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(54) **A METHOD TO CLEAN AND DECONTAMINATE TEXTILE PRODUCTS, PROTECTIVE GEAR AND EQUIPMENT**

(57) A method to decontaminate textile products is provided which method comprises

- providing a textile product or textile products in a cleaning vessel;
- performing a first cleaning step by treating said textile product or textile products in said vessel with one of a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;
- removing said one of a compressed nonpolar gas and

a compressed polar gas from said vessel;

- performing a second cleaning step by treating said textile product or textile products in said vessel with the other of a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;

- removing said other of a compressed nonpolar gas and a compressed polar gas from said vessel.

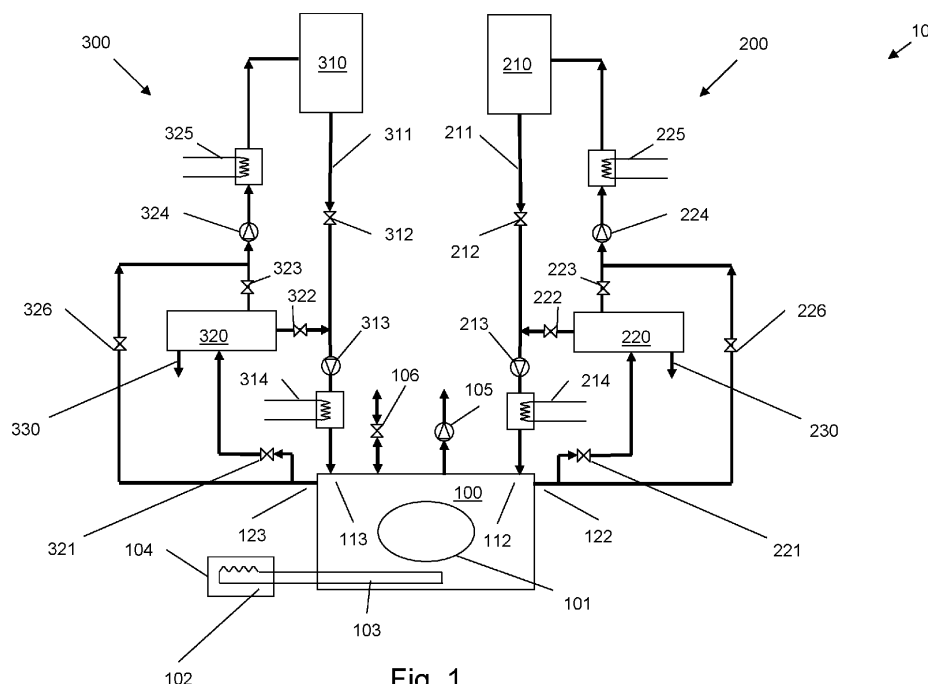


Fig. 1

Description

Field of the Invention

[0001] The present invention generally relates to methods to decontaminate, disinfect and clean, textile products. The invention also relates to decontaminate, disinfect, clean and sterilize materials, i.e. machines, tools, PPE, devices and (medical) instruments.

Background of the Invention

[0002] Cleaning or decontaminating textile products is a task which has been performed since ages. In most applications, water and detergents are used to submerge the textile products in, while applying a mechanical action. Household washing machines are a very well-known example of such cleaning or decontaminating activity.

[0003] In other cleaning or decontamination processes, a solvent is used to dissolve the contamination on the textile products.

[0004] Lately, the idea of using liquified gasses to clean or decontaminate textile products has gained more interest again. The advantage is that the washing liquid, i.e. the compressed gasses, can be recuperated to a large extent, and is not to be thrown away or drained. In most processes, the gas CO₂ is used, in compressed liquid or even supercritical state, to clean the textile products. This is e.g. known from WO2021105501.

[0005] In some processes, a mixture of gasses are compressed and used in liquid or supercritical state, such as in EP1388376A. CO₂ and N₂O are mixed and compressed to a liquid state, and the mixture is used to decontaminate products, a.o. textile products.

Summary of the Invention

[0006] According to a first aspect of the invention, a cleaning or decontamination method was found, which allows to remove substantially more and more efficiently all contamination from textile products.

[0007] According to a first aspect of the invention, a method to decontaminate textile products is provided which method comprises

- a) providing a textile product or textile products in a cleaning vessel;
- b) performing a first cleaning step by treating said textile product or textile products in said vessel with one of a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;
- c) removing said one of a compressed nonpolar gas and a compressed polar gas from said vessel;
- d) performing a second cleaning step by treating said textile product or textile products in said vessel with the other of a compressed nonpolar gas and a com-

pressed polar gas, said compressed gas being in liquid or supercritical state;

e) removing said other of a compressed nonpolar gas and a compressed polar gas from said vessel.

[0008] Though decontamination with a compressed nonpolar gas, like CO₂ may be sufficient to clean textile products, it was found that the use of two separate cleaning steps, one using a polar gas and one a nonpolar gas liquid or supercritical state increases even the decontamination efficiency and result. The use of two separate cleaning steps, one using a polar gas and one a nonpolar gas liquid or supercritical state, has the advantage that not only all contaminants, i.e. polar and nonpolar contaminants, can be removed, but that unmixing effects of polar and nonpolar gasses in liquid state are no longer to be taken care of, as mixtures of polar and nonpolar gasses in liquid state tend to separate, the latter providing failing or uncomplete decontamination.

[0009] In the context of this method to decontaminate, i.e. clean, textile products, the term textile product is to be understood as a garments a piece of clothing or any Personal Protective Equipment (such as helmets and boots), such as but not limited to technical garments and clothing, medical or surgical garments and clothing, protective garments and clothing, workwear, firemen garments and clothing, trousers, vests, t-shirts, skirts, pants, gloves, scaffolds, socks, sweaters, dresses, hoodies, shorts, coats, jeans, suits, polo shirts, caps, hats, leather products, boots, helmets, face shields, goggles, gowns, head covers, masks, respirators, shoe covers, ballistic vests, fall protection systems, chaps and alike.

[0010] According to some embodiments, the compressed polar gas may be used in the first cleaning step, a compressed nonpolar gas being used in the second step.

[0011] Alternatively, a compressed nonpolar gas in the first cleaning step and a compressed polar gas is used in the second step.

[0012] According to some embodiments, the steps b) to e) may be repeated once or more than once, thereby performing cleaning steps using alternately a compressed nonpolar gas and a compressed polar gas.

[0013] Preferably during the cleaning steps using nonpolar gas, the same nonpolar gas is used. Preferably during the cleaning steps using polar gas, the same polar gas is used.

[0014] According to some embodiments, the at least one cleaning step using a compressed nonpolar gas may be performed using said compressed nonpolar gas in liquid state

[0015] Possibly all cleaning steps using a compressed nonpolar gas are performed using said compressed nonpolar gas in liquid state.

[0016] Alternatively one, more or all cleaning step using a compressed nonpolar gas are performed using said compressed nonpolar gas in supercritical state.

[0017] According to some embodiments, the at least

one cleaning step using a compressed polar gas may be performed using said compressed polar gas in liquid state

[0018] Possibly all cleaning steps using a compressed polar gas are performed using said compressed polar gas in liquid state.

[0019] Alternatively one, more or all cleaning step using a compressed polar gas are performed using said compressed polar gas in supercritical state.

[0020] According to some embodiments, in at least one cleaning step using a compressed polar gas, a detergent may be added to said compressed polar gas in liquid or supercritical state

[0021] Detergents, such as amphiphilic substances, may be added to the compressed nonpolar or the compressed polar gas in liquid or supercritical state. Preferably the detergent or detergents are added in the compressed polar gas in liquid or supercritical state.

[0022] During the cleaning step, the compressed nonpolar or the compressed polar gas in liquid or supercritical state may be circulated, optionally to agitate the textile product cleaned. During this circulation, the compressed nonpolar or the compressed polar liquid or supercritical may contact a filter, which has a larger affinity to the detergent and/or the contaminants. The detergent and/or the contaminants may as such be removed from the circulating compressed nonpolar or the compressed polar liquid or supercritical. Additionally or alternatively, during this circulation, the compressed nonpolar or the compressed polar liquid or supercritical may be evaporated, and compressed again, leaving the detergent and/or the contaminants in the evaporation device. Preferably the compressed nonpolar or the compressed polar liquid or supercritical is evaporated at a pressure of more than 1 bara, in order to avoid evaporation of possible humidity dragged along with the liquid or supercritical.

[0023] After the cleaning step, the compressed nonpolar or the compressed polar liquid or supercritical may be evaporated, preferably at a pressure of more than 1 bar, in order to avoid evaporation of possible humidity dragged along with the compressed nonpolar or the compressed polar liquid or supercritical. The detergent and/or the contaminants is left in the evaporation device.

[0024] Before taking the first cleaning step, the vessel being provided with said textile product or textile products, may be drawn vacuum to a level of some millibar absolute, e.g. to a pressure less than about -0.7 barg. As such a too large amount of O₂ or N₂, present in the ambient atmosphere during loading of the textile in the vessel, will remain present the vessel being provided with the compressed nonpolar gas or a compressed polar gas. This remaining O₂ or N₂ will behave as a gas during the cleaning step or steps, as these gasses remain far above their critical temperature.

[0025] After the last cleaning step is performed, and the compressed nonpolar gas or a compressed polar gas is removed from the vessel to about the ambient pressure, this vessel may be brought under vacuum. This vacuum

may be broken by introducing atmospheric air in the vessel up to reaching the ambient pressure before opening the vessel to remove the cleaned textile. Alternatively, the vessel may be degassed by a purging step, such as providing ambient air to the vessel, while keeping an exhaust of the vessel open. This is in particularly preferably done when a gas other than CO₂ was used as the last compressed gas during the last cleaning step.

[0026] Possibly, once one of a compressed polar gas or compressed nonpolar gas is recuperated from the vessel, care may be taken that no remnant of said polar and nonpolar gas gets mixed with the other of a nonpolar or polar gas in the vessel.

[0027] According to some embodiments, after one, more than one or all steps of removing said a compressed nonpolar gas or a compressed polar gas, a purging step may be performed.

[0028] Though several nonpolar gasses are useful, like He, Ne, Ar, Kr, Xe, H₂, D₂, N₂, O₂, CH₄, C₂H₄, C₂H₆, CF₄, SF₆ and CO₂, and mixtures thereof, the most useful one is CO₂. He, Ne, Ar, Kr, Xe, H₂, D₂, may be considered not economic for the use as cleaning gasses. CH₄, C₂H₄, C₂H₆ may be too dangerous seen their flammability. Freon (CF₄) and SF₆ are considered too ecologically unfriendly, hence unacceptable in practice. N₂ and O₂ have to be cooled too deep in order to be liquid, hence not practical in use.

[0029] According to some embodiments, CO₂ may be used as nonpolar gas.

[0030] Though several polar gasses are useful, like HNO₃, HCl, NH₃, CO, CH₃Cl, CH₃F and N₂O and mixtures thereof, the most useful one is N₂O. HNO₃ and HCl may be too acid and may destroy the textile to be cleaned to a too large extent. CO, CH₃Cl and CH₃F are unstable and considered too ecologically unfriendly, hence unacceptable in practice.

[0031] According to some embodiments, N₂O may be used as polar gas.

[0032] The purity of the nonpolar or polar gasses is preferably equal or more than 90%v. Possibly, substantially pure nonpolar or polar gasses are used. A substantially pure gas means that the gaseous fluid comprises more than 99 %v of said gas. The nonpolar or polar gasses may be of grade N2.0, N3.0, N4.0, N5.0 or even N6.0.

[0033] Most preferably, N₂O is used as polar gas and CO₂ is used as nonpolar gas. This because these two gasses have a very similar phase diagrams, critical temperature and critical pressure. This however does mean that contamination of one gas in the other is more difficult to recuperate or remove. Most preferably the first cleaning step uses N₂O, after the vessel has been brought to about vacuum. The second cleaning step, after purging of the N₂O, uses CO₂. As such, contamination of the N₂O by CO₂ can be prevented to a large extent, while contamination of the CO₂ gas by remainder of N₂O is less problematic, in particularly from the point of view of economically performing the method according to the

invention. CO₂ is less expensive to replace or to refresh. During performing the method, the operator also is less to not exposed to traces of N₂O when taking out the cleaned textile from the vessel, and losses of N₂O to the workplace environment may be prevented to a large extent, even completely.

[0034] According to some embodiments, the nonpolar or polar gas may be at least partially recuperated after the step of removing the nonpolar or polar gas from the vessel.

[0035] Such recuperation of nonpolar or nonpolar gas may comprise decompressing said compressed nonpolar gas or a compressed polar gas in liquid or supercritical state to provide a gaseous fluid, the contaminants being removed from the clothing being left as residue, and recompressing the gaseous fluid to a liquid state, optionally a supercritical state.

[0036] Also during the cleaning step, the compressed nonpolar gas or a compressed polar gas in liquid or supercritical state may be circulated in the vessel, and/or removing and decompressing a part of said compressed nonpolar gas or compressed polar gas in liquid or supercritical state to provide a gaseous fluid, the contaminants being removed from the clothing being left as residue, and recompressing the gaseous fluid to a liquid state, optionally a supercritical state, which on its turn is returned to the vessel.

[0037] CO₂ and N₂O are preferably used as nonpolar respectively polar gas. The operating temperature during the cleaning steps may be between -10°C and 30°C when working with liquid CO₂ and N₂O, or may even be above 30°C when working with supercritical CO₂ and N₂O. The pressure during the cleaning step may range up to more 73 bara for liquid CO₂ and N₂O, or may even be above 73 bara when working with supercritical CO₂ and N₂O. The pressure may e.g. range up to 650 bara.

[0038] The benefit of using alternately a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state, has several advantages.

[0039] The use of a compressed nonpolar gas in liquid or supercritical state allows to remove nonpolar contamination from the textile products, while the use of a compressed polar gas in liquid or supercritical state allows to remove the polar contamination from the very same textile products. Hence substantially all contamination may be removed, while using only one of a compressed polar or nonpolar gas in liquid or supercritical state will remove only part of the contaminants. By keeping the compressed nonpolar gas in liquid or supercritical state separate from the compressed polar gas in liquid or supercritical state, mixing of the two basically non mixable liquids is avoided, in particularly when the gases are in subcritical state. Further, as detergents typically only dissolve in the compressed polar gas in liquid or supercritical state, a more efficient use of detergents can be obtained when using the two of compressed nonpolar and polar gasses in liquid or supercritical state. By keep-

ing the compressed nonpolar gas in liquid or supercritical state separate from the compressed polar gas in liquid or supercritical state, pure gasses may be recuperated and handled, which is far easier as compared to a mixture of both gasses, since the composition of such mixed gas is not to be monitored, controlled and adjusted.

[0040] According to a second aspect of the invention, a cleaning apparatus for cleaning a textile product or textile products is provided. The apparatus comprises

- a vessel for receiving the textile product or products, the vessel being adapted to receive a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;
- a first gas handling system for circulating a nonpolar gas in compressed, liquid or supercritical state from and to the vessel, and
- a second handling system for circulating a polar gas in compressed, liquid or supercritical state, from and to the vessel;

wherein the vessel has one or more inlet ports for receiving said compressed nonpolar gas and said compressed polar gas and one or more outlet ports for evacuation said compressed nonpolar gas and said compressed polar gas, and wherein the first and second gas handling system are configured to avoid mixing said polar and nonpolar gas.

[0041] This cleaning apparatus is adapted to perform a method according to the first aspect of the invention.

[0042] According to embodiments, the first and second gas handling system may be fully separated systems.

[0043] According to embodiments, the vessel may have a first set of one or more inlet ports and one or more outlet ports for receiving and evacuation said compressed nonpolar gas and a second set of one or more inlet ports and one or more outlet ports for receiving and evacuation said compressed polar gas.

[0044] The cleaning apparatus may be an apparatus for cleaning or decontaminating textile product on industrial scale. Such apparatus typically may have a vessel in which 10 kg or more contaminated textile products can be decontaminated during one process, e.g. up to 25 kg or even up to 75 kg.

[0045] The cleaning apparatus may be an apparatus for household use, cleaning or decontaminating textile product on smaller scale. Such apparatus typically may have a vessel in which up to 10 kg contaminated textile products can be decontaminated during one process, e.g. 4kg, 5kg, 6kg, 7kg or 8kg. The method according to the first aspect of the invention may be used for cleaning one or more textile products. One product may be cleaned individually, but preferably a number of textile products may be cleaned simultaneously.

[0046] Hence according to a third aspect of the invention, the method according to the first aspect of the invention is used for cleaning technical garments and clothing, medical or surgical garments and clothing, pro-

protective garments and clothing, workwear, firemen garments. The apparatus according to the second aspect of the invention may be used for cleaning one or more textile products. One product may be cleaned individually, but preferably a number of textile products may be cleaned simultaneously.

[0047] Hence according to a fourth aspect of the invention, the apparatus according to the second aspect of the invention is used for cleaning technical garments and clothing, medical or surgical garments and clothing, protective garments and clothing, workwear, firemen garments.

[0048] It is understood that features of one aspect of the invention can be combined with one or more other features of one or more other aspects of this invention.

[0049] In the context of this invention, when references are made to ranges, the ranges are to be understood as being inclusive, unless otherwise specified.

Brief Description of the Drawings

[0050] Fig. 1 illustrates schematically an apparatus according to the invention.

Detailed Description of Embodiment(s)

[0051] A cleaning apparatus 10 being an apparatus for cleaning or decontaminating textile product on industrial scale is shown schematically in figure 1. The apparatus comprises a vessel 100, which may be provided with textile products to be decontaminated. As an example, such textile products may be technical garments and clothing, medical or surgical garments and clothing, protective garments and clothing, workwear, firemen garments and clothing, trousers, vests, t-shirts, skirts, pants, gloves, scaffolds, socks, sweaters, dresses, hoodies, shorts, coats, jeans, suits, polo shirts, caps, hats, leather products and alike. The textile products may comprise any relevant type of fiber material, such as but not limited to natural, manmade (or synthetic) or semi-manmade fibers, polyesters, polyamides, polyaromatic amides (or polyaramides), like Kevlar®, Nomex®, Tyve®, polybenzimidazole (PBI), cotton or any other cellulose based fibers, wool, and alike. The vessel comprises a drum 101 to receive the textile products, through an opening which can be tightly closed and can resist the pressure during the cleaning steps. The vessel further comprises a heating and cooling means 102 to heat and/or cool the liquid provided in the vessel. Thermal energy is provided or extracted to a heat exchanging fluid in the tubing 103 of the heating and cooling means 102 in a heat exchanger 104.

[0052] The vessel 100 is coupled to a compressor 105, enabling the vessel to be brought under vacuum. The vessel 100 is also coupled to a venting system 106, enabling the vessel to be vented when being under pressure. Optionally this venting system comprises a safety valve as well. The venting system may as well

be used in the reverse way, allowing ambient air to be taken into the vessel 100 when the vessel is brought under vacuum.

[0053] The cleaning apparatus 10 comprises two separated gas handling systems 200 and 300. One gas handling system 200 is adapted to circulate nonpolar gas in compressed, liquid or supercritical state from and to the vessel 100. The other gas handling system 300 is adapted to circulate polar gas in compressed, liquid or supercritical state from and to the vessel 100.

[0054] Both gas handling systems 200 and 300 are similar to each other. each gas handling system comprises a storage means 210 or 310 to store the polar or nonpolar gas in compressed liquid state. Via tubing 211 or 311, a valve 212 or 312, a compressor 213 or 313 and a cooler/condenser 214 or 314, the polar or nonpolar gas in compressed liquid state can be provided to one of the inlet ports 112 or 113 for receiving either compressed nonpolar gas or compressed polar gas in liquid or supercritical state.

[0055] One or more outlet ports 122 are provided to the vessel 100 for evacuation the compressed polar gas. Via valve 221, the compressed polar gas in liquid state can be guided to the evaporator 220, where the liquid evaporates back to a gaseous state. During the cleaning step, the evaporated polar gas may be guided back to the vessel via an opened valve 222, compressor 213 and condenser 214. After the cleaning step, the evaporated polar gas may be guided back to the storage 210 via an opened valve 223, compressor 224 and condenser 225. Once the liquid is removed from the vessel 100, the gaseous polar gas can be drawn from the vessel 100 by opening valve 226 and using the compressor 224 and condenser 225, thereby recuperating the polar gas to the storage 210. From the evaporator, decontaminants and optionally detergents can be purged via outlet 230.

[0056] In a similar way, one or more outlet ports 123 are provided to the vessel 100 for evacuation the compressed nonpolar gas. Via valve 321, the compressed polar gas in liquid state can be guided to the evaporator 320, where the liquid evaporates back to a gaseous state. During the cleaning step, the evaporated nonpolar gas may be guided back to the vessel 100 via an opened valve 322, compressor 313 and condenser 314. After the cleaning step, the evaporated polar gas may be guided back to the storage 310 via an opened valve 323, compressor 324 and condenser 325. Once the liquid is removed from the vessel 100, the gaseous nonpolar gas can be drawn from the vessel 100 by opening valve 326 and using the compressor 324 and condenser 325, thereby recuperating the nonpolar gas to the storage 310. From the evaporator, decontaminants and optionally detergents can be purged via outlet 330.

[0057] This apparatus 10 can be used to decontaminate textile products. First, textile products are provided in a cleaning vessel 100. The vessel is pulled vacuum by compressor 105. In a first cleaning step the textile products is cleaned with compressed polar gas, being N₂O

being in liquid or supercritical state. The vessel is filled with N₂O by opening the valve 212, and optionally using the compressor 213 and condenser 214. During the cleaning step, the N₂O is circulated via the opened valve 221, though the evaporator 220 and back to the vessel 100 via the compressor 213 and condenser 214. When the cleaning step is finished, the N₂O is evacuated and recuperated via the opened valve 221, though the evaporator 220 and to the storage 210 via opened valve 223, the compressor 224 and condenser 225. Once the liquid is removed, the N₂O in gaseous state is drawn from the vessel 100. Valve 221 is closed, valve 226 is opened. The polar gas is brought to the storage 210 via opened valve 223, the compressor 224 and condenser 225.

[0058] By this action, substantially all N₂O can be drawn from the vessel 100.

[0059] In the consecutive cleaning step the textile products is cleaned with compressed nonpolar gas, being CO₂ being in liquid or supercritical state. The vessel is filled with CO₂ by opening the valve 312, and optionally using the compressor 313 and condenser 314. During the cleaning step, the CO₂ is circulated via the opened valve 321, though the evaporator 320 and back to the vessel 100 via the compressor 313 and condenser 314. When the cleaning step is finished, the CO₂ is evacuated and recuperated via the opened valve 321, though the evaporator 320 and to the storage 310 via opened valve 323, the compressor 324 and condenser 325. Once the liquid is removed, the CO₂ in gaseous state is drawn from the vessel 100. Valve 321 is closed, valve 326 is opened. The polar gas is brought to the storage 310 via opened valve 323, the compressor 324 and condenser 325.

[0060] The pressures used during the cleaning steps are well above the critical pressures, as well as the temperatures being preferably above the critical temperature. Pressures of 74 bar and more, like 75 bar or more are used. The temperature is preferably above 32°C, even above 33°C or more. Higher pressures are preferably used to utilize the liquid character of the supercritical fluid to a larger extent. Ionic as well as non-ionic detergents may be used.

[0061] Optionally a sequence of these two steps may be repeated once or several times.

[0062] When the cleaning steps are finished, the vessel is under vacuum. The valve 106 may be opened to allow ambient air to flow into the vessel 100. Once the vessel is at the same pressure as ambient, the door can be opened and the cleaned textile products can be evacuated from the drum 101.

[0063] Although the present invention has been illustrated by reference to specific embodiments, it will be apparent to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied with various changes and modifications without departing from the scope thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being

indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein. In other words, it is contemplated to cover any and all modifications, variations or equivalents that fall within the scope of the basic underlying principles and whose essential attributes are claimed in this patent application. It will furthermore be understood by the reader of this patent application that the words "comprising" or "comprise" do not exclude other elements or steps, that the words "a" or "an" do not exclude a plurality, and that a single element, such as a computer system, a processor, or another integrated unit may fulfil the functions of several means recited in the claims. Any reference signs in the claims shall not be construed as limiting the respective claims concerned. The terms "first", "second", "third", "a", "b", "c", and the like, when used in the description or in the claims are introduced to distinguish between similar elements or steps and are not necessarily describing a sequential or chronological order. Similarly, the terms "top", "bottom", "over", "under", and the like are introduced for descriptive purposes and not necessarily to denote relative positions. It is to be understood that the terms so used are interchangeable under appropriate circumstances and embodiments of the invention are capable of operating according to the present invention in other sequences, or in orientations different from the one(s) described or illustrated above.

Claims

1. A method to decontaminate textile products, said method comprises

- a) providing a textile product or textile products in a cleaning vessel;
- b) performing a first cleaning step by treating said textile product or textile products in said vessel with one of a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;
- c) removing said one of a compressed nonpolar gas and a compressed polar gas from said vessel;
- d) performing a second cleaning step by treating said textile product or textile products in said vessel with the other of a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state;
- e) removing said other of a compressed nonpolar gas and a compressed polar gas from said vessel.

2. A method according to claim 1, wherein a compressed polar gas is used in the first cleaning step, a compressed nonpolar gas being used in the second

step.

3. A method according to any one of the preceding claims, wherein steps b) to e) are repeated once or more than once, thereby performing cleaning steps using alternately a compressed nonpolar gas and a compressed polar gas. 5

5. A method according to any one of the preceding claims, wherein at least one cleaning step using a compressed polar gas is performed using said compressed polar gas in liquid state. 10

6. A method according to any one of the preceding claims, wherein in at least one cleaning step using a compressed polar gas, a detergent is added to said compressed polar gas in liquid or supercritical state. 15

7. A method according to any one of the preceding claims, wherein after one, more than one or all steps of removing said a compressed nonpolar gas or a compressed polar gas, a purging step is performed. 20

8. A method according to any one of the preceding claims, wherein CO₂ is used as nonpolar gas. 25

9. A method according to any one of the preceding claims, wherein N₂O is used as polar gas.

10. A method according to any one of the preceding claims, wherein the nonpolar or polar gas is at least partially recuperated after the step of removing the nonpolar or polar gas from the vessel. 30

11. A cleaning apparatus for cleaning a textile product or textile products, said apparatus comprises 35

- a vessel for receiving the textile product or products, the vessel being adapted to receive a compressed nonpolar gas and a compressed polar gas, said compressed gas being in liquid or supercritical state; 40
- a first gas handling system for circulating a nonpolar gas in compressed, liquid or supercritical state from and to the vessel, and 45
- a second handling system for circulating a polar gas in compressed, liquid or supercritical state, from and to the vessel;

wherein said vessel has one or more inlet ports for receiving said compressed nonpolar gas and said compressed polar gas and one or more outlet ports for evacuation said compressed nonpolar gas and said compressed polar gas, and wherein the first and second gas handling system are configured to avoid mixing said polar and nonpolar gas. 50 55

12. A cleaning apparatus according to claim 11,

wherein the first and second gas handling system are fully separated systems.

13. A cleaning apparatus according to any one of the claims 11 to 12, wherein said vessel has a first set of one or more inlet ports and one or more outlet ports for receiving and evacuation said compressed nonpolar gas and a second set of one or more inlet ports and one or more outlet ports for receiving and evacuation said compressed polar gas.

14. The use of a method according to any one of the claims 1 to 10 for cleaning technical garments and clothing, medical or surgical garments and clothing, protective garments and clothing, workwear, firemen garments.

15. The use of an apparatus according to any one of the claims 11 to 13 for cleaning technical garments and clothing, medical or surgical garments and clothing, protective garments and clothing, workwear, firemen garments.

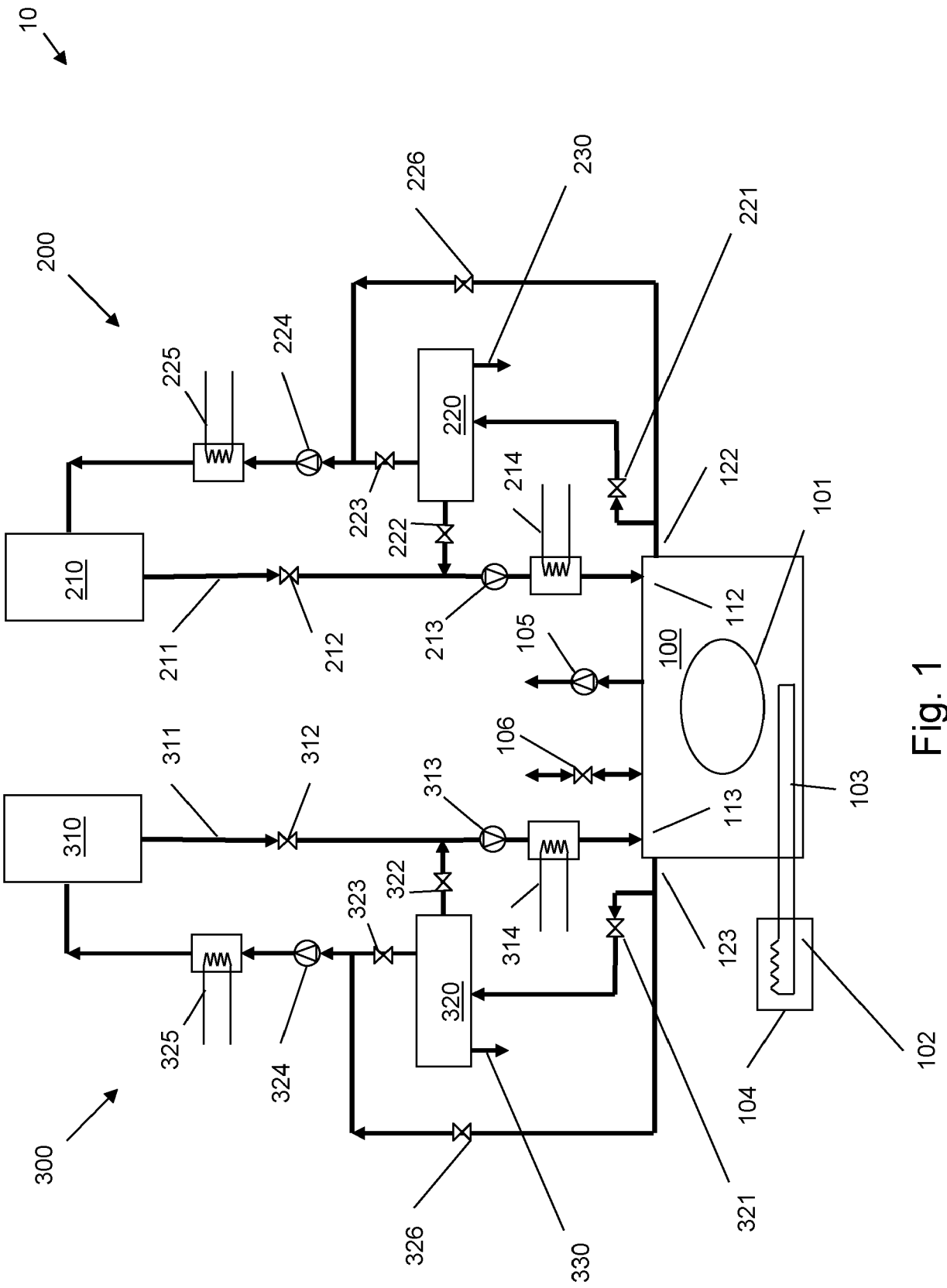


Fig. 1



EUROPEAN SEARCH REPORT

Application Number

EP 23 18 1765

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2022/401854 A1 (FLEURY BLAISE [US] ET AL) 22 December 2022 (2022-12-22) * paragraphs [0002], [0019] - [0021], [0036]; claims 1,12; figures 1-2 * -----	1-14	INV. D06L1/00 B08B7/00 D06F43/02 D06F43/08
A	DE 102 36 493 A1 (MESSER GRIESHEIM GMBH [DE]) 19 February 2004 (2004-02-19) * paragraphs [0001], [0006] - [0008], [0011]; claim 8 * -----	1-14	
			TECHNICAL FIELDS SEARCHED (IPC)
			D06L D06F B08B
The present search report has been drawn up for all claims			
Place of search		Date of completion of the search	Examiner
The Hague		8 December 2023	Menard, Claire
CATEGORY OF CITED DOCUMENTS			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			
T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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REFERENCES CITED IN THE DESCRIPTION

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