Technology Profile

Value to Wood

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An Evaluation of the Detection Capacity of Automated Defect Detection Systems

Using automation to maximise yield from increasingly rare and costly raw materials is a solution that can help secondary wood producers improve their profitability. By integrating an automated defect detection system, lumber producers can potentially increase production output and grade recovery, helping them to strengthen their strategic business advantage.

To develop a reference tool to assist in the choice of an appropriate defect detection system, Forintek conducted a detection capacity evaluation of commercially available equipment. Nineteen (19) manufacturers who work in the area of defect detection in lumber were contacted; of these, four agreed to participate in the study.

The project objectives were based on requests from the producers: the evaluation focussed on the detection capacity of specific defects and not on the performance of the overall system. Defects were identified and an experimental evaluation was conducted to determine if the equipment recognised the defects or not. A decision tool based on a multi-criteria analysis has been proposed in the completed project report, to help producers identify the most appropriate defect detection system. However, no evaluation can be offered for the overall performance of the systems assessed, as production needs differ from producer to producer.

Defects

Defects are defined as non-tolerated wood characteristics. Acceptance for each defect depends on the end-use of the material: something that is unacceptable for one producer may be useful to another. In order to determine whether a characteristic is acceptable, it is essential that the physical characteristics and location of the defect be identified.

Natural defects differ among species and defects that are caused during processing cannot always be accurately pre-defined. Consistency in the operator's decisions and recognition during display by an automated system are requirements that are not easy to satisfy.

Samples of dried and planed yellow-birch boards were selected for the evaluation. Each board contained one or more defects known to be difficult to detect using automated visual technologies. In Table 1 an "X" marks the presence of defects in each of the 11 sample boards.

Defect Detection Technology

There are an increasing number of manufacturers of defect detection systems. The four manufacturers who participated in the evaluation have developed systems that combine more than one type of vision technology. For each manufacturer, one specific system was evaluated but other versions with different technologies are available.

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Table 1. Defects in each sample board

Defect	Board										
	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
Mineral streak						X					X
Fleck	X						X		X	X	X
Coloration	X	X		X							
Sound knot								X			
Pin knot			X								
Black knot								X			
Bark pocket								X	X		
Curl							X		X		
White speck				X							
Decay								X			
Blue stain					X						
Worm hole				X		X	X				
Cluster of worm holes				X							
Wane		X	X								X
Split		X					X				X
Shake							X				
Through shake	X										
Hit and miss						X					
Mechanical burn						X					

ATB Blank (www.atb-technology.de), located in Roggenburg, Germany, makes the **Spectra** system. It performs a quality control function in three steps: evaluation of color variation, measurement of the thickness of each board, and identification of defects using cameras, a linear laser and a tracheid effect laser, respectively.

COE Manufacturing (www.coemfg.com), located in Salmon Arm, British Columbia, makes the **AddVantage** system. It combines a tracheid effect laser and a profile detection laser.

Innovativ Vision AB (www.ivab.se), located in Linköping, Sweden, makes the **WoodEye** system. It combines a black-and-white camera, color camera, tracheid effect laser and a profile detection laser. Additional vision technologies can be added to detect specific defects such as hit and miss.

LuxScan Technologies (www.luxscan.lu), located in Ehlerange, Luxembourg, makes the **X Scan Combi** system. It uses x-rays, two color cameras, and two LaserScans. The color cameras inspect the edges of the boards while the LaserScans are placed above and below the boards. The LaserScans simultaneously evaluate tracheid effect, red image, infrared image and board geometry.

Results

The objective was to gather data on the location, dimension and nature of defects on boards. Evaluating defect location involved analysing whether each system correctly located the defects on the board. Evaluating defect dimensions allows analysis to determine if the dimensional limits of the defects are accurately seen, while the correct identification of the nature of the defect was evaluated to ensure that the defect was properly recognised by each system.

The evaluation was limited to direct detection which combines the detection of existing defects, and the non-detection of defects that do not exist. Therefore, the two types of possible errors, under- and over-detection, were not analysed.

The information provided from the **Spectra** and **AddVantage** systems was limited to photographic images of boards. This allowed confirmation of the location of defects by locating them schematically. This binary evaluation of detection is in itself a weakness because it groups every defect into a single category.

The information provided from the **WoodEye** and **X Scan Combi** systems included the coordinates of the defect which allowed, in certain cases, the ability to calculate a detection yield. The location and dimensions of the defects were evaluated using only X coordinates that identified the position in reference to the length of the board.

Table 2 summarises the results from the experimental evaluation of the detection capacity of the defect detection systems. The results produced by the **Spectra** and **AddVantage** systems did not allow an evaluation of their ability to identify the dimension and nature of defects, therefore, the corresponding boxes have been crossed out. The results of the evaluation were graded as follows: correct detection, partial detection or no detection.

Conclusion

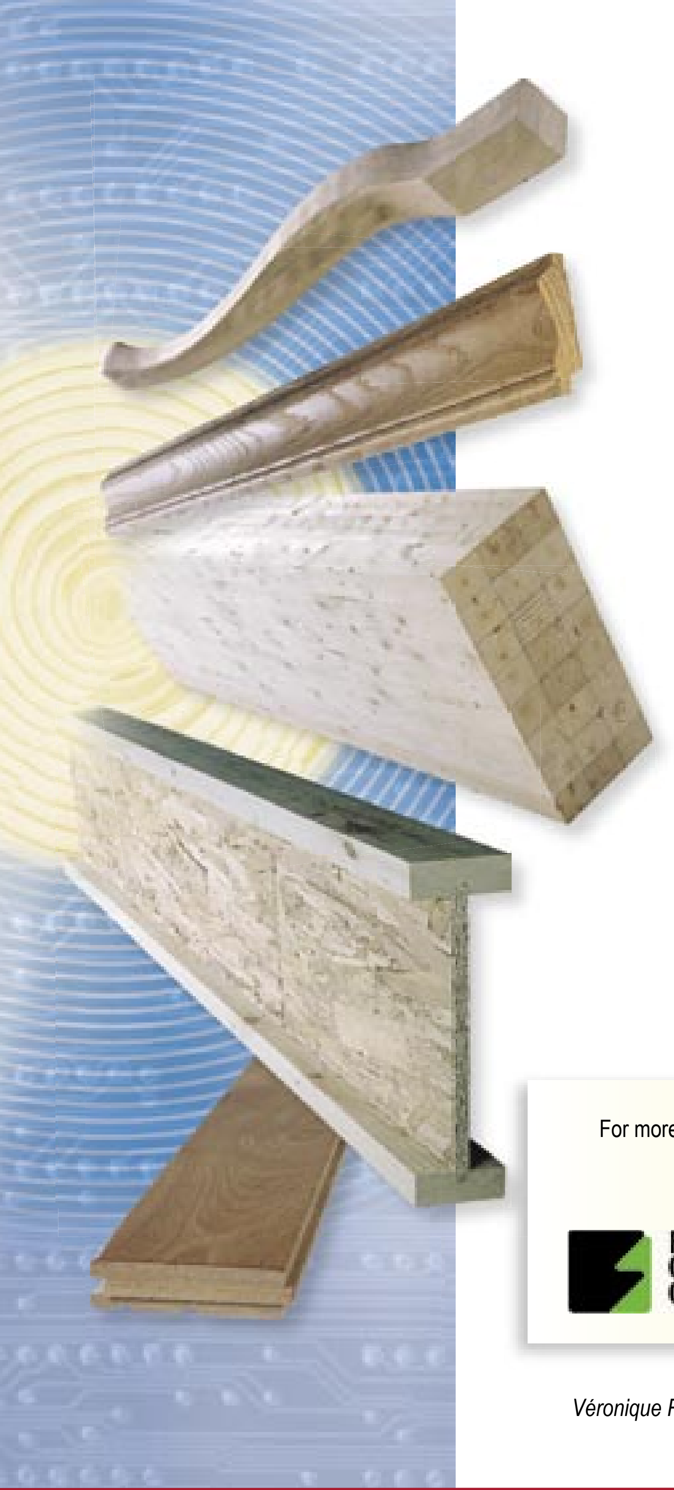
The evaluation of the detection capacity of automated defect detection systems indicated that the systems tested were unable to correctly detect all the defined defects in hardwood.

While this study provides general information on the detection capacity of visual systems, it does not reflect what must be undertaken prior to evaluating a defect detection system prior to installation in a mill. Specific details regarding detection of certain characteristics and regrouping product specifications would allow for the adjustment of system parameters, thus providing better site-specific results.

Table 2. Detection capacity

Defect	Detection	Technology			
		Spectra	AddVantage	WoodEye	X Scan Combi
Mineral streak	location	–	–	+	+
	dimensions	/	/	+	+
	nature	/	/	+	+
Fleck	location	+	+	+	–
	dimensions	/	/	+	–
	nature	/	/	–	–
Coloration	location	+	+	++	+
	dimensions	/	/	++	+
	nature	/	/	++	+
Sound knot	location	++	++	++	++
	dimensions	/	/	++	++
	nature	/	/	++	++
Pin knot (< 3.175 mm)	location	–	–	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–
Black knot	location	–	++	++	++
	dimensions	/	/	++	++
	nature	/	/	++	++
Bark pocket	location	++	++	++	++
	dimensions	/	/	++	++
	nature	/	/	–	–
Curl	location	–	–	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–
White speck	location	–	+	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–
Decay	location	–	–	+	+
	dimensions	/	/	+	+
	nature	/	/	–	–
Blue stain	location	–	–	+	++
	dimensions	/	/	+	++
	nature	/	/	+	–
Worm hole (1.15 mm)	location	+	–	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–
Cluster of worm holes	location	+	+	+	–
	dimensions	/	/	+	–
	nature	/	/	–	–
Wane	location	+	+	+	+
	dimensions	/	/	+	+
	nature	/	/	++	–
Split (0.30 mm and +)	location	+	+	+	+
	dimensions	/	/	+	+
	nature	/	/	++	++
Shake	location	**n.a.**	+	+	–
	dimensions	/	/	+	–
	nature	/	/	+	–
Through shake	location	+	–	+	+
	dimensions	/	/	+	+
	nature	/	/	–	+
Hit and miss	location	+	+	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–
Mechanical burn	location	–	–	–	–
	dimensions	/	/	–	–
	nature	/	/	–	–

Legend: /, not evaluated; **n.a.**, not applicable; **–**, not detected; **+**, partially detected; **++**, correctly detected



Given the cost and complexity of integrating a defect detection system, it is recommended that a structured process for choosing the appropriate equipment be adopted. The following steps aim to help identify the automated system that most appropriately meets the needs of producers and assist them in taking a more active role in evaluating the various options.

1. Assess the situation and identify the need: determine whether automation is truly the right method to use.
2. Set a clear objective. Set measurable benchmarks (for example, reduce labour costs by X per cent, improve material or value yield by X per cent, reduce bad ranking by X per cent, reach a system speed of X m/min, obtain a defect detection efficiency of X per cent).
3. Determine the specific tasks that the system must perform, i.e., which specific defects must be detected.
4. Identify the combination of technologies required to detect the targeted defects.
5. Visit the equipment manufacturers with a clear statement of needs and perform trials.
6. Allocate the resources necessary to justify the investment: human, monetary, time, space, etc.

To speak with your nearest Forintek Industry Advisor about this article, or other ways to improve the performance of your business, call Forintek at the numbers below, or visit us at **www.valuetowood.ca** to find out about upcoming workshops or seminars in your area.

For more information on the 2004-2005 ***Value to Wood*** research program, visit www.valuetowood.ca (Research and Development). The partners involved are:

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*Ce **Profil technologique** est également disponible en français.*

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As part of the ***Value to Wood*** program, funded by Natural Resources Canada, Forintek's Industry Advisors are providing technical services to value-added wood product manufacturers in all regions of Canada. If you need information on any technical issue related to wood product manufacturing, you can:

- Send a request via *valuetowood.ca* (Help Desk).
- Contact a *Value to Wood* co-ordinator at one of the following locations:

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