Autograding

Structural Framing and Component Products

New Zealand

Mark Maleta
Optimization Business Development Manager
Timber Grading Trivia

• 1754
  – Scandinavian named Swan Alverdson devised first lumber grading rules

• 1924
  – American Lumber Standard Committee (ALSC)

• 1993
  – NZS3603 Timber Structures Standard (April 2007)

• 2004
  – NZS3622 Verification of Timber Properties
    ➢ VSG & MSG
Common Misconceptions

• Timber has defects
  – Timber does not have defects, it has characteristics
  – Various grades allow more or less character

• Automated grading must be perfect & run graderless
  – It’s not and it best not
    ➢ Machine is reliable and consistent at what it does well
    ➢ Human intervention adds value
MGP – Application Requirements

- Structural Grade plus MSG target requirements
  - Bending strength
    - MOR (Modulus of Rupture)
  - Stiffness
    - MOE (Modulus of Elasticity)

- Meet NZS3622 Verification of Timber Properties
  - Initial process evaluation
    - Verified timber certification trademark
  - Daily quality control requirements
Conventional MSR

- Board deflection based machines (since 1960's)
  - Measure local on flat stiffness
    - MOE
  - Predict on edge stiffness
    - MOE
  - Predict on edge strength
    - MOR

On flat

On edge
Conventional MGP Grading Process (Mechanical)

Step 1

Measure
On flat MOE

Quality Control: Machine & End Product

Step 2

Visual Grading

Predict
On edge MOE

ScanTECH 2008
Automated Structural Grading Machine
Typical Automated Structural Grading Technology

- High Resolution Image of Timber
  - 3D shape
    - Lasers
  - External surface characteristics
    - Cameras
      - Black & White
      - Color
      - Multi-spectral
  - Internal characteristics
    - Typically X-Ray, Dielectric, Ultrasound
DataFusion™ - Structural Grading

- **X-ray Sensor**: Density data (AOI)
- **Vision Cameras**: Vision data (Direct, Scatter, Gray, Dot Vector)
- **Laser Profile Cameras**: Dimensional data (Range, offset)

**Optimizer Computer**

- Fully Assembled Defects
  - e.g. Knots, Holes, Stain, Wane, Splits, Shakes

**XRY**

**VIS**

**DFA**

**LPR**

Density data (AOI)

Vision data (Direct, Scatter, Gray, Dot Vector)

Dimensional data (Range, offset)
Methodology - Structural Autograding

- DataFusion™ - Utilizes proven strengths of multiple technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Laser</th>
<th>X-ray</th>
<th>Vision</th>
<th>Tracheid/dot</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knots</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Pith</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Splits &amp; Shake</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Decay</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Slope of Grain</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Width of Growth Rings</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Wane, Want</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Distortion</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cup</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Automated MSG Machine (Non-contact)
Typical Automated MSR Grading Technology

- High Resolution Image of Timber
  - Density (MOR)
    - Typically X-Ray, Dielectric, Ultrasound
  - Stiffness (MOE)
    - Mechanical
    - Vibration
    - Sonic resonance
  - Bending strength (MOR)
    - Mechanical
    - X-Ray
MSR prediction - Laser based vibration measurement

MOE = f (Vibration frequency, board density)
DataFusion™ - Structural & MGP Autograding

- **X-ray Sensor**
  - Density data
  - MOR/MOE correlations and knot location

- **Vision Cameras**
  - Vision data (Direct, Scatter, Gray, Dot)
  - Dot Vector – Slope of grain

- **Laser Profile Cameras**
  - Dimensional data
  - Board vibration – MOE measurement

- **Optimizer Computer**

  Fully Assembled Image
  e.g. all dimensional, surface and internal characteristics, MOE and MOR ratings
**Methodology - MGP Autograding**

- DataFusion™ - Utilizes proven strengths of multiple technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Quantity Measured</th>
<th>Wood Attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>X-ray</td>
<td>Density</td>
<td>Strength, stiffness</td>
</tr>
<tr>
<td>MC (External input)</td>
<td>Moisture content</td>
<td>Quality - Drying process</td>
</tr>
<tr>
<td>LPR laser sensors</td>
<td>Flatwise vibration frequency</td>
<td>Stiffness, strength</td>
</tr>
<tr>
<td>Vision - Dot Vector</td>
<td>Grain angle</td>
<td>Strength</td>
</tr>
</tbody>
</table>
Enhanced MSR Approach

• Measure/estimate strength & stiffness controlling attributes
  – Grain angle
  – Fiber quality
  – Moisture content
  – Knot type, KAR
  – Other defects – splits, hole, etc.

• Combine this information with
  – X-ray data on density
  – Laser generated vibration data for stiffness

• Provides enhanced MOE/MOR predictions
Enhanced MOE Prediction Algorithm

• Combined calculation
  – MOE-V
    ➢ Vibration frequency for specified sections
  – MOE-X
    ➢ X-Ray prediction, including information on knots

• Resulting MOE-XV calculation
  – Used as a local MOE prediction
    ➢ Computed multiple times for all possible cutting solutions
    ➢ Utilized together with structural product grade requirements
Stiffness profile - Steep grain angle/Low stiffness

ScanTECH 2008
Strength profile - Grain angle & knots/Low strength

CWE Strength

MOR (psi)

ScanTECH 2008
Stiffness profile - Area with knots/Low stiffness
Strength profile - Knots & grain angle/Low strength

![Graph showing strength profile with CWE Strength on the y-axis and Position (Inch) on the x-axis. The graph indicates variations in strength across different positions.]

ScanTECH 2008
Structural & MSR Grading Application Specifications

• Operational
  – Feed speed: 245 mpm – 1220 mpm
  – Temperature: -30 C to +50 C

• Material and Products:
  – Sizes: Thickness 33 – 55 mm
     Width 70 – 300mm

• Species (To date):
  – Radiata, Slash, and Pinaster Pine
  – Southern Yellow Pine
  – W-SPF, E-SPF
  – DF/Larch, Hem-Fir and ESLPF mixes
## Potential MGP integrated configurations

<table>
<thead>
<tr>
<th>Model</th>
<th>Technology</th>
<th>Configured for best performance based on specific application requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>XLG</td>
<td>X-ray</td>
<td>Inexpensive solution for strength controlling species. Also available as a short frame for mills with extreme space limitations</td>
</tr>
<tr>
<td>XLG-SR</td>
<td>X-ray and Sonic Resonance</td>
<td>Simple strength and stiffness solution, where stiffness profile is not required and external Sonic Resonance Input is available</td>
</tr>
<tr>
<td>XLG-MC</td>
<td>X-ray and External MC</td>
<td>Variable moisture is important concern</td>
</tr>
<tr>
<td>XLG – E-Valuator</td>
<td>X-ray and LPR</td>
<td>Effective overall MSG solution if stiffness is the major concern</td>
</tr>
<tr>
<td>Conventional MSR</td>
<td>External flatwise MOE profiles</td>
<td>For mills with adequate space for conventional MSG machine, where strength is not major concern</td>
</tr>
<tr>
<td>XLG, E-Valuator and Vision</td>
<td>X-ray, Vision, and LPR with optional external MC</td>
<td>Best MSG solution for stiffness and strength, With integrated structural grading capability</td>
</tr>
</tbody>
</table>
Quantifying the Benefits

- Traditional manual grading process vs. Automated Grading with integrated Quality Assurance process
  - Reduce trim loss (Increase trim accuracy)
  - Increase Grade Yield (Decrease above grade)
  - Reducing Below Grade risk (Stay in Control)
Regional Automated Grading Implementation

• A Newnes McGehee customer in Australia is currently implementing a Structural & MGP Autograding solution with a fully integrated Linear High Grader package utilizing
  – Lasers for dimension and vibration (E-Valuator)
  – X-ray
  – Vision
  – External MC input
Conclusion/Future Development Plans

• Lab and production testing prove significant opportunities exist for quick ROI
  – Improved grade yield and value (Cut-in-Two)
  – Reduction in trim loss

• Future potential developments include
  – Continued correlation and prediction algorithm improvements
  – Probability based stiffness and strength prediction
  – Closed loop QC
Wespine – Prior to Implementation of LHG

- MGP Grading
  - Metriguard HCLT
    - Determine board “stiffness”
    - Grade each piece based on ‘E low point’
  - 3 to 4 Visual Graders
    - Assess all boards for strength (knots) and utility (wane, want, distortion, holes, etc.) requirements
    - Grading required turning board and applying grade mark
    - Needed to be done in 1-1/2 to 2 seconds per board
Wespine Process Improvement Opportunities

- Unable to chop faults out of long lengths
  - Diverting affected material to off-line chop saws
    - 8 to 10 people full-time keeping up with docking
  - Constrained to 35m³/hr production
Wespine – Implementation of LHG

- Installed upstream of Metriguard HCLT
  - LHG includes Laser profiling and X-ray Knot sizing
    - E-valuater (Stiffness and Strength) and VIS modules not available in 2005
  - Combined Grading Methods
    - HCLT determines on-flat stiffness
    - LHG detects and sizes knots and grades utility requirements

- LHG considers HCLT stiffness profile in final grade solution
  - Looks for most valuable cut in 1, 2 or 3 solution
    - Use only one visual ‘check’ grader on the line
    - Grading for splits, resin pockets, fractures & bark encased knots
Wespine – Quality Control Requirements

• QC Personnel remained unchanged
  – Two QC officers each shift
    ➢ Sr. QC monitors performance, routine testing on MSG
    ➢ 2\textsuperscript{nd} QC in QC Lab, continuous MSG monitoring

• Requirements for QC officers changed somewhat
  – Computer literate, navigate in HMI environments
  – Proactive, vigilant and investigative in their approach
Wespine – After Implementation of LHG

• Current benefits
  – Reliability and consistency
    ➢ Set exact limits, grade to exact limits
  – Knot size measurement
    ➢ Improvement in ‘pack check’ compliance
    ➢ Fine tune knot sizing on centre and edge knots to ‘steer’ output
Wespine – After Implementation of LHG

• Current benefits
  – Utility requirements, such as wane
    ➢ Accuracy excellent
    ➢ Adjust limits depending on specific MGP section sizes
  – Overall production now at 50m³/hr, a 43% increase
Wespine – After Implementation of LHG

• Future potential benefits available
  – Conducted testing on LHG Vision module in March 2007
    ➢ Four sided Vision module able to detect splits and resin with enough accuracy to justify future upgrade
  – LHG E-valuator (Stiffness and strength) module
    ➢ Testing not done at this time for this site
    ➢ Currently being implemented in another mill in Australia
Linear High Grader