SOLAR LUMBER DRYING IN COLORADO

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Drying lumber to the moisture content in keeping with end-use requirements is one of the most important operations in the lumber manufacturing process. Improper drying of lumber has been a major criticism of the many small producers, characteristic of the Central Rocky Mountain area, and undoubtedly, one of the most important reasons for lack of acceptance of local species.

Kiln drying and air drying are the two methods used in drying lumber. Despite some obvious disadvantages to air drying, this method is by far the most widely used. The weather conditions however for air drying are favorable during most of the year. Another factor encouraging air drying is the markets for the bulk of the lumber production have been less critical with regard to the final moisture content.

Kiln drying has been limited because many mills are small, less than 25 M bd. ft. daily capacity, and the limited timber supplies pose a major problem for investment in expensive kilns. The effort is directed to find a low-cost, efficient kiln of necessary capacity to meet the drying needs and to improve the quality of lumber drying in the area. As a result, the quest has lead to investigation of a solar heated dryer having a relatively small capacity, low cost and which will successfully dry lumber to a desired moisture content during all seasons of the year.

OBJECTIVES

Recent research shows solar energy may be used to improve the economy of the drying operation by reducing energy costs, drying time, drying degrade or possible combinations of these. The solar heated lumber dryer at Fort Collins, Colorado was designed basically by the U. S. Forest Products Laboratory. The drying studies underway are being conducted jointly by the Rocky Mountain Forest and Range Experiment Station, U. S. Forest Service, and the Wood Utilization Laboratory, Colorado State University. These studies are evaluating the applicability of solar heating as a method for drying softwood lumber.

The main objective of the studies at Colorado State University is to assess the feasibility of the solar lumber dryer in the Central Rocky Mountain Region. Based on the studies conducted by the U.S. Forest Products Laboratory in the vicinity of Madison, Wisconsin, solar dryers show considerable promise both in reduced drying time and improved drying quality (2). The high intensity of sunlight, as well as the number of days that sunshine occurs in the Central Rocky Mountain region offers some natural advantages for the system.

SOLAR DRYER

The dryer was oriented on a site near the Wood Utilization Laboratory to provide for maximum exposure to the sun. The frame structure as shown in Figure 1, was built on a 12' x 18' concrete slab with a drain in the floor. The plates and studs are 2" x 4" dimension lumber and the roof rafters are 2" x 6" dimension lumber. The north wall is covered with plywood whereas all other walls and ceiling covered with film. The access door for loading the dryer is in the lower one-half of the north wall. This door which is counter-balanced by weights built in wells at each end of the wall slides vertically.

The roof and the east, south and west walls are covered with clear, plastic film made by the E. I. DuPont de Nemours and Company under the tradename of "Tedlar" PVF film. The film is mounted on wood frames (see Figures 2 & 3) made from 1 5/8 by 1 11/16" stock with 1/2" splines.

* Number in parentheses refer to Literature Cited at the end of the paper.
recessed in the frames and fastened in place with No. 8, one inch wood screws spaced six inches apart. Two layers of film were placed on each frame. The double film acts as a solar trap. Exposed to the outside, a film four mils thick was used; inside, a one mil thickness. It was not necessary to stretch the films since pressing the splines into the recesses of the frames made the film taut.

The unique properties of "Tedlar" film (3) include excellent resistance to weathering, discoloring, outstanding mechanical properties and inertness towards a wide variety of chemicals, solvents, and staining agents. It has been proved experimentally that the "Tedlar" film allows only a fraction of the sun's radiation to pass through it. At optimum conditions, this film, admits 90 percent of the ultra-violet rays. It has been illustrated that only ultra-violet rays with wave lengths between 0.4 - 2.4 microns are used in the drying operation; surface dust; finger marks and scratches decrease the transmission efficiency of the film.

HEAT

In order to appraise the radiation from direct sunlight and the skylight response in the Fort Collins, Colorado area, the average daily radiation is shown in Table 1 for the monthly periods in values of Btu's per square foot of surface. The direct sunlight response of the roof of the dryer is air effective 200 square feet of surface or for April the average daily radiation amounted to 238,200 Btu's. The Eppley pyrheliometer used to record the radiation is the most widely used solarimeter and limits the wave length response to wavelengths shorter than 3.5 microns. These are in the electromagnetic spectrum that result in thermal radiation.

<table>
<thead>
<tr>
<th>Month</th>
<th>Btu's/ft²/day</th>
<th>Month</th>
<th>Btu's/ft²/day</th>
<th>Month</th>
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<td>August</td>
<td>1,956</td>
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</table>

* Data from Eppley pyrheliometer located at Horticulture Department, Colorado State University, Fort Collins, Colorado

CIRCULATION

Two 24-inch, eight bladed fans are used in the dryer to circulate air through the package of lumber. Each fan is powered by a one-half horse-power, 208-vold singlephase, electric motor. The fans are controlled separately by manual switches. The motors can be reversed, allowing the air to be circulated in the opposite direction through the lumber package. The air velocity will vary between 100-350 cfm on the leeward side of the lumber package depending on the direction of the fan rotation. Due to the pitch of the fan blades, one fan rotation direction is about 40 percent more efficient than the other.
HUMIDITY CONTROL

Four vents provide a method for control of humid air in the dryer. The vents are located in the east and west walls near the floor of the dryer. A wood element hygrostat operates a micro-switch which actuates motors that open and close the vent dampers. The wood element swells as the humidity rises and this results in the activation of the micro-switch controlling the vent motors.

RECORD KEEPING

A three element Foxboro recording device records the dry bulb temperature and the dew point inside the drying chamber. One dry-bulb element is located outside on the north side of the dryer and records the outdoor temperature. The temperature sensing element inside the dryer is 18 feet long and averages the temperature along the length of the dryer. The dew cell sensing element has a thin plywood protective shield around it to insure accurate functioning.

All of the sensing elements are connected to a seven-day recording device with a 12-inch circular chart. The weather data at the Colorado State University weather station are being used in the study. It is located within one-half mile of dryer. Continuous records of solar radiation are collected at the nearby Eppley pyrliometer.

The most important climatological data are solar radiation values. As an adjunct the previously mentioned radiation values, radiation information is collected intermittently in the dryer to analyze the various responses obtained in drying. The outside temperature being the second most important bit of information is obtained by a continuous record and the next valuable piece of information to work with is air velocity. This variable is controllable because fan motors are of a constant speed with the reversing of the rotation of the fans being the only change possible.

Drying curves are produced from information from whole board samples located in the dryer change. As shown in Figure 4 the whole board samples are weighed periodically during the drying period and then average moisture content determined by a resistance type moisture detector after the lumber is below the fiber saturation point. The average final moisture content of the lumber is determined at the end of the drying period and the moisture detector and these data are compared with the whole board samples.

SUMMARY

Experiments are currently underway and plans are to continue the study for three years to determine effects on drying lumber in a solar heated dryer. This period of time will also give an indication of the service life of the dryer structure. If the pressing problems of providing a small, low-cost lumber capable of satisfactorily drying lumber during all seasons of the year, a real contribution will be made to improve the quality of dry lumber in the Central Rocky Mountain region.

Studies conducted (2, 4) in Wisconsin and Puerto Rico have shown promising information, of both a reduction in drying and improved drying quality. The results of the first two runs with the solar dryer in Colorado are promising. Indications are 4/4 lodgepole pine-Englemann spruce, boards can be dried in the spring months from a moisture content of about 50 percent to 15 percent in a two-week period. Air drying would take slightly longer.

Air temperatures in April outside the dryer ranged from maximums of 40° F to 77° F and minimums of 26° F to 40° F. Temperatures inside the dryer showed corresponding maximum and minimum temperatures range differentials of 25° F to 56° F. The highest temperature recorded was 136° F. It is too early in our experimenting to develop any trends and establish the best procedures for drying boards in the solar dryer, however, the solar dryer may be a solution to winter and spring drying problems in the arid west.

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LITERATURE CITED


FIGURE 1. The frame structure of solar lumber dryer during construction.

FIGURE 2. A view of the west and side of the solar dryer. The west side has three film panels and two vents. The south side has five film panels, as does the roof area.
FIGURE 3. Solar dryer showing the east and north sides. The film side (east) has three panels, two layers of film separated by an 1 5/8" air space, and near the bottom are two vents. The door side is on the north and the lower one-half is a solid door, 1 3/4" thick, which is counter-balanced and opens vertically.

FIGURE 4. Solar dryer loaded with 4/4 lodgepole pine and Englemann spruce lumber. The loading door in the north wall is open and Jack Mercier is removing a whole sample board for weighing.