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(54) **DEVICE TO REMOVE FLUIDS, AND WASHING APPARATUS COMPRISING SAID DEVICE**

VORRICHTUNG ZUM ENTFERNEN VON FLUIDEN UND WASCHVORRICHTUNG MIT DIESER
VORRICHTUNG

DISPOSITIF D'ÉLIMINATION DE FLUIDES ET APPAREIL DE LAVAGE COMPRENANT LEDIT
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Description

FIELD OF THE INVENTION

[0001] The present invention concerns a device to remove fluids, and an apparatus to wash fabrics comprising said device, usable in the industrial field of the manufacture of textile products. In particular, said textile products can consist of textile fibers of the animal, plant, artificial, synthetic or mixed type.

[0002] More particularly, the invention concerns a washing apparatus which uses carbon dioxide as the main washing fluid and a device to remove carbon dioxide.

BACKGROUND OF THE INVENTION

[0003] In the industrial field of textile production, it is known to perform at least one washing treatment, for example upon completion of the work, or during one or more of the intermediate steps, to eliminate pollutant substances such as oils and fats present in them as working residues.

[0004] In the textile industry, one of the steps that precedes the dyeing and finishing of the fabrics is the cleansing/washing of the fabric, defined in the field by the English word "scouring". This step of the process is fundamental for the removal of oils and/or paraffins or other textile auxiliaries used during spinning and/or weaving.

[0005] If these substances are not properly removed, stains and non-uniform parts can be formed during the dyeing operations, which therefore require further dyeing passes with the corresponding use of very high quantities of water; in addition, during the heat-setting processes that follow immediately, said residual textile auxiliaries tend to cause problems with regard to emissions into the atmosphere.

[0006] The washing processes generally used, depending on the type of pollutant to be eliminated, usually use solvents, hydrocarbons and/or aqueous solutions containing particular soaping substances, detergents, wetting agents, surfactants or suchlike.

[0007] Washing processes that use water with detergents to facilitate the removal of pollutants have been widely used until now, despite having a very negative environmental impact. However, safety and environmental protection legislation is becoming increasingly restrictive, and therefore it is necessary to identify industrial washing processes that have minimal or no environmental impact.

[0008] It is therefore fundamental to use processes that, on the one hand, do not use pollutant substances for the environment, but on the other hand, ensure that oils are optimally removed from the fabric.

[0009] At present, on an industrial level, a macro-distinction is identified between plants that treat fabrics discontinuously and plants that treat fabrics continuously.

[0010] Plants that treat fabrics discontinuously are

comparable to large industrial washing machines that treat the fabric (or garments) in batches with different systems such as:

- 5 - hydrocarbons (of which different types are available on the market);
- tetrachloroethylene or perchloroethylene;
- water combined with detergents, dispersants and various agents;
- 10 - carbon dioxide CO₂.

[0011] Such plants are generally equipped with recovery and recycling systems for the product used. The productivity of these plants is limited by the load capacity.

15 **[0012]** In plants that treat the fabric continuously, the fabric is collected in a roll or on trolleys, it is then unwound and inserted into the treatment unit and processed continuously. At the end of the treatment, the fabric is re-wound in a roll or deposited in layers.

20 **[0013]** The plants that work continuously are essentially divided into water washing systems and dry cleaning systems.

[0014] The former use large amounts of water and soaps, together with dispersing and wetting agents and surfactants to increase the effectiveness of the process. The processed fabric must then be dried, which implies considerable use of energy and consequent processing costs. Furthermore, the water used requires expensive purification plants.

30 **[0015]** On the contrary, dry cleaning plants use tetrachloroethylene (perchloroethylene), which allows to treat the fabric from dry to dry: this chlorinated solvent, although it does have excellent solvent properties (high Kauri-Butanol (Kb) index = 90) and is compatible with all kinds of fabric, nevertheless has negative aspects related to its toxicity for aquatic environments and its suspected carcinogenicity. For these reasons, heavy regulatory limits have been set for the use of this substance, with a view to progressively eliminate its use.

40 **[0016]** The modern machines that use tetrachloroethylene are obligatorily subject to a series of measures intended to ensure the almost total distillation and recovery of the solvent used. A part of solvent, however, remains in the sludge to be disposed of, that is, in oils extracted from the fabric, causing it to be classified as "hazardous waste".

45 **[0017]** At present, there are no plants operating continuously that provide to use hydrocarbons or CO₂ to treat the fabrics. This limit is intrinsically linked to the physical-chemical properties of said substances.

[0018] In the case of hydrocarbons, it would be necessary to use an expensive vacuum distillation system due to the low flammability values of the hydrocarbons. Furthermore, since these substances have low solvent power (Kauri-Butanol index values of about half, or less than perchloroethylene), the process times would be considerably lengthened, limiting productivity.

[0019] In the case of carbon dioxide, working condi-

tions in the liquid state make it necessary to work at very high pressure values: in discontinuous machines values of around 50 bar or higher are mentioned. These conditions preclude the construction of a continuous plant at competitive costs on the market.

[0020] CO₂ has a variety of properties that make it particularly suitable for scouring/washing fabrics.

[0021] Liquid carbon dioxide has a considerable solvent power, especially for apolar substances; these features allow to achieve and even improve the cleaning results obtained until now with the other known processes.

[0022] Carbon dioxide is a substance easily available on the market and at low cost since it is a residue of other production processes from which it can be suitably worked to be re-used.

[0023] In its liquid state, CO₂ has very low surface tension and viscosity values, which make CO₂ a very good wetting agent, able to remove from deep in the fabric even very viscous liquids, such as complex composition mineral oils, fluid oils of a hydrocarbon nature or paraffins.

[0024] It should be noted that carbon dioxide is an excellent solvent in each of its physical states.

[0025] Given the regulatory approach that is increasingly directed toward the elimination of hazardous substances and the progressive elimination of water consumption, CO₂ proves to be the most appropriate solution for taking apolar auxiliary textiles into solution and removing them from the fabrics.

[0026] The CO₂ washing processes used in the state of the art are generally intended for installation in laundries, and provide to treat mainly garments by immersing them in a bath of liquid carbon dioxide inside a pressurized treatment chamber. Known washing processes generally operate at pressures around 50 bar or higher. Generally, the garments are inserted in an apparatus provided with a rack that rotates inside a drum, as in traditional washing machines.

[0027] On this subject the following documents are known:

US-A-4012194 describes a process for extracting and washing garments using liquid carbon dioxide in a closed chamber with a corresponding CO₂ recirculation/recovery system and filtration/expulsion of the oils.

US-A-5858022 describes the washing of finished articles into a rotating drum by means of a mixture of CO₂, water, surfactant and an organic co-solvent.

US-A-5904737 describes a method for washing garments which uses the different pressure conditions to recirculate the solvent in a system consisting of a main chamber in which the garments are washed, and a series of storage tanks connected to a compressor. CO₂ is injected inside the chamber with nozzles that contribute to create a mechanical action on the products to be dry cleaned.

US-A-5412958 describes the washing of finished

garments in a chamber equipped with a rotating drum for separating and collecting the "dirt". The CO₂ used in the process is filtered and recovered.

[0028] One disadvantage of these processes is that, if industrial fabrics are inserted into said apparatuses, it is unlikely that they will be cleaned uniformly. In fact, said fabrics do not remain uniformly positioned in the bath during the entire washing cycle, and therefore some areas can be treated and cleaned better than others, resulting in consequent uneven washing or the presence of stains on the fabric.

[0029] Another disadvantage is the fact that there are obvious limits on the productivity of the process, dictated by discontinuous working conditions (batches).

[0030] There are also CO₂ washing applications on upstream processes, that is, directly on the fibers, before weaving.

[0031] US-B-6183521 provides to use supercritical CO₂ with pressures comprised between 90 and 350 bar and temperatures comprised between 40°C and 120°C. This process allows to improve the properties of strength and elongation of the fibers compared to traditional methods used for scouring.

[0032] Different systems are also known for the recovery and distillation of the CO₂ used in fabric washing machines.

[0033] In this regard, EP-A-2098307 describes a distillation system for CO₂ dry-cleaning machines for garments, that is, it concerns small machines. This plant provides to distil the CO₂ used in the process in two steps: a first step carried out in a first distillation unit, in which most of the CO₂ is separated from the extracted substances, and a second step, performed in a second distillation unit, with the purpose of increasing the total efficiency of separation.

[0034] However, in the context of continuous processing, the Japanese document JP-A-2010180385 (JP'385) describes a continuous, high-pressure treatment on generic films. The treatment provides an unwinding and re-winding device of the treated product inside a chamber divided into two or more compartments with different operating conditions.

[0035] One disadvantage of the state-of-the-art systems is that they only allow a partial recovery of the carbon dioxide used in a washing process, since much of the liquid carbon dioxide remains trapped in the fibers of the fabric.

[0036] The solutions described in the documents cited above, such as for example JP'385, because of how they work, necessarily have the problem of removing the carbon dioxide from the washed fabrics or garments, a problem which, however, is neither described nor resolved in any way.

[0037] The solutions proposed in the various documents, therefore, are limited in their use, and are not easily implemented in practice.

[0038] In the case of a single garment, removing car-

bon dioxide from it can be simple, since it is sufficient to hang it out to dry at the end of the treatment, or to dry it using known systems.

[0039] The problem of removing carbon dioxide is, however, very complex in the case of industrial-scale rolls of fabrics. After the fabric has been impregnated and wound, in fact, it is extremely difficult to remove carbon dioxide from it, as it cannot stratify outward and evaporate.

[0040] By way of example, at the end of the washing operations, considering that it is carried out at a value comprised between 35-40 bar, the fabric is at a temperature comprised between 1°C and 6°C. When the treatment chamber is depressurized to allow the fabric to be removed, the temperature of the carbon dioxide is consequently lowered. The very heat of the fabric, combined with the heat input deriving from the cooling of the liquid CO₂, make a part of the carbon dioxide that is trapped in the fabric evaporate, which is generally around 45% of the overall absorbed carbon dioxide.

[0041] However, inside the fabric there is still a significant part of carbon dioxide which, when the pressure in the treatment chamber goes down, tends to solidify (in the CO₂ status diagram, the triple point is at 5.11 atm and - 56.6 ° C).

[0042] The solidified and frozen carbon dioxide trapped in the fabric also increases its weight considerably. By way of example, considering a fabric roll weighing about 400 kg, the carbon dioxide remaining trapped in it can correspond to about 220 kg (which represents 55% of the impregnated carbon dioxide).

[0043] In this case, to remove the frozen carbon dioxide from the fabric, further treatments are needed, with consequent increased production times, and the need to use strategies to prevent the carbon dioxide from dispersing into the environment.

[0044] By making tests and experiments, Applicant has understood this problem, and has sought a solution to solve it.

[0045] Starting from the state of the art as described above, in the context of the washing of fabrics using liquid carbon dioxide in a treatment chamber, in particular fabrics in rolls, one purpose of the present invention is to obtain an apparatus and a related washing process which allow to almost completely remove the carbon dioxide from a fabric at the end of the washing treatment, before removing the fabric from the treatment chamber.

[0046] Another purpose of the present invention is to obtain a washing apparatus and a connected process which will allow to obtain, at the end of a washing treatment and at exit from the treatment chamber, a roll of fabric with a weight substantially corresponding to the weight which the roll of fabric had before the washing treatment, except for the substances and oils removed during the process.

[0047] Another purpose of the present invention is to obtain a washing apparatus and connected process which allow to recover and recirculate in a closed circuit

substantially all the carbon dioxide used in the washing process, without any dispersion thereof into the environment.

[0048] Another purpose is to obtain the residual sludges containing oils, fats, etc., free from contaminants such as solvents, etc., so that said sludges can be disposed of as non-hazardous waste.

[0049] Another purpose is to provide a washing process that is of low environmental impact and is not polluting but at the same time is efficient and allows to obtain a good cleaning of the fabrics.

[0050] The Applicant has devised, tested and embodied the present invention to overcome the shortcomings of the state of the art and to obtain these and other purposes and advantages.

SUMMARY OF THE INVENTION

[0051] The present invention is set forth and characterized in the independent claims, while the dependent claims describe other characteristics of the invention or variants to the main inventive idea.

[0052] In accordance with the above purposes, the present invention concerns a device for removing carbon dioxide from a fabric, usable inside a pressurized treatment chamber suitable for washing said fabric to remove from it the apolar substances.

[0053] The removal device comprises a mechanical removal member suitable to exert a mechanical action on a fabric to remove a part of the carbon dioxide trapped in the fibers, and a thermal removal member configured to heat the fabric and make the part of the residual carbon dioxide still trapped in the fibers evaporate.

[0054] According to some embodiments, the thermal removal member is disposed directly downstream of the mechanical removal member.

[0055] The combined and sequential action of mechanical removal and thermal removal of carbon dioxide allows to substantially remove the entire liquid carbon dioxide absorbed by the fabric, so as to obtain a substantially dry fabric.

[0056] The present invention also concerns an apparatus for washing fabrics which comprises at least one treatment chamber to perform a washing treatment on a fabric using carbon dioxide, and a circuit to recirculate and recover carbon dioxide associated with the treatment chamber.

[0057] According to some embodiments, the recirculation and recovery circuit is provided with pressure regulation means configured to set and adjust the desired pressure inside the treatment chamber.

[0058] The treatment chamber comprises at least two winding/unwinding rollers configured respectively to wind and unwind a rolled fabric to make it pass from one to the other, possible return rollers that define a travel for the fabric to be treated, and a containing tank suitable to contain a bath of liquid carbon dioxide in which the fabric can be made to transit during the travel from one to the

other of the winding/unwinding rollers.

[0059] According to one aspect of the present invention, the apparatus comprises at least one removal device according to the invention, configured to remove the liquid carbon dioxide substantially completely from the fabric at the end of the washing treatment.

[0060] The removal device is disposed inside the treatment chamber, in an intermediate position between the containing tank and the winding/unwinding roller on which the fabric is wound at the end of the treatment.

[0061] This ensures, on the one hand, that the carbon dioxide used in the washing process is completely recovered, allowing it to be reused in a closed circuit without dispersing it into the environment.

[0062] This can be particularly advantageous in the case of a washing apparatus that comprises two or more treatment chambers that share a single carbon dioxide recirculation and recovery circuit.

[0063] The complete removal of the carbon dioxide from the fabric before it is extracted from a treatment chamber allows it to be reused completely in another treatment chamber, without needing to provide for each washing cycle further carbon dioxide to compensate for the carbon dioxide trapped in the just washed fabric.

[0064] The present invention also concerns a process for washing fabrics which provides to insert a roll of fabric to be washed into a treatment chamber, drawing it in on at least two winding/unwinding rollers and possibly on return rollers that define a travel for the fabric to be treated; to create a desired pressure inside the treatment chamber, and perform at least one fabric washing treatment cycle by making it transit in a bath of liquid carbon dioxide during its travel from one to the other of the winding/unwinding rollers; to restore the atmospheric pressure in the treatment chamber, and finally to extract the roll of fabric from the treatment chamber.

[0065] According to one aspect of the invention, the washing process provides to remove substantially completely the carbon dioxide trapped in the fibers of the fabric in the bath of liquid carbon dioxide before extracting the fabric roll from the treatment chamber.

[0066] According to some embodiments, the washing process provides to remove the carbon dioxide from the fibers of the fabric before winding it on the winding/unwinding roller.

[0067] According to further embodiments, the process provides to perform a mechanical removal action by squeezing/compressing the fabric to remove a first part of liquid carbon dioxide from it, and a thermal removal action by heating the fabric to make it evaporate and remove the residual carbon dioxide.

[0068] According to further embodiments, the mechanical removal action and the thermal removal action are performed in temporal sequence one immediately after the other, so as to optimize the overall efficiency of the removal and to obtain a substantially dry fabric before winding it onto the winding/unwinding roller at exit.

[0069] Since the fabric is dried before being wound,

the roll ready to be extracted from the treatment chamber at the end of the washing process will have a weight that substantially corresponds to the weight that it had when it entered, except for the substances and oils removed.

[0070] Furthermore, the roll of fabric exiting from the treatment chamber can be used directly, or subjected to further work processes, without needing to provide intermediate treatment steps to remove the residual carbon dioxide, with a consequent reduction in overall production times and costs.

BRIEF DESCRIPTION OF THE DRAWINGS

[0071] These and other characteristics of the present invention will become apparent from the following description of some embodiments, given as a non-restrictive example with reference to the attached drawings wherein:

- fig. 1 is a schematic representation of a washing apparatus according to embodiments described here.

[0072] To facilitate comprehension, the same reference numbers have been used, where possible, to identify identical common elements in the drawings. It is understood that elements and characteristics of one embodiment can conveniently be incorporated into other embodiments without further clarifications.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

[0073] We will now refer in detail to one embodiment of the invention, an example of which is shown in the attached drawing.

[0074] Embodiments described here with reference to fig. 1 refer to a washing machine 10 usable in the fabric production sector, for example for the removal of oils and/or paraffins or other textile auxiliaries used during the spinning and/or weaving step.

[0075] The washing apparatus 10 according to the invention comprises at least one treatment chamber 14 inside which a roll of fabric 12 to be washed can be introduced.

[0076] By the term fabric 12, here and hereafter in the description, we mean fabrics generally consisting of textile fibers of the animal, plant, artificial, synthetic or mixed type.

[0077] The fabrics 12 can also be open fabrics, tubular fabrics, or fabrics folded longitudinally on themselves and sewn.

[0078] The washing apparatus 10 also comprises a recovery and recirculation circuit 16 of the washing fluid, in this case carbon dioxide (CO₂). According to some embodiments, the treatment chamber 14 is provided with a liquid CO₂ entrance 17 disposed on a lateral wall of the treatment chamber 14, and a liquid CO₂ exit 18 disposed in correspondence with a bottom wall.

[0079] According to some embodiments, the liquid

CO₂ exit 18 cooperates with a containing tank 22 disposed inside the treatment chamber 14, suitable to contain a bath 23 of liquid carbon dioxide in which the fabric 12 to be washed can be made to transit.

[0080] The treatment chamber 14 also comprises a gas aperture 19 through which the carbon dioxide in a gaseous state can transit.

[0081] According to some embodiments, the recovery and recirculation circuit 16 can comprise pressure regulation means 30, 32 associated with the treatment chamber 14 in correspondence with the gas aperture 19, and configured to set and adjust a desired pressure inside it.

[0082] The recovery and recirculation circuit 16 can also comprise at least one liquid carbon dioxide collection tank 36, connected to both the liquid CO₂ entrance 17 and also to the liquid CO₂ exit 18.

[0083] According to further embodiments, the recovery and recirculation circuit 16 can comprise a condenser device 34, connected to the pressure regulation means 30, 32 and the collection tank 36, and configured to condense the gaseous carbon dioxide, obtaining liquid carbon dioxide.

[0084] According to some embodiments, the treatment chamber 14 comprises at least one pair of winding/unwinding rollers 20a, 20b configured respectively to wind and unwind a roll of fabric 12 from one to the other.

[0085] In particular, the fabric 12 to be washed is wound onto a first unwinding roller 20a and drawn onto a second winding roller 20b. According to possible solutions, the treatment chamber 14 can comprise one or more return rollers 21 configured to define a travel P for the fabric 12 inside the treatment chamber 14 and to keep the fabric 12 stretched between one and the other winding/unwinding rollers 20a, 20b.

[0086] Although fig. 1 shows one sense for the travel P from the unwinding roller 20a to the winding roller 20b, it can be provided that the winding/unwinding rollers 20a, 20b can be interchangeable, so that both can perform the function of winding or unwinding of the fabric 12, so that it is possible to invert the travel P of the fabric 12, unwinding it from the unwinding roller 20b and winding it onto the winding roller 20a.

[0087] According to some embodiments, delivery nozzles 24 can be provided inside the treatment chamber 14, configured to deliver carbon dioxide in liquid form onto the fabric 12 during the winding/unwinding thereof.

[0088] According to some embodiments, the delivery nozzles 24 are fed by the recovery and recirculation circuit 16 through the liquid CO₂ entrance 17.

[0089] According to other embodiments, the treatment chamber 14 can comprise inside it beating rollers 25, configured to beat the fabric 12 in the section of travel between one and the other of the winding/unwinding rollers 20a, 20b, creating a mechanical beating action, so as to increase the movement of the fabric 12 itself and thus further promote the removal of the pollutant substances.

[0090] According to one aspect of the present inven-

tion, the apparatus 10 comprises at least one removal device 29 configured to remove the liquid carbon dioxide substantially completely from the fabric 12 at the end of the washing treatment.

[0091] The removal device 29 is disposed inside the treatment chamber 14, in an intermediate position between the containing tank 22 and the winding roller 20a, 20b, on which the fabric 12 is wound at the end of the treatment.

[0092] According to further embodiments, the apparatus 10 can comprise two removal devices 29, each of which is disposed between one of the winding/unwinding rollers 20a, 20b and the containing tank 22.

[0093] In this way, the fabric 12 can be dried suitably both in the case of a washing process with an odd number of washing cycles and also in a washing process with an even number of washing cycles, wherein by washing cycle we mean the complete unwinding/winding of the fabric 12 from one to the other of the winding/unwinding rollers 20a, 20b.

[0094] According to the invention, the removal device 29 comprises a mechanical removal member 27, suitable to exert a mechanical action on the fabric 12 in transit downstream of the carbon dioxide bath 23 to remove at least a part of the carbon dioxide trapped in its fibers.

[0095] The removal device 29 also comprises a thermal removal member 28 configured to heat the fabric 12 and to make the remaining part of carbon dioxide still trapped in its fibers evaporate before winding it onto one of the winding/unwinding rollers 20a, 20b at the end of the washing treatment in order to make the carbon dioxide retained in the fabric 12 gaseous.

[0096] In this way the carbon dioxide can be completely removed from the fabric 12 and can be recovered from the treatment chamber 14 more efficiently by means of the recovery and recirculation circuit 16.

[0097] According to some embodiments, the thermal removal member 28 is disposed directly downstream of the mechanical removal member 27.

[0098] According to some embodiments, the mechanical removal member 27 can comprise at least one squeezer roller 26 cooperating with a drawing or return roller 21a, idle or drawing, to squeeze the fabric 12 in transit so as to remove from it most of the liquid carbon dioxide retained in its fibers.

[0099] According to some embodiments, the thermal removal member 28 can be, for example, a heated roller with a single-chamber or double chamber, on which the fabric 12 can be made to transit.

[0100] According to further embodiments, the thermal removal member 28 can comprise one or more heated plates.

[0101] According to possible embodiments, the thermal removal member 28 can comprise, or be connected to, heat generation means, for example steam generators, resistances, diathermic oil, hot water, infrared rays, ultrasounds, or other.

[0102] According to some embodiments, more

squeezer rollers 26a can be provided, disposed in correspondence with the containing tank 22, to squeeze/compress the fabric 12 at exit from the liquid carbon dioxide bath 23 before immersing it into it again.

[0103] According to some embodiments, the carbon dioxide recovery and recirculation circuit 16 can comprise a plurality of pipes and communication and transit lines for the carbon dioxide, provided with one or more regulation/interception valves.

[0104] The valves can be opened or closed to allow or prevent the transit of the carbon dioxide in the respective pipe or respective communication line, and possibly to adjust the flow rate.

[0105] According to further embodiments, not shown, a washing apparatus 10 can comprise two or more treatment chambers 14 which can share a single carbon dioxide recovery and recirculation circuit 16.

[0106] In particular, by opening/closing the valves, each treatment chamber 14 can be selectively connected on each occasion with the pressure regulation means 30, 32, with the collection tank 36 and/or with another treatment chamber.

[0107] According to some embodiments, the recovery and recirculation circuit 16 also comprises at least one suction device 30 configured to suck up the gas present in the treatment chamber 14 so as to define a desired pressure inside it.

[0108] According to some embodiments, the recovery and recirculation circuit 16 also comprises a compression device 32, which can be connected to the treatment chamber 14 by means of the gas aperture 19.

[0109] According to possible variant embodiments, the compression device 32 is a dry compressor, which acts on carbon dioxide in gaseous form.

[0110] According to some embodiments, the compression device 32 is also connected to the suction device 30.

[0111] According to some embodiments, the compression device 32 is disposed downstream of the suction device 30 so as to receive at entrance the gaseous carbon dioxide sucked in by the latter from the treatment chamber 14.

[0112] According to some embodiments, the recovery and recirculation circuit 16 also comprises a condenser device 34 which can be connected to the compression device 32.

[0113] In accordance with further embodiments, the condenser device 34 can also be connected to the collection tank 36 of the liquid carbon dioxide.

[0114] According to further embodiments, the treatment chamber 14 is also connected to the collection tank 36 by the liquid CO₂ exit 18 in correspondence with the accumulation zone of the liquid carbon dioxide.

[0115] In accordance with some embodiments, thanks to the removal device 29 and the recovery and recirculation circuit 16, the apparatus 10 is able to recover substantially all the carbon dioxide used for each washing treatment of the fabrics 12 in the treatment chamber 14, obtaining only the oils and the substances extracted as

waste to be eliminated.

[0116] In particular, the apparatus 10 allows to recover the carbon dioxide in liquid form through the liquid CO₂ exit 18 and to recover the carbon dioxide in gaseous form through the gas aperture 19.

[0117] It should be noted that, if the washing apparatus 10 according to the invention comprises more than one treatment chamber, it allows to perform a "semi-continuous" treatment of the fabric 12, or to perform a washing treatment on a first roll of fabric 12 in a first treatment chamber 14 while at the same time a second treatment chamber (not shown) can be cleared of the previous washing cycle and loaded with a second roll of fabric 12 to be treated.

[0118] Embodiments described here also concern a process for washing a fabric 12 in a treatment chamber 14.

[0119] According to some embodiments, the washing process comprises: inserting a roll of fabric 12 into a treatment chamber 14, said fabric 12 being drawn on a plurality of rollers 20, 21; impregnating the fabric 12 by spraying liquid carbon dioxide onto it; immersing it into the liquid carbon dioxide bath 23, and winding it onto a winding roller 20.

[0120] After the fabric 12 has been inserted and drawn in, the treatment chamber 14 is closed and pressurized.

[0121] According to some embodiments, when performing a washing treatment on the fabric 12, the pressure inside the treatment chamber 14 can be comprised between about 10 and about 60 bar.

[0122] Once the washing process has been completed, the treatment chamber 14 is depressurized to allow the roll of washed fabric 12 to be extracted.

[0123] According to further embodiments, the treatment chamber 14 can be subjected to a high vacuum cycle, in order to eliminate possible residues of the previous washing cycle, before being loaded with a new roll of fabric 12.

[0124] According to some embodiments, for example, it can be provided that the treatment chamber 14 is brought to a pressure of about 0.001 bar.

[0125] According to some embodiments, the washing treatment provides to perform at least one fabric washing cycle, defined by the complete unwinding/winding of the fabric 12 from one to the other of the winding/unwinding rollers 20.

[0126] According to some embodiments, the number of washing cycles, that is, the number of times a fabric 12 is unwound/wound on the respective winding/unwinding rollers 20, can be chosen depending on the type of fabric 12 and/or the type of pollutants that need to be removed.

[0127] According to some embodiments, the washing process can provide to make the fabric 12 pass in the liquid carbon dioxide bath 23 once, twice or more times in succession, to promote the removal of the fatty substances present on the fabric 12 which bond with the molecules of liquid carbon dioxide.

[0128] According to variant embodiments, the fabric 12 can be made to pass inside and outside the liquid carbon dioxide bath 23 using one or more return rollers 21, suitably positioned.

[0129] According to some embodiments, the washing process can be carried out at washing temperatures comprised between about -40°C and about 25°C.

[0130] Carbon dioxide has excellent antibacterial properties, so it guarantees deep cleansing and bactericidal action even at low temperatures.

[0131] According to some embodiments of the invention, the washing process provides to remove substantially completely the carbon dioxide trapped in the fibers of the fabric 12 in the liquid carbon dioxide bath 23 before the roll of fabric 12 is extracted from the treatment chamber 14.

[0132] According to some embodiments, the washing process provides to remove the carbon dioxide from the fibers of the fabric 12 before winding it onto the winding/unwinding roller 20a or 20b.

[0133] According to further embodiments, the process provides to perform an action of mechanical removal by squeezing/compressing the fabric 12 to remove a first part of liquid carbon dioxide from it, and a thermal removal action by heating the fabric 12 to make the remaining carbon dioxide evaporate and to remove it.

[0134] According to further embodiments, the mechanical removal action and the thermal removal action are performed in temporal sequence one immediately after the other so as to optimize the overall efficiency of the removal action, and to obtain a substantially dry fabric 12 before winding it on the winding/unwinding roller 20 at exit.

[0135] Furthermore, the roll of fabric 12 at exit from the treatment chamber 14 can be used directly or subjected to further treatment processes, without needing to provide intermediate treatment steps for the removal of the carbon dioxide, with consequent reductions in the overall production times and costs.

[0136] According to some embodiments, if the washing apparatus 10 comprises two or more treatment chambers 14, the fabric washing process also provides to continuously recirculate and regenerate the carbon dioxide used in the first treatment chamber 14 during a washing cycle through the recovery and recirculation circuit 16, and to re-use it in a closed circuit in the second treatment chamber 14.

[0137] According to some embodiments, the liquid carbon dioxide can be continuously undercooled and/or maintained at the specific temperature at which the process is to be carried out, for example by means of undercooler devices and/or heaters, not shown.

[0138] For example, the undercooler device can cool the carbon dioxide to a temperature of about -40°C, so as to keep it in the state of undercooled liquid.

[0139] According to some embodiments, the liquid carbon dioxide used in the treatment chamber 14 can be continuously filtered during the washing cycle in order to

eliminate the impurities and pollutant substances collected therein.

[0140] According to some embodiments, at the end of each washing cycle, the liquid carbon dioxide can be extracted from the treatment chamber 14 to be cleaned of the apolar substances removed during the washing cycle, such as for example oils, fatty substances, paraffins.

[0141] In accordance with other embodiments, the liquid carbon dioxide can be cleaned and regenerated in combination with or as an alternative to ultrafiltration, with other membrane technologies such as microfiltration, nanofiltration or reverse osmosis for example.

[0142] In accordance with variant embodiments, the liquid carbon dioxide containing the pollutant substances can be distilled without using ultrafiltration.

[0143] It is clear that modifications and/or additions of parts can be made to the apparatus and method for washing fabrics as described heretofore, without departing from the field and scope of the present invention.

Claims

1. Removal device (29) to remove liquid carbon dioxide from a fabric (12) usable inside a treatment chamber (14) under pressure, whereby said treatment chamber (14) is suitable to wash said fabric (12) in a bath (23) of liquid carbon dioxide in order to remove apolar substances from it, **characterized in that** said removal device (29) comprises a mechanical removal member (27), suitable to exert a mechanical action on the fabric (12) in order to remove a part of the carbon dioxide trapped in the fibers, and a thermal removal member (28) configured to heat the fabric (12) and make the residual part of the carbon dioxide still trapped in the fibers evaporate.
2. Removal device (29) as in claim 1, **characterized in that** said thermal removal member (28) is disposed directly downstream of said mechanical removal member (27).
3. Removal device (29) as in claim 1 or 2, **characterized in that** said mechanical removal member (27) comprises at least a squeezer roller (26) and a drawing or return roller (21a), said squeezer roller (26) being configured to squeeze/compress the fabric (12) in transit against said drawing or return roller (21a).
4. Removal device (29) as in any of the claims from 1 to 3, **characterized in that** said thermal removal member (28) comprises at least a heated roller with a single chamber or double chamber, around which the fabric (12) can be made to transit.
5. Removal device (29) as in any of the claims from 1 to 3, **characterized in that** said thermal removal

member (28) comprises one or more heated plates.

6. Removal device (29) as in any claim hereinbefore, **characterized in that** said thermal removal member (28) comprises heat generation means, such as steam generators, resistances, diathermic oil, hot water, infrared rays or ultrasounds.
7. Apparatus to wash fabrics (12) comprising at least a treatment chamber (14) to carry out a washing treatment on a fabric (12) using carbon dioxide, and a recovery and recirculation circuit (16) of the carbon dioxide associated with said treatment chamber (14), **characterized in that** said treatment chamber (14) comprises at least two winding/unwinding rollers (20a, 20b) configured respectively to wind and unwind a rolled fabric (12) from one to the other, and a containing tank (22) suitable to contain a bath (23) of liquid carbon dioxide in which said fabric (12) can be made to transit during its travel from one to the other of the winding/unwinding rollers (20), **and in that** said apparatus comprises at least one removal device (29) as in any of the claims from 1 to 6 disposed inside said treatment chamber (14), in an intermediate position between said containing tank (22) and the roller (20a, 20b) on which the fabric (12) is wound at the end of the treatment.
8. Apparatus to wash fabrics (12) as in claim 7, **characterized in that** it comprises two removal devices (29), each of which being disposed between one of said winding/unwinding rollers (20a, 20b) and said containing tank (22).

Patentansprüche

1. Entfernvorrichtung (29) zum Entfernen von flüssigem Kohlenstoffdioxid aus einem Textil (12), verwendbar in einer Behandlungskammer (14) unter Druck, wobei die Behandlungskammer (14) imstande ist, das Textil (12) in einem Bad (23) aus flüssigem Kohlenstoffdioxid zu waschen, um unpolare Substanzen daraus zu entfernen, **dadurch gekennzeichnet, dass** die Entfernvorrichtung (29) aufweist ein mechanisches Entfernelement (27), das imstande ist, eine mechanische Aktion auf das Textil (12) auszuüben, um einen Teil des in den Fasern gefangenen Kohlenstoffdioxids zu entfernen, und ein thermisches Entfernelement (28), das eingerichtet ist, um das Textil (12) zu heizen und den verbleibenden Teil des Kohlenstoffdioxids, das noch in den Fasern gefangen ist, verdampfen zu lassen.
2. Entfernvorrichtung (29) gemäß Anspruch 1, **dadurch gekennzeichnet, dass** das thermische Entfernelement (28) direkt stromabwärts von dem mechanischen Entfernelement (27) angeordnet ist.

3. Entfernvorrichtung (29) gemäß Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das mechanische Entfernelement (27) wenigstens eine Presswalze (26) und eine Zieh- oder Rückführwalze (21a) aufweist, wobei die Presswalze (26) eingerichtet ist, um das Textil (12) zu Pressen/Komprimieren beim Vorbeilauf gegen die Zieh- oder Rückführwalze (21a).
4. Entfernvorrichtung (29) gemäß irgendeinem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das thermische Entfernelement (28) wenigstens eine beheizte Walze mit einer Einzel-Kammer oder einer Doppel-Kammer aufweist, um welche das Textil (12) vorbeilaufen gelassen wird.
5. Entfernvorrichtung (29) gemäß irgendeinem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** das thermische Entfernelement (28) eine oder mehrere beheizte Platten aufweist.
6. Entfernvorrichtung (29) gemäß irgendeinem vorigen Anspruch **dadurch gekennzeichnet, dass** das thermische Entfernelement (28) Wärmezeugungsmittel aufweist, wie z.B. Dampferzeuger, Widerstände, diathermisches Öl, Heißwasser, Infrarotstrahlen oder Ultraschall.
7. Vorrichtung zum Waschen von Textilien (12), aufweisend wenigstens eine Behandlungskammer (14), um eine Waschbehandlung an einem Textil (12) durchzuführen unter Verwenden von Kohlenstoffdioxid, und einen Rückgewinnungs- und Rezirkulations-Kreis (16) des Kohlenstoffdioxids, der mit der Behandlungskammer (14) verknüpft ist, **dadurch gekennzeichnet, dass** die Behandlungskammer (14) aufweist wenigstens zwei Aufwickel/Abwickel-Rollen (20a, 20b), die jeweils eingerichtet sind, um ein gewalztes Textil (12) von einer zur anderen aufzuwickeln und abzuwickeln, und einen Behältertank (22), der imstande ist, eine Bad (23) aus flüssigem Kohlenstoffdioxid zu enthalten, durch welches das Textil (12) durchlaufen gelassen werden kann während seiner Bewegung von der einen zu der anderen der Aufwickel/Abwickel-Rollen (20), **und dass** die Vorrichtung wenigstens eine Entfernvorrichtung (29) gemäß irgendeinem der Ansprüche 1 bis 6 aufweist, die in der Behandlungskammer (14) angeordnet ist in einer Zwischenposition zwischen dem Behältertank (22) und der Rolle (20a, 20b), auf welche das Textil (12) am Ende der Behandlung aufgewickelt wird.
8. Vorrichtung zum Waschen von Textilien (12) gemäß Anspruch 7, **dadurch gekennzeichnet, dass** sie zwei Entfernvorrichtungen (29) aufweist, von denen jede zwischen einer der Aufwickel/Abwickel-Rollen (20a, 20b) und dem Behältertank (22) angeordnet ist.

Revendications

1. Dispositif d'élimination (29) pour éliminer du dioxyde de carbone liquide à partir d'un tissu (12) utilisable à l'intérieur d'une chambre de traitement (14) sous pression, ladite chambre de traitement (14) étant adaptée pour laver ledit tissu (12) dans un bain (23) de dioxyde de carbone liquide afin d'en éliminer des substances apolaires, **caractérisé en ce que** ledit dispositif d'élimination (29) comprend un élément d'élimination mécanique (27), adapté pour exercer une action mécanique sur le tissu (12) afin d'éliminer une partie du dioxyde de carbone piégé dans les fibres, et un élément d'élimination thermique (28) configuré pour chauffer le tissu (12) et amener la partie résiduelle du dioxyde de carbone encore piégée dans les fibres à s'évaporer. 5 10 15
2. Dispositif d'élimination (29) selon la revendication 1, **caractérisé en ce que** ledit élément d'élimination thermique (28) est disposé directement en aval dudit élément d'élimination mécanique (27). 20
3. Dispositif d'élimination (29) selon la revendication 1 ou 2, **caractérisé en ce que** ledit élément d'élimination mécanique (27) comprend au moins un rouleau presseur (26) et un rouleau d'étirage ou de retour (21a), ledit rouleau presseur (26) étant configuré pour presser/comprimer le tissu (12) en transit contre ledit rouleau d'étirage ou de retour (21a). 25 30
4. Dispositif d'élimination (29) selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** ledit élément d'élimination thermique (28) comprend au moins un rouleau chauffé avec une chambre unique ou chambre double, autour duquel le tissu (12) peut être amené à transiter. 35
5. Dispositif d'élimination (29) selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** ledit élément d'élimination thermique (28) comprend une ou plusieurs plaques chauffées. 40
6. Dispositif d'élimination (29) selon l'une quelconque des revendications précédentes, **caractérisé en ce que** ledit élément d'élimination thermique (28) comprend des moyens de génération de chaleur, tels que des générateurs de vapeur, des résistances, de l'huile diathermique, de l'eau chaude, des rayons infrarouges ou des ultrasons. 45 50
7. Appareil pour laver des tissus (12) comprenant au moins une chambre de traitement (14) pour effectuer un traitement de lavage sur un tissu (12) en utilisant du dioxyde de carbone, et un circuit de récupération et de remise en circulation (16) du dioxyde de carbone associé à ladite chambre de traitement (14), **caractérisé en ce que** ladite chambre de traitement (14) comprend au moins deux rouleaux d'enroulement/dérroulement (20a, 20b) configurés respectivement pour enrouler et dérouler un tissu enroulé (12) de l'un à l'autre, et un réservoir de confinement (22) approprié pour contenir un bain (23) de dioxyde de carbone liquide dans lequel ledit tissu (12) peut être amené à transiter pendant son déplacement de l'un à l'autre des rouleaux d'enroulement/dérroulement (20), et **en ce que** ledit appareil comprend au moins un dispositif d'élimination (29) selon l'une quelconque des revendications 1 à 6 disposé à l'intérieur de ladite chambre de traitement (14), dans une position intermédiaire entre ledit réservoir de confinement (22) et le rouleau (20a, 20b) sur lequel le tissu (12) est enroulé à la fin du traitement. 55
8. Appareil pour laver des tissus (12) selon la revendication 7, **caractérisé en ce qu'il** comprend deux dispositifs d'élimination (29), dont chacun est disposé entre l'un desdits rouleaux d'enroulement/dérroulement (20a, 20b) et ledit réservoir de confinement (22).

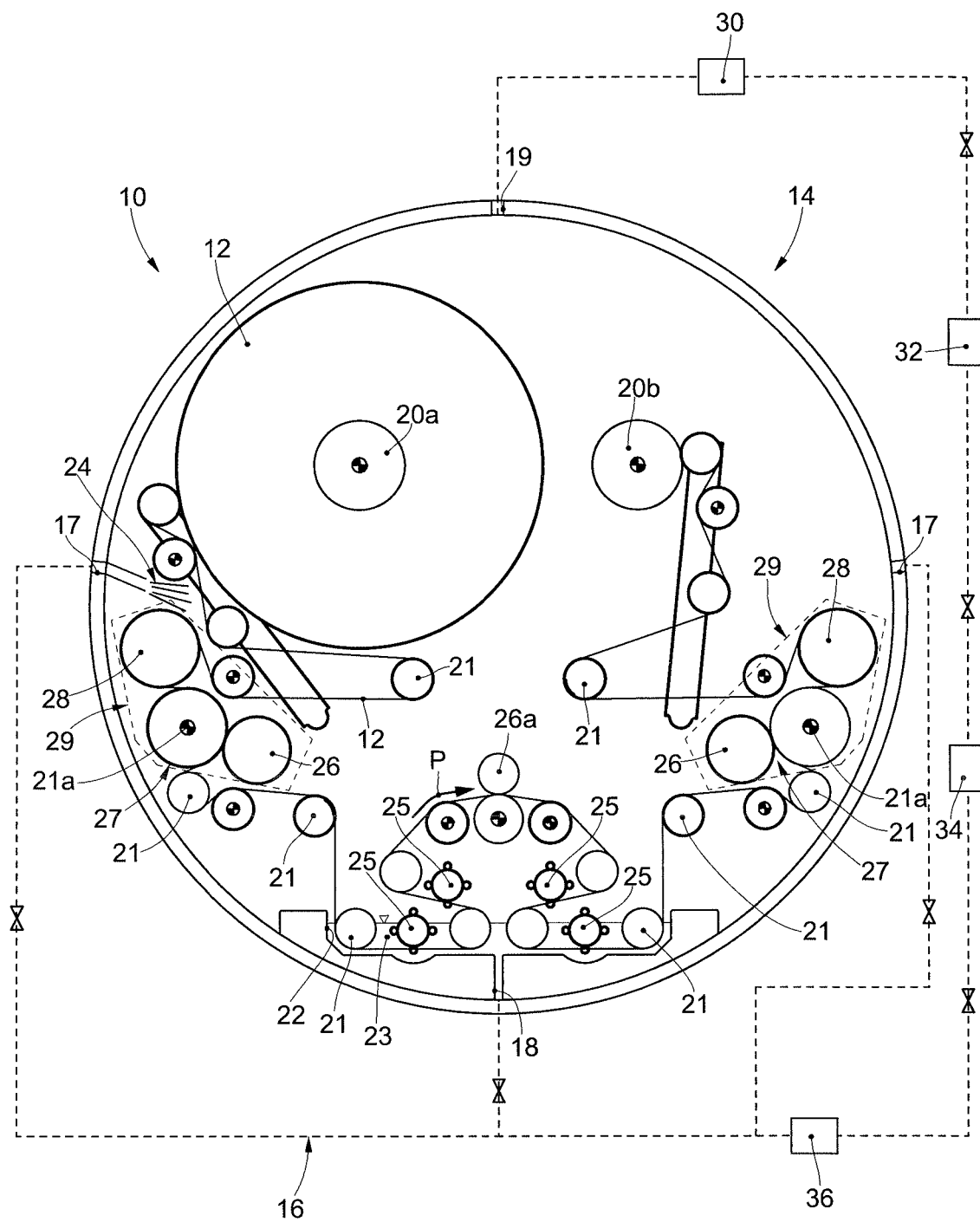


fig. 1

REFERENCES CITED IN THE DESCRIPTION

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