

MOISTURE SENSING IN THE DRY KILN

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Agenda

- Why use in-kiln moisture sensing?
- How does it work?
- What variables are involved?
- What kind of results are expected?

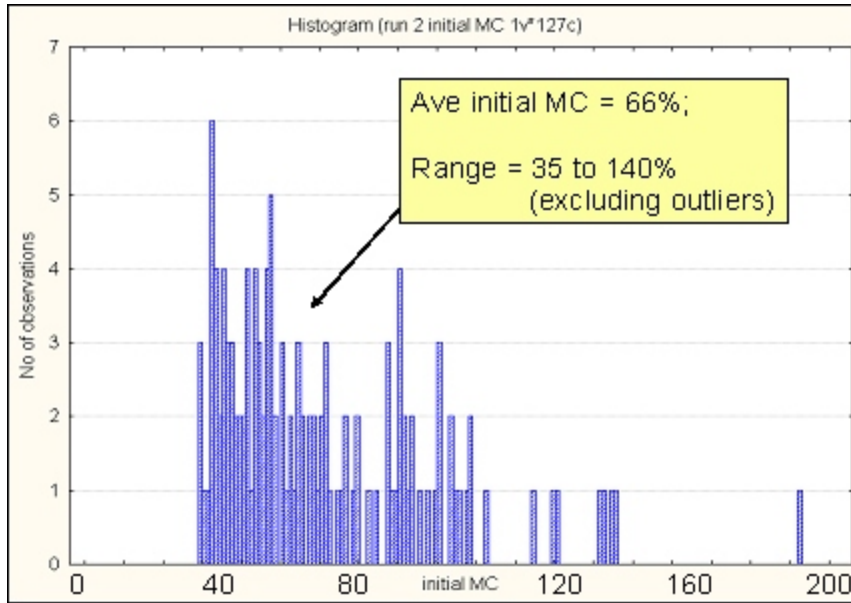
Benefits of Using an In-Kiln Moisture Measurement System

Three key advantages:

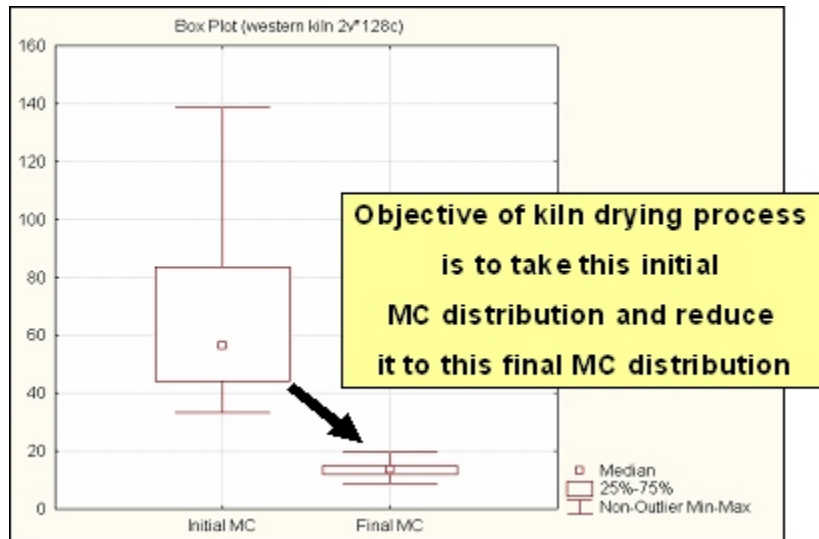
Reduced degrade
Improved throughput
Lower energy costs



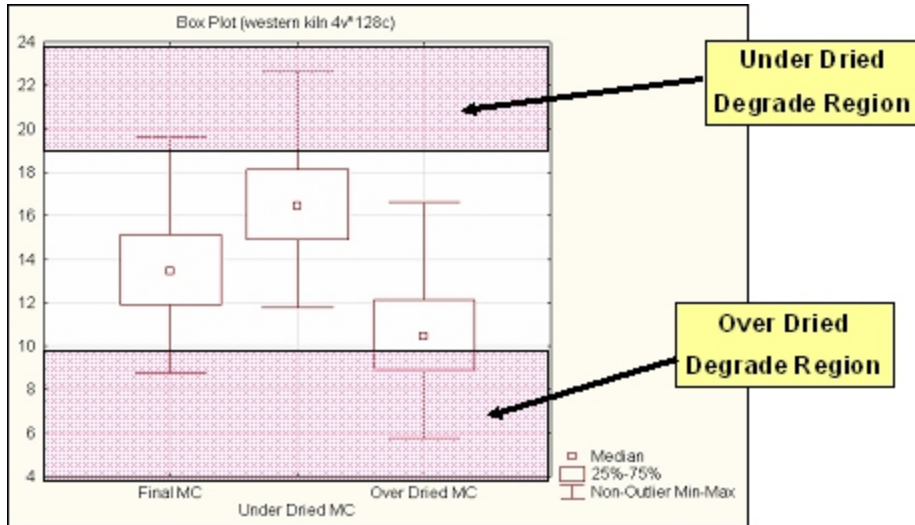
SPF Kiln Package, Initial MC Distribution
 Typical kiln package change in MC, 128 board sample, (kiln study Jan 2006)



How Does Drying Impact the Distribution?
 Typical kiln package change in MC, 128 board sample, (kiln study Jan 2006)



How Does In-Kiln Moisture Measurement Reduce Degrade?
 A closer look at the final MC distribution – effect of 3% error in final MC



How Does In-Kiln Moisture Measurement Reduce Degrade?
 A closer look at the final MC distribution – effect of 3% error in final MC
 128 board sample, (kiln study Jan 2006)

Controlled to accurate final ave MC: 14% target
 Percent under-dried (over 19% FMC): 3.1% (4 of 128)
 Percent over-dried (under 10% FMC): 7.0% (9 of 128)

Probable impact if under-dried by 3%: 17% ave
 Percent under-dried (over 19% FMC): 19.5% (25 of 128)
 Percent over-dried (under 10% FMC): 0

Probable impact if over-dried by 3%: 11% ave
 Percent under-dried (over 19% FMC): 0
 Percent over-dried (under 10% FMC): 42.2% (54 of 128)

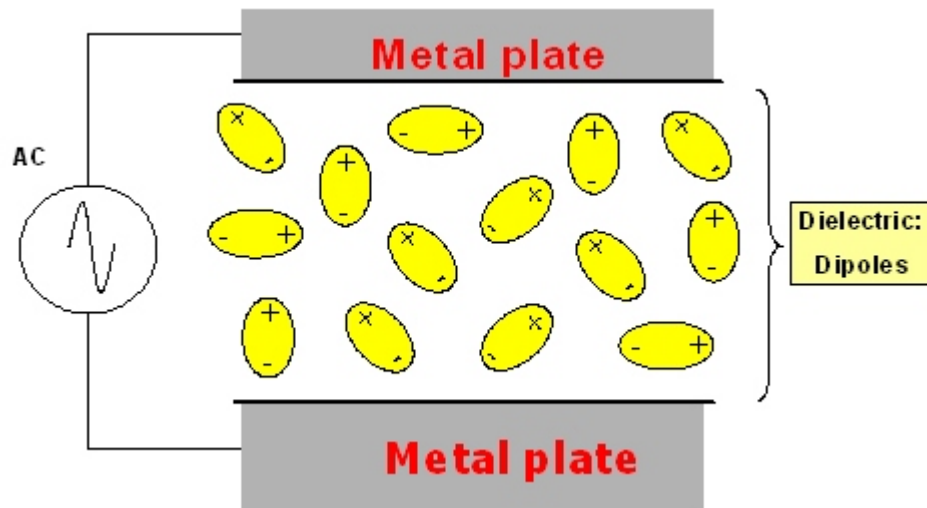
What About Improved Throughput and Reduced Energy Costs?

- Frequently see 20% or more reduction in the length of the kiln cycle because unnecessary over-drying is avoided
- Allows you to move the next load in sooner – improved throughput
- Saves energy due to reduced kiln residence time
- After you reach the optimum final MC, if you don't stop drying you are paying for energy just to cause more degrade!

How Does In-Kiln Moisture Sensing Work?

1. Based on dielectric properties
 - a. Electrical properties of wood
 - i. Conductance (ability to transmit current)
 - ii. Capacitance (ability to store energy)
 - (1) Capacitance measure is the key input
 - (a) Capacitance is driven by dipoles
 - (b) Water is the major dipole in wood

What is a Capacitor?



What Impacts the Capacitance?

1. $C = \epsilon A / d$
2. A = area of the plates
3. D = distance between the plates
4. ϵ = dielectric constant of material between the plates
 - a. Typical dielectric constants
 - i. air is about 1
 - ii. dry wood is about 4
 - iii. water is about 80
5. Presence of water drives the capacitance signal
6. High correlation between MC and capacitance

Sensor Plates Removed from Stack



Top Sensor Plate Inserted in Stack



Both Sensor Plates Attached



Capacitor Formed In-Kiln Stack

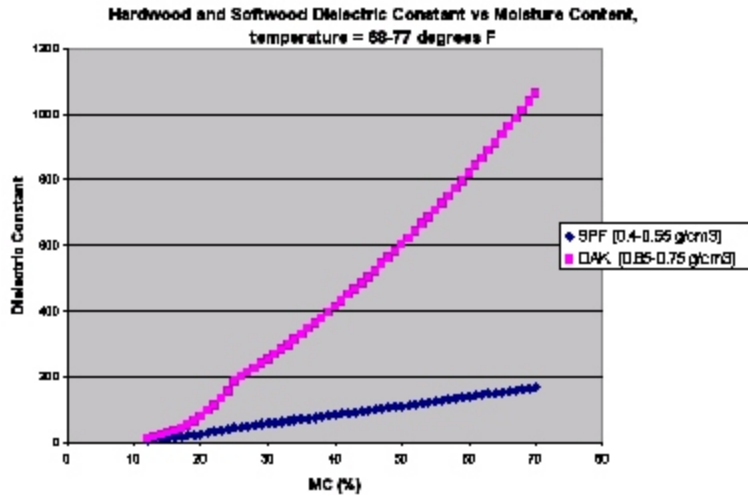
- Place two stainless steel Plates in stack
- Typically about 40 inches apart
- Plates are typically about 5-6 square feet
- Lumber between the plates=dielectric
- Typically up to 8 measurement points in one kiln

What Variables Impact the Readings?

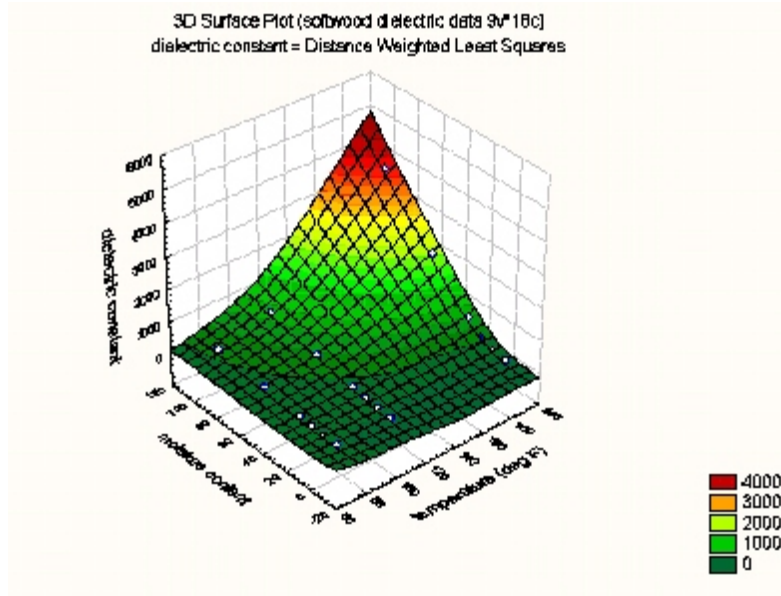
Best reference is Torgovnikov, Dielectric Properties of Wood and Wood-Based Materials

- Significant effects
 - Species and density
We have separate HW and SW models
 - Temperature
Less of an impact under FSP
- Lesser Effects
 - Humidity in the kiln
 - Water pockets
 - Ratio of latewood vs earlywood
 - Even grain direction (not an issue for us—we are always oriented in the same direction)

Hardwood vs Softwood Dielectric Constant (Torgovnikov, Table 5.1).



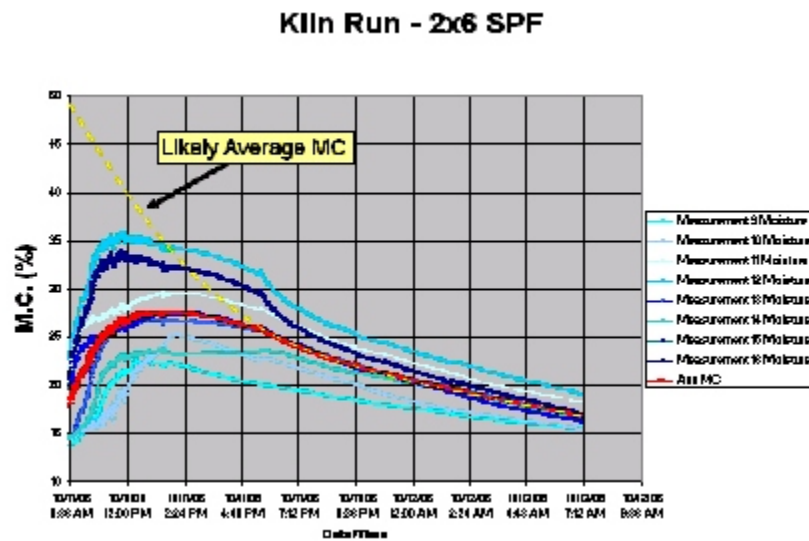
Dielectric constant as function of temperature and moisture content (Torgovnikov, Appendix 2).



In-Kiln Moisture Measurement

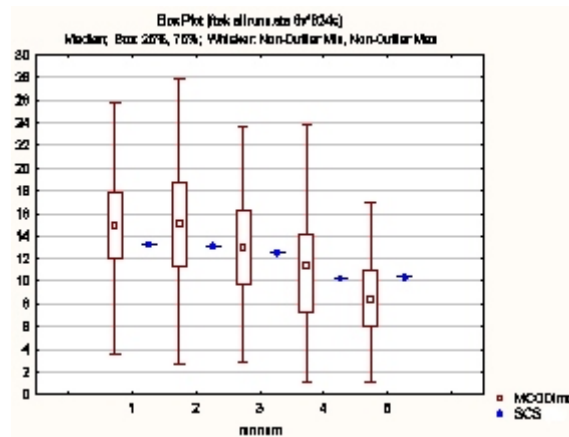
1. Not very accurate early in run (above FSP) due to:
 - a. Ramp up to temperature
 - b. Ramp up to WBSP
 - c. High moisture
 - i. not a perfect capacitor, very lossy
 - ii. lots of running water, free ions, conductive paths, etc.
2. Accuracy improves dramatically from FSP on down
 - a. Conform to more ideal mode of a capacitor
 - b. Very stable relationship between CAP and MC in this temperature and humidity range

Data from in-kiln moisture system (8 channels: Ave MC in red)



What Kind of Results are Expected?

Comparison of SCS Final MC vs Oven Dry Weight
5 kiln runs, 128 board samples, (kiln study Jan 2006)





Questions

If you didn't get all your questions answered here, you can contact me at:
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