THE PROBLEM: What precautions will minimize seasoning defects in the kiln drying of green oak lumber?

The Answer:

by O. W. TORGESON, Technologist
U. S. Forest Products Laboratory, Forest Service
U. S. Department of Agriculture

Oak, when kiln dried green from the saw, is particularly susceptible to surface checking and honeycombing. The initial relative humidity must be high to minimize surface checking and early temperatures must be low to avoid honeycombing. To minimize the danger of honeycombing, as well as to increase the kiln output capacity, oak is very commonly air dried before it is kiln dried. Surface checking during air drying, however, is often severe, and could be prevented in the kiln by proper relative humidity conditions. Another advantage of kiln drying green from the saw is the shorter over-all drying time, and it is usually for this reason that requests are made for information on this subject.

Certain fundamentals in the drying of wood have been studied, and the acquired information has been used in formulating schedules that minimize kiln-drying defects. These schedules are given in a recent publication. U. S. Forest Products Laboratory Report No. D1791, "Schedules for the Kiln Drying of Wood." In general, the schedules given for oak are intended to be sufficiently conservative for quality drying, and, if desired, they can be made somewhat more severe for oak whose use requirements are not particularly exacting. The problem of selecting an optimum schedule for some specific use, however, is complicated by the many variables that can influence the results. For example, the seasoning characteristics of the many oak vary considerably, with the northern highland oaks being considered the easiest and the southern swamp oaks the hardest to dry. Furthermore, there are often considerable differences between trees in the same area; even differences between boards from the same trees have been noted. Another variable is the difference in the abilities of kilns and kiln operators to maintain the scheduled drying conditions and to obtain uniformity throughout the kiln charge.

For those operators who have had little or no experience in the kiln Rept. No. D1769-11

FIGURE 1—DRYING time data for 4/4 northern red oak when dried under kiln schedule T4-D2 (Forest Products Laboratory Report No. D1791). The time shown is that for a single 4-foot-wide pile in a small fan kiln that provided an air circulation of about 200 ft. per minute through the load.

July 1951

FOREST PRODUCTS LABORATORY | FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

NEWS AND VIEWS OF THIS KILN DRYING BUSINESS

Drying Stresses

In drying green wood, the surface fibers are first in tension and the interior fibers are in compression because the surface fibers dry first and tend to shrink but are prevented from doing so by the wetter interior wood. The shell thus becomes stretched and set in an expanded condition, while the core is compressed and possibly, to some degree, set in this condition. As drying continues the interior wood dries below a moisture content of 30 percent (the fiber saturation point of wood) and starts to shrink, thus causing a gradual reversal of stresses, from tension to compression in the shell and from compression to tension in the core.

Surface Checking

Surface checks will occur during the initial stage of drying if the strength of the wood in tension perpendicular to the grain is exceeded. For this reason, the initial relative humidity should be high so that the surface fibers will not become excessively dry.

For best results with average oak the initial relative humidity should be 85 to 87 percent for 4/4, 5/4 and 6/4, and 90 percent for 8/4 stock. Relative humidities of 80 to 82 percent for lumber up to 6/4 inclusive, will result in some checking, but many boards will still remain sound. Reversal of stresses usually takes place at a moisture content of approximately 35 to 45 percent, as indicated by the fact that surface checks start to close at about this stage of drying. The (Continued on page 54)
Kiln-Drying Green Oak Lumber

Greatest danger of surface checking has then been passed, and thereafter the relative humidity can be lowered more rapidly to the final setting without much danger from further surface checking. A very general guide is to start the changes in relative humidity after the wood has lost about 1/3 of its original green moisture content and then to reach the final desired relative humidity by the time the wood has lost the second 1/3 of its water content.

Honeycombing

Honeycombing (open checks in the interior of the wood) may be formed by end checks or surface checks progressing inwardly and opening up in the interior as they close on the surface, or they may be strictly interior failures caused by tension stresses in excess of the strength of wood weakened by excessively high temperatures. The greatest weakening effect occurs while the wood is wet, and then gradually such effects become of little importance as the wood dries to a moisture content below 30 percent, the fiber saturation point of wood. For most oaks, it has been found safe to use an initial temperature of 110°F. For highland stock 115°F. is not considered excessive, but temperatures much in excess of this may lead to trouble. It has been found also that it is advisable to maintain the initial temperature until the moisture content reaches 30 percent. Gradual changes can then be made as drying continues to a moisture content of 15 percent, at which time it becomes safe to increase the temperature to a final temperature of 180°F. for 4/4, 5/4, and 6/4, and to 160°F. for 8/4 stock if desired. Because of longer drying periods and the greater possibility of high-moisture-content cores, a more conservative final temperature is recommended for the thicker stock.

Southern Swamp Oaks

The southern swamp oaks, especially overcup oak from lowland areas, are very difficult to dry without an excessive amount of seasoning defects. No kiln schedule has been found that is satisfactory for the drying of the thick stock, and even 4/4 stock causes considerable trouble. Low-temperature drying is particularly necessary for such oak, and for that reason thorough air drying before final drying in the kiln often produces the best results. In air drying, good protection from sun and rain are essential to prevent excessive checking. Proper piling methods for air drying are illustrated and described in Forest Products Laboratory Report No. R1657.

Use of Schedules

Figure 1 shows the kiln-drying data for a kiln charge of 4/4 northern red oak as dried in a small experimental-type kiln. The width of the load was 4 feet, and the air velocity was about 200 feet per minute through the load. The temperatures and relative humidities used were those of schedule T4-D2 in Forest Products Laboratory Report No. D1791. The rather long drying period of 28 days was due to the high initial moisture content of the stock and to the facts that (1) the initial drying conditions were sufficiently mild to prevent practically all surface checking, and (2) the final drying, equalizing, and conditioning were prolonged sufficiently to give very good uniformity of moisture content and relief of case-hardening stresses.

The somewhat more severe schedules, T4-E2 or T4-D3, can be used to decrease drying time, but a small increase in the amount of checking may occur. Even more severe humidity schedules can be tried, but this should be done only after one has had previous experience with the type of oak to be dried and only when some closed checks are not particularly detrimental to the product for which the oak is to be used. They would not be advisable for table-top material where even tightly closed checks may eventually show through the finish. In other words, it must be expected that relatively short kiln-drying periods, such as 16 to 20 days, can be achieved only by some sacrifice in the soundness of the wood.