BRAIN WORK IN KILN OPERATION

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There is no phase of kiln drying that stands out more clearly as essential to success or directly responsible for failure than the intelligence and attention that is given to the operation of the kiln. Those who have watched with particular interest the progress of the practice of kiln drying lumber, especially under the stress of war conditions, have seen that the greatest difference between success and failure has been in the operation more than in the kilns themselves, whether it has been with airplane stock, green oak vehicle stock, ship timbers, or wooden legs. Poor kilns and good operation have often produced as good results as good kilns and poor operation. But in the long run, the big problems of artificially seasoning lumber will be solved only by a happy combination of the two factors. It takes a good kiln and good operation to obtain really good results.

It has frequently been brought to the attention of the Forest Products Laboratory of the United States Forest Service at Madison, Wisconsin, that with a given type of dry kiln, handling similar kinds of stock according to the same recommended schedule, one concern has dried its material with practically no loss while another suffered a loss of 40 to 50 per cent.
If the art of kiln drying lumber has come through its recent trials trimmed of some non-essential ideas and benefited by new conceptions, the sum total of our information concerning it has been greatly increased. On the other hand, if there is still a vestige of the old notion that "this kind of kiln will dry lumber in half the time with less checking than that kind of kiln", a big load of inertia must still be moved.

Emphasis on the operation of the dry kiln means the injection of the human, intelligent, interested element into kiln drying which is too frequently absent in the methods of many concerns. The kind of kiln operation that is possible at the hands of an ex-lumber piler who has become too old to work efficiently anywhere else, or of a man who has grown up with the company and in his later years deserves an easy job, or of a fireman at the plant who has a few extra hours to fill in - that kind of kiln operation does not enter into this consideration.

The kiln drying of lumber, unless it be the drying of air-seasoned softwoods, is an art involving special knowledge, skill and good workmanship. Without detracting from the credit of the practical lumberman, it may be said that the greatest advances in kiln drying have come in the last few years. This advance, reflected in new methods of seasoning, is the outgrowth of accumulated scientific knowledge of
the physical and mechanical properties of wood. The successful dry kiln operator today has to think of characteristics of wood in terms which are unfamiliar and in many instances distasteful to the older type of practical lumberman.

As a matter of fact this conception of the role of operation in kiln drying is opposed to a more or less general commercial tendency to make kiln drying an automatic process from which the element of personal judgment is removed as much as possible, thereby attributing to dry kilns in themselves whether of one particular design or another some mystic, secret capacity to dry lumber perfectly with the minimum watching by a competent operator. Or often lumber is supposed to be dried successfully by some so-called "patented process." Sad experience shows that it is impossible to put lumber in a dry kiln like a potato in an oven and take it out all done to a queen's taste.

It is not uncommon to read in advertisements in trade journals that this or that kind of dry kiln or process dries lumber without checking, honey-combing, or casehardening. Such a statement is the danger signal. A simple statement that temperature and humidity conditions are flexible and under the immediate control of the operator would inspire more confidence.

The most satisfactory types of kilns yet developed are those with features of automatic temperature and humidity
control which make the operator a complete master of his kilns in that any conditions which he regards beneficial to the lumber may be maintained hour after hour, or day after day, until he considers it desirable to change such conditions.

The kiln operation itself can never become automatic although the control of drying conditions may well be that, and efforts to bring about automatic control of such phases are most decidedly on the right track. A brief and general discussion of some of the features of kiln operation which are of utmost importance may throw additional light on the importance of the skilled operator as apart from the kiln.

Relation Between Method of Piling and Uniformity of Drying

The first opportunity for an exhibition of skill in kiln operation is in the adoption of the proper system of piling the lumber in the kiln. It may be safely said that comparatively few kilns are operated with any thought as to whether the piling suits the kiln or not. Because of the very definite relation that exists between method of piling and the circulation of air in the kiln, this subject is to be as strongly emphasized as careful temperature control and regulation of the humidity.
First and foremost, lumber is piled in the dry kiln so as to dry uniformly and as quickly as possible. There is no more effective way of bottling up the circulation in a kiln and slowing up the drying rate than by piling in lumber across the path of the moving air. The piling should be such as to offer the least obstruction to a free and positive circulation of air within the kiln. Methods of piling which lead to complete utilization of all space and in greatest economy of handling the lumber through the kiln are important features to be sure, but entirely secondary and subordinate to the method that conforms to the circulation system of the kiln. The method of piling must be such as will throw the "stickers" parallel to the predominant air currents and never perpendicular to and obstructing it.

End piling in a progressive type of kiln, which depends for its circulation on the passage of air from the hot, dry end to the green, cool end places great obstruction to free and uniform passage of air and is obviously wrong. Cross piling in a type of kiln in which the circulation is vertical-lateral as in many types of ventilated and condenser kilns, is just as serious in that the normal air currents are obstructed.

This point is illustrated clearly by a case of practical experience. Some 4/4 green maple was loaded into
Sketches of representative commercial installations of a type of progressive kiln in which the circulation of air is from end to end. Note that in end piling the "stickers" oppose and obstruct the intended circulation.

Both end and cross piling are often used in this type of kiln, but cross piling is distinctly superior to end piling, from the standpoint of circulation. This illustrates the lack of attention to a very important item of kiln drying.
LUMBER FILED CROSSWISE IN AN INSTALLATION OF COMPARTMENT KILNS
FURNITURE PLANT IN PENNSYLVANIA

LUMBER FILED ENDWISE IN AN INSTALLATION OF SIMILAR KILNS
FURNITURE PLANT IN MICHIGAN
Sketches of representative commercial installations of a type of compartment kiln in which the circulation of air is up in the center and down and out at the sides. Cross piling places greatest obstruction to this system of circulation. At one plant the lumber is piled crosswise and at the other is piled endwise. There is only one of the two methods which can be right. Another illustration of failure to give attention to circulation in the kiln.
a dry kiln having vertical-lateral circulation. Part of the stock was end piled and part of it cross piled. Temperature readings were taken daily at different parts of both piles. After the run was well started the difference between the hottest and coolest portion of the end-piled stock was 100, while the difference in the cross-piled stock was 580. This had a marked effect on the uniformity of drying. The end-piled stock dried from 30 per cent to a maximum moisture content of 6 per cent in 10 days while it took 13 days for the stock piled crosswise to dry from 30 per cent down to 12 per cent. This shows that there is a right and wrong way for lumber to be piled in every type of kiln. To those interested in even, rapid drying, this point is of great practical significance.

Knowledge of Actual Conditions in Kiln
Prevents Losses in Stock

After the lumber is properly piled in the kiln and the heat turned on, the competency of the operator again comes into play. It is essential that the operator know accurately the drying conditions in every part of the kiln. The determination of the conditions to which the lumber is actually subjected is a critical phase of kiln operation. With that knowledge available to the operator no lumber need
An actual record of temperature conditions during the kiln drying of heavy, green oak at an auto body plant in Ohio. Note the great difference in temperature readings obtained from the recording instrument in one part of the kiln and from a standard thermometer in another part. The operator of the kiln did not know under what condition the lumber was actually being dried. Result was loss of 70 per cent.
be ruined in any dry kiln. If one part of the kiln is warmer than another, that fact should be known by the operator and allowances made therefore. If one end of the kiln runs at lower humidity than the other, that fact should be known and reckoned with. When measurements of temperature and humidity are taken they are too often taken by sticking an instrument through a hole in the big door and assuming that all parts of the kiln read the same as near the door. The temperature and humidity taken at any one part of the kiln are no criterion of the condition in other parts of the kiln unless the circulation is more perfect than in most kilns.

The kiln operator should know the behavior of his kiln when lumber is being dried in it as an engineer knows the correlated workings of his gas engine.

**Regulation of Kiln Should be Based Entirely on Moisture Condition of Lumber**

The fundamental basis of kiln regulation is the actual condition of the lumber in the kiln. This statement ought to be as easily and broadly recognized by kiln operators as the fact that the amount of fire under a boiler is the measure of the amount of heat produced, and yet there is a most flagrant disregard of this fundamental truth in many kiln drying operations. Ordinary practice involves kiln operation based on the number of days that the lumber has been in
the kiln. The variation in the original condition of the lumber is so great, the difference in the drying conditions in the kiln are so pronounced that this method is uncertain. This practice when applied to the commercial drying of heavy green oak has resulted in exorbitant losses.

The whole dry kilning operation is linked up with the amount of moisture in wood and obviously the operation of the kiln must be on that basis.

It is a well established fact that there is a point in the drying process around which the entire drying schedule should center. It is the point which marks the dividing line between green and partially seasoned wood. Up to this point the drying condition must be moderate and constant and after which the drying may take place more rapidly. Technically this point in the drying is called the fiber saturation point and practically it corresponds roughly to moisture content of 25 per cent based on the bone dry weight of the wood.

There is no way of knowing when the lumber in the kiln is ready to stand higher temperature except by knowing how much moisture there is left in the wood. The number of days that the lumber has been in the kiln is of slight importance and no significance in this connection.
The one criterion of regulation is the moisture content of the lumber and its fitness to withstand more severe drying conditions and never the number of days that the lumber has been in the kiln.

**It Pays to Watch Behavior of Lumber During Kiln Drying**

Brain work in connection with kiln operation shows up more than anywhere else in watching the effect of the drying on the condition of the stock itself. To go into a warm moist kiln, especially on a hot summer day, and look for surface checks and other defects is not the most agreeable thing in the world but it is worth while when a kiln load of expensive lumber is at stake. In the old-time kiln operation to spend any time in the dry kiln was never thought of, in fact, in most kilns there is no way to get into the kiln except the main door be opened, thereby letting out the heat and exposing the lumber.

A furniture man when consulted regarding his troubles in kiln drying green oak was urged to cut a small door in the large kiln door so that the operator could get in easily to watch the condition of the stock from day to day. His contention in opposition was that a small door was a nuisance; that it was continuously getting out of repair and that it so
weakened the big door that it would go to pieces in two or three years. The stock in his dry kiln cost him around $1000. He could have built a new kiln door, when the old one was too weak, for $100, but the lumber in the kiln, according to this business man's reasoning was not worth the kiln door. It is a matter of record that his $1000 worth of oak was a total loss, but that his kiln door is still in good condition.

What are some of the things that can be seen by watching the stock? And the answer is: Practically all of the things that result in losses of lumber during kiln drying. Symptoms can be seen and they can be fought just as a physician fights the symptoms of disease. If the temperature in the kiln is too high and the lumber too green, the stock checks and casehardens. Maybe the class of work is such that a few surface checks do not count. Maybe the operator knows that the checks will close during the remainder of the drying. What closes these surface checks? Usually a compression on the surface and a tension on the inside which is called casehardening. And the force which is powerful enough to close these surface checks is also powerful enough to cause an internal rupturing of the fibers or honeycombing, which happens when the condition is allowed to continue. When checks under the force of this tremendous compression strain begin to develop concave sides upon continued drying and begin to "pinch in"
I. A slight surface check has developed into a deep check because of too rapid drying from the surface. At this stage, the outside in tension.

II. Surface check begins to close as drying proceeds. A crack forms on the outside opposite the creases.

III. Surface check pearly closed as drying proceeds. Creases still form further and case hardening increases.

IV. Surface check entirely closed by the force of compression on outer surfaces. Pinching in of the check occurs. This is the time to steam to relieve case hardening.

V. Pinching in becomes more severe due to the inside of the surface. Surface condition of honeycomb.

VI. Final stage of honeycombing resulting from improper closure of surface. Check is offset along the grain, which is a surface condition of honeycomb.
Stages in the development of honey-combing from a surface check which has developed early in the drying and allowed to close up without proper steaming treatment in the dry kiln. The application of steam at the proper time prevents honey-combing.

The sketches are to be regarded as imaginary cross-sections cut through the same check during successive stages in the drying.
at the surface - the danger sign is out. The operator must be there to see the sign.

**Wise Steaming is Both a Pound of Prevention and Ounce of Cure**

The remedy to be applied to lumber which shows defects and danger signs during drying is a comparatively recent one, not completely understood but of broad application and great value. It consists of the application of saturated steam for a period of time and at a temperature which in the judgment of the operator suits the case at hand. The application of this curative principle must be understood before applied because, like most effective treatments, it can work detriment as well as benefit.

This principle may be used at the beginning of the run to heat the lumber through to the center before drying from the outside begins; also in the case of partially seasoned stock to relieve the tendencies toward casehardening which have been set up during air drying. As such it is often called preliminary steaming. A steaming or sweating of this nature is usually for a period of about 6 hours per every inch in thickness and at a temperature of only about $25^\circ$ higher than the temperature at which the run is to start. The practice of steaming for a period of several days at the start is a
big waste of drying time; does not accomplish more than can be accomplished in a few hours and actually damages the stock.

To kill mold that develops on the lumber in the kiln when the drying conditions are mild, an application of saturated steam for an hour at a temperature of 165-180 degrees is most effective.

The most valuable application of the remedy is to lumber which has become casehardened to the extent that the wood fibers tend to give way to the stresses set up or when the surface checks show indications of "pinching in." It is necessary to steam at a temperature of 160-180 degrees for a period of one to several hours, depending on the severity of the case as judged by the operator. This saturated steaming at high temperature moistens the outside of the wood and reduces the stresses and the hard bony surfaces that have been set up in the wood fibers. With these stresses removed, the danger of honeycombing is gone and the drying may continue according to schedule until perhaps the stresses become serious again, necessitating another application of steam. When the lumber is ready to be removed from the kiln and it is severely casehardened with the tendency to warp after machining in the shops and upon resawing, proper application of saturated steam removes the casehardening set up and greatly improves the quality of the material.
Operation of Kiln Most Important Element in Kiln Drying

Operation means knowing the exact temperature and humidity at which the lumber is actually drying all over the kiln, it means knowing how the wood is reacting to the conditions as told by symptoms such as checking, casehardening and moisture distribution.

When these things are appreciated and known accurately, the art of kiln drying lumber will have taken a step forward and more general commercial success will be realized.