CAM OPERATED KILN CONTROL SYSTEM

by

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Introduction

A feature of most lumber dry kiln recorder-controllers in use today is that temperature and humidity conditions are manually set according to predetermined schedules. These schedules developed through long experience and research consist of periodic stepwise changes of kiln condition. Since moisture escapes from wood continuously rather than in abrupt steps, it seems logical to also change kiln conditions continuously throughout a kiln run. This, of course, can only be accomplished with a cam operated controller or other automatic programming device.

A possible reduction in the required kiln drying time without a harmful effect on lumber quality could be expected when kiln conditions change continuously. When stepwise drying schedules are employed, optimum drying conditions are obtained only at the time of temperature and/or humidity change or shortly thereafter. During the period between two subsequent steps of a given schedule, the kiln conditions become increasingly less efficient until the moisture content of the lumber reaches a predetermined level at which the next change in kiln conditions is made. This thought was to be tested by changing a commonly used stepwise kiln schedule to one in which the kiln conditions are gradually changed by the action of a cam.

Of the many devices that may be employed to measure and control the temperature in lumber dry kilns, instruments of the fluid filled, thermal expension type are almost always preferred to bimetallic thermometers or thermal-electrical controller-recorders. These instruments of the fluid filled type actually transmit the temperature dependent expansion and contraction of a liquid, vapor, or gas to a mechanical linkage which, in turn, activates air pressure or motor operated valves. In most cases, vapor actuated systems are installed in lumber dry kilns.

Vapor pressure instruments have many excellent features, but possess one that often becomes a disadvantage when accurate low temperature control is desirable in predryers or kilns employed for drying refractory species. Their response is not linear and the sensitivity decreases at low temperatures. Such a disadvantage is not encountered in gas filled instruments where a linear relationship between the expansion and contraction of the gas with temperature results in uniform scale divisions and a uniform recording accuracy over the entire temperature range. Because of this it was of interest to test a nitrogen filled pressure-spring instrument in a lumber dry kiln.

Objectives

The objectives of our study were: 1) to compare the accuracy of a temperature recorder-controller equipped with nitrogen gas filled bulbs and pneumatic transmitters to a system having vapor filled bulbs and to a recording potentiometer with thermocouples, and 2) to investigate the possibility of a reduction in the drying time of partly air seasoned, heavy segregation 4/4 inch redwood lumber of the "Clear and A" grade by gradual rather than stepwise changes of kiln conditions and, if possible, by also slightly modifying this new schedule based on gradual temperature changes.

Two pneumatic pressure-controllers connected by means of temperature transmitters to nitrogen gas filled bulb thermometers were installed on the 5 M bd. ft. capacity kiln at the California Forest Products Laboratory.

One of these two instruments operated on an "on-off" principle and recorded and controlled the dry bulb temperature. The two nitrogen gas filled dry bulbs, which were connected each to a pneumatic temperature transmitter by a small capillary tube, provided a calibrated signal that was converted to air pressure. The air pressure was transduced through a 3/8 inch copper tubing to a spring type pressure element in the recorder controller. The dry bulb at the entering air side of the kiln was selected by a three-way solenoid valve and activated by the reversible fan motor of the kiln to control the dry bulb temperature.

The other instrument was installed to control the relative humidity in the kiln and obtained its temperature signal from a single wet bulb. This instrument was a narrow band proportional controller and with it the opening of the steam spray valve or of the ventilation system could be adjusted to be proportional to current steaming of ventilation requirements.

Air of 40 to 60 psi pressure was supplied by an air compressor to a filter-regulator where it was reduced to the pressure of 20 psi required for the temperature transmitters and record-controllers. The temperature range that could be recorded and controlled extended from 50^{o} to 200^{o} F. A rotating aluminum cam on each instrument provided the automatic temperature and humidity control.

Four experimental kiln runs were carried out. The first three 5 M bd. ft. loads were of approximately the same initial average moisture content (about 43 per cent), the fourth load was somewhat wetter (52 per cent average moisture content).

Drying of the first load was performed according to a normally used, stepwise kiln schedule supplied by personnel of the Union Lumber Company. This established a basic reference in respect to drying rates and kiln performance. The second kiln run was controlled by cams following the same cardinal points of dry bulb and wet bulb temperatures outlined in the basic schedule with the only exception that these points were connected by lines that gradually increased or decreased with time.

In the third kiln run, use was made of the experience gathered in previous drying studies on redwood lumber (1). Results of these investigations had indicated that lower relative humidities than those employed in the first and second kiln run would increase the drying rate appreciably without causing defects. Thus the schedule was streamlined to run for 10 rather than the original 11 days. The connection lines between cardinal points of the schedule actually followed logarithmic curves because it has been previously determined that the drying rate of redwood can be expressed as exponential function of its moisture content. In this manner an attempt was made to change the temperature in the kiln at a rate similar to the moisture content changes of the wood.

The fourth kiln run was carried out with the primary objective of varifying observations made previously. Because of the higher initial moisture content of the lumber the schedule was extended to twelve days by twice turning the cam back for 24 hours.

Moisture content changes during all kiln runs were observed on eight, four feet long moisture sample boards per run. After the completion of each kiln run, stress and moisture content sections were cut. All the lumber was returned to Fort Bragg where it was surfaced on four sides and inspected for drying defects.

<u>Results</u>

The sensitivity of the two recorder-controllers was 0.01 per cent of scale for the range of 50^{o} to 200^{o} F according to specifications. Under the kiln conditions used during the test runs, a temperature variation of 3^{o} F as recorded on the thermocouple connected potentiometer could be read as a 2^{o} F variation on the instruments. The variation in the wet bulb temperature could be limited to a $\pm 1/2^{o}$ deviation from the preset value because of the proportional control arrangement.

The reading and setting accuracy of an instrument depends partly on the number of scale divisions per inch. In this respect, the gas expansion type instrument had an advantage over most other kiln instruments in use today. While the temperature range from 100^{o} to 180^{o} F, in which most kiln schedules operate, extends over 1.26 to 1.69 inches on charts of most vapor expansion instruments installed in lumber dry kilns, the same range extended over 2.20 inches on the chart of the gas expansion instrument used in our study.

The cam control of temperature was satisfactory from an operational standpoint, when gradually changing kiln conditions were desired. A comparison of drying rates obtained in kiln runs 1 and 2 had already showed that the continuous change of kiln conditions as implemented in the second run had resulted in faster drying than was possible with the original step by step schedule. An inspection of the unsurfaced dry lumber indicated that slightly faster drying did not affect the lumber quality. Therefore the third kiln run was carried out according to a slightly changed schedule. In it a lower relative humidity during the middle portion was specified. Another change was the maintainance of a dry bulb temperature level of 170^{o} F during the equalization period. In the commercial stepwise schedule the lowering of the dry bulb temperature from 170^{o} to 160^{o} F is usually necessary prior to the conditioning period in order to prevent a temperature rise above 170^{o} F as soon as the steam spray was turned on. The gradual change in humidity leading to the conditioning period in kiln run 3 did not cause such excessive heating.

The result of all these changes was a reduction in drying time from eleven to ten days. The inspection of the surfaced lumber dried in the first three kiln runs did not show an increase in the amount of drying defects.

The fourth kiln run ended after twelve days of drying. However, not all the kiln samples had come to the desired final moisture content of 10 per cent. It was concluded that a 12 day schedule was slightly too short for lumber starting at an average moisture content of 52 per cent. The quality of the surfaced lumber was good and therefore only a slightly longer equalization time would have been required.

Future verification runs

The kiln control system discussed has been transferred to Union Lumber Company and installed in a commercial kiln where it is being tested under industry conditions at the present time.

Reference

(1) Resch, H. and B. A. Ecklund, 1964, Accelerating the drying of redwood lumber. Cal. Agr. Exp. Sta. Bull. 803

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