DRYING OF DIFFICULT LUMBER SPECIES WITH ADVANCED TECHNOLOGY

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In America today, there is an awakening interest in better drying practices. It results from an urge to save energy. That in the process of saving energy, better quality of lumber can result, does not seem to have occurred to operators of kilns.

The grade and quality of American lumber can be substantially improved if lumber producers are willing to change their handling methods. Prior to the advent of lift trucks, lumber was carefully stacked on trucks which rolled on rails. Packages were often very neat and trim. The lift truck seemed to offer an opportunity to reduce labor. In exchange, the quality of packages deteriorated. Even when stacked with a mechanical stacker, the rough and careless handling often moved layers and caused blocked or partially blocked air passages. Instead of a kiln with separated rail lines, the package style of kiln with through the lumber air travel of 24 feet (7.5M), produced undreamed penalties in drying quality.

For an explanation of what has happened, let us briefly examine the drying process. When we hear the word kiln we think of heat. Truly, heat is important. The rate of drying increases with temperature. At 50 degrees Fahrenheit drying is very, very slow.

The heat we are speaking of is the temperature of the lumber and not that of the surrounding air. Three-inch green persimmon blocks will dry in a few minutes with ambient air at zero degrees Fahrenheit, if exposed to high frequency energy.

Generally, for economic reasons, lumber is heated with an outside energy source such as steam under pressure in steel pipes, or by the products of combustion of an available fuel. To transfer this energy to the lumber, fans are employed that will produce adequate pressure to force the air between layers of lumber separated by air spaces. Each unit of air will carry heat which will be absorbed into the lumber. This is because the lumber is colder than the air. If the air temperature is maintained at a constant level, ultimately heat will cease to flow and drying will cease. As moisture evaporates from the surface of wood, it absorbs energy from lumber and thereby cools it. The greater the temperature difference between wood and air the faster the flow of heat. As the wood surface becomes dry, moisture by various means flows toward the surface from the interior. If the process is continued, ultimately everything will be in equilibrium.

The variations in cell structure and of wood resins control the movement of water. Water flows slowly through oak, maple or beech and rapidly through basswood or black spruce.

Let's look at a kiln having four 6-foot wide packages stacked adjoining one another so that with fans forcing air into one package it in turn passes through the other three and exits into the plenum on the other side of the kiln. Depending on the amount of
air and its velocity between the boards, the temperature will fall. The wet bulb characteristic remains substantially constant and as the dry bulb lowers, the rate of drying will diminish. In drying easy to dry species in typical kilns of 1950 vintage, drying ceases in the last eight feet of travel. This is because the circulating air is saturated and cannot absorb any more moisture. When the fans reverse air direction, the truck of lumber that didn't dry is exposed to the initial heated air. The package on the other side of the kiln ceases to dry. By increasing the quantity of air passing between the boards two results will accrue toward drying. (1) The drying will be more rapid and equally important (2) more uniform. The quantity of air is normally measured by its velocity. In most kilns manufactured 25 to 30 years ago, the velocity ranged from 0 to 200 fps measured on the leaving air side of the load. A few enterprising lumber producers demanded more air and enjoyed the benefits. As late as the 1930s, one well known kiln manufacturer advertised "Dry lumber nature's way. Do not use harsh fan methods."

The drying capacity of a kiln is a partnership between kiln manufacturers and the lumber producers. It is equally important for the lumber producer to use judgment in arriving at a stacking procedure as for the kiln manufacturer to provide fans for adequate air circulation. The efficiency of propeller fans falls rapidly with increase of static pressure above 3/4". The air mass movement increases rapidly as resistance falls below 3/4" S.P. Thin stickers, 24 feet of air travel, and poor baffling all decrease the weight or mass of air passing through the board spaces. To be sure, in a 15 foot high stack, a 14% increase in lumber holding capacity with 3/4 stickers can be compared with a 1/4 increase in drying capacity using 1" stickers. If a plant could dry 50,000 feet of 4/4 maple in 10 days using 3/4 stickers, it could dry 43,000 feet in 7-1/2 days using 1" stickers. In a kiln using 3/4 stickers it could dry 1,800,000 feet per year. In the same kiln using 1" stickers, probably 2,000,000 feet.

What this adds up to, putting it another way, is that for almost any species, it is important that the equipment is sized to deliver adequate air for the desired schedule. The sticker size be agreed upon in advance, and that systematic culling of undersized stickers be carried out--forever! One inch thick stickers will dry almost two times the loads of 3/4" stickers.

For fast drying lumber 12 feet is a firm maximum of air travel before the air is reheated. Baffles at all points where there may be openings must be provided and used.

If these conditions are met by the kiln manufacturer and the customer, there should be few complaints of uneven or slower than expected drying.

Many species of both softwoods and hardwoods may be quite economically dried with temperature above the boiling point of water. Even oak may be dried to the final MC after it reaches from 20 to 25%--without degrade and with much less time required for equalizing and conditioning. Four quarter yellow poplar dries in 60 to 65 hours and 4/4 white pine in 72 hours from dead green. (It requires an unusual schedule. 230 degrees F. dry bulb and 115 degrees F. wet bulb.) Along with this we must not overlook the air circulation between boards of no less than 700 feet per minute.
A mathematician by the name of Reynolds, in working with airflow formulas, came up with a number series relating to all aspects of airflow. Experiments by researchers disclosed that when air passes through a pipe, or rectangular duct, the state of the interior surface of the duct affects the velocity. Numbers applied to calculations are called Reynold's Number.

Air near the surface is slowed by roughness. This is both a help and a hindrance. The resulting drag causes turbulence that assists in moving a dead insulating film of air on the surface. At too low a flow velocity the turbulence ceases and transfer of heat to the lumber by the circulating air is reduced. This condition is called laminar flow. Obviously, rough boards provide a relatively rough interior for a duct. Slow air movement reduces drying out of proportion. The velocity to provide turbulent flow must increase with temperature. That is why 700 feet per minute minimum for drying at 230 degree dry bulb is important.

In addition, we have stickers that are basically 3/4", there will be some that are thinner. More air pressure is required to produce a given velocity between boards as the space between them diminishes. In the plenum on the side of the kiln, this static pressure is relatively uniform. Therefore, boards separated by 5/8" stickers will receive less air than those boards separated by 3/4" stickers. The result is some wet boards remaining when your samples showed that the lumber was dry!

What does this add up to? Uniform drying is essential. Beyond certain basic structures, the dry kiln cannot of itself produce uniform drying unless the lumber is placed in the kiln in such a manner that every board receives air and heat in relatively equal quantity.

In recording moisture content of samples, all operators are aware of the wide initial variation of moisture content from board to board. This may be corrected by the final equalizing and conditioning process. Or, it may be corrected in the drying process--IF there is adequate air circulation. For with rapid flow of air past the board surface the drying need not take place with wet bulb depressions of 20 to 50 degrees but rather from 3 to 18 degrees. Until the boards are near 30%.

This slows the surface drying in the early stages and hastens the warming of the interior of the board. Much of the opposition to high air velocity comes from lack of consideration of the drying process. We stated earlier that a board is dried in relation to its temperature and not to the temperature of the air surrounding it. If temperature sensors are inserted in boards being dried, and a record made by chart or by timed readings, it will be observed that so long as cell moisture is available, the wood is cooled by its evaporation to approximately the wet bulb temperature. Drying a hardwood in the early stages with a 30 or 40 degree depression is necessary only when the air flow is in the range of 0 to 500 feet per minute. Much of the damage from surface checking is the result of inadequate air circulation rather than the opposite. Surface checking results from very dry air.