DRYING UPDATE

Drying Tech Focuses On Kiln Control

EDITOR'S NOTE: The following items were submitted by the manufacturers and suppliers. All statements and claims are attributable to them.

Since it is impractical to measure lumber MC directly during drying, kiln control is highly dependent upon: (1) selection of a controlled variable that correlates well with MC of the lumber; and (2) use of as large a sample as possible. The two most commonly used methods for indirectly measuring MC are: (1) electrical conductivity of wood; and (2) delta T (temperature drop across the load). Reliability of control systems based on either method is affected by unexplained variation in the controlled variable thus causing errors in predicting MC. Perfect correlation between MC and the controlled variable, e.g. conductivity, would have a correlation coefficient squared (R^2) value equal to 1.0. Unexplained variation is measured by ($1-R^2$). For example, if the correlation coefficient (R) for lumber MC vs conductivity is equal to 0.90, the amount of unaccounted variation is 19% leaving only 81% of the variation in MC explained by conductivity. This demonstrates the importance of selecting, as the basis for a kiln control system, a controlled variable having maximum correlation with MC.

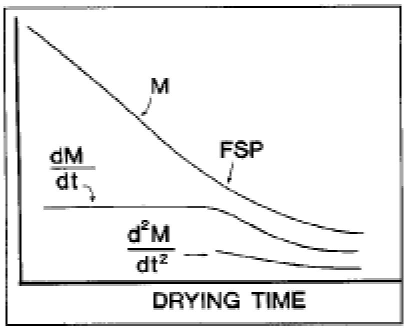

Figure 1

A number of kiln control systems have been installed using delta t (temperature drop) as the predictor for end-point lumber MC and for comparing MCs between zones. Apparently these were installed without proper knowledge of the conditions under which it is valid to use temperature drop as a predictor for MC. Predictably, use of temperature drop for determining endpoint MC and especially for controlling zone-to-zone MC has been replaced in many control systems with some other parameter such as wet bulb or elapsed drying time. Such systems then have no way of forcing zones toward a common endpoint MC, which is a most important requirement of a good kiln control system. Conditions under which the use of delta T (temperature drop) is valid for a kiln control system were determined during the development of the DELTA T model and are presented below.

Drying Technology, Inc., Silsbee, Tex., developed and patented the DELTA T kiln control model, $MC = K_1(dT)^p - K_2(D_t)^q$, where MC of the lumber is related to the delta T (dT) across the load, and the drying time (D_t). It defines kiln drying in terms of a variable (delta T) that is easily determined. However, in order for it to be valid for predicting MC and for comparing MCs between zones, drying must be in the falling-rate period and dry bulb temperature and air flow to each zone must be equal. Since these conditions are seldom met, it would appear that use of temperature drop as the basis for a kiln control system is not wise. For this reason a new kiln control system has been developed that retains the DELTA T model but eliminates the errors involved in predicting single values of MC.

Due to the possible errors associated with the use of conductivity and delta T, some other basis for kiln control is needed that significantly reduces such errors. Based on recent installations, it appears that the use of drying rates and the rate of change in drying rate offer a more accurate basis for comparing zones and controlling zones toward a common MC setpoint. These new control paramenters are obtained by differentiating the Delta T model with respect to time to obtain, $-[dM/dt]$ = the drying rate, and taking the second derivative gives $-[d^2M/dt^2]$ = change in drying rate.

This method eliminates unaccounted for errors associated with the delta T (dT) vs MC correlation by the differentiation step. Since the correlation coefficient (R) between moisture and its first and second derivative is 1.0, this new method offers excellent reliability as the basis for a kiln control system.

Moisture, drying rate and rate of change in drying rate, when plotted against time, are shown by Figure 1. Notice that after the initial period to bring up to kiln operating temperature, the drying rate is constant and continues as such for a period of time called constant-rate drying. Drying during this period is heat-transfer controlled, i.e., drying rate is proportional to the amount of heat that can be introduced. At the lumber fiber saturation point (FSP), essentially all free water has been removed, leaving only bound water, Drying now is much slower being controlled by the rate of diffusion of water to the surface. This falling-rate period is shown by Figure 2 where the curves turn downward toward zero. Drying rate cannot be increased during this period by adding heat above a minimum value. This is the basis for installing variable speed fans to save energy during the period of low heat demand. Each parameter, delta T, drying rate and rate of change in drying rate are available; however, drying rate and rate of change in drying rate are more accurate as predictors of MC than is delta T alone.

Based on this new development, Drying Technology offers a kiln control system utilizing drying rates and rate of change in drying rates along with three other parameters, drying time, delta T and wet bulb depression. This control system, the Five Parameter Differential Calculus Method, has been successfully validated for both multi-zoned steam and direct-fired kilns. Its higher reliability is based on eliminating the error associated with individual temperature drop values shown as $[(dT_1 + error) - (dT_2 + error)] = d(dT)$.

Figure 2 depicts typical drying rate curves displayed by the control system for a multi-zoned steam heated kiln. Drying rates are monitored and forced toward the setpoint value corresponding to the desired final lumber MC.

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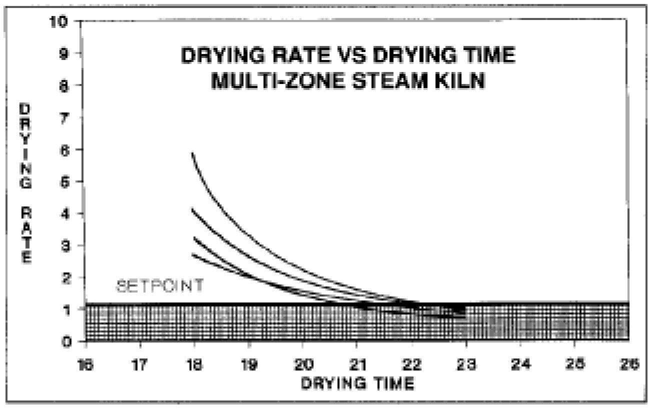

Figure 2

AS APPEARED IN TIMBER PROCESSING MAY 1993