

THE USE OF CHARGE WEIGHT TO MONITOR DRYING AND DETERMINE FINAL AVERAGE MOISTURE CONTENT

Fred Taylor
Mississippi State University
Mississippi State, MS

INTRODUCTION

This presentation is not based on a classical research project with experimentation that resulted in data that could be analyzed to prove or disprove a hypothesis. It is, instead, an idea that is being presented for discussion and criticism. The idea has grown from experimentation at the Mississippi Forest Products Laboratory, but I can take no credit for originality. Others have considered using charge weight for kiln control, but they have not published these thoughts nor used the method commercially.

Interest developed because there is a research kiln at the laboratory that has a weighing system. It is used for developing drying curves, monitoring rate of drying, and other research data collection. However, researchers very quickly started using charge weight to determine when lumber was dry.

FINAL AVERAGE MOISTURE CONTENT DETERMINATION

Determining when lumber in a high-temperature kiln is dry is difficult. Kilns cannot be entered, so some remote technique must be used to estimate moisture content. Techniques currently used for estimating when southern pine is dry are time schedules, temperature drop across loads (TDAL), and electrical measurements. Using the internal temperature of wood has been proposed.¹

Time schedules are the most commonly used approach. If lumber with similar green moisture content and drying characteristics is dried in successive charges by the same drying schedule, the time required to reach a desired final moisture content is constant. In practice, kiln operators adjust drying time to compensate for the width of lumber being dried, for lumber sawn from logs stored in water, for summer to winter ambient temperature differences and for other variables. The time schedule is very accurate in most cases, but the schedule is not reliable if the kiln operation is interrupted while a charge is drying.

TDAL is being used successfully to estimate moisture content. Although TDAL decreases as moisture content decreases, values are erratic and are not highly correlated to lumber moisture content.² Strict use of TDAL for kiln control may result in premature termination of drying. Some computer programs use TDAL to determine when to terminate drying. Such programs prevent a premature

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Panow, Stan and M.R. Nester. 1985. Drying endpoint determination during high-temperature drying. *Forest Prod. J.*, 35(10):51-55.

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Landock, D.M. and F. Taylor. 1989. Examination of the air temperature profile across lumber in the high temperature drying of southern pine. *Proceedings West Coast Dry Kiln Association Meeting*, May 2-4, 1989, Coeur D'Alene, ID.

stoppage of the drying process by restrictions such as specifying a minimum drying time, using a moving average of TDAL, placing constraints on fan reversal, or imposing a time constraint that requires the TDAL value to be maintained for a specified time period. Like time schedules, TDAL procedures lose effectiveness when kiln operations are interrupted.

Electrical techniques (wood temperature or resistance measurements) require electrical connections and usually require that sample boards (monitoring locations) be scattered through the charge. Resistance measurements are affected by moisture and temperature gradients in wood. Therefore, these measurements are calibrated for assumed gradients at the desired final average moisture content. Also, electrical techniques give little information about moisture content on drying rate above the fiber saturation point of wood.

CHARGE WEIGHT AS AN ESTIMATOR OF AVERAGE CHARGE MOISTURE CONTENT

The weight of a piece of wood depends upon its size, specific gravity and moisture content. All of these factors vary from piece-to-piece in Southern pine lumber. The green weight of 16 foot 2 x 6's at one southern mill is known to vary from 37 pounds to 59 pounds, and calculated oven dry weights vary from 20 pounds to 34 pounds. Such wide variations preclude the possibility of using weight alone to estimate the moisture content of any board. But when a large number of 2 x 6's are considered collectively, the piece-to-piece size and specific gravity are normally distributed around a specific mean values. So, the mean size and specific gravity of pieces in one charge are similar to the average size and specific gravity of other charges. Therefore, the oven-dry weight of one kiln charge is approximately the same as the oven-dry weight of another charge containing the same number of pieces.

This contention is supported by the data presented in Table 1. The range of the calculated oven-dry weights of these charges was only 313 pounds, from 12,372 pounds to 12,059 pounds. This close agreement was obtained from mill run lumber in charges of approximately 5,000 board feet. For larger charges in commercial kilns, the relative range should be even less.

Table 1. Weight and moisture content values for 7 charges of pine lumber. Each charge contained 330 pieces of 2x6x16 (5,280 bd. ft.).

Green Weight #	Dry Weight #	Final Avg. MC. %	Calculated O.D. Weight #	Calculated Weight @ 12% #
21,635	13,820	14.6	12,059	13,506
24,350	13,550	11.4	12,159	13,618
23,950	13,660	12.0	12,196	13,660
23,580	13,680	12.0	12,214	13,680
23,895	13,790	11.8	12,335	13,815
23,030	13,810	11.8	12,353	13,835
23,705	13,685	14.6	12,372	13,857

Since oven-dry weights are constant, charge weight can be used to estimate moisture content at any time during the drying cycle. Factors necessary for the calculation include the weight of non-lumber items (kiln trucks, stacking sticks, etc.) and the number of pieces of each nominal size in the kiln. In modern Southern pine mills, these values are easy to obtain. Kiln trucks are of the same design and constructed of all metal. Stackers build stacks containing the same number of layers of one length and width board. Therefore when kilns are charged, a piece count can be obtained by knowing the nominal size of each unit stack in the kiln.

ADVANTAGES OF USING CHARGE WEIGHT TO DETERMINE FINAL AVERAGE MOISTURE CONTENT

The use of charge weight to monitor drying and determine final average moisture content has several advantages. Moisture content predictions are independent of drying schedule and unrelated to moisture gradients in the wood. Permanently installed hydraulic or mechanical equipment can be used to measure weight. Information about drying rate above FSP is available. Zone control along the length of the kiln is possible.

If the kiln operation is altered, either intentionally or accidentally by an equipment failure of the kiln or heating system, charge weight continues to give a true estimate of average moisture content. End-point can be determined accurately no matter how much the normal schedule is shortened or lengthened.

Charge weight can be used to study moisture loss during drying (Figure 1). The slope of the drying curve is the rate of drying. Therefore, it is possible to determine the effect of wet bulb depression or changes in air velocity on drying rate at any time during the drying cycle.

If the weighing system is segmented so that the weight of discrete sections along the length of the kiln are weighed separately, the average moisture content of wood in individual zones can be estimated. If weight is used to control the drying rate in zones, then zones could be dried at different rates.

CONTROLLING KILN CONDITIONS BY CHARGE WEIGHT

Hardwood kilns use schedules that are based on moisture content and that consider drying rate. Moisture contents are determined by weight measurements of sample boards located throughout the kiln. Not only are samples used to determine the average initial moisture content, they are also weighed repeatedly during drying to monitor moisture content changes on which schedule changes are made. If a similar sampling method was used to determine the average initial moisture content of a charge, then charge weight could be used to control the rate of drying, to start the equalizing schedule, and to condition the lumber. With the aid of a computer controller, changes could be made at the appropriate time without intermittent weighing of sample boards by operators.

Current moisture content schedules consider the moisture content of individual samples. Schedule decisions are based on the wettest or driest samples instead of on the average moisture content of the charge. Therefore, schedules would need to be modified for making changes based on average moisture content values. Effective schedules could probably be developed for most species and sizes because the sample board selection process is aimed at selecting a range of samples to represent the average.

SUMMARY

The proposition is made and supported with experimental data, that charge weight can be used to estimate average moisture content of lumber drying in a kiln. For Southern pine lumber, the variables of piece size and specific gravity are normally distributed, so charge weight can be an accurate estimator of average moisture content. Therefore, charge weight can be used to determine desired final average moisture content when the number of pieces of each nominal size in the charge is known. Such piece counts are easily determined in modern pine mills because lumber is stacked for drying in packages of constant size and uniform piece count.

For charges of mixed length and width lumber or for charges of lumber that is not green trimmed or square edged, average green moisture content must be determined. If average green moisture content is known, charge weight can be used to monitor drying rate. Charge weight can also be used as a basis for making schedule changes, equalizing, conditioning and terminating drying.