

CURRENT DRYING RESEARCH AT THE WESTERN FOREST PRODUCTS LABORATORY

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Research laboratories in the field of wood seasoning are concerned with the development of kiln schedules which will dry their commercial species to criteria defined by the industry, or by national or international standards associations, or both. Research may also be concerned with peripheral interests, such as the calibration and use of moisture meters, the strength of kiln-dried lumber, and characteristics of dry kilns. The Western Forest Products Laboratory has been concerned with all these matters, but its seasoning staff has been limited, effectively, to one professional scientist. Over the past three years this has been increased to three scientists.

Two years ago, it was decided to make an up-to date analysis of industrial practice in order to determine the present nature and economic importance of problem areas, and to make an assessment of the areas where economic improvement could be made most efficiently by research within the terms of reference of the laboratory and within the competence of personnel. For this purpose, I made a trip through most of British Columbia, visiting about 50 mills and discussing problem areas, and observing mill and kiln-drying practices. Subsequently, through the cooperation of the lumbermen's associations in the interior of B. C., we received copies of the monthly moisture-content reports of kiln-dried lumber. Later we made a detailed study of the drying practice of 22 mills.

The purpose of all these activities was to determine the problems of industry, and to institute research programs that would most efficiently solve them. It is not suggested that all of the problems reported had not been recognized previously. On the contrary, some had not only previously been identified, but were being actively pursued by researchers in other areas. Nonetheless, to make our assessment as complete as possible, these were included in the report.

Waste-Heat Utilization

A very obvious example of the need for research in lumber seasoning is in the fuel used to fire dry kilns. It is almost unbelievable that mills and kilns operated in remote areas of the province will incinerate their sawdust and waste, with the loss of billions of BTUs of heat and the generation of air pollution, and will then pipe in or truck in at considerable expense natural gas, propane or butane to produce some millions of BTUs per hour to dry their lumber. It is estimated that about 2 million M fbm of lumber in the interior of the province is dried annually in gas-fired kilns. Assuming that fuel costs \$1 per M fbm of lumber dried, a conservative estimate, then the industry is spending about \$2 million per year to dry lumber in gas-fired kilns alone. Since the heat value of waste wood is several times the heat required for lumber drying, several million dollars per year in recoverable heat is being wasted.

The reasons for this are, of course, economic. The traditional method of converting wood waste to heat is by means of a steam boiler. But provincial regulations regarding steam boilers require that they be tended by a steam engineer. For small operations, the cost of the extra personnel required does not justify this approach in view of the alternative of buying natural gas, propane or butane. It is understood that for two kilns or less, gas firing is more economic than steam, but for three kilns or more, steam generation is more economic.

One way of avoiding the requirements of the Boiler Act is to run the system at 15 psi or less. While this eliminates the need for the extra personnel, it still requires the moderately costly installation of a boiler system and introduces another disadvantage: the kilns have a limiting temperature of 180°F and are restricted to relatively slow schedules.

Another method, which has already been discussed by one speaker is the grinding of waste fuel and its burning in suspension. The exhaust gases can then be used directly to dry lumber, in the same way that combustion products of natural gas are used. Again, the installation costs are rather significant.

A third method is to burn waste as received from the mill in conformity with pollution standards and, by means of heat exchanger or directly, recover enough heat to operate the kilns. This method is not believed to be in use at present.

For the involvement of the Western Forest Products Laboratory in this area, somewhat over a year ago, we prepared a report of the current status of waste wood burning and heat recovery. We are not at this time involved in the technology of burning because our staff does not include a combustion engineer.

In-Kiln Moisture Meter

Our surveys of industrial drying practice have made it abundantly clear that the final average moisture content of kiln-dried lumber may be anywhere from 9 to 21 percent mc. It is apparent that kiln control would be much better if a remote-type moisture meter were devised to provide some indication of moisture content while wood is still drying.

The idea is not new. Several years ago, a "Kil-mo-trol" was used for this purpose. This was, in its simplest form, a pair of nails driven into a board and connected by long leads to a moisture meter in the control room. Unfortunately it had disadvantages. The nails conducted heat into the wood, drying it out at that point and causing local checks at the nails. The meter, therefore, read low. But, in addition, there was the work involved in electrode preparation, and the danger of leaving nails in lumber and damaging the planer knives during dressing. As a result, this method is no longer used in British Columbia.

More recently, we understand that others are considering micro-wave and other sophisticated systems to measure moisture. We at the Western Forest Products Laboratory are looking at a system for making these measurements. At the present time, we have made only a few preliminary experiments, and do not know whether our present approach will meet with success. We believe, however, that if a workable system can be achieved and accepted by industry generally, it would be a most important step toward meeting the new drying standards.

Mathematics of Drying

As most of you are aware, the drying of wood consists of several physical processes. These are: conduction of heat into wood, evaporation of moisture, and diffusion of moisture to the wood surface where it is carried away. At some universities, courses are offered on the diffusion of moisture in wood and researchers, from time to time, have worked out diffusion coefficients under various conditions. Presumably, then, scientists should be able to calculate, by mathematical processes, the effect on drying rate of changing such parameters as temperature and humidity. With few exceptions, all of them very recent, research laboratories involved in the development of kiln schedules have approached their task by trial and error, and with little or no reference to the theory of drying. This indicates either the theory is faulty and has no application to practical problems, or that scientists are not using all the tools available to them in the solution of their problems.

Based on the assumption that theory can be a useful tool when used intelligently, we have tried to define in general terms the processes involved in drying, both within a board and within a charge, and have drawn up mathematical expressions for these processes. The next step is to determine the parameters, i. e. the constants for these equations based on experimental data. If this can be completed successfully, we expect to have a complete mathematical statement of the thermodynamics of drying wood.

A further aspect will then be considered: that is, the effect of shrinkage and stresses on checking and degrade. These will determine the maximum severity of schedule that can be tolerated before lumber starts to check. In this regard, we are preparing instrumentation which is, in effect, a small microphone plugged into lumber during drying. As the lumber dries, it generates micro-checks which are detected by the microphone and recorded on a chart. Preliminary tests suggest that a certain level of micro-checking will take place before a check develops visibly and degrade begins. With this apparatus, it will be possible to determine what conditions of temperature and humidity result in excessive checking, so that these conditions can be avoided. The final phase will be to use these data to develop kiln schedules by computer simulation before checking schedules in a kiln. By this approach, researchers will expect to develop the most efficient schedules for any species, and to make these schedules available to industry.

Kiln-Schedule Development

Another area of research in which we are actively engaged is in the development of kiln schedules by traditional methods. At the present time, our areas of concern are in flooded timber, as will be described in another paper today by Marian Salamon; in drying alpine fir (Abies lasiocarpa) and in drying poplar (Populus tremuloides and P. balsamifera) so that this new commercial species group can be used in light framing and construction.

It is interesting to note the difference in philosophy between laboratory and industry in the matter of kiln schedules. Industrial drying times are determined by production demands. With a given kiln capacity and a given rate of lumber production, it is a matter of simple division to determine how much time a mill can "afford" to dry a charge of lumber.

As mill production increases, drying time must be reduced accordingly. This concept certainly works well in the front office. All one needs to calculate drying time is a slide rule or pencil and paper. However, making sure that the lumber is dry in the calculated drying time is a little more difficult.

National and international standards have defined rather clearly what is acceptable kiln-dried material and what is not. When our laboratory turns out a schedule, you can be rather sure that the lumber will conform to standards. We cannot be quite so sure for commercially dried material. And this is the principal reason why laboratory schedules require longer times than industrial schedules. We feel that, within the temperatures and air velocities now considered "conventional"--that is, less than 190°F and 250 fpm--we are close to the best times possible while still conforming to standards for spruce and pine. It therefore appears that improvements in drying time will be made only by increases of both temperature and air velocity. To the extent that larger fans, motors and burners will be required to attain these higher temperatures, companies must be prepared to invest in these changes. It appears to be the only way that drying times demanded by production and drying quality demanded by standards can both be achieved. Regarding the effects of temperature and air velocity on drying rate, a recent paper by Marian Salamon gives some very practical results as to how drying times were reduced by their intelligent use.

Industrial engineering studies should also be done to determine if and when detection and recycling of wet lumber is justified. Not only is an economic study required, but to make the concept feasible, an efficient sorting, stacking and recycling system is required, as well as drying schedules suitable for partially dried stock.

Liaison with Industry

Our final area of interest is in making our findings available and usable to the lumber industry. This requires a high degree of communication and liaison between research and industry. For our part, it means we must learn to think like industry and like kiln operators, as well as thinking like scientists.

We must recognize industry's problems on industry's terms and analyze and translate the problems to scientific terms. As and when the problem is resolved, the solution must not be left in scientific terms, as occurs in so many cases. It must be translated to the mill, to the kiln, and demonstrated there where management and kiln operators can see the solution.

Kiln courses must also be prepared on this basis. Although we have had kiln courses at our laboratory for many years, and have tried to meet operators' needs in our teaching methods, we have had difficulty in understanding suggestions that the courses be made more "practical." We are now beginning to understand these suggestions and will be including more demonstrations to make these courses more meaningful to both operators and management.