

Drying Hard Maple (*Acer saccharum* L.) Lumber in a Small Dehumidification Kiln

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Abstract

Portable sawmill owners quickly recognize the advantage to kiln drying lumber they produce. Having the ability to provide properly kiln-dried lumber opens new market opportunities and can increase profit margins. However, the construction and operation of a dry kiln must be economical and simple. A small dehumidification dry kiln constructed and tested in Princeton, WV indicated that costs can be much less than a package kiln, and electricity costs to run the kiln seem to be very reasonable. The kiln did a good job drying maple lumber.

INTRODUCTION

Portable sawmill owners quickly recognize the advantage to kiln drying lumber they produce. Having the ability to provide properly kiln-dried lumber opens new market opportunities and can increase profit margins. However, the construction and operation of a small dry kiln must be economical and simple. A small dehumidification kiln with an 800 board foot (bf) capacity (Fig. 1) was constructed by the U.S. Forest Service in Princeton, WV. Construction and initial use of the kiln were discussed in an article in “Independent Sawmill & Woodlot Management” (Bennett 2012). The cost of the dry kiln included \$2500 for the dehumidification unit and \$500 for construction materials. Scrap materials were used where possible to keep construction costs down.

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Figure 1.—Dry kiln. Photo by Neil Bennett, U.S. Forest Service.

The kiln was initially tested with two loads of 4/4 white oak boards that had been air dried to less than 25 percent moisture content (MC). Yet, questions remained as to this kiln's ability to dry fresh cut green lumber and the costs associated with drying a load of lumber. In November 2011, the U.S. Forest Service acquired 33 hard maple trees from the Fernow Experimental Forest in Parsons, WV for use in another research study. After completing the study, many of the butt logs were sawn into lumber and used to further test the dry kiln's capabilities.

PROCEDURES

Hard maple (*Acer saccharum* L.) trees were felled in mid-November 2011, and 12 logs were sawn into 4/4 lumber with a portable sawmill on December 13, 2011. All logs were end coated prior to sawing. After jacket boards were edged, 441.4 bf of lumber was placed in the kiln as stack 1 on December 14, 2011. An average MC of 54 percent for the lumber stack was measured using five oven dried samples collected as the stack was being put together.

Two sample boards created using standard procedures outlined in the "Dry Kiln Operator's Manual" (Simpson 1991) were placed in the front of the lumber stack and were weighed approximately every other day to keep track of drying progress. A second load of 4/4 hard maple lumber was sawn between April 10-12, 2012, using 18 logs from the batch previously collected. Jacket boards were edged and a stack of 700 bf (stack 2) was placed in the dry kiln on April 13, 2012. This load had an average MC of 39 percent. Again, two sample boards were created using standard procedures and were placed in the front of the lumber stack to monitor drying progress.

This kiln dries lumber by dehumidification, only adding heat once the lumber is dried to 40 percent MC. At this point the heating element is employed, but the temperature is never increased more than 5 °C per day. The dehumidifier manufacturer provides a chart that outlines the maximum safe temperature that should be set according to the MC

(ranging from 40 percent down to 0 percent) of the lumber. Maximum temperature setting for the unit is 50 °C.

To measure the electricity used by the dry kiln, power was run from a 110v receptacle to an electric wattage meter and then to the dry kiln (Fig. 2). The meter required the entry of our facility’s electricity cost which was 7 cents per kilowatt-hour (kWh).



Figure 2.—Electricity wattage meter. Photo by Neal Bennett, U.S. Forest Service.

RESULTS AND DISCUSSION

Stack 1 dried to an average moisture content of 6.5 percent in 39 days. Moisture content was measured on samples collected from each tier of boards, starting from the top:

Row	Moisture Content (%)
1	4.8
2	5.8
3	6.3
4	5.4
5	6.4
6	6.2
7	6.2
8	9.4
9	7.5
10	7.3
11	6.2
12	7.1

No drying defects were discovered with prong tests. Methods for creating stress sections, including prong tests, are described in Chapter 6 of the “Dry Kiln Operator’s Manual” (Simpson 1991). Some of the boards cupped slightly (Fig. 3). Boards in this stack were “log run,” and most of the cupped boards appeared to be from near the center of the log from which they were sawn.



Figure 3.—Stack 1 after drying. Photo by Neal Bennett, U.S. Forest Service.

Boards sawn from near the log pith have a greater tendency to cup or split than boards sawn from the outer portions of a log. Also, the stack was only 12 tiers high, and cupping might be reduced by placing additional weight on top of the stack while in the dry kiln. In the future, solid concrete blocks could be added for top weight. It was observed that there were very few end splits on the kiln-dried lumber in stack 1. Electricity usage for drying stack 1 was 520 kWh, resulting in a cost of \$36.43 or 8.3 cents per bf.

The second stack of hard maple lumber was removed from the dry kiln in 45 days. Oven dried samples were collected from each tier of boards, and moisture content was measured:

Row	Moisture Content (%)
1	5.6
2	5.6
3	5.1
4	6.0
5	5.1
6	5.3
7	6.5
8	5.7
9	5.4
10	6.0
11	5.6
12	6.3
13	6.9
14	15.0
15	8.1
16	7.3
17	12.3

Boards from the top 13 tiers dried to acceptable levels, but the bottom 4 tiers had boards that still contained unacceptable moisture contents. These four tiers of boards were placed back in the kiln for an additional 5 days until oven dried samples resulted in an average MC of 6 percent. Stack 2 only had a few boards near the top that cupped, but many of the wider boards had end splits. A slower initial drying rate might reduce shrinkage defects,

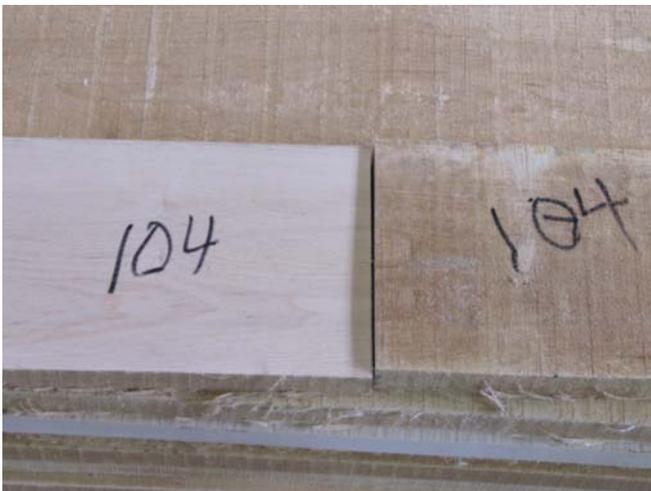


Figure 4.—Board with mold on right, sanded view on left.
Photo by Neal Bennett, U.S. Forest Service.

but you also need to be concerned about preventing stain in the lumber. About 15 of the 131 total boards used developed a light mold on the surface after a couple of weeks in the kiln. Mold growth indicated drying was too slow or relative humidity in the kiln was too high. After removal from the kiln, these boards were lightly sanded to determine the extent the mold penetrated the board. Examination of the sanded boards revealed that the mold affected the surface only (Fig. 4). This particular dry kiln has a very low air flow rate (6 meters/min) when measured at the front of the lumber stack. A low air flow rate could increase the risk of staining of the lumber.

Additional fans could be added to the dry kiln to alleviate this, but that would add to the construction

and operating cost of the dry kiln. Electricity usage for drying the second stack of lumber was 566 kWh, resulting in a cost of \$39.66 or 5.7 cents per bf.

SUMMARY AND CONCLUSIONS

The goal of this study was to evaluate the limits of this dry kiln as built. I feel that I almost overwhelmed the dry kiln on the second larger load. Moisture removed from the lumber could not be removed from the dry kiln quite fast enough by the dehumidification unit. The dehumidifier was set to run continuously, and the temperature was raised to the maximum amount recommended by the dehumidifier manufacturer. No harm was done to the boards, but if the lumber stack was to be sold, the few boards that molded on the surface could be an issue. The wetter boards on the bottom of the stack are also an issue that must be addressed. Both problems are likely due to the low air velocity. Air drying the lumber first or drying amounts smaller than a full load should prevent these issues. Maintaining a bright appearance is an important attribute in drying hard maple lumber. Figures 5 and 6 illustrate the color of the hard maple lumber before and after sanding, respectively.

Electricity usage and drying costs were much less than anticipated. Our research lab is located in southern West Virginia, and 7 cents per kWh for electrical usage seems to be on the low side nationwide. To calculate drying costs for your location, multiply the kWh used above by your local power rate. Divide this amount by the lumber volume in each stack to get drying cost per bf. To calculate your savings, check the difference between the cost of green and kiln-dried lumber prices at your local sawmill or consult the “Hardwood Market Report” (Hardwood Market Report 2013). It must be noted that drying costs are for this particular dry kiln. Power usage is dependent upon the size of the dry kiln, quantity of insulation, moisture content of the lumber, and ambient temperatures outside of the dry kiln. Any reported operating costs for this kiln would not be accurate for another dehumidification dry kiln. Air drying of lumber before kiln drying will reduce kiln drying costs. Stack 1 was dried for 13 days at a rate of 48 cents per day before the heating unit was turned on. Stack 2 was dried 6 days before the heating unit was turned on. As the dry kiln temperature was gradually increased, drying costs increased to about \$1.50 per day.

One remaining concern is the effect of outside temperatures on drying quality and electricity costs. Our dry kiln was located inside a wood shop that was heated during office hours. After office hours and on weekends, shop temperatures were allowed to fall to 12.8 °C (55 °F). During the winter months when the shop temperatures did drop, the heating element in the dry kiln could not maintain the set temperature. Drying still occurred, but at a slower rate and obviously at a higher cost. Quality of the lumber was not affected. Of more concern is if this dry kiln was placed outside and exposed to the summer sun. It is likely the dry kiln temperature could get too hot too fast and could damage the lumber. We were fortunate to possess heavy equipment that allowed us to move our dry kiln inside or outside, giving us more flexibility in its use.

This small dehumidification kiln has done a good job drying hardwood lumber to this point. Any challenges of drying green lumber can be lessened by carefully air drying first or drying smaller amounts of lumber in each load. I consider this particular dry kiln a “niche” kiln. Annual drying volume would probably be less than 10 thousand board feet (mbf)



Figure 5.—Furniture blank from kiln-dried maple.
Photo by Neal Bennett, U.S. Forest Service.



Figure 6.—Furniture blank after sanding.
Photo by Neal Bennett, U.S. Forest Service.

unless most of the user's lumber is well air dried beforehand. One may have to consider this an "inside" kiln in order to use the kiln year round if local temperatures reach extremes in summer or winter. Construction costs for this dehumidification dry kiln can be much less than a package kiln, and electricity costs to run the kiln seem to be very reasonable.

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