APPLICATION OF TOMOLOG X-RAY LOG SCANNER
AND GOLDENEYE X-RAY LUMBER SCANNER TO THE
NEW ZEALAND & AUSTRALIAN RADIATA PINE RESOURCE

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EXECUTIVE SUMMARY

The TOMOLOG X-Ray scanner, produced by MiCROTEC of Italy, was first commissioned in European wood processing plants in 2001. Preliminary studies based on Chilean radiata pine pruned logs have shown that TOMOLOG detected and interpreted the internal log characteristics with accuracy. Introduction of this 3D technology into the Australasian wood processing industry is considered to have immediate application in merchandising yards for optimisation of both appearance and structural log grades. In the sawmill, application of TOMOLOG is considered best placed prior to the secondary break-down saws for the scanning of cants to optimise clearwood recovery. Furthermore, an X-Ray lumber scanner produced by MiCROTEC called GOLDENEYE will have application for automated lumber grading and automated identification and recovery of blocks and clear cuttings components.
X-Ray LOG SCANNER TOMOLOG

Introduction

The TOMOLOG X-Ray log scanner was developed by MiCROTEC of Italy and first installed for commercial application in the year 2001. The scanner can be applied as a single, double or treble source, depending on the application required. The X-Ray scanner is contained in lead covered housing for required safe operation.

TOMOLOG has been developed for the European log processing industry to produce a realistic transparent 3D image of the log with a longitudinal conveyer speed of up to 200 meters per minute. The result is an image showing the exact position and dimensions of branches, knotty core, and defects. These internal wood characteristics are detected based on the gradient of wood density present. The denser the wood, the lower the X-Ray transparency. The data are processed by the optimising computer to produce an exact 3D model of the log.

Layout of the TOMOLOG X-Ray system

Two-source X-Ray TOMOLOG scanner operating in Hasslacher Drauland Holzindustrie’s Merchandising Yard, Austria.
Application of TOMOLOG in Europe

The application of TOMOLOG in Europe (currently seven X-Ray log scanners in operation) is largely for the purpose of segregating logs in merchandising yards based on the following parameters and accuracy:

- Diameter: up to 0.8mm
- Branch size: + - 5mm
- Internode length: + - 5mm
- Wood density: + - 1kg/m³
- Foreign objects

In Europe detection of foreign objects in logs (largely shrapnel resulting from wars) is an application of TOMOLOG.

A two-source TOMOLOG X-Ray image (X & Y planes) enables internal log qualities to be identified including branch size, internode length, wood density, heartwood and sapwood.

The primary timber species being processed in countries such as Austria where TOMOLOG is in use, is spruce, commonly around 150 years of age. While some log diameters range up to 85cm, the average log diameter of approximately 30cm SED is similar to Chilean radiata pine but obviously smaller than New Zealand radiata pine. This smaller log size means that most of the European log resource can be successfully read by the current 500mm diameter limit of TOMOLOG.

The primary application of TOMOLOG is to segregate logs based on internal quality along with true shape. European merchandising yards commonly segregate up to 86 sorts or log batches based on external and internal quality characteristics. Each batch is homogeneous and difference between batches including log size is small. Such segregation enables greatly accelerated volume through-put with sawing speeds of up to 140m/minute. Uniform log sizes with homogeneous internal qualities are feed end-to-end into profilers and saws applying the same sawing pattern. Because the difference between the log batches is small, change over
time for re-setting saws is commonly only 15 minutes. Log conversion to sawn lumber is commonly required to meet a minimum of 60%. Such sawmills commonly have throughput of 5,500 m$^3$ logs daily, resulting in 1.25 million m$^3$ of log or over 800,000 m$^3$ of timber out-turn annually. Segregation and sawing of logs based on both external and internal characteristics also enables better matching of log quality to customer and end product requirements.

150 year-old spruce logs ready for X-Ray scanning and segregating in a merchandising yard.

European merchandising yards are commonly used to segregate logs into more than 80 batches.

Log batches produced using X-Ray scanning contain uniform internal characteristics.
European log batches containing homogenous exterior and interior characteristics enables accelerated sawn timber out-turn of over 800,000 m³ annually.

European log batches containing homogenous exterior and interior characteristics also enables a better match to customer and end product demands.
FIRST VALIDATION OF TOMOLOG X-RAY SCANNING TO RADIATA PINE

In 2004 the first validation of TOMOLOG based on radiata pine was carried out by Forestal Mininco S.A., Chile. Fifteen pruned logs with a maximum SED of 420mm were flown to an Austrian sawmill where they were scanned. Images were then compared with the actual size and position of the knotty core based on destructive sampling methodology.

Results showed that TOMOLOG was able to adequately scan the knotty core and the software was able to interpret it.

Radiata pine pruned log scanned image showing pruned knotty core.

Chilean pruned radiata pine logs being destructively sampled to quantify the size and position of the knotty core following scanning.
Software was able to be applied to the scanned image for the purpose of defining the size and position of the knotty core, and applying the optimum sawing solution.
APPLICATION OF TOMOLOG X-RAY SCANNER TO NEW ZEALAND AND AUSTRALIAN RADIATA PINE

1. Merchandising yard
The greatest application of the TOMOLOG X-Ray scanner is in a merchandising yard, processing full or partial stems, albeit currently constrained to log diameters of up to 50cm. The advantages of such technology are:

a) By combining stem shape with the internal stem quality, optimum log-grade out-turn can be achieved using bucking algorithms.

b) By combining stem shape with the internal log characteristics, quality of each pruned and unpruned log can be precisely quantified based on; knotty core size and position, branch size, internode lengths, and strength & stiffness, ensuring that logs are precisely matched to sawmill and end product requirements.

c) Scanned pruned logs can be segregated based on external and internal characteristics enabling high speed batch sawing as practiced in Europe, if desired.

d) Use of a benign ID tag inserted into pruned logs can also act as reference point for the scanned image, and automated wood processing.

e) Pruned and unpruned logs with known internal qualities will remove processing risk and enable ease of pricing, on an individual log basis if desired.

f) Merchandising yards may become forest warehouses where growers are paid on log quality delivered and wood processors purchase logs of precise quality.

The largest value proposition for use of TOMOLOG X-Ray scanner will be via use in merchandising yards to optimise both appearance and structural log grade out-turn.
The X-Ray image of pruned logs is interpreted by the software to apply a precise quality description for each pruned log relating to exterior shape, size and position of the defect core.

The X-Ray image of unpruned logs is also interpreted by the software to apply a precise description of branch size, whorl depth, internode length, and strength and stiffness.
2. Sawmill

The specific advantage of TOMOLOG X-Ray scanner in a pruned log sawmill will be its application to precisely identify the edge of the knotty core and apply a sawing pattern to maximise clearwood recovery (as shown below). A detailed explanation of the current methodology to describe pruned log quality and potential for further value gains associated with individual internal log description using TOMOLOG is presented in Appendix I.

The ultimate future application of TOMOLOG will be its installation prior to the head-rig of a pruned log sawmill for scanning of logs enabling application of a sawing pattern to optimise clearwood recovery. However until such time as X-Ray technology is able to scan larger logs, TOMOLOG will be best positioned prior to the secondary breakdown saws for the purpose of scanning cants. In this application the head-rig can be used to produce cants of up to approximately 450mm thickness.

It is speculated that such large cants incorporating an opening face on opposing sides, (using a chipper canter) could be produced at a merchandising yard and supplied to the sawmill with an ID and known defect core position and size.

Installation of TOMOLOG X-Ray scanner in sawmills will be best positioned for scanning of cants prior to the secondary breakdown saws. Such large cants could also be manufactured and scanned in the merchandising yard.
The benefits of scanning for internal defect recognition are clearly significant. While the absolute log values in the Table below, may not be precise, the relative potential gains based on internal defect recognition are shown to be large.

3. Plymill

The application of TOMOLOG X-Ray scanner for rotary plywood manufacturing will enable the following, albeit X-Ray scanning advantages are currently limited to logs of up to 500mm diameter until such time as the diameter limit of the technology is increased.

   a) Delivery and purchase of peeler logs with the required internal qualities to meet product demand.
   b) Pruned peeler logs to be classified for ‘Clear Veneer Potential (CVP)’.
   c) Knotty zone boundary to be determined precisely enabling automated peeling of pruned logs relating to change of veneer thickness for clear and knotty zones.
   d) Unpruned peeler logs to be classified for ‘Clear Veneer Potential (CVP)’ and internode length.
TOMOLOG will enable automated peeling of smaller pruned logs relating to change of veneer thickness for clear and knotty zones.

**GOLDENEYE X-RAY LUMBER SCANNER**

The GOLDENEYE X-Ray lumber scanner produced by MiCROTEC will have application in Australasian wood processing plants for automated grading of both appearance and structural lumber. This scanning technology will also enable automated grading and recovery of blocks and clear cuttings components.
The application of the GOLDENEYE X-Ray lumber scanner will enable automated grading of lumber and identification and recovery of blocks and clear cuttings components.
APPENDIX I

Quality index for pruned logs:

A Pruned Log Index (PLI) for sawlogs and Clear Veneer Potential (CVP) index for peeler logs was developed by Jim Park in 1989 and 1999 respectively. Both indices are based on log size, log shape and size of defect core using different mathematic expressions for calculation as shown below. PLI uses a scale of 1 to 10, whereas CVP uses a scale of 10 to 70.

\[
\text{PLI} = \left(\frac{D_{1.3} - DC}{10}\right)^{0.5} \times \frac{D_{1.3}}{DC} \times \left(\frac{C_{\text{vol}}}{L_{\text{vol}}}\right)^{1.6}
\]

\[
\text{CVP} = \left(\frac{R_{\text{vol}} - PDC_{\text{vol}}}{L_{\text{vol}}}\right) \times 100
\]

Where

- \(D_{1.3}\) = diameter (mm) under bark 1.3 m from the butt end
- \(DC\) = defect core diameter (mm)
- \(C_{\text{vol}}\) = volume of common wood (m\(^3\))
- \(L_{\text{vol}}\) = under bark log volume (m\(^3\))
- \(R_{\text{vol}}\) = perfect cylinder volume based on the minimum radius from the log central axis (m\(^3\))
- \(PDC\) = vol of peeler defect core volume based on the radius of the longest pruned branch stub and associated occlusion (m\(^3\)).

Input variables to calculate PLI are obtained via cross sectional destructive sampling or by sawing assessment at the time of pre-harvest.

Both indices are well correlated with clearwood recovery based on board grades and veneer grades respectively. Furthermore PLI and CVP have a strong relationship with net log value regarding production costs and market prices.
Most pruned logs have a strong and direct relationship between PLI & CVP, except for those logs with displaced defect cores.
3.1.2 Quality index for unpruned logs.
Meneses M. & Guzman S. (2002) developed an index for unpruned logs based on Internode Index, called Largo de Internudo Base (LIB). This index is defined as “50% of the log length contains internodes of a length equal or greater than LIB”.

\[
\text{LIB} = \frac{\sum (\text{IL} \geq b)}{LL} \times 100
\]

Where
\( \text{IL} \) = Internode length
\( \text{LL} \) = Log length
\( B \) = 0.2m to 1.6m

Low LIB means shorter internodes for finger joint lumber recovery to maximise production of blanks. High LIB means longer internodes with high potential for shop lumber recovery to maximise door and windows clear cutting components. Several mathematic models have been fitted by Meneses & Guzman (2002, 2006). Stand input data is obtained by measuring the internode lengths of either standing or felled trees.

Fig. Relationship between LIB and recovery of Shop2 & better.

While stands can be assessed to determine an average PLI, or segregated into PLI grades, the relationship with clearwood recovery is only moderately high. But without the detailed knowledge of the size and position of the defect core on an individual log basis, application of a sawing pattern to achieve the best clearwood recovery will continue to be a guesstimate.
Observed relationship between D1.3 and PL (left):

\[ y = 0.1309x - 0.0349 \]

\[ R^2 = 0.2797 \]

Observed relationship between PLI and clear wood recovery (right):

\[ y = 5.8852x - 9.6572 \]

\[ R^2 = 0.6914 \]