(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 759 137 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
04.02.1998 Bulletin 1998/06

(21) Application number: **95918005.0**

(22) Date of filing: **11.05.1995**

(51) Int Cl.[6]: **F26B 21/10**, B27K 5/00

(86) International application number:
PCT/FI95/00252

(87) International publication number:
WO 95/31680 (23.11.1995 Gazette 1995/50)

(54) METHOD FOR PROCESSING WOOD AT ELEVATED TEMPERATURES

VERFAHREN ZUR BEARBEITUNG VON HOLZ BEI ERHÖHTEN TEMPERATUREN

PROCEDE DE TRAITEMENT DU BOIS A DES TEMPERATURES ELEVEES

(84) Designated Contracting States:
AT DE DK ES FR GB NL SE

(30) Priority: **11.05.1994 FI 942209**
11.05.1994 FI 942210

(43) Date of publication of application:
26.02.1997 Bulletin 1997/09

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Description

The present invention relates to a method according to the preamble of Claim 1 for processing wood at an elevated temperature.

Wood is processed at elevated temperatures in connection with, e.g., seasoning, thermal modification, and different manufacturing processes in general. Wood expands when heated. However, the traditional view is that thermal expansion is a small-scale phenomenon, and accordingly, it has not been taken into account in connection with thermal treatments. In fact, however, only longitudinal wood expansion occurs on a small scale; cross-grain expansion even exceeds that of aluminium. Significant thermal expansion in the cross-grain direction of wood easily gives rise to internal cracks unless taken into consideration in developing different types of processes.

It is an object of the present invention to overcome the drawbacks hampering the prior art techniques and to achieve a concept for controlling the phenomena related to thermal expansion of wood, particularly for preventing the generation of internal cracks in the wood, where wood is heated to a temperature exceeding 90 °C, typically exceeding 100 °C.

The invention is based on the principle that, during processes where wood is kept at an elevated temperature, the temperatures of the wood core and the outer surface of the wood, respectively, are continuously determined, and the difference between the two temperatures is kept reasonably small, this too occurring on a continuous basis. These measures are taken both during the heating step, whereby the temperature of the wood is raised for the purpose of, e.g., seasoning, and the cooling step, whereby the wood is cooled back to its basic temperature. The temperature difference is preferably about 30 °C at the most. Surprisingly, it has been noted that this concept can be used to even totally prevent the generation of internal cracks in the wood material.

More specifically, the method according to the invention is mainly characterized by what is stated in the characterizing part of Claim 1.

In the context of the present invention, the term "internal temperature" of wood is used to denote the temperature of wood at some distance from the outer surfaces of the wood. Depending on the shape of the piece of wood, the "internal temperature" is typically measured at a depth of at least about 2 to 5 cm.

The "external temperature" is the temperature measured at or slightly below the wood surface. Thus, in many cases the "external temperature" essentially corresponds to the ambient temperature, for instance the temperature in a drying oven.

The arrangement according to the invention can be carried out in, for instance, a drying oven provided with adjustable temperature and means for vapour discharge.

When prior art techniques are used to dry, for instance, room dry wood at about 200 °C, it quickly reaches the same surface temperature, that is, about 200 °C. However, the warming up of the inner parts of the wood will cease at about 100 °C until the moisture content of the inner parts of the wood has been reduced to a value below 5 %. It is only then that the temperature of the inner part of the wood will begin to rise rapidly. As a result of the warming up the combined effect of the temperature differences and the degree of dryness of the wood will give rise to internal cracks which are not visible on the outside but which, however, render the wood unusable.

According to the invention, the temperature is gradually raised such that the temperature difference between the surface and the inner part of the wood is not allowed to exceed 30 °C. The temperature difference is advantageously kept constant at a value between 10 and 30 °C. In practice, the temperature difference is kept constant with a margin of at least about 5 °C depending on the thermostatic controllers used, whereby the external temperature is altered along with the rising internal temperature.

The concept according to the invention can be implemented by fitting a test piece with at least two sensors, one sensor measuring the internal temperature and the other sensor the surface temperature of the wood. When seasoning larger amounts of timber, it is advisable to provide several test pieces with sensors. In industrial-scale arrangements, the measurement results are used as basis for devising a suitable heating-up program for each type of wood, thereby observing the effect of the initial moisture content on the process.

According to an alternative embodiment, the actual thermal treatment according to the invention is not initiated until the moisture content of the wood core has been reduced to a value below 30 %, advantageously below 10 %, in some cases below the above-mentioned limit at 5 %. Thus, during a first step of this alternative method, a piece of wood at room or factory temperature is inserted into a drying oven at a temperature of about 110 to 140 °C for the purpose of removing the main part of the water. Next, when the internal temperature of the wood has risen to at least approximately the said value, the ambient temperature, that is, for instance, the temperature of the drying oven is subjected to a gradual increase while the difference between the internal and external temperatures of the wood is kept constant at a value below approximately 30 °C.

The concept according to the invention is applicable in particular in the context of hot drying and thermal processing of wood. During high temperature drying, wood is dried until it exhibits a moisture content of, e.g., below 15 %, in some cases advantageously below 10 %.

In implementing the process, it is of advantage to use vapour throughout the treatment, whereby the relative humidity remains extremely high and the oxygen content low in the ambient air.

According to a particularly advantageous embodiment of the present invention, a solution is achieved for rapidly seasoning wood.

Conventional solutions for seasoning wood have been based on "gentle" seasoning of wood into high-quality joinery timber. These drying methods are exemplified by air drying/kiln drying, vacuum drying, and condensing drying. In these drying techniques, the aim has been to control the drying event by monitoring, among other things, the difference between wet and dry temperature. For fear of internal cracks, it has not been possible to raise the temperatures greatly above 100 °C to accelerate the seasoning process. So as to achieve more rapid drying techniques, methods have been developed whereby the evaporation of water at lower temperatures is intensified or some other kind of method is used, e.g., the above-cited condensing-drying method, whereas no attention has been paid to achieving a more rapid transmission of heat to wood, nor to keeping the wood surface moist for as long as possible.

The prior art techniques are hampered by considerable drawbacks due to, among other things, the long drying times required (normal drying of spruce timber typically takes 5 to 7 days) and the great total energy consumption.

An advantageous embodiment of the present invention can be implemented to remove the problems related to conventional drying techniques. The invention is based on the notion that, apart from joiner timber, colour changes and resin discharges are acceptable in most practical wood applications, for instance when wood is used as construction material. Even in these applications, however, is is necessary to prevent the generation of internal cracks in the wood.

Consequently, when implementing the rapid drying method according to the invention used for effective and rapid drying of wood, merely the prevention of drying cracks is attended to. It has been found that this goal can be attained by using vapour which protects the wood and contributes to the warming up thereof during seasoning as well as by controlling the difference between the surface and internal temperatures of the wood in the above-described manner.

Thus, the seasoning method is based on the combination of the following three steps:

a) first, the temperature of the drying oven is raised to at least about 90 °C, advantageously to at least 100 °C, and is then kept at this value until the wood reaches at least approximately the same temperature,

b) second, the oven temperature is gradually raised such that the difference between the internal temperature of the wood and the oven temperature remains constant and does not exceed 30 °C until the desired wood moisture content is attained, and

c) third, the oven temperature is decreased such that the difference between the internal temperature of the wood and the oven temperature remains at a constant value not exceeding 30 °C until the core part of the wood reaches the desired temperature.

During the first step (step a) of the seasoning process, the oven temperature is advantageously set at a temperature between 100 and 150 °C, preferably in the range 100 to 130 °C. The heating is continued until the moisture content of the wood has been reduced to a value below at least 30 %.

During the second step (step b) the heating is discontinued when the wood exhibits a low enough moisture content in view of the intended use. Generally speaking, a moisture content of about 1 to 20 % is aimed at, preferably below 15 % and typically between about 10 and 15 %. During step b, the temperatures inside the wood and at the outer surface of the wood, correspondingly, can be continuously determined by means of, e. g., sensors fitted on the piece of wood, whereby the difference between said temperatures can be continuously kept moderately small on the basis of the measurement results.

During step b, the temperature can be raised to a value exceeding 130 °C, even exceeding 150 °C, whereby the time needed for the evening out of the wood temperature can be reduced, as the drying of the core part of wood is more effective at a higher temperature, thus reducing the differences in moisture content between the core and the surface.

The difference between the temperatures is monitored both during the heating step b, whereby the temperature of the wood is raised to dry the wood, and the cooling step (step c) during which the wood is cooled back to its basic temperature. The temperature difference is advantageously kept at a constant value which is approximately 30 °C at the most, preferably about 10 to 30 °C. Too small a difference in temperature will prolong the seasoning process, whereas a great difference will increase the risk of internal crack generation. It has been found that the solution disclosed herein (i.e., temperature difference < 30 °C) can be implemented to even totally prevent the formation of cracks in the wood.

Step c comprises reducing the oven temperature until the internal temperature of the wood has reached a value below 100 °C. As stated above, it is of advantage to keep the difference between the inner and outer temperatures of the wood smaller than 30 °C even during the cooling step in order to prevent the formation of internal splits.

During steps a, b, and c, water vapour is introduced into the oven, and the so called wet bulb temperature is kept at about 80 to 120 °C, preferably about 100 °C, using this vapour. The same water vapour introduction is applicable even at other points in the inventive method.

The present invention offers considerable benefits. Thus, the invention can be used to accelerate normal seasoning, to control special seasoning processes at

temperatures exceeding 100 °C, and to develop compression seasoning applications. What is more, the formation of internal splits in the wood subjected to treatment can in practice be totally prevented during seasoning and heat treating.

In the following, the invention is examined in closer detail with reference to the appended drawings.

Fig. 1 illustrates the temperatures measured at different points in the wood as a function of time during heating and during the seasoning of fresh spruce timber at 220 °C for 5 hours in accordance with the prior art,

Fig. 2 illustrates the corresponding temperature measurements with unseasoned spruce which has been heated to the same temperature for 24 hours, whereby the temperature difference between the internal and external parts of the wood has been kept at a value smaller than 30 °C in accordance with the invention,

Fig. 3 illustrates measurement results corresponding to those of Fig. 1 (obtained by conventional methods) for the seasoning of aspen wood, and

Fig. 4 shows the temperature measurement results obtained for aspen wood using the inventive method.

Example 1

Seasoning of fresh spruce timber and processing of same at an elevated temperature

When wet spruce timber (50 x 100 x 1500 mm) with a moisture content of about 40 % was heated for 5 hours in accordance with Fig. 1 without in any way limiting the temperature difference between the internal parts and external surfaces, small internal cracks were found when the test piece was cleft. As a result of the treatment, a final moisture content of less than 5 % was obtained after seasoning.

When a test piece of wet spruce timber having identical dimensions was subjected to heating for 24 h in accordance with the invention, thereby implementing the inventive concept of keeping the difference between the internal and external temperatures at 30 °C, no cracks were generated in the test piece (Fig. 2). The final moisture content of the seasoned test piece was less than about 5 %.

Example 2

Seasoning of aspen timber and processing of same at an elevated temperature

When seasoned aspen timber (38 x 100 x 1500 mm) was subjected to heating for 7 h, thereby implementing the concept according to the invention, a rapid and controlled seasoning was obtained, and no cracks were generated in the timber (Fig. 4). When the corresponding thermal treatment was carried out for 3 h without in any way limiting the difference between the internal and external temperatures (Fig. 3), small internal cracks were found in the internal parts of the pieces, such cracks in practice rendering the timber unfit for use.

In both cases, the test pieces exhibited a final moisture content of below 5 %.

Claims

1. A method for processing wood at an elevated temperature, wherein the temperature of the wood is raised to a value of at least over 100 °C, **characterized** in that
   - during the process, the temperatures of the internal part of the wood and its external surface, respectively, are measured, and
   - in raising the temperature, the difference between the internal and external temperatures of the wood is kept at an essentially constant value of 10 to 30 °C.

2. The method according to Claim 1, **characterized** in that the wood is processed in the presence of vapour.

3. The method according to Claim 2, **characterized** in that vapour is used whose wet temperature is kept at about 80 to 120 °C, preferably at about 100 °C.

4. The method according to one of the Claims 1 to 3, **characterized** in that the temperatures in the internal part of the wood and at the external surface of the wood, correspondingly, are determined on a continuous basis, and, in raising the temperature of the wood, the temperature of the external surface of the wood is altered as a function of the internal temperature such that the difference between the two temperatures is kept constant at 10 to 30 °C which a margin of approximately 5° at the most.

5. The method according to one of the Claims 1 to 4, wherein the temperature of the wood is first raised and then lowered to a desired value, **characterized** in that the the difference between the internal and external temperatures is kept constant at 10 to 30 °C both during heating and cooling of the wood.

6. The method according to Claim 1, **characterized** in that, prior to thermal processing, the timber is subjected to seasoning for reducing the moisture content of the wood to a value below 30 %.

7. The method according to Claim 1, wherein wood is seasoned in a drying oven in the presence of vapour,
   characterized in that

a) first, the temperature of the drying oven is raised to at least 100 °C and is then kept at this value until the wood reaches at least approximately the same temperature,
b) second, the oven temperature is gradually raised such that the difference between the internal temperature of the wood and the oven temperature remains constant at 10 to 30 °C until the desired wood moisture content is attained, and
c) third, the oven temperature is gradually decreased such that the difference between the internal temperature of the wood and the oven temperature remains at a constant value of 10 to 30 °C until the core part of the wood reaches the desired temperature.

8. The method according to Claim 7, **characterized** in that, during step a, the temperature of the drying oven is set at 100 to 120 °C and is kept at this value until the temperature of the wood reaches this temperature range and a moisture content below 30 %.

9. The method according to Claim 7 or 8, **characterized** in that, during step b, heating is discontinued when the wood has a moisture content between 1 and 20 %.

10. The method according to one of the Claims 7 to 9, **characterized** in that, during step b, the wood is heated to a temperature of at least 130 °C.

11. The method according to one of the Claims 7 to 10, **characterized** in that, during step c, the temperature of the oven is lowered until the internal temperature of the wood reaches a temperature below 100 °C.

Patentansprüche

1. Verfahren zur Behandlung von Holz bei erhöhter Temperatur, wobei die Temperatur des Holzes auf mindestens über 100 °C erhöht wird, dadurch **gekennzeichnet**, daß

   - während der Behandlung die Temperaturen im inneren Teil des Holzes respektive auf dessen Außenfläche gemessen werden, und
   - bei der Temperaturerhöhung der Unterschied zwischen den inneren und äußeren Temperaturen des Holzes im wesentlichen auf einem Konstantwert von 10 - 30 °C gehalten wird.

2. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß das Holz in Anwesenheit von Dampf behandelt wird.

3. Verfahren nach Anspruch 2, dadurch **gekennzeichnet**, daß Dampf verwendet wird, dessen Feuchttemperatur bei ca. 80 - 120 °C, vorzugsweise bei ca. 100 °C gehalten wird.

4. Verfahren nach einem der Ansprüche 1 - 3, dadurch **gekennzeichnet**, daß die Temperaturen des inneren Teils des Holzes respektive der Außenfläche des Holzes kontinuierlich bestimmt werden und bei der Temperaturerhöhung des Holzes die Temperatur der Außenfläche des Holzes als eine Funktion der Innentemperatur des Holzes derart geändert wird, daß der Unterschied zwischen den beiden Temperaturen konstant bei 10 - 30 °C mit einem Spielraum von höchstens ca. 5 °C gehalten wird.

5. Verfahren nach einem der Ansprüche 1 - 4, wobei die Temperatur des Holzes zuerst erhöht und danach bis zu einem gewünschten Wert gesenkt wird, dadurch **gekennzeichnet**, daß der Unterschied zwischen den inneren und den äußeren Temperaturen sowohl während dem Erwärmen als auch dem Erkalten des Holzes konstant bei 10 - 30 °C gehalten wird.

6. Verfahren nach Anspruch 1, dadurch **gekennzeichnet**, daß das Holz vor der Wärmebehandlung einer Trocknung zur Senkung des Feuchtigkeitsgehaltes des Holzes auf unter 30 % unterworfen wird.

7. Verfahren nach Anspruch 1, wobei das Holz in einem Trockenofen in Anwesenheit von Dampf getrocknet wird, dadurch **gekennzeichnet**, daß

   a) zunächst die Temperatur des Trockenofens auf mindestens 100 °C erhöht und danach auf diesem Wert gehalten wird, bis das Holz mindestens annähernd dieselbe Temperatur erreicht,
   b) dann die Temperatur des Ofens progressiv so erhöht wird, daß der Unterschied zwischen der inneren Temperatur des Holzes und der Ofentemperatur konstant bei 10 - 30 °C bleibt, bis der gewünschte Holzfeuchtigkeitsgehalt erreicht ist, und
   c) schließlich die Ofentemperatur progressiv derart gesenkt wird, daß der Unterschied zwischen der inneren Temperatur des Holzes und der Ofentemperatur einen konstanten Wert von 10 - 30 °C behält, bis der innere Teil des Holzes die gewünschte Temperatur erreicht.

8. Verfahren nach Anspruch 7, dadurch **gekennzeichnet**, daß während der Phase a) die Temperatur des Trockenofens auf 100 - 120 °C eingestellt und auf diesem Wert gehalten wird, bis die Temperatur des Holzes diesen Temperaturbereich und einen Feuchtigkeitsgehalt von unter 30 % erreicht.

9. Verfahren nach Anspruch 7 oder 8, dadurch **gekennzeichnet**, daß während der Phase b) die Erwärmung eingestellt wird, wenn das Holz einen Feuchtigkeitsgehalt von 1 - 20 % aufweist.

10. Verfahren nach einem der Ansprüche 7 - 9, dadurch **gekennzeichnet**, daß während der Phase b) das Holz auf eine Temperatur von mindestens 130 °C erwärmt wird.

11. Verfahren nach einem der Ansprüche 7 - 10, dadurch **gekennzeichnet,** daß während der Phase c) die Temperatur des Ofens gesenkt wird, bis die innere Temperatur des Holzes eine Temperatur unter 100 °C erreicht.

Revendications

1. Procédé de traitement du bois à température élevée, dans lequel la température du bois est portée à une valeur supérieure à 100 °C au moins, caractérisé en ce que:

   - au cours du traitement, la température de la partie intérieure du bois et celle de la surface extérieure, sont mesurées, et
   - au cours de la montée en température, la différence entre les températures intérieure et extérieure du bois est maintenue à une valeur pratiquement enstante, comprise entre 10 et 30 °C.

2. Procédé selon la revendication 1, caractérisé en ce que le bois ests traité en présence de vapeur.

3. Procédé selon la revendication 2, caractérisé en ce que la vapeur utilisée humide est à une température maintenue entre environ 80 et 120 °C, de préférence à environ 100 °C.

4. Procédé selon l'une quelconque des revendications 1 à 3, caractérisé en ce que les températures respectives de la partie intérieure et de la surface extérieure du bois sont déterminées de façon continue, et que, lors de la montée en température du bois, la température de la surface extérieure du bois est modifiée en fonction de la température intérieure, d'une manière telle que la différence entre les deux températures est maintenue constante, à une valeur comprise entre 10 et 30 °C, avec une marge d'environ 5 °C au plus.

5. Procédé selon l'une quelconque des revendications 1 à 4, dans lequel la température du bois est d'abord élevée, puis abaissée à la valeur désirée, caractérisé en ce que la différence entre les deux températures est maintenue constante, à une valeur comprise entre 10 et 30 °C, à la fois au cours du chauffage et au cours du refroidissement du bois.

6. Procédé selon la revendication 1, caractérisé en ce que, avant de procéder au traitement thermique, le bois brut est sousmis à une mise en condition destinée à réduire sa teneur en humidité à une valeur inférieure à 30 %.

7. Procédé selon la revendication 1, dans lequel le bois est mis en condition dans une étuve de séchage en présence de vapeur, caractérisé en ce que:

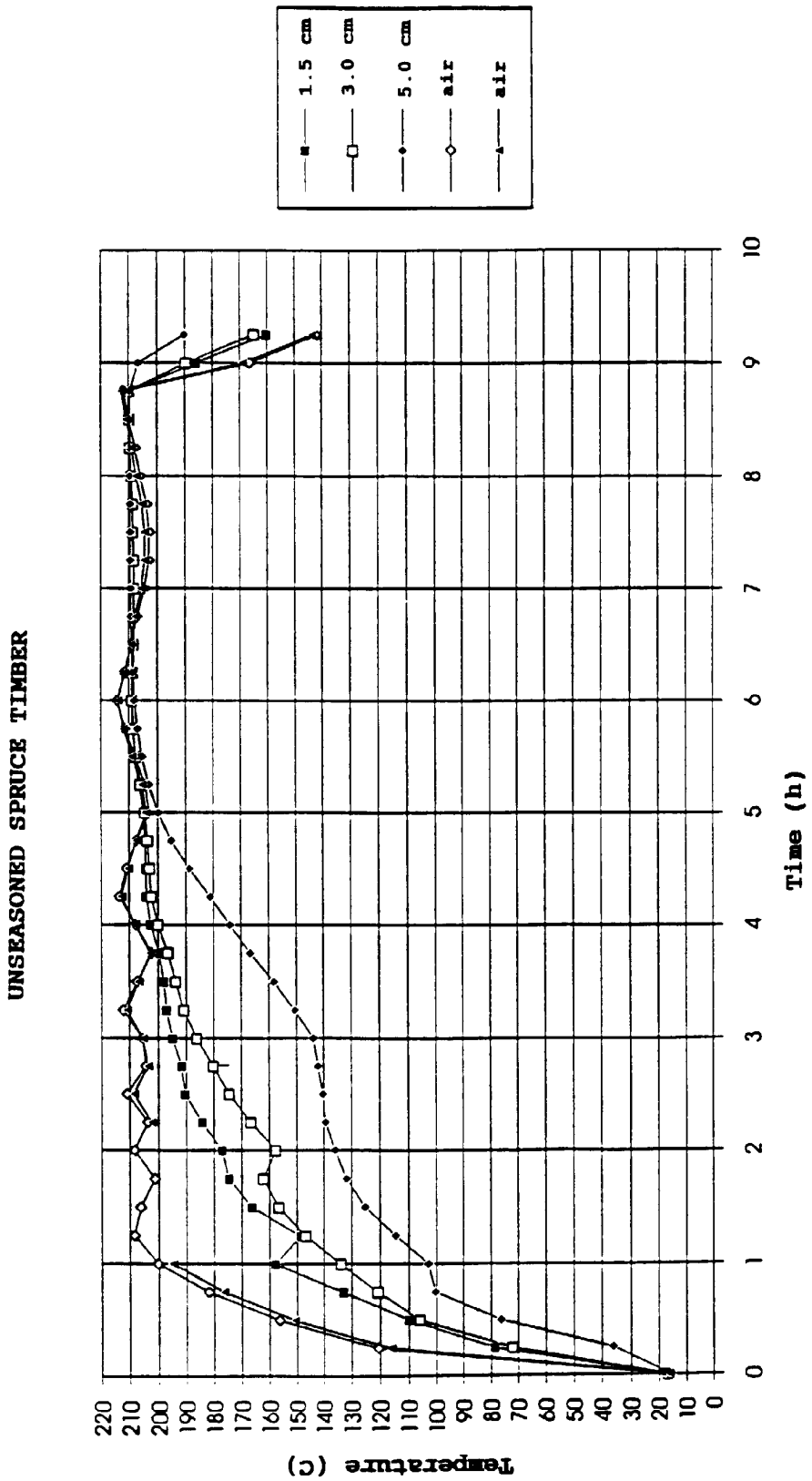
   (a) premièrement, la température de l'étuve de séchage est amenée à au moins 100 °C, et maintenue ensuite à cette valeur jusqu'à ce que le bois atteigne approximativement, au moins cette même température,
   (b) deuxièmement, la température de l'ètuve de séchage est élevée progressivement d'une manière telle que la différence entre la température intérieure du bois et la température de l'étuve reste comprise entre 10 et 30 °C, jusqu'à ce que la teneur en humidité du bois atteigne la valeur voulue, et,
   c) troisièmement, la température de l'étuve est abaissée progressivement d'une manière telle que la différence entre la température intérieure du bois et la température de l'étuve reste à une valeur comprise entre 10 et 30 °C, jusqu'à ce que la partie centrale du bois atteigne la température voulue.

8. Procédé selon la revendication 7, caractérisé en ce que, au cours de l'étape (a), la température d l'étuve de séchage est réglée entre 100 et 120 °C, et est maintenue à cette valeur jusqu'à ce que le bois atteigne une témperature comprise dans cet intervalle, et une teneur en humidité inférieure à 30 %.

9. Procédé selon la revendication 7 ou la revendication 7 ou la revendication 8, caractérisé en ce que, au cours de l'étape (b), le chauffage est interrompu lorsque le bois a une teneur en humidité comprise entre 1 et 20 %.

10. Procédé selon l'une quelconque des revendications 7 à 9, caractérisé en ce que, au cours de l'étape (b), le bois est chauffé à une température d'au moins 130 °C.

11. Procédé selon l'une quelconque des revendications 7 à 10, caractéris' en ce que, au cours de l'étape (c), la température de l'étuve est abaissée jusqu'à ce cque la température intérieure du bois atteigne une valeur inférieure à 100 °C.


UNSEASONED SPRUCE TIMBER
1.5 cm
3.0 cm
5.0 cm
air
air
Temperature (C)
Time (h)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
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2
3
4
5
6
7
8
9
10

Fig. 1

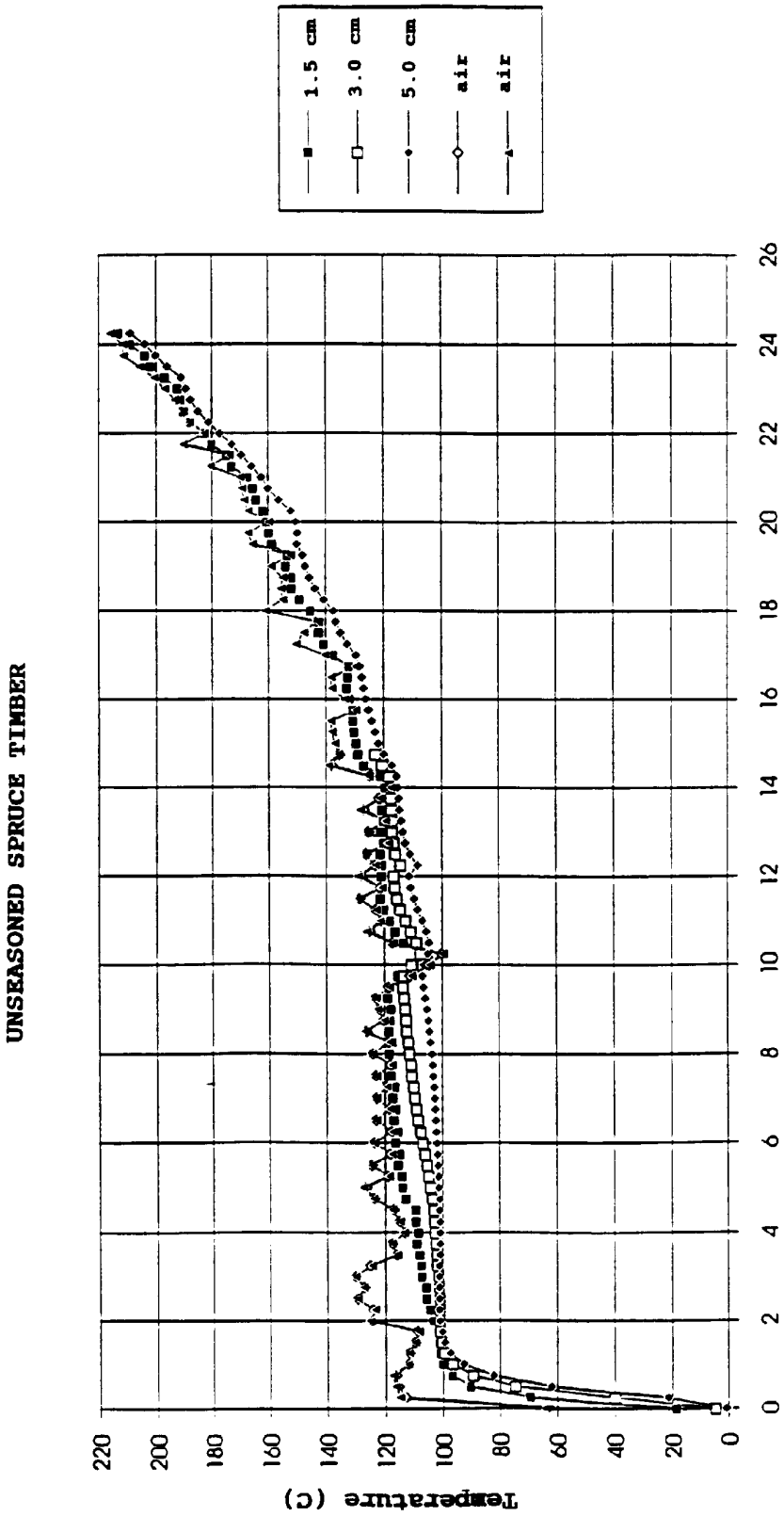
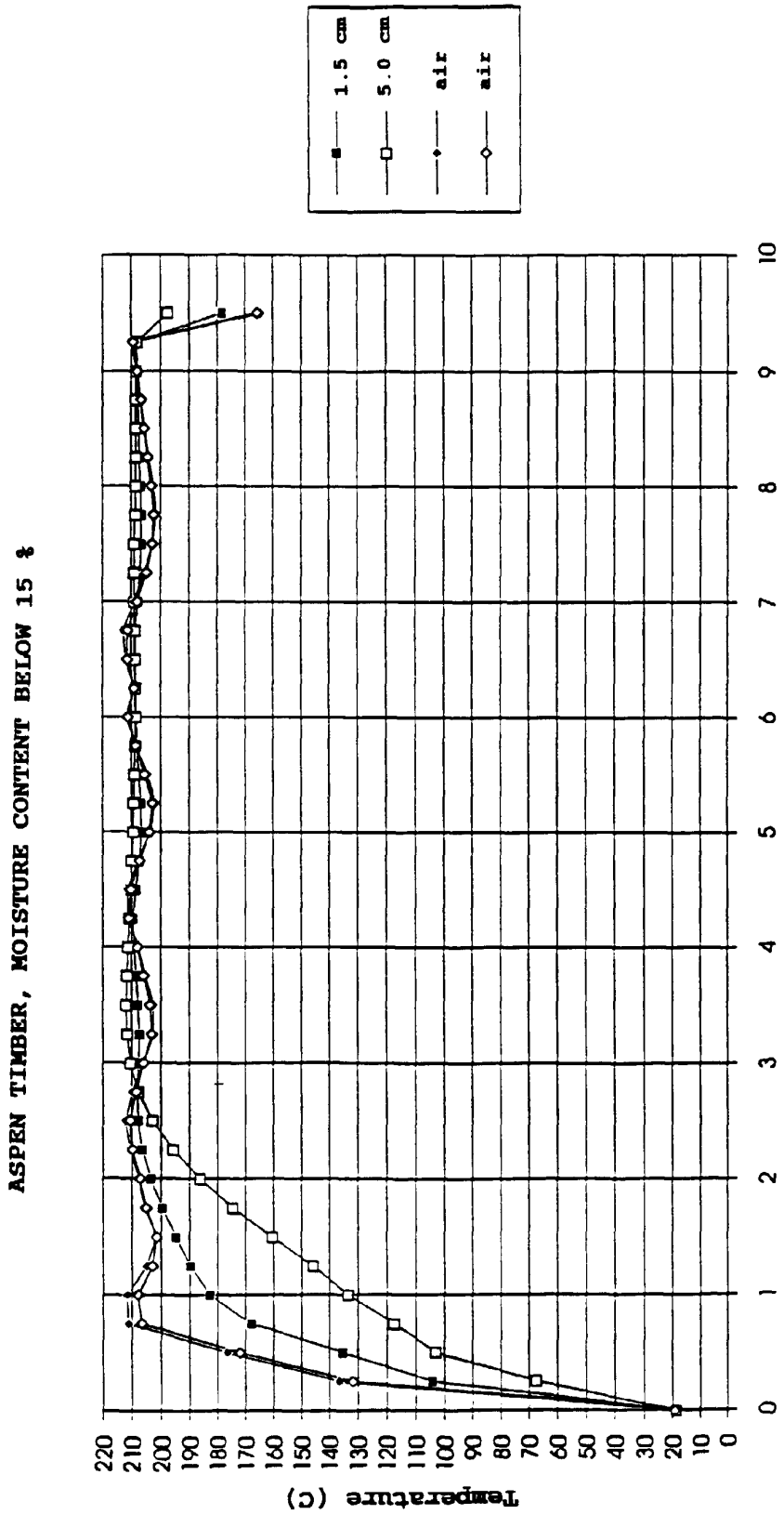

UNSEASONED SPRUCE TIMBER
1.5 cm
3.0 cm
5.0 cm
air
air
Temperature (C)
Time (h)
0
20
40
60
80
100
120
140
160
180
200
220
0
2
4
6
8
10
12
14
16
18
20
22
24
26

Fig. 2


ASPEN TIMBER, MOISTURE CONTENT BELOW 15 %
1.5 cm
5.0 cm
air
air
Temperature (C)
Time (h)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
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3
4
5
6
7
8
9
10

Fig. 3

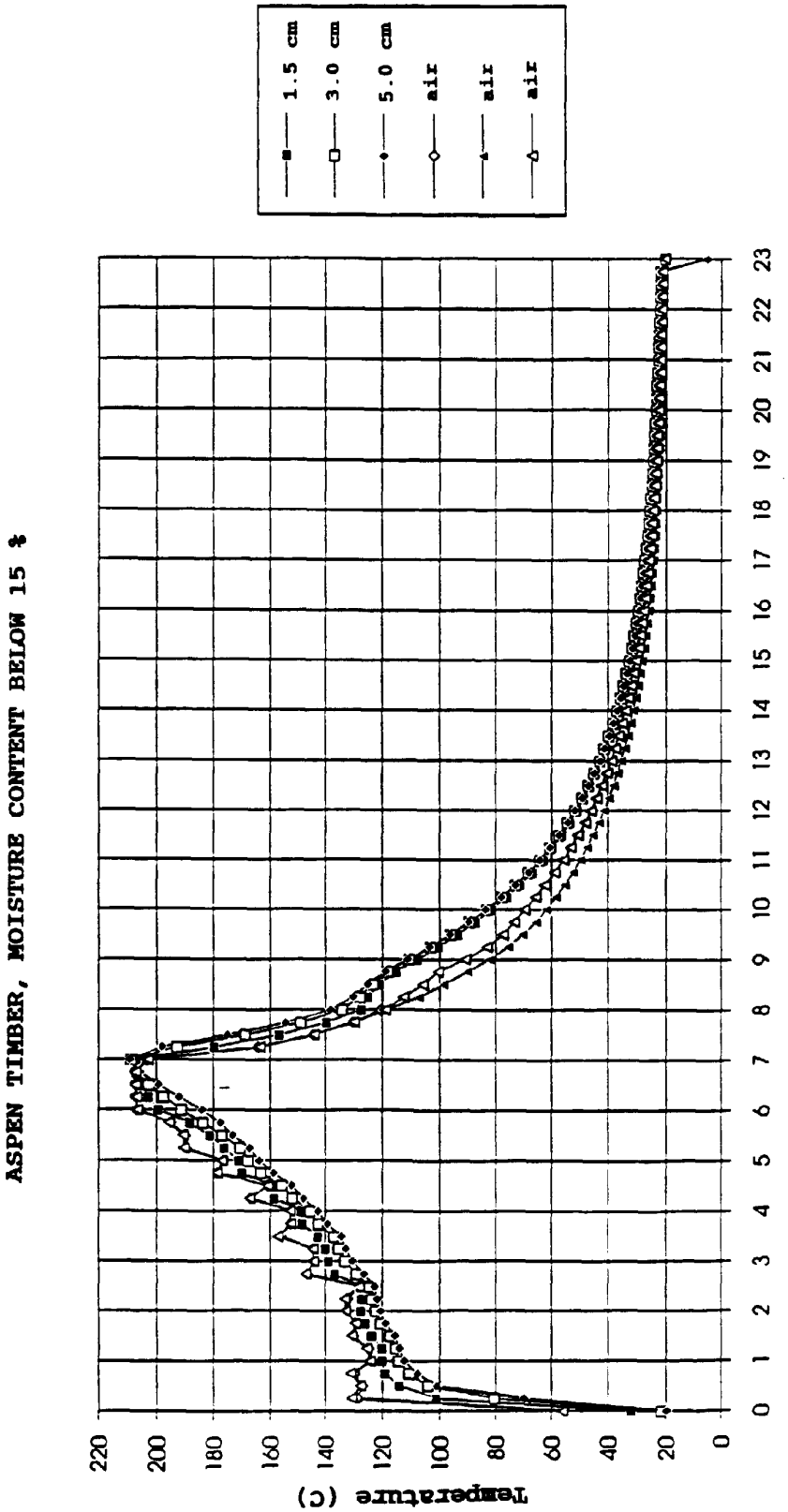
ASPEN TIMBER, MOISTURE CONTENT BELOW 15 %
1.5 cm
3.0 cm
5.0 cm
air
air
air
Temperature (C)
Time (h)
0
20
40
60
80
100
120
140
160
180
200
220
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

Fig. 4