PROPER DRYING DEMANDS GOOD CIRCULATION

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In many ways the circulation of the air in the kiln is the determining factor in the success of the drying operation. Given a uniform, ample circulation throughout the kiln, it is usually fairly simple to provide and maintain the correct temperature and humidity. If, however, the circulation is bad, no amount of expensive equipment and apparatus will serve to yield satisfactory drying conditions. The accuracy required in maintaining these drying conditions varies, of course, with the wood to be dried and the state of seasoning in which it enters the kiln. Any old hot box may do to kiln dry previously air-dried inch stock of pine or fir, but mighty few types of kiln are capable of drying thick southern oak vehicle stock green from the saw!

One of the big problems just now is the remodeling or adapting of old kilns, formerly used only on previously air-dried stock, for the drying of stock green from the saw, and much trouble is being experienced in the solution of it. A thorough knowledge of the possibilities should be helpful to those who are confronted with this problem, and it is hoped that this article may be of some assistance in stimulating thought and investigation along these lines.

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Uniform and ample circulation is needed principally to distribute the heat uniformly to all parts of the pile, and to permit the humidity-regulating system to act uniformly and quickly throughout.

The sketches are entirely diagramatic and intended merely to illustrate principles, rather than details of design.

While the circulation in those types having a central chimney through the lumber is indicated, in all the sketches, as being upward, it is quite possible to produce circulation in the reverse direction, especially in kilns provided with forced circulation. The type indicated is usually preferable on account of the greater uniformity of circulation produced in the chimney through the baffling or mixing effect which the two converging streams of air have upon each other.

Circulation in compartment kilns is produced in a number of ways, which depend principally upon differences in the temperature of the air at different points and upon mechanical means, such as fans or blowers. To a lesser extent, dependence is placed upon jets of steam or water.

**Compartment Kilns**

Compartment kilns may be divided roughly into "ventilated" and "recirculating" types; in the former, the circulation is intended to be produced by means of chimneys or flues, taking cold air from the outside and discharging hot
air from the kiln, and in the latter it is intended to be mainly internal, the same air being used over and over again. Circulation in straight ventilated kilns is usually very slow and lacking in uniformity; that in recirculating kilns may, with proper design, be made to reach almost any desired speed.

Figure I illustrates the simplest possible type of ventilated kiln. Fresh air enters at the bottom, becomes heated as it passes over the heating coils, and is supposed to move upward through the lumber pile, and escape through the vent at the top. While this kiln undoubtedly operates more or less as intended, the circulation is usually very poor, and the air often descends through the main portion of the pile instead of ascending, particularly if the lumber is very moist. Further, two important principles are violated: first, the moving air should come in contact with both broad surfaces of each piece of lumber to be dried; and second, the tendency of the air which has come in contact with the lumber to sink instead of rise should be assisted instead of opposed. The actual amount of circulation, of course, depends largely upon the amount of heating surface and the size of the ducts.

Figure II illustrates much the same type, embodying, however, the two principles violated in Figure I. The chimney in the center of the pile of lumber allows the heated air to rise before entering between the boards, and assists in producing a natural downward lateral circulation. The location of the openings in the outlet flues increases this tendency.
Although a distinct improvement over Figure I, this kiln still leaves much to be desired in the way of ample, uniform circulation.

Even when the circulation through the ventilating ducts is comparatively small, it is still usually necessary to provide additional moisture to keep up the humidity in the kiln. Figure III illustrates one way in which the circulation can be increased, and the humidity raised at the same time by means of a steam jet in the intake. This also serves to heat the air, and thus reduces the load on the steam coils.

Figure IV illustrates the principle that the heating coils do not need to be distributed uniformly from side to side of the kiln when the heated air is taken up through a chimney in the pile.

The first four sketches show straight ventilating kilns, recirculation being prevented by means of solid horizontal partitions. The simplest arrangement of a recirculating kiln is shown on the right half of Figure V. The left half illustrates a modification in which the heating efficiency has been increased by a rearrangement of the heating coils, and the direction of the air movement assured through the use of baffles (B). These baffles help to guide the heated air up the central chimney and to prevent it from passing upward along the side walls of the kiln. The circulation in a kiln of this type depends largely upon the cooling effect upon the air of
the lumber and of the side walls of the kiln and must be feeble at best. No provision for humidity control is made. With this feature added, the kiln might appear like Figure VI. Here humidity control is secured by means of the steam jet line (S) and the intake and exhaust flues, the steam increasing the humidity when necessary, and the flues providing for the escape of moisture-laden air and its replacement by dry air. The jet line is so placed that the circulation is increased by the escaping steam. Another means for removal of moisture from the air in the kiln is illustrated in Figure VII. The condensers (C) have cold water circulating through them; moisture condenses on the cold pipes and is drained off through suitable gutters. The resultant cooling of the air assists the circulation considerably. However, even with this help, the circulation is not always sufficient to maintain uniform conditions. In these cases recourse may be had to internal fans, as shown in Figure VIII. Eighteen-inch or twenty-inch propeller fans, spaced about four or five feet apart throughout the length of the kiln will produce circulation ample for practically all drying conditions. Unless specially designed for this work, the life of the fans is liable to be very short when used under severe drying conditions.

The Internal Fan Kiln

Just as it is possible to reduce the humidity by means of vents, as in Figure VI, so is it also feasible to do this in the case of the internal fan kiln. Figure IX illustrates how
this may be done. It also indicates a housing around the the steam pipes and a steam jet line under the chimney. The purpose of the housing is simply to assist in guiding the air.

The regulation of humidity and the production of a high circulation by a single means are accomplished in the water spray kiln illustrated in Figure X. The water sprays (W) produce this dual effect by cooling the air to the dewpoint and by creating a circulation through impact on the air as well as through temperature difference. The temperature of the dewpoint, which controls the humidity of the air, is in turn controlled by the water temperature, which is automatically regulated. The baffles (B) remove entrained spray water from the air before it strikes the heating coils. Condensers and steam spray pipes are usually added: the former to use in place of the water sprays at the end of the run and the latter for periodic steaming to relieve drying stresses. This type of kiln is especially adapted to difficult drying conditions.

The External Blower Kiln

Quite different from the other types is the external blower kiln, indicated in cross-section in Figure XI. There are many possible arrangements of the ducts, the one illustrated being typical. These ducts run the full length of the kiln, and are provided at intervals with openings for the intake or discharge of the air. Heating may be either by means of a
single heating unit located at the discharge side of the blower or by means of individual heating units distributed throughout the intake (or pressure) duct in the kiln. Humidity may be regulated by means of steam jets and condensers or vents. Kilns of this type usually have ample circulation fairly uniformly distributed, and are capable, when properly designed, of operating under severe drying conditions. The direction of forced circulation, however, should always be with and not opposed to the natural gravity effect, otherwise irregular conditions and stagnation are almost certain to occur.

Endwise flat piling is essential in all of the kilns except the type indicated in Figure I, in which either endwise or crosswise flat piling may be used. Vertical piling of either kind could also be used in a kiln of this type, as shown in Figure XII. In fact, with sufficient heating surface and large enough ducts, much improved circulation and more uniform drying might be secured. This form of piling permits the air to pass over both broad sides of each board.

All of the types so far mentioned use air as the medium of heat and moisture transference. The kiln sketched in Figure XIII differs from them in that it uses superheated steam for this purpose. It also differs from them in that it is provided with means for periodically reversing the circulation through the lumber. Steam for circulation is supplied through the four spray lines (SL and SR), only one pair working at a
time, and the temperature is maintained by means of the heating coils on the side walls. The discharge of the steam from the jets produces a very rapid circulation. Means for the escape of steam from the kiln must be provided—often there is enough leakage around the doors to take care of this. This type of kiln is adapted only to woods capable of being dried at temperatures of about 225 degrees Fahrenheit.

**Variations of Circulation**

While the sketches indicate the direction of the circulation, it frequently happens that the air in the kiln actually circulates in some other manner. This is especially true in those types in which the circulation is not very positive, and eddy currents or stagnation cause much of the uneven drying found in these types. Further, lack of uniform heating often produces a longitudinal circulation which may be much greater in volume than that in the indicated directions. Short-circuiting of the air around the lumber frequently causes slow and uneven drying and should be avoided.

A remedy for any specific kiln trouble can not usually be satisfactorily prescribed without an individual study of this kiln from the inside to determine the direction and amount of the circulation and the temperature distribution. Once the faults are charted, the remedy usually becomes evident. If circulation be ample, it is usually possible to guide it by means
of suitable baffles and proper arrangement of heating and humidity regulating elements. If more circulation is needed, however, recourse must generally be had to mechanical means, such as fans or blowers or other means, frequently necessitating more or less remodelling. As stated in the introduction, ample circulation is a prerequisite to the satisfactory drying of green stock of difficult species, and it is useless to attempt to do this kind of drying in kilns which are not capable of producing the necessary circulation. Parenthetically, most ordinary ventilated kilns fall in this class. Kilns of the water spray and blower types are capable of producing, under commercial conditions, a circulation of from 25 to 50 feet per minute through the lumber pile itself; this necessitates, of course, a much higher circulation through the inlet and return ducts.

In conclusion, the operator having trouble with his kilns is advised to get inside and "smoke out" the kinks in his circulation.
Figure 1. Simplest type of ventilated kiln.

Figure 2. Ventilated kiln with outlet ducts opening at bottom of pile. This arrangement permits the air to drop downward and outward through the lumber.

Figure 3. Ventilated kiln with outlet ducts opening at bottom of pile and steam jet to maintain humidity and increase circulation.

Figure 4. Ventilated kiln with heating coils concentrated near center. In kilns with central flues it is not always necessary or desirable to distribute the heating coils uniformly under the entire pile.

Figure 5. Simplest type of recirculating dry kiln. Baffles "B" assist in preventing the heated air from passing upward along the kiln walls.

Figure 6. Recirculating type of dry kiln, with steam jet to increase humidity and vents to reduce it.
The condensers assist the circulation besides serving to remove the moisture from the air.

Figure 7. Recirculating condenser dry kiln. The condensers assist the circulation besides serving to remove the moisture from the air.

Figure 8. Recirculating condenser dry kiln, with internal fans to promote circulation.

Figure 9. Internal fan type of dry kiln, with steam jet to increase humidity and vents to reduce it.

Figure 10. Typical water spray dry kiln. The water sprays produce circulation and regulate humidity.

Figure 11. External blower type of dry kiln. Steam jets may be provided to increase humidity, and dampered fresh air connections on the suction side of the blower to reduce it.

Figure 12. Simplest type of ventilated dry kiln with vertical stacking.

Figure 13. Reversing type of superheated steam kiln. The right-hand and left-hand sprays are turned on and off alternately, producing a reversal of the circulation through the lumber pile.