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(54) **Drying apparatus**

(57) The present invention relates to a drying apparatus (1) for drying timber (13) formed of both round and sawn timber. The drying apparatus comprises, as in the prior art, a drying chamber for receiving the timber to be dried, circulation means (16, 17) for guiding heated drying air in the drying chamber and members (30) for leading water vapour (29) into the drying chamber. A longitudinal drying chamber is provided with a partition wall (10) dividing the chamber in its longitudinal direction into

two separate drying spaces (11, 12) in which the drying is arranged to take place by the circulation of drying air through both the spaces. To heat the drying air, the apparatus is provided with heat exchangers (18, 19) which are arranged into flow spaces (20, 21) connected to the drying spaces. The heated drying air circulates in longitudinal gaps (14, 15) in the timber load by impact of a pressure difference produced at the opposite ends of the timber load by means of the circulation means.

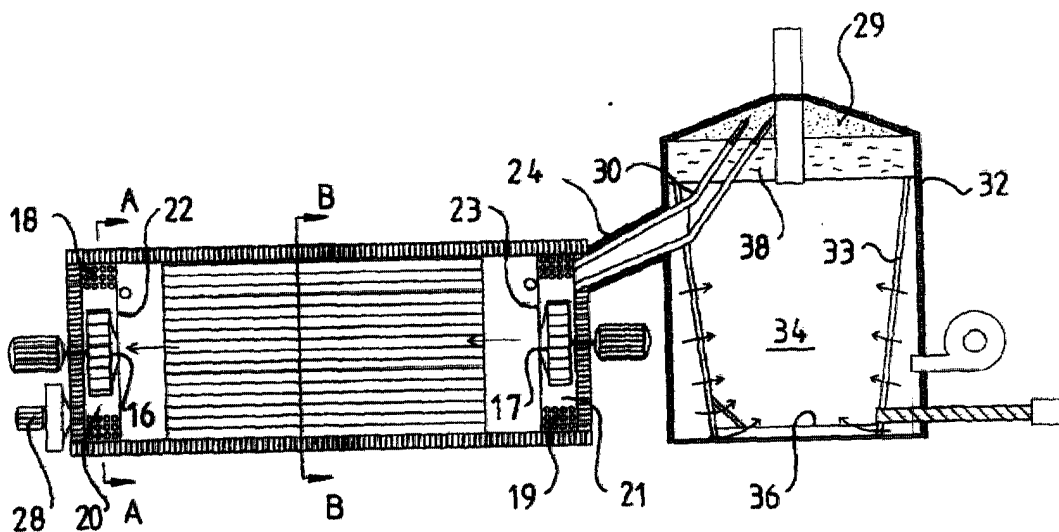


FIG. 2

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a drying apparatus for drying wood according to the preamble of claim 1.

BACKGROUND OF THE INVENTION

[0002] Prior art knows diverse apparatuses and facilities for drying wood. For example, wood is dried in drying chambers moistened with water vapour where moisture is made to evaporate from the wood to be dried, also known as the load, by subjecting it to heated air, to microwave radiation, or by decreasing air pressure in the drying chamber.

[0003] However, there are major drawbacks of the prior art. The prior art solutions require the wood to be re-stacked before the drying. To ensure sufficient evaporation of moisture in these drying methods, horizontal battening is arranged in between the timber. The stacking of wood prior to the drying is most laborious and thereby the drying process is expensive and time-consuming.

[0004] Wood is usually inserted into the drying chamber in truck bundles from an openable side wall, or loaded in separate trolleys or on loading pallets and guided into the drying chamber from either end of the chamber. The latter solution, for example, requires specific mechanical rail or guide arrangements to be used which disadvantageously increase the total cost of the drying apparatus.

BRIEF DESCRIPTION OF THE INVENTION

[0005] It is an object of the present invention to reduce problems caused by the drawbacks of the prior art and to provide a completely novel solution which essentially facilitates and, at the same time, speeds up the drying of wood.

[0006] This object is achieved with a drying apparatus according to the present invention provided with the characteristics defined in the claims. More specifically, the apparatus of the invention is primarily characterized by what is stated in the characterizing part of claim 1.

[0007] The invention is based on the idea that by increasing the temperature of the water contained in the load placed into the drying chamber to over hundred degrees, the water is made to evaporate and a significant, even thousandfold, change in volume takes place. The water vapour the volume of which is thus considerably expanded exits the wood in a pressurized form, improving at the same time the resilience of the wood. The timber dried in the drying apparatus also withstands cracking better.

[0008] The preferred embodiments of the invention are disclosed in the dependent claims.

[0009] The invention provides significant advantages. By allowing drying air of sufficiently strong flow and high pressure to be provided in the flow spaces, it makes the heating of the drying air significantly more effective. Due to this, the apparatus of the invention allows the drying time to be significantly reduced compared with conventional drying. The efficiently heated drying air allows the drying temperature in the drying chambers to be increased to a sufficiently high level, whereby drying times of even only about a fifth of conventional drying times are achieved, also when the drying is carried out in a low-pressure drying apparatus. Nevertheless, the apparatus produces wood of a highly uniform quality.

[0010] Since the timber arranged into the drying chamber of the drying apparatus is oriented to its longitudinal direction and the drying air is arranged to circulate through the longitudinal gaps formed within the timber material, the timber can be arranged into the drying chambers of the drying apparatus of the invention through a hatch on the top of the apparatus. The filling of the drying apparatus is therefore particularly quick and easy, because it can be carried out from the top, without any horizontal battening being needed to improve the drying.

[0011] The apparatus of the invention is simple in structure and reliable to operate, whereby it is economical to build and to use as well. Its structure also allows most diverse sources of heating to be used for heating the drying air.

[0012] In a preferred embodiment of the invention there are heat exchangers which comprise tube-like means arranged into the flow space of the drying apparatus for circulating flue gas led from a heating facility, the means allowing economical, solid fuel to be used for heating the drying air. At its simplest, the air is circulated between the heat exchanger tubes using centrifugal rotors as circulating means to provide rapid heating of the drying air. Said centrifugal rotors being arranged into flow spaces facing each other such that they are connected to the adjacent drying chambers of the drying apparatus, a pressure difference needed for the rapid circulation of the drying air within the timber material can be easily obtained in connection with the flow spaces facing each other.

[0013] By enabling the direction of flow of the drying air provided in the drying space by means of the circulating means to be reversed allows the drying spaces to be heated more evenly at their entire length. This ensures the uniform quality of the end product in the heat treatment of wood, for example.

[0014] By guiding the vapour to be led into the drying chamber to the immediate vicinity of the flow chambers in the manner provided by the invention, ensures that the vapour is evenly distributed into the entire drying chamber and thereby the drying is as uniform as possible and cracking is avoided.

[0015] The drying apparatus of the invention preferably utilizes economical, solid fuel in the combustion fur-

nance of the heating facility. The drying can thus be carried out using waste wood, for example, or some other low-cost fuel. Moreover, a water cushion bordering on the combustion space in the combustion furnace allows the vapour needed in the drying to be most advantageously produced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] In the following the invention will be described with reference to the accompanying drawing which schematically illustrates a preferred embodiment of the invention and in which

Figure 1 is a cross-sectional top view of a drying apparatus of the invention and an associated heating facility;

Figure 2 is a cross-sectional elevation view of the drying apparatus and heating facility of Figure 1;

Figure 3 is a cross-sectional view along line A-A B of Figure 1 where the hatch on the top of the apparatus is closed; and

Figure 4 is a cross-sectional view along line B-B of Figure 1, where the hatch on the top of the apparatus is partly open.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] A preferred embodiment of the invention is described below with reference to the above Figures. The drying apparatus described comprises structural parts marked with reference numerals in the drawings, the numerals corresponding to those used in this specification.

[0018] The preferred embodiment of the drying apparatus 1 and a heating facility 2 shown in the Figures thus comprises two separate parts. Of these, the drying apparatus comprises a structure which is preferably in the form of a rectangular prism comprising a bottom 3, side walls 4 and 5 and end walls 6 and 7 as well as an openable hatch 9 mainly serving as a cover 8 of the apparatus in the position of use shown in the Figures. These elements enclose a drying chamber comprising at least two separate drying spaces 11 and 12 separated by a partition walls 10. Timber 13 can thus be lowered into the drying chamber from the top in bundles, the timber being arranged into the drying spaces of the drying chamber substantially parallel with the longitudinal axis of the chamber from one end wall to another. In the Figures the drying spaces are filled both with round timber and sawn timber, and, as shown in the Figures, with no horizontal battening arranged between the horizontal layers of timber to improve the drying.

[0019] When the timber material 13 is being dried, hot air is circulated within it in a manner known per se. However, unlike in the prior art solutions, in the present drying apparatus the circulating takes place in the longitudinal direction of the timber, more specifically in gaps 14

forming between individual round timber items arranged next to each other when the drying chamber is filled, or in gaps 15 formed by the vertical spaces between sawn timber bundles. In the embodiment of the present drying apparatus, the circulation of air in the drying chamber is arranged using circulating means 16 and 17 included in the apparatus by providing a pressure difference between the different ends of the timber, the magnitude of the pressure difference determining the flow rate of the drying air.

[0020] The direction of flow provided by the circulating means can be reversed easily, either with guiding plates provided in the drying chamber or even by changing the circulating means from being connected to one drying space to be connected to the other.

[0021] The hot air circulating in the drying chamber is in turn generated using for example heat exchangers 18 and 19 arranged at both ends of the drying apparatus. The heat exchangers are arranged in separate flow spaces 20 and 21 connected to the drying chambers in the apparatus. In the preferred embodiment of the apparatus shown in the Figures, the flow spaces are arranged at ends 6 and 7 of the drying chamber where partition walls 22 and 23 separate them from the drying spaces. Through flow openings in the partition walls, the flow spaces are connected to both drying spaces at the same time to circulate hot air in both drying spaces. Each drying space is provided with at least one circulating means 16 or 17 which is arranged to provide both a turbulent air flow and the pressure difference between the flow openings in the flow space. The strongly flowing air is thereby efficiently heated as it flows between the preferably tube-like heat exchanger elements 18 and 19. In addition to the strong turbulence, the circulating means thus causes an excess pressure at one of the flow openings of the flow space, the excess pressure forcing the heated air from the flow opening into the drying space where it continues, still by the impact of pressure, between the timber material in the flow space towards the flow opening of the flow space at the other end of the drying apparatus, assisted by the negative pressure prevailing at its vicinity. In the second flow space the air is heated again and its pressure increased, whereby the air moves into the second, adjacent flow space and flows between the timber material in the space back to the first flow space. This circulating of the drying air continues until the desired moisture content of the timber is obtained.

[0022] The circulating means 16 and 17 of the described drying apparatus 1 are preferably implemented using centrifugal propellers. The heat exchanger 18 or 19 is arranged around a conventional centrifugal propeller known per se to replace a propeller frame, the drying air being forced to circulate between the heat exchanger elements to heat the air. The heat exchanger in question comprises for example electric resistors or a set of tubes, as in the present embodiment, for supplying a hot medium into the flow space. In the embodiment shown

in the Figures, flue gas is led into the heat exchangers from the heating facility 2 arranged in connection with the drying apparatus. For this purpose, there is a duct 24 connecting the heating facility to a supply opening 25 at the other end wall 6, the flue gases being led from the opening to flue gas conduits 26 and 27 arranged on the other side wall 5 of the drying apparatus, the conduits being preferably arranged to run substantially longitudinally along to the top and bottom edges of the side walls of the drying apparatus. The flue gas conduits are preferably connected to each other through the heat exchanger tubes. On the end wall 7 of the drying apparatus, opposite to the supply opening and preferably on the lower part of the apparatus, there is a suction device 28. The purpose of the suction device is to produce the circulation of flue gases needed in the flue gas conduits and heat exchangers.

[0023] The heating facility 2 of the preferred embodiment disclosed is also used to employ waste heat to produce water vapour 29 which is led to the duct 24 between the heating facility and the drying apparatus 1 and further to an upper flue gas conduit 26 for superheating. The water vapour is led into the drying spaces 11 or 12 in at least one steam pipe 30 arranged in the duct and the flue gas conduit, the steam pipes being arranged to supply the superheated water vapour into the air flow prevailing in the drying spaces as the air flows from the flow space 20 or 21 into the drying space.

[0024] In the preferred embodiment of the Figures, the heating facility 2 comprises a combustion furnace 31 utilizing solid fuel, such as waste wood. The combustion furnace in question comprises an outer housing 32 and, inside the housing, a combustion space 34 enclosed by fire walls 33. Combustion air is arranged to be led through the fire walls by means of a blower 35 arranged on the outer housing of the combustion space. A prior art arrangement known per se, such as a screw compressor 37, is then used to supply wood cuttings and waste wood, for example, to the bottom 36 of the combustion space for burning. The purpose of the described combustion furnace is to produce hot flue gases as efficiently as possible for use in the drying apparatus 1. To improve the durability of the combustion furnace, a water cushion cover 38 is provided on its upper part which serves at the same for producing the water vapour 29 to be led into the drying apparatus. In the apparatus of the preferred embodiment, the duct 24 used for leading the flue gases into the drying apparatus comprises an inner lining consisting of a tube 30 with a double envelope. The water vapour generated in the water cushion is then led between the tube envelopes into the drying facility, whereby the steam is superheated as it travels in the duct, protecting at the same time the duct structures from excessive heating.

[0025] The drying apparatus in question functions as follows. The drying chamber divided into two drying spaces 11 and 12 with the partition wall 10 is filled with timber 13 through the hatch 9 on the top surface of the

apparatus. Since the timber is dried in its longitudinal direction, no horizontal battening needs to be arranged between the timber material, but the timber is dried by air flowing through longitudinal gaps 14 or 15 appearing in the stacked timber or made there, the flow being particularly efficient when round timber is being dried. The air is made to circulate in the longitudinal direction of the timber, i.e. horizontally, in the drying spaces by means of the centrifugal rotors 16 and 17 arranged at the end walls 6 and 7 of the drying chamber. The partition walls 22 and 23 separate the rotors from the drying spaces but there is a connection between them through separate flow openings.

[0026] When the combustion furnace of the heating facility 2 is being heated, the suction device 28 arranged in the drying apparatus 1 leads the flue gas generated through the duct 24 into the upper flue gas conduit 26 at the side wall 5 of the drying apparatus. The flue gases then continue into the heat exchanger tubes 18 and 19 at the end walls and thereby heat the air in the flow space 20 and 21. To provide more efficient heat exchange and air circulation, both flow spaces are provided with the centrifugal rotor 16 or 17 which causes a strong turbulent and pressurized mass of air. This vibrantly moving mass of air hits the heat exchange tubes whereby it is effectively heated. Forced by the centrifugal rotor, the pressurized heated air is arranged to flow through the flow opening into the drying space and between the timber material therein, whereby it increases the temperature in the space rapidly and strongly. Since both ends of the drying apparatus are provided with centrifugal rotors, they are arranged at opposite ends of adjacent drying spaces. The air sucked by the centrifugal rotor 16 from the first drying space 11 is heated and pressurized whereby it moves through the flow opening at the end of the second drying space 12 into the drying space under excessive pressure. The opposite end of this drying space is in turn provided with the second centrifugal rotor 17 which causes a negative pressure at the other end of the timber 13 to be dried in the drying space, which in turn produces a strong circulation of heated air between the timber material, the air being arranged to make the moisture in the timber to evaporate. The heated air then moves through the centrifugal rotor 17 and the flow space 21 surrounding it at the end of the drying space back to the end of the first drying space 11 whereby it is again heated and under excessive pressure. This circulation of air continues in the apparatus at a rate of about one round in two seconds. At the same time, superheated water vapour 29 is led into the drying spaces of the drying apparatus in the steam ducts 30 from the water cushion cover 38 of the combustion furnace 31. These steam ducts terminate substantially at the flow openings at the excessive pressure side of the drying spaces whereby the water vapour is efficiently distributed into the drying spaces which increases the resilience of wood and speeds up the transfer of heat from the heat exchangers into the drying air and from the drying air

into the timber.

[0027] The suction device 28 arranged in connection with the flue gas conduits prevents the flue gases from entering the drying chamber and having any impact on the properties of the wood.

[0028] It is to be understood that the above specification and the related figures are only intended to illustrate an embodiment of the present drying apparatus. Consequently, the structure of the drying apparatus is not restricted to the embodiment described above or defined in the claims, but a person skilled in the art will find it apparent that many variations and modification can be made within the inventive idea disclosed in the appended claims.

[0029] The apparatus of the invention is therefore most efficiently utilized not only for the drying but also for the heat treatment of wood.

Claims

1. A drying apparatus (1) for drying timber (13), the drying apparatus comprising a drying chamber for receiving the timber to be dried, circulation means (16, 17) for guiding heated drying air in the drying chamber and members (30) for leading water vapour (29) into the drying chamber, **characterized in that**

the drying chamber comprises a preferably rectangular space, the top surface (8) of the chamber being provided with a hatch (9) that can be opened for use, the space comprising side walls (4, 5), end walls (6, 7) and a bottom (3); the drying chamber being provided with a partition wall (10) dividing the chamber in its longitudinal direction into two separate drying spaces (11, 12) in which the drying is arranged to take place by circulating the same drying air in such a way that

the drying air is arranged to be heated by heat exchangers (18, 19) arranged in flow spaces (20, 21) provided in the drying apparatus (1) and connected to the drying spaces (11, 12), the drying air being arranged to circulate in the drying spaces by impact of pressure difference produced at the opposite ends of the timber load by means of the circulation means, for which purpose

the timber arranged into the drying space (11, 12) is oriented to the longitudinal direction thereof and the drying air is arranged to circulate through longitudinal gaps (14, 15) formed between the timber material.

2. A drying apparatus (1) according to claim 1, **characterized in that** the flow spaces (20, 21) are arranged at the opposite ends of the drying chamber.

3. A drying apparatus of claim 1 or 2, **characterized in that** the heat exchangers (18, 19) comprise tube-like means arranged in the flow space (20, 21) and circulating flue gases lead from a heating facility (2).

4. A drying apparatus (1) according to any one of the preceding claims, **characterized in that** there are at least two circulating means (16, 17) and they comprise centrifugal rotors, the heat exchangers (18, 19) being arranged to surround the rotors.

5. A drying apparatus (1) according to claim 4, **characterized in that** the circulation means (16, 17) are arranged into flow spaces (20, 21) facing each other such that they are directly connected to the adjacent drying spaces (11, 12).

6. A drying apparatus (1) according to claim 5, **characterized in that** the circulation means (16, 17) are arranged to produce a negative pressure at the drying space (11, 12) end to which it is directly connected and an excessive pressure to the adjacent drying space (11, 12) end to which it is indirectly connected.

7. A drying apparatus (1) according to any one of the preceding claims, **characterized in that** the direction of flow produced in the drying space (11, 12) by the circulation means can be reversed.

8. A drying apparatus (1) according to any one of the preceding claims, **characterized in that** the members (30) for leading the water vapour (29) are arranged in the immediate vicinity of the flow spaces (20, 21).

9. A drying apparatus (1) according to claim 3, **characterized in that** the heating facility (2) comprises a combustion furnace (31) for burning solid fuel.

10. A drying apparatus (1) according to claim 9, **characterized in that** the combustion furnace (31) comprises a water cushion (38) bordering a combustion space (34) in the combustion furnace to produce water vapour (29) and to lead it into the drying chamber.

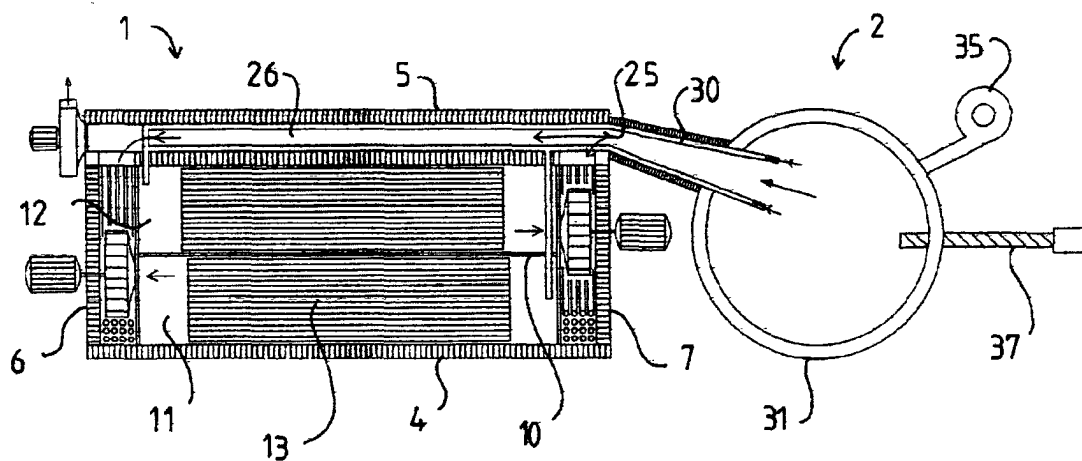


FIG. 1

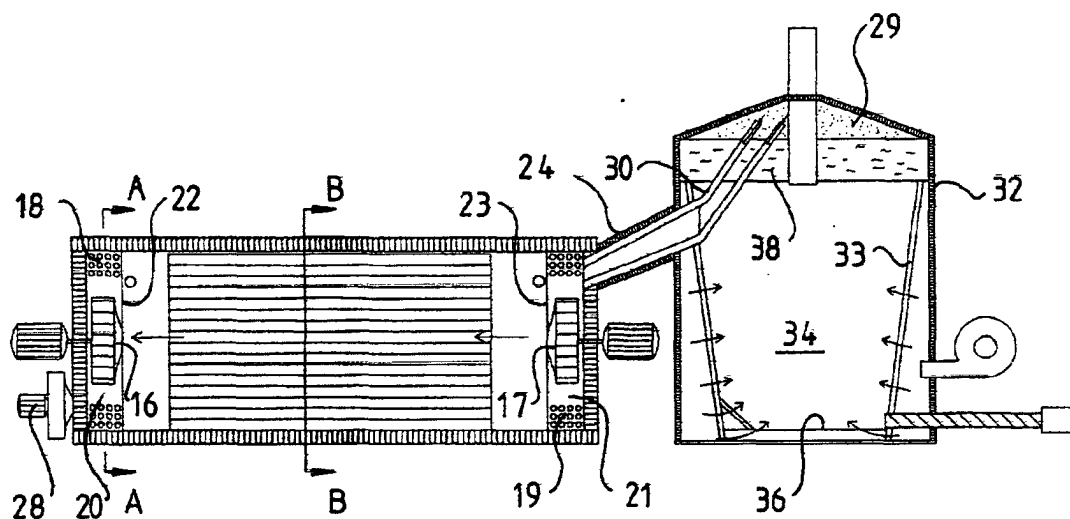


FIG. 2

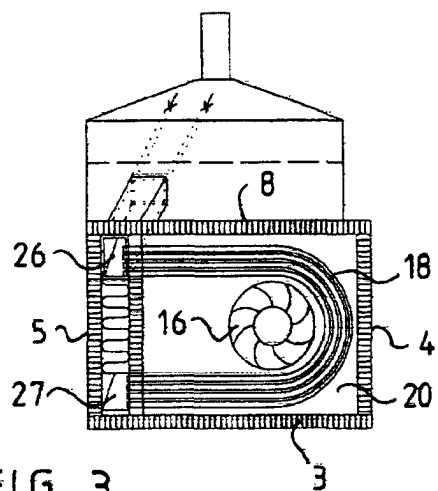


FIG. 3

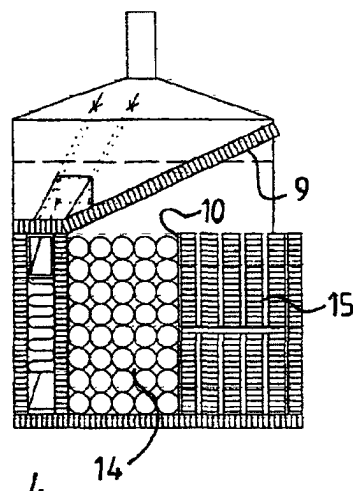


FIG. 4