Advantage

Restricted to FERIC Members and Partners Vol. 4 No. 12 April 2003

Contents

Determining log moisture using time domain reflectometry: case study results

Abstract

Until recently, wood product manufacturers have lacked the appropriate technology to manage log inventories based on moisture content. The conventional oven-drying method cannot generate the required amount of data quickly. The Forest Engineering Research Institute of Canada (FERIC) has proven the effectiveness of time domain reflectometry (TDR) as an on-site, nondestructive method for generating moisture readings in standing or felled wood at any stage in the fibre supply chain. Industry implementation of TDR moisture profiling has potential to improve the cost and quality of manufactured wood products. This report summarizes the results of four case studies that address specific issues related to log moisture monitoring.

Keywords

Time domain reflectometry (TDR), Log moisture content, Log inventory management.

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Introduction

Log moisture content has a significant impact on the efficiency and cost of wood products manufacturing. Pulp mills need chips with sufficient moisture to achieve good fibre strength when pulped. Sawmills want to avoid degrade due to the radial checking that is common in dry logs. Sawmill personnel would also like to control moisture content variability, which can adversely affect kiln drying and result in an inconsistent product. Oriented strand board (OSB) producers require enough moisture to ensure flake quality and minimize fines that can result from flaking dry fibre. However, excessive moisture adds to the cost of flake drying and can contribute to clogged dryers.

Effective log inventory management requires a volume of moisture content data that is impractical to generate using traditional oven-drying methods. To overcome this, in 2000 FERIC modified a soil-moisture analysis technology called time domain reflectometry (TDR) for use as an on-site moisture profiling technique for standing or felled wood at any stage in the fibre supply chain. FERIC demonstrated the capability of TDR for log moisture measurement at Weyerhaeuser Company Limited's Drayton Valley OSB operation (Ewart 2001).

The main advantages of TDR are speed and the determination of average moisture content at any point along the stem's length. Averaging is important because field work has shown that the moisture content variability within each stem can exceed 30%. Unlike the traditional oven-drying method, TDR does not require destruction of the tree to retrieve a sample or the hours of laboratory time to process it. As many as 50 TDR readings an hour may be generated on site. However, TDR will not work in frozen wood.

Objectives

Since the initial TDR trial with Weyerhaeuser in 2000, FERIC has conducted four more case studies with members to address specific issues related to log moisture monitoring. The objectives of this report are to:

- Summarize the results of the four case studies.
- Suggest ways that TDR moisture profiling could be applied in the future for more effective log inventory management.

Figure 1. Environmental Sensors' model MP-917 moisture measuring instrument.

Figure 2. Dual-head drill attachment.

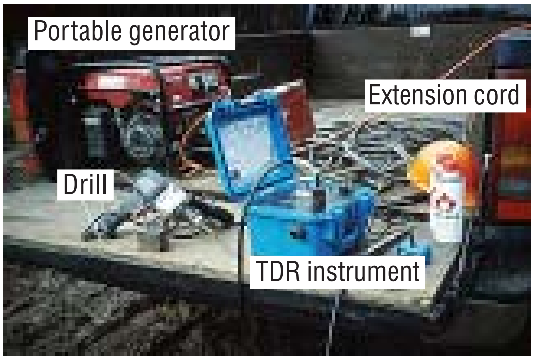

Figure 3. Required field equipment.

TDR equipment description

Figure 1 illustrates the TDR apparatus used in the case studies. The model MP-917 instrument was manufactured and supplied by Environmental Sensors Inc. of Victoria, B.C. A two-prong, 15-cm-long probe is inserted into 6-mm-diameter holes that are drilled radially into the stem; a dual-head drill attachment ensures the holes are parallel and spaced correctly (Figure 2). Pressing a button on the instrument panel initiates a signal down the probe; and the dry-basis moisture content[1] is displayed on the readout after 20 seconds.

In addition to the instrument and drilling equipment, field sampling requires a portable generator to power the drill and 100 m of power cable to reach the standing timber (Figure 3).

Case studies

Each of the four case studies spanned several months and addressed log moisture

[1] The moisture content of wood is expressed as either the weight of water divided by the weight of dry fibre (dry base) or the weight of water divided by the weight of dry fibre plus the weight of water (wet base). This report shows moisture content in dry base, as recorded by the TDR equipment. The conversion of dry base (Wd) to wet base (Ww) moisture content is as follows:

$$Ww = Wd/(1+Wd)$$

For example, 90% dry base moisture content is 0.9/(1+0.9) = 47% wet base moisture content.

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ISSN 1493-3381

changes resulting from differences in region, climate, and inventory management strategies. In most instances, sample sizes exceeded 20 readings. Rotten material was indicated by the ease of drilling and was excluded from the samples.

Case 1: Louisiana-Pacific Canada Ltd.

Louisiana-Pacific Canada Ltd. wanted to eliminate plugging of two, triple-pass dryers at its OSB operation in Dawson Creek, B.C. This condition was believed to be caused by precipitation of heavy, wet balsam poplar flakes at the points of flow reversal. Mill personnel felt the condition was controllable by sufficient inclusion of drier aspen. This problem was less recurrent in its single-pass dryer. Louisiana-Pacific asked FERIC to collect TDR data on moisture variability to help determine the appropriate species blends for improved dryer operation.

Samples were taken from both standing trees and from felled wood decked at roadside. Standing wood was measured only at breast height (Figure 4). However, readings on short logs were taken at either end and at the centre of the log (Figure 5). Some longer stems were measured at four or five places.

Readings taken in June and September 2001 showed a 12% decrease in the average moisture content for standing aspen, from 93 to 81%. There was a 34% decrease for standing balsam poplar, from 146 to 112%. In each study, there was little difference between the average moisture content for standing and decked wood within each species.

The September survey targeted aspen wood decked on July 26 and on August 31, and balsam poplar wood decked earlier in the year on January 11. The inventories for both aspen and balsam poplar were 15% drier than in June. However, the log ends averaged 7% drier than the centres for the aspen decked for the longer period. This indicates a pattern of drying that had not yet developed in the more recently decked aspen. This pattern was evident to a lesser degree in the balsam poplar.

Although this was a short study, it demonstrated that moisture monitoring of log inventories could be a management option for increasing the availability of dry wood to alleviate the clogging of flake dryers.

The site- and species-related variability of these data suggests an opportunity to classify incoming logs based on moisture content. Also, it may be prudent to leave a wider space between log decks to allow air circulation and sun exposure to dry the log ends. The evidence of seasonal variability indicates an advantage in procuring balsam poplar during the late summer and fall. Although wood harvested in the summer will be drier, immediate processing will eliminate any opportunity for atmospheric drying in inventory. Nevertheless, there may be a net advantage in processing this wood immediately while allowing the winter-harvested wood to dry through the summer.

Figure 4. Measuring moisture of standing timber at breast height, near Dawson Creek.

Figure 5. The September inventory survey at Dawson Creek.

Case 2: Alberta Plywood Ltd.

The Chisholm fire in northern Alberta covered 116 000 ha in May 2001, including a mixedwood stand southeast of Slave Lake. Alberta Plywood Ltd. asked FERIC to perform a TDR moisture-content profile of the stand to see if it met the minimum moisture requirements of its pulp mill clients.

In July and September 2001, the breast-height moisture content, stem diameter, and species were recorded for 186 standing trees on seven sites representing the variability of elevation, ground moisture, and fire damage (Figure 6). Two of the sites were in undamaged forest.

Sixty percent of the trees were aspen with an average moisture content of 86%. The remaining trees were spruce and had an average moisture content of 42%. The average moisture content found in both species was virtually the same for both surveys. However, moisture was higher in the unburned sites while the burned, dead trees had less moisture. As a result, more spruce fell below the fibre-saturation point (fsp) of 28% in the second survey (Table 1).[2]

Figure 6. Measuring standing burned wood south of Slave Lake.

Case 3: Vanderwell Contractors (1971) Ltd.

Vanderwell Contractors (1971) Ltd. asked FERIC to investigate the potential for sawlog moisture monitoring using TDR, to predict when moisture depletion causes significant radial checking that can result in lumber degrade. Wood shrinkage and radial checking begin when wood moisture drops below the fsp. The objective was to identify a correlation between moisture content and radial checking.

In May 2002, FERIC numbered 155 short, freshly felled logs at Slave Lake and took TDR moisture readings at both ends and in the middle. The logs were then piled to simulate decked inventory. These results were compared with re-measurements made the following September.

In September, the short logs were classified into three groups according to the degree of radial checking:

- Class 1 indicated little or no checking.
- Class 2 indicated minor checking up to 2 mm wide.
- Class 3 indicated more serious checking, sometimes with a spiral pattern, that could result in lumber degrade.

[2] The fsp is the moisture content at which the cell walls are saturated. Shrinkage and swelling can occur as a result of moisture changes below the fsp (Quarles n.d.)

Table 1. Moisture class distribution

	Percent of samples with a greater moisture content than:											
	20%		24%		28% (fsp)		32%		36%		40%	
Species	July 24–27 (%)	Sept. 18–21 (%)	July 24–27 (%)	Sept. 18–21 (%)	July 24–27 (%)	Sept. 18–21 (%)	July 24–27 (%)	Sept. 18–21 (%)	July 24–27 (%)	Sept. 18–21 (%)	July 24–27 (%)	Sept. 18–21 (%)
Aspen	100	100	100	100	100	99	99	99	99	99	98	99
Spruce	100	100	100	84	100	82	80	71	64	64	54	54
Overall	100	100	100	95	100	93	93	90	88	88	83	84

A moisture-based inventory management system was assumed to recognize a minimum threshold that would define acceptable sawlogs. The September average moisture content for each log was used to classify the log according to a series of test thresholds. The results were then examined to determine which threshold value provided the best agreement with the radial checking classifications.

There was a 16-percentage-point drop in the overall average from 54% in May to 38% in September. A minimum threshold value of 25% provided the best agreement between log acceptance and the results of the checking classification. Logs measuring above this threshold included 95% of the acceptable Class 1 and 2 logs. However, logs measuring below this threshold included only 40% of the reject Class 3 logs.

The method of classifying radial checking was subjective and the Class 3 designation may have been applied to some sawlogs that could convert to lumber with no degrade. The agreement level for the reject logs may have been higher if the Class 1 and 2 definitions were more inclusive and if fewer logs were designated as Class 3.

Further drying of the test logs will amplify radial checking which should give better definition to the reject classification. Also, the moisture content of reject logs should become less variable as it approaches zero. Better definition and less moisture variability, and possibly a lower minimum threshold value, may result in a more consistent and realistic moisture-based identification of reject logs. Therefore, a repeat assessment of the test logs is planned for the summer of 2003.

In September, FERIC also did some minor profiling of Vanderwell's inventory that revealed drying trends similar to those found at Dawson Creek. The opportunity was also taken to survey burned stands from the House River fire north of Lac La Biche, Alberta. All but three of the 168 trees measured were above the fsp, suggesting that they had not dried much in the four months since the fire and that they still met the pulp mill's minimum moisture requirements. Moisture conservation was likely attributable to the light damage and undisturbed condition of the bark on most of the trees.

Case 4: Tembec Industries Inc.

Tembec Industries Inc.'s Forest Resource Management group in Cranbrook, B.C. asked FERIC to measure the loss of moisture in standing burned trees north of Cranbrook. As with the Vanderwell study, the objective was to develop a correlation between moisture content and the onset and progression of radial checking. Two field evaluations were conducted, the first one year after the fire (which occurred in May 2001), and the second five months later. Sixty-seven trees on four sites were identified and sampled on both occasions. Six species of trees were included in the sampling: Douglas-fir, western larch, subalpine fir, western red cedar, lodgepole pine, and Engelmann spruce.

The overall average moisture content dropped from 50% in June to 36% in October. This pattern was consistent over the four sites. By October, radial checking had occurred in all trees to the point where lumber degrade would occur, except for the Douglas-fir and a single larch.

Although the single larch tree may not have been representative, it showed no loss in moisture. Similarly, the average moisture content reduction of the Douglas-fir was only 4%, possibly attributable to its thick protective bark.

At the other end of the scale, the average losses for subalpine fir and western red cedar were 26% and 23%, respectively. Pine showed the next largest average loss at 17%, then spruce with a loss of 12%.

Trees displaying radial checking in June lost almost twice as much moisture by October as those trees only showing radial checking in October. This demonstrated how the drying rate accelerates as the wood fibre is more exposed with the onset of radial checking.

The data demonstrated a direct correlation between moisture depletion in standing burned stems and the progression of radial checking. This relationship will provide only general, but useful, planning guidelines for harvesting fire-killed stands. The data suggest that, for the best recovery, harvesting of burned wood should begin as soon as possible following a fire, with priority given to stands of thinner barked species.

Conclusions

Profiling standing trees or decked logs using TDR can be a cost-effective alternative to oven drying methods of determining wood moisture content. Wood moisture values generated through TDR are available at the time of sampling, rather than 24 hours later as with oven drying. Quick access to moisture data improves the options for log inventory management based on wood freshness or moisture thresholds.

FERIC has applied TDR sampling techniques to assist members overcome challenges concerning material handling issues in OSB production, fibre suitability for pulp conversion, and avoidance of checking defects in lumber production.

Implementation

Although each case study of TDR moisture monitoring techniques was initiated to investigate a specific issue, all attempted to establish some measure of log freshness in a quick and cost-effective way.

TDR technology can be used to measure moisture content in logs in the millyard to facilitate the blending of logs by their moisture properties. This will allow moisture balancing of OSB flakes through the mill's drying system. Managing log flow into OSB mills by moisture content has potential to improve both flake yield and drying costs.

If the moisture content of standing timber killed by recent wildfires or insects can be determined, the harvest planners can target damaged stands with the highest potential values for both pulp and sawlogs and avoid stands that do not meet customer specifications. Sampling standing timber during exceptionally dry periods should also enable inventory management to provide timely manufacturing to achieve the best product possible. Moisture profiling using TDR equipment is a simple and time efficient process for prioritizing harvesting of standing timber.

TDR can be used to determine the best millyard log decking practices to preserve wood freshness and minimize the amount of degraded lumber from radial checking. It can also be used in standing timber to determine the relationship between wood moisture content and the advancement of radial checking in fire-killed trees, and if the rate of checking varies by species.

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Acknowledgements

The author appreciates the cooperation of the staff and management of the following organizations and their expertise, essential to the execution of this study:

- Environmental Sensors Inc., Victoria, B.C.
- Weyerhaeuser Company Limited, Drayton Valley, Alta.
- Louisiana-Pacific Canada Ltd., Dawson Creek, B.C.
- Alberta Plywood Ltd., Slave Lake, Alta.
- Vanderwell Contractors (1971) Ltd., Slave Lake, Alta.
- Tembec Industries Inc., Forest Resource Management, Cranbrook, B.C.