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Power Consumption and Lumber Yields for Reduced-Kerf Circular Saws Cutting Hardwoods

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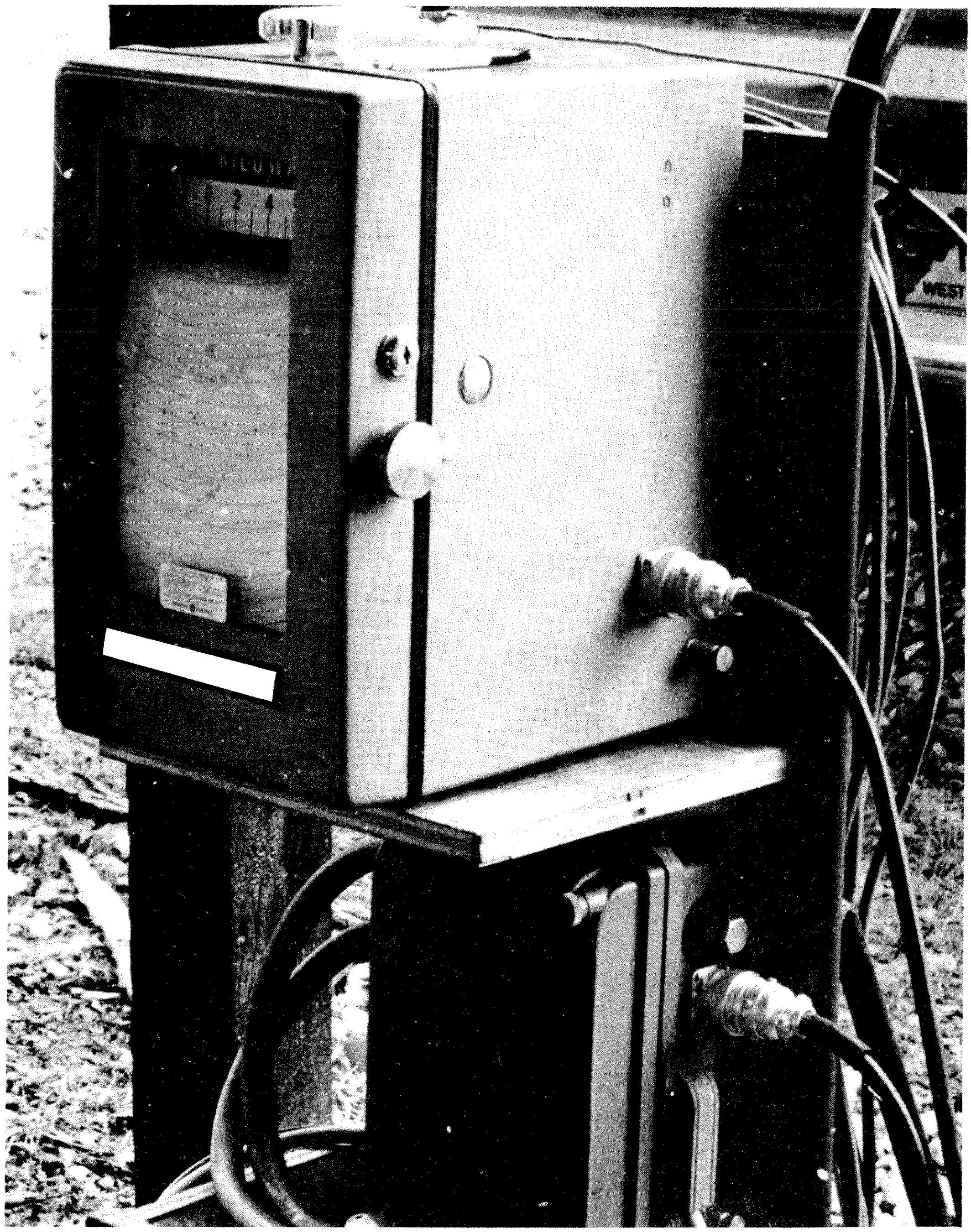

The Author

Donald G. Cuppett received his bachelor of science degree in forestry from West Virginia University in 1950. In 1950–52 he served as a farm forester for the West Virginia State Forestry Department, and in 1953–54 as assistant state forester. In 1955 he joined the Union Carbide Corporation as a forester, becoming department head in 1958, a position he held until 1962, when he joined the staff of the Northeastern Forest Experiment Station, Forestry Sciences Laboratory, at Princeton, West Virginia, as research forester and project leader.

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Abstract

Two 50-inch diameter headsaws were used for sawing (a) hardwood cants into boards, and (b) hardwood bolts into pallet parts. One saw had a 9x10 gage plate with 1/4-inch kerf teeth, and the other had a 7x8 gage plate with 9/32-inch kerf teeth. Power consumption for the two saws was determined with a watt-hour meter, measuring power used for paired cuts in 6-inch thick hardwood cants. Product yields for the two saws were compared by sawing matched samples of hardwood bolts into pallet parts. The 1/4-inch kerf saw consumed an average of 15 percent less power than the 9/32-inch kerf saw. Product yield for the 1/4-inch kerf saw averaged 8 percent more than yield for the 9/32-inch kerf saw. Both power consumption and product yield differences for the two saws were highly significant.

Introduction

Most sawmills designed for small hardwoods use circular saws. The most commonly used circular headsaws have 7x8 gage plates (7 gage or 3/16-inch eye thickness and 8 gage or 5/32-inch rim thickness), with 17/64- or 9/32-inch kerf teeth. Some circular resaws are equipped with 3/16-inch kerf carbide-tooth saws, but many have standard tooth saws as heavy as 6 gage (13/64-inch thickness) with up to 3/8-inch kerf teeth. Scragg and bolter mills are frequently equipped with 6x7 gage saws having 5/16- to 3/8-inch kerf teeth.

Relatively thick saws have been used for hardwoods because thick saws perform better than thinner saws under sustained heavy loads, and because the thick saws require less skilled maintenance, advantages that have been judged to offset their lower product yield and higher power consumption. But increasing timber and energy costs have renewed interest in reducing kerf losses in hardwood sawmills.

Past research in the use of thin-kerf saws for hardwoods is scanty. Telford (1949) analyzed the effects of 11 factors on the power required to operate 7x8 gage saws cutting 10-inch thick cants. He found that with other factors constant the cutting torque required for different kerf widths was as follows:

8/32-inch kerf: 1,028 lb-inches
9/32-inch kerf: 1,460 lb-inches
10/32-inch kerf: 1,600 lb-inches

Although cutting torque was least for the 8/32-inch teeth, sawing was not sustained long enough to determine whether extended operation with 8/32-inch teeth would be successful. In 1954, Telford reported that a 1/8-inch difference in kerf results in a difference of approximately 10 percent in board yield per log.

During studies of product yields from low-grade logs and bolts, we operated a 50-inch diameter 7x8 gage saw with 8/32-inch kerf teeth for extended periods. Mixed hardwood logs including oak and hickory up to 16 inches in scaling diameter were sawn into 4/4-inch boards without saw heating or faulty board sizing. Four- and six-foot bolts up to 14 inches scaling diameter were sawn into cants and side lumber with similar results. It appeared that kerf could be significantly reduced in commercial hardwood sawmills processing small logs or bolts. In this report we compare power consumption and product yields of a 7x8 gage, 9/32-inch kerf saw with those of a 9x10 gage, 1/4-inch kerf saw processing hardwood bolts.

Procedure

Four- and six-foot-long bolts from thinning hardwood poletimber stands were used for the experiment. Clear or nearly clear bolts were selected for the power consumption tests; woods-run sound bolts having 1-inch or less absolute sweep were used for the product yield comparisons. Three species groups were included: the oaks, yellow-poplar—cucumber, and beech-birch-maple.

Two 50-inch diameter circular saws with 44 "F" style teeth were obtained for the study. The saws were made by the same firm, and were identical except for plate thickness and kerf width. Sawing was done on a mobile sawmill having a four-block manual carriage and 4-inch belt feedworks. The saw mandrel is turned at 600 r/min by a 50-horsepower electric motor.

Power Consumption Experiment

Three lines were cut with each saw on 20 or more 6-inch thick cants for each species group. Paired cuts, one with each saw, were made at the sides and near the pith of each cant (Fig. 1). Saw cuts

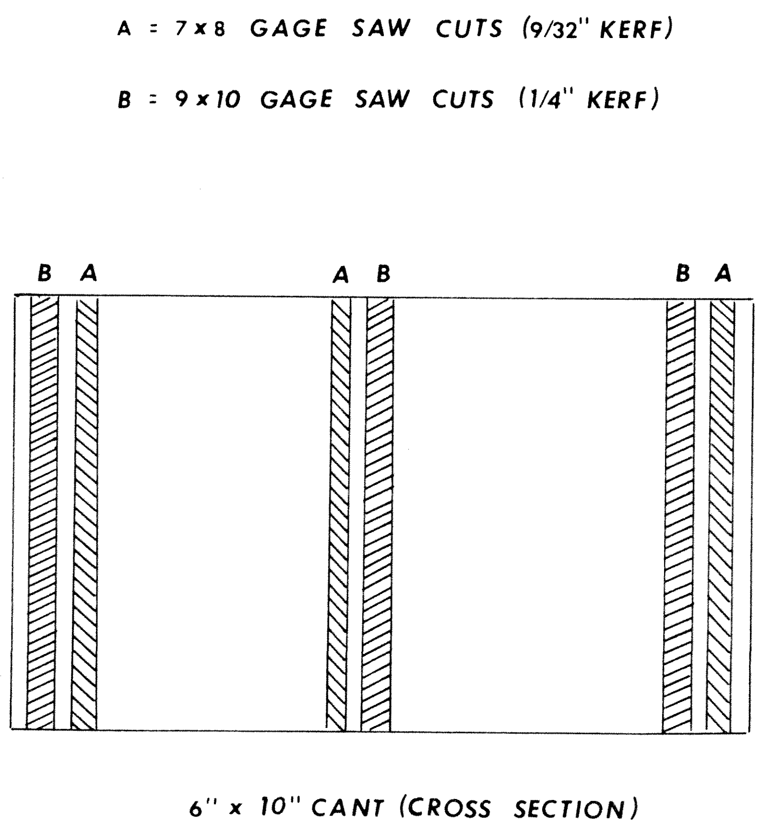

Figure 1.—Diagram of the end cross-section of a cant, showing placement of experimental saw cuts.

were placed as close together as possible to minimize differences in wood density for the matched saw cuts. First cuts on the sides of the cants were alternated between the two saws.

A separate saw was used for producing the cants used in the power consumption test. For the initial species group, the new teeth on each test saw were ground lightly to remove damage caused in shipment. After each species group was sawn, the teeth were reground to establish sharp tooth corners, but the teeth were not side-dressed.

Power consumption for the individual saw cuts was measured by a portable watt-var recorder[1] (Fig. 2). Differences in power consumption for the two saws on matched cuts were analyzed by paired t-tests.

Product Yield Experiment

Bolts for the product yield comparison were sorted by species groups, numbered, and measured as follows: average d.i.b. (diameter inside bark) to nearest 1/10-inch on both ends, length to nearest 1/10-inch, and absolute sweep to nearest 1/2-inch. This information was used to separate the bolts into samples matched by species, diameter, length, cubic volume, and sweep class for the two saws.

Sample bolts were sawn into standard dimension pallet deckboards and stringers on both test saws. Saws were sharpened at the beginning of each species group run. No intermediate sharpening was required. Teeth were ground on the faces only, just enough to reestablish sharp corners. Sawing pat-

[1] General Electric CH-11.

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Figure 2.—Portable watt-var recorder used for measuring electric power consumption of saws.

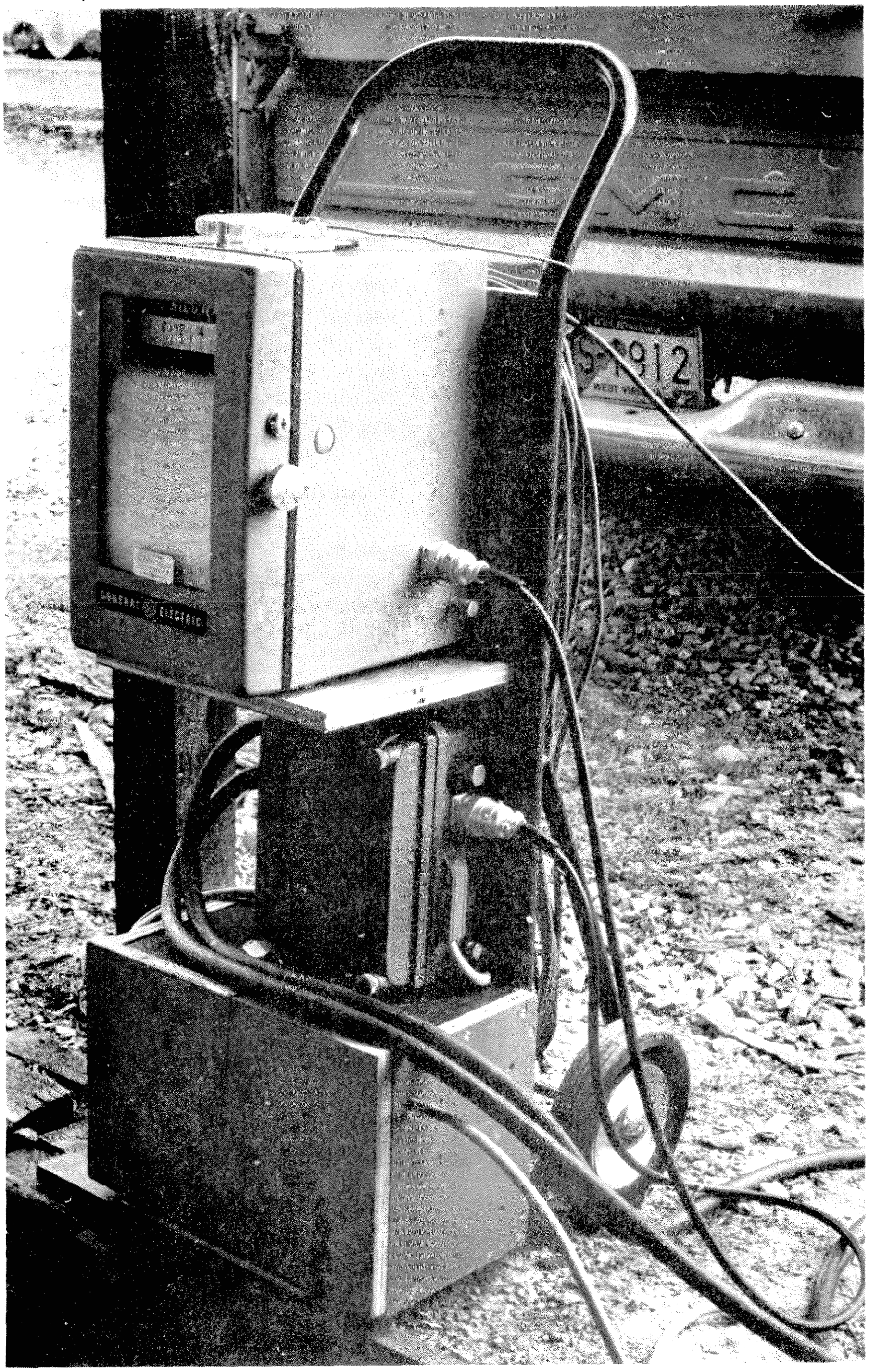
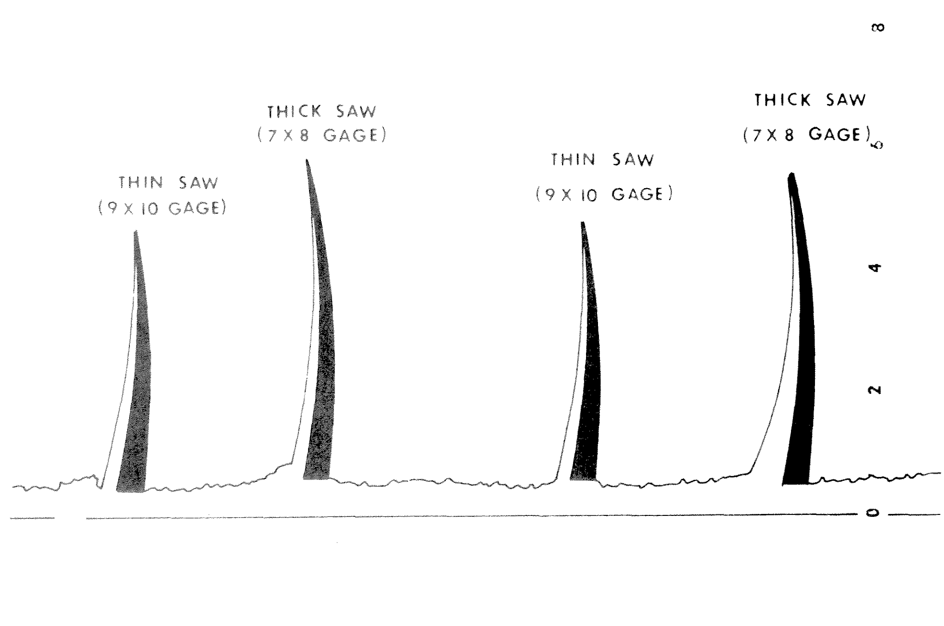


Table 1. Comparison of power consumption for 7x8 gage, 9/32-inch kerf saw versus a 9x10 gage, 8/32-inch kerf saw for cutting 6-inch thick cants

Species	Type cut	Cuts per saw	Index of power consumed: 9/32″ kerf saw	Index of power consumed: 8/32″ kerf saw	% additional power for 9/32″ kerf saw	t/df
Yellow-poplar	Plain	52	5.105	4.500	13.4	9.047/51
Yellow-poplar	Quartered	26	2.455	2.050	19.7	5.552/25
Oaks	Plain	30	6.245	5.470	14.1	7.657/29
Oaks	Quartered	15	3.490	2.960	18.9	6.221/14
Beech-Birch-Maple	Plain	36	9.010	7.390	21.9	9.468/35
Beech-Birch-Maple	Quartered	18	5.090	4.270	19.2	6.071/17

Figure 3.—Watt-var recorder chart illustrating relative power consumption for two pairs of matched cuts on a maple cant. Saw gage is marked at the apex of the stylus mark for each cut. Shaded areas indicate the amount of power consumed for each saw cut.



terns for the two saws were identical and simulated the patterns used on Scragg mills; i.e., 4-inch thick cants were cut from bolt centers; and the resulting cants and slabs were resawn into stringers and deckboards. Four-inch opening faces were cut on 6-, 7-, and 8-inch-diameter bolts; 6-inch opening faces were cut on 9-inch and larger bolts.

Differences in parts yields from the sample bolts processed by the two saws were analyzed by analysis of covariance, with the midpoint bolt diameter as the covariate.

Results

Power Consumption Experiment

Relative power consumptions for the two saws are shown in Table 1. They include both the power used to cut the wood and power to operate the carriage feed. The power consumption index is the planimetered area (in square inches) contained between the base line and the stylus mark on the recorder chart for each saw cut (Fig. 3). Table 1 index values are the sums of planimetered areas for all saw cuts with each saw, by species and type of cut.

The 9/32-inch kerf saw required from 13.4 percent to 21.9 percent more power than the 8/32-inch kerf saw, depending on species and type of cut. By t-tests, power consumption differences for the two saws were significant at the 0.001 level for all species and type-of-cut groups (Table 1).

Some of the sample cants contained knots, and there were some slight differences in knot sizes for the paired saw cuts. Also, it was impossible to maintain identical feed speeds for the two saws in all paired cuts. Since both knot size and feed speed influence power consumption, a separate comparison of power consumption for the two saws was made between paired cuts in clear wood or where knot diameters were equal, and where feed speeds for the paired cuts varied by not more than 6 feet per minute (limit of recorder accuracy). The 9/32-inch kerf saw required from 14.7 to 19.2 percent more power than the 8/32-inch kerf saw, depending on species. Power consumption differences for the two saws were significant at the 0.001 level for all species groups (Table 2).

Product Yield Comparison

Table 3 shows a summary of volume and size data for the matched bolt samples used for comparing product yields for the two saws. Scaling diameters were almost perfectly matched. The sample match by cubic-foot volume shows a slight advantage for the 1/4-inch saw; most of the difference occurred in 6-foot yellow-poplar bolts, where the sample bolt volume for the 1/4-inch kerf saw was 0.57 cubic feet (about 0.6 percent) higher than for the 9/32-inch kerf saw. Sample bolts ranged from 6 to 13 inches in scaling diameter; average scaling diameter was about 8.2 inches for the yellow-poplar, 7.0 inches for the oaks, and 7.6 inches for beech-birch-maple bolts.

Product yields for the 1/4-inch kerf saw exceeded yields for the 9/32-inch kerf saw by an average of 8.1 percent in board-foot volume and 8.0 percent in cubic-foot volume (Table 4). Yield gain for the 1/4-inch kerf saw was slightly higher for the oak and beech-birch-maple bolts than for the yellow-poplar bolts, probably because the sample yellow-poplar bolts contained less sweep and averaged about 1 inch larger in scaling diameter than the oak and beech-birch-maple bolts.

Covariance analysis showed that yield differences between the two saws were highly significant for all species groups:

Species Group		*F value*	*PR>F*	*df*
Yellow-poplar	4-foot bolts	14.44	0.0002	1
Yellow-poplar	6-foot bolts	16.13	0.0002	1
Oaks	4-foot bolts	10.27	0.0010	1
Beech-birch-maple	4-foot bolts	8.23	0.0046	1

Table 2. Power consumption comparison for 7x8 gage, 9/32-inch kerf and 9x10 gage, 1/4-inch kerf saws cutting clear or equally knotty wood at identical feed speeds

Species	Type saw	Average power consumption index	Standard error	% additional power for 9/32-inch kerf saw
Yellow-poplar	8/32″ kerf	0.0828	0.0079	
	9/32″ kerf	0.0950	0.0073	
	Difference	0.122***	0.0018	14.7
Oaks	8/32″ kerf	0.1983	0.0098	
	9/32″ kerf	0.2319	0.0114	
	Difference	0.0336***	0.0043	16.9
Beech-birch-maple	8/32″ kerf	0.1911	0.0176	
	9/32″ kerf	0.2278	0.0203	
	Difference	0.0367***	0.0060	19.2

*** Statistically significant at the 0.001 level.

Table 3.—Sample bolt matching data for product yield comparison

Species group	Bolt length	9/32″ kerf saw			1/4″ kerf saw		
		Bolts	Sum of scaling diameters	Volume	Bolts	Sum of scaling diameters	Volume
	ft	*No.*	*inches*	*ft*^{3}	*No.*	*inches*	*ft*^{3}
Yellow-poplar	4	46	385.2	74.62	46	385.2	74.85
Yellow-poplar	6	45	361.7	99.56	45	362.0	100.13
Oaks	4	58	407.0	65.61	58	406.8	65.58
Beech-Birch-Maple	4	41	309.9	54.39	41	309.9	54.31
Totals		190	1,463.8	294.18	190	1,463.9	294.87

Table 4. Product yields for a 7x8 gage, 9/32-inch kerf saw versus a 9x10 gage, 1/4-inch kerf saw for cutting hardwood bolts into pallet parts

Species	Bolt length	Product yields				Yield gain for 1/4″ kerf saw	
		9/32″ kerf saw		1/4″ kerf saw			
	ft	*bd ft*	*ft*^{3}	*bd ft*	*ft*^{3}	*bd ft/%*	*ft*^{3}
Yellow-poplar	4	565.10	38.26	605.73	40.96	40.63/7.2	2.70/7.1
Yellow-poplar	6	737.00	47.89	795.00	51.58	58.00/7.9	3.69/7.7
Oaks	4	429.02	29.22	466.21	31.70	37.19/8.7	2.48/8.5
Beech-Birch-Maple	4	344.44	23.35	377.05	25.57	32.61/9.5	2.22/9.5
Totals		2,075.56	138.72	2,243.99	149.81	168.43/8.1	11.09/8.0

Discussion

The study results indicate that significant savings in power consumption—slightly more than 15 percent—can be achieved by a 1/32-inch reduction in saw kerf. In commercial operations, this saving would apply to power consumed by saws and feed mechanisms during use; power required for saw and feed system idling, and for conveyors, debarkers, or other auxiliary equipment would not be affected. But since actual sawing operations account for a large portion of total power consumption in most sawmills, the power saved by a 1/32-inch kerf reduction should be significant.

Product yield averaged about 8 percent more for the 1/4-inch kerf saw than for the 9/32-inch kerf saw. The economic effect of such yield gains on commercial sawing operations would be substantial. For example, a mill producing 3 million board feet per year of pallet parts would realize an additional 240 thousand board feet of parts from the same volume of raw material, and at little added cost. At a parts value of $150 per thousand board feet, the additional production would be worth $36,000 per year.

Application

Commercial feasibility of using thin kerf saws will depend on saw performance in sustained production, and on the degree and cost of maintenance required for the thin saws. During the study, the 9x10 gage 1/4-inch kerf saw performed as well as the thicker saw under identical operating conditions and maintenance. But the duration of sawing was too brief to conclude that results would be similar in commercial operation. We have, however, made extensive use of 7x8 gage saws with 1/4-inch kerf teeth for sawing both hardwood bolts and small sawlogs; the saws performed satisfactorily with normal maintenance.

Two pilot tests will be conducted to evaluate the performance of 9x10 gage saws under long-term use. In one test, the saw will be fitted with 7/32-inch kerf teeth (minimum theoretical kerf width for the 9x10 gage saw) and used for sawing hardwood bolts into pallet parts. For the second test, a 9x10 gage saw will be used by a commercial operator for sawing woods-run sawlogs into standard lumber. Saw performance and maintenance requirements will be compared with those of the thicker saws normally used.

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A 9x10 gage, 1/4-inch kerf saw and a 7x8 gage, 9/32-inch kerf saw were used for cutting matched samples of hardwood cants and bolts into pallet parts. The 1/4-inch kerf saw consumed about 15 percent less power than the 1/4-inch kerf saw. Product yield for the 1/4-inch kerf saw averaged 8 percent more than yield for the 9/32-inch kerf saw.

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Keywords: Headsaw performance; conversion efficiency; pallet production

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