

LUMBER DRYING AND HEAT STERILIZATION RESEARCH AT THE U.S. FOREST PRODUCTS LABORATORY

William T. Simpson
US Forest Products Laboratory
Madison, WI

INTRODUCTION

The Forest Products Laboratory (FPL) has a long history of research and technology transfer in lumber drying. Many of the dry kiln schedules used in industry today were developed by the staff of the Laboratory, and for many years the Laboratory conducted a kiln drying short course for training dry kiln operators. The purpose of this report is to describe the Laboratory's current research activities in lumber drying as well as the more recent issue of heat sterilization.

RESEARCH ACTIVITIES

The current active research projects at FPL are:

- Drying manuals and kiln schedule website
- Estimates of lumber air drying times
- Drying lumber and rounds from small-diameter softwood trees
- Drying low-grade maple lumber for structural applications
- Heat sterilization of wood
- Moisture content monitoring in kiln drying

DRYING MANUALS AND KILN SCHEDULE WEBSITE

Three drying manuals have been published by FPL. The latest (2000) is "Drying Hardwood Lumber." This is a major rewrite of "Drying Eastern Hardwood Lumber." "Air Drying of Lumber" (1999) is also a revision of an earlier manual. The "Dry Kiln Operator's Manual" was revised in 1990, and several sections of it will need revising before too many more years.

"Drying Hardwood Lumber" focuses on common methods for drying lumber of different thicknesses, with minimal drying defects, for high quality applications. The manual also includes predrying treatments that, when part of an overall quality-oriented drying system, reduce defects and improve drying quality, especially of oak lumber. Special attention is given to drying white wood, such as hard maple and ash, without sticker shadow or other discoloration. Several special drying methods, such as solar drying, are described, and proper techniques for storing dried lumber are discussed. Suggestions are provided for ways to economize on drying costs by reducing drying time and energy demands when feasible. Each chapter is accompanied by a list of references. Some references are cited in the chapter; others are listed as additional sources of information.

"Air Drying of Lumber" describes how lumber can be air-dried most effectively under outdoor conditions and illustrates the principles and procedures of air-drying lumber that were developed through field investigations and observations of industrial practices. Particular emphasis is placed on the yarding of lumber in unit packages. Included are topics such as why lumber is dried, advantages and limitations of the drying process, properties of wood in relation to drying, layout of the drying yard, piling methods, causes and remedies of air-drying defects, and protection of air-dried lumber.

"The Dry Kiln Operator's Manual" describes both the basic and practical aspects of kiln drying lumber. The manual is intended for several types of audiences. First and foremost, it is a practical guide for the kiln operator - a reference manual to turn to when questions arise. It is also intended for mill managers, so that they can see the importance and complexity of lumber drying and thus be able to offer kiln operators the support they need to do their job well. Finally, the manual is intended as a classroom text, either for a short course on lumber drying or for the wood technology curriculum in universities of technical colleges.

In addition to the kiln schedules for US domestic species given in the "Dry Kiln Operator's Manual," FPL has a website (www1.fpl.fs.fed.us/drying.html) for retrieving known recommended kiln schedules for all U.S. native hardwoods and many tropical hardwoods. Kiln schedules have been developed for many hardwood species, but many more, especially tropical hardwood species, do not have a recommended schedule. A study recently completed investigated the possibility of estimating kiln schedules using specific gravity. Using known schedules and specific gravity data of 268 hardwood species, a classification approach and linear regression analysis were applied and compared to establish the relationship between kiln schedule code number (as described in "The Dry Kiln Operator's Manual") and specific gravity. In general, schedule predictions matched reasonably well with recommended schedules, but for some species the differences were large.

ESTIMATES OF LUMBER AIR DRYING TIMES

Published data on estimated air drying times of lumber are of limited usefulness because they are restricted to a specific location or to the time of year the lumber is stacked for drying. At best, these estimates give a wide range of possible times over a broad range of possible locations and stacking dates. A study done at FPL developed an analysis method for estimating air drying times for specific locations by optimizing a drying simulation using existing experimental air drying times for northern red oak, sugar maple, American beech, yellow-poplar, ponderosa pine, and Douglas fir. The results of the analysis are parameters for a computer simulation that make it possible to estimate the air drying times of these species regardless of when they are stacked, in any location where average temperature and relative humidity are known, and for lumber of any thickness dried to any final moisture content. A report has been published that contains graphs of these estimated air drying times to several final moisture contents for several nominal thickness of lumber at various locations within the growing range of the six species studied.

DRYING LUMBER AND ROUNDS FROM SMALL-DIAMETER SOFTWOOD TREES

Dense stands of small-diameter softwood trees in the western U.S. are creating a fire and forest health hazard. It is expensive to remove these trees, so there is interest in finding value-added uses for lumber or rounds from them. One problem in using lumber from these trees is that it is notorious for warping during drying. FPL has conducted two studies to characterize and control warp in nominal 2 x 4 inch dimension lumber sawn from small-diameter ponderosa pine trees. One study was conducted at a commercial sawmill with trees harvested in central Arizona. The other study was conducted in experimental kilns at FPL using lumber harvested in central Idaho. The three main variables in the studies were top loading, presteaming, and a high-temperature kiln schedule. A limited study of hot press drying was also included. The high-temperature kiln schedule in the experimental kilns reduced drying time to about half that of the conventional temperature schedule. Press drying time was slightly more than three hours. Crook and bow caused most of the warp and grade loss from warp. There was no evidence that presteaming affected warp or grade loss from warp. Top loading had a modest effect in reducing warp and grade loss from warp. High-temperature drying did not affect measured warp immediately after drying compared with the conventional temperature schedule. Grade loss from warp in lumber that had been moisture-equalized in storage was less, by about one-half, in high-temperature than in conventional temperature dried lumber. This latter effect was encouraging enough that a follow-up study is planned to explore it in more detail.

DRYING LOW-GRADE, MAPLE LUMBER FOR STRUCTURAL APPLICATIONS

This topic is described in depth in these proceedings in the report by Xiping Wang (page 63).

HEAT STERILIZATION OF WOOD

Heat sterilization of wood in various forms is currently receiving attention as a means of killing insects and pathogens to prevent their transfer from one region of the world to another in trade. One concern is the amount of time required to heat wood of various cross-sectional sizes and configurations to a temperature that will kill the insects or pathogens. Estimation of heating time depends on many variables. One estimation method uses heat conduction equations. A study was performed to determine heating times of several sizes of red maple and aspen lumber and timbers, and then analyzed with the heat conduction equations. A report was written reviewing the heat conduction equations and their application for round and rectangular cross sections, and their validation with the experimental data. It was found that the heat conduction equations apply only when saturated steam is the heating medium. Use of dry heat extends heating times beyond the estimates provided by the heat conduction equations. An FPL report was published where tables are given for the estimated time required to

heat the center of cross sections of various round and rectangular dimensions to various temperatures at different heating temperatures, moisture contents, specific gravities, and starting from different initial temperatures.

The finding that dry heat extends heating time beyond that in saturated steam prompted a follow-up study to look more closely at the effect of wet-bulb depression on heating time. Wet-bulb depression was systematically increased in test runs with slash pine from near zero degrees at full saturation to dry heat at a 50°F depression. The heating time increased exponentially with wet bulb depression. When the wet bulb temperature in the kiln was below the desired center temperature, heating times were extended far beyond the times when target center temperature was greater than the wet bulb temperature. This effect was less in air-dried lumber than in green lumber.

MOISTURE CONTENT MONITORING IN KILN DRYING

Accurate measurement of moisture content in lumber is important to good kiln schedule control. Additional desirable qualities of a measurement system are remote and non-destructive, the ability to measure moisture content above 30 percent, flexibility to place sensors anywhere across the width of a lumber stack, and the ability to direct a kiln control system. Research has been conducted at FPL on the use of speed of sound to estimate moisture content of red oak, hard maple, and ponderosa pine during drying. Two useful findings were 1) that speed of sound gives good estimates of moisture content all the way from green moisture contents well above 30 percent to dry, with a linear relationship between the transit time of sound waves and moisture content; and 2) that the sensors have the ability to be easily mounted on the ends of full-length boards in the center of a lumber stack in a dry kiln. This latter ability allows us to track the drying progress of the slower-drying center boards rather than be limited to the faster-drying edge boards.

Proceedings of the 29th Annual Hardwood Symposium

Sustaining Natural Resources on Private Lands in the Central Hardwood Region

2001 NHLA Annual Symposium
French Lick Springs Resort & Spa
French Lick, Indiana
May 16 - 19, 2001



Proceedings of the 30th Annual Hardwood Symposium

Current Topics in the Processing and Utilization of Hardwood Lumber

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