FRDA REPORT 102

ADVANCES IN SAWMILL TECHNOLOGY

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ADVANCES IN SAWMILL TECHNOLOGY

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by
G.R. Middleton

PROCEEDINGS OF A FORINTEK CANADA CORP. SEMINAR

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by

THE CANADA - BRITISH COLUMBIA FOREST RESOURCE
DEVELOPMENT AGREEMENT

in cooperation with

THE LUMBER MANUFACTURING ASSOCIATIONS
OF BRITISH COLUMBIA

October 1989
PREFACE

Forintek Canada Corp.'s 1988-89 research program achieved important developments in sawing, saw control, moisture sorting and incising for treating and seasoning of lumber. These achievements, along with the results of mill performance tests of camera scanners for computer-optimized log bucking and of curve sawing equipment, were reported to Forintek's member companies through a series of seminars, the proceedings of which are provided here.

The seminars took place in Prince George, Williams Lake and Kelowna, B.C., June 8, 13 and 15, 1989 respectively.
ACKNOWLEDGEMENTS

Forintek Canada Corp. thanks the Canada-British Columbia Forest Resource Development Agreement for their financial support of the seminar and the publication of these proceedings. Thanks also to the Lumber Manufacturing Associations of British Columbia for their support and help in managing and advertising the seminar venues.
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KEYNOTE ADDRESS

by

M. J. Heit

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Forest Development
Forestry Canada
Pacific and Yukon Region
KEYNOTE ADDRESS

by

M. J. Heit

This seminar is part of a series of regional seminars and it is a good example of Forestry Canada and FRDA funding working in collaboration with Forintek and the B.C. Lumber Manufacturers’ Associations to bring practical research and development to you.

FRDA’s objective has been aimed at security of supply issues. Our normal way of “Fixing” this has been to increase timber yield in the field through improved silvicultural practices. The traditional methods of planting, brushing and weeding, thinning and fertilization have made a significant impact to bring about security of supply. In British Columbia to December 31, 1988 FRDA expenditures totalled $193 million dollars resulting in employment of over nearly 839,000 person days and in approximately 105,000 hectares of NSR land being restocked.

These “new volumes”, however, will offer supply relief only in regions of the province where there is sufficient volume of mature timber present to sustain current harvest levels. In other regions, because of poor age class distribution or over cutting, this increased supply will not pay real dividends in merchantable timber supplies for some years down the road.

This seminar takes a different tact. The more product (both physical and
value wise) we get out of a tree, the fewer trees we use for a given amount of output. In this sense, an efficient sawmill is also about security of supply. Increased utilization and conversion at the mill end is as important as planting trees. Forintek’s research program produced important developments last year in sawing, saw control, moisture sorting and incising for treating and seasoning. Rapid field testing and technology transfer has been made possible by funding from Forestry Canada and the industry Forintek Partnerships. These seminars, through presentations from Forintek Staff and co-operating sawmill production people will provide you with an up-to-date report on these very exciting projects.

Forestry Canada, perhaps through the next FRDA Agreement, will be considering a technology transfer program which is aimed at mill efficiency and added value. As supply gets tighter through land alienation, fire, insects and disease and environmental constraints industry must consider increased utilization, development of new products and improved processing. We will address these issues in future programs. Using the current FRDA, Forestry Canada has expanded lands traditionally in forestry by funding reforestation activities on Indian reserves, and on private lands. In future programs, we hope to focus on under-utilized resources in B.C., such as hardwoods, decadent cedar and hemlock, salvage wood, wood from commercial thinning, etc.

The B.C. forest industry has maintained its competitive position largely
by practicing cost reduction and productivity improvement. Reduced timber supply threatens that method of maintaining productivity. Future profits will have to come from producing a higher value product and from technological improvements in conversion processes that emphasize higher recovery rather than increased throughput. Sawmills with low recovery factors will increasingly find no place in our industry where supply is virtually 100% committed. It is not right for the public purse to allocate scarce funds to increase yield at the planting stage, if some operations are still not maximizing utilization at the milling stage. If we are going to look at good forest management, security of supply activities have to be intensified all the way from seed to sale.

With that I am sure you are very anxious to here about new flexible saw guides, camera scanners, and moisture sorting and all the other good things you will hear about today. Every good wish for a very productive seminar here, and I thank you for this opportunity to be able to address a few opening remarks to you. Thank you.
MOISTURE SORTING

by

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This discussion will focus on mill results which deal with moisture distributions and their importance. Sorting green lumber into moisture content (MC) classes before kiln drying is an essential ingredient in improving lumber grade, reducing drying time and energy costs and increasing kiln capacity. In order to sort by moisture content, data on MC distribution must be available to make the following decisions:

1) To determine the drying rates of the species mix.
2) To establish cut off points if there is an on-line moisture meter.
3) To provide data relating drying rates of a mixed kiln charge to determine which species is not meeting MC standard when dried to 16%.

In this study 4 sites were sampled, to show the effect of the natural resource on the types of moisture distribution:

1) Finlay Forest Products (MacKenzie)
2) The Pas Lumber (Prince George)
3) Westar (Castlegar)
4) Blue Ridge (Whitecourt, Alberta)

Specimens were wrapped in plastic and sent to the laboratory for analysis.
From each board, two samples were cut, weighed in green condition and then ovendried. Moisture contents were calculated and frequency distributions plotted. Species identification of each specimen was performed using a light microscope.

RESULTS AND DISCUSSION

Site 1. Finlay Forest Products (MacKenzie, B.C.)

Samples from the site consisted of SPF mix. Each specimen was identified in the mix for moisture content and species. The MC ranges from 25% to 225%, yet the average is 68%. The quantity of pine, spruce and fir were 16%, 39% and 45% respectively.

The samples were separated into 2 kiln charges, below 45% MC (A) and above 45% MC (B). The two charges were dried to 16%. The kiln drying times were 19 and 38 hours.

The kiln charge which was under 45% MC consisted of 11% pine, 71% spruce and 17% alpine fir. Charge B (over 45% MC) contained 18% pine, 10% spruce and 62% alpine fir. The perception commonly held that all alpine fir boards have a high moisture content is false because kiln charge (A) contained 17% alpine fir under 45% moisture content.

Each board was weighed after kiln drying to calculate the oven dried MC.
The results showed that the percentage of wets in charge A and B was 6% and 8% respectively. This preliminary result showed that alpine fir can be dried with spruce and pine, if the 3 species are sorted according to moisture content class. The economic savings to many mills can be substantial because alpine fir logs are sorted, stored, and processed separately.

Site 2. Blue Ridge (Whitecourt Alberta)

The average moisture content of the SPF mix is 54%. Spruce which is considered to be the species with the lowest MC is showing samples with 115% MC. The average MC of the pine in this mix was 78%. The average for alpine fir was 97%. These two moisture distributions show that both pine and alpine fir contain a large percentage of wet wood. The wet pine in the mix did not meet moisture content standards. When these two SPF sites are compared, one can clearly see that not only the average MC varies but also the percentage of pine, spruce and fir in the kiln charges.

Site 3. The Pas Lumber Co. (Prince George)

The samples from this site were Alpine fir which is processed separately at this mill. The logs are stored up to 3 months before they are sawn into lumber. The average MC for the first series studied (Figure 1) was 65% and for the second series which was sampled one month later (Figure 2)
was 60%. The minimum average MC for alpine fir in the Prince George area is 55% (Figure 3) and the maximum 65%. The initial moisture content for alpine fir differs from one location to another.

Site 4. Westar Timber (Castlegar, B.C.)

Westar Timber has increased its production of interior hemlock and very little data is available on the initial moisture content which is an important factor in the kiln drying process (Figure 4). Figure 5 shows the frequency distributions of the overall samples for Douglas Fir/Larch. These samples were then broken down into various dimensions: 2x4, 2x6, 2x8, 2x10 and 2x12 (Figures 6-10). The specimen cut from 2x10 had the lowest initial MC. The reason for this is that the 2x4 boards are cut from smaller diameter logs and consist mostly of sapwood while the 2x10 is cut from larger diameter logs which is mostly heartwood.

The moisture distributions from these sites provide good examples of the importance which should be placed on knowing the characteristics of the natural resources. An intimate knowledge of this aspect will lead to better moisture sorting, efficient drying, minimize degrade, and cut down planer downtime.

Examples where Forintek has installed laboratory models of the moisture sensor for sorting are:
a) Weldwood of Canada (Williams Lake): The first mill trial was conducted at this plant and showed that the economic benefit derived through sorting was $8.50 per thousand board feet. This figure was calculated by the plant and is a very conservative one. This mill used about 35% as a cutoff point for sorting.

b) West Fraser Mill (Williams Lake): This plant sorted above 20% and below 20% MC. The lumber under 20% was planed and was not kiln dried. A saving of $17.00 per thousand was realized at this plant.

c) Westar (Castlegar): Douglas fir/larch mix was sorted at this plant and the cut off point was above 45% MC and below 45% MC. An economic saving of $20.00 per thousand board feet was realized at this plant. This included grade, energy saving, planer downtime, and a saving in kiln drying time.
FIGURE 1  Balsam/Fir Moisture Content Distribution (1" x 2" x 4")
FIGURE 2  Balsam/Fir Moisture Content Distribution  (1" x 2" x 6")
THE PAS LUMBER

AVG MC = 55.48%
TOT PC = 24

FIGURE 3  Balsam/Fir Moisture Content Distribution (1" x 2" x 8")
FIGURE 4  Interior Hemlock Moisture Distribution
FIGURE 5  Moisture Content Distribution (Douglas-fir & Larch)
FIGURE 6  Moisture Content Distribution (2" x 4")
FIGURE 7  Moisture Content Distribution (2" x 6")

AVG MC: 48.03%
TOT PC: 52
FIGURE 8  Moisture Content Distribution (2" x 8")

WESTAR TIMBER LTD.

AVG MC: 45.39%
TOT PC: 60
FIGURE 9  Moisture Content Distribution (2" x 10")

WESTAR TIMBER LTD.

AVG MC: 42.97%
TOT PC: 55
FIGURE 10  Moisture Content Distribution (2" x 12")

WESTAR TIMBER LTD.

AVG MC: 49.16%
TOT PC: 43
BENEFITS OF MOISTURE SORTING

By
C. Fancy

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BENEFITS OF MOISTURE SORTING

by

Chris Fancy

My presentation today will focus on the benefits of moisture sorting lumber. I will start with an overview of our system, present some moisture content data which will include some of Forintek's information as well as our in-house information, and then follow by discussing opportunities offered by moisture sorting.

Our mill produces approximately 200 million board feet a year of Spruce-Pine-Fir (SPF), Douglas-fir and Hemlock. The SPF and Douglas-fir each constitute about 35% of our log mix, and Hemlock makes up the remaining 30%. The SPF species group has 25% Alpine Fir.

Our sorting system is located downstream from the Chip-N-Saw line, between the trimmers and bin sorters. The line speed underneath the scan zone is between 180 - 225 feet per minute which is equivalent to 60-75 lugs per minute. The bin sorter has 45 bins and we have dedicated 10 bins for wet wood sorts. Five of these bins are for 2X4's of varying lengths, and the other 5 bins are for 2X6's. The wet-sorted lumber is dried separately in one of four gas-fired, computer-controlled kilns, each of which has a capacity of 300 thousand board feet.

Figure 1 shows a general view of the sorting system. The moisture sensor
system supplied by Forintek is the aluminum square frame in the middle. The catwalk on the right was used during start-up for making installation adjustments. This is a side view of the system, showing the lumber flowing from left to right. The lumber first passes underneath the two heaters, and then passes underneath three temperature sensors which are attached to the right side of the aluminum frame.

The large steel frame system shown in Figure 2 provides protection for the two radiant heaters which are fragile. Without this protection, they can be bumped by bowed wood and short-circuit. The two heating elements, located between the protective frame, run parallel to the lumber flow. They are set 2 inches above the lumber on the line. The protective frame is set 1 inch above the lumber. The two temperature sensors shown on the right in Figure 3 are lined up with the heaters directly in front of them; the temperature sensor on the left is aimed at the unheated area of a board. Figure 4 provides a close-up view of a temperature sensor lined up with a heater on the right, and the cold reference sensor on the left. The operating principle for determining the moisture content is based on the difference in temperature between the heated zone and the unheated zone. Wet wood heats up at a slower rate than dry wood and thus the difference between an unheated zone on the left, and the heated zone on the right, is very small if the wood is wet; and conversely very large if the piece is dry. Sorting is performed using the measured difference in temperature.

Figure 5 shows the computer system supplied by Forintek. On the bottom is the PC which has the operating program. Immediately above the PC is the
communications interface which takes signals from the three temperature sensors. The computer processes these signals and determines moisture content using criteria that is based on Forintek's moisture content distribution work.

A close view of the display on the monitor in Figure 6 shows a column with the word "Bell" appearing on several lines. The word "Bell" indicates that a board does not meet the minimum moisture requirement to be considered dry. Thus, it is sorted out as wet. We have a high percentage of wets but not for all widths. Forintek's research shows that the wettest boards are predominantly 2x4s and 2x6's, so we don't sort the wider sizes by moisture content.

The Programmable Logic Controller, or PLC, is shown in Figure 7. It takes the signal provided by the Forintek system along with information from our size measuring system (Figure 8) and makes the sort decision. Once the PLC has all this data, it compares it against what we have defined as valid sorts. Valid sorts are defined by using the PLC input panel shown here in Figure 9. The PLC is set up so that we can pick any length, width, and thickness combination and define it as a wet sort or a dry sort.

If a 2x4 or 2x6 board is wet, the PLC issues a signal to the end-spray system (Figure 10) down-stream from the measuring system. The board is then sorted into the correct bin. Figure 11 shows the end result: on the right, the painted, wet-sorted boards; and on the left, the unpainted dry-sorted boards.
The Forintek system started up without a flaw. Forintek has to be commended for its program which works very well.

The flow chart in Figure 12 shows the flow of information between the components of the moisture system. Data from the temperature sensors are fed to the Forintek PC. The wet or dry signal is fed from the Forintek system to the PLC, which also collects the length, width, and thickness data. A highlight of this system is that the PCL automatically shuts the heater off after 30 seconds if the line is not moving. This innovation is credited to Bob Williams, our Electrical Supervisor, and his crew. This feature eliminates ignition problems with lumber kept under the heat source for a long period of time. The PLC keeps checking to see if the line is moving and once it is moving again the heaters go back on. The PLC then checks if the heaters are active because they could be down due to a short circuit. If the heaters are inoperative, all the wood that would have otherwise have been found wet would be sorted into what we call Species One sort designation - the default sort designation which is redefined as a dry sort designation when the moisture system is in service. If the PLC has received a wet signal from the Forintek PC, the piece would continue to its wet sort bin down the sorter, while dry pieces would drop into a dry sort bin. The wet wood is given a Species Two destination. Before sorting to this designation, the PCL asks if the board's length, width, and thickness measurements are defined as a valid sort. The reason for this is that the "wet" wood must be a 2X4, or 2X6 to be valid. If it doesn't pass that test, (its a 2X8, 10 or 12) it will go
through the default species One sorts.

Finally, the PLC will check that a wet sort bin is available. If yes, a signal will be sent to the solenoid spray before being sorted; if no, the board will be routed to a species One bin.

Next we will look at initial moisture content data. Figure 13 was extracted from Forintek’s data. Hemlock and Douglas-fir data are graphed together so they can be compared. Hemlock presents more drying problems because of the very broad initial moisture distribution; while D-fir, which shows a tight distribution, dries very well. Drying time for Hemlock was 44 hours versus 34 hours for Douglas-fir. SPF has a drying time of around 39 hours which falls between that of D-fir and Hemlock. Given the 25% Alpine Fir in our SPF, its moisture distribution is going to look very similar to that of Hemlock. But we expect, as was pointed out in the previous talk, that the wet sort will not be limited strictly to Alpine Fir—Pine and Spruce will produce wets also.

Now we will consider the kiln-dried moisture distribution data that was collected in our mill by our planer Quality Supervisor for 2x4s, and 2x6’s. Table 1 shows the moisture content data for both sorted and unsorted material. You can see that the Douglas-fir has an average moisture content of 13.5%, and a very low wet percent. Hemlock, on the other hand, has a high component over 19% for 2x4s and to some extent for 2x6’s.
Table 2 shows sorted material. On the graph for Hemlock (Figure 14) the wet sort is the line with box points and it is compared to the common dry sort, with cross points. The common dry sort is taken on the line from which the wet material is sorted plus the unsorted material from the second lumber sorter. The distributions are very similar. The little bumps in the graph are attributable to common dry stock. Looking just at this data we can see that there is an advantage to using the moisture system, and reducing the 19% or greater component.

Drying times for these two sorts - the wet sort and the common/dry sort, were very similar - both averaged 44 hours. But the difference becomes very clear when the over 19% component is considered. The dry sort had 17.1% of its pieces with over 19% MC, versus 5.8% for the wet sort.

Now we will move on to discuss the opportunities that exist with moisture sorting. The Forintek system is very capable of differentiating between wet wood and dry wood, and it is flexible enough to suit different needs in terms of species, sawmill parameters and kiln characteristics. Controlled moisture distribution is an obvious benefit, because keeping the 19% and over content down has a positive impact on the customer. High over content results in claims and lost customers.

One of the tangible benefits of moisture sorting is reduced planer downtime. Right now we have about 40 minutes of downtime per 16 hours of operation that is due to drying defects. That downtime alone is worth about $117,000 so gains can obviously be made there. Energy saving in the
kilns is another benefit. Fuel costs for our gas-fired kilns are about $75,000 a month. If we achieve a 10% reduction in drying time by sorting out pure dries and running that dry stock through the planer, savings at the kiln would equate to about $23,000 a year. Similarly a 20% reduction would be worth $68,000 a year.

We previously sorted out our small Alpine Fir, 16 inch and under, from the Spruce and Pine out in the woods. Since we installed the moisture sorter system we have stopped sorting our logs and at a conservative estimate that should save about $60,000 a year. We have not yet quantified the grade outturn, but if we make a one point improvement from a No. 3 to a No. 2 and better, it will be worth about $120,000 annually.

In summary, potential gains on an annual basis, can range from $60,000 to $240,000, on the conservative side, and possibly up to $500,000. These potential benefits make a very short pay back period for the commercial moisture sorter which costs around $85,000.
FIGURE 1  General view of sorting system
FIGURE 2  Protective frame
FIGURE 3  Temperature sensors
FIGURE 4  Close-up view of temperature sensors
FIGURE 5  Forintek computer system
FIGURE 6  Monitor display
FIGURE 7  Programmable logic controller (PLC)
FIGURE 8  Size measuring system
FIGURE 9 PLC input panel
FIGURE 10 End spray system
FIGURE 11 Sorted lumber
FLOW OF INFORMATION

TEMPERATURE SENSORS (3)

FORINTEK PC

WET/DRY SIGNAL

LENGTH DATA WIDTH DATA* THICKNESS DATA *(encoder data)

PLC

IS LINE MOVING?

NO

SHUT HEATERS OFF AFTER 30 SECONDS

YES

HEATERS ACTIVE?

NO

SPECIES 1 SORT DESIGNATION

YES

IS $dT < dT$ MIN?

NO

DRY SORT BINS

YES

SPECIES 2 SORT DESIGNATION

ARE L, W, & T VALID?

NO

IS A SORT AVAILABLE?

YES

Solenoid spray signal

WET SORT BINS

UPDATE TALLY

FIGURE 12 Logic diagram
GREEN MOISTURE DISTRIBUTION
D. FIR & HEMLOCK - ALL WIDTHS

FIGURE 13 Green moisture distribution
K.D. MOISTURE DIST’N: 2x4 + 2x6

HEMLOCK

FIGURE 14 Moisture distribution for kiln-dried wet and dry sort hemlock
### TABLE 1

**SORTED AND UNSORTED KILN-DRIED LUMBER**

**MOISTURE CONTENT SUMMARY**

<table>
<thead>
<tr>
<th>SPECIES</th>
<th>SIZE</th>
<th>AVG. M.C.</th>
<th>OVER 19%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>KFIR</td>
<td>2 x 4</td>
<td>13.6</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>2 x 6</td>
<td>13.5</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>COMBINED</td>
<td>13.5</td>
<td>0.8</td>
</tr>
<tr>
<td>HEMLOCK</td>
<td>2 x 4</td>
<td>15.2</td>
<td>12.6</td>
</tr>
<tr>
<td></td>
<td>2 x 6</td>
<td>13.3</td>
<td>4.8</td>
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<tr>
<td></td>
<td>COMBINED</td>
<td>14.5</td>
<td>9.6</td>
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</tbody>
</table>

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TABLE 2

SORTED KILN-DRIED HEMLOCK
MOISTURE CONTENT SUMMARY

<table>
<thead>
<tr>
<th>SORT TYPE</th>
<th>AVG. M.C. (%)</th>
<th>OVER 19% (%)</th>
<th>AVG. DRYING TIME (HRS)</th>
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<tr>
<td>WET</td>
<td>13.8</td>
<td>5.8</td>
<td>43.6</td>
</tr>
<tr>
<td>COMMON</td>
<td>15.4</td>
<td>17.1 (1)</td>
<td>44.3</td>
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CAMERA SCANNERS FOR COMPUTER

OPTIMIZED BUCKING SYSTEMS

By

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CAMERA SCANNERS FOR COMPUTER OPTIMIZED BUCKING SYSTEMS

by

D.R. Giles

1. COMPUTER OPTIMIZED BUCKING SYSTEM

Computer Optimized Bucking (COB) systems have been used for many years to help sawmill operators improve profitability by bucking the stems into the best combination of sawlogs. Steve Wang and I commenced our studies of COB systems about three years ago by looking at the performance of longitudinal light curtain and transverse photo cell scanning systems. Recently I have been evaluating camera scanners systems which have been installed at three member mills.

First, let's review the recommendations, from our initial studies, to improve successful implementation of computer optimized bucking systems in your sawmills. These recommendations (Wang and Giles, 1987) are:

1.1 Debark log before bucking, unless scanner can accurately measure underbark log diameter

Scanning logs with bark intact means that the optimization process must include average bark thickness factors to calculate inside bark diameter measurements. Bark thickness varies with species, diameter, tree age, and distance up the stem from the butt. In addition, systems are not capable
of ignoring bark correction factors at points along the stem where the bark may have been removed during logging or transportation. These variables make it difficult to determine the underbark log diameters which, of course, are required for calculating the lumber recovery from each sawlog segment.

1.2 Diameter and sweep scanning be accurate to 0.4 centimetres or better

The importance of accuracy of diameter and sweep estimates varies with whether the scanning system has one- or two-axis scanning. Our recommendations were the accuracy level be near 0.4 cm for two-way scanning and 0.6 cm for one-way scanning.

1.3 Diameter and sweep be scanned in two perpendicular planes

Two perpendicular scans of the log are desirable, but most two-axis systems have scanning angles between 60 and 75 degrees, theoretically sufficient for accurate optimization.

1.4 Length be accurate to 2 centimetres

Length accuracy is also important since, if the system cannot determine the correct length of the long stem, the bucking solution cannot be optimal. Most systems are designed to have length accuracies within 2 cm, but our studies have shown that length estimates are not always that good.
1.5 Logs do not bounce, slide, roll or slip while being scanned

This point is particularly important in systems where the log travels through the scan zone. One system we studied showed that the log top diameter estimates were not even close to the field-measured diameters. I attributed the error to the fact that the stem top was not lying on the conveyor but was vibrating in the air as it was being scanned. The vibrating movement of the stem may be much faster than the calculated speed of the conveyor belt on which scanning accuracy has been determined. The important point is to try to reduce log movement during the scanning cycle and, of course, that is one advantage of camera scanning system design.

1.6 Nominal two-foot saw spacing be used for transverse bucking systems

Simulation studies of the transverse bucking system we studied showed that decreasing inter-saw spacing from four- to two-feet improved the value recovery of bucking solutions by one percent. If a full compliment of saws is not planned, a variable bumper to add flexibility to the butt log solution would be an alternative improvement.

1.7 Optimization program be able to achieve optimum solutions quickly

Any COB system you install should be able to calculate the optimum solution in time for the operator to view and complete the sawing solution without delay to the mill production flow.
1.8 Hardware be capable of operating in adverse mill conditions

Although the computer hardware may be built for 'industrial' installation, make sure the computer room is isolated from as much vibration and dust as possible. I have seen extremes in computer environments in the last year - very clean, self-contained, air-conditioned computer facilities and a setup where the computer was located in the operator's booth, right over the saw equipment with all the vibrations and dust associated with the operation. How the computer continued to function, in this latter design, was a mystery.

1.9 Self-diagnostic capability be built-in for the computer and scanning systems

Systems come equipped with a variety of reporting and diagnostic features. The ability to quickly determine the operating status, and detect system failures and other problems before too much time and profit are lost to non-optimal bucking decisions would be an important advantage.

1.10 Lumber output for log segments be determined accurately and classified by diameter, sweep, taper and length

Make sure that the algorithms accurately simulate the log breakdown process and recovery obtained in the mill. Small recovery tests can help determine the accuracy of the optimization program in the COB system.
1.11 Butt ends be manually squared before scanning or be optimally squared by the scanning system

Improper bucking in the woods should be corrected so that the butt log length is sufficient for full length lumber recovery. Some systems incorporate the use of a mechanical bumper which will allow adjustment to the location of the stem end relative to the sawlines, thereby correcting poor bucking practices in the woods. Another advantage of a bumper is that the scanning system location of the log end is known which should improve the accuracy of length estimates.

1.12 Lumber prices and operating costs be specified accurately

Operating costs and lumber prices are used to determine the value of each possible log segment. Shorter logs will result in increased downstream costs because of the increase in piece counts. Often the price table is manipulated to control the length distribution of sawlogs, but this can lead to unrealistic lumber prices over time, which will produce sub-optimal bucking solutions.

1.13 Log trim allowance be reduced to near the minimum required

Many sawmills use a 4-inch trim allowance at the bucking station. We
measured the actual bucking accuracy at one mill and found a consistent 4-inch trim. We recommended that they reduce their trim to 2.5 to 3 inches. Improvement in lumber recovery from this change would come from additional two-foot increments for some bucking solutions and larger top diameters for the sawlogs which would result in the selection of a larger set pattern for some logs.

Those were the recommendations and requirements we identified for achieving maximum performance from COB log bucking in our previous study. I will show you that they still apply for camera scanning technology for computer optimized bucking.

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2. CAMERA SCANNING TECHNOLOGY DESCRIPTION

Camera scanning technology, based on video edge detection, has been developed by Applied Scanning Technology of California (AST 1987). There are three systems installed at Forintek member mills in British Columbia and Alberta. Overhead cameras scan about eight feet along the length of the log, so the required number of cameras can be determined by the overall length of your logs.

The cameras should be mounted on a sturdy framework to minimize the vibrations from the mill operations. The other critical feature of this technology is the lighting. Rows of spot lights are directed towards the edge of the log so the overhead cameras can detect the difference between
the log and the log deck background. The lighting angles are very critical for the cameras to operate efficiently.

The system has built-in self calibration capability which is one of the recommendations from our initial study. It also has computer diagnostic routines that can assist mill management determine how the system is functioning and allow corrections or adjustments if something is wrong.

System interface with the operator controls can range from simple display of the bucking solution at the operator’s control panel to automatic interface with saw positioners, log stops and other controlling devices. A system installed at one sawmill includes complete control of all the bucking hardware except the actual dropping of the two bucking saws (although the system was not yet completely debugged). This system was designed to drop the appropriate log stop to buck the butt log, and position a second travelling cross cut saw at the appropriate distance from the stationary bucking saw. The operator could then activate the drop saws to buck two sawlog lengths at once.

3. SYSTEM OPERATION

Each camera takes a snap shot of the entire field of view and determines the location of the log edges approximately every two inches along the length. The lighting allows the edge of the log to be detected. The scan data is computer analyzed to determine which data points are log and which
are background. The mapping takes about 1.25 seconds for a 60-foot stem, which is very fast.

Using the 'raw' log data, a log modelling process calculates stem parameters by quadratic equations that describe the log as a truncated curve form. These equations are then used to calculate the 'fit' of the log by diameter and shape along its entire length.

Bucking solutions are calculated by use of algorithms and customer entered parameters such as saw kerfs, cutting patterns, product prices and operating costs. The optimization program is customized to simulate individual mills. All bucking combinations are evaluated and the solution generating the highest revenue (or highest recovery) is chosen. The optimum solution is displayed to the operator who can then choose that solution or, alternately, a manual solution if desired.

There are a variety of reports that this system can produce, ranging from 'raw' scan data, log data after the 'fit', a 25 log summary and production summary reports.

4. MILL TEST PROCEDURE

The field procedure to evaluate or test the efficiency of a bucking system involves careful measurement of a sample of long logs, processing them through the bucking system, collecting the bucking data, and then
determining downstream the lumber recovery factor. Alternatively to collecting LRF data, sawing can be simulated using SAWSIM, or some other computer program.

Mill personnel are responsible for setting out the sample of stems. We examine each log, marking points where the shape or diameter changes abruptly, or at least every four feet along the stem. Starting at the large end of the log, the horizontal and vertical sweep is measured with the aid of a laser transit and diameters in both planes are estimated using calipers. This information is collected in a form compatible to that required for the SAWSIM simulation program. Figure 1 shows a sample of the field data collected for each stem.

5. PRELIMINARY RESULTS OF FIELD STUDY

I will show graphs of a few sample stems which compare field collected data with that produced by the camera scanning system for the log shape, diameter and length. The vertical scale of these graphs, which represents stem diameter, is quite exaggerated giving the logs a short, fat appearance. I plotted the scan data for the same points along the stem at which we measured the sweep and diameters.

The first stem (Figure 2) is about 57 feet long. The top graph (a) is what we measured in the field - this is the sweep and diameter as measured in the horizontal plane. The bottom graph (b) is the camera scan data (after
smoothing). I plotted only the points along the stem where we measured the log in the field, but computer information was actually calculated every two inches along the stem.

We took two scans of every log - one under normal operating conditions where the hour glass rollers were moving under the log as it was scanned, and the second when all equipment was stopped. This second scan was activated by the operator. The moving and stopped length estimates for the log were both 53 feet, while the actual length was 56.8 feet. The length estimates were not very accurate but you can see that the scan information for diameter and shape fits quite well.

The bucking solution (Figure 2b) for this log was two 18-foot and a 16 residual (in reality the residual would be 20 feet). Both moving and stopped scans produced the same bucking solution. It may appear obvious from the graph that the first buck should be at 16 feet to incorporate the change in sweep direction. The analysis is incomplete, but a possible explanation may be that curve sawing technology at this mill (which Steve Wang and John Hards will be discussing later) may be capable of handling this amount of sweep - its about 2.2 inches in 18 feet.

Figure 3 shows the field measured data (horizontal view) on top (a), matched with the scan data (b) on the bottom for a second log. The computer fitted data smooths the raw (scanned) data so that all the small jogs and deviations are not reproduced. The length estimates for the moving and stopped scans were 53.3 and 49.3 feet, respectively, compared
with actual length of 50.8 feet - a slight improvement in length accuracy with the stopped scan. The bucking solution also changed (Figure 3b). The optimization process initially identifies severe crook and sweep and bucks those sections - in this case the 8-foot third log. The moving scan bucking solution was 20, 8, 8 and a 16 residual (which would be a 12 in reality). The stopped scan recalculated the solution as 16, 12, 8 and 12. The main difference was therefore in the location of the butt log cut.

Laboratory analysis will determine if there are significant differences in the bucking solutions between the moving and stopped scans as well as the theoretical solutions based on field measured data. We will continue to work with Applied Scanning Technology, the system supplier, to suggest improvements which could be made to the camera scanning technology.

6. SUMMARY

Our studies have indicated that there are several points to consider if you are planning to implement computer optimized bucking with camera scanning, and these continue to be applicable to camera scanning systems.

6.1 Debark before scanning

Lighting of the log is critical for a good scan and experience at these installations shows that color changes caused by surface moisture, missing bark, and tree species increase the difficulty of detecting the edge of
the log.

6.2 Stop the log for scanning

All our field studies show an improvement in length measurement when the logs were stopped for scanning. Analysis of the change in bucking solution will determine if improvements result in significant bucking changes.

6.3 Reduce handling impact of stems before and after scanning

Deck design can decrease log breakage and help improve scanning accuracy by reducing log movement during the scan cycle. Dropping of logs onto conveyors should be avoided. One system design incorporated lift bars which were employed to lower the log gently from the log singulator into the scan zone. This greatly reduced log vibration and log breakage.

6.4 Even-end stem to specified point before scanning

Even-ending the stem before scanning should improve length accuracy by positively identifying the location of one end of the log.

6.5 Involve operational staff for system acceptance

Employee attitude to technological change is very important to the success of installations and reduction of training and debugging phases of implementation. Technology which is viewed suspiciously by incumbent
operators is almost bound for failure or at least costly implementation.

6.6 Lumber prices should compromise between product prices and demand

Bucking software packages usually allow mill management to adjust lumber prices and other variables on which the solutions are based. It becomes very easy to manipulate the product mix to desired lengths (and lumber sizes) by changing individual lumber prices. It is important that these values be checked periodically to ensure their magnitudes have not been skewed in favour of particular lengths or widths. Make sure the price and demand tables are realistic.

6.7 Improved equations to define the end segments of stem profiles

Investigate the type of algorithms used in the optimization process to ensure that the best bucking solutions are obtained. Applied Scanning Technology is planning to improve the equations for fitting the raw data to shape the log by incorporating different quadratic equations for the butt and top sections of the stem. Algorithms are usually proprietary so sawmill testing is recommended to evaluate the efficiency of the software to simulate sawmill performance.
7. REFERENCES


**SAMSIM STEM DATA FORM**

Date: **May 3/69**  Stem Number: **3**

### Spruce

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<th>Diameter Inch</th>
<th>Sweep Inch</th>
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Zero end will be near the fence stop of the bucking station. Log surfaces defined as right (R), left (L), bottom (B), and top (T) as viewed from the zero end of the log.

**FIGURE 1** Field data sheet for diameter and sweep measurements
FIGURE 2  Comparison of measured and scanned diameter and sweep data (stem 1)
FIGURE 3  Comparison of measured and scanned diameter and sweep data (stem #2)
LUMBER INCISING

By
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There is an increasing demand for treated wood in the United States and this represents a significant opportunity for Canadian lumber producers. Unfortunately, our Canadian wood species, particularly spruce-pine-fir (SPF), do not treat easily due to low permeability. This places them at a disadvantage to Southern pine which currently supplies the market. Southern pine is a very permeable species that dries more quickly than our SPF and is easy to treat.

The question is what can we do to our wood to increase its permeability? One simple answer is incising. Not incising as used in the past, but an incising process that is fast, at least 1000 ft/min., which would allow it to be used in-line at a sawmill rather than at a treatment plant; and incising that does not degrade the wood surface, but produces a dense pattern of incisions that are barely visible yet penetrate at least 10 mm. or more into the board.

Forintek has developed a prototype lumber incising machine, that we feel meets these specifications. The design of the machine's incising head comes from Forintek's research on veneer incising and has been patented by Forintek. The incising head is a single steel roll with wedge-shaped teeth machined right in which makes it more durable than
heads with conventional inserted teeth. The head is nickel plated and this, along with the shape of the teeth and the high feedspeed, reduces stripping of the lumber. The head produces denser incision patterns than those made by conventional incisors.

The machine is built to incise green 2" x 4" lumber to a depth of 10-12 mm. along the grain. Since it does not cut the wood fibers, strength loss should be negligible. Tests are being conducted with two incising roll designs. The first provides a density pattern of 9-10,000 incisions/m.

The machine at present, has a single incising roll, however once the optimum roll design is established it will be modified to four rolls, allowing the boards to be incised on all sides in one pass. The machine is easy to transport and once its design is complete it will be made available to members for on-site testing.

Preliminary drying tests with the lower density incising roll indicate a reduction in lumber drying time and a significant improvement in preservative uptake. Tests with the higher density roll are presently underway and the results should be out shortly.
INCISING FOR DRYING

By
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INCISING FOR DRYING

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The objective of using incising as a pretreatment to drying is simply to open up more pathways for water to flow through the wood. By incising, water has less distance to move until it reaches an open space where it can be evaporated. In practical terms what we are really trying to do is to change the drying properties of our species, SPF in particular, closer to those of some competing species such as U.S. Southern Yellow Pine and Australian radiata pine. Wood of these species is extremely permeable and can be dried very rapidly, without degrade at temperatures in excess of 240°F. Drying SPF in these conditions usually produces high levels of degrade that offset any economic benefits resulting from reduced drying times. If we can improve the permeability of SPF, fast drying can likely be achieved with acceptably low levels of degrade.

A number of approaches to increasing permeability for drying have been investigated previously but none has achieved commercial acceptability. Examples include, drilling holes parallel to wide faces in aspen studs, and incising with nails, needles and lasers in a variety of softwood and hardwood species. One of the most serious drawbacks to some of these methods and to incising as is carried out prior to preservative treatment, is that of poor surface appearance that may not be acceptable in the marketplace.
The Forintek incisor has the advantage of producing a very large number of 'holes', but in such a way that appearance is not sacrificed. The tests described below compare drying of matched kiln runs of SPF 2x4x3 ft. lumber where half of the material was incised on four sides with the Forintek high density incisor, while the remainder was unincised controls.

The first shipment of SPF was first sorted according to green moisture content (MC). The high MC group averaged about 87% MC and the low MC group averaged about 44% MC. Following incising of half of the pieces in each MC group, drying was conducted in a small laboratory kiln using conditions of 240°F dry bulb temperature, 160°F wet bulb temperature and an air velocity of 600 ft. per min. through the load. As shown in Figure 1, in both MC groups the incised lumber dried faster than the unincised controls. To a target dry MC of 16%, the reduction in drying time for the high MC group was 20% and for the low MC group was 23%.

The second shipment of SPF that was tested was considerably drier than the first. The procedures used in preparing test loads were as described above. The high MC group averaged about 46% MC while the low MC group averaged about 27% MC. Kiln conditions used were dry bulb temperature 300°F and wet bulb temperature 160°F with an air velocity of 600 ft. per min. through the load. Again, as shown in Figure 2, the incised lumber dried faster than the unincised. To a target MC of 16%, the reduction in drying due to incising was 19% for the high MC group and 52% for the low MC group.
Although degrade could not be adequately evaluated in lumber samples of the length used, surface appearance of incised pieces was excellent with no evidence of fiber pull-out or extension of the incisions into surface checks. Upon completion of a 10-inch wide incising head we will be evaluating the impact of incising on 2x10x8 ft. lumber in terms of both drying rates and dried lumber quality.
FIGURE 1. Drying rate curves for incised and control SPF 2 x 4 lumber (shipment 1).
FIGURE 2: Drying rate curves for incised and control SPF 2 x 4 lumber (Shipment 2)
INCISING/PRESERVATION

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