An Overview of Innovations

New Concepts and Tools in Moisture Measurement and Data Analysis Enabling Grade Recovery Improvement

Presented by Ed Wagner, President
Normal vs. Lognormal

STATISTICS

Analyzing Moisture Content Measurements of Lumber in Dry Kilns

What is the Distribution?

- Wagner Electronics and the University of British Columbia have partnered to develop a new mathematical model to solve overdrying problems in kiln drying.
Normal Statistics used in most mills today

- **It is symmetrical**
  - The mean and median are equal

- **It is bell-shaped**
  - About 68% of values are within one standard deviation $\sigma$ away from the mean $\mu$

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Frequency Distribution of Some Wood

- **Histogram**
- **Y-axis**: Frequency
- **X-axis**: Avg MC
Lognormal Distribution

- The lognormal distribution is the single-tailed probability distribution of any random variable whose logarithm is normally distributed.

Gathering Moisture Data and Sorting on the Green End

Using Gamma Waves
Finding the Best Sorting Method

• 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 takes into account that it is harder to remove the 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

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Green Density Distribution

![Green Density Distribution Graph](image-url)
Creating Higher Accuracy with Moisture Meters

Correcting for Density Variations in Wood

Capacitive Based Measurement Technologies

- Capacitive techniques involve measuring the dielectric properties of water.
- Higher MC increases the ability of wood to store an electromagnetic field’s energy.
- Calibration methods are usually species specific, utilizing an “average” density of board samples.
- Subsequent MC Measurements are based on the calibrated S.G. average.
Typical Density Distribution for Douglas Fir

Normal Dist of density for Douglas Fir
0.49 s.g. Mean, 0.06 s.g. STDEV

Moisture Meter Inaccuracies due to Natural Density Variability

Normal Dist for 19% MC for Douglas Fir
0.49 s.g. Mean, 0.06 s.g. STDEV

(All samples have the same amount of water.)
Mills Response to Density Issues

• Mills know about density effects resulting in inaccuracies in MC Measurements

• They either:
  – Do nothing and lose potential value added dense lumber.
  – Tend to overdry to prevent wet claims
  – Underdry to capture denser, higher valued lumber.

• Improper sorting of dense lumber into the “too wet” category

• Improper sorting of less dense lumber (actually wet) into “good” category which could cause “wet” claims.

• Highly dense boards are often high quality and many should be placed into the highest grade. Higher dense boards hold more moisture than less dense boards of equal MC % as defined by the oven-dry method, but conventional moisture meters will mark these denser boards as being “wet”, causing unnecessary degrade.
Mills Response to Density Issues

- Many times customers adjust their marker to a level where they let more of the dense boards through the system. This also allows boards with lighter densities that are too wet, to get shipped into the marketplace. If the marker is adjusted in this manner, the mill is very vulnerable to getting wet claims as well as having mold grow on their lumber.
- If the mill over dries the lumber so that dense pieces are dry enough to not get dropped out, they will be over drying their lumber. Over-drying by only 2% in a mill that produces 100 mmbf per year can cost the mill $400,000.00 per year, according to Huber.

Independent Density Determination

- To determine MC to a high degree of accuracy, one must determine the specific board density.
- Capacitive based measurement systems do not measure density.
- Hybrid technology utilizing independent density measurement is the key.
- Density compensated systems will enable accurate board level MC determination.
Potential Improvements in Accuracy

Normal Dist for 19% MC for Douglas Fir
0.49 s.g. Mean, 0.06 s.g. STDEV

Moisture Management and Grade Recovery Program
Joint Project with Mike Milota of Oregon State University
Control chart for kiln

**X-Bar Chart For Charge MC (all charges)**

- **Upper Control Limit**
- **Mean**
- **Lower Control Limit**

Chart trend is a measure of the variability from limits, denote an out-of-control situation. Control limits are 3xSD.

- **Moisture content, %**
  - Kiln 1

- **Charge start date**
  - 20 Jan 08
  - 25 Jan 08
  - 30 Jan 08
  - 4 Feb 08
  - 9 Feb 08
  - 14 Feb 08
  - 19 Feb 08

Range chart for kiln

**Range Chart For Charge MC (all charges)**

- **Upper Control Limit**
- **Range**

Chart trend is a measure of package-to-package variability over time. Points outside the control limits denote an out-of-control situation. Control limits are 3xSD.

- **Moisture content, %**
- **Kiln 1**

- **Charge start date**
  - 20 Jan 08
  - 27 Jan 08
  - 3 Feb 08
  - 10 Feb 08
  - 17 Feb 08
Is process getting better or worse?

Average standard deviation of MC based on all boards within a charge (all charges)

Chart trend is a measure of board-to-board variability within the packages over time. The solid line slopes downward if process is improving. Values are based on the Sum of squares between and within packages (total SS).

Not all distributions are normal

The proper statistical methods depend on the type of distribution

Histogram of MC for this charge

Histogram of MC for this charge

Moisture content, %
How representative are hand-held readings?

![Hand-held vs planer moisture content graph]

How representative are in-kiln readings?

![In-kiln vs planer moisture content graph]
How consistent are the operators?

MC at planer by Operator

Finding the Sweet Spot - The Final Achievement

$ Lost per Charge ($300 per mbf)
Fine Tuning the Sweet Spot

Histogram of MC for this charge

Conclusions

I only had time to summarize a number of innovations still in development.

I would like to invite participants to a future webinar with speakers from the University of British Columbia, Oregon State University and Wagner Electronics to explain each innovation in additional detail. A date and time will be published on our website at wagnermeters.com.