DRY KILN DEFECTS

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KILN DRYING DEFECTS

INTRODUCTION

Many defects in lumber are caused by the kiln which dried the wood. In this thesis the common defects will be discussed in order to give a fairly complete understanding of their cause and remedy.

CASEHARDENING

Casehardening is the difference in stresses between the outside and the core in a piece of lumber. When rapid drying occurs in lumber the outer layer dries first. The wood in this outer layer tries to shrink but it is prevented from doing so by the core which has not shrunk enough yet. The outside then becomes set in this condition. If the center of the piece dries out it tries to shrink but it can not. The final result is that the core is set in tension and the outside in compression.

In the drying of lumber, casehardening usually follows when too rapid surface drying occurs caused by either the temperature being kept too high, the humidity being too low, or a combination of both of these factors. Another factor causing casehardening may be due to uneven drying. This may be due to sluggish or uneven circulation or to large fluctuations of temperature and humidity.

In order to prevent casehardening in the kiln, it is necessary to control the kiln so that the surface of the lumber will not dry out too rapidly. This can be done by using higher humidities and a lower temperature. There must be enough circulation, and the circulation must be uniform throughout the lumber. The temperature and humidity must be controlled, preferably with automatic controls.

Casehardening may be prevented beforehand by frequent periodic steamings. If the material is very thin stock it may be necessary to place heavy weights on top of the loads.

During the run, frequent tests of casehardening and moisture distribution should be made. Thick stocks and dense wood, which have a tendency to caseharden severely, may need to be steamed once or several times during the run. If the wood has been air seasoned before putting in the kiln it may be already casehardened. If air dry lumber contains less than 18 per cent moisture content it should not be steamed at 100 per cent humidity, but at 65 to 85 per cent humidity for 10 to 30 hours at 160 to 180 degrees, the time depending on the moisture content and the thickness of the stock. For moisture contents much lower than 18 per cent the humidity should be between 60 and 70 per cent.

When casehardening has occurred the lumber should be steamed at temperatures from 165 to 185 degrees Fahrenheit, irrespective of species or thickness with the follow-

ing humidies:

If the center of the stock contains over 18 per cent moisture, 100 per cent humidity for ½ to 3 hours should be used, unless the stock is checked, in which case 85 to 95 per cent humidity should be used for 10 to 20 hours.

If the center of the stock contains below 15 per cent moisture content, 60 to 70 per cent humidity should be used for 20 to 30 hours.

During the process of steaming a very rapid circulation should be maintained. The time of steaming depends on the thickness of the stock and the depth to which the outer set layer extends. The time limit refers to the time the temperature is maintained and does not include the time required to meet all the conditions. The length of time required in each case applies to stock 1 inch in thickness. Proportionally longer time is required for thicker stock. Care must be taken not to add too much moisture to the surface layers or the stresses may be reversed, or if there are checks in the lumber they will open up on further drying and will not close up later.

SURFACE CHECKING

Surface checking occurs in casehardening when the strain on the surface of the boards becomes too great and the fibers are not strong enough to resist the strain, causing them to be pulled apart and forming small cracks on the

surface. These breaks usually occur on the weaker spots along the pith rays. Wood having large rays like the oak, beech, sycamore, and locust check more easily than the others.

Surface checking may be caused by uneven drying due to uneven and inadequate circulation which may cause the lumber to dry out on one side but not on the other; the boards may be protruding from the ends of the pile; or the lumber may be improperly piled so that the drying was uneven. Dripping from the ceiling will cause lumber to check by keeping one part wet and allowing the rest of the board to dry out.

Checking is often incurred during air seasoning. Unless this is noticed the checking may be blamed on the kiln.

If too much moisture is added to the wood to relieve casehardening checking may result.

In order to prevent surface checking it may be necessary to secure better circulation. It may be necessary to use higher humidities at the beginning of the run in order to slow up the surface drying. Frequently it is necessary to steam periodically. If the lumber is not piled correctly it may be necessary to pile it so that more adequate circulation can be maintained. If water is dropping from the ceiling it may be necessary to insulate the ceiling or use ceiling coils to keep the ceiling warm. The use of

narrow stickers will help to secure better circulation which may help in preventing checking.

Checking can not be remedied but further checking can be prevented by using the same treatment as in the relief of casehardening.

Often checks can be closed if dried evenly and to a low moisture content, but the checks are still in the piece and it is not so strong as it was before checking occurred.

UNEVEN DRYING

Uneven drying can be caused by too much variation of temperature and humidity through the kiln. This is usually the result of poor circulation in the kiln. In some kilns there is a lack of control, that is the humidity and temperature are not well controlled. The circulation may be inadequate or unbalanced. Perhaps the circulation is just going around the lumber piles and not through them. Perhaps the lumber is improperly piled so that the air circulation cannot be forced through the pile. It may be that the lumber is flat stacked when it should be vertical. The lumber may be piled too close or overhanging ends may be unevenly drying. Doors that are not well enough insulated cause uneven drying. Drip from the ceiling will keep certain parts of the lumber wet while the rest is drying.

Leaky steam pipes will raise the humidity in certain places.

In order to prevent uneven heating the heating system should be balanced. The coils must be completely gone over to repair the leaks and to make sure that there is adequate drainage. If the coils keep filling up with air it may be necessary to install an air vent. A pitch of from one to two feet for each hundred feet of pipe coil is adequate.

Automatic or hand operated air valves should be installed near the bottom of the pipe coils to blow out the cold air which accumulates in the pipes. These valves must be mounted or fitted on the upper side of the pipe coils, otherwise they will become water logged. These air valves can be adjusted by an adjusting screw.

In some cases where exhaust steam is used it may be necessary to use a steam and oil separater before the steam is turned into the pipe coils. Exhaust steam, if not separated from the oil may form a film of oil on the inside of the pipe coils which prevents condensation.

If the steam pressure is too low the steam will take too long to travel the length of the pipe coils. The steam will evaporate before it has run the length of the coils. This will cause uneven heating and can be remedied by shutting off one side of the pipe coils during the run or else by increasing the steam pressure. Sometimes when tests are made in a compartment kiln they show that the heat at the

entering end is higher than the heat at the opposite end. This may be due to the steam condensing on the entering end. In this case the steam pressure may be too low. It may be advisable to run the steam into only one of the sets of coils after the kiln is heated up. By doing this a more uniform flow of steam can be maintained into the pipe coils.

In order to have even drying it is necessary to have automatic regulation. Self contained thermostats will control the temperature within two degrees either way, while air operated instruments will control the temperature with a variation of one degree either way. The circulation must be balanced in a dry kiln, to get even drying.

Uneven drying is often due to improper piling. The safest rule to follow in all cases is to pile the lumber as the kiln builder intended the lumber to be piled. Operators often try to force the hot air up through the lumber in edge stacked lumber. In this case the circulation should be reversed so that the circulation is down through the lumber. It is best to have reversible circulation in flat stacked lumber. In Douglas Fir the velocity should be averaged 75 feet per minute if flat stacked and 100 feet per minute if edge stacked.

It may be necessary to leave more air space in the piles to facilitate circulation. If there is uneven drying in a kiln not using forced draft it may be necessary to install steam jet blowers or fans.

The air vents must be regulated to keep the humidity up high enough. Smoke tests should be used to see whether or not the dry or moist air is traveling through the vents. The fresh air brought in must also be regulated so that there are the correct number of changes per hour.

In a compartment kiln in which the lumber is flat stacked it is necessary to use baffle plates on top of the load to force the air through the lumber.

In a compartment kiln a small repair door should be located where the operator or workman can enter during the drying period to make tests and minor repairs or adjustments. This will prevent changes in temperature by not opening the large doors. Some facilities for illumination must be provided for the workmen.

If the lumber is not evenly dried frequent periodic steaming may help to remedy this situation. A final steaming or high humidity treatment will also help.

After the lumber has been taken out of the kiln and found to be unevenly dried, it must be left in dry storage longer to even up the moisture content.

If the lumber cannot be dried evenly in the type of kiln used it is advisable to use a modern drying system.

WARPING, TWISTING, CUPPING

Warping, twisting, and cupping of lumber usually are

caused by the improper piling of the lumber on the trucks. The stickers may be uneven, there may not be enough stickers and the stickers used may be incorrectly placed. Overhanging ends are another source of trouble.

If the circulation is unbalanced it may also cause warping, twisting, or cupping. The unbalanced circulation may be due to lumber too closely piled, stagnant ventilation, leaky doors, or a poor kiln design. Lumber that has been too severely casehardened will warp, twist, or cup. In order to prevent warping, twisting, and cupping, the lumber should be carefully piled.

The stickers should be planed to a uniform size. They should be spaced not over four feet apart and less for lighter material. They should be evenly spaced. The stickers should be placed flush with the end of the pile and have no overhanging ends. In kilns without adequate forced circulation it may be necessary to leave an air space between boards. In some kilns it may be necessary to leave a chimney in the center of the piles. All corners of the trucks must be solid.

The circulation should be improved by piling the lumber carefully. The stickers should be placed so that they will not interfere with circulation. The flues may need to be cleaned out. It may be necessary to build the stacks higher to prevent the circulation from going around the piles.

In lumber that is flat stacked, air baffles should be placed on top of the pile of lumber so that the air can circulate through the lumber instead of going around the pile as it would if not forced through the lumber by the baffle plates.

In an external blower kiln the circulation should be upward through the center flue, laterally outward through the lumber, and downward along the side walls. The air is then drawn through the return duct to the blower, which is located at one end of and outside the kiln and then passing through the inlet duct it escapes again into the central chimney. The cycle is then repeated. Fresh air enters the intake located on the suction side of the blower. The excess moisture passes out of the leaks or through the outlet flues. Steam jets are usually located in the heater, or steam-spray lines may be mounted at the side of the kiln.

In compartment kiln with flat piled lumber the fans are placed on two shafts running the length of the kiln. Each fan is surrounded with a housing which takes the air from the bottom of the kiln over the heating coils and up one side of the kiln. The air is then forced through the lumber in a horizontal direction by baffle plates on top of the load. The air is brought down on the other side over the heating circle and through the fan housing into the bottom of the kiln where it is picked up on the other side.

It is necessary to reverse the direction of air current every few hours to keep the moisture content of the load fairly even. The direction of the fans are reversed by reversing the fans. The steam jets are located about the same place as the pipe coils.

It must be remembered in this type of a kiln that a particle of air does not travel in an endwise direction but only in a lateral direction. Therefore it is necessary to have the same amount of heat and humidity throughout the kiln. This is a little difficult on account of the fact that the steam enters the coils at one end. Probably the best way to correct this is by trial and error.

In an internal fan kiln the lumber is piled so that it has a chimney in the center of the load which is covered on top with a few courses of lumber. The lumber is flat stacked and end piled. Under this chimney runs a shaft with fans located 4 to 8 feet apart surrounded by box like housing which directs the air. The fans should be reversible so as to change the direction of the air. On each side of the fan are the heating coils. The air is drawn into the fans which are run in a clockwise direction distributing the air up through the entire length of the chimney. The air is then forced through the lumber in a horizontal direction out to the walls where it is drawn downward through the heating coils and into the fans again. Two rows of steam jets are placed above the fan. The upper one is turned on to facilitate the

circulation when the direction of air travel is up through the chimney. The lower one facilitates the circulation of air when the air current is reversed.

In the water spray kilns the spray chambers run the entire length of the walls. The spray heads are located 12 to 14 inches apart and point directly downward to the open spray chambers at the bottom. The air comes down the side of the walls and passes through these chambers where it is cooled to the dew point and the weight increased by these water sprays. The impact of the water on the air exerts a strong pressure also. These two forces together produce a very rapid circulation.

Pipe condensers are used in pipe condenser kilns and also in water spray kilns too at the end of the run. They cool the air and increase its weight, but they do not cause such a great deal of circulation due to the fact that they do not cool the air down to the dew point nor do they have the impact effect.

In a superheated steam kiln the atmosphere is steam, and circulation is produced by steam jets, the circulation is reversible, and passes entirely through the single pile in a lateral direction. The heating coils are placed on the side of the kiln and steam jet lines running the entire length of the kiln are placed in each corner. When the steam is turned in the steam jets, located on the right side of the kiln, the steam passes to the left hand side of the kiln over and under

the pile to the left hand side where the steam goes in a vertical direction. The steam then returns through the lumber to the right hand side and the process is repeated.

In the natural draught compartment kiln the lumber is piled with a few courses of lumber over the chimney. The fresh air enters the bottom of the kiln through an inlet duct with a slotted top which distributes the air throughout the length of the kiln. A steam jet may be used to assist the movement of the incoming air. The heating coils are directly under the load and over the inlet duct. As the air enters the inlet duct it passes up through the pipe coils and into the chimney of the load. From there it travels laterally to the walls and down. Steam jets should be placed on the side of the walls just below the top of the wood pile pointing downward to facilitate circulation. The air must be baffled down to the bottom of the kiln from where it will go on through the pipe coils and into the chimney again. Outlet flues should be placed on the walls near the top of the kiln to carry away the excess moist air. The difference between the hot air rising, the cool air falling, and the draft of the outlet flues will produce fair circulation of air.

In the progressive kilns the circulation is as a general rule very poor. Many schemes have been developed to combat this poor circulation. Probably the best scheme is now being developed on a commercial scale by the Forest

Products Laboratory. This consists of producing a cross circulation by sprays and baffles essentially the same as in the compartment kilns. Difference in humidity and temperature are produced by separate heating coils and spray lines controlled by independent controlling devices.

Centrifugal blowers or large dise fans can be used to produce the circulation in progressive kilns. They are located at the dry end of the kiln and are equipped with external heating coils located in a large housing on the suction side of the fans. The air is blown directly into one end, and travels a full length of the kiln and is discharged on the other end. This system is not very satisfactory but is often better than the ordinary dry kiln.

HONEYCOMBING, HOLLOWHORN

Honeycombing or hollowhorning is interior checking of lumber.

The usual causes of this in kiln drying is a too severe drying schedule, failure to steam periodically after appearance of surface checks, and failure to use higher humidities after surface checks appear. Honeycombing often appears after the kiln dried lumber is taken out of the kiln and stored in a damp place. The outer layers of wood absorb moisture, causing the outer part of the wood to swell and pull the fibers apart in the center of the piece. Certain

woods will honeycomb if stored in a hot climate immediately after sawing. The cause of the honeycombing must be first determined before placing the blame on the dry kiln.

If the honeycombing occurs in the kiln the cause must be determined. If surface checking and casehardening occur it may be necessary to use a more moderate drying schedule.

Frequent periodic steaming will prevent casehardening and surface checking and may help to reduce the honeycombing. The circulation throughout the piles must be checked on.

Once the lumber is badly honeycombed no known treatment will take it out.

In case the lumber is only slightly honeycombed, severe cases can be prevented from becoming severe by frequent steaming and the use of lower temperature and higher humidities.

COLLAPSE

Certain woods such as redwoods, western red cedar, swamp oak, red gum, and cottonwood are extremely hard to kiln dry on account of collapse. The sides of the lumber seem to cave in. Collapse is due to the flattening out of the cells after the moisture is drawn out. Collapse occurs most readily in areas infected with decay in some species, notably in redwood.

In very wet wood some of the cells are filled with water. As this water leaves the cavities air should take its place. However it is extremely difficult for air to pass into the cell cavities. As the water is pulled out of the cell cavities the cohesive force of the water leaving the cavities exerts a tremendous pull on the interior of the cell. The atmosphere outside of the cell also tends to collapse the cell. It is thought that the pressure outside the cell is not strong enough to collapse the cell, but rather that the cohesive force collapses the cells.

Collapse takes place much more readily in kiln drying because the wet wood becomes hot and therefore much more plastic.

If the surface of the wood is dried too fast in the early period of drying, the water leaves the wood too rapidly while the cells are full of water thus causing collapse.

In cases of severe casehardening, certain woods will have the tendency to collapse because it is difficult for the air to get into the wood.

It has been found that by using low temperatures, high humidities and a very fast circulation, that collapse can be prevented and very good results obtained in drying woods that have a tendency to collapse. In all cases, it is necessary to have a slower drying schedule at least until the lumber has passed the fiber saturation point. Periodic

steaming to prevent casehardening should be practical in kiln drying wood that has a tendency to collapse.

Good results have been obtained by the Rankin controlled air dryer in drying heavy redwood in large units of 500,000 to 1,000,000 board feet.

This dryer consists of a rectangular building of frame construction using double one inch boards and a single ply asbestos paper between the walls and ends. The roof is removable, being constructed of 2x6 planks laid flat, upon which tarpaulins are battened down. The lumber is handled in and out by Gantry cranes used for handling lumber in the yards.

The air circulation is provided by Moore type disc fans, divided into two groups, one group on each side, set in a partition about the middle of the building. The fans are placed one above the other and are reversible, the speed being about 620 revolutions per minute. In place of roof ventilation the dryers are arranged with a duet system whereby a desired amount of the saturated air can be extracted to keep the proper humidity.

The temperature used in drying redwood is between 110 and 120 degrees Fahrenheit and brings very good results. The stock can be dried down to 6 or 8 per cent moisture content. Very little degrade has been found due to the kiln. No doubt this will work very well in other species.

The cost of drying in these dryers is very low due to

their large holding capacity, the simplified handling arrangements, the first low cost of the building and equipment in proportion to capacity, and the lower power consumption.

Once collapse has occurred, it is difficult to remove it. It has been found possible to restore some pieces of collapsed lumber to their full size by steaming them at 100 per cent humidity and 180 to 190 degrees Fahrenheit until they have a moisture content of 25 per cent, and then re-dry them. Shingles must be steamed 48 hours and shingles in bundles or 1 inch stock must be steamed longer.

END SPLITTING AND CHECKING

End splitting and checking occurs when the end of the piece dries faster than the rest of the piece. It is caused by too rapid drying on the end and too slow drying in the center. The stickers may be uneven and placed irregularly. Overhanging ends have a tendency to dry too fast causing end splitting. Often end splitting is caused by the air currents going around the pile and not through it. Leaky doors that let in a draft on one end of the lumber or a radiate heat too fast, will cause splitting on the end. If checks are present on the end where it is put in the kiln, there is a tendency for the checks to become larger in the kiln.

In order to remedy this situation the lumber should be carefully piled. The stickers should be placed flush with

the ends of the boards at one end of the pile. Plenty of air space must be left in the pile.

In flat piled lumber the air must be baffled so as to force through the lumber.

Once end splitting has occurred it can not be repaired. Periodic steaming during the run will help to prevent this damage from getting worse. Further damage can also be prevented by first steaming with the humidity fairly high and then drying at higher humidities. The end splitting can be prevented also by cutting off split ends before stacking, by nailing cleats across the ends of boards and by coating the ends of stock with moisture and heat resisting material.

[1] The coatings ordinarily used can be divided into two classes: (1) a liquid at ordinary temperatures, which can be applied cold; (2) a solid at ordinary temperatures, which must be applied hot. Cold coatings may be used as easily on logs and lumber as on kiln samples and dimension stock; hot coatings, because of the method of application (end dipping), are not easy to use on large stock.

Either the cold or the hot coatings can be used effectively for drying temperatures up to 140 degrees F. Temperatures much above this cause blistering in the cold coatings but make the hot coatings plastic enough to form new surfaces as fast as the old ones break. For this reason the hot coatings are apt to be more effective than the cold coatings for temperatures from 140 up to 170 degrees F., where they liquefy to such an extent that they run off. No coating has been found which is entirely satisfactory for temperatures above 170 degrees F. Cold coatings are perhaps somewhat better than hot coatings for temperatures above 170 degrees F. and for use on kiln samples when the temperatures are high enough to cause the loss of part of a hot coating.

Cold coatings, to be effective, should have

about the consistency of heavy syrup. The amount of filler required ranges from one-half to four parts by weight to one of the vehicle. Cold coatings used at the Forest Products Laboratory have been found effective about in the following order, the most effetive being placed first:

Hardened gloss oil thickened with barytes and asbestine.....Very cheap
Chinawood oil and barytes.....Cheap
Linseed oil and white lead (very heavy).....Moderate cost
Linseed oil and red lead (very heavy).....Moderate cost
High-grade spar varnish and barytes.....Expensive

The gloss oil coating is made as follows: The oil itself should be of a thick grade, made up (by the paint manufacturer) of about 8 parts quicklime, 100 parts rosin, and 57.5 parts spirit. To 100 parts of the gloss oil is added 25 parts of barytes and 25 parts of asbestine. One or two parts of lampblack may also be added if a black coating is desired. The asbestine assists materially in preventing the settling out of the pigment. Any paint manufacturer can make up this coating.

The hot dips are effective in the following order:

213 degrees coal-tar pitch.....Cheap
254 degrees coal-tar pitch.....Cheap
Rosin and lampblack (100 parts of rosin to 7 parts of lampblack)...Moderate cost

Some asphalts are highly moisture-resistant, but they are hard to apply because of the high temperatures required to make them plastic.

Paraffin has proved very satisfactory as an end coating for stock during air seasoning but cannot be used in the kiln because of its low melting point.

Excessive shrinkage of the wood and rough handling often cause the end coatings to chip or shear off, so that a fresh application of the coating must be made.

To reduce end drying sufficiently there must be a thick coating over the entire end surface. When hot dips are used, the wood

should be dipped half an inch into the liquid.

Once the lumber has checked or split on the end the damage cannot be repaired.

Further damage can be prevented by first steaming and then drying at higher humidies.

If the material is checking or splitting, the periodic steaming should be resorted to wherever the stock starts to check or split.

MILDEW AND MOLD

Mildew and mold occur when there is not enough circulation or when the humidity is too high and the temperature too low.

In order to prevent mildew and mold it may be necessary to speed up the circulation. The temperature should be above 135 degrees in order to prevent the mold.

If mold has occurred in the lumber the lumber should be steamed at 165-170 degrees for one to two hours. This will not entirely kill the spores. These may later germinate making it necessary to steam the lumber again in a week or two if the humidity is high enough to make possible the growth of a second crop.

BLUE STAIN

Slow drying in a humid atmosphere usually is the

cause of blue stain. This may also be due to poor circulation caused by improper piling.

When blue stain occurs in the lumber it should be kiln dried immediately after the log is cut up.

After blue stain has occurred there is no way to get rid of it. It will not spread in dry wood so consequently the best thing to do is to dry the wood immediately after it is sawed out of the log. If it has not spread too far most of it will dress off in the planer.

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