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(54) **METHOD AND ARRANGEMENT FOR DRYING WOOD**
VERFAHREN UND ANORDNUNG ZUR HOLZTROCKNUNG
PROCEDE ET SYSTEME POUR SECHER DU BOIS

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Description

Field of the Invention

[0001] The present invention relates to a method for drying wood by circulating hot air around and through one or more piles of wood, arranged in batches in one or more closed drying chambers in a chamber drier, the circulating hot air first being caused, in a heating phase, to heat the wood to the starting temperature for drying, subsequently in one or more drying phases accomplishing the actual drying, and finally, in a conditioning phase having a specially adapted air moisture content and air temperature other than during drying, being caused to level, as completely as permitted by the method, the moisture ratio and stresses in the wood after drying. The invention also relates to an arrangement for carrying out the method according to the invention. This comprises a chamber drier having at least one drying chamber and intended for drying of wood in batches, means for moving one or more piles of wood into and out of the drying chamber, means for circulating hot air in the drying chamber, and means for conditioning the hot circulating air and for conveying it to and from the drying chamber.

Background of the Invention

[0002] In artificial chamber drying of wood, hot air is today used as heat- and moisture-conducting medium. This means that heat is transferred by convection to the wood surfaces during the heating phase as well as the drying phase. Experiments have also been made with alternative heating methods, for example by supplying, by microwave energy, the necessary thermal energy for heating and evaporation. Today however, the air circulation principle is the predominant drying method in the sawmill industry, among other things because bark and sawmill refuse can be used as inexpensive fuel in the sawmill's own central boiler plant.

[0003] Since more and more wood is dried to a lower moisture ratio, which is adapted to the requirements of the carpentry industry, it is also necessary to finish the drying with a so-called conditioning phase. This finishing phase of the drying aims at levelling out differences in moisture ratio within as well as between "wood individuals", and at eliminating the stresses in the wood that are built up during the drying phase. If this conditioning phase is left undone or is carried out in an incorrect manner, the wood will be deformed during processing and splitting.

[0004] The development that has been going on up to now in order to improve the chamber drying has mainly aimed at developing the programmed control of the climate during drying and conditioning, given certain basic performance characteristics in the form of maximum thermal effect, batch volume, wood dimensions etc. On the other hand, considerably less has been accomplished to study critical phases during drying in respect of incidence of loss and time expenditure/drying capacity for the purpose of optimising the drying process. In this context, it can be established that the heating phase and the conditioning phase have been especially neglected.

Technical Problem

[0005] In conjunction with the drying of wood, certain quality-reducing damage may be caused to the wood, that is related to the drying technique. For example, the formation of cracks is a type of drying damage which frequently arises in wood of great thickness. The formation of cracks in wood is drying damage arising early in the drying process. This is a consequence of the fact that the mechanisms which are the basis of a crack arising are strongly associated with the moisture and stress conditions of the wood surface. A crack arises basically when the tensile stress transversely of the direction of the fibres exceeds the tensile strength.

[0006] It is generally known that interaction between strength and modulus of elasticity, which together produce the property break elongation, leads to the inclination to cracks decreasing with an increasing temperature of the material. In addition, wood acts more and more plastically at higher temperatures, i.e. wood has the aptitude for acting in a nonelastic manner. For example, wood may creep, especially under the action of stress and variation in moisture. Such creeping, which is frequently called mechanosorptive creeping, is in fact a condition of drying wood of great thickness, with no formation of cracks.

[0007] When sawing the wood before drying, wood surfaces are uncovered, which will then emit water vapour to the environment, i.e. a drying of the surface begins. At this stage, this drying is uncontrolled, i.e. outer conditions in the form "wind and weather" determine the drying intensity: It has been found that wood that is left in a woodyard will already obtain surface checks after some day, probably earlier in hot and dry weather. These checks then grow during the continued artificial drying owing to the stress concentration arising in the initial cracks. In this case, it thus is not possible to dry such wood without the occurrence of considerable cracks.

[0008] However, it has been found that such surface checks may also arise during the heating phase in the drier. The purpose of this phase is to heat the batch of wood to the starting temperature of the actual drying phase. If heating is carried out by convection by circulating air through the wood, this air will be dehumidified fairly immediately by condensing on the cold wood surfaces. Subsequently, an uncontrolled drying begins by the warmer and warmer air absorbing moisture from the wood surfaces, which thus will dry. At this stage, the surfaces will already be so dry that tensile stress arises transversely of the direction of fibres, especially if the surface contains heartwood of low water content, and a crack may form. The wood also has a low temperature at the initial stage of the heating, which is unfavourable in respect of the tendency to forming cracks.

[0009] Summing up, it can be established that uncontrolled pre-drying and heating of wood by dry air causes initial cracking of the wood, and growing of these cracks during the continued drying.

[0010] In air circulation drying, a gradient in moisture ratio always arises from the surface. The surface will then be drier than the interior parts of a piece of wood, and this difference (gradient) in moisture ratio corresponds to the driving power that leads to moisture flowing to the surface. The stress then arising causes creeping, which results in a stress condition at the end of the drying. The surface will then be in a condition of compression stress, while the interior parts of the wood will be in a condition of tensile stress. These differences in stress lead to deformations, especially when splitting the wood.

[0011] In addition to the difference in stress, which is the consequence of air circulation drying, also a moisture ratio gradient will, as mentioned above, develop during the drying. The highest moisture ratio will be found in the centre of the wood, while the surfaces are significantly drier. When splitting the wood, an undesired deformation will arise also for this reason, since the moistest parts will be uncovered and dry further during shrinking and, thus, deformation. In both cases as related, it may be established that drying that is finished without the moisture ratio gradient in the cross-section of the wood being levelled, leads to deformation problems in the further processing of the wood.

[0012] It may also be established that levelling of the moisture ratio in the wood individual at low temperatures (room temperature) does not yield stress-free wood. This is due to the fact that the necessary stress relaxation requires a high temperature of the material. Thus, a conditioning of the wood after the actual drying phase must be carried out at basically such a high temperature of the material as is possible in respect of production engineering, thereby making it possible to implement the goal which is "stress-free wood having a levelled moisture ratio".

<u>Object of the Invention</u>

[0013] As discussed above, it is thus important to heat the wood without initiating surface checks and to finish the drying process with an efficient conditioning. Today, the programmed control of the heating is in many cases taken but little notice of, which can imply that the heating is carried out with air that is too dry. If, on the other hand, it is desired to keep the air moisture at a sufficiently high level so as to avoid the formation of cracks, this results in prolonged heating times, which reduces the capacity of the drying plant.

[0014] Today, the conditioning phase is carried out by increasing, at the final stage of the drying, the moisture of the air by supplying water through nozzles, or directly as vapour from special evaporating boilers. The most common problem in this case is that water nozzles supply too small amounts of moisture, and that if vapour is supplied directly, the evaporating boiler of prior art designs is heavily underdimensioned. In these two cases, the supply of vapour aims at setting a balanced climate in the drying atmosphere, which results in a moistening of the wood surfaces corresponding to but a few per cent above the intended final moisture ratio (mean value). In practice, this conditioning process requires at least 24 hours for plank dimensions.

[0015] From DE-A-2020049 it known a method for drying wood by circulating hot air around in a chamber drier where in the heating phase, the wood is heated to the starting temperature for drying, subsequently accomplishing the actual drying and finally, in a conditioning phase having a specially adapted air moisture content and air temperature other than during the drying, being caused to level the moisture ratio and stresses in the wood after drying.

[0016] US-A-3468036 describes a method and apparatus for drying wood by means of circulating air condensation systems wherein the moisture content of the circulating air contacting the wood is intermittently increased and decreased. Within the circulating air heating unit and an evaporator unit is arranged.

[0017] However, neither of these references, DE-A-2020049 and US-A-3468036, do relate to method to were the heating of the wood during the heating phase is carried out by supplying saturated water vapour to such an extent that the energy needed for heating is transferred to the wood by condensation of the saturated vapour in the surfaces for the wood. A radically different technique is applied in, above all, New Zealand, in which after high-temperature drying of Pinus radiata (radiata pine), the wood is introduced into special conditioning chambers in which vapour is generated from open water tanks. A considerable moistening of the wood surfaces is accomplished, which levels the moisture ratio and prevents the formation of internal cracks in conjunction with the cooling. To implement this, the wood must, however, be cooled for some time to 70-80ºC so as to cause condensation on the wood.

[0018] The object of the present invention is to provide such a method and such an arrangement for drying wood in a chamber drier

that the heating time before drying is shortened, at the same time as the initiation of cracks during heating is prevented, and

that the conditioning, which is carried out for levelling of the moisture ratio and stresses in the wood after the drying phase, is shortened and made more efficient.

Solution of the Problem

[0019] According to the present invention, this object is achieved by a method of the type mentioned by way of introduction and characterised in that, during the heating phase, saturated water vapour is supplied at atmospheric pressure to the hot air circulating around the wood, in the drying chamber used for the heating, said water vapour is supplied at a vapour generating capacity of 6-28 kW/m^3, preferably 10-15 kW/m^3 batch volume of the wood so that the water vapour are condensed on the colder wood surfaces and thereby transfer condensation heat to the wood. According to a preferred embodiment of this method, the supply of vapour to the drying chamber occurs immediately from the start of the heating phase and is then continued preferably continuously without interruption and preferably up to the end of the heating phase.

[0020] Optimum heating of the wood before drying aims at avoiding the initiation of cracks in the wood, at the same time as the heating should be effected in as short a time as possible. According to the invention, this is accomplished, as mentioned above, by supplying water vapour at atmospheric pressure to the drying chamber during the heating phase. The water vapour will then condense on the colder wood surfaces. As a result, these are protected against uncontrolled drying and, resulting therefrom, the formation of cracks. Moreover, condensation heat is transferred as the water vapour condenses on the wood, which yields a significantly greater heat transfer as compared with heating by convection only. In other words, this means an essentially quicker warming of the wood before the drying.

[0021] Although the object of the method according to the invention is to dry the wood, this drying process is surprisingly begun by strongly wetting the wood with condensing vapour during the heating phase. If vapour is supplied immediately from the start of the heating phase, a quick heating by the hot circulation air and, besides, a complete wetting of the wood surfaces will be obtained even from the beginning by transferred condensation heat in addition to heating by convection. As a result, the initiation of cracks in the wood is avoided, which permits a drying process according to the invention for producing wood which, to the greatest possible extent, is free of cracks.

[0022] As mentioned above, it is not possible, however, to completely avoid the formation of cracks, if, after the sawing, which is carried out before the "artificial' drying, the wood is stored in such a manner in, for instance, a woodyard that already at this stage, small surface checks arise, which then will grow. If the wood is correctly stored after sawing, ready-dried wood of very high quality can, according to the invention, be produced in a method which is time-effective and, thus, cost-effective.

[0023] The heating rate in degrees per unit of time is ultimately limited by the thermal conductivity of the wood, so that only such an amount of heat can be supplied to the surfaces as the wood is capable of conducting to the interior parts. In practice, this means that the heating rate is highly dependent on dimensions and ultimately depends on the surface/volume ratio of the wood. However, a condition is that sufficient enthalpy of vaporisation is available.

[0024] For a drying chanter having a batch volume of 150 m^3, a power of about 2MW transferred to enthalpy of vaporisation is sufficient to produce heating times of about 2 hours. This corresponds to a vapour generating capacity of about 13 kW/m^3 batch volume of the wood. The vapour generating capacity should, according to the invention, be kept in the range of 6-28 kW/m^3 batch volume, preferably 10-15 kW/m^3 batch volume. The duration of the heating phase is generally between 1.5 and 2.5 hours, and at the end of the heating phase, the wood has obtained a temperature of between 50°C and 65°C. This heating time prevails under normal conditions, and it is understood that in winter, when the wood can even be frozen, the heating time will be considerably longer.

[0025] The batch volume may vary between different driers, today's driers in many cases having a batch volume of 150 m^3, whereas older driers generally have a lower batch volume, for example 60-70 m^3.

[0026] After the heating phase, the drying of the wood is carried out in one or more drying phases, during which hot drying air is caused to circulate through the piles of wood. The drying phase may last between 2 and 14 days. During this period, dry air is supplied to the drying chanter, and moist air is removed. After the drying phase, when the wood has been given a final temperature of between 50°C and 90°C, the conditioning phase is initiated.

[0027] A convenient embodiment of the inventive method is characterised in that during the conditioning phase, water vapour is supplied at atmospheric pressure to the hot air circulating around the wood in the drying chamber used for the conditioning phase, and that this supply of vapour is begun immediately when starting the conditioning phase and essentially directly after completion of the drying phase/s and that the water vapour supplied during this phase should be supplied at a capacity of 6-28 kW/m^3, preferably 10-15 kW/m^3 batch volume of the wood. Preferably, the same drying chamber should be used for the heating phase, the drying phase/s and the conditioning phase.

[0028] Efficient conditioning of wood after drying should be carried out such that the temperature of the wood is as high as possible. Then the stresses relax quickly, and variations in moisture are levelled. By supplying water vapour to the drying chamber directly after completion of the drying, vapour will condense on the wood surfaces. Since heat is then released, the temperature of the wood rises, which is positive for the stress relaxation, at the same time as the dry wood surface is moistened and the moisture gradient is levelled.

[0029] By analogy with the conditions in the heating phase, the vapour generating capacity in the conditioning is dimensioned on the basis of the heating rate. It may be proved that the initial heating requires the highest capacity/kg of wood, and so it may be established that a vapour generating capacity of about 2 MW/150 m^3 of wood during the conditioning phase is sufficient to level out the moisture ratio and stresses of wood in 1-2 hours. During the conditioning phase, a final temperature of between 70°C and 98°C is imparted to the wood.

[0030] One embodiment of the inventive method is characterised in that the heating phase and/or the conditioning phase is controlled by the temperature increase which during the conditioning phase, can be measured by means of the ordinary temperature transducer of the drying chamber used, being followed and converted into medium moisture ratio increase of the wood. The connection between temperature increase and amount of condensate renders this possible. Since the heat transmission is efficient, the temperature of the wood will thus be close to the temperature recorded by the ordinary temperature transducer of the drier. By following this development of temperature, it is possible to convert the temperature increase into a medium moisture ratio increase of the wood, which permits an advantageous control of the conditioning process. Thus, the drier need not be equipped with special transducer systems for this purpose.

[0031] A preferred embodiment of the inventive method is characterised in that in a steam generator, high-quality vapour is generated and kept pressurised in an accumulator, and that the vapour from said accumulator is distributed to connected drying chambers by the actuating of valves.

[0032] According to another preferred embodiment of the inventive method, the primary energy for generating the used vapour is taken from the sawmill's own solid fuel central boiler plant. This means that sawmill refuse, mainly bark, can be utilised for production of high-quality vapour.

[0033] The hot water is conducted from the solid fuel central boiler plant to a central steam generator. In this steam generator, the hot water is conducted through tubes in a cylindrical tank, partly filled water. The heat is transferred to the water which is caused to boil, whereby a vapour volume is generated in the upper part of the cylinder. The system is kept pressurised, such that the vapour can be quickly discharged in the mains made of stainless steel, which serve to distribute the vapour to the connected drying chambers. The distribution of the vapour to each chanter is finally carried out by the actuating of valves.

[0034] The advantage of such an arrangement is that a central vapour generator can serve a plurality of chambers sequentially for both the heating phase and the conditioning phase. Moreover, the method implies that the change-over times will be short since vapour is supplied to the chamber as soon as the valve opens.

[0035] Vapour is supplied to the drying chamber in the saturated state or slightly superheated. If the vapour is supplied via a tube system, a certain superheating (and thus excess pressure) of the vapour will become necessary to produce the requisite pressure through the distribution system from the vapour generator. The excess pressure can be between 0 and 1 atm. gauge. However, the vapour is not allowed to be too superheated, since too much dry heat will then be supplied. Decisive of the invention is that the dew point of the vapour both during the heating phase and during the conditioning phase is above the dew point of the wood, thus ensuring condensation on the wood surfaces. In case of the vapour being generated directly in the drying chamber in an open vaporisation system, the vapour is supplied in the saturated state.

[0036] An embodiment of the invention will be described below, reference being made to the accompanying drawings in which:

Fig. 1 is a schematic vertical section of a chamber drier as seen from the side, and
Fig. 2 is a schematic horizontal section of the chamber drier as seen from above.

[0037] Fig. 1 illustrates a chamber drier 1 having a drying chamber 2 intended for drying of wood in batches, the wood being in the drying chamber in the form of one or more piles 3. The piles of wood are arranged on a carriage 4 or the like, and means (not shown) are available to move one or more piles 3 of wood into and out of the drying chamber 2 through the openable door 5. The drying chamber further contains means 6 (schematically shown) for circulating hot air in the drying chamber for carrying out all or at least one of the steps heating, drying and conditioning of the wood, and means (not shown) for supplying dry air and discharging moist air which is transported to and from the drying chamber through ducts 7, 8. The arrangement according to the invention is characterised in that the drying chamber further comprises means 9 for introducing and spreading of saturated water vapour at atmospheric pressure in the drying chamber, and that a vapour generator 10 is arranged to supply water vapour to these means through conduits 11.

[0038] The means 9 may consist of adjustable valves with nozzles and can be arranged in one or more positions in the drying chamber for introducing the water vapour directly into the free air volume of the drying chamber. Alternatively, they can be arranged to introduce the water vapour into the hot circulation air in connection with the circulating means 6. They can also be arranged to supply water vapour both directly to the drying chamber and to the circulating means.

[0039] Fig. 2 illustrates an embodiment having a plurality of drying chambers 2 a-f, provided with means 9 a-f for supplying vapour to the respective chamber.

The vapour generator 10 serves all drying chambers sequentially for both the heating phase and the conditioning phase. The vapour generator should be provided with an accumulator (not shown) for vapour and be designed to be kept pressurised to supply vapour, via the means 9 a-f, to the respective drying chamber. The means 9 a-f suitably consist of nozzles with valves which can be remote-controlled. Thanks to the vapour accumulator, it can be ensured that sufficient vapour capacity is available for each drying chamber both during the heating phase and during the conditioning phase.

[0040] The vapour generator 10 can be arranged to be supplied, preferably via a hot water conduit 12, with energy from a solid fuel central boiler plant, schematically shown as 13, which works by burning sawmill refuse, mainly bark.

Claims

1. A method for drying wood by circulating hot air around and through one or more piles of the wood, arranged in batches in one or more closed drying chambers in a chamber drier, the circulating hot air first being caused, in a heating phase, to heat the wood to the starting temperature for drying, subsequently in one or more drying phases accomplishing the actual drying, and finally, in a conditioning phase having a specially adapted air moisture content and air temperature other than during the drying, being caused to level, as completely as permitted by the method, the moisture ratio and stresses in the wood after drying, **characterised in** that during the heating phase, saturated water vapour is supplied at atmospheric pressure to the hot air circulating around the wood, in the drying chamber used for the heating phase, said water vapour is supplied at a vapour generating capacity of 6-28 kW/m^3, preferably 10-15 kW/m^3 batch volume of the wood so that the water vapour are condensed on the colder wood surfaces and thereby transfer condensation heat to the wood.

2. The method as claimed in claim 1, **characterised in** that water vapour is supplied to the drying chamber substantially immediately from the start of the heating phase.

3. The method as claimed in claim 1, **characterised in** that water vapour is supplied to the drying chamber substantially to the end of the heating phase.

4. The method as claimed in claim 1, **characterised in** that the supply of water vapour to the drying chamber during the heating phase occurs substantially continuously without interruption.

5. **The method as claimed in claims 1-4, characterised in** that the duration of the heating phase is between 1.5 and 2.5 hours.

6. **The method as claimed in claims 1-5, characterised in** that during the heating phase, the wood is given a final temperature of between 50°C and 65°C.

7. **The method as claimed in claims 1-6, characterised in** that during the conditioning phase, water vapour is supplied at atmospheric pressure to the hot air circulating around the wood, in the drying chamber used for the conditioning phase, and that this supply of vapour is begun immediately when starting the conditioning phase and substantially immediately after the end of the drying phase/s and that the water vapour supplied at atmospheric pressure during the conditioning phase is supplied at a vapour generating capacity of 6-28 kW/m^3, preferably 10-15 kW/m^3 batch volume of the wood.

8. **The method as claimed in claim 1 or 7, characterised in** that the same drying chambers are used for the heating phase, the drying phase/s and the conditioning phase.

9. **The method as claimed in claims 7-8, characterised in** that the duration of the conditioning phase is between 1 and 2 hours.

10. **The method as claimed in claims 7-9, characterised in** that during the conditioning phase, the wood is given a final temperature of between 70°C and 98°C.

11. **The method as claimed in claim 1 or 7, characterised in** that the heating phase and/or the conditioning phase are controlled by the temperature increase, which can be measured by the ordinary temperature transducer of the used drying chamber, being followed and converted into medium moisture ratio increase of the wood.

12. **The method as claimed in claim 1 or 7, characterised in** that in a vapour generator, high-quality vapour is generated and kept pressurised in an accumulator, and that the vapour from the accumulator is distributed to the connected drying chambers by the actuating of valves.

13. The method as claimed in claim 12, **characterised in** that the primary energy for generating the used vapour in the vapour generator is taken from the sawmill's own solid fuel central boiler plant from the sawmill refuse, mainly bark.

14. The method as claimed in claim 13, **characterised in** that a central vapour generator serves a plurality

of drying chambers sequentially for both the heating phase and the conditioning phase.

15. The method as claimed in claim 1, **characterised in** that the wood during the drying phase/s, between the heating phase and the conditioning phase, is given a temperature of between 50°C and 90°C, and that the drying phase has a duration of between 2 and 14 days.

16. The method as claimed in the preceding claims, **characterised in** that the vapour is supplied at an excess pressure between 0 and 1.0 atm. gauge.

17. An arrangement for carrying out the method as claimed in claim 1, comprising a chamber drier (1) having at least one drying chamber (2) and intended for drying of wood in batches, means for moving one or more piles (3) of the wood into and out of the drying chamber (2), means (6) for circulating hot air in the drying chamber for carrying out all or at least one of the steps heating, drying and conditioning of the wood, and means for conditioning the hot circulation air and transporting it to and from the drying chamber, **characterised in** that said drying chamber (2) further comprises means (9) for introducing and spreading of saturated water vapour at atmospheric pressure in the drying chamber (2), and that a vapour generator (10) is arranged to supply water vapour to said means (9).

18. The arrangement as claimed in claim 17**, characterised in** that said means (9) for introducing and spreading water vapour are arranged in one or more positions in the drying chamber (2) for introducing the water vapour directly into the free air volume of the drying chamber.

19. The arrangement as claimed in claim 17, **characterised in** that said means (9) for introducing and spreading water vapour are arranged to introduce the water vapour in connection with the means (6) for circulating the hot air.

20. The arrangement as claimed in claim 17, **characterised in** that said vapour generator (10) is provided with an accumulator for vapour and adapted to be kept pressurised, and via conduits (11) and means (9 a-f) to supply vapour to the respective drying chamber (2 a-f).

21. The arrangement as claimed in claim 17, **characterised in** that the vapour generator (10) is arranged to be supplied, preferably via a hot water conduit (12), with energy from a solid fuel central boiler plant (13) adapted to work by burning sawmill refuse, mainly bark.

22. The arrangement as claimed in claim 21, **characterised in** that the vapour generator (10) is adapted to serve a plurality of drying chambers (2 a-f) sequentially for both the heating phase and the conditioning phase.

23. The arrangement as claimed in claims 17-22, **characterised in** that said means (9, 9 a-f) consist of valve means provided with nozzles.

Patentansprüche

1. Verfahren zum Trocknen von Holz durch Zirkulieren von Heißluft um und durch ein oder mehrere Holzstapel, die in Chargen in einer oder mehreren geschlossenen Kammern in einem Kammertrockner angeordnet sind, wobei die zirkulierende Heißluft zuerst in einer Erwärmungsphase das Holz auf die Starttemperatur zum Trocknen erwärmt, daraufhin in einer oder mehreren Trocknungsphasen die tatsächliche Trocknung bewerkstelligt und schließlich in einer Befeuchtungsphase mit speziell angepasstem Luftfeuchtigkeitsgehalt und Lufttemperatur, die anderst sind als während des Trocknens, soweit wie es durch das Verfahren erlaubt ist, das Feuchtigkeitsverhältnis und die Spannungen im Holz nach dem Trocknen ausgleicht, **dadurch gekennzeichnet, dass** während der Erwärmungsphase gesättigter Wasserdampf bei atmosphärischen Druck in die für die Erwärmungsphase verwendete Trocknungskammer zu der um das Holz zirkulierenden Heißluft eingespeist wird, wobei der Wasserdampf bei einer Dampferzeugungskapazität von 6-28 kW/m^3, vorzugsweise 10-15 kW/m^3 Chargenvolumen des Holzes eingespeist wird, so dass der Wasserdampf an den kälteren Holzflächen kondensiert und hierdurch die Kondensationswärme auf das Holz übertragen wird.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** Wasserdampf im Wesentlichen unmittelbar vom Beginn der Erwärmungsphase an in die Trocknungskammer eingespeist wird.

3. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** Wasserdampf im Wesentlichen zum Ende der Erwärmungsphase in die Trocknungskammer eingespeist wird.

4. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** die Wasserdampfeinspeisung in die Trocknungskammer während der Erwärmungsphase im Wesentlichen kontinuierlich, ohne Unterbrechung erfolgt.

5. Verfahren nach einem der Ansprüche 1 - 4, **dadurch gekennzeichnet, dass** die Dauer der

Erwärmungsphase zwischen 1,5 und 2,5 Stunden beträgt.

6. Verfahren nach einem der Ansprüche 1 - 5, **dadurch gekennzeichnet, dass** dem Holz während der Erwärmungsphase eine Endtemperatur zwischen 50°C und 65°C verliehen wird.

7. Verfahren nach einem der Ansprüche 1 - 6, **dadurch gekennzeichnet, dass** während der Befeuchtungsphase Wasserdampf bei atmosphärischen Druck zu der um das Holz zirkulierenden Heißluft in die für die Befeuchtungsphase verwendete Trocknungskammer eingespeist wird, und dass diese Dampfeinspeisung unmittelbar zu Beginn der Befeuchtungsphase beginnt und im Wesentlichen unmittelbar nach dem Ende der Trocknungsphase bzw. der Trocknungsphasen, und dass der während der Befeuchtungsphase bei atmosphärischen Druck eingespeiste Wasserdampf bei einer Dampferzeugungskapazität von 6 - 28 kW/m^3, vorzugsweise 10 - 15 kW/m^3 Stapelvolumen des Holzes zugeführt wird.

8. Verfahren nach Anspruch 1 oder 7**, dadurch gekennzeichnet, dass** die gleichen Trocknungskammern für die Erwärmungsphase, die Trocknungsphase oder Trocknungsphasen und die Befeuchtungsphase verwendet werden.

9. Verfahren nach einem der Ansprüche 7 - 8, **dadurch gekennzeichnet, dass** die Dauer der Befeuchtungsphase zwischen 1 und 2 Stunden beträgt.

10. Verfahren nach einem der Ansprüche 7 - 9, **dadurch gekennzeichnet, dass** während der Befeuchtungsphase dem Holz eine Endtemperatur zwischen 70°C und 98°C verliehen wird.

11. Verfahren nach Anspruch 1 oder 7, **dadurch gekennzeichnet, dass** die Erwärmungsphase und/oder die Befeuchtungsphase durch die Temperaturzunahme gesteuert werden, die durch den herkömmlichen Temperaturaufnehmer der verwendeten Trocknungskammer gemessen werden kann, wobei dann eine Konvertierung in eine mittlere Feuchtigkeitsverhältniszunahme des Holzes erfolgt.

12. Verfahren nach Anspruch 1 oder 7, **dadurch gekennzeichnet, dass** in einem Dampferzeuger hochqualitativer Dampf erzeugt und unter Druck in einem Sammler gehalten wird und dass der Dampf von dem Sammler zu den hiermit verbundenen Trocknungskammern durch die Betätigung von Ventilen verteilt wird.

13. Verfahren nach Anspruch 12, **dadurch gekennzeichnet, dass** die Primärenergie zur Erzeugung des verwendeten Dampfes in dem Dampferzeuger von der Sägemühle eigenen Festkraftstoff-Zentralboileranlage aus den Sägemühlenabfällen, hauptsächlich Rinde, entnommen wird.

14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** ein Zentraldampferzeuger mehrere Trocknungskammern nacheinander sowohl für die Erwärmungsphase wie auch die Befeuchtungsphase versorgt.

15. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** dem Holz während der zwischen der Erwärmungsphase und der Befeuchtungsphase liegenden Trocknungsphase bzw. den Trocknungsphasen eine Temperatur zwischen 50°C und 90°C verliehen wird, und dass die Trocknungsphase eine Dauer zwischen 2 und 14 Tagen hat.

16. Verfahren nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Dampf mit einem Überdruck zwischen 0 und 1 atm eingespeist wird.

17. Anlage zur Ausführung des Verfahrens nach Anspruch 1, mit einem Kammertrockner (1), der wenigstens eine Trocknungskammer (2) hat und zum Trocknen von Holzchargen bestimmt ist, einer Einrichtung zum Herein- und Herausbewegen eines oder mehrerer Holzstapel (3) in und aus der Trocknungskammer (2), eine Einrichtung (6) zum Zirkulieren von Heißluft in der Trocknungskammer, um alle oder wenigstens einen der Schritte Erwärmen, Trocknen und Befeuchten des Holzes auszuführen, und eine Einrichtung zum Befeuchten der heißen Zirkulationsluft und zum Ein- und Ausbringen dieser heißen Zirkulationsluft in und aus der Trocknungskammer, **dadurch gekennzeichnet, dass** diese Trocknungskammer (2) ferner Einrichtungen (9) zum Einbringen und Verteilen von gesättigtem Wasserdampf bei atmosphärischen Druck in die Trocknungskammer (2) umfasst, und dass ein Dampfgenerator (10) zum Zuführen von Wasserdampf zu der Einrichtung (9) vorhanden ist.

18. Anlage nach Anspruch 17, **dadurch gekennzeichnet, dass** diese Einrichtungen (9) zum Einbringen und Verteilen von Wasserdampf an einer oder mehreren Stellen in der Trocknungskammer (2) angeordnet sind, um den Wasserdampf direkt in das freie Luftvolumen der Trocknungskammer einzubringen.

19. Anordnung nach Anspruch 17, **dadurch gekennzeichnet, dass** diese Einrichtungen (9) zum Einbringen und Verteilen von Wasserdampf so

angeordnet sind, dass der Wasserdampf mit der Einrichtung (6) zum Zirkulieren der Heißluft eingebracht wird.

20. Anordnung nach Anspruch 17, **dadurch gekennzeichnet, dass** der Dampferzeuger (10) mit einem Sammler für Dampf ausgestattet ist und dazu bestimmt ist, diesen unter Druck zu halten und über Leitungen (11) und Einrichtungen (9a - f) Dampf zu den jeweiligen Trocknungskammer (2a - f) zuzuführen.

21. Anlage nach Anspruch 17, **dadurch gekennzeichnet, dass** der Dampferzeuger (10), vorzugsweise über eine Heißwasserleitung (12), mit Energie aus einer Feststoff-Zentralboileranlage (13) versorgt wird, die durch brennenden Sägemühlenabfall, hauptsächlich Rinde, betreibbar ist.

22. Anlage nach Anspruch 21, **dadurch gekennzeichnet, dass** der Dampferzeuger (10) dazu bestimmt ist, mehrere Trocknungskammern (2a - f) nacheinander sowohl für die Erwärmungsphase als auch für die Befeuchtungsphase zu versorgen.

23. Anlage nach einem der Ansprüche 17 - 22, **dadurch gekennzeichnet, dass** die Einrichtungen (9, 9a - f) aus Ventilen bestehen, die mit Düsen ausgestattet sind.

Revendications

1. Procédé pour sécher du bois en faisant circuler de l'air chaud autour de et à travers une ou plusieurs piles du bois, arrangées en lots dans une ou plusieurs chambres de séchage fermées d'un séchoir à chambres, l'air chaud en circulation étant tout d'abord amené, dans une phase de chauffage, à chauffer le bois jusqu'à une température de démarrage pour le séchage, puis, exécutant le séchage réel dans une ou plusieurs phases de séchage et étant finalement amené, dans une phase de conditionnement comportant une teneur en humidité de l'air et une température d'air spécialement adaptées, autres que pendant le séchage, à uniformiser, aussi complètement que cela est permis par le procédé, le taux d'humidité et les tensions régnant dans le bois après le séchage, caractérisé en ce que, pendant la phase de chauffage, de la vapeur d'eau saturée est fournie à la pression atmosphérique à l'air chaud qui circule autour du bois, dans la chambre de séchage utilisée pour la phase de chauffage, ladite vapeur d'eau est fournie à une capacité de production de vapeur de 6 à 28 kW/m^3, de préférence de 10 à 15 kW/m^3 du volume de lot du bois, de manière que la vapeur d'eau se condense sur les surfaces de bois plus froides et transmette ainsi de la chaleur de condensation au bois.

2. Procédé selon la revendication 1, caractérisé en ce que de la vapeur d'eau est fournie à la chambre de séchage sensiblement immédiatement à partir du démarrage de la phase de chauffage.

3. Procédé selon la revendication 1, caractérisé en ce que de la vapeur d'eau est fournie à la chambre de séchage sensiblement jusqu'à la fin de la phase de chauffage.

4. Procédé selon la revendication 1, caractérisé en ce que la fourniture de vapeur d'eau à la chambre de séchage pendant la phase de chauffage se produit de façon sensiblement continue sans interruption.

5. Procédé selon les revendications 1 à 4, caractérisé en ce que la durée de la phase de chauffage est comprise entre 1,5 et 2,5 heures.

6. Procédé selon les revendications 1 à 5, caractérisé en ce que, pendant la phase de chauffage, on fait prendre au bois une température finale comprise entre 50°C et 65°C.

7. Procédé selon les revendications 1 à 6, caractérisé en ce que, pendant la phase de conditionnement, de la vapeur d'eau est fournie à la pression atmosphérique à l'air chaud circulant autour du bois, dans la chambre de séchage utilisée pour la phase de conditionnement, et en ce que cette fourniture de vapeur est commencée immédiatement au démarrage de la phase de conditionnement, et sensiblement immédiatement après la fin de la ou des phase(s) de séchage, et en ce que la vapeur d'eau fournie à la pression atmosphérique pendant la phase de conditionnement est fournie à une capacité de production de vapeur de 6 à 28 kW/m^3, de préférence de 10 à 15 kW/m^3 de volume de lot du bois.

8. Procédé selon la revendication 1 ou 7, caractérisé en ce que les mêmes chambres de séchage sont utilisées pour la phase de chauffage, la ou les phase(s) de séchage et la phase de conditionnement.

9. Procédé selon les revendications 7 et 8, caractérisé en ce que la durée de la phase de conditionnement est comprise entre 1 et 2 heures.

10. Procédé selon les revendications 7 à 9, caractérisé en ce que, pendant la phase de conditionnement, on fait prendre au bois une température finale comprise entre 70°C et 98°C.

11. Procédé selon la revendication 1 ou 7, caractérisé en ce que la phase de chauffage et/ou la phase de conditionnement sont commandées par l'augmentation de température, qui peut être mesurée par le transducteur de température ordinaire de la chambre de séchage utilisée, et qui est accompagnée d'une augmentation du taux d'humidité moyen du bois et convertie en cette augmentation.

12. Procédé selon la revendication 1 ou 7, caractérisé en ce que, dans un générateur de vapeur, de la vapeur de haute qualité est produite et maintenue sous pression dans un accumulateur et en ce que la vapeur issue de l'accumulateur est distribuée dans les chambres de séchage raccordées en manoeuvrant des vannes.

13. Procédé selon la revendication 12, caractérisé en ce que l'énergie primaire pour produire la vapeur utilisée dans le générateur de vapeur est prise sur une installation à chaudière centrale à combustible solide appartenant à la scierie, à partir de déchets de scierie, principalement d'écorce.

14. Procédé selon la revendication 13, caractérisé en ce qu'un générateur de vapeur central dessert une pluralité de chambres de séchage en séquence pour les deux phases, de chauffage et de conditionnement.

15. Procédé selon la revendication 1, caractérisé en ce que, pendant la ou les phase(s) de séchage, entre la phase de chauffage et la phase de conditionnement, on fait prendre au bois une température comprise entre 50°C et 90°C, et en ce que la phase de séchage a une durée comprise entre 2 et 14 jours.

16. Procédé selon les revendications précédentes, caractérisé en ce que la vapeur est fournie à une surpression comprise entre 0 et 1,0 atm de pression relative.

17. Installation pour la mise en oeuvre du procédé selon la revendication 1, comprenant un séchoir à chambre(s) (1) comprenant au moins une chambre de séchage (2) et destiné à sécher du bois en lots, des moyens destinés à introduire une ou plusieurs piles (3) du bois dans la chambre de séchage (2) et à l'en ou les en extraire, des moyens (6) destinés à faire circuler de l'air chaud dans la chambre de séchage pour l'exécution de toutes ou d'au moins une des phases de chauffage, séchage et conditionnement du bois, et des moyens destinés à conditionner l'air en circulation chaud et à le transporter à la chambre de séchage et l'en extraire, caractérisée en ce que ladite chambre de séchage (2) comprend en outre des moyens (9) destinés à introduire et à répandre de la vapeur d'eau saturée à la pression atmosphérique dans la chambre de séchage (2), et en ce qu'un générateur de vapeur (10) est agencé pour fournir de la vapeur d'eau auxdits moyens (9).

18. Installation selon la revendication 17, caractérisée en ce que lesdits moyens (9) destinés à introduire et à répandre de la vapeur d'eau sont agencés dans une ou plusieurs positions dans la chambre de séchage (2) afin d'introduire directement la vapeur d'eau dans le volume d'air libre de la chambre de séchage.

19. Installation selon la revendication 17, caractérisée en ce que lesdits moyens (9) destinés à introduire et à répandre de la vapeur d'eau sont agencés pour introduire la vapeur d'eau en liaison avec les moyens (6) destinés à faire circuler l'air chaud.

20. Installation selon la revendication 17, caractérisée en ce que ledit générateur de vapeur (10) est équipé d'un accumulateur pour la vapeur et est adapté pour être maintenu sous pression, et, pour fournir de la vapeur, par l'intermédiaire de conduits (11) et de moyens (9a-f), à la chambre de séchage respective (2a-f)

21. Installation selon la revendication 17, caractérisée en ce que le générateur de vapeur (10) est agencé pour être alimenté en énergie, de préférence par l'intermédiaire d'un conduit d'eau chaude (12), à partir d'une installation de chaudière centrale à combustible solide (13) adaptée pour travailler en brûlant des déchets de scierie, principalement de l'écorce.

22. Installation selon la revendication 21, caractérisée en ce que le générateur de vapeur (10) est adapté pour desservir une pluralité de chambres de séchage (2a-f) en séquence, pour les deux phases, de chauffage et de conditionnement.

23. Installation selon les revendications 17 à 22, caractérisée en ce que lesdits moyens (9, 9a-f) sont constitués par des moyens formant vannes équipés de buses.

Fig. 1

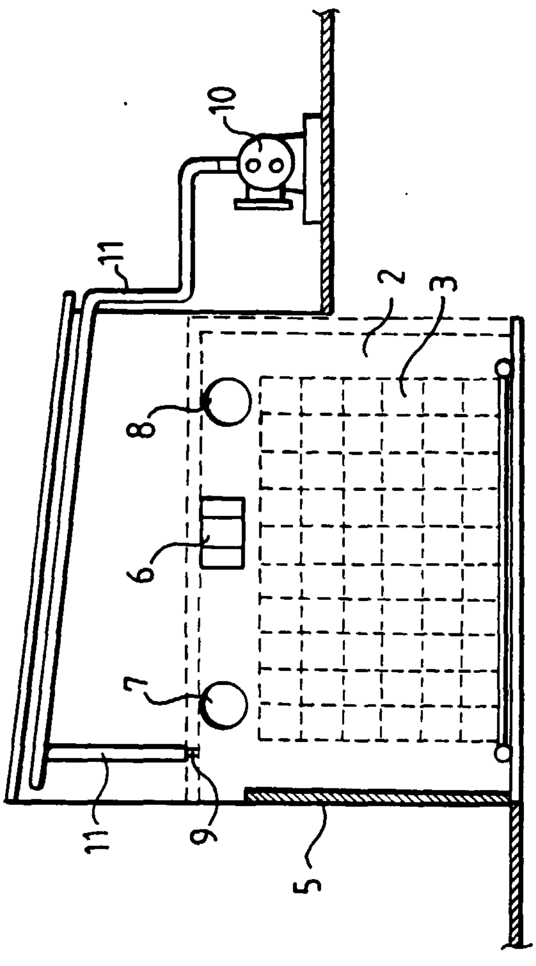

Fig. 2