

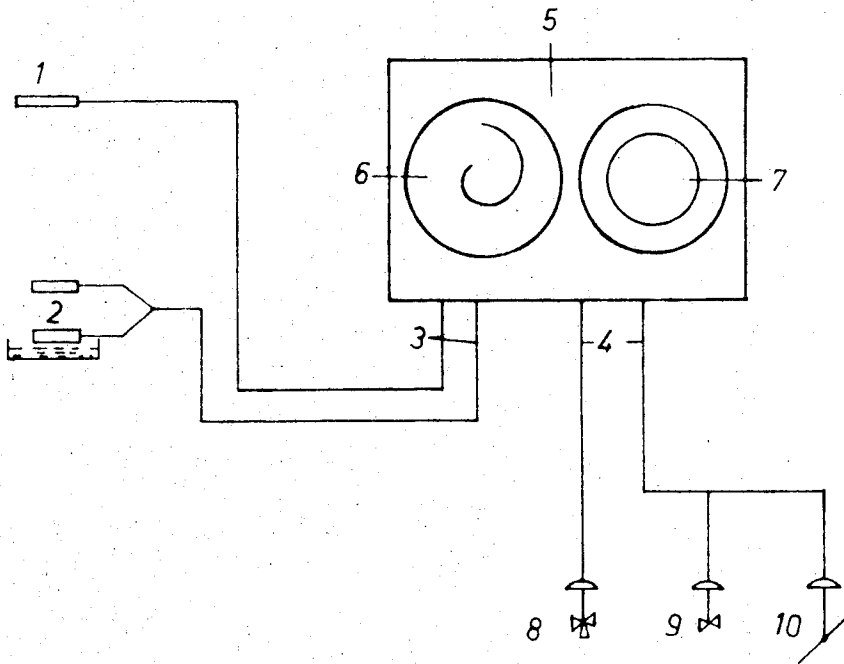
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METHOD AND APPARATUS FOR DRYING LUMBERBOARD

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METHOD AND APPARATUS FOR DRYING LUMBERBOARD

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4 Claims

ABSTRACT OF THE DISCLOSURE

A novel method for drying lumberboard is disclosed as is an apparatus for carrying out the novel method. The inventive method is directed to the control of the climatic drying sequence in lumberboard drying installations and is characterized by the feature that the psychrometer difference during the drying time is increased in the same manner, i.e., steadily and in a uniformly logarithmic fashion, in which the wood moisture of the wood decreases.

The instant invention generally relates to drying methods and apparatus therefor and particularly concerns a drying method wherein the climatic drying sequence in lumberboard drying installations is controlled.

Considering artificial drying particularly of hardwoods, it is necessary to control the climatic drying course or sequence in dependency upon the drying time in such manner that, on one hand, no drying damage occurs and, on the other hand, a drying time is obtained which is as short as possible and thus more economical.

In this regard, it is known to control the drying climate pursuant to empirical or experience-obtained values or drying tables. When utilizing these tables, control of the drying climate takes place empirically in accordance with the respective wood moisture. Accordingly, the respective wood moisture must first be obtained during drying of the wood by means of weighing, by taking samples, or by electrical measurements made by electrodes, such that the drying climate can be controlled as a function of the momentary wood moisture. It is possible to set this control means and utilize this technique in an economic fashion only after one has gained sufficiently long experience in the art and after one has worked with the same type of wood, source of wood, thickness of wood, initial and final wood moistures, and the like for some time.

It is also known in the art to achieve control of the climatic drying sequence in such a manner so as to keep the so-called "Drying Drop" (ratio of the momentary wood moisture to the set equilibrium wood moisture) constant. Here too, it is, of course, necessary to know the momentary wood moisture. If the "drying drop" has been chosen correctly from the empirical values or drying tables, then it is true that the drying process will proceed gently. But the drying process will not be achieved in the most optimum economical manner inasmuch as in the second half or portion of the drying period, the wood could dry significantly more intensely than in the first half or period. In order to prevent this result, it is therefore necessary to correct the chosen "drying drop" one or more times during the latter phase of the wood drying process.

It is at this point that the instant invention comes to the fore and has as its primary object the elimination of the disadvantages inherent with prior-art techniques. Specifically, the object of the instant invention is to achieve a time-depending economical and, so far as is possible, an automated control of the drying climate for

any desired wood of different types, thicknesses, and initial wood moistures.

With the inventive method or technique applied to wood drying as is discussed herein, the drying time Z approximates an exponential function of the wood moisture u in accordance with the following equation:

$$Z = f_1 \cdot f_2 \cdot f_3 \cdot \dots \cdot f_n \cdot \log \frac{u_a}{u} \quad (1)$$

in which u_a equals the initial wood moisture and f_1 to f_n represent different factors which depend upon temperature, type of wood, thickness of wood, psychrometer difference, air velocity, and the like. Since an equation such as Equation 1 does not provide information concerning the required relative air humidity, such equation is unsuitable for the actual control of the wood drying and is only useful for providing a rough estimate of the entire drying time in conjunction with empirical values and tables. On the other hand, the drying temperature is chosen with consideration being given to the initial wood moisture, the tendency of the wood to crack or discolor, the outflow of sap, and the quality of the wood itself. For example, pin woods and leafy woods, the latter having been pre-dried in the open air, can be dried at a constant drying temperature.

So as to gently pre-heat the wood and so as to gently produce the wood moisture drop in the cross-section of the wood, which is required for drying, the actual drying process is commenced at a low psychrometer difference or wet bulb depression. The terms "psychrometer difference" or "wet bulb depression," as used herein, relates to the difference of the temperature between a dry bulb thermometer and wet bulb thermometer subjected to the same medium, namely the water vapor-air mixture in the drying area or chamber. It has been shown in the art that the following psychrometer differences are suitable and adequate for drying hardwoods, for example:

Initial moisture, percent:	Psychrometer difference, ° C.
Fresh from the forest up to 30%	3
30 to 20	4
Below 20	>5

The instant invention provides a solution to the problem posed in such a manner that the psychrometer difference is regulated so that the time-wise increase of the logarithm of the psychrometer difference remains at least approximately constant throughout the drying time. This regulation ensures that the time-wise decrease of the logarithm of the wood moisture also remains constant throughout the drying time such that the psychrometer difference is increased in the same manner as the wood moisture decreases, i.e., steadily and in a uniformly logarithmic fashion. As is explained hereinbelow, this also makes it possible to predetermine the drying time of the wood.

Further features and objects of the instant inventive technique and apparatus will become apparent as will the details of the instant invention from the following description of the preferred inventive technique and exemplary apparatus for carrying such technique into effect, such description referring to the appended drawing wherein the single figure depicts a wood drying installation utilized for carrying out the inventive method.

Equation 1 set forth above is first replaced by a new equation which depends upon the psychrometer difference $\Delta T = T - F$, this new equation being as follows:

$$\frac{d(\log u)}{dZ} = g_1 \cdot \frac{d(\log \Delta T)}{dZ} + g_2 \quad (2)$$

Equation 2 serves to describe the course or curve of the wood moisture u in dependency upon the psychrometer difference ΔT which governs in each instance.

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Two terms relating to the instant inventive drying technique have been added to Equation 2:

The first term is the time-wise decrease of the logarithm of the wood moisture u which is the differential quotient derived from the drying time Z

$$\frac{d(\log u)}{dZ} = \text{grad. } u$$

which can conveniently be described as "gradient u " in the following description.

The second term is the time-wise increase of the logarithm of the psychrometer difference ΔT , that is to say, the differential quotient of the same, derived from the drying time Z

$$\frac{d(\log \Delta T)}{dZ} = \text{grad. } T$$

which will conveniently be described as "gradient T " throughout the following description.

It has been found that it is both economical and useful during the drying process of one type of wood of a given board thickness if grad T is maintained constant under the assumption that the wood has previously been stored outdoors prior to drying and that the wood has been pre-dried to about 30% or less moisture content.

It has further been found that, in drying hardwoods of various gross density r_0 [g./cm.³], various initial degrees of moisture, but having the same board thickness, a linear relationship exists between grad u and grad T in accordance with Equation 2. For example, the following values are valid for 28 mm. board thickness:

$$\text{grad } u = 0.245, \text{ grad } T = 0.001 \quad (3)$$

For wood types having different gross densities, the following guide values can be derived for grad T :

Gross density r_0 :	Grad T
1.1-0.9	0.003-0.012
0.9-0.8	0.012-0.018
0.8-0.7	0.018-0.025
0.7-0.6	0.025-0.037
0.6-0.5	0.037-0.062
0.5-0.4	0.062-0.115
0.4-0.3	0.115-0.250

All of the numbered values above are valid for an economical air velocity of about 2.5 m./sec as measured between the board layers.

For wood having different initial degrees of moisture for example, oakwood 28 mm. thickness), the following suitable values for grad T have been found:

Initial wood moisture u_a , percent	Grad T
80	0.002-0.003
60	0.003-0.004
40	0.006-0.010
35	0.012-0.015
30	0.025-0.035

For the relationship of Equation 3, it is possible to calculate the expected drying time in accordance with the following formula:

$$Z = \frac{\log \frac{u_a}{u_o}}{\text{grad. } u}$$

Now, having the above mathematical development firmly in mind, the inventive method can be carried out in the following fashion.

After having chosen, in a customary manner, the temperature and initial psychrometer difference, and further after having set the same at a control means for the drying installation, the drying installation or chamber is then set into operation. Thereupon, a graphic chart, preferably one drawn in double logarithmic ruling, is immediately taken of the abovementioned relationship between grad u and grad T and a suitable guide value is selected when dealing with a yet completely unknown type of

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wood, for example, for grad T in accordance with the gross density and initial wood moisture of the particular type of wood. This value is set at a special control device provided for the purpose of keeping grad T constant throughout the entire drying time, such control device being aided by and utilized with known mechanical or electrical setting means such as cam plates, for example, or program storage means, such as punch cards.

Thereafter, the value of grad T determined from grad u in accordance with the above-mentioned function is taken and the expected drying time for the wood is calculated. The drying chamber is turned off either manually or automatically after this expected drying time.

The inventive method will be described as follows with reference to an actual utilizing numerical values:

EXAMPLE

Assume initially that it is desired to dry oakwood of 28 mm. thickness, such wood having an initial moisture of 30%, a desired terminal or finished wood moisture of 8% and, accordingly, a customary drying temperature of approximately 70° C. and initial psychrometer difference of 3° C.

Oakwood has a medium gross density of 0.62 g./cm.³. Since, in the case of 30% initial wood moisture, the wood normally has been pre-dried in open air, it is not necessary to be concerned with the influence of the initial wood moisture upon grad T .

In accordance with the above concepts, a grad $T = 0.03$ can be taken, for example, and this value can be set on the control device of the drying installation.

Thereupon, grad u can be determined with the aid of a graphic chart or directly from the above-mentioned function or equation and, in this example, will be found as:

$$\text{grad } u = 0.245, 0.03 \div 0.001 = 0.00835$$

The expected drying time for the wood therefore comprises:

$$Z = \frac{\log \frac{30}{8}}{0.00835} = 69 \text{ hours}$$

During the automatic drying of the wood, the drying progresses in the following fashion as calculated from grad u and grad T :

Drying time, hours	Respective wood moisture, percent	Psychrometer difference, ° C.	Wood moisture equilibrium, percent
0	30	3	14.7
9.5	25	6	11.1
14.0	23	8	9.6
21.0	20	13	7.0
36.0	15	36	~2
Etc.			

In contrast with this drying operation and sequence, conventional drying such as would be undertaken in accordance with the periodical "Holz als Roh- und Werkstoff," vol. 22, p. 29, would illustrate the following sequence:

Wood moisture, percent	Psychrometer difference, ° C.	Wood moisture equilibrium, percent
30-25	3	14.7
25-20	5	12.1
20-15	8	9.6
15-10	14	6.7
10-8	25	3.7

If the drying of the wood were undertaken "with constant drying drop" pursuant to the known techniques or methods, then the drying would take a course or sequence similar to that of the conventional case, but would still dry slower from the fourth sequential step onward.

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In contrast therewith, when utilizing the inventive method, the psychrometer difference is increased during the drying time in the same manner in which the wood moisture decreases, i.e., steadily and in a uniformly logarithmic fashion. With the selected value of grad T, the uniform intensity or "sharpness" of drying is obtained during the entire drying time and a faster drying, particularly in the second half or period of the drying time or cycle is achieved.

The instant inventive method is particularly advantageous if one desires to develop an economical drying program for a certain material. In connection therewith, a preliminary drying of the material would first be carried out with a relatively low guide value for grad T (from the table), and additional dryings would each be carried out with respectively higher values for grad T. The drying would be continued in this manner until such time that a surface crack formation is initiated indicative that a further increase of grad T is no longer permissible. Proceeding further in this fashion, the economical optimum of the drying time would be quickly reached, whereas in the heretofore employed control methods of the prior-art, it was very difficult to learn during which point in time of the drying process it was possible to dry more intensely than before.

As should be apparent, by utilizing the instant method, it is feasible to employ higher psychrometer differences toward the end of a drying process than can normally be obtained in drying chambers. In this regard, one can normally obtain only about 25 to 30° C. psychrometer difference due to the humidity of the absorbed fresh air. By means of pre-drying the fresh air, higher psychrometer differences can be obtained in the chamber.

The advantages of the instant inventive method over the methods of the prior-art are thus manifold and, in particular, it should be apparent that drying can be carried out during the drying process in accordance with economic considerations and that operation of the drying chamber is only required at the beginning and at the end of the drying process without necessitating the conduction of running wood moisture measurements during the drying process. As a result, the optimum drying time is quickly reached in the course of only 3 to 4 drying processes utilizing, for example, the same type of wood, thickness of wood, and the like, by means of a stepwise increase of grad T. Additionally, the steady increase of the psychrometer difference without going through step intervals enables faster drying.

With customary temperatures found in most artificial wood drying techniques, an approximately linear relationship exists between the logarithm of the psychrometer difference and the equilibrium wood moisture u_{G1} . For example, for 70° C. drying temperature:

$$u_{G1} = 20.2 - \frac{1}{0.08416} \cdot \log(T - F)$$

From that one obtains by transposition:

$$\frac{d(\log \Delta T)}{dZ} = \text{grad } T = -0.08416 \cdot \frac{du_{G1}}{dZ} \quad (4)$$

If this value is inserted into the found relationship:

$$\text{grad } u = g_1 \cdot \text{grad } T + g_2$$

one obtains, for example, for a 28 mm. wood thickness:

$$\text{grad } u = -0.02062 \cdot \frac{du_{G1}}{dZ} + 0.001$$

Accordingly, the drying process can also be controlled

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with a constant time-wise decrease of the equilibrium wood moisture du_{G1}/dZ instead of with a constant grad T if such is found to be advantageous as far as the measurement or control techniques are concerned.

Referring now to the single figure of the appended drawing, an installation or apparatus suitable for carrying out the inventive method is disclosed. Such installation comprises a dry-bulb thermometer 1 and a psychrometer 2 adapted to be placed in the drying chamber (not illustrated). The measuring values obtained from the thermometer and the psychrometer are fed through a conductor 3 to a control apparatus 5 having a variable drive for program discs. The control quantity or signals derived from the control apparatus 5 is fed through conductor 4 to the actual correcting or final control elements such as a heat control valve 8 for controlling the drying temperature, a spray evaporation valve 9, and opening and closure flaps 10. A curved disc or cam plate 6 is utilized for the psychrometer difference and a curved disc or cam plate 7 is utilized for the drying temperature as the means for setting the ideal or theoretical values for the control quantity or signal.

As should now be apparent, the objects initially set forth at the outset of this specification, have now been successfully achieved.

Accordingly, what is claimed is:

1. A drying method for controlling the climatic sequence in lumberboard drying installations, comprising the steps of placing the lumberboard to be dried in a drying area, subjecting the lumberboard to a drying operation, and during the drying operation increasing the wet bulb depression steadily and uniformly logarithmically as a function of the logarithmic decrease with time of the moisture content of the wood being dried.

2. The drying method for lumberboard as defined in claim 1, further including the steps of regulating the wet bulb depression such that the drying time (Z) can be determined from the function

$$Z = \frac{\log \frac{u_a}{u_e}}{\text{grad } u}$$

wherein u_a represents the initial wood moisture content and u_e the final wood moisture content, and wherein u_a/u_e represents the ratio of the initial and final moisture content of the wood, and wherein grad u denotes the decrease with time of the logarithm of the wood moisture.

3. A drying method for lumberboard as defined in claim 1, including the step of regulating the wet bulb depression in a manner that the increase of the logarithm with time of the wet bulb depression remains at least approximately constant during the drying period.

4. The drying method for lumberboard as defined in claim 1, further including the step of maintaining the temperature in the drying area at least approximately constant during the drying period.

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