Artificial Seasoning of Timber*

Methods and Principles Adopted for Various Materials

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The artificial seasoning of timber is usually carried on in what are known as dry kilns. These kilns may be variously classified, depending on construction, method of operation, etc. Old kilns were constructed with a chamber in which fuel was burned, and a second chamber in which the timber to be dried was placed, the burnt gases flowing from the combustion chamber to the drying room and over the piled lumber. With the present use of steam for drying, almost all modern kilns can be divided into two classes as to construction—radiator kilns and hot-blast kilns.

Radiator kilns are built with steam pipes under the floor of the drying chamber. Air passes through these coils, up through the floor, and on to the lumber.

Hot-blast kilns have a bank of heating coils placed in a separate housing, through which air is blown by a fan and forced on to the drying room.

Radiator kilns are thought of as those having the heating elements in the same room as the lumber to be dried, and circulation produced by difference in temperature; while hot-blast kilns are thought of as those having the heating element separate from the drying room, and circulation produced by a blower.

Kilns are also classified as to operation into hot-blast kilns and moist-air kilns, although this is a very unsatisfactory classification. This is based on former practice, in which the relative humidity in blower kilns was low, and so the type was called "hot-blast"; while in radiator kilns and box kilns the relative humidity could be raised by decreasing circulation or by closing the dampers, and these became known as "moist-air" kilns. A better classification as to operation would be moist-air kilns and dry-air kilns, as either blower or radiator kilns could be so regulated as to obtain a high or low relative humidity in the drying chamber.

A third classification, which is based on a combination of operation and construction, divides kilns into either compartment kilns or progressive kilns. In the former the lumber is piled in a chamber and allowed to stay in one position until dry, while in the latter the lumber is moved along the length of the kiln at intervals; dry lumber being taken out at one end when a fresh truck load was run in at the other.

A kiln is being developed on the Pacific Coast at the present time in which superheated steam is used, the steam coming in direct contact with the lumber. Some difficulty, however, has been experienced, as the temperature of the steam used was above the ignition point of the lumber; and if care was not used to exclude air, charring would occur, and in some cases, where the doors were opened prematurely, combustion has taken place.

In all kiln-drying operations, the primary object is to release the contained moisture from the wood and to leave the wood in the best condition possible. The moisture is taken from the wood by evaporation; and to cause evaporation, heat is necessary, and in sufficient quantity to evaporate all the moisture to be released. Approximately 1,000 heat units are required for the evaporation of each pound of water contained in the lumber, and a second quantity (at present unknown) is required to overcome the attraction between the wood and water. This attraction is known as "hygroscopicity."

The first object, then, is to supply the required amount of heat necessary to evaporate the moisture. The second object is to supply the heat and to produce evaporation under such conditions as will leave the lumber in the best possible condition when dry. To do this, several factors—namely, temperature, relative humidity, circulation and rate of drying—must be controlled and correlated.

The various combinations of these factors depend upon the species of lumber to be dried, its size, and initial moisture content.

The rate of drying is dependent upon the other three factors. It is determined in any particular case by weighing samples at intervals of time and making moisture determinations. Moisture determinations are made by weighing a sample piece before and also after oven dryng, and calculating the per cent loss based on the dry weight, or the ratio of the weight lost to the dry weight. This is called the "per cent moisture," and the rate of change of the per cent moisture is proportional to the rate of drying.

Relative humidity is usually determined by the use of wet and dry bulb thermometers, although some form of hygrometer, such as a hair hygrometer, is sometimes used. Methods of hygrometric determinations in dry kilns are not at present entirely satisfactory. Temperatures are measured by a mercury thermometer, and circulation by an aneometer, although the latter determination is rarely made.

In most kilns it is impossible to control these factors independently. For example, if the temperature in a radiator kiln is increased by increasing the supply of steam to the radiator, circulation will be increased and the relative humidity decreased.

The ideal method of drying would be one in which all factors could be varied independently, and the right combinations obtained in any particular case to give the best results in time and quality of product.

In some cases lumber is subjected to a treatment of steam or a mixture of steam and air before being dried in the kiln. In the first case a steel cylinder is provided, in which the lumber is submitted to steam under pressure for a short time, usually from 5 minutes to 30 minutes, and then transferred to the kiln. In the second case, a portion of the kiln is divided off into a steaming chamber of a size to contain one truck load, and there the lumber is heated by steam sprayed in from the steam pipes. The effect of this treatment is to heat the wood thoroughly in a saturated atmosphere and prevent surface evaporation during initial heating. However, care must be used; for if the lumber is changed suddenly to an atmosphere of much lower humidity, surface evaporation will result, and the lumber will be checked. This is due to the fact that evaporation will increase with a decrease in relative humidity, the heat being supplied from within the wood; and rapid evaporation at the surface will cause unequalized shrinkage, and consequently considerable checking.

The rate of drying may be increased by a rise in temperature, a decrease in relative humidity, or an increase in circulation. The rate of drying is a very important factor in producing proper results. With high moisture contents the rate of evaporation or drying tends to be greater than with lower moisture content. The tendency is, then, for the drying to so progress that if a moisture time curve should be plotted it would have a much greater tangent slope at the beginning than at the end of the process. If the slope of the curve is too great at the beginning, the result will be "casehardening" and probably "honeycombing."

Just why this produces "casehardening" is a matter of speculation, although the effects are very evident. If the rate of evaporaion is too great, the distribution of moisture through any section of a piece of lumber will not be uniform. It is impossible, of course, to obtain absolute uniformity in the moisture distribution within a finite time. However, as it is a matter of degree only, for practical results a certain minimum limit would be set for variation in a section without injury. As a result of too rapid drying, the center of a piece may be above the fiber saturation point, while the surface is as dry as can be obtained in the kiln. This will cause, first, "casehardening," as mentioned before; then either deep checks from the surface or "honeycombing." Woods having pronounced medullary rays would in this case "honeycomb."

Again, if this material is resawed, warping will undoubtedly take place. If timber, however, is properly dried, the product is something which is not only free from moisture and liability of checking and warping, but it is much stronger than in the green state.

The effect of moisture on wood, as explained in United States Forestry Service Circular 108, is to weaken it up to the fiber saturation point, but beyond this point an increase of moisture has no effect on the strength. Shrinkage is also connected with the fiber saturation in that no shrinkage occurs until the moisture content has been reduced to the fiber saturation point; but if from that point the moisture is still further reduced, the shrinkage is proportional to the loss of moisture. The shrinkage affects the strength, as the cross section of a dry piece is less than the same piece green. However, the gain in strength due to drying of the fibers overbalances the loss due to shrinkage.

Various species of wood have characteristics which must be taken into account if successful drying is to be expected.

Most conifiers dry easily, and can be submitted to relatively high temperature and rate of evaporation and low relative humidity without injury.

The oaks, however, on account of more complicated structure, soft medullary rays and greater shrinkage, must be handled with much more care; and if a high temperature is used in drying, a high relative humidity must also be used, particularly at the start; also the rate of evaporation must be limited, depending upon the condition of the wood. In some cases it is not advisable to evaporate more than one per cent, or even one half per cent, moisture content per day.

Other woods, such as red gum, are subject to warping and twisting when dried. Care must be taken in that case to dry slow, keep up the humidity and to have the material carefully piled in the kilns.

With hardly an exception, all users of dry kilns expect to have hard wood lumber air dried or partially air dried before placing it in the kiln. Usually, however, the lumber goes into the kiln without the manufacturer knowing very much as to just what the condition is. Properly, moisture determinations should be made.

If the lumber manufacturer wishes to air dry his material before placing it in the kiln, he would gain nothing, as some expect, by allowing it to lie in the yards after the air-dry condition has been reached. Timber will probably be no drier after lying 5 years than after lying 1 year, unless of unusual size. The air-dry condition is a moisture content which is a balance between the relative humidity of the atmosphere and the hygroscopicity of the wood. For a given locality this content will be fairly defined within certain limits. In this locality the air-dry condition is a moisture content of from 12 to 15 per cent; and when lumber has once reached that condition, no length of air seasoning will make it any drier.

Lumber should be dried in the kiln, not until the workmen say that it works right under the tool or until the superintendent says that by the sound and smell it is dry, but until it has reached the per cent of moisture content most desired for the purpose for which it is to be used. There is no necessity for kiln drying lumber which is to be exposed to the atmosphere without paint. Material to be used in vehicles should be, and is in well-regulated kilns, dried to about 8 per cent, when the vehicles are to be used in the North and East. If the vehicles are to be used in the hot, dry climates of the Southwest, the material should be dried to about 4 per cent. Furniture and wood for interior finishing should be dried to about 6 per cent and used before having an opportunity to reabsorb moisture.

It is good practice to allow lumber to stand for a time—say, 1 or 2 days, depending upon the conditions—before being worked. On coming out of the kiln, it is probable that the surface will be drier than required, while the center may not be dry enough. If allowed to stand in a dry, warm place, a distribution will take place which will produce more uniformity of moisture, with less liability to warping or cupping when worked.

As stated before, the theoretical kiln should be subject to independent control of all factors involved—temperature, relative humidity, circulation and rate of drying. Also, it should be known for any given lot of lumber just how these factors should be varied to produce ideal results. The evaporation time curve should probably be a straight line parallel to the time axis. The moisture content time curve should be a straight line, with a negative slope, although the tendency is toward a curve of increasing radius of curvature, as previously explained. The relative humidity time curve should be one having an increased slope, with an increase of time.

When the exact form of all these curves and the method for obtaining in the kiln what they represent is known for any given set of initial conditions, then the particular lumber can be dried perfectly and the performance duplicated, with assurance of success.

This would also bring the practice of kiln drying to the point where previous air drying would be useless, and green material could be placed immediately in the kiln.

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Production of Iron Ore

According to figures given out by the United States Geological Survey, 55,526,490 gross tons of iron ore were mined in this country in 1915. This output is exceeded only by that of 1910 and 1913.