DRYING IN ZONES

By **John Robinson**

True multi-zone kiln control must accomplish several objectives.

Two positive developments in the 1980s were multi-zoned kilns and a moisture content (MC) sensor using as its basis temperature drop across the load (TDAL). TDAL has been used since then as the basis for controlling the lumber MC from multi-zoned kilns. However, control systems based on TDAL do not effectively control a multi-zoned kiln because individual zone TDALs are not comparable and, when used as such, introduce error. An effective multi-zoned kiln control system must be able to accurately compare the drying in each zone; determine when and how much control action is needed to force each zone average MC toward the target with minimum MC variation; and to minimize the total drying time. Figure 1 depicts a cross-section of a typical multi-zoned kiln with TDAL temperature sensor locations.

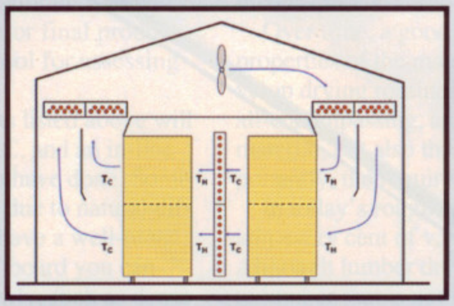


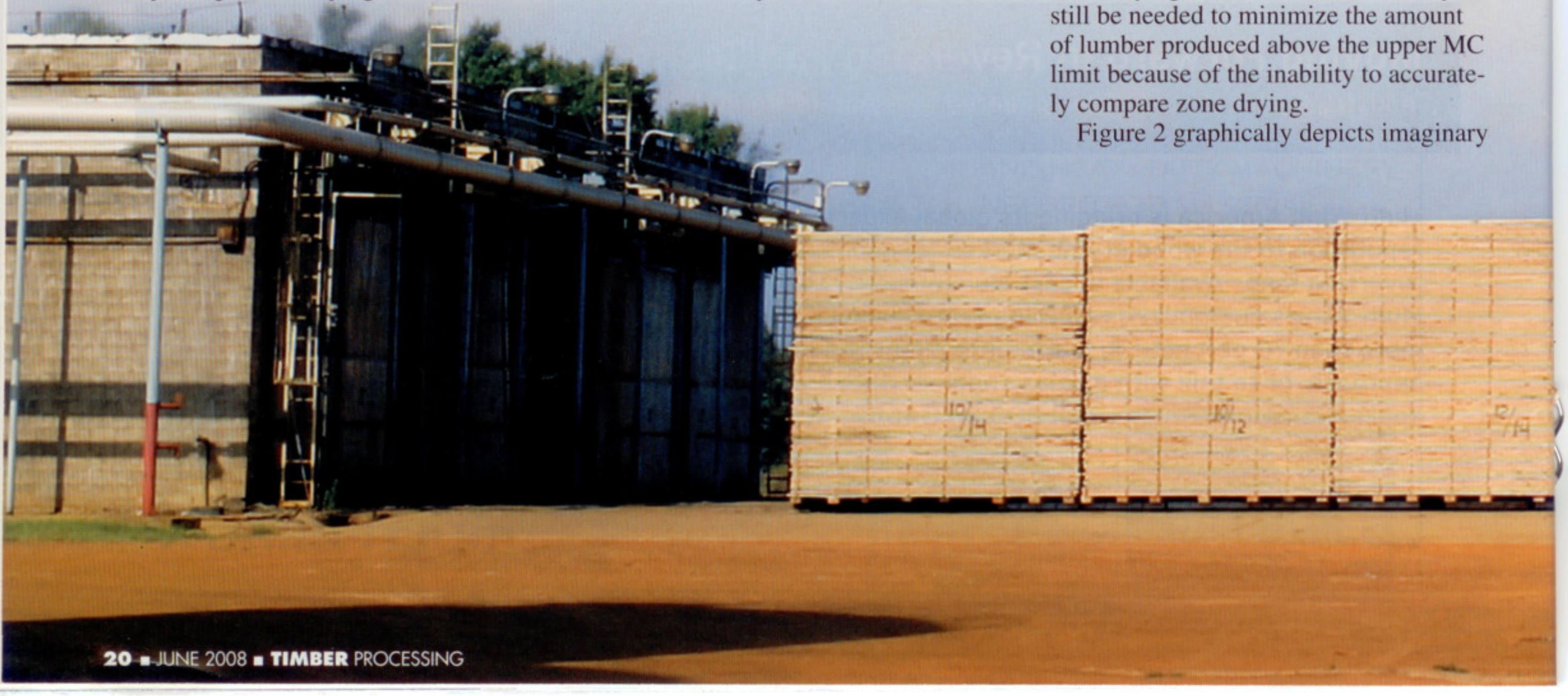
FIGURE 1: Temp Drop Across The Load

CONTROL SOLUTION

The temperature drop (Delta T) moisture control model for batch and continuous dryers was mathematically derived by the author from first principles in 1978, and initially used to control wood veneer MC used in plywood manufacture. Later, it was applied for the control of multi-zone lumber kilns because it offered true zone control resulting from the use of comparable zone drying rates rather than TDALs that are not comparable. Drying rates are directly proportional to the MC when drying is in the lower part (falling-rate) of the drying curve as depicted by Figure 3. Calculation of the drying rates eliminates the error present in raw TDAL data.

The control objective for a multi-zoned kiln is to dry the average MC of the entire lumber load toward the target MC value with a minimum MC variation around that target value and within a reasonable drying time. This control objective was impossible to accomplish using large, single-zone kilns, thus providing the impetus for development of multi-zoned kilns. The only method for controlling single-zoned kilns was to over-dry the lumber such that there was only minimal production above the upper MC specification limit. This, of course, produced a high percentage of degrade. Over-drying in multi-zoned kilns may still be needed to minimize the amount of lumber produced above the upper MC limit because of the inability to accurately compare zone drying.

Figure 2 graphically depicts imaginary



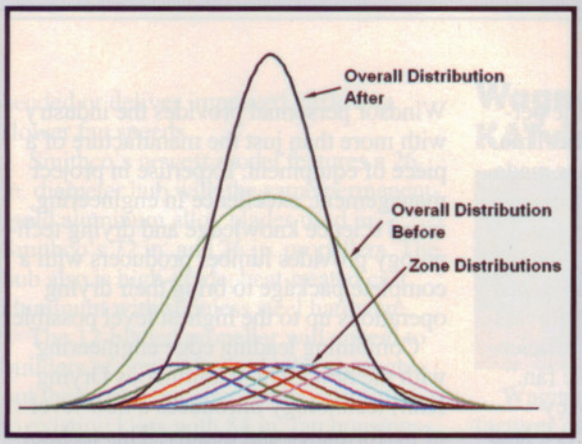


FIGURE 2: MC Distribution Before and After True Multi-Zone-Control

zone MC distributions whose MC means comprise points on the overall distribution curve before multi-zone control. The more narrowed normal curve (after multi-zone control) represents the total dried lumber in a multi-zone kiln produced using the improved MC control system. Although individual zone MC distributions are probably not normally distributed, their means will be normally distributed and may be represented by points on the before control curve. Since MC is proportional to drying rate, comparable drying rate for each zone can be calculated and used to force the zone MCs toward the overall mean MC. These important principles are the underlying justification for using multi-zone kilns; however, true zone control depends completely on the use of a comparable variable such as drying rate.

CONTROL RATIONALE

Effective control of a multi-zoned kiln is totally dependent upon the ability to calculate individual zone drying rates. Figure 3 is a plot of drying rates versus drying time for individual zones of a four-zone kiln. The transition point between constant and falling-rate drying is the fiber saturation point (FSP). It is a very important parameter for determining how, when and to what extent zone drying rates should be forced toward convergence with the target MC mean.

The horizontal portion of individual curves of Figure 3 represents constant rate drying. The drying rate is constant prior to reaching the FSP (about 25% MC), and continuously falls (falling-rate drying) thereafter. Moisture control commences as soon as the first zone reaches the FSP, represented by the first dot on the left. The appearance of the first FSP indicates that this zone is drying faster than the other zones. As successive FSPs are reached, hot air temperatures to the remaining zones are increased to speed up drying. When all zones have reached the FSP they should all be converging toward the target MC. Forced convergence is continued until the target MC is reached and the kiln is automatically shut down using one or a combination of selectable parameters such as relative humidity, absolute humidity, wet bulb, delta t, drying rate, etc.

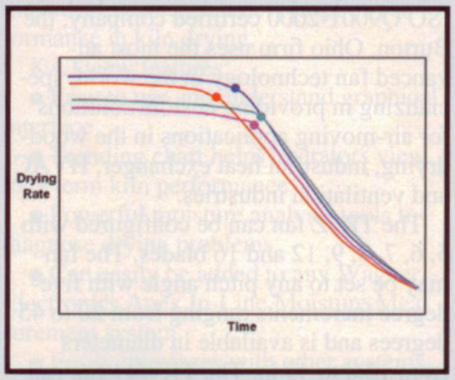


FIGURE 3: Drying Rates Versus Time For Multi-Zone Lumber Kilns

IMPROVED CONTROL

The advantage of this improved multi-zone kiln control system lies in its ability to separate each zone of the kiln in terms of its drying rate. Since drying rates are comparable, each zone may now be classified as to what temperature increase is needed to force all zones to converge on the target MC. Since each zone is being moved toward the overall MC target, this tends to superimpose all zone MC distributions and should produce a finished product on target, with minimum MC variation and over a shorter time period.

Drying rate decreases as MC falls below the FSP and becomes more time dependent. If a kiln is equipped with variable speed fans, the capability for detecting the FSP enables when, where and how much the fan speed may be reduced for energy conservation. Horsepower consumed by a fan motor is proportional to the cube of the ratio of the new fan speed divided by the old fan speed. For example, a fully loaded 30 HP motor at a fan speed of 700 rpms, when reduced to 350 rpms, would pull only 17.3 HP, a 43% decrease. For a high temperature multi-zone kiln, the fans might be slowed during the final 30-35% of the entire schedule. Electrical energy savings for conventional kilns would be greater due to the longer duration of the schedule.

Due to the high cost of degraded lumber, a true zone-controlled system should be considered for new kilns and as a retrofit for existing TDAL based kiln control systems. In addition to significantly reducing the amount of degrade lumber produced, electrical energy savings are possible using the FSP for determining when to and how much to reduce fan speed. TP

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