A COMPARISON OF CONVENTIONAL AND NEW DRYING METHODS[1]

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Lumber drying for the furniture manufacturer is a very expensive and time consuming operation. Losses in drying (due to checks, cracks, splits, warp and honeycomb) can easily exceed the operating costs and additionally result in a loss of raw material and wasted labor.

Recently, three drying methods--predrying (PD) followed by kiln drying, radio-frequency combined with vacuum (RF), and vacuum only (VAC)--have come to the forefront as methods of reducing drying losses, shortening drying times, and reducing costs. These three methods, although researched and developed over 25 years ago, are particularly intriguing in light of today's high cost of lumber and inventory. The furniture plant management asks which system is best for their facility.

Objective

The objective of this study is to compare these three drying systems drying oak lumber by considering costs, drying times, drying quality, changes in physical and mechanical properties, and so on. With this information available, a manager will be able to ascertain if one system is more suitable than another.

System Descriptions

The radio-frequency-vacuum method of drying (RF) dries solid-piled lumber (no stickers) in a steel chamber (10 MBF capacity). A partial vacuum is drawn so that the water will boil out of the wood at temperatures around 100°F. The energy needed to evaporate water is supplied by radio-frequency energy at 7 to 9 MHz.

The vacuum system (VAC) also uses a partial vacuum to keep wood temperatures low, but uses conventional heat and fans along with "no-vacuum" to "partial-vacuum" variable conditions.

The predryer system (PD) uses a nominal temperature of 80°F, relative humidity of 55 to 70%, and low air flow to dry lumber in a large warehouse from green to 25% MC. Lumber is dried from 25% to 6% in a standard dry kiln.

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[1]This study was conducted with the advice and support of the National Association of Furniture Manufacturers and the Southern Furniture Manufacturers Association and results were presented at the Joint Production Division Meetings at Louisville, KY, September 10, 1982.

Methods

Eighteen hundred board feet of 5/4 and twelve hundred board feet of 8/4, No. 1 Common, red oak lumber, freshly sawn from logs less than five days old, was obtained from a sawmill in western Virginia. Approximately 10% of the lumber was from logs that were bacterially infected and would therefore be prone to drying problems, and 15% was from logs with wide growth rings, also characteristic of difficult-to-dry material.

The 5/4 lumber was divided into three groups (one for each drying process) and the 8/4 was divided into two groups for RF and VAC drying. Each group was matched closely as possible to the other of similar thickness. The lumber was dipped to prevent fungal staining.

Before drying, each piece of lumber was numbered, weighed, and thickness and width measured at three locations. [This data was used to establish shrinkage and green moisture content (MC) after drying.] Grain angle, ring patterns, bacterial infection, and any other apparent significant characteristics were noted.

After initial measurements, the lumber was conveyed to the three drying operations, dried[2] to 6% MC, and returned to Virginia Tech. Each piece was reweighed, and measured for warp and shrinkage. The lumber was then cut into fourteen pieces which were used to determine the extent of end checking, surface checking, internal checking, final MC, MC gradients, drying stress (casehardening), color, toughness, stability, surface hardness, microscopic differences, and machining characteristics.

Results

(It should be noted that predrying is the best of conventional drying. An air-drying/kiln-drying process would typically have poorer results--more losses, higher costs, and so on.) The results below are for 5/4; no substantial difference was seen for 8/4, except as noted.

A. Green MC: Average green MC was 85% (RF), 85% (VAC), and 87% (PD).

B. Final MC: Average final MC was 6.0% (RF), 6.0% (VAC), and 6.8% (PD).

C. MC Range: Final MC ranged from 2.9 to 26.5% (RF), 4.9 to 10.3% (VAC), and 5.6 to 9.6% (PD).
The RF has 48% of the lumber below 5% MC and 6% above 9% MC; the VAC had 1% below and 3% above; the PD has 0% below and 4% above.

D. MC Gradients: The MC gradient from end-to-end exceeded a 2% MC difference 15% (RF), 3% (VAC), and 1% (PD).
The MC gradient from shell-to-core (surface-to-center) at the middle of the piece of lumber exceeded a 2% MC difference 3% (RF), 3% (VAC), and 0% (PD).

[2]Our thanks to General Wood Processors in Easely, SC; Vacutherm Inc. in Warren, VT; and Merillat Industries in Atkins, VA for providing their facilities and labor for drying this material.

E. Drying Time:

	5/4	8/4	
RF	2 days	4 days	
VAC	13 days	23 days	(extrapolated from 55% to 6% MC drying time of 15.75 days)
PD	38 days	75 days	(estimated)

F. Shrinkage: Average shrinkage in thickness of all pieces was essentially the same and averaged 5-1/2%. Average shrinkage in width was substantially less for RF. Average volumetric shrinkage (sum of width and thickness): 11.2% (RF), 12.4% (VAC), 12.3% (PD).

G. Stability: No difference in shrinkage was noted (after drying) as the relative humidity was cycled up and down.

H. Warp:

Pieces With Excessive Warp

	Bow	Cup	Crook
RF	5%	1%	4%
VAC	7	1	13
PD	3	0	11

I. Surface Checks: Surface checks, four feet from each end, were found in 11% of the RF lumber, 5% of the VAC, and 9% of the PD. None were deep enough (over 1/8" deep) to cause manufacturing problems. Most were in bacterially infected lumber.

J. End Checks: One end of each piece of the green lumber was end coated within an hour of sawing. For the RF, the coating was removed just before drying. An end check was recorded if it was 1/4" long or longer. RF had substantially less end checks.

Occurrence of End Checks

	Lumber Affected	Coated End	Uncoated End
RF	33%	--	19%
VAC	54%	28%	41%
PD	50%	25%	42%

The end coating was extremely beneficial in both VAC and conventional PD even with 5/4 lumber. At the coated end, the end checks were less than two inches long (average).

K. Internal Checks (Honeycomb): There were no internal checks with RF and VAC; there were 3% with PD.

L. Casehardening (Residual Drying Stress): Residual stresses of sufficient magnitude to cause problems in ripping, heavy machining and so on were present in 17% of RF lumber, 4% VAC, and 21% PD. (The high PD was caused by equipment malfunction and is not typical.)

M. Color: Qualitative assessment of color by seven observers indicated that over one-half of the RF lumber was lighter in color than any VAC and PD lumber. Also, VAC was somewhat lighter than PD.

N. Toughness and Surface Hardness: Toughness, a sensitive indicator of potential strength losses, was not significantly different between the drying methods. Hardness, measured by impacting a small sphere into the surface, was the same for all drying methods.

O. Drying Costs: As a very rough estimate, based on lumber value of $400/MBF, energy cost of 6.5¢/KWH, interest at 16%, amortization of five years, stacking, no degrade, no tax credits, no administrative or sales expense, no profit, and the aforementioned drying times, we estimate the following costs. Note: VAC is presently available only on a lease basis, so the cost below is really a "price."

	5/4	8/4
RF	$152/MBF	$170/MBF
VAC	208	285
PD	103	168

P. Dimension Parts: The RF method appears to have several advantages over VAC and PD for drying green parts (dimension pieces) including reduced shrinkage, few end checks, no stickers and lighter color. Further analysis appears warranted.

Summary

We were impressed that RF and VAC could provide as good or better drying of oak as the best of today's conventional drying systems.