ANALYSIS OF PROBLEMS RELATING TO UNIFORMITY OF KILN CONTROL

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ANALYSIS OF PROBLEMS RELATING TO UNIFORMITY OF KILN CONTROL

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Introduction

To provide good dry-kiln performance, all integral parts of the lumber kiln, such as coils, traps, vents, steam sprays, fans, and controlling instruments, must be designed correctly and function efficiently. The failure of any one or more of these integral parts will result in poor control of drying conditions and yield an unsatisfactory kiln-dried product.

It is not always practical, however, to adopt the best kiln design. Plant layout and cost of dry-kiln construction or modification are usually the deciding factors in design. Therefore, dry-kiln manufacturers and engineers frequently design dry kilns and dry-kiln equipment to meet such practical limitations, even though they know the kiln will not perform in the most efficient manner. They do, however, give to the purchaser of dry kilns and dry-kiln equipment sound engineering advice on any given dry-kiln problem. As far as possible, therefore, the management, and all others concerned, should accept and follow their suggestions and recommendations.

Even a perfectly designed dry kiln, however, will fail to perform in a satisfactory manner if any of its integral parts should fail. Such failures can and do occur. Occasionally, they are caused by faulty design, but more frequently through the lack of proper maintenance.

To detect improper kiln performance, kiln temperatures must be checked from time to time by means of temperature-measuring devices, such as thermometers and potentiometers. These temperatures should be taken simultaneously at various places throughout the kiln. If there are large temperature variations, their cause or causes can usually be found by examination of the integral parts of the kiln.

The purpose of this report is to call attention to the more common faults in design and to the common failures of integral parts of a dry kiln, and to their effects on the control of drying conditions.

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Common Causes of Nonuniform Drying Conditions

Coil Problems

Head room.--In some kilns, sufficient head room is not available to permit the use of coils of proper design and construction and with adequate drainage. Some such kilns are equipped with long coils that lie almost flat. In such coils, gravity does not assist the flow of the condensate toward the discharge end. The result is that the coil may become waterlogged and air-bound, a condition which will result in nonuniform temperatures along its length.

Frequently, in order to obtain proper drainage, the drain end of the coil is resting on the ground or even may, in some cases, be covered with dirt. If this be the case, no air movement can take place around the covered portion of the coil and the kiln temperature in the affected zone will be low.

Intermittent coil operation.--In many kilns the coils are not designed for intermittent steam feed. If the coils are designed so that the steam is on only for a short time, such as 15 seconds, and off for 10 minutes or more, and if the steam pressure is not high enough, they will not be cleared of air and condensate, and these will cause a wide variation in temperature along their length. The longer the steam is off, the greater becomes this temperature differential along the length of the coil. On the other hand, if the steam pressure is great enough to clear a large coil of air and water in a short time, the temperature-time cycle is increased so that the kiln drying conditions vary tremendously, not only longitudinally, but in any one location.

Change in heating capacity.--The effective length of a coil is decreased when it becomes waterlogged or air-bound, because the steam does not fill its length. Extreme variations in kiln temperatures and severe losses in the heating efficiency of the coils result.

Header feed.--If the steam feed line is attached to an end of the header, the steam flows rapidly through the header to its opposite end, so that the coil pipes near this end are supplied with a greater amount of steam than those near the feed end of the header. Air-binding and waterlogging may result in the pipes with little, if any, steam flow, and coil efficiency will be greatly impaired.

This same result will occur when the feed line is attached at the side and longitudinal center of the supply header. In this case, a large
amount of steam flows through the pipes directly opposite the feed line and very little steam through the pipes near the ends of the header.

Short and long coils in parallel.--When coils of unequal length are fed from the same feed line, the shorter coil is the more efficient. The reason for this is that, at any given steam pressure with intermittent feed, the shorter coil offers less resistance to the steam flow, so that the steam has a tendency to short-circuit through it and to flow less freely through the longer coil. Eventually, the longer coil will become so waterlogged and air-bound that nonuniform temperatures will result.

Unbalanced coils.--In some kilns an unbalanced coil arrangement causes extreme variations in temperature. Such lack of balance may occur in several ways. It can be illustrated, however, by a single example.

A kiln 100 feet in length is equipped with two horizontal return-bend coils, each extending half the length of the kiln. Both are operated under the same steam pressure, but are controlled by separate dry bulbs. The coil at the rear end has the correct amount of radiating surface for the temperature required. The coil at the front end is twice as large. Therefore, the small coil is under constant steam feed, while the large coil is fed intermittently. The result is that the small coil is operating efficiently and produces uniform temperatures along its length, while the large coil is not operating efficiently, creates a distinct temperature cycle, and produces non-uniform temperatures along its length.

Long coils.--With intermittent coil action, the use of long coils causes excessive longitudinal temperature variations unless the condensate can be removed from the coils by gravity alone. The amount of headroom necessary to obtain enough pitch so that gravity can remove the condensate will, however, increase the cost of kiln construction. If long coils are used, higher steam pressures are essential in order to discharge the condensate and air. If the radiation is excessive, high pressures, however, will in turn increase the temperature-time cycles to a point where it is impossible to obtain stable drying conditions. On the other hand, operating pressures of approximately 20 to 25 pounds per square inch may not be enough to eject all the condensate and air that gradually build up while the coil is inactive. Eventually, the coil may become completely waterlogged and air-bound. Temperatures along a coil that is completely filled with water may be fairly uniform, but high temperatures cannot be obtained. If the coil is partly filled with water, the temperature along its length will vary greatly.

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Large radiating surface.--The results to be expected from large radiating surfaces are similar to those produced by long coils or short circuits. The larger the radiating surface, the longer will be the interval between the closing and the opening of the heating valve, and the longer will be the cooling period. During this cooling period, a vacuum is created in the coils that pulls air and water into them through the trap from the discharge line. This air and water cause a large temperature variation along the length of the coil.

Return-bend coils.--Coils of the multiple-bend header type should be installed in an upright position. If such a coil is laid on its side, the proper pitch of the runs can be obtained only with great difficulty, the coil does not drain properly, and long coils tend to become waterlogged and thereby to lose heating efficiency.

Occasionally, coils of the single-bend header type are located at track level and are so arranged that the condensate must be forced upgrade to reach the drain header. A coil so constructed will become waterlogged and air-bound and will produce uneven temperatures along its length.

Elbows, valves, pipe diameter, fin pipe.--The installation in a plain-pipe coil of any valves, elbows, unions, lengths of pipe of larger or smaller diameter, or lengths of fin pipe will increase the radiating surface or cause other difficulties. By installing sections of larger pipe or fin pipe in a coil made of plain pipe, higher local temperatures will result. It is poor practice to build such sections into a coil unless it is necessary to correct other difficulties that exist within the kiln, such as a cold zone caused by kiln leakage and cold-air infiltration. Even then, it is preferable to correct these difficulties directly rather than to increase the radiating surface in specific zones, and thereby to cause unbalanced radiation.

The installation of pipe of smaller diameter, such as those used in springer sections on certain types of coils, will sometimes cause clogging of the coils, especially if low steam pressures are used. The long cooling period permits condensate to gather in the springer section and impurities from it to settle on the pipe walls that will eventually clog the pipe and thereby seriously reduce the efficiency of the coil. An excessive number of fittings, especially if they are rough on the inside, tends to obstruct the flow of steam or condensate and causes pockets in which dirt and scale can collect.

Leaky valves.--Leaky valves will allow steam to enter the heating coils at all times and thereby result in excessive temperatures and possible kiln degrade.

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Trap Problems

The heating units in lumber dry kilns usually contain large volumes of air and condensate, and their steam pressure as well as their steam consumption may vary considerably from time to time. This condition creates many trap problems, each of which will result in waterlogging and air-binding. These conditions in turn will produce nonuniform drying conditions within the kiln.

Trap size.--Very frequently too small a trap is used. When this occurs, the trap may not be able to handle all of the air and condensate from the heating coils, so that the coils will eventually become waterlogged and air-bound. Also, even though the trap can remove the air and condensate, its frequent operation of filling and dumping will cause rapid wear on all its working parts that will eventually result in complete trap failure.

Working pressures.--In a great many cases traps are required to operate over a wide pressure range and to handle quantities of condensate that vary greatly. Usually the rate of condensation is at the maximum and the steam pressure at a minimum when the steam first enters the heating coils. The low initial pressure decreases the force available to move condensate through the trap and, in this case, the orifice must be large enough to handle the peak condensate load at the minimum pressure. On the other hand, the trap must be large enough to open the discharge orifice at the maximum pressure that will be encountered. Back pressures in the return line will reduce trap capacity.

Trap location.--Frequently traps are located above the unit being drained. This arrangement will cause air-binding and waterlogging by allowing water to flow back into the coils.

Short-circuiting.--Two or more coils connected to a single trap may result in short circuits. If every coil used exactly the same amount of steam at the same pressure, a trap sufficiently large could handle all the condensate. This condition, however, is seldom encountered; usually one coil is properly drained and the others become so air-bound and waterlogged that nonuniform drying conditions result.

Dirt in traps.--Any dirt accumulating in traps may plug the trap vent or prevent the bucket from working. Either of these conditions will result in the air-binding or waterlogging of the coil. On the other hand, dirt caught between the discharge valve and the valve seat will result in the loss of steam.

Worn parts.--Worn parts may result in steam losses through the trap due to "blow-by" through the discharge valve, or they may result in failure.
of the trap to release condensate or air, which failure will cause air-binding or waterlogging.

Return lines.--If the return lines are too small, they may cause back pressures that will result in improper trap performance. They may also become clogged with dirt, which will result in complete failure of the trapping system.

Receiving tanks in return lines.--Occasionally open receiving tanks are installed in the return lines. If these are used, their water level must be kept below the discharge line from the traps. If the end of the discharge pipe is below their water level, each time a vacuum is pulled in the heating coils during cooling periods, the water in the receiving tanks will be pulled back into the coils, where it will seriously affect kiln temperature conditions.

**Vent Problems**

Ventilators in a dry kiln assist in maintaining uniform relative humidity conditions. They permit the escape of hot, moist air from and the entry of cold, dry air into the kiln. The tighter the kiln walls, ceilings, and doors, the more important becomes the action of the ventilators.

In as far as the vents are concerned, the drying conditions can be affected by vent location, vent size, and vent operation.

Vent location.--Actually, the location of vents in a dry kiln does not materially affect wet-bulb temperatures. The amount of air to be vented from kilns over a specific period of time will depend upon the species being dried. For a fast-drying species such as pine, a tremendous amount of hot, moist air must be expelled from the kiln; while for a slow-drying species such as oak, the amount of air to be vented is considerably less. If all the vents in a kiln that is used for drying a species from which the moisture loss is extremely rapid, are located at one end of the kiln, all the hot, moist air will be vented from the kiln in this end zone and all the cool, dry outer air will enter the kiln in this same zone. This condition will result in much greater heat demands from the coils at this end than from those located in the rest of the kiln. This difference in heat demands will result in rapid steam flow through the coils in the zone of high heat demands and in long cooling periods in the rest of the coils. Eventually, these long cooling periods may result in waterlogging and air-binding in some of the coils that will prevent maintenance of uniform temperature and relative-humidity conditions.
Vent size.--The vents in a dry kiln must be large enough to expel the hot, moist air in an amount necessary to maintain the desired relative humidity. Naturally, the wetter and faster-drying is the lumber composing the kiln charge, the larger must be the vents. If the vents are too small, the relative humidity will be too high, drying will be retarded, and in some cases, mold may develop.

Vent operation.--Manually controlled vents should be operated so as to maintain the desired kiln conditions at all times. If the relative humidity within the kiln becomes too high, they should be opened so as to facilitate drying. On the other hand, if the relative humidity becomes too low, they should be immediately closed. If this is not done, steam consumption will be increased through the unnecessary action of the steam sprays.

Automatic vents, operated by the controlling instrument, are becoming more common. These vents assist materially in maintaining the desired relative-humidity conditions and thereby facilitate the drying rate and reduce steam costs. Kilns have been found, however, where these vents are hooked up in a reverse manner, so that they open when they should close, and vice versa. Such a hook-up will, of course, seriously interfere with drying conditions.

Steam Sprays

Size of spray lines and spray openings.--If the spray lines and openings are too large, so that they supply more moisture than is required, the relative humidity, temperature, ventilation, and heat consumption will be increased. These increases will in turn increase drying time and costs.

Steam pressure.--Steam pressures are very important. If a steam-spray system designed for low pressures is operated under high pressure, the same effects as mentioned in the preceding section will result.

Leaky valves.--Leaky hand or automatic steam-spray valves will result in waste of steam and, if severe, will result in high relative humidities and temperatures, and in increased ventilation and heat consumption.

Air-circulation Problems

The effect of air circulation upon temperature is pronounced. To obtain uniform kiln temperatures throughout a kiln, air circulation must be uniform. The most common causes for nonuniform air circulation are outlined as follows:
Damaged fans.—A damaged fan will have a decided effect upon air circulation in its particular zone. It has been found that a multiple-disc fan with a few blades bent out of line will cause a temperature drop in its zone of as much as 8° F. More serious damage, such as the loss of all blades through corrosion or being hit by falling objects, etc., will cause much greater temperature variations. In one such case, a drop of 24° F. within a 6-foot zone was recorded.

Fan baffles.—In kilns equipped with fans blowing the air against baffles running diagonally across the kiln, the air tends to move in a longitudinal as well as in a transverse direction. The greater this longitudinal movement along the coils, the hotter becomes the air. Therefore, at the point where the longitudinal movement is broken up, either at the ends of the kiln or where the diagonal baffles reverse themselves, the kiln temperature becomes greater than that desired. The magnitude of this temperature pile-up will depend upon the length of the kiln and the angle of the diagonal baffles. It has been found in actual cases, however, that temperatures ranging from 15° to 34° F. in excess of those desired, have resulted in zones where the longitudinal air movement was broken up.

Any damaged fan baffles will result in the air short-circuiting the loads of lumber and in increasing the drying time.

Piling problems.—Air circulation can be seriously disrupted through improper piling practices. Whenever this disruption occurs, the drying time will be increased and the moisture content of the kiln charge as a whole may vary considerably.

Figure 1 shows the ends of two truckloads of lumber piled with uneven ends. When they are butted end to end in the kiln, a large void will result. A considerable amount of the air will short-circuit through this void and the volume of air moving through the various courses of lumber in the loads will be reduced, less moisture will be carried away from the lumber, and the drying time will be increased.

The same results can be expected when lumber of unequal lengths is piled on the same kiln truck, as shown in figure 2. Furthermore, if long boards are piled on top of short boards without a supporting floor, their ends will bend downward and dry in this shape.

Figure 3 shows a load of lumber with ragged sides. Air traveling downward or upward between the sides of this load and the kiln wall will strike the edges of the boards that project outward, be deflected by them away from the load, and several courses of lumber will be short-circuited. This will also result in nonuniform moisture content of the lumber and prolonged drying time of the kiln charge as a whole.
Size of supply ducts and air passages.--If the air-supply ducts and air passages in a dry kiln are too small, back pressures will develop from which a nonuniform delivery of air through the kiln charge will result. This condition will produce nonuniform drying.

General Problems

Cracks in the kiln walls and ceilings and improperly fitted and poorly maintained doors will permit the infiltration of cold air from the outside atmosphere into the kiln and also heat losses from the kiln. These leakages may result in extremely cold zones within the kiln, that will seriously affect the drying rate and increase steam consumption.

Water seepage into the kiln will also seriously disrupt drying conditions. Kilns located near large bodies of water or located above a high water table should be elevated above the water-seepage level. In one particular case, a battery of kilns with the fans located below the rails was located near the ocean. During periods of high tide, sea water seeped into the kiln and covered the floor to a depth of 5 inches. This water was picked up by the fans and thrown throughout the kiln. Not only were the drying conditions seriously affected, but the corroding of all metal parts within the kiln by salt water necessitated their frequent replacement.
WRONG

LOAD OF LUMBER WITH RAGGED EDGES