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NEED FOR UNIFORMITY OF TEMPERATURE IN A FORCED-AIR-CIRCULATION, VENTILATED, COMPARTMENT DRY KILN

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NEED FOR UNIFORMITY OF TEMPERATURE IN A FORCED-AIR-CIRCULATION, VENTILATED, COMPARTMENT DRY KILN

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In order to produce uniformly dried lumber quickly and with a minimum of seasoning degrade, the drying conditions on the entering-air side of the kiln charge must be quite uniform. The wet-bulb temperature throughout a dry kiln at any specific stage of drying is usually quite uniform. Therefore, variations in drying conditions on the entering-air side of the load are usually associated with nonuniform dry-bulb temperatures.

The purposes of this report are to (1) point out the need for uniform temperatures, (2) indicate some of the ill effects of nonuniform drying conditions, and (3) point out some of the major causes for nonuniform temperatures.

Need for Uniform Temperatures

Lumber and wood items are usually kiln dried under prescribed drying schedules. These schedules are rather mild in the initial stages of drying of green stock, and become more severe as the moisture content of the wood decreases.

To hold drying costs to a minimum, the lumber should be dried as rapidly as possible. Therefore, the dry-kiln operator should use drying conditions that are as severe as is practical during all stages of drying. Excessive variations above or below these drying conditions due to differences in entering-air temperatures are likely to result in any one or a combination of excessive drying defects, excessive variations in final moisture content, and increased drying time.

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[1]Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Ill Effects of Nonuniform Temperatures

Drying Defects

There are three classes of defects associated with nonuniform temperatures: those caused by drying stresses, fungi, and chemical stains. Drying-stress defects that occur in localized zones in a dry kiln are usually caused by excessively high temperatures. Molds and stains resulting from fungal attack are the result of excessively low temperatures coupled with high humidities. Chemical stains may be associated with excessively high or low temperatures, depending upon the species being dried.

Drying-stress defects:--The major defects caused by excessive drying stresses are surface checks, end checks, splits, honeycomb, and ring separation. If the proper drying schedule is used, these defects will occur only in zones in the kiln in which the entering-air temperature is excessively high. These are commonly called "hot zones."

The degree to which the temperature in the hot zone can exceed the desired temperature, without the development of excessive defects caused by drying stresses, depends on variables such as the drying schedule used, the species being dried, and the thickness and moisture content of the lumber. If the schedule is a critical one, slight variations in temperature above the set-point may, in the initial stages of drying green refractory woods, result in excessive end checking, surface checking, and splitting. If the drying conditions are not corrected, end and surface checks will very likely increase in depth and cause serious internal failures.

Specific cases of excessive losses associated with too high temperatures can be given. In 1 dry kiln, a hot zone with an initial drying temperature 7° F. above that desired resulted in the loss of 40 percent of a truckload of 5,000 board feet of 4/4 red oak being dried green from the saw. This loss was caused by excessive end and surface checks and splits. Excessive losses associated with honeycombing occurred in 2 charges of 8/4 oak dried in a kiln that had a hot zone in which the temperature exceeded that desired by 12° F. The cause of the excessive temperature was found and corrected, and losses due to honeycombing were materially reduced. In still another kiln, a kiln truckload of 2-inch-thick Sitka spruce was badly degraded because of a hot zone in which the temperature exceeded that desired by 13° F.

Chemical and fungal stains:--Stains caused by fungi are associated with temperatures below 115° F. Chemical stains may be associated with excessively high or low temperatures. In the drying of many green refractory hardwoods, particularly those 1-1/2 inches or more in thickness, the initial drying conditions are quite mild. Temperatures may be 115° F. or below, with wet-bulb depressions of 6° F. or less. Under such a schedule, only a slight reduction in temperature below that desired, due to a cold zone,

will generally result in the development of fungal stains and some of the chemical stains, particularly brown stains in some of the softwoods. While these stains do not effect the strength of the wood, they do result in discolorations that are, in many cases, considered defects. The growth of fungi can be retarded and sometimes prevented by sterilization treatments, but such treatments prolong drying time.

Molds:--Molds frequently develop on the surfaces of wood in cold zones in a kiln, particularly if mild drying conditions are used in the initial stages of drying green wood. In one instance in the drying of a charge of green, 3-inch white oak bending stock, a cold zone with a temperature 3° F. below that desired resulted in the development of mold so thick that the air passageways between courses of lumber were practically closed. In another instance, a cold zone with a temperature 8° F. below that desired resulted in heavy mold growth on green walnut gun-stock blanks. In both of those cases, sterilization treatments were required during the initial stage of drying before the mold growth could be stopped. The result was increased drying time and steam costs.

Variations in Final Moisture Content

The drying rate of lumber varies, among other things, with the drying conditions. The more severe the drying conditions, the faster the lumber dries. It follows, therefore, that any variation in drying conditions will result in increasing differences in moisture content between boards in the hot and cold zones of a kiln as drying progresses. The end result will be that the faster drying material may be over-dried or the slower drying material may be pulled from the kiln at too high a moisture content. This has been found to be true at many plants.

A plant manufacturing furniture experienced considerable trouble with warping and glue-line failures in their finished product. Moisture studies revealed a considerable variation in the moisture content of the kiln-dried lumber. This variation in moisture was subsequently found to be associated with a cold zone in the kiln near a badly damaged door.

Increased Drying Time

It has been mentioned that variations in entering-air temperatures affect the drying rate of wood, and thereby its final moisture content. The drying conditions used in drying a charge of lumber are generally governed by the wetter stock in the kiln. Therefore, in kilns with localized cold zones, the drying time of a large portion of the kiln charge will be unnecessarily extended because of slower drying in the cold zone.

Also, variations in moisture content near the final stage of drying will prolong the equalization treatment given to establish uniformity of moisture content between boards. In some extreme cases, equalizing treatments that should have taken 1 day have been extended to 3 days in order to obtain the desired moisture uniformity.

Causes for Nonuniform Temperatures

There are three major causes for nonuniform drying conditions in a lumber dry kiln: improper design, poor maintenance, and improper operation. Any of these, singly or collectively, will result in poor drying.

Kiln Design

Most modern forced-air-circulation kilns are well designed, and when properly operated and maintained will produce well-dried lumber in a minimum drying time. There are, however, many individuals who design and construct their own kilns. Some of these kilns do a satisfactory job of drying. But, generally speaking, "home-made" kilns will not produce properly dried lumber because of poor design. Money will be saved and better kiln-dried lumber will be obtained by building a kiln designed by manufacturers of such equipment.[2] All dry kilns should be equipped with instruments that automatically control the temperature and humidity.

Kiln Maintenance

A lumber dry kiln is one of the most important pieces of equipment at a wood-using plant. Good product design, machining, and fabrication will in themselves be of little value if the wood is not dried to the proper moisture content with a minimum of drying defects. Dry kilns, however, regardless of how well they are designed and constructed, are not indestructible. They are subjected to very adverse operating conditions, such as extreme variations in temperature and relative humidity, the corrosive action of volatile substances from the wood being dried, and damage from falling lumber due to carelessness on the part of workmen. Kilns cannot operate indefinitely without maintenance.

Poor maintenance of a dry kiln and its component parts will result in extreme variations in temperature. Cracks in the kiln structure, damaged doors, fans, fan and load baffles, and poorly maintained control instruments are common causes for nonuniform temperatures.

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[2] "List of Dry-Kiln Companies and Engineers and Consultants in the United States." Forest Products Laboratory Report 1031. 1955.

Kiln Operation

Improper operation of a dry kiln will frequently result in nonuniform temperatures. Three of the most common causes of nonuniform temperatures associated with the operation of a kiln are (1) varying steam pressure, (2) excessive radiation, and (3) nonuniform air circulation. The kiln operator can minimize trouble associated with these three causes by (1) maintaining uniform steam pressure, (2) operating on the minimum of radiation necessary to maintain desired temperatures, and (3) piling and baffling the loads properly to prevent the air from short circuiting.

Conclusions

Kiln-drying defects, variations in moisture content, and drying time can be materially reduced by obtaining uniform entering-air temperatures throughout a dry kiln. This all adds up to reduced drying costs.

Temperature differences in a dry kiln can be located with thermometers spotted throughout the kiln. Also, examination of the lumber and kiln samples during drying will reveal excessive temperature variations. If the lumber and samples in any zone of the kiln develop excessive drying defects associated with drying stresses, excessively high temperatures are indicated. If mold and fungus stains develop in specific zones, excessively low temperatures are generally the cause.

When nonuniform temperatures are found, their cause should be determined and corrected. Good maintenance of the kiln and its component parts is absolutely essential to obtain lowest cost, properly dried lumber.