate resaws are used to saw thicker cants. Because none of the hardwood sawmills in this study employed two resaws, those sawmills using single arbor gang resaws for cant breakdown must resaw all cants with the same machine. Hardwood sawmills probably require a wider kerf width for single arbor gang resaws than for double arbor gang resaws because of the greater cant depths sawn by the single blade of the single arbor gang resaws.

Within-board sawing variation reflects the combined result of feedworks and sawing inaccuracies (3). Because double and single arbor gang resaws have identical feedworks, within-board sawing variation differences may be attributed to saw wander during sawing. Within-board variation values for the two machines (Table 1, Figure 2) did not differ significantly, which indicates equivalent blade stability. This result suggests that the thicker blades of the single arbor gang resaws result in sawblade stabilization equivalent to the double arbor gang resaws.

No significant difference in kerf width was found between the band linebar resaw and the vertical band splitter resaw.

These two machines have identical functions but different feedworks systems. No difference in kerf width would, therefore, be expected between these machine types.

The sawing machines in this study fell into two groups with respect to within-board sawing variation (Figure 2) . While the double arbor gang resaw and single arbor gang resaw did not differ significantly, they did have significantly lower within-board sawing variation than the band linebar resaw, band headrig, vertical band splitter resaw, and circular headrig. The latter four machines did not differ significantly among themselves.

One factor in the relatively accurate within-board sawing variation performance of the double and single arbor gang resaws was that their kerf widths were thicker than those of all other machine types with the exception of the circular headrig. The feedworks of these machines should also contribute to low within-board sawing variation. Because these machines process cants on rollers, the flat surfaces and the weight of the cants help reduce movement of the workpiece with respect to the sawblade during sawing. This type of feedworks has been shown to provide superior within-board sawing accuracy when sawing softwoods (16).

The three band machines (band linebar resaw, band headrig, vertical band splitter resaw) and the circular headrig had the highest within-board sawing variation. This result was expected for band sawblades because this blade type is known for wander in the cut (l), and a previous study noted relatively high within-board sawing variation for bandsaw machine types (16). Few, if any, of the bandsaws in the present sample were of the type that uses high strain on the blade to reduce sawblade wander. The probable reason for the high within-board sawing variation of circular headrigs is the use of a very large blade with an inadequate guide system as was described previously.

Between-Board Sawing Variation

Between-board sawing variation is generally a measure of the functioning of the setworks of a sawing machine (3). Results of the statistical analysis of between-board sawing variation data by machine type are shown in Table 1 and Figure 3. The double and single arbor gang resaws had significantly lower between-board sawing variation than the circular headrig, vertical band splitter resaw and band headrig. The band linebar resaw values were between these two groups and did not differ significantly from either group. Low between-board sawing variation is known to be a characteristic of double and single arbor gang resaws (16) . Elimination of the potential for setworks malfunction or setworks wear due to the multiple preset saws of these machines (10) explains their good between-board sawing variation performance.

In practice, the band linebar resaw often saws the same thickness repeatedly without resetting the setworks. This situation is similar to that for the preset blades of the gang resaws in that absence of movement reduces potential error from setworks malfunction. This fact probably explains the band linebar resaw's relatively good between-board sawing variation performance.

The complexity of the feedworks of circular and band headrigs provides a high potential for feedworks mechanism wear and malfunction. A complicated setworks mechanism is required to position logs on both circular and band headrig carriages. The higher between-board sawing variation of these-machines was as expected.

Total Sawing Variation

Total sawing variation is a function of within- and between-board sawing variation (3). The three machines that ranked with lowest total sawing variation (Table 1, Figure 4) were those that had lowest within- and between-board sawing variation. These three machines were the double arbor gang resaw, the single arbor gang resaw, and the band linebar resaw. These three machines were not significantly different in total sawing variation from the band headrig.

Two of the three machines with lowest total sawing variation (the single and double arbor gang resaws) were those that employed small-diameter circular saws and that fed a flat-faced cant past preset saws. A previous study found that this combination of features produced low total sawing variation for softwood sawing machines (16). The relatively wide kerf of the single and double arbor gang resaws may also have reduced the within-board sawing variation component of the total sawing variation values for these two machines by stabilizing the saw blades during cutting.

The band linebar resaw had the third lowest total sawing variation. This machine has some of the characteristics of the double and single arbor gang resaws. A flat-faced cant is processed and, as has been observed, the setworks may not be reset for long periods of time. This lack of setworks movement would, like the preset saws of the double and single arbor gang resaws, reduce the potential for between-board sawing variation.

The two machines with highest total sawing variation were the circular headrig and vertical band splitter resaw. These machines did not differ significantly from each other and did not have any features in common except consistently high within-board and between-board sawing variation. The poor total sawing variation performance of the circular headrig stems from the fact that it had highest within-board and between-board sawing variation values of all machine types. These high values resulted from saw wander due to an inadequate blade guidance system coupled with setworks error provided by a complex setworks mechanism with considerable opportunity for wear and malfunction.

SUMMARY

The circular headrig had the significantly highest kerf width value of all machines. Compared to the band headrig, the circular headrig kerf width was 0.120 inch wider. Within-board sawing variation values showed these two machines to have equivalent stability during sawing. This result was apparently due to the heavier kerf width of the circular headrig compared to band headrig. The heavy kerf of the circular headrig apparently compensated for other factors, such as inadequate guides, that would result in blade instability.

The double and single arbor gang resaws had the significantly highest kerf width of the resaws because the remaining types were band sawblades. The need for the single arbor gang resaw to saw deeper cants with a single blade was hypothesized to result in the higher kerf width values found for these machines compared to the double arbor gang resaw.

Single arbor gang resaws had within-board sawing variation equivalent to that for the double arbor gang resaws. This result indicates that the increased kerf width of the single arbor gang stabilized the sawblade in deeper cuts.

Heavy kerf width and feedworks type appeared to explain the significantly superior within-board sawing variation performance of the double and single arbor gang resaws. Feedworks that process flat-faced cants on rollers are known to provide superior within-board sawing variation performance. Band sawbladed machines were probably in the group with significantly highest within-board sawing variation because of the known characteristic of bandsaws to wander during sawing.

Between-board sawing variation was low for the double and single arbor gang resaws, presumably due to their preset saws. The band linebar resaw also showed good between-board sawing variation performance, probably because this machine’s setworks are often not reset between subsequent cuts.

The sawing machines with lowest total sawing variation were those that employed small-diameter circular saws with relatively heavy kerf width and that fed a flat-faced cant past preset saws. The circular headrig was among the group of machine types with the highest total sawing variation due to the fact that it had highest within-board and between-board sawing variation. The machine characteristics that contributed to high within-board and between-board sawing variation for the circular headrig were an inadequate guidance system and a complex feedworks system with considerable opportunity for wear and malfunction.

LITERATURE CITED

1. Allen, R. E. 1973. High-strain /thin kerf. Modern Sawmill Techniques. Proceedings, First Sawmill Clinic, Feb. 15-17. Portland, OR. Miller Freeman Publications, San Francisco, CA. 312 pp.

2. Aune, J. E., and E. L. Lefebvre. 1975. Small-log sawmill systems in Western Canada, Inf. Rept. VP-X-141. Can. Forest Serv., West. Forest Prod. Lab., Vancouver, B.C., 59 pp.

3. Brown, T. D. 1982. Quality control in lumber manufacturing. Miller Freeman Publ., San Francisco, CA 288 pp.

4. Calvert, W. W., and J. S. Johnston. 1967. Test shows lumber, chip recovery higher on band than circular saws. The Northern Logger and Timber Processor, November. pp. 23-27.

5. Clapp, V. W. 1982. Lumber recovery: How does your mint[s] performance rate? Forest Ind. Magazine, March. p. 26.

6. Dobie, J. 1975. Lumber recovery practices in British Columbia coastal sawmills. Inf. Rept. V6T 1X2. Can. Forest Serv., West. Forest Prod. Lab., Vancouver, B.C. 29 pp.

7. Freund, R. J. and R. C. Littell. SAS for linear models. 1981. SAS Institute, Inc. Cary, N.C. 231 pp.

8. Johnston, J. S., and A. St. Laurent. 1978. Sawing accuracy in Eastern Canadian sawmills. Can. Dept. Environ. , East. Forest Prod. Lab., OPX 216E. 12 pp.

9. Kirbach, E. 1974. A survey of sawing technology in Western Canada. Inf. Rept. VP-X-124. Can. Forest Serv., West. Forest Prod. Lab., Vancouver, B.C. 29 pp.

10* Koch, P. 1964. Wood Machining Processes. The Ronald Press Co., N.Y. 530 pp.

11. National Hardwood Lumber Association. 1982. Rules for the measurement and inspection of hardwood and cypress lumber. National Hardwood Lumber Assoc., Memphis, TN. 115 pp.

12 . Patterson, D. W. 1984. Saw kerf width versus sawtooth width. Forest Prod. J. 34(7/8):33.

13 . Peterson, T. A., and D. S. Ermer. 1981. Evaluation of alternative statistical techniques in use for monitoring sawmill machine centers. Staff Pap. Series No. 12. Univ. of Wisconsin Forestry Dept. , Madison, WI. 29 pp.

14. Robichaud, Y. 1975. Band resaws for sawing hardwoods: a comparison between horizontal and vertical resaws. Can. Dept. Environ. , East. Forest Prod. Lab. OPX 148E. 13 pp.

15. Steel, R. G. H., and J. H. Torrie. 1980. Principles and procedures of statistics. 2nd ed. McGraw-Hill Book Co. 633 pp.

16. Steele, P. H., F. G. Wagner, and R. D. Seale. 1986. Analysis of sawing variation by machine type. Forest Prod. J. 36(9):60-65.

17. Steele, P. H., R. Bennett, F. G. Wagner, and R. D. Scale. 1987. Wood loss per sawline. Forest Ind. Msg. pp. 40-41.

18. Steele, P. H., F. G. Wagner, R. D. Scale, F. W. Taylor, and R. Bennett. 1987. Kerf width by machine type. Forest Prod. J. 37(3):35-37.

19. Usenius, A., K. O. Sommardahl, and E. Halonen. 1975. Dimensional accuracy and surface smoothness of sawn timber and the quality of chips and sawdust achieved by some sawing lines. Tech. Res. Centre of Finland, Res. Rept. 194. 82 pp.

20. Williston. E. M. 1976. Lumber Manufacturing. Miller Freeman Publ., San Francisco, Calif. 512 pp.

Table 1. Mean values of kerf width, within-board sawing variation, between-board sawing variation, total sawing variation and wood loss per sawline by machine type.

Machine type	Machine code	Sample size	Kerf width	Within-board sawing variation	Between-board sawing variation	Total sawing variation
Band headrig	1	50	.162	.022	.016	.047
Circular headrig	2	168	.282	.026	.015	.054
Band linebar resaw	3	10	.139	.021	.012	.040
Vertical band splitter resaw	4	8	.158	.026	.016	.060
Single arbor gang resaw	5	24	.258	.011	.006	.032
Double arbor gang resaw	6	6	.232	.011	.005	.026

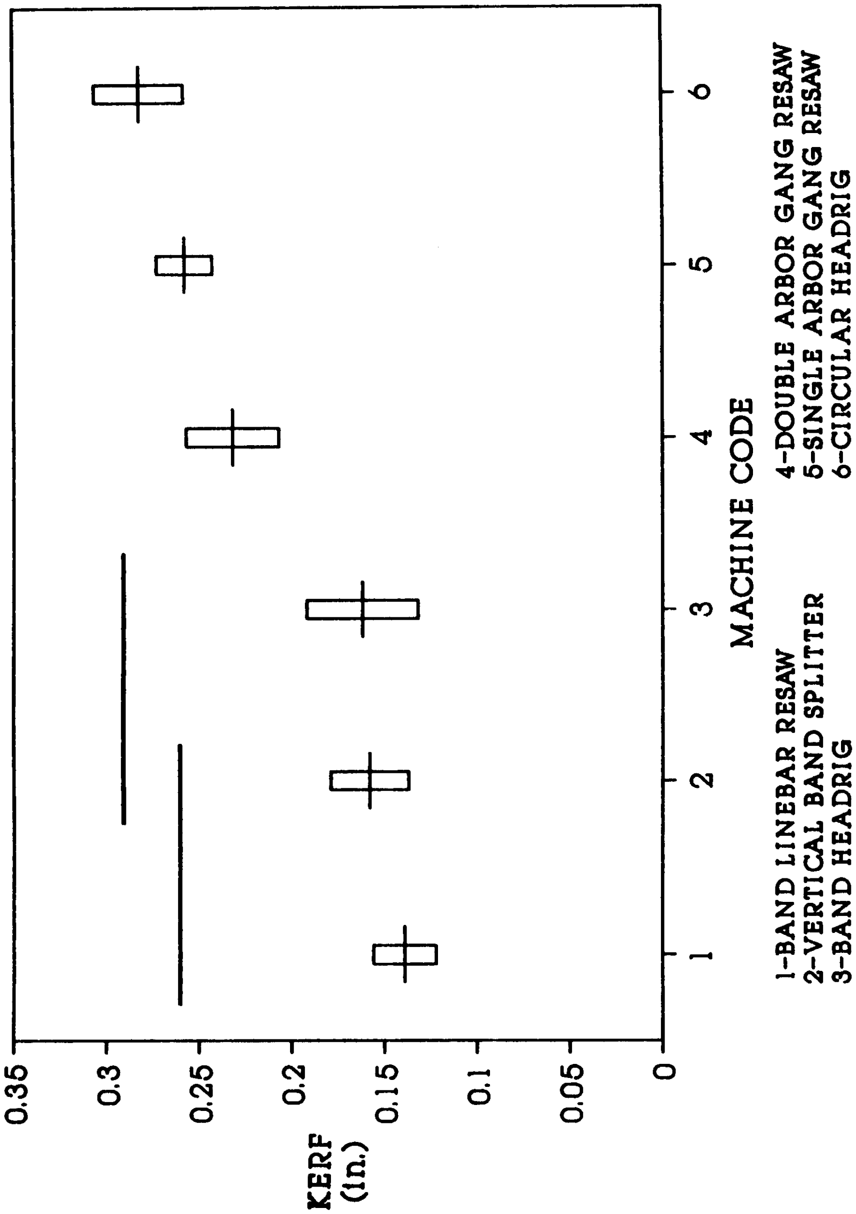

Figure 1. Mean and ± l-standard deviation kerf width values by machine type with results of separation of means tests. Length of vertical bars indicate ± l-standard deviation about the mean. Horizontal lines indicate no significant difference between the machine types beneath them.

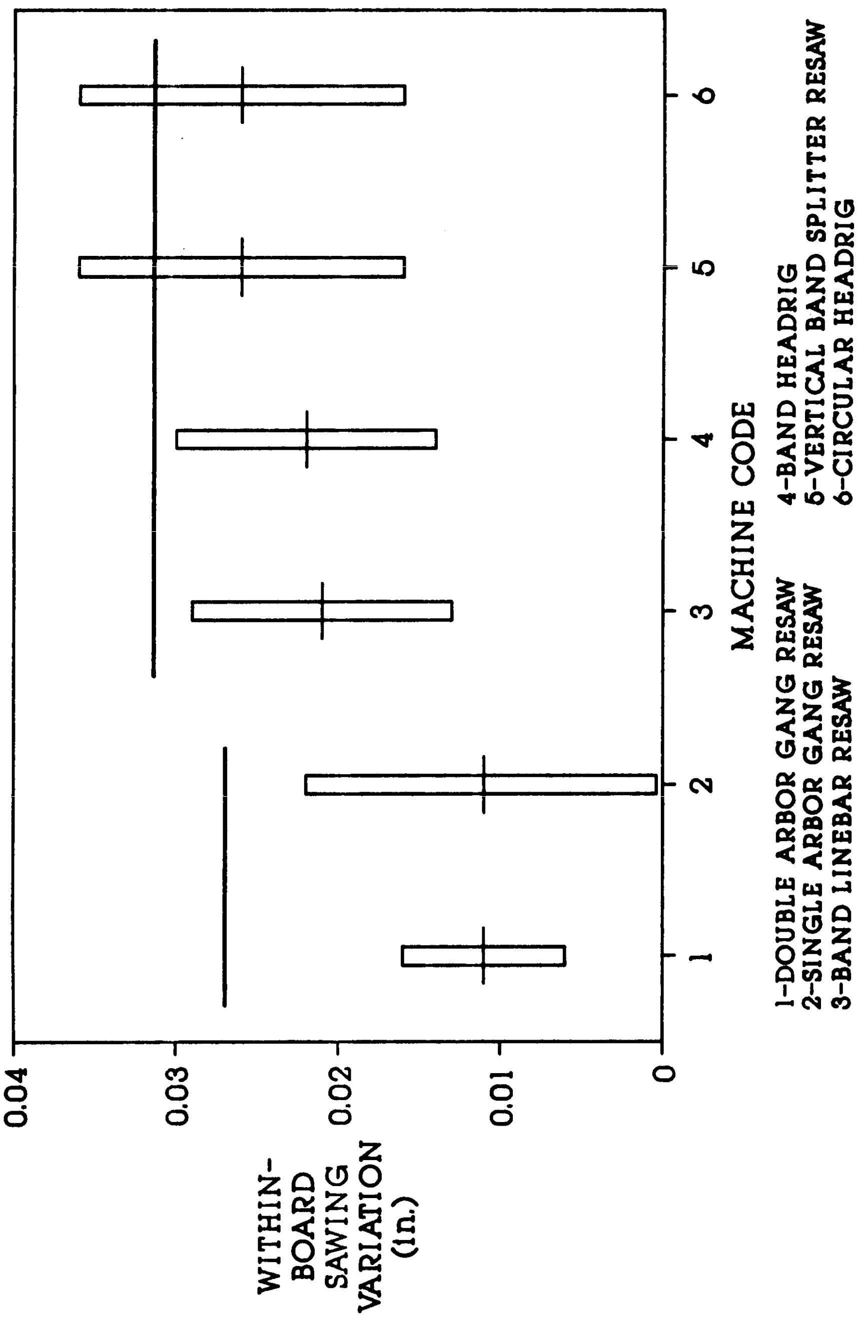

Figure 2. Mean and ± l-standard deviation within-board sawing variation values by machine type with results of separation of means tests. Length of vertical bars indicate ± 1-standard deviation about the mean. Horizontal lines indicate no significant difference between the machine types beneath them.

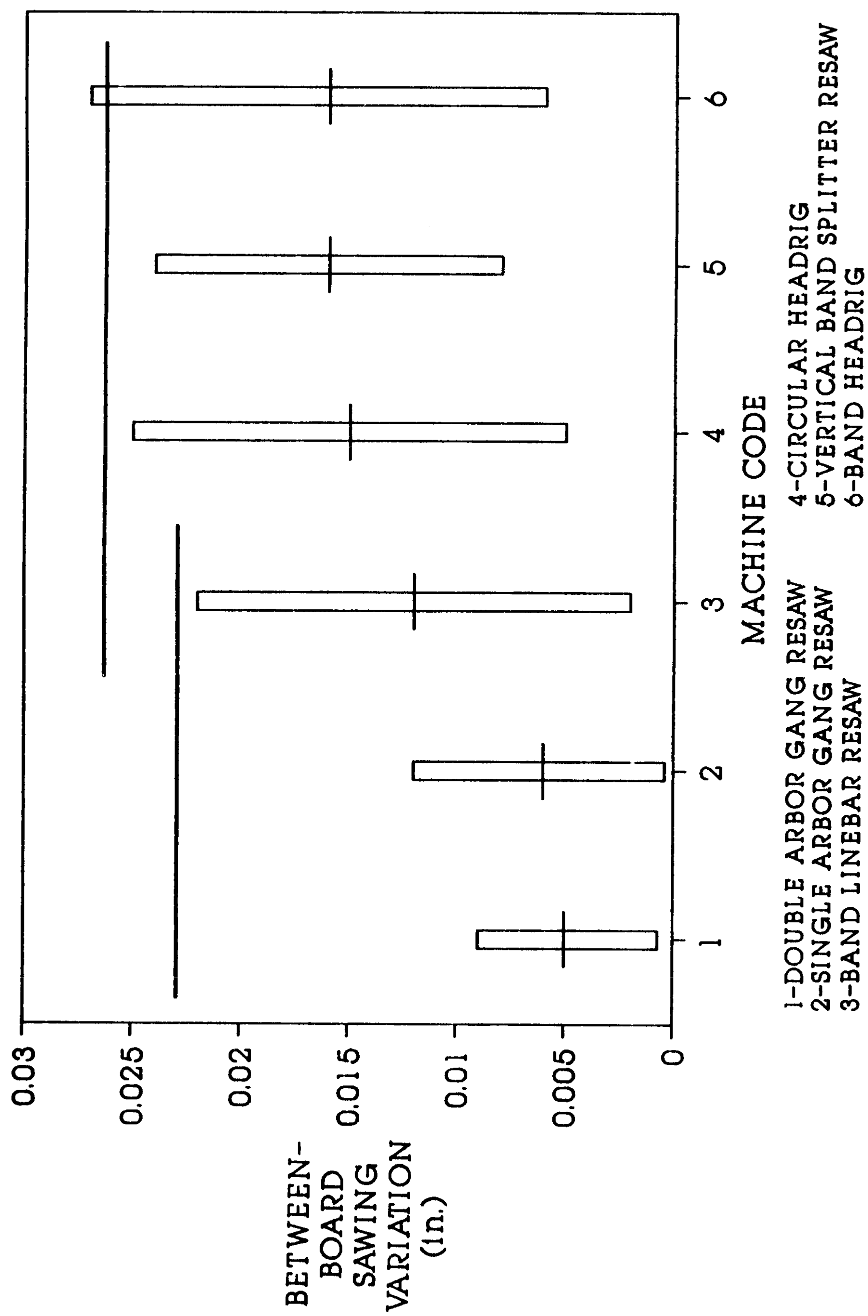

Figure 3. Mean and ± l-standard deviation between-board sawing variation values by machine type with results of separation of means tests. Length of vertical bars indicate ± 1-standard deviation about the mean. Horizontal lines indicate no significant difference between the machine types beneath them.

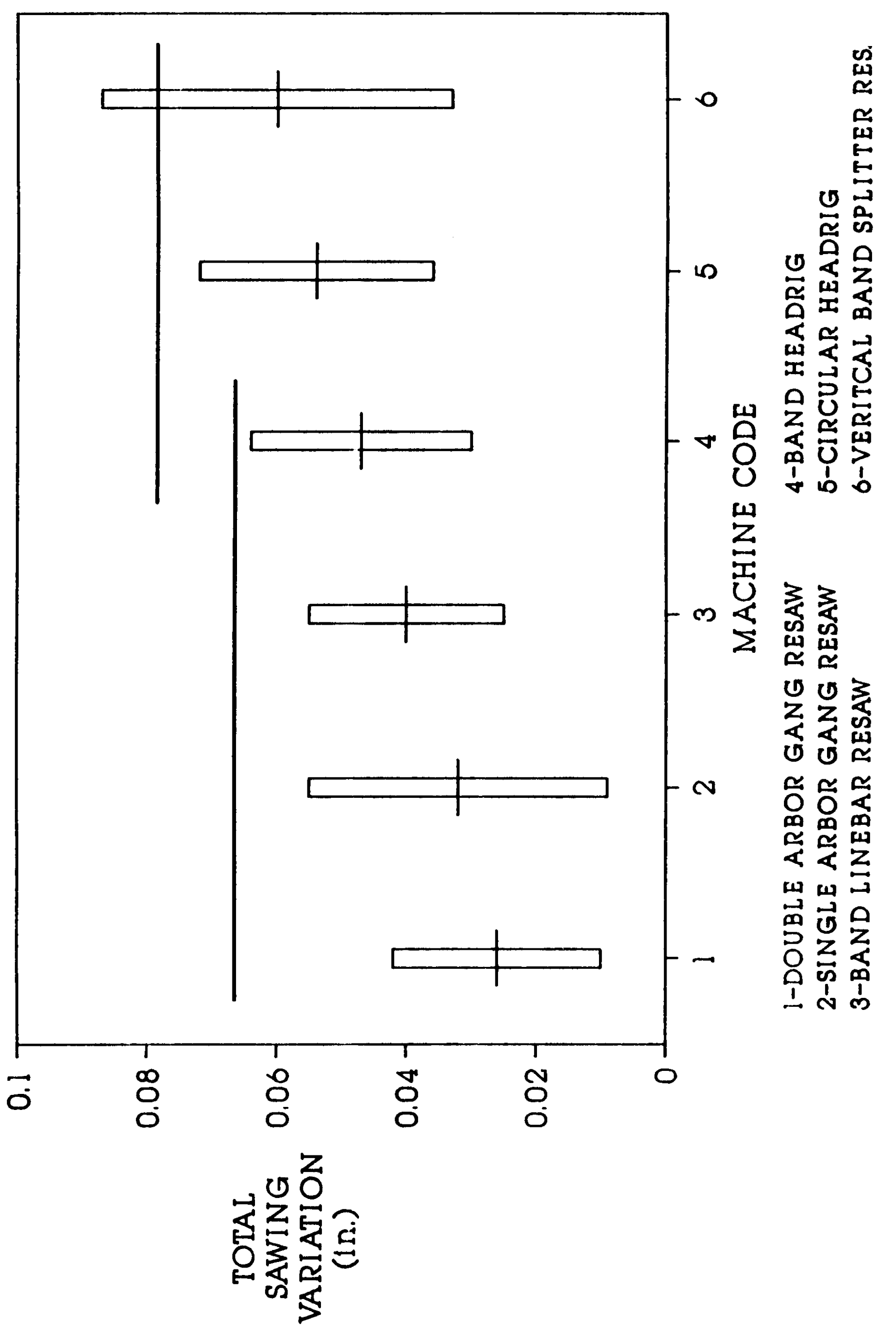

Figure 4. Mean and ± l-standard deviation total sawing variation values by machine type with results of separation of means tests. Length of vertical bars indicate ± l-standard deviation about the mean. Horizontal lines indicate no significant difference between the machine types beneath them.

PROCEEDINGS OF THE

NINETEENTH ANNUAL HARDWOOD SYMPOSIUM

OF THE

HARDWOOD RESEARCH COUNCIL

FACING UNCERTAIN FUTURES AND CHANGING RULES IN THE 1990S

In Cooperation With The
School of Forest Resources
Mississippi State University

Starkville, Mississippi

March 10-12, 1991

An Activity of the *National Hardwood Lumber Association*