EFFECT OF PILING METHODS ON AIR CIRCULATION IN A LUMBER DRY KILN

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Natural Circulation Kilns

Need for Vertical Flues

The rate of air movement in natural-circulation kilns is dependent upon gravity alone and is usually insufficient to give maximum drying rates, particularly when drying green lumber under low temperature schedules. For this reason, the piling of the lumber should be such as to provide rather large unobstructed vertical flues about 3 inches or more in width and spaced about 18 inches or less apart. In some cases rather large "A" flues are provided in the lower center of the load so that heat from the coils below can penetrate up into the load before being deflected laterally by the downward tendency of the air when cooled by evaporation. Because of these opposing forces, the openings through the center of the pile must be relatively large to prevent stagnation of air circulation and a resulting wet area.

This is particularly true in drying green lumber, and for that reason it is thought best to provide an arrangement that conforms more nearly to the tendency of the air to rise or fall. In such an arrangement, the heating coils should be placed on the sides so that the heated air can rise unobstructed to the top of the loads and the cooled air can drop through the vertical flues into the open area below. Additional coils located directly below the loads, however, will be beneficial if used only during the latter stages of drying. Opposition to convection currents will then be relatively small and better uniformity of drying will result from this reversal of air circulation. To permit such cycles of air circulation to take place efficiently, the space above the loads should be approximately 1-1/2 to 2 feet in height and that below the tracks about 4 feet, or more, if possible. The heating coils should be suspended well above the floor of the pit.

Spacing of Trucks in Cross-piled Kilns

In a kiln where the boards are piled crosswise with respect to the length of the kiln, there is sometimes very little space between the walls and the ends of the boards. In such cases, it would be best to leave a 1- or 2-foot space between each kiln truck to reduce some of the resistance to vertical circulation.

Arrangement of Flues in Box-piling

In piling random-length lumber, box-piling is one way to prevent excessively large vertical flues and to divide and distribute them uniformly on each side of the more solid center portion. If possible, the outer tiers are carried up with full-length boards and the short boards are placed between them and alternately staggered so that each board has one end flush with either one or the other end of the pile. The staggering in successive layers should be similar, so that a board above is supported directly by the boards below and not by unsupported stickers.

Arrangement of Flues in Edge-piling

Another method of providing vertical flues in natural circulation kilns is to pile the boards on edge. The boards are horizontal lengthwise, but the layers of boards and the stickers are vertical. The air must circulate up or down the full height of the pile within the sticker spaces and then complete the cycle through the open spaces around the piles. Where the heating coils are directly below, this method of piling is not conducive to good air circulation when drying green lumber, and it has, therefore, been used principally with woods that can stand high temperatures that stimulate moisture diffusion through the wood as well as air circulation.

External Blower Kilns

Where Air Enters from Ducts Below the Loads

In the case where air is supplied from ducts below the loads, the air must enter the load vertically through "A" flues in the loads and then pass laterally between the layers of lumber before entering the return ducts on the sides. In order to get uniformity of air distribution throughout the kiln, the holes or slots in the air ducts must be properly distributed and the "A" flue in the pile must be amply large.

Where Air Enters and Leaves Through Perforated Plates on the Sides

A design whereby air enters and leaves through perforated plates on the sides permits flat piling with the boards edge to edge on the kiln trucks. Uniformity of air distribution is obtained by providing a plenum chamber between the perforated plate and the wall and by the proper size and distribution of the holes.

Cross-circulation, Internal-fan Kilns

Uniformity of Air Distribution as Affected by the Width of the Entering-air Space

The best distribution of air through a load of lumber is obtained when the air on the entering-air side of the pile has a low velocity pressure and a high static pressure. Ignoring resistance losses, the total pressure of the air after it leaves the fan remains constant and, accordingly, the static pressure changes with changes in air velocity. An ample space between the kiln wall and the side of the lumber pile can thus act as a plenum chamber in decreasing the air velocity and increasing the static pressure. For the modern fan kilns, at least a 2-foot space is desirable. A space of 2 feet or more is helpful also in entering the kiln when placing or removing kiln samples. Spaces up to 3 feet in width would be better from an air-distribution standpoint and should be considered in designing new kilns. Data on this subject are given in table 1 of Forest Products Laboratory report R1267.

One advantage of a double-track kiln is the additional plenum chamber that is provided for the loads on the leaving-air side of the kiln. This results in better air distribution through the second trucks and is a strong reason for reversible circulation in order to obtain uniformity of drying on both sides of the kiln.

Uniformity of Air Distribution as Affected by Projecting Edges on the Entering-air Side

Air tends to travel in a straight line, especially at high velocities, until deflected by some opposing surface. A board projecting from the side of the load can deflect enough air through that layer to reduce greatly the amount of air passing through the layers below it if the fans are above the loads, or through those layers above the projecting board if the fans are below. This subject is discussed on page 3 of report R1267.

Uniformity of Air Distribution as Affected by the Thickness of the Stickers

The use of stickers as thin as 1/2 inch is desirable in order to increase the kiln-loading capacity and to obtain better air distribution through the load. The breakage, however, is greater than when the more conventional 3/4- or 7/8-inch stickers are used. Furthermore, because of the greater possibility of distortion in thin stickers and the more complete blocking of the sticker spaces by warping of the stock, variation in air velocity may be increased locally with decreases in sticker thickness. Warping, of course, is increased by variations in thickness of both stickers and stock as well as by poor alignment of stickers. The data presented in table 2 of Report R1267, however, indicate that the average uniformity of air distribution through the

load is improved by a decrease in sticker thickness. One reason for this is the increase in static pressure caused by the increase in resistance.

Spacing of Boards in a Cross-piled Kiln

In a cross-circulation, internal-fan kiln, the piling should be such that the boards are parallel to the length of the kiln and are solidly piled across each layer. In a remodeling job, however, the cost of converting a cross-piled kiln and its transfer system over to an end-piled system may be considered excessive. In this case, the air must move against the stickers, and consequently a space must be left between the edges of the boards so that the air can pass through the sticker barriers. The spacing required would vary with the board widths, but in most cases a spacing of about 2 inches would be sufficient. Such an arrangement will not give uniformity of air distribution over the board surfaces and will greatly reduce the fan delivery because of the increased resistance to air flow.

Methods of Measuring Air Velocity

Use of Smoke from Tobacco, Punk Sticks, or Rope (For Slow Air Velocities)

The velocity of the air in a dry kiln can be measured by the use of smoke from tobacco, punk sticks, or rope. The smoke supplied by this method, however, is usually insufficient for satisfactory tests. Another objection is the fire risk. It is a convenient and expedient method; but in using smoke from such burning substances, it must be remembered that the smoke will tend to rise on account of its higher temperature and that the true circulation will not be indicated until the smoke has cooled to the air temperature.

Use of Chemicals (For Slow Air Velocities)

A special form of smoke machine has been developed for dry-kiln work. This consists of two small glass bottles, one of which contains hydrochloric acid and the other ammonia. Air is blown by mouth, or by means of a bulb, through connecting tubes so that the fumes of the two become mixed, thus producing a dense fog or smoke. Another chemical is titanium tetrachloride, which produces smoke when exposed to the air. The procedure is merely to drop a small amount on some surface where smoke is desired or to use a swab stick that can be dipped into the bottle of the chemical and then carried about as desired.

Use of Anemometers or Air-velocity Meters

The dial of an ordinary anemometer reads in lineal feet and must be used with a stop watch to obtain the air velocity in feet per minute. To obtain correct readings, the axis must be parallel to the air movement and a calibration-correction factor must be applied as directed by the instrument manufacturer. To obtain some idea of the velocity between layers of lumber, the anemometer can be placed against the edges of the boards on the leaving-air side of load, but the readings will probably indicate velocities from 0.5 to 0.8 of the true velocities because only a part of the vanes are exposed to the air stream. Another instrument is the direct-reading air-velocity meter which is equipped with a duct jet attachment that can be inserted between layers. The velocity, in feet per minute, can be read directly on the dial of the meter.