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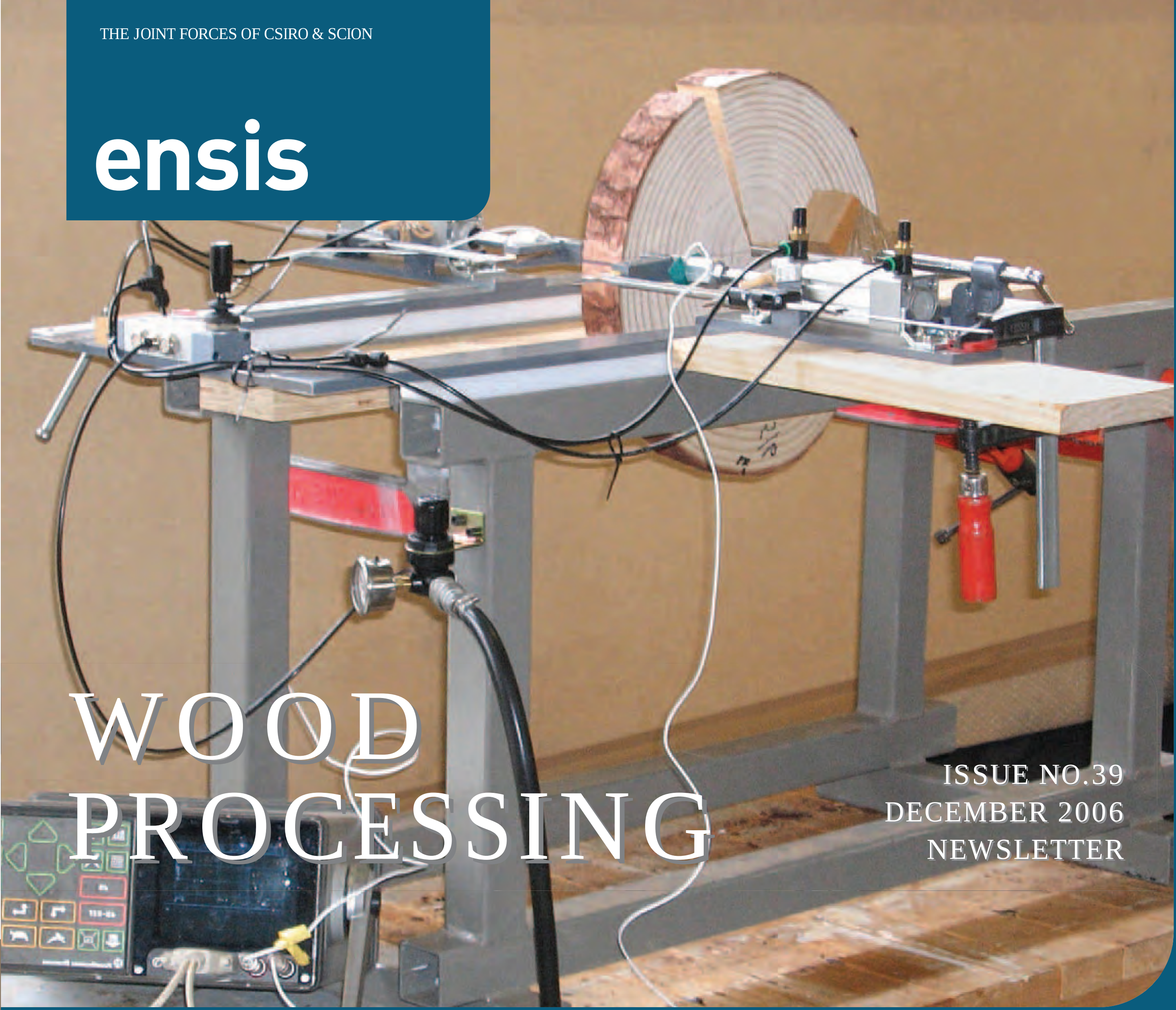

WOOD PROCESSING

ISSUE NO.39
DECEMBER 2006
NEWSLETTER

MAPPING TREE STIFFNESS

BIOENERGY

BORON SPOT TEST

DRY WITH MINIMUM DELAY!

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Sawmilling

Issue No. 39 December 2006

RADAR SCANNING ON GREEN PRUNED LOGS

Richard Parker and John Roper
with Matt Watson of ScanTec Geophysical Consultants

Radar scanning offers the potential to non-destructively collect commercially valuable information about the internal structure of a log. Such information can then be used to make decisions about pruned log grading and cutting. Conventional radar is used to detect objects at a distance such as aircraft and mountains. However, radar can be adapted to detect objects at much closer range, less than 1 m.

Radar relies on the differences in dielectric permittivity of materials being detected. Features inside the log have differing dielectric properties due to their moisture content, physical structure, and chemical composition. The presence of water enables the radar to identify sapwood, heartwood, and knots. In radiata pine, sapwood has 150% (or more) moisture content and heartwood has around 50% moisture content. Fortunately, knotty material forming pruned branch stubs typically gives some dielectric contrast with surrounding sapwood and heartwood, and hence is visible in the scans.

A scanning study was undertaken to determine the ability of radar to reliably identify internal features of pruned radiata pine logs, particularly the occluded knotty core.

Logs were scanned along their length at 10° intervals around the circumference (Fig. 1), resulting in a total of 36 length-wise scans of each log. Scan speed was approximately 10 m/min but, as it was hand driven, it was subject to considerable variation. Distance encoding was also done manually at 1-m intervals with a click device attached to the scanner handle. There was some inaccuracy of distance along the log, as the clicks were performed in real time whilst the scanner was moving. In addition, difficulty was experienced in coping with the surface topography of the logs while scanning, as the surface bumps caused the angle of the scanner head to alter frequently. All these inherent inaccuracies contributed to scan data variability.

Figure 1. Scanning log by hand.

Once scanned, the logs were sawn length-wise into quarters and each quarter was sawn on a specially modified bandsaw into 10° radial segments. The resulting boards were then laid out to match the orientation of the radar scan images created by the radar software. Location of knots and depth of the heartwood / sapwood boundary were recorded for later correlation with radar scanning images.

Interpretation of radar images (Fig. 2) takes experience and significant computer-based image processing.

This initial study found that 36% of the knots of the three test logs were located accurately by the radar. However, the radar registered a further 31% as being in a slightly different location from their actual location. These “offset” knot registrations were most probably the result of manual movement (pitching and yawing) of the radar antenna as it was moving along the surface of the log.

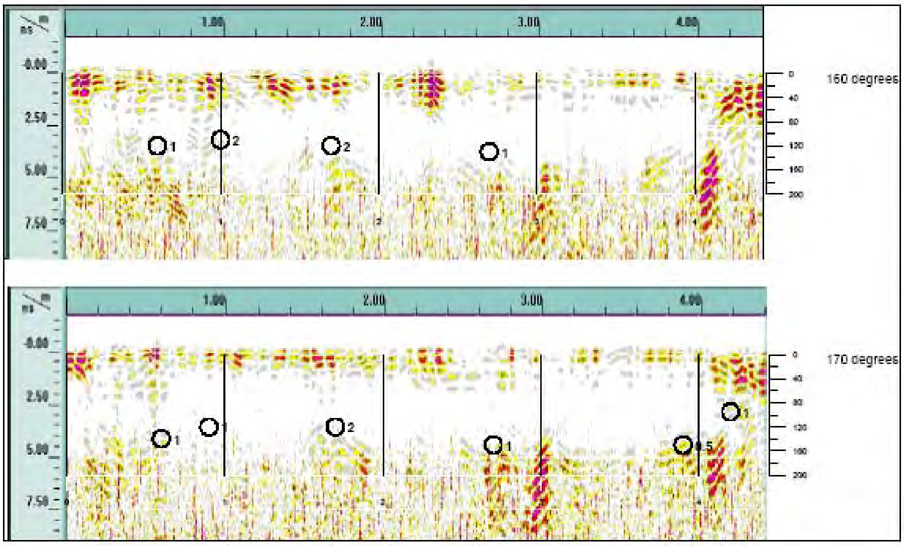


Figure 2. Radar image of the internal structure of a radiata pine log and actual location of knots (marked as circles).

A future study being planned will use a mechanism to keep the antenna steady while it is moving along the log. Also, a rotary encoder will be used to continuously and accurately record the distance along the log. At this stage it is not known why the radar failed to register the remaining 28% of knots. This will be the subject of further research.

The radar was able to locate the longitudinal position of 67% of all occluded knots present in the logs. Such information would be of use for log-bucking of pruned stems where inter-node length is required. Radar, at this stage, cannot determine the depth of occluded knots to the accuracy which is required for sawmilling. For this to occur, more accurate determination of dielectric constant of the wood has to be made to calibrate the scan depth.

Radar scanning of fresh radiata pine logs appears to be a promising technology for locating internal features. The equipment is relatively portable and lightweight, comparatively inexpensive, and has no known health and safety occupational risks associated with its use. The first challenge is to improve the scanning head accuracy for position by employing a rotary encoder, in addition to eliminating yaw and pitch as the head is moved along the log. The second challenge is to improve the human factors of the system by making the signal processing and feature depth detection more easily interpreted by non-specialist users before wider field application to log scanning can be contemplated.

SAWING OVAL LOGS

Christine L. Todoroki,

with Robert A. Monserud and Dean L. Parry of USDA Forest Service,
and Richard Gilbert of Laval University

Over the years dedicated sawmillers have by trial and error determined the most advantageous way to improve recovery from their logs. For swept logs, the "horns down" position is widely accepted as a way of providing good recoveries. For oval shapes, sawing along the longer axis has generally been accepted as the "correct" or most beneficial position. The old days of expensive sawing studies, designed to define optimal sawing for different saw patterns, have been replaced with sawing simulation models. This article exemplifies such modelling to show that empirical findings for oval logs have been basically confirmed with mathematical modelling of oval log shapes. The effect of ovality on conversion was examined through a series of sawing simulations using AUTOSAW.

In spite of the myth that logs are round, oval logs are more common than is realised — in fact, more common than truly circular shapes. Causes of log ovality are not fully understood, but are associated with the swaying of stems by the wind, leaning boles, and formation of reaction wood. However, the effect of ovality has been associated with errors in stem volume estimates and perceived as reducing sawn recovery. The amount of ovality found in logs generally tends to be greater for larger logs, and also greater for those logs from the lower parts of the stem. If ovality is defined as the ratio of the perpendicular diameter to the largest diameter (Fig. 1a), then truly circular logs would have the maximum possible ovality of 1.0 and oval logs would have ovality less than 1.0. In a recent study of 119 cross-sections from 20 radiata pine stems, ovality-ranged from 0.99 (nearly circular) down to 0.84 (approaching egg-shaped) (Fig. 1b).

For the computer simulation, five groups of 52 digitised logs ranging from full circular cross-sections (control) to those with ovality of 0.8° (in increments of ovality of 0.05) were modelled to determine whether conversions increased or decreased with increasing ovality. The logs comprised a range of cross-sectional areas for small-end diameters and taper. Each group had identical cross-sectional areas, volumes, and taper for each replicate log.

The AUTOSAW log sawing simulator used a cant sawing pattern, cutting 50-mm and 25-mm thicknesses, and produced boards ranging upwards from 100 mm wide in 50-mm increments, and 2.0 m in length and longer in 0.3-m increments. Wane was not permitted on boards in these simulations, to enable the full effect of ovality on conversion to be examined.

Logs were rotated and repeatedly sawn over the full range of rotational settings in 5-degree increments (giving some 18 720 simulations in all, 72 rotations × 52 logs × 5 ovality groups). By sawing at 5-degree increments, conversions could be tracked across rotations and thus the rotation at which the maximum conversion occurred could be identified. For the circular logs, even though conversions were expected

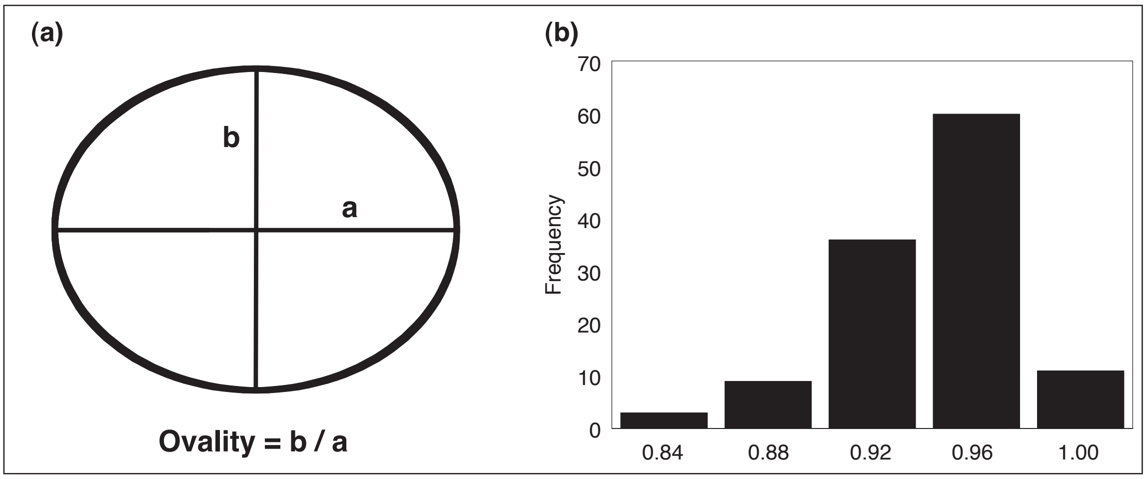


Figure 1. (a) Definition of ovality as the ratio of the diameter perpendicular to the largest diameter. (b) Frequency distribution of ovality of 119 radiata pine cross-sections.

to be identical for all rotations, simulations were still performed to ensure the programme worked correctly. At the initial orientation of 0° (and at 180°) logs were sawn along the shorter axis, and at 90° (and 270°) they were sawn along the longer axis.

An example is drawn in Figure 2 showing how log conversion changes with rotation. At the initial orientation the log shown in Figure 2 had a conversion of 53%. At 45° conversion was reduced to 46% and at 90° conversion reached a maximum of 56%.

Overall the 90° and, due to symmetry, the 270° rotations provided the best orientations for positioning oval logs (Fig 3). At those two orientations average conversion from oval logs exceeded that of the circular logs. At the 0° and 180° rotations average conversions for circular and oval logs were similar. However, at rotations other than 0°, 90°, 180°, and 270°, average conversion for the oval logs was substantially less than that for the circular logs. Conversion for circular logs naturally remained constant for all rotations.

When sawn at their best orientations, oval logs tended to have greater conversions than circular logs. Maximum conversions also tended to increase with increasing ovality. However, on average across the range of rotations, and in contrast to maximum conversions, average conversions were lower for oval logs than for circular logs. So, while maximum conversions increase with increasing ovality, average conversions decrease. Therefore, orienting oval logs correctly prior to sawing is important to maximising conversions, and the rule-of-thumb developed by sawmillers (sawing along the longer axis) is, in the absence of sweep, a good rule to adopt.

Our research illustrates that we have the tools and techniques to answer and verify the non-trivial problems a sawmiller faces on a daily basis.

To focus solely on the effects on conversion of orientation and ovality, our log models were simplified. This simplification will be removed in a future study where we will include other log characteristics that affect conversions, such as sweep.

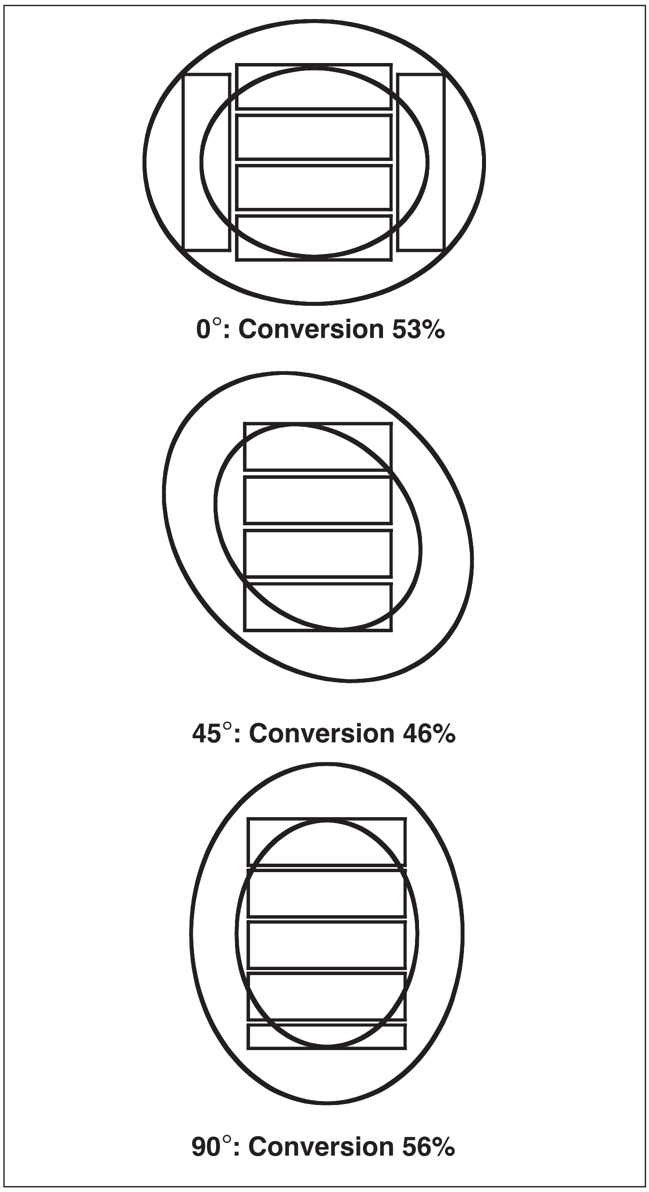


Figure 2. Conversion of a log with ovality 0.80, at 0°, 45°, and 90° rotations respectively.

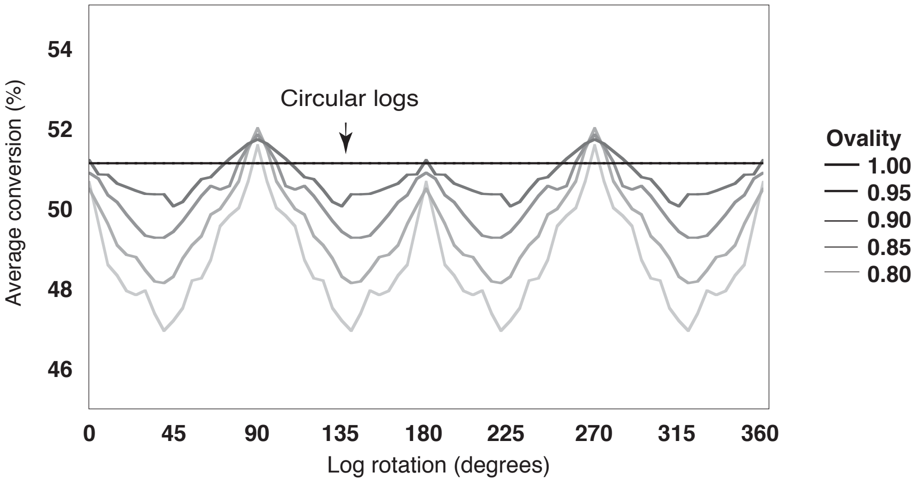


Figure 3. Average conversion across rotations for each ovality class

Wood Quality

Issue No. 39 December 2006

MAPPING THE STIFFNESS PROPERTIES IN TREES

Grant Emms and Charles Hosking

Observing the variations of wood properties within a tree can give insight into a number of wood quality issues. One particular issue of concern is stability. A property that provides some insight into stability is the variability of the "specific stiffness" — the stiffness per unit mass of wood fibre. The specific stiffness in the direction of the axis of the tree is determined by the grain angle of the wood fibres, and the angle of the microfibrils within the cell walls of the wood fibres. Large microfibril angles tend to result in larger longitudinal shrinkage of the wood fibres when the moisture content is reduced; large grain angles also result in larger longitudinal shrinkage due to the much greater shrinkage which occurs across the grain. An important driver of the stability of sawn timber is the different shrinkages which occur throughout the piece of timber as the moisture content is changed.

An effective way to measure the specific stiffness of a material is to measure the speed at which an acoustic compression wave travels through the material. Since the acoustic speed is the square root of the ratio of the stiffness to the density, by taking the square of the acoustic speed we end up with specific stiffness. Applying this to wood, we can find the specific stiffness of the wood fibres as long as we know the amount of water in the wood so that we can remove the effect water has on the calculations.

At Ensis, Rotorua, we used ultrasonic transducers (500 MHz) mounted on pneumatic rams coupled with digital callipers, interfacing hardware and software to make a system which is able to quickly measure acoustic speeds at a point on a tree disc. The system in operation is shown in Fig. 1.

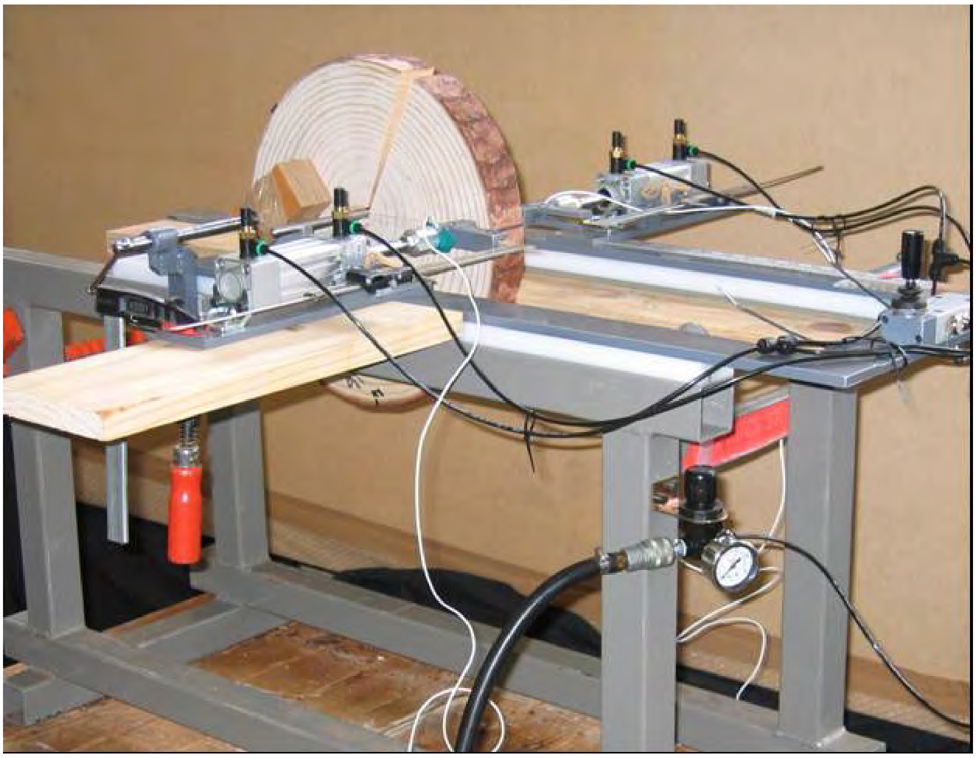


Figure 1. Apparatus designed to measure the longitudinal ultrasonic sound speed across a tree disc. In the picture the ultrasonic transducers (obscured) are placed on the disc faces using pneumatic rams which apply a small force to couple the transducers to the wood more consistently.

By using the system to measure the acoustic speed at points across a dry disc we can build up a map of the specific stiffness across the disc. We can clearly see in the specific stiffness map in Fig. 2 the low specific stiffness of the juvenile wood and the compression wood.

Current Research

Current research funded by the Foundation for Reaearch, Science and Technology and the Wood Quality Initiative is aimed at quantifying how well microfibril angle can be predicted from specific stiffness (or acoustic speed) for radiata pine specimens. However, in order to accurately predict microfibril angle from acoustic speed measurements, we also need to know the grain angle. Additional research is aimed at developing an acoustic method to measure grain angle in a disc.

The aim of this research and development is to be able to map the microfibril and grain angles in tree discs, enabling a profile of these important properties to be generated for a tree from successive discs.

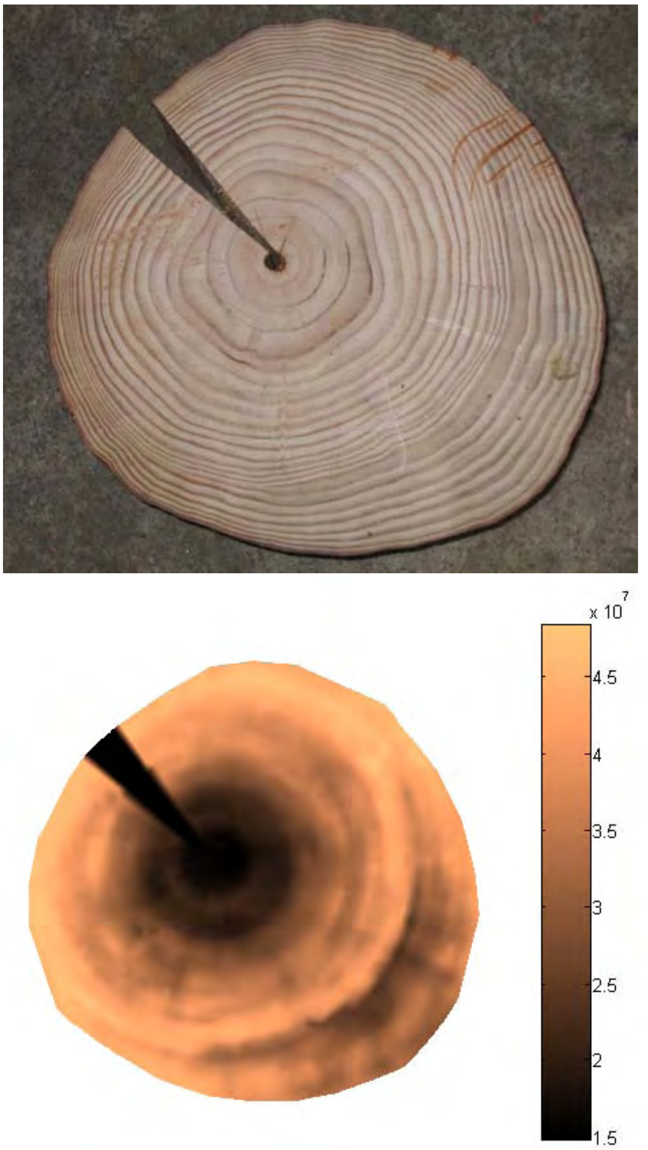


Figure 2 - Top. Disc of radiata pine with obvious signs of compression wood. A stress releasing cut was made in the disc prior to drying.
Bottom. Map of the specific stiffness (Pa/kg) in the disc measured ultrasonically.

PROBING WOOD-COATING INTERFACE USING COMPARATIVE MICROSCOPY

Adya Singh and Bernard Dawson

As part of wood properties enhancement programme at Ensis we are probing the wood-coating interface of a wide variety of textured-wood products. We are using a range of microscopic and analytical techniques to obtain information on wood and coating interaction, knowledge which is vital for undertaking developments to optimise the performance of protective coatings. This article describes a third technique used to investigate the wood-coating interface and complements those described earlier in Newsletters No. 36 and 38.

This third technique uses comparative microscopy employing light, confocal, and scanning electron microscopy performed on the same section from a coated wooden board. This technique was especially developed for examining the wood-coating interface in radiata pine boards, which had been sawn to produce a rough surface texture and subsequently coated with a semi-transparent film-forming stain.

The observations and techniques presented are based on a study of coated wooden boards supplied to us by a product development company based in New Zealand, which is keen to market a pre-finished product they have developed, and who have approached us for assistance in evaluating their product.

The coated product examined was radiata pine plywood, which had been band-sawn to produce a rough texture and subsequently coated with a specially formulated semi-transparent acrylic stain system. Comparative microscopy was undertaken by sequentially examining the same section using light microscopy (LM), confocal laser scanning microscopy (CLSM), and scanning electron microscopy (SEM) to assess the suitability of the three different types of microscopy for resolving the highly distorted surface tissues of band-sawn plywood panels in order to understand the interaction of the tissues with the applied coating.

For LM, sliding microtome sections 90 μm thick, cut perpendicular to the surface, were taken from the coated panels in the region of the wood-coating interface. The sections were stained with 0.05% aqueous toluidine blue to enhance the contrast of wood tissues. The resulting turquoise colour of wood cell walls contrasted well against the natural brown colour of the coating. Stained sections were mounted in glycerol on a glass slide and examined with a Zeiss Photomicroscope II after a cover glass had been placed over the sections. For confocal microscopy, the same section which had been examined by LM was imaged with a Leica TCS/NT CLSM. Confocal images were acquired using an argon/krypton laser with excitation wavelengths of 568 and 647 nm and emission wavelengths of 600 and 660 nm. A 16x multi-immersion lens with a numerical aperture of 0.5 was used for all images. The same section which had been examined by LM and CLSM was also examined by SEM. The section was first floated on water from the slide, then transferred to ethanol for a few minutes, before being placed between two glass slides for drying at room temperature. Subsequently, the section was placed on an aluminium stub with an adhesive carbon disc, coated with carbon, and examined with a Cambridge Stereoscan 240 SEM in the backscattered mode.

In Figures 1, 2, and 3 are shown LM, CLSM, and SEM images respectively of the same transverse section through a highly distorted surface tissue region of the coated band-sawn plywood panel. Despite a satisfactory differentiation in contrast between the natural brown colour of the coating and the turquoise colour of wood cell walls after toluidine blue staining, the highly distorted surface tissues are poorly resolved by LM (Fig. 1) because of its inability to bring the distorted surface tissues, underlying parent tissues and the coating film, into the same focal plane. The use of CLSM readily overcame this difficulty as the surface tissues were clearly resolved, providing a clear view of the pattern of distribution of

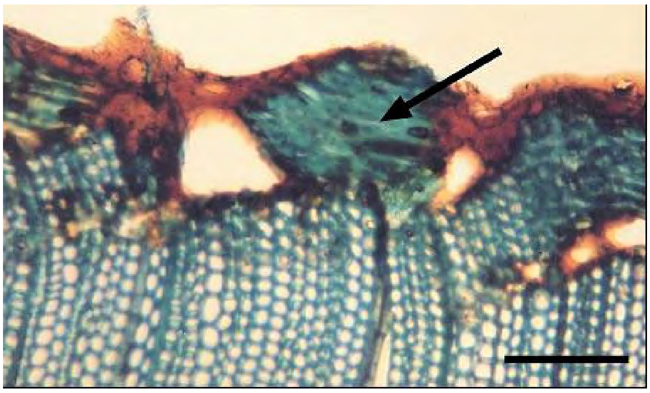


Figure 1. Light micrograph showing greatly distorted surface tissue masses and associated large cracks. The distorted tissues appear fuzzy and are not clearly resolved (arrow). Bar = 200 μm.

the coating on the plywood panel and within the damaged surface tissues (Fig. 2). The ability to form a composite image of a series of successive optical sections, free of any distortions, is a unique capability of CLSM, which enables one to obtain information from relatively thick biological tissues. In our work, we examined the composite images made from optical sections taken through depths of 12 to 20 μm from the surface of sections, which made it possible to resolve the details of even the most highly distorted surface tissues of panels, as illustrated in Fig. 2. Distorted surface tissues were also clearly resolved by SEM because of its superior depth of focus (Fig. 3). However, this microscopy did not provide any additional information beyond that achieved by CLSM. Besides, SEM caused beam damage to the rather thin sections, which tended to split in places. Also, differentiation between the coating and wood tissues was inferior to both LM and CLSM, despite the use of backscattered mode, which has been widely used in the studies of composite materials to differentiate components based on their atomic number differences.

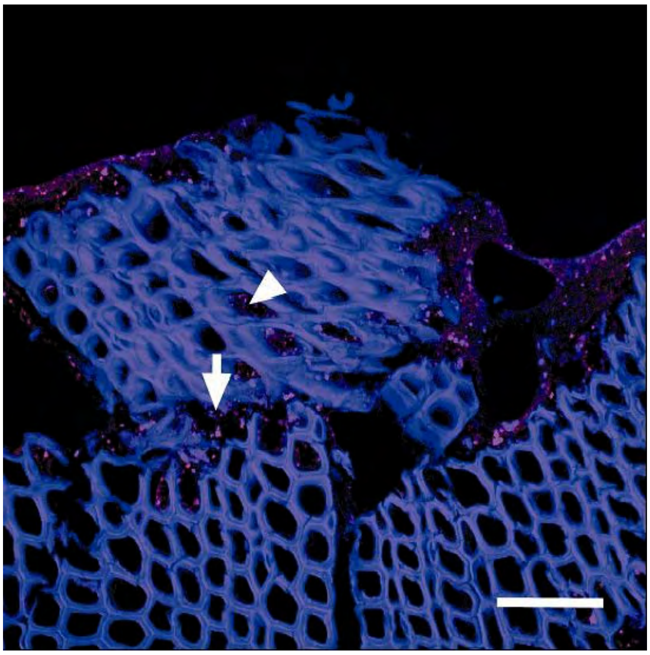


Figure 2. Confocal fluorescence micrograph of the distorted group of tissues indicated by an arrow in Fig. 1. The cell walls in this tissue mass are well defined. Coating in cell lumina and fine cracks in cell walls is resolvable (arrowhead). Also resolvable is the presence of coating within a large crack (arrow) that formed during band-sawing. Bar = 100 μm.

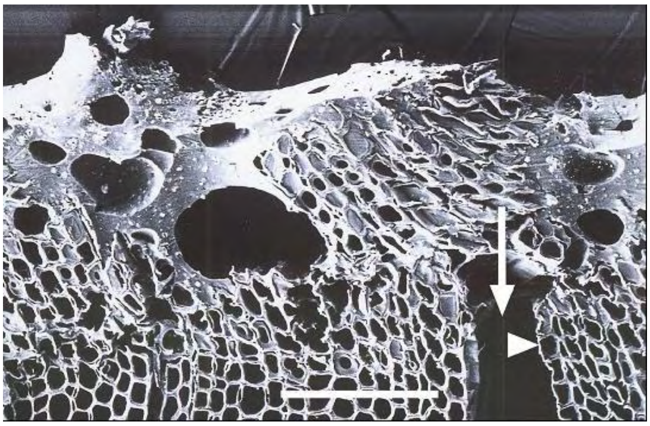


Figure 3. Scanning electron micrograph of the severely distorted group of tissues indicated by an arrow in Fig. 1. The cells in this mass of distorted tissues are well defined. The location of coating material is also detectable. However, the contrast between the coating and cell walls is inferior to that in Fig. 2. Cracks (arrow) and cell wall delaminations (arrowhead) have developed due to beam damage. Bar = 200 μm.

The illustrated LM, CLSM, and SEM images of the same section from a coated plywood panel that had been band-sawn prior to coating application, demonstrate the usefulness of comparative microscopy in examining highly distorted surface tissues in relation to the distribution of applied coating. Although use of rough textured plywood is highly desired in outdoor situations, examining highly distorted surface tissues of such plywood by microscopy is challenging, and can best be achieved by a combination of microscopy, as demonstrated here.

Wood Drying

Issue No. 39 December 2006

Steve's FAQ file

Each issue we will delve into our files and give answers to frequently asked drying questions, trying to add to our general understanding of the technical issues behind the art of Wood Drying

WHY IS IT RECOMMENDED THAT RADIATA PINE BE PROCESSED WITH MINIMUM DELAY BETWEEN CUTTING AND DRYING?

The short answer is that delays between cutting and drying increase the propensity for surface checking.

Remember, as wood dries it begins to shrink as the free water in its cells is removed and its bound water, in the cell walls, also begins to be removed. This occurs first on the surface, which is unable to shrink, because the bulk of the wood below it has not yet begun to shrink. Thus if the surface-to-core moisture content (MC) difference is too great, the shrinkage stress (tension stress) on the surface will be excessive and break fibres causing surface checks. The idea of controlled drying is make sure that the core to surface MC difference remains below the point at which any rupturing will occur. As drying temperature increases, the surface drying conditions can become more severe, but the transport of liquid water to the surface (called diffusion) improves with temperature, thus a balance is maintained. Successful drying schedules control temperature and humidity to maintain the correct balance. Now radiata pine is a very forgiving species, as it is very permeable. Freshly sawn radiata pine is very difficult to surface check in a kiln, because moisture moves freely to the surface, and so radiata pine can be dried at very high temperatures, because at high temperatures the movement of moisture to the surface can be kept in balance with the rate of removal from the surface.

All this changes if the surface layer (outer 1 mm) is already dry when the wood goes into the kiln. When the kiln is turned on, the Dry Bulb temperature rises, and the surface heats up before the core does. With surface conditions hot but internal temperatures very low, the surface layer immediately begins drying further, trying shrink even more. Since the core isn't shrinking, a large tension stress can develop on the surface. Often this is beyond the yield point for that temperature and surface checking occurs.

What can be done?

- Minimise delays between sawing and drying. Less than 2 or 3 days is okay. After a week, especially in summer, remedial action might be necessary.
- If the delay is too long, the situation can be alleviated by pre-steaming before drying. Ideally, boil the water bath to reach 80°–100°C and leave long enough to heat the wood before drying commences. Definitely reach the Wet Bulb with the bath alone and leave long enough for the surface to be re-wet. This has the effect of delaying shrinkage on the surface until moisture diffusing from the core can begin diminishing the MC gradient.
- Steaming water baths are ideal as humidity is added with no extra heat. If a water bath is not available, heat the kiln with the vents shut and sprays on. Rewetting the surface with hoses has been done but we have no data on how effective this is.

EMC of ambient air conditions

Ambient air conditions even in NZ can be quite severe. Even in winter RH is often below 50% and can even be below 20% (*see* Fig. 1, graph of Hamilton for 1 week in May). From Table 1 quite low EMCs can be expected

When the RH is low, the surface of the wood will try to reach very low moisture levels as seen in Table 1. The restrained shrinkage can lead to such high stress levels that surface checking can occur. In this case no amount of pre-steaming will rescue the wood. Often these checks can be very fine and they close up when the surface goes into compression as the core begins to dry — but they re-appear eventually. Severe ambient conditions are one of the reasons we kiln dry in the first place.

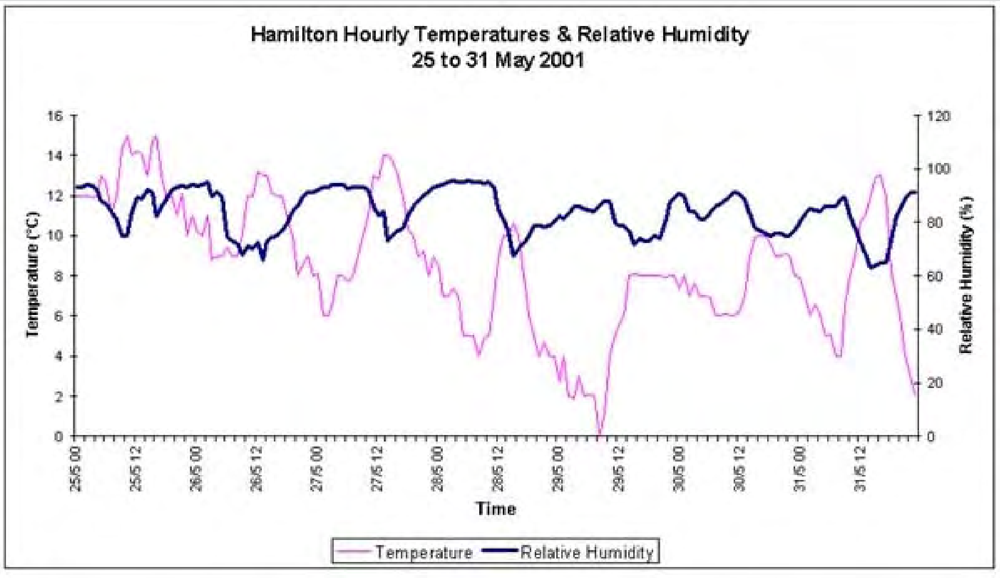


Figure 1. Hourly air conditions (NIWA 2006 – used with permission)

Table 1: EMC of wood at 12°C

RH%	EMC
50	9.4
40	7.6
30	6.2
20	4.6
10	2.7
5	1.5

Believe it or not!

- When we were studying surface checking in radiata pine, it was difficult to make it check. We actually had to get sawn timber and leave it in fillet outside for 2–3 weeks.

- Surface checking is not a new phenomenon, but has become more prominent as finishing techniques for timber have improved. It was observed back in the 70s when dehumidifiers first arrived. These units unfortunately were often undersized, having being designed for slower-drying species, and thus could not cope with the large amount of water so readily extracted. Air drying prior to dehumidification was done to improve throughput; however, the degrade from surface checking was unacceptable thus dehumidifiers tended to be upsized to units with much greater drying capacity.

- The longer the delay between sawing and drying, the darker the surface colour becomes after remedial steaming. Especially after high-temperature drying, wood that has been steamed for 4 hours and has had less than a 2-day delay between sawing and drying is noticeably “blonder” than wood with 1 week’s delay. This effect continues as the delay increases, with wood having 3 weeks’ or more delay being a dark almost chocolate colour. This is a surface effect and is not considered to be Kiln Brown stain which is a phenomenon that occurs ~1 mm below the surface .

KILN AUDITS IMPROVE KILN PERFORMANCE

Ian Simpson

Introducing a revamped service to the timber drying industry — the OptiKiln^{TM} service.

Ensis now offers two types of kiln audits as part of the OptiKiln^{TM} service:

(1) Acceptance Audit of new kilns against performance specifications.

(2) Performance audit of existing operations.

These audits provide a wood processing business further access to the knowledge and equipment of the Ensis Drying team.

OptiKiln Acceptance Audit

The Acceptance Audit is conducted to compare the actual performance of a kiln against a performance specification. These audits are usually conducted on new kilns, where the final payment for the kiln is dependent on its satisfactory performance against the performance specification.

During an Acceptance Audit, the following parameters are measured on one or two kiln charges:

- Airflow forward and reverse, airflow variability across the kiln stack.
- Kiln heatup time to setpoint.
- Temperature variability during drying.
- Accuracy of temperature control during drying.
- Heatup time and temperature during final steaming.
- Conditions achieved during final steaming.
- Final moisture content and stress levels of dry kiln charge.

The benefits of conducting an Acceptance Audit are:

- Independent assessment of the performance of a new kiln against performance specifications.
- Identification of kiln performance problems before making the last payment on the kiln.
- Benchmarking the performance of a kiln against accepted industry standards.

OptiKiln Performance Audit

The Performance Audit is normally conducted at a site with established kilns. The audit offers an independent review of operating practices and compares the site practices against industry standards. The audit may include aspects of other areas of the timber processing business, including the sawmill, sales, and planning. Activities in these areas of the processing industry, such as sawing variation and kiln charge build, have a large effect on the drying operation. The audit may also include some on-site training of personnel, which is specific to the equipment and schedules being used.

Areas that are covered by a Performance Audit include:

- A review of kiln schedules.
- Standard of kiln stacking.
- Maintenance of kiln equipment.
- Assessment of the quality of dry timber.

a Use of quality control data to optimise the business.

- Kiln utilisation.
- Level of kiln operator knowledge.

The benefits of conducting a Performance Audit are:

- Specific recommendations on improving kiln performance.
- Identification of kiln maintenance and design problems.
- Customised training of your staff on your premises.

Examples of the likely benefits from an OptiKiln^{TM} audit are indicated by the following case studies.

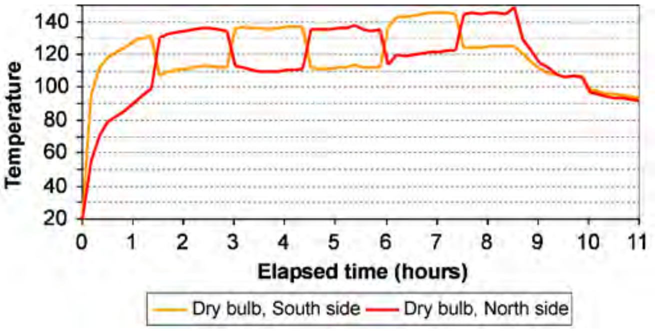
CASE STUDY 1: Acceptance Audit

Company A had purchased a new HT kiln and steaming chamber worth about $800,000 and had compiled a performance specification for the kiln. The final payment to the kiln supplier was dependent on satisfactory performance of the kiln.

Ensis was employed as an independent group to conduct a Performance Audit of the kiln against the performance specification. Airflow and temperature variation was measured.

The airflow was specified to be at least 8.0 m/s, with the difference between forward and reverse to be less than 10%. The testing showed that the airflow did exceed 8.0 m/s (8.5 and 8.3 m/s) and that the variation in airflow was acceptable.

Heatup of the kiln to 120°C was within the specified 2 hours. The temperature variation was within the allowed 5°C temperature variation.



Graph showing typical heatup time and control of dry bulb temperature during six fan circulations.

The kiln specification also included an estimated annual kiln production. This was estimated on the charge details from the first five kiln charges.

At the completion of testing, the purchaser of the kiln received the kiln audit report and was able to make the final payment on the kiln with confidence that his kiln was performing according to the specifications.

Testing airflow in a kiln.

CASE STUDY 2: Performance Audit

The kiln operator at Company B resigned giving short notice of his departure. A replacement was found from within the company, but the new kiln operator had limited experience at operating kilns and there was little time for training from the departing kiln operator.

The new kiln operator was left with the challenge of operating several computer-controlled kilns, with a large selection of kiln schedules. There seemed to be a schedule for each size and type of timber, for each of the kilns. The company was also concerned about the performance of their kilns.

Several days were spent on-site with a major focus on training of the new kiln operator. The extensive library of schedules was reviewed and whittled down to several schedules for the main product types.

Airflow was measured in two ACT kiln chambers, Kilns 1 and 2. A modern ACT kiln would be expected to have an airflow of at least 4 m/s. The airflow in Kiln 1 was found to be only 2 m/s and highly variable. The airflow in Kiln 2 was almost twice as high as in Kiln 1. Missing baffles in Kiln 1 are likely to have caused the airflow variation, but additional baffles were unlikely to double the airflow to that measured in Kiln 2. The lower airflow in Kiln 1 was calculated to result in a 40% longer drying time than Kiln 2, which the company could now allow for in their production planning.

	Air velocity (m/s)	
	Forward	Reverse
Kiln 1	2.0	2.3
Kiln 3	4.3	3.7

Benefits to the company

- Kiln operator was better informed about the operation of his kiln.
- The library of kiln schedules was reduced and the purpose of each schedule step was explained to the operator.
- Greater understanding of:
  - The airflow characteristics of the two kilns and how these affected drying times.
  - The effect that too lengthy a period of green timber storage can have on drying variability and surface checking.
  - The importance of baffles and their maintenance to minimise uneven airflow.

Wood Protection

Issue No. 39 December 2006

BORON PENETRATION IN LOW UPTAKE PROCESSES — A COMPARISON OF VISUAL AND ANALYTICAL CORE PENETRATION

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The New Zealand Standard NZS 3640:2003 "Chemical preservation of sawn and roundwood" requires complete sapwood penetration. Full sapwood penetration is deemed to have been achieved if the preservative is detectable in the central one-ninth core of sapwood. For preservatives which have copper as an active ingredient, this is readily confirmed using rubeanic acid or chrome azurol spot tests because they produce strong colour reactions in the presence of very low levels of copper. On the other hand, spot tests for boron are much less sensitive and checking for full sapwood penetration compliance by spot tests alone can be inconclusive.

Low uptake processes for water-based preservatives (considered ≤150 l/m^3) can use double vacuum, low pressure Lowry, or Rueping schedules. These schedules are designed to keep the moisture content of framing timber low, and minimise swelling, so there is no need for kiln drying after treatment.

Often very low uptake processes result in a streaky penetration pattern which, from visual assessment, is not accepted as full sapwood penetration. However, if core samples are analysed, penetration compliance is frequently confirmed.

The Ensis preservation group undertook to investigate the discrepancy between visual and analytical pass/failure for boron penetration tests when solution uptakes are low. For the investigation, 30 kiln-dried, 4x2, 2.4-m studs containing mostly sapwood were cut into two end-matched samples for treating in two charges, A and B. Both treatment charges used very low uptake schedules, with charge B targeting a slightly lower uptake than A. Boards were treated with a 14.8% boric acid equivalent (BAE) solution. Density of treating solution was 105.5 g/100 ml. The moisture content of all boards was measured before treatment and all boards were weighed before and after treatment to determine treating solution uptake.

From the 30 boards, 10 end-matched samples (the five highest and five lowest uptakes) were selected from both charges, for analysis for boron penetration and retention. Turmeric Spot test reagent was used to determine extent of preservative penetration. In this test, areas containing boron compounds develop an orange red to deep red-pink colour. Treatment results are summarised in Table 1.

Cross-section and core analyses for the matched five highest and five lowest uptakes in each charge are shown in Table 2. Samples were analysed following the procedure for NZS 3640, H1.2, which requires complete sapwood penetration (boron detectable by analysis in the central one-ninth core) with retention of at least 0.40% BAE w/w oven-dry weight of wood in the cross-section. In Charge A, all sapwood cross-section retentions exceeded the minimum 0.4% w/w BAE cross-section loading. In addition, all sapwood cores passed the core loading requirement, which also is indicative of complete penetration of boron. For Charge B which had lower uptakes, two out of the 10 cross-sections analysed were marginal failures (0.37 and 0.39% BAE), but five of the 10 samples failed the spot test full sapwood penetration requirement.

In Treatment A, three sapwood samples failed the penetration spot test, but none failed by chemical analyses. In Treatment B, the high failure rate was obvious, both by spot test (five samples) and by analyses (four samples).

Table 1. Treatment results

	Charge A	Charge B
MC % before treatment	13.3 (20.4*)	13.3 (20.4)
MC % after treatment	20.8 (16.8)	19.5 (18.2)
MC % increase	7.5	6.2
Solution uptake (l/m^3)	34.5	28.1
Calculated retention (kg BAE/m^3)	5.1 (31.2)	4.2 (31.7)
Calculated retention (BAE % w/w)	1.3 (31.2)	1.0 (31.7)

* Number in parentheses is coefficient of variability (%)

Table 2. Analytical results of loading for selected samples

Sample Number	Sapwood (%)	Penetration pass/fail by spot test	BAE % in cross sections (w/w)	BAE % in cores (w/w)	Penetration pass/fail by analysis
Charge A					
2	0	Fail	0.42	<0.01	Fail
9	100	Fail	0.45	0.02	Pass
10	80	Fail	0.51	0.03	Pass
12	100	Pass	1.00	0.42	Pass
16	100	Pass	1.34	1.28	Pass
18	100	Pass	0.61	0.02	Pass
19	100	Fail	0.57	0.02	Pass
20	100	Pass	0.80	0.52	Pass
22	100	Pass	0.88	0.27	Pass
27	90	Pass	1.74	0.11	Pass
Charge B					
2	80	Fail	0.44	<0.01	Fail
9	100	Fail	0.39	<0.01	Fail
10	100	Fail	0.37	<0.01	Fail
12	100	Pass	0.86	0.26	Pass
16	100	Pass	1.06	0.53	Pass
18	100	Fail	0.60	0.02	Pass
19	100	Fail	0.53	<0.01	Fail
20	100	Pass	0.73	0.34	Pass
22	100	Pass	1.18	0.41	Pass
27	100	Pass	0.84	0.04	Pass

Results clearly demonstrate that, to confirm complete sapwood penetration when using low uptake treatments with boron preservatives, chemical analysis is advisable, spot-testing alone is not reliable.

Boron spot tests for the samples analysed are shown in Figures 1 and 2. Samples 2, 9, 10, 18, and 19 had lowest uptake/penetration; 12, 16, 20, 22, and 27 had highest uptake/penetration in both Charges A and B.

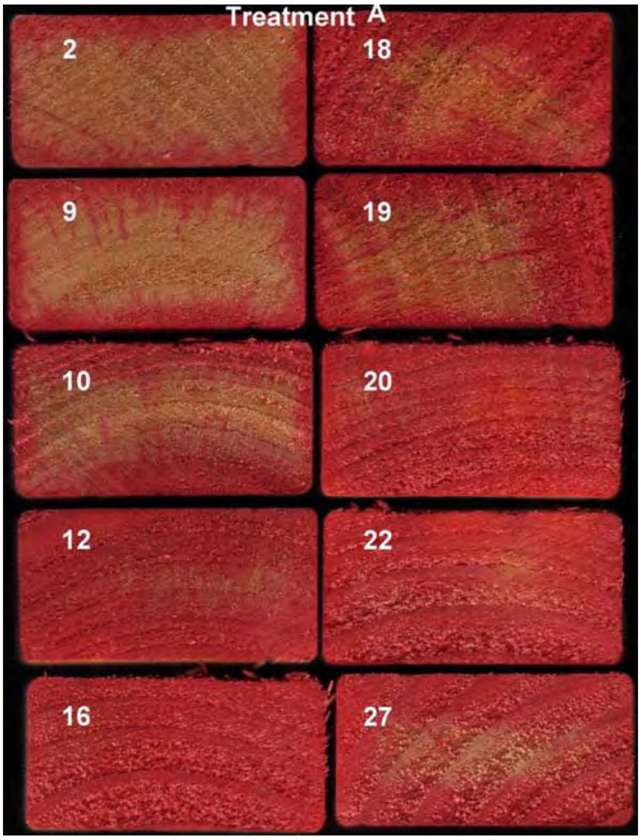

Figure 1. Boron spot test results for the samples analysed from Charge A

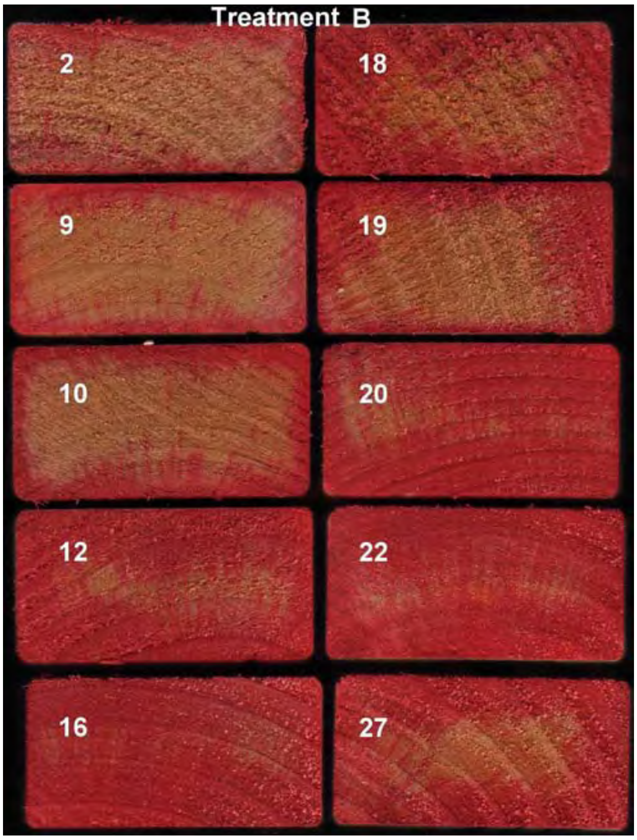

Figure 2. Boron spot test results for the samples analysed from Charge B

BIOACTIVE RESEARCH AT ENSIS; UNDERSTANDING MODE OF ACTION OF CHITOSAN

Tripti Singh, Damiano Vesentini, Colleen Chittenden, and Adya P. Singh

In Newsletter No. 38 (June 2006) we introduced an area of research at Ensis concerned with protecting wood and wood products through development and use of environmentally friendly technologies. The aim of the bioactive group is to identify a range of bioactive molecules which could be used for protection of green wood, as well as wood placed in service, against bacteria and fungi. Although we have identified a number of natural products with potential for the applications we seek, to date chitosan has received our closest attention. The exploratory work done using chitosan, a naturally abundant polymer, has shown considerable promise in controlling the growth of important sapstain and other wood-degrading fungi. We are presently undertaking fundamental studies to understand the primary cellular target(s) of chitosan within the hyphae of affected fungi.

The effect of chitosan treatments on the common wood-degrading fungus *Sphaeropsis sapinea* was examined using a range of physiological, biochemical, and microscopic methods. The data presented here and the electron microscopic images suggest that the growth-inhibitory effect of chitosan on *S. sapinea* is related to significant alteration in the composition and organisation of vital cell components, with plasma membrane being the primary target of this bioactive molecule.

We wanted to know whether reactive oxygen species (ROS) are included in fungal responses to this treatment. Organisms produce ROS during their normal metabolic processes; however, production of ROS in excess of requirement under stress conditions can be lethal to cells.

Initially, we examined the effect of chitosan on *S. sapinea*. The fungus was grown on nutrient medium amended with different concentrations of chitosan (0.01 to 0.1%). The formation of superoxide and hydrogen peroxide radicals was monitored after the plates were flooded with either Nitro Blue Tetrazolium (NBT) in propane sulfonate-NaOH to detect superoxide that reacts with NBT to form a blue precipitate, or dimaminobenzidine and horseradish peroxidase in potassium phosphate buffer to detect peroxide that triggers the accumulation of a red precipitate. The colour intensity that reflected accumulation of precipitates is shown in Fig. 1 and 2 expressed as average colour intensity for all three colours monitored.

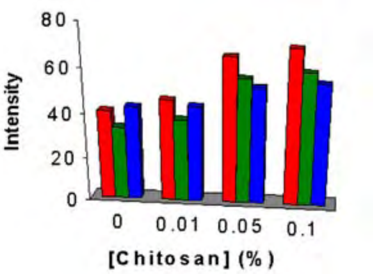

Figure 1. Effect of increasing chitosan concentrations on superoxide production in *S. sapinea* after 2 days of incubation, as shown by increasing colour intensity.

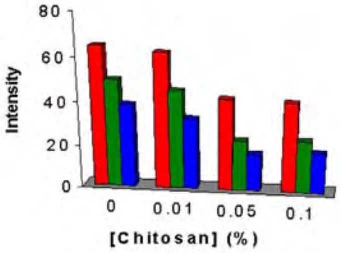

Figure 2. Effect of increasing chitosan concentrations on peroxide production in *S. sapinea* after 2 days of incubation, as shown by decreasing colour intensity.

The method for measuring colour intensity provides results which are inversely proportional to the brightness or darkness of the colour. Thus a light precipitate colour typical of low levels of ROS will be expressed as high-intensity readings, and vice versa.

The occurrence of oxidative stress caused by the presence of ROS was evident during the initial stages of growth of *S. sapinea*. At increasing chitosan concentrations a decrease in superoxide formation was observed, associated with an increase in hydrogen peroxide.

Figure 1 shows a significant ($p<0.01$) increase in the colour intensity values recorded, as compared to the controls. The decrease in superoxide accumulation observed was accompanied by an increase ($p<0.01$) in the accumulation of hydrogen peroxide at the highest concentrations of chitosan (Fig. 2). This could be indicative of a rapid conversion of superoxide to hydrogen peroxide in the presence of chitosan. Persistent high levels of hydrogen peroxide can cause oxidative stress, leading to alterations in cell physiology and metabolism.

The presence of chitosan in the growth medium caused the leakage of potassium ions K^+ from fungal cells. This effect was observed as early as 5 min after chitosan treatment of fungal cultures. K^+ leakage steadily increased over a period of 30 min after treatment. The lowest concentration of chitosan tested (0.01%) was sufficient to initiate the leakage of K^+ and the effect was more pronounced at higher concentrations. These results indicate a profound effect of chitosan on the integrity of the cell membrane, with a consequent loss of functionality which could explain the growth inhibition observed in the fungi after chitosan treatment.

Microscopic observation revealed that the chitosan affected the morphology and ultra-structure of hyphae. Light microscopy showed excessive hyphal branching and reduction in hyphal diameter and length, and the alterations were observable even at the lowest concentration of chitosan (0.01%). Hyphae exposed to 0.1% chitosan showed pronounced vacuolation, and hyphae appeared almost empty (Fig. 3).

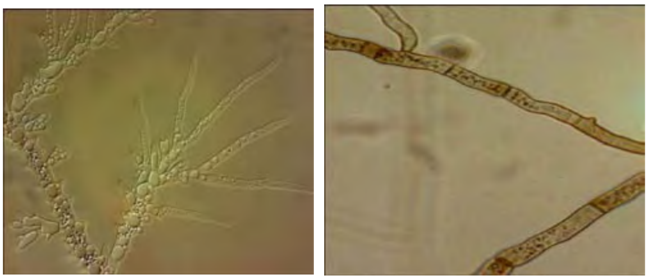

Figure 3. (*left*) Excessive branching and vacuolation in the mycelium of *S. sapinea* after 4 days' exposure to 0.1% chitosan. (*right*) Lack of vacuolation and excessive branching in untreated mycelium.

Examination by scanning electron microscopy (SEM) showed a profound effect of chitosan on the cell wall, even at the lowest concentration tested. The cell surface became corrugated and this phenomenon became more pronounced as the concentration of chitosan increased. It was also observed that at higher concentration of chitosan, hyphae tended to aggregate and form hyphal bundles (Fig. 4c). This phenomenon was also associated with the occurrence of warts on the hyphal surface, which was observable only at higher magnifications.

The transmission electron microscopy (TEM) examination of chitosan-treated and untreated *S. sapinea* hyphae provided evidence of ultrastructural changes in all cell components. Disruption in plasma membrane, vesiculation of membranes, aggregation of cytoplasmic contents and residues, and delamination of cell-walls were induced even by the lowest concentration (0.01%) of chitosan used (Fig. 5a). In comparison, the untreated *S. sapinea* hyphae contained intact cell walls and plasma membrane and well preserved organelles (Fig. 5b).

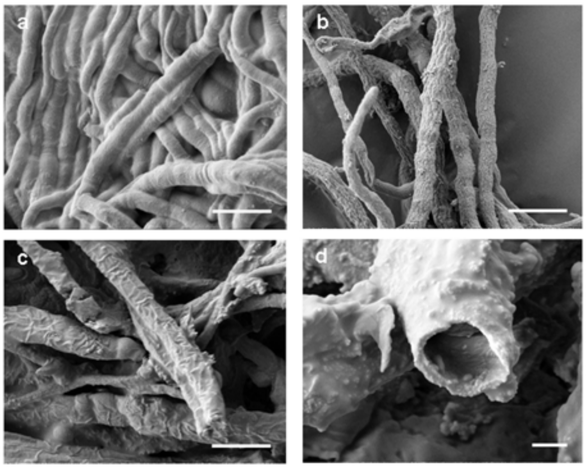

Figure 4. Hyphae of *S. sapinea* under SEM, (a) untreated, (b) exposed to 0.01% chitosan, (c) exposed to 0.1% chitosan (lower magnification), (d) exposed to 0.1% chitosan (higher magnification)

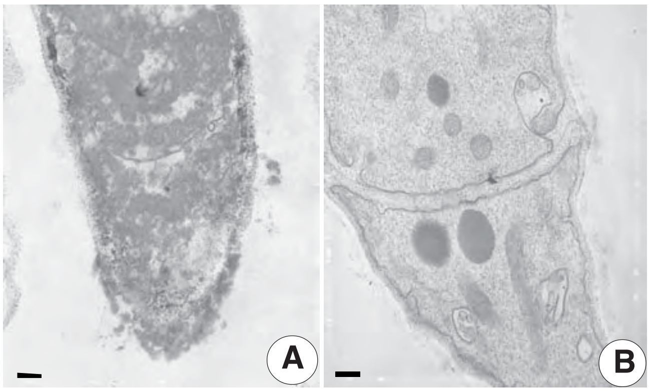

Figure 5. Hyphae of *S. sapinea* under TEM, (a) treated with 0.01% of chitosan, plasma membrane disrupted, cytoplasm is dense and organelles disintegrated, (b) untreated hypha exhibiting intact cell wall and plasma membrane and well-preserved organelles.

Taken together these observations suggest a primary effect of chitosan on membrane structure and permeability. Lipids are important components of cell membranes, and ROS build-up in excess of normal physiological requirements can cause lipid peroxidation, resulting in altered membrane structure and properties. The evidence presented in our work suggests that chitosan has affected *S. sapinea* hyphae by triggering oxidative stress.

The fundamental knowledge on the mode of action of chitosan will help us develop a strategy for application systems where use of bioactives will be based on specific cellular targets, such as plasma membrane.

Environmental

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OPENING THE BIOENERGY GATEWAY

Per Nielsen

As concern grows about the rising price of fossil fuels, the forest industry is offering a viable alternative through the use of wood waste. The opportunity to use this waste more effectively has been identified by both the forest industry and the Government. The Forest Industry Development Agenda (FIDA) Bioenergy Programme is funding a new initiative that will help develop the market for wood waste in this country and provide growers with the potential to cash in on harvesting residues.

New Zealand already makes good use of renewable energy sources, particularly in terms of hydro and geothermal electricity production. However, the market is growing for other renewable energy sources such as wind, solar energy, and industrial waste (including wood). In order for the forest industry to capitalise on this opportunity, a market must be created for buying and selling wood waste on a larger scale.

To facilitate this market development, the Energy Efficiency Conservation Authority (EECA), which administers the FIDA Bioenergy Programme, has engaged with Scion, Sysdoc Ltd (the website consultants, www.sysdoc.co.nz), and the Energy Library (www.energylibrary.org.nz to form the Bioenergy Knowledge Centre. This Knowledge Centre has two main services. The first is to provide access to a pool of experts via a “call centre” to assist evaluation and analysis of bioenergy opportunities (0800 BIOENERGY). The second is a web-based service “Bioenergy Gateway”, provided for forest owners, wood processors, or investors in bioenergy facilities (www.bioenergy-gateway.org.nz).

The Bioenergy Knowledge Centre will:

- Build the overall profile of bioenergy
- Increase knowledge of technologies both in New Zealand and internationally
- Ensure a broad range of information is available to potential users
- Build a community of like-minded companies where practical experience in implementing bioenergy alternatives can be shared.

The website will also enable forest owners to determine the potential value of forest residues on their cutovers and compare this value to that of the equivalent volume of other fuels.

The forestry sector is already a major user of wood waste for the generation of process heat in the wood-processing industry. This is used mainly for wood-drying kilns. Large processing sites also use cogeneration to produce electricity from burning wood waste, but much more wood waste could be used for energy production in forestry and other sectors if a better infrastructure were in place for the buying and selling of forestry residues on harvesting sites.

EECA and Scion envisage that the Bioenergy Knowledge Centre will help raise awareness of these opportunities, provide vital information, and create a market for the industry. The overall objective of the Bioenergy Knowledge Centre is to reduce risks (technical, financial, and operational) and create opportunities related to bioenergy projects.

The Bioenergy Knowledge Centre will be formally launched on 24 November 2006. The main target audiences during the first year of operation will be sawmillers, forest owners, and wood processors. In future, the focus of the Bioenergy Knowledge Centre will expand to include a range of other industries, the general public, and national and local policy makers.

EECA is managing the FIDA Bioenergy project and the project manager of the Bioenergy Knowledge Centre is Scion (formerly Forest Research). Co-funding in the establishment phase is provided by the Rotorua Trust (the former Rotorua Energy Charitable Trust).

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HOW “GREEN” IS THE WOOD PROCESSING INDUSTRY?

Carolyn Hodgson

The programme Ecological Footprint Plus (EF Plus) will answer this question. It will determine the environmental impacts of the wood processing industry as well as other primary industries in New Zealand. The industries to be studied are forestry, meat and dairy farming, and the processing industries of wool, meat, milk, and wood.

Scion has been sub-contracted to provide data on resource use and resource outputs (including wastes) from the various wood processing sectors including sawmilling, panel products, and pulp and paper, and also the forest management and logging sector.

Results from the EF Plus programme can be used to identify processes that have a high resource use or level of emissions. Minimising the input of material, energy, and land into our rural-based industries, and minimising their production of waste, are critical steps towards making them (and therefore New Zealand) more sustainable.

The EF Plus programme will develop a model to enable the whole “planetary impact” of a business, process, or technology to be determined. In contrast to existing ecological footprint analyses, this model will include carbon dioxide assimilation, and also the impacts of solid and liquid effluents and air emissions.

This research programme, which is administered by Canesis (formerly Wool Research), is conducted on a collaborative basis between four main organisations: Massey University, ESR (Environmental Science & Research), Canesis, and Scion.

A further part of this programme concentrates on the effect of the human dimension on progress towards sustainability. The programme will identify what features exist within our organisational and cultural structures that promote or inhibit decisions and behaviour that support sustainability, and what prompts are required to encourage sustainability.

Minimising the use of resources and the production of waste is a critical step towards improving sustainability.

By engaging industry representatives in a process of consultation we will gain understanding of the structural changes necessary to promote sustainable criteria in industry and in individual everyday decisions.

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Timber Grading / Timber Utilisation	John Turner / Doug Gaunt (NZ) Russell Washusen (Aus)
Remanufacturing	Jeremy Warnes / John Turner (NZ)
Wood Quality	Dave Cown (NZ)
Alternative Species (to radiata)	John Roper / Russell McKinley (NZ) Russell Washusen (Aus)
Timber Drying	Steve Riley (NZ) Richard Northway (Aus)
Timber Engineering	Doug Gaunt (NZ) Richard Northway (Aus)
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