

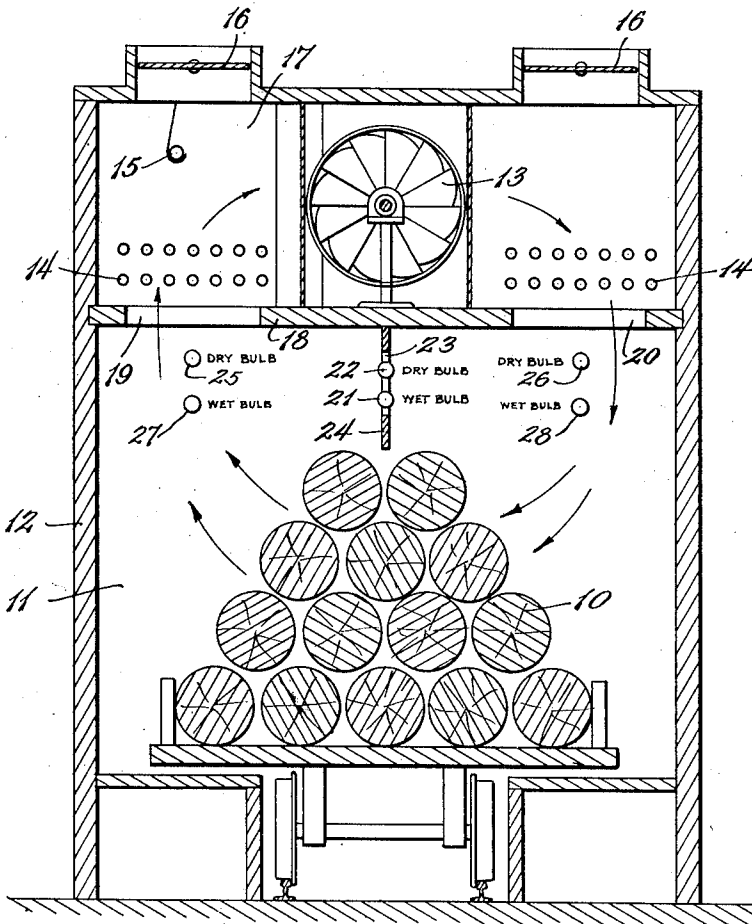
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METHOD OF ACCELERATING AIR DRYING OF WOOD IN KILNS

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METHOD OF ACCELERATING AIR DRYING
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This invention relates to the kiln drying treatment of wood or timber and aims to provide an improved practicable and economical method of accelerating air drying or conditioning of wood or timber without subjecting it to severe cracking or checking strains.

In the art of drying or conditioning wood for further processing or for use where green wood or partially air-seasoned wood cannot be used successfully, there are three general and well known methods employed, viz: "Air-seasoning," "steam-and-vacuum conditioning" and "kiln-drying." Whereas, each of these methods has its own merits and uses, each also is subject to certain definite objections, particularly in the wood preserving industry.

Air-seasoning has its drawbacks in that it requires long periods of time, heavy investments in stocks and there is always a chance of some stock losses due to the development of decay during the air-seasoning period. In addition to these disadvantages, it has been found that air-seasoned stock does not dry satisfactorily during certain seasons of the year.

Steam-and-vacuum treatment offers a quick and relatively inexpensive method of conditioning wood, but unfortunately this method does not produce a satisfactory redistribution and equalization of the moisture in the wood, and if the material has air-seasoned for a short period before steam-and-vacuum conditioning is applied it has been found that the outside dryer layers of wood act as an insulator and prevent heat transfer into the more moist or actually wet inside layers. As a consequence, longer steaming periods are required to condition the timber than are economical. It is also a matter of common knowledge in the industry that steaming produces certain weaknesses in the timber.

Kiln-drying, due to the usual long time required to dry large timbers, is relatively expensive and in some industries the expense is entirely prohibitive. In addition to this, it is practically impossible to kiln-dry large sawn timbers and round timbers without producing severe checking and the formation of deep V-shaped checks or cracks.

In such industries as those dealing with the preservative treatment of forest products, the matter of proper conditioning of the wood prior to treatment is of the utmost importance as customer requirements demand deep penetration and uniform distribution of the preservative.

It is therefore an object of this invention to provide an improved method of conditioning

wood and equalizing the moisture content of the wood in such a manner as to overcome the above mentioned objections and at the same time provide a mode of treatment which will be relatively inexpensive and serve to increase plant capacities. Another object is to condition timber substantially uniformly for immediate preservative treatment and thus eliminate the necessity for classifying the timber to determine its approximate degree of seasoning. A further object is to provide an accurately controlled method of conditioning large or round timbers without producing severe checking and without the development of "pitch bursts" which are frequently produced by steam-and-vacuum conditioning of green timbers. A further object is to determine and control accurately the rate and extent of drying during the treatment period. A further object is to condition green or partially air-seasoned wood, such as round timbers, poles and piling, in a relatively short conditioning period without setting up drying strains and stresses in the wood which produce excessive and objectionable checks in the wood.

Other aims and advantages of the invention will appear in the following description considered in connection with the accompanying drawing, in which the figure is a diagrammatic illustration of an ordinary kiln used for practicing the method.

In the usual kiln drying operations, wood is dried to a moisture content of 20% or less. The moisture in wood is made up of the moisture in the cells which is known as free moisture and the moisture in the fiber, which is known as fiber moisture. The removal of free moisture from wood causes no shrinkage, and it is only when the fiber moisture begins to be removed that stresses, strains and shrinkages are set up in the wood itself. Therefore, drying of wood is accomplished in two stages, the first being the period during which the free moisture is removed and the second being the period during which the fiber moisture is extracted. During the first stage, it has been found that for pine and many other species of wood no detrimental effects have resulted on account of removing the free moisture at the fastest possible rate, as long as no part of the stock is dried much below the fiber saturation point, which is approximately 25%. It has also been found that during the rapid drying or rapid removal of this free moisture, a capillary action takes place and as the free moisture content is decreased, the capillary action decreases accordingly. The object of this inven-

tion is to reduce the time required for this first stage of drying during which the free moisture or a large part thereof is removed, and the method takes advantage of the capillary action which takes place during this particular drying period. Thus, wood with a very high percentage of free moisture can be exposed to air of very low humidity whereby an outer layer of the wood would become very dry but the depth of such layer can be only of skin thickness, due to the wick or capillary action of the free moisture in the wood. However, as the free moisture is reduced, the outer coating or layer of wood which will become too dry, will increase in depth, unless the humidity of the air to which the wood is exposed is gradually increased. This invention, therefore, provides a mode of control whereby this surface condition and capillary action can be definitely determined and from such information the wet bulb depression or humidity of the air in the kiln can be adjusted to cause continued removal of free moisture at a maximum rate, without any detrimental effect to the timber itself.

The improved method can best be explained by reference to the illustrative apparatus and the standard practice of kiln drying. The method is conveniently practiced in any ordinary dry kiln of the air circulated type. In the accompanying diagrammatic illustration, there is shown a load or charge of timber 10 such as green poles, for example, in the drying compartment 11 of a kiln 12 of the cross-circulating type having the usual reversible fans 13, heating coils 14, steam spray pipe 15 and ventilators 16 in a compartment 17 separated from the drying compartment by a partition 18 having openings 19 and 20 through which the circulating air is delivered to and discharged from the drying compartment 11, the arrangement being such that, when the fans are reversed, the direction of circulation of the air in the treating compartment is reversed. This is done to prevent unequal drying of the timber on the outlet side of the load. A wet bulb thermometer 21 and a dry bulb thermometer 22 are usually arranged in an opening 23 in a central partition 24 within the drying chamber above the load or charge. The usual practice is to maintain a predetermined set of conditions of wet bulb and dry bulb temperatures to produce a relative humidity which may be translated into equilibrium moisture content and wood shrinkage. An ordinary control instrument (not shown) is usually set to produce the conditions. In some cases, attempts have been made to decrease the humidity of the air as the drying operation progresses. In other cases, a fixed humidity of the drying air has been maintained without reference to the rate of free moisture extraction or evaporation from the timber or in the charge. The disadvantages of these modes of treatment have already been explained.

In accordance with the present invention, the condition of the drying air is so controlled as to produce a maximum permissible rate of drying or moisture extraction throughout the period of treatment without breaking the continuous capillary action or moisture flow through the sap wood induced by surface evaporation. To accomplish this result, it is necessary to ascertain or determine the exact condition of the timber charge at all times or at intervals during the treatment period and regulate the condition of the drying air accordingly. It has been found that the dry bulb and wet bulb temperatures of the outgoing air from the drying chamber after

it passes through the charge, are dependable indications of the condition of the timber. Accordingly, dry bulb thermometers 25 and 26 and wet bulb thermometers 27 and 28 are arranged in the drying chamber on opposite sides where one set of them is always in the outgoing stream of air. The instruments in the outgoing stream are observed and the readings may be compared with the dry bulb temperature of the conditioning air and the temperatures of the dry and wet bulbs in the incoming air stream. Incidentally, each set of bulbs is incorporated in an ordinary psychrometer. When the operation is first started, a maximum wet bulb depression of the drying air is maintained; that is to say, very dry air is used to produce very rapid moisture extraction from the timber by setting up rapid surface evaporation. The dry bulb temperature of the outgoing stream is much lower than that of the drying air. This operation is carried on for a relatively short period until the dry bulb temperature of the outgoing air increases several degrees, indicating that the rate of moisture evaporation has decreased and that the surface of the wood is becoming relatively dry. When the temperature reaches that point at which continued operation using the same wet bulb depression would cause objectionable checking and cracking, the flow of air is reversed. Then the dry bulb reading on the outgoing side is correspondingly lowered because of the increased rate of moisture evaporation from the timber on the opposite side. The operation is then continued until the dry bulb temperature of the outgoing air on the opposite side of the drying chamber approaches the temperature which was reached on the first side and the dry bulb and wet bulb readings of the outgoing air indicate a decrease in the rate of moisture removal from the load. Then the flow is again reversed. The starting dry bulb temperature on the outlet side at this stage is higher than it was at the beginning of the drying operation because of the reduced rate of moisture evaporation from the surface of the timber. That is to say, the wet bulb depression at this point is too great for continued operation. Therefore, it is necessary to increase the humidity or wet bulb temperature of the treating air to prevent the drying action from progressing too fast and breaking up the capillary action in the timber. These operations are repeated until the desired condition of the timber is reached, the wet bulb temperature of the drying air being periodically increased until it approaches the dry bulb temperature of the treating air to maintain a continuous capillary action at a decreasing rate throughout the drying period. This operation is practically the reverse of the usual practice. It permits very rapid initial extraction of the free moisture and the rate of extraction is reduced either gradually or periodically until the timber reaches the desired moisture content.

The following is an illustrative example of the method as applied to drying poles for preservative treatment. After the load to be dried has been placed in the kiln and the doors shut, the fans are started, the heater and spray coil valves opened and the control instrument is set at the desired dry bulb and wet bulb starting conditions, say dry bulb 160° F. and wet bulb 120° F. If the direction of the fans is such that the air flow through the load is from left to right, the right hand dry and wet bulbs will record conditions of the outgoing air. The initial direction of the air

stream is continued until the readings of the wet and dry bulbs in the outgoing air stream indicate, by comparison with dry and wet bulb readings of the incoming air stream, that the rate of moisture removal is reduced and the surface of the pieces in the load is becoming too dry. This indication is easily made by calculation of the moisture in the two air streams. The direction of the air flow is now reversed and the incoming and outgoing dry and wet bulb temperatures are again compared. When the readings again show a decrease in moisture removal the fans are again reversed. As the time period for the rate of moisture removal is reduced, thus indicating that a relatively dry condition of the surface of the pieces of timber in the load, the wet bulb of the control instrument is raised, say to 145° F., in order to force more moisture in the incoming air stream and again establish capillary movement of moisture in the wood and to continue drying of the wood, at the same time increasing the moisture content of the outer layers of the timber. These changes in direction of air flow and the increases in the setting of the wet bulb temperature control are continued until readings indicate that the load has reached a predetermined moisture condition. In some instances, it is desirable to also increase the controlled dry bulb temperature after the controlled wet bulb temperature has about reached the initial dry bulb setting. When this is done the process is continued as before until the desired moisture condition of the timber in the load is reached. At this point, all wet and dry bulb temperatures will have approached the controlled dry bulb temperature setting.

In the wood preserving industry, the first stage treatment, as practiced in accordance with this method, is carried on until the moisture content is reduced to between about 35% and 45%. The moisture content of the outer layers of the pieces is about 20% to 25% and the moisture content of the innermost layers of the wood three or four inches from the surface may be 50% to 60%.

Repeated experiments have demonstrated that the improved method of accelerated drying produces a more uniform distribution of moisture in the wood and makes it possible to obtain a low moisture gradient throughout the drying

period without weakening the timber. It is most advantageous in the drying treatment of large sawn or round timbers and the method can be practiced on such timbers without producing any objectionable checking. Furthermore, the method can be practiced to accelerate the drying time of wood or timber used in other industries; that is to say, the first stage of drying may be accomplished by this method and the subsequent drying operation or second stage can be accomplished in the usual drying kilns.

Having thus described one mode of treatment embodying the invention, it is to be understood that the invention is not limited to a strict conformity with the described steps in the method, but is capable of a wide variety of changes within the scope of the appended claims.

What is claimed is:

1. In the art of drying wood or timber by circulating hot air through a charge of wood in a kiln, the steps which comprise recording psychrometer readings of the air stream after it leaves the charge and of the air stream entering the charge to determine the approximate rate of moisture removal from the charge and the condition of the wood; controlling the operation of the kiln by increasing the humidity and varying the dry bulb temperature of the drying air as the rate of moisture extraction decreases, to prevent excessive and objectionable checking of the wood; and reversing the direction of flow of air through the charge to promote uniform drying of the charge.

2. In the art of drying wood or timber by circulating air through a charge of wood in a kiln wherein the direction of flow of the air is reversible, the steps which comprise obtaining psychrometer readings of the air stream both before it passes through the charge and after it leaves the charge; controlling the operation of the kiln by increasing the humidity and varying the dry bulb temperature of the drying air as the rate of moisture extraction decreases; recirculating the air through the charge; and periodically reversing the direction of flow of air through the charge to promote uniform drying of the wood.

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