Why You Should Presort Your Lumber Before Kiln Drying

Gavin Wallace

Kiln drying of softwoods

The aim in kiln drying is to dry each and every piece of timber to the same (known) moisture content:

- without moisture gradient across the pieces
- without internal stresses developing in the pieces
- as quickly (and cheaply) as possible
Sweden – typically slow, low temperature
108 hrs and 75 °C

28x127mm spruce
kiln-dry MC not much
related to green MC

Overall mean MC = 13.95%
Std Dev = 1.26%
=> boards remained in
equilibrium when drying

A’Asia: boards are roasted:

• 50 mm thick structure grade lumber is dried
  at about 140°C, for periods around 12 hours
• Need fewer kilns, higher throughput
• Board MC’s do not remain in equilibrium in
  kiln
• Very difficult to get a uniform MC at end of
  kiln drying
Why is this so hard?

Every piece of wood to be dried is different:
- different initial moisture content
- different grain orientation
- different permeability

This means that when we put them all together in a kiln and dry them under the same conditions we can end up with an equally diverse range of final moisture contents, induced stresses and consequent loss of value of the final product.

The solution:

1. What is needed is a means of assigning each piece of timber a “driability” rating i.e. the optimum time and conditions required to dry that piece of timber to its required final moisture content without causing any loss of value
2. Then grouping pieces with reasonably close driability ratings together
3. Putting them in a kiln for the time and under the conditions best suited to that group.
1. It has been found that the green density of a piece of timber is a good indicator of the “dryability” of the piece.

2. These two pieces have the same green density but different moisture contents and basic densities.

3. After drying the wood density remains different but the final moisture content is similar.

**Moisture Content Sorting**

Most people would think that drying boards with widely varying MCs will result in big variations in final MCs. This can be very incorrect.

2006 trial: 100 juvenile southern yellow pine boards – very poor correlations
Reasons for this:

1. MC is inversely proportional to basic wood density
2. It is much easier to drive out water from lower density wood
3. So, low MC+high SG wood dries at same rate as high MC+low SG wood

Note: basic wood density = SG x density of water
e.g. 0.5 x 1000 = 500 kg/m³

In this extreme example, MC and SG combine to give very little variation in green density
...and it is this small variation in green density that results in a small variation in dried MC, despite large variations in basic wood density and MC

**Fig. 3:** results of kiln drying, 100 SYP boards

<table>
<thead>
<tr>
<th>green density</th>
<th>kiln dry MC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>700</td>
<td>5</td>
</tr>
<tr>
<td>800</td>
<td>10</td>
</tr>
<tr>
<td>900</td>
<td>15</td>
</tr>
<tr>
<td>1000</td>
<td>20</td>
</tr>
<tr>
<td>1100</td>
<td>25</td>
</tr>
<tr>
<td>1200</td>
<td>0</td>
</tr>
</tbody>
</table>

**Conclusion:** green density is the equivalent of dryability, and

- dryability is a measure of the difficulty in drying wood
- green density is a good measure of moisture content
- and has the advantage that it takes into account the increased difficulty of removing water from timber of higher basic density than lower basic wood density i.e. permeability of water in timber is proportional to its basic wood density

SYP is a hard pine, and most softwood species have much larger variations in green densities, and sorting by green density for kiln drying of softwoods is very beneficial
Intuitive selection - green density distribution may be affected by board dimensions
A trial was carried out to determine the benefits of using green density as a predictor of drying rate.

Measurements gave the frequency distribution of green density.

The pieces were selected into 3 equal size groups and measured density was plotted against drying time.
We then plotted reduction in moisture content against drying time for:
- all-in
- <650 kg/m³
- >650 kg/m³

1. Overall drying time is shorter
2. Variability is greatly reduced
### Trial: 25mm *p. radiata* boards (not sorted)

<table>
<thead>
<tr>
<th>Green density kg/m³</th>
<th>Moisture content %</th>
<th>SD %</th>
<th>mean MC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;650</td>
<td>0.0</td>
<td>3.2</td>
<td>13.6</td>
</tr>
<tr>
<td>650&lt;GD&lt;800</td>
<td>5.0</td>
<td>1.7</td>
<td>15.2</td>
</tr>
<tr>
<td>800&lt;GD&lt;950</td>
<td>10.0</td>
<td>3.2</td>
<td>19.4</td>
</tr>
<tr>
<td>GD &gt; 950</td>
<td>15.0</td>
<td>6.4</td>
<td>23.9</td>
</tr>
<tr>
<td>all in</td>
<td>20.0</td>
<td></td>
<td>21.0</td>
</tr>
</tbody>
</table>

### Trial: 50mm *p. radiata* boards (structural)

<table>
<thead>
<tr>
<th>Green density kg/m³</th>
<th>Final moisture content</th>
<th>SD %</th>
<th>mean MC %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;850</td>
<td>0.0</td>
<td>1.5</td>
<td>4.37</td>
</tr>
<tr>
<td>&gt;850</td>
<td>5.0</td>
<td>3.2</td>
<td>13.6</td>
</tr>
<tr>
<td>all in</td>
<td>10.0</td>
<td></td>
<td>11.0</td>
</tr>
</tbody>
</table>

**Graph of green density vs moisture content after kiln drying**
Trial: 50mm *p. radiata* boards

- In A’Asia, 50 mm thick structure grade lumber is dried at about 140°C, for periods around 12 hours
- In the lab. test shown previously, boards were overdried – target was 12%
- Nevertheless, trial demonstrated:
  - Drying time of 7¼ hours was about right for higher density group
  - Only 6 hours was necessary for lighter group, a reduction of 1¼ hours
  - The combined weighted drying time is 6.6 hours, an overall saving of 15%
- Distortion, especially twist, in pine is approximately linear with reduction in MC below 30%; a green density sort significantly reduces loss of timber

**Fig. 2:** Variation of green MC with green density

\[ y = 0.1787x - 59.213 \]

\[ R^2 = 0.7985 \]

**Fig. 8:** Variation of kiln-dried MC% with green density

NB: green density is a reasonable indicator of MC

Boards dried in same charge [target 14%]
Trials: 6m boards 50x100mm

Fig. 10: sorted kiln-dried moisture content distribution

<table>
<thead>
<tr>
<th>% distribution of boards</th>
<th>high</th>
<th>low</th>
<th>all</th>
</tr>
</thead>
<tbody>
<tr>
<td>low</td>
<td>13.5</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>high</td>
<td>20.0</td>
<td>16.7</td>
<td></td>
</tr>
<tr>
<td>all</td>
<td>16.7</td>
<td>16.7</td>
<td></td>
</tr>
</tbody>
</table>

SD: 5.2, 5.5, 5.2

Green density sort power savings
Reduces overall kiln drying time and power usage:
- High green density batch is dried in same time as unsorted charge
- Low green density batch can have drying time reduced by 40% or more
- Low density batches can be 50% of production
- Actual 3-sort example (US): saving 19.4%

<table>
<thead>
<tr>
<th>density</th>
<th>low</th>
<th>med</th>
<th>hi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production amount</td>
<td>25%</td>
<td>50%</td>
<td>25%</td>
</tr>
<tr>
<td>Change in drying hours</td>
<td>-30</td>
<td>-20</td>
<td>0</td>
</tr>
<tr>
<td>New drying hours</td>
<td>60</td>
<td>70</td>
<td>90</td>
</tr>
</tbody>
</table>

- 2-sort more usual – 15% saving typical
Other benefits from sorting can exceed power savings:
Reduces spread in final moisture content:
- Copes with seasonal variations in moisture
- Reduces wets – enhances timber value
- Accurate prediction of properties

Additional sort benefits
- Reduces over-dries
  - Reduction in distortion due to over-drying
  - Reduced trim loss
  - Promotes recovery of boards to higher grades
- Tighter control over shrinkage from drying:
  - reduction in ‘skip’ - hit or miss when planing
  - improved timber recovery from tighter cutting tolerances
- Tighter control of board properties
Tighter control on final moisture content provides better tolerance on board dimensions.

With that better dimensional control, you can cut to finer tolerances, and therefore increase recovery.

An 0.6mm reduction in green cut dimensions of dried 47x147mm board is a 1.6% improvement in wood recovery.
Measurement of green density:

- Gamma ray transmission
- Load cells
- Impact grader

These are usually combined with acoustics to also measure MOE/MSG of boards

Gamma ray transmission: LDS 200

- Uses very low energy gamma rays emitted by sources placed beneath the timber chain
- Gamma rays are measured continuously by detectors placed above the timber chain
- When a board passes between the source and detector some of the gamma rays are absorbed by the timber, so the count rate at the detector goes down
- The amount of decrease is proportional to the green density of the timber and the thickness of the timber
- Board thickness is measured using laser systems
Typical LDS200 calibration, accuracy <4.5%, limited by mix of timber in board (repeatability <1.5%)
LDS 200 - specifications

- Up to 210 pieces per minute at common lug spacings
- Continually self calibrating
- Non contact
- Does frozen wood
- Small footprint
- Quick installation
- Manages power interruptions, safety requirements; self contained
- 20 systems installed

Load cell systems

- Weigh board while moving
  - Can have slower speeds
- Contact system
- Poor signal-to-noise
  - Early systems had poor accuracy
- Several systems on offer, normally aimed at MOE measurements

Dynalyse Precigrader
Load cell system – A Grader

Load cell system – Lakeland Steel
**Impact grader – TIG100**

- New, simpler to install, smaller footprint
- Greater sensitivity to mass
- 3 systems installed – Isoscan
- Determines both density and MOE

**TIG 100 – measure mass by displacement when transversely-moving board is pushed on end**
**Isoscan**

### Static Calibration

**KiwiLumber 20080408 - High : m(est) vs Weight (error = 0.60Kg, 2.9%)**

\[ y = 0.9993x \]

\[ R^2 = 0.9938 \]

**KiwiLumber 20080408 - Med : m(est) vs Weight (error = 0.56Kg, 2.7%)**

\[ y = 0.9994x \]

\[ R^2 = 0.9946 \]

### Dynamic Calibration

**TIG 100 – does both density and green velocity to enable estimation of dry MOE**

**TIG 100**

Mass measurement is novel

**DryTech 2008**
If proof testing, it is vital that this is done at the correct MC.

**Graph:**
- Comparison of proof-tested MOE with TIG100 prediction.
- Line of best fit: $y = 0.9041x$.
- $R^2 = 0.4037$.

**Legend:**
- Over dried boards - no density sort.
- Kiln-dry MC.
- Green density kg/m³.
- In this example, mean kiln-dried MC was 9%, and proof testing results were inflated by 10%.
- Boards would be graded too high in MSG.
- Better kiln drying control will minimise this risk.

**Question:** Any questions?

**Answer:**
- Gavin Wallace.