(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
10 June 2004 (10.06.2004)

PCT

(10) International Publication Number
WO 2004/048867 A1

(51) International Patent Classification[7]: F26B 5/00

(21) International Application Number:
PCT/LV2003/000003

(22) International Filing Date: 15 April 2003 (15.04.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
P-02-203 25 November 2002 (25.11.2002) LV

(71) Applicant and
(72) Inventor: **PASHIN, Vladimir** [LV/LV]; Vainodes Str. 18 - 1, LV-1004 Riga (LV).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **PASHIN, Andrei** [LV/LV]; Vainodes Str. 18 - 1, LV-1004 Riga (LV). **SHAPARENKO, Gennady** [LV/LV]; Skolas Str. 13/2 - 43, LV-2121 Salaspils (LV).

(74) Agent: **SMIRNOV, Alexander**; P.O.Box 1440, LV-1050 Riga (LV).

(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

WO 2004/048867 A1

(54) Title: HIGH TEMPERATURE WOOD DRYING METHOD

(57) Abstract: The invention relates to high temperature wood drying in hydrophobic liquids, namely to high temperature wood drying in heated petrolatum. When drying a hardwood, there are two stages in a drying operation according to the method. An initial exposure to heated petrolatum is carried out at 100 °C and proceeds till the hardwood is warmed up to 100 °C to the whole width in crosscut. In the later stage the temperature of the petrolatum is gradually increased at a rate of 0,5-1,0 °C/hour, in that way eliminating internal cracks formation. Then, the drying operation is proceeded by the exposure at so increased temperature, which is kept unchanged. The method provides a higher balance in water partial pressure distribution in the direction from the wood surface area to the crosscut inner zone resulting in a higher evenness in the course of the drying operation.

HIGH TEMPERATURE WOOD DRYING METHOD

TECHNICAL FIELD

The present invention relates to methods for high temperature wood drying in hydrophobic liquids, namely to methods of wood drying in petrolatum, that is in a mixture of paraffins and ceresins with highly viscous purified oil, which is obtained in oil refining process. A melting point of said mixture is 55 °C and its flash point is not lower than 250 °C.

BACKGROUND ART

Previously known methods for high temperature wood drying in petrolatum have not met with success in attempts to eliminate formation of cracks in the inner parts of a hardwood exposed to drying.

It is known, that high temperature wood drying in petrolatum, in comparison with chamber drying and open air drying, is characterized by the absence of cracks at the exterior of the wood even when a cross-section of the wood, which is to be dried, is 50 mm and more. For these cases there is not alternative for drying in petrolatum if the absence of cracks at the exterior of the wood is required.

A distribution of moisture content in crosswise direction of a lumber exposed to drying in petrolatum points to the fact of existence of considerable internal layer-to-layer stress, which is proportional to a difference between average moisture content of the lumber and moisture content of the layer in question.

If, on drying of a hardwood, a temperature of petrolatum is rising sharply, an intensive water steam formation takes place in the inner parts of the hardwood. Layers in the inner parts, being spaced closely to each other, are exposed to high compression. At these circumstances a running out of a resultant water steam derived from the layers in the inner parts of the hardwood is hampered. An ebullition of leaving water bubbles followed by their blowout takes place. Said blowout causes dynamic fracture of fibers in the inner parts resulting in bloating out of the hardwood surface and formation of concealed craters and subcutaneous blowholes.

The closest prior art to the present invention is a method for high temperature wood drying according to a Latvian patent LV 12776 (P-00-66), 22.05.2000, which comprises stacking of wood into a pile, dipping into petrolatum preliminary heated up to temperatures in the range 130 - 140°C, holding at this temperature range for 8-12 hours, then allowing to petrolatum to drain.

However, in actual practice, drying of hardwood according to the said method is effected by considerable internal cracking. An unevenness in warming up of internal layers caused by hampered heat penetration into the inner zone due to a high density of the hardwood is the primary reason to that. When drying the hardwood, an excessively intensive steam formation derived from layers in the inner zone, which are unable to be preheated before steam formation starts, is observed at temperatures of petrolatum ranging from 130 up to 140 °C. At these circumstances the kinetic energy of leaving water bubbles is so high that said bubbles break out fibers in the inner parts of the hardwood. This results in internal cracking and formation of blowholes at points of break out.

Generally there are two well-defined stages in a drying operation using heated petrolatum. At the first stage there is a tension at the hardwood surface area and compression in its inner zone. At the second stage said tension and compression replace one another.

The subsequent plastification of the surface area in the hardwood processed by heated petrolatum performed with an intention to eliminate a resudial stress which gives rise to formation of cracks, is achieved, according to known methods, either by exposure of the hardwood to water saturated steam or by long-term exposure to heated petrolatum under final processing temperature after the hardwood has progressed in drying to the point when its moisture content corresponds to the final preset value.

When drying wood according to known methods, just lack of uniformity in temperature layer-to-layer fluctuations and related to that nonuniformity in water partial pressure give rise to breaking out of fibers in the inner parts of the wood to be dried.

DISCLOSURE OF THE INVENTION

The present invention is directed toward finding a drying mode capable to suppress a development of conditions responsible for fiber fracture in the inner parts of the wood, namely to suppress an excessively intensive steam formation in the wood inner zone as drying progresses. This effect - said excessively intensive steam formation, is the characteristic feature especially in drying of wood with high initial moisture content, that is 80% and more, as well as in drying of the hardwood.

The aim of the present invention is to attain a higher evenness in layer-to-layer temperature distribution in crosswise direction of the wood, that is a greater evenness in partial pressure distribution in the direction from wood surface area to the inner zone.

The high temperature wood drying method under the present invention comprises complete dipping of the wood stacked on a charge container into a tank with petrolatum preliminary heated up to temperature in the range of 100 – 160 °C and succeeding exposure to heated petrolatum which covers a period of 4 to 24 hours, depending of particular wood species and a width in crosscut. A particular temperature value to be used in the range of 100 – 160 °C corresponds to the maximum permissible drying temperature which still eliminates formation of internal cracks in particular species of wood to be dried. Said maximum permissible drying temperature should be empirically predefined for particular species of wood to be exposed to drying operation.

The following considerations supported by experimental results are given below as reasoning for the temperature range as mentioned above.

It has been found experimentally that internal cracks and cracks at the wood exterior surface do appear when the temperature of petrolatum exceeds 160°C. Furthermore, an intensive chemical decomposition (thermal degradation) resulting in a lowering of the wood mechanical strength is under way when the temperature of petrolatum is over 160°C.

From the other hand, if drying is carried out in petrolatum heated below 100 °C, when an impregnation of the wood, not drying itself, takes place. Said impregnation on numerous occasions is undesirable in succeeding working out of

the wood exposed to drying operation. On retention of temperature within the range of 100-160°C according to the method, actual depth of penetration of petrolatum into the wood is not more than a thickness of a surface area commonly removed in succeeding smooth planning.

The lower limit of 100 °C as starting point for drying of the hardwood in heated petrolatum eliminates badly intensive steam formation. Said excessively intensive steam formation in drying operation according to known methods took place in the period of dipping into petrolatum and on initial phase of drying operatiion in petrolatum most commonly heated in the range of 130-140 °C. Said steam formation was accompannied by an intensive motion of high-speed water bubbles having kinetic energy sufficient for breaking out of wood fibers in the inner parts of the wood due to deficiency of time required for completion of heat penetration into the inner zone.

Contrary to the usual practice, according to the invention the dipping of the hardwood into petrolatum preheated up to 100 °C causes less intensive steam formation at the initial stage of the drying operation, though the hardwood has the same moisture content. On these conditions complete warming up of the hardwood inner zone eliminating fiber fracture by leaving water bubbles has been provided. The reason to that is that a kinetic energy of the bubbles at temperature of 100 °C is much more less than that at temperature of 130 °C and 140 °C.

Thus, the drying regime according to the invention eliminates excessively intensive steam formation. At the same time the regime provides equal emission of water bubbles derived from surface layers and those from the inner zone. In this way a higher uniformity in distribution of water partial pressure between different layers has been achieved. That results in a higher evenness in the course of the drying operation.

Drying of the hardwood (such as oak, beech, cherry-tree, nut-tree) according to the invention comprises complete dipping of the hardwood stacked on a charge container into a tank with petrolatum preliminary heated up to temperature of 100 °C. After the hardwood has been dipped into petrolatum it is initially exposed to heated petrolatum at temperature of 100 °C for a time period required for completion of warming up of the hardwood to the whole width in crosscut up to

the temperature of 100 °C. Said time period depends on species of the hardwood to be dried and the hardwood width in crosscut. This time period for particular species of the hardwood should be predetermined by way of experiments. The experimental data for the time period for completion of warming up of soft species of wood and hardwood up to the temperature of 100 °C to the whole width in crosscut, when the temperature of petrolatum is 100 °C, are shown in the Table below.

Time period for completion of warming up of wood up to 100 °C to the whole width in crosscut at temperature of petrolatum 100 °C, min								
Wood initial moisture content	Soft species of wood width in crosscut, m				Hardwood width in crosscut, m			
	0,020	0,040	0,055	0,100	0,020	0,040	0,055	0,100
60 %	**30**	**50**	**80**	**145**	**40**	**85**	**110**	**235**
70 %	**30**	**55**	**85**	**150**	**40**	**90**	**115**	**240**
80 %	**35**	**60**	**90**	**150**	**45**	**90**	**120**	**240**

When the inner zone of the hardwood has been completely warmed up to the temperature of 100 °C to the whole width in crosscut, the temperature of petrolatum is smoothly increased at a rate in the range of 0,5-1,0 °C/hour. Upon achievement of the maximum temperature, which has been predetermined by way of experiments, and which still eliminates inner fibers fracture in the course of drying of particular species of the hardwood, an exposure to heated petrolatum at a new constant temperature of a higher level is continued up to the end of the drying operation.

A practical implementation of the drying method under the invention points to the fact that, for instance in case of oak drying, the above mentioned maximum permissible temperature of petrolatum, which still eliminates inner fibers fracture and at which further rise in temperature is to be terminated, is the temperature of 115 °C.

When the method according to the invention is used for drying of the hardwood, thanks to heat penetration to the whole width in crosscut at relatively low temperature inherent to the first stage of the drying operation under the

invention, that is to the stage when moisture content in the hardwood is at its maximum level, a rate of an emission of water bubbles is substantially leveled off. In this way an excessively intensive steam generation in the inner zone of the hardwood is eliminated. At the same time that allows to reduce irreversible deformation caused by stretching strain in the hardwood surface area. All the above mentioned results in reduction of tensions remaining after completion of the drying operation.

In the course of exposure of the wood to the heated petrolatum under the unchanged temperature of 100 °C according to the method, moisture content in the wood gradually lowers, and water partial pressure in the inner zone of the wood drops.

Just for keeping the emission of water bubbles from fibers in the inner parts of the wood after completion of warming up of the wood to the whole width in crosscut, as mentioned above, the temperature of petrolatum is smoothly increased at the rate of 0,5-1,0 °C/hour. In this way a differential pressure required for further water bubbles emission from the wood is produced.

On these new conditions, when moisture content in the wood has already been lowered, and wood inner zone has been completely warmed up, a stepless increase in the temperature does not give rise to any intensive steam generation. Emitting water bubbles therewith have a kinetic energy insufficient for fiber fracture in the inner parts of the wood. Under these conditions a formation of internal cracks does not take place.

A variation of the method according to the invention constitutes the method which, in addition to the steps as mention above, comprises introduction into petrolatum preliminary pulverized polymer, such as organosilicon polymer, melamine phenolic resin, polyurethane epoxide resin and others, in concentration of 5–20 % by weight, for instance, in a powder form or in the form of fine fibers. Polymers in a powder form are best suited.

Therewith an intensive thermal circulation of heated petrolatum at the temperature of exposure as mentioned above according to the invention, that is at the temperature in the range of 100 - 160 °C, ensures uniform distribution of polymer as suspended matter over the whole volume of petrolatum and

subsequent sedimentation of polymer particles within the exposure time, forming a film over entire surface of the wood.

Furthermore, upon formation of said polymer suspension in petrolatum, an overall viscosity of the suspension, in comparison to that of petrolatum alone under the same temperature conditions, increases. So increased viscosity of the newly formed drying agent ensures decreased flowability of the drying agent and lower motional energy of emitting water bubbles. On these conditiones, as it is evidenced by actual practice, said motional energy is insufficient for breaking out of fibers in the inner parts of the wood. Thereby, temperature conditions being equel to those before introduction of the pulverized polymer, a likelihood of formation of internal cracks in the wood to be dried becomes all the more lower.

Upon completion of the exposure of the wood to the drying agent represented by the suspension of the polymer in petrolatum, a coating formed by polymer particles along with petrolatum film adhered to the wood surface has been created after petrolatum has been drained.

When on subsequent storekeeping of the dried wood ambient humidity exceeds predetermined final moisture content up to which the wood has been dried, the above mentioned petrolatum film formed on dried wood surface with adhered polymer particles eliminates repeated penetration of moisture into the dried wood, and in this way ensures keeping the wood really dry. What is more, the said film formed on the wood surface, thanks to the presence of polymer particles melting down under contact with an open flame, in case of fire initiation, creates a blanket, which prevents the wood from direct flame contact and eliminates oxygen penetration to the wood surface. Hereby the said petrolatum surface film with adhered polymer particles forms the blanket which makes the wood hardly flammable.

BEST MODE FOR CARRYING OUT THE INVENTION

Below there are some specific embodiments of the high temperature wood drying method according to the invention, that, however, do not limit all possible implementations of the method.

Example 1. Oak boards 0,5 m in length; 0,1 m in width; 0,03 m in thickness; having initial moisture content of 64 %. Drying to final moisture content of 10 %.

Oak boards were stacked edgewise as a square-angled lumber pile on a pallet of a charge container. Thin cross pieces having thickness of 15-20 mm were placed between adjacent boards. Height and width clearance of the charge container ensured free dipping of the container into the tank filled with petrolatum.

By means of a lifter, such as an electric hoist, the charge container with stacked oak boards was lifted from the loading place and dipped into the tank filled with petrolatum preliminary heated up to 115 °C. Palletized oak boards were entirely dipped into petrolatum. The top palletized wood row was not less than 20 cm below the petrolatum-face level. There remained a reserve petrolatum free space in the tank, not less than 90 cm over the petrolatum-face level, eliminating foam splash which usually develops in the course of drying. Oak boards were exposed to heated petrolatum under the temperature of 115 °C for 18 hours before the petrolatum was drain.

Example 2. Oak boards 1,0 m in length; 0,2 m in width; 0,05 m in thickness, having initial moisture content of 60 %. Drying to final moisture content of 9 %.

Oak boards, stacked on the charge container in a manner similar to that for the Example 1, were dipped into the tank filled with petrolatum preliminary heated up to 100 °C and kept at this temperature for 4 hours for completion of heat penetration to the whole width of oak boards crosscut. Then, the temperature of petrolatum was smoothly increased at a rate of 1 °C/hour till the temperature of petrolatum has reached 115 °C. Thereafter the temperature of petrolatum was kept unchanged and oak boards were exposed to heated petrolatum at 115 °C for 4 hours. After this time period the petrolatum was drained. The overall drying operation time under a procedure according to the Example 2 was 24 hours.

Example 3. Pine boards 3,0 m in length; 0,15 m in width; 0,05 m in thickness, having initial moisture content of 60 %. Drying to final moisture content of 8 %.

Pine boards, stacked on the charge container in a similar manner as in the Example 1, were dipped into the tank filled with petrolatum preliminary heated up to 140 °C and kept at this temperature for 5 hours for completion of heat penetration to the whole width of pine boards crosscut. Thereafter the petrolatum was allowed to drain.

Example 4. Birch boards 1,0 m in length; 0,12 m in width; 0,04 m in thickness, having initial moisture content of 50 %. Drying to final moisture content of 12 %.

Birch boards separated by wood spacing pieces 15-20 mm in thickness were stacked as a square-angled lumber pile on a pallet of the charge container and dipped into the tank filled with petrolatum preliminary heated up to 130 °C and kept at this temperature for 5 hours. After this time period the petrolatum was drained. Drying according to this procedure ensured even drying-out of birch boards to the whole crosscut.

Example 5. One of possible variations of the method according to the invention is a method of drying of the hardwood, such as oak, which is intended for special-purpose use, other than for standard building materials. This variation of the drying method provides a useful implementation for drying of the hardwood for projected use in restoration works and imitation to the hardwood exposed to long-term aging agression.

According to this variation of the method oak wood was dipped into the petrolatum preliminary heated up to the temperature in the range of 120-135 °C. Particular predetermined temperature within this range was kept at fixed level within the whole time of the drying operation which lasted for 8 hours. On these conditions breaking out of oak wood fibres in the inner parts progressed, forming blowholes, air pockets, pinholes, elongated cavities by form giving an impression of tracks made by shipworms in the inner zone of the oak wood. In parallel with formation of said blowholes changes in colour of the oak also took place. A specific colour tone was dependant of particular temperature value chosen within the range of 120-135 °C. The higher the temperature – the brighter the colour tone of the dried oak wood was obtained. A resulting colour tone available from this drying procedure approached the colour of bog iron oak.

INDUSTRIAL APPLICABILITY

Embodiments of this invention have the same and more uses and applications than the ubiquitous wood drying methods. The drying method under the invention is applicable in all fields, without exception, when crack-free wood drying is required.

CLAIMS

1. High temperature wood drying method, which comprises stacking of wood on a charge container, dipping into a tank with preliminary heated petrolatum, exposure to heated petrolatum over a drying period, and succeeding drain of petrolatum, characterized in that said exposure to heated petrolatum is carried out at empirically predefined maximum drying temperature permissible for particular species of the wood in the range of petrolatum temperature 100 – 160 °C within a period of 4 – 24 hours, depending on particular species of the wood and a width in crosscut.

2. High temperature wood drying method according to claim 1, characterized in that the exposure at the temperature of 100 °C is fulfilled till the inner zone of the wood has been warmed up to 100 °C to the whole width in crosscut, then the temperature of petrolatum is smoothly raised at a rate of 0,5 – 1,0 °C/hour to the level of empirically predefined maximum drying temperature permissible for particular species of the wood, and then is kept unchanged up to the end of the drying operation.

3. High temperature wood drying method according to claim 1 or 2, characterized in that prior to a start-up of the drying operation a pulverized polymer in the proportion of 5 - 20 % by weight is introduced into petrolatum.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/LV 03/00003

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F26B5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F26B B27K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE EPODOC 'Online! EUROPEAN PATENT OFFICE, THE HAGUE, NL; XP002248762 cited in the application abstract -& LV 12 776 B (PASINS VLADIMIRS) 20 January 2002 (2002-01-20) ---	1
A	US 3 928 677 A (ANTHONY WILSON B) 23 December 1975 (1975-12-23) the whole document ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 144 (M-1386), 23 March 1993 (1993-03-23) & JP 04 319401 A (KOUGEISHIYA:KK;OTHERS: 01), 10 November 1992 (1992-11-10) abstract -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 July 2003	05/08/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	Silvis, H

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/LV 03/00003

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
LV 12776	B	20-01-2002	LV	12776 A	20-12-2001
US 3928677	A	23-12-1975	CA	1018763 A1	11-10-1977
			DE	2361119 A1	12-06-1974
			FR	2209644 A1	05-07-1974
			GB	1439950 A	16-06-1976
			JP	49093504 A	05-09-1974
JP 04319401	A	10-11-1992	JP	2083430 C	23-08-1996
			JP	7118969 B	20-12-1995