

VACUUM DRYING IN A SMALL COMMERCIAL KILN — 18 MONTHS EXPERIENCE

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New drying processes are always being proposed and tested in order to dry lumber at a lower cost. One of the major cost items in lumber drying is degrade (or the loss of quality). As "time is money," faster drying processes are also attractive. Finally, new processes that are simpler to operate (or are computer controlled) are popular.

Through the years a number of alternative drying methods have been tested by industry and by universities, including boiling in azeotropic liquids, radio frequency heating, and vacuum drying. Most of the methods or the past equipment have had serious drawbacks (such as environmental hazards) which have prevented widespread commercial adoption, are too expensive to purchase and/or operate, or result in a dried product which is unsuitable for many applications (for example, unacceptable discoloration).

Recently, vacuum drying equipment has been developed which offers new possibilities for advances in drying. A good commercial size vacuum dryer manufactured by VacuTherm in Warren, VT was discussed in the FPRS Drying News Digest of June 1981. A smaller vacuum drying unit, 1 MBF capacity, is discussed herein.

Laskowski Enterprises (who make the "Wood Miser" sawmill) of Indianapolis, Indiana manufacture a small, portable lumber dry kiln using the vacuum principles. They loaned the kiln to Virginia Tech for 18 months to experiment with drying various East Coast hardwoods and softwoods.

In addition to exposing the lumber to a vacuum, this equipment also includes a set of cold (air conditioning) coils that condense the evaporated water so it can easily be pumped outside the chamber. Heat for the drying process is provided by electric blankets (aluminum foil laminated between two layers of heavy plastic). The blankets are over 100 feet long and are woven back and forth between each layer of lumber in the kiln. Each piece of lumber is in contact with a blanket on both top and bottom faces. A low voltage, high amperage current is passed through the blankets, from end to end, thereby creating the heat.

PRINCIPLES

Water boils at normal atmospheric pressure at 212°F. When in a reduced pressure atmosphere, water will boil at lower temperatures (Table 1). With a vacuum process when the water is boiling out of the wood, drying is usually very rapid as moisture movement is by total pressure flow rather than diffusion. Drying times of 2 to 4 days from green to 6% moisture content (MC) are not uncommon (compared to 30 days for 4/4 red oak in a conventional system). In order to take full advantage of the

vacuum principle, the wood being dried must be porous. Nonporous woods (such as white oak) do not dry very rapidly.

Table 1. Boiling temperatures of water

Pressure (psi)	Temperature (F)
14.7	212
7.5	180
3.75	150
0.25	60

The lumber in a vacuum kiln does not need to be stickered--the nooks and crannies on the surface of rough lumber are sufficient to provide for moisture removal. Similarly, there are no fans for air circulation, as there isn't any air. (Without air, alternate heating systems have to be used in vacuum drying to provide the heat necessary for evaporating water. Hence, the blankets in this dryer.)

As in conventional drying processes, the wood in a vacuum dryer dries from the outside, inward. As a result, drying stress patterns can develop. However, with the fast flow of moisture out of the wood and the low temperature, the wood is better able to withstand these stresses. If drying is too rapid, however, stresses may become too high and checking and splitting will result. Conversely, if drying is too slow, then stain could be expected. In many ways, therefore, the process is like normal temperature, hot air drying, except that it is much faster.

Two major differences are 1) when the vacuum system is operated corrected, the moisture gradients in the lumber are quite small, and 2) most of the water removed initially is "free" water (rather than a mixture of free and bound water. If the surface dries much below fiber saturation, moisture moving rapidly from the interior will bring the surface back to a higher MC. As a result, many times there are no casehardening stresses in vacuum drying. On the other hand, without casehardening (or tension set) and the dry outside shell, vacuum drying may produce more warp.

More development work is needed to fully understand and control the process, but we know enough already to do a fairly good job.

RESULTS

In 18 months, we dried over 30 loads of lumber--oak to pine, 3/4-inch to 16/4-inches thick. The overall quality of the dried wood has been excellent with very little splitting or checking, minimal casehardening, and very good color. From time to time, for reasons not fully understood by us, we did notice more cup than we would have expected in conventional drying. We also seemed to find, every so often, a piece of lumber that had a region of high MC even though the rest of the piece was quite dry and the average MC of the load was under 10% MC. (For example, the final MC averaged 6 to 8% MC, but there might be a small section on a few boards that was 10% MC or even a little higher.) These areas disappeared if we dried to a low final MC (2 to 4%

MC). We did have trouble in estimating the average final MC without opening up the chamber and sampling the lumber. Although this is no worse than conventional systems, it sure would be helpful to have reliable remote sensing of MC.

We found that white oak did not dry satisfactorily, as expected from the theoretical discussions above.

We found that shorter pieces dried to a more uniform MC and faster than long pieces. We found that squares dried better than lumber. We suspect that these observations are a result of more end grain per volume of wood with shorter lumber and more surface area per volume with squares. Thinner lumber dried better and more evenly than thicker.

We did not measure energy consumption or calculate drying costs. One estimate of energy costs was \$75/MBF. The loading method, requiring the blanket to be placed between each layer, is quite labor intensive. Yet the rapid turnover and simplicity of the system keeps costs low.

As with all condensation drying methods, there is some concern about the safe disposal of the condensed water. Although the procedures may not make sense, the disposal of water with chemicals that can be considered toxic must be done within the requirements of the Federal Toxic Waste Disposal Law.