(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 2 030 700 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.03.2009 Bulletin 2009/10

(21) Application number: **07017001.4**

(22) Date of filing: **30.08.2007**

(51) Int Cl.:
B08B 7/00 *(2006.01)* ***B08B 3/08*** *(2006.01)*
D06F 43/00 *(2006.01)* ***D06L 1/02*** *(2006.01)*

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

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(54) Method for cleaning

(57) The present invention relates to a process for cleaning goods comprising the following steps: a) placing the goods to be cleaned in a pressure-resistant cleaning vessel, b) introducing a cleaning solvent into the cleaning vessel, c) removing the residues carrying solvent from the container, d) separating the residues from the solvent, characterised in that, step b and step c are carried out at least twice, therefore leading at least to a first and second cleaning bath, using a halogenated and/or hydrocarbons containing solvent in one cleaning bath, and using a pressurised fluid containing solvent in another cleaning bath. Furthermore, the present invention relates to a process of the kind mentioned above, characterised in that, step b and step c are carried out at least once, therefore leading at least to one cleaning bath, using a halogenated and/or hydrocarbons containing solvent in combination with a pressurised fluid containing solvent in at least one cleaning bath.

EP 2 030 700 A1

Description

[0001] The present invention relates to a process for cleaning goods comprising the following steps: a) placing the goods to be cleaned in a pressure-resistant cleaning vessel, b) introducing a cleaning solvent into the cleaning vessel, c) removing the residues carrying solvent from the cleaning vessel, d) separating the residues from the solvent.

[0002] In this field the usage of halogenated, e.g. chlorinated, solvents and hydrocarbon containing solvents is very common.

[0003] In recent years, the usage of a pressurised fluid, for example liquid or supercritical carbon dioxide has become known. Furthermore, the usage of organic solvents such as esters or hydrocarbon containing oxygen functionalities has been described in combination with subsequent CO_2 cleaning.

[0004] The following documents give an impression of the state of the art of the last two cleaning methods mentioned: US 4,012,194, US 5,980,648, US 5,759,209 and EP 0 587 169 B1 for CO_2 cleaning and WO 02/086222 A1, WO 02/086223 A1, WO 01/29305 A1 and WO 01/29306 A1 for the usage of organic solvents.

[0005] Whilst halogenated, e.g. chlorinated, solvents as well as hydrocarbons are very effective solvents, their use is to be seen in relation to concerns about their toxicity and flammability. The recovery of these solvents is therefore exceedingly important, but also expensive as well as time and energy consuming.

[0006] Therefore, it is an object of the present invention to provide an improved cleaning process.

[0007] In accordance with the present invention this object is solved by a process for cleaning goods comprising the following steps: a) placing the goods to be cleaned in a pressure-resistant cleaning vessel, b) introducing a cleaning solvent into the cleaning vessel, c) removing the residues carrying solvent from the cleaning vessel, d) separating the residues from the solvent, characterised in that, step b and step c are carried out at least twice, therefore leading at least to a first and second cleaning bath, using a halogenated and/or hydrocarbons containing solvent in one cleaning bath, and using a pressurised fluid containing solvent in another cleaning bath.

[0008] The first and the second cleaning may be carried out in the same cleaning vessel as well as in different cleaning vessels. Thus, it is also possible to place the goods in a first cleaning vessel and to clean the goods with a first cleaning solvent and then transfer the goods to a second cleaning vessel wherein the goods are cleaned with a second cleaning solvent. One of the first or the second cleaning solvent comprises a pressurised fluid whereas the other cleaning solvent comprises a halogenated and/or hydrocarbons containing solvent.

[0009] The object of the present invention is also solved by a process of the kind mentioned above, characterised in that, step b and step c are carried out at least once, therefore leading at least to one cleaning bath, using a halogenated and/or hydrocarbons containing solvent in combination with a pressurised fluid containing solvent in at least one cleaning bath.

[0010] The inventive processes both combine in a very advantageous way the techniques of cleaning with halogenated, especially chlorinated, solvents and/or hydrocarbon solvents with pressurised fluid cleaning techniques. For example, less impact by reduced need of solvents of the first mentioned type and less losses of such solvents and less energy consumption of the processes are to be mentioned as great advantages.

[0011] It has to be stressed that there is a very broad variety of combining different cleaning bathes containing solvents from a wide range of combinations or single substances to solve the object of the present invention.

[0012] Chlorinated solvents, especially perchloroethylene (PER) ar given as examples for the halogenated solvents that can be used in the present invention. Isoparaffins (german abbreviation: KWL) are an example for the hydrocarbon containing solvents that can be used in the present invention.

[0013] The present invention achieves a siginificant reduction in the amount of halogenated, especially chlorinated, solvents and/or hydrocarbon solvents needed to achieve an equal or even improved residues (impurities, dirt) removal effect compared to the cleaning processes known. This reduction is very favorable in terms of achieving a process with less environmental impact.

[0014] According to step c of the present invention an efficient removal of solvent from the goods to be cleaned is achieved and very favorable for the inventive process.

[0015] In order to achieve a good solvent recovery, it is very favorable to use a pressurised fluid containing solvent, because of the possibility to recover the pressurised fluid by destillation. This recovery method enhances the ability of the system to work with much more than one cleaning bath.

[0016] Furthermore, the pressurised fluid can be used to take out the halogenated and/or hydrocarbons containing solvents from the goods, if the order of the cleaning bathes is such, that a pressurised fluid containing bath takes place after a cleaning bath containing halogenated and/or hydrocarbons containing solvents. This is a further advantage of using the inventive combination, especially because the pressurised fluid has a very good cleaning effect in addition.

[0017] The order of the cleaning bathes using one or more of the mentioned solvents according to the present invention can be freely chosen and combined in numerous ways and so adapted to a broad variety of cleaning duties. Also the modes of solvent recovery can be chosen from a wide range of possibilities and be adapted to the needs of every combination of cleaning bathes.

[0018] According to a preferred embodiment of the present invention the pressurised fluid is liquid carbon dioxide and/or supercritical carbon dioxide. The cleaning ability of liquid or supercritical carbon dioxide is known to be very good and increases for supercritical carbon

dioxide.

[0019] The recovery of CO2 by destillation is easy to manage. Therefore, the use of CO2 is very favorable, especially in view of combining a few cleaning cycles, i.e. using a few cleaning bathes one after another, which normally takes place in one cleaning vessel.

[0020] According to a preferred embodiment of the present invention the goods to be cleaned are garments. The present invention is suitable for cleaning of textile as well as leather garments.

[0021] According to an alternative embodiment of the present invention the goods to be cleaned contain metal, plastic, stone and/or glass material. The goods can be metal, plastic, stone and/or glass objects as well as objects containing parts of the mentioned materials. Further examples for goods to be cleaned are industrial parts or medical devices.

[0022] According to an embodiment of the present invention the goods to be cleaned are contaminated by chemical substances, organic residues and/or particles resting on the surface or within the structure of the goods. The residues can also be called impurities or dirt of any kind.

[0023] According to a preferred embodiment of the present invention in at least one cleaning bath a mixture of a pressurised fluid with halogenated and/or hydrocarbons containing solvent is used. The mixing of said substances in one cleaning bath is especially advantageous in view of the cleaning quality.

[0024] According to an embodiment of the present invention every cleaning bath is operated at an elevated pressure, i.e. a pressure at least above atmospheric pressure.

[0025] According to a very advantageous embodiment of the present invention the final cleaning bath, e.g. the second cleaning bath, is carried out using CO_2 in a concentration of at least 90% in weight of the whole solvent amount of the cleaning bath, preferably at least 95%, even more preferably at least 99%, the remainder being CO_2 or a detergent.

[0026] According to an preferred embodiment of the present invention the process is carried out using a pressure within the cleaning vessel of at least 30 bar, preferably of more than 40 bar, even more preferably of more than 50 bar. The cleaning efficiency is especially good under high pressure.

[0027] According to an alternative embodiment of the present invention, which might be very useful for special applications, the process is carried out using a pressure within the cleaning vessel of less than 30 bar, preferably of less than 20 bar, even more preferably of between 2 and 10 bar. This embodiment works with moderately elevated pressure and therefore is able to save costs in view of the necessary pressure resistance of the components, e.g. the cleaning vessel.

[0028] Concerning the pressure in the cleaning vessel it should be mentioned, that it is very easy to operate at moderately elevated pressure (i.e. Pressure above atmospheric pressure) for an hydrocarbons containing cleaning bath. When CO2 is added it can be used to increase the pressure. When liquid carbon dioxide is added in such an amount, that it will be present in liquid form in the cleaning bath, the pressure will be above 35 bar, preferrably above 40 bar and even more preferrably above 50 bar.

[0029] According to an embodiment of the present invention the goods to be cleaned and/or the cleaning vessel are heated. For example, this method will increase the cleaning efficiency. For example, the goods to be cleaned and/or the cleaning vessel is heated when recovering gaseous CO2.

[0030] According to an embodiment of the present invention a solvent recovery system is used showing a recovery rate of at least 98%, preferably of at least 99%. Due to the reduced amount of halogenated or hydrocarbon containing solvents the recovery system for this substances can be of a smaller scale than usual. In certain embodiments one recovery system may be in service for more than one cleaning vessels, eventually situated at a different location. The pressurised fluid is best recovered by destillation.

[0031] According to an embodiment of the present invention the solvent recovery system uses a vacuum pump to increase the solvent recovery rate. It may be especially advantageous to combine the heating up of the goods to be cleaned and/or the cleaning vessel with the use of the vacuum pump. For example, the goods to be cleaned and/or the cleaning vessel is heated when recovering gaseous CO2 and the vacuum pump is used after the recovery of gaseous CO2 in order to increase the removing rate of all other solvents from the goods to be cleaned.

[0032] According to an embodiment of the present invention two recovery systems may be in use, one for halogenated and/or hydrocarbons containing solvents and one for pressurised fluid containing solvents. For example, a high pressure recovery system for CO_2 can be used first, followed by a recovery system for halogenated and/or hydrocarbons containing solvents, which can be of high pressure or of low pressure type. Gaseous CO_2 can also be recovered in a low pressure system, but liquid CO_2 needs a high pressure recovery system. The residues (impurities, dirt, e.g.) can be recovered, i.e. separated from the solvents, in any recovery system, but most effectively this takes place in the last recovery system used.

[0033] According to a preferred embodiment of the present invention the final cleaning bath is heated to a temperature in the range of zero to 100°C, preferably not exceeding 40°C, even more preferably not exceeding 30°C. This feature is especially advantageous for cleaning delicate garments and/or when it is important to further improve the removing and/or recovery rate for the halogenated and/or hydrocarbons containing solvents.

[0034] The present invention is very advantageous in view of many aspects, a few of them given below:

The combination of the use of halogenated and/or hydrocarbon containing solvents with pressurised fluid as a solvent, especially liquid or supercritical carbon dioxide, allows the reduction of the amount of the first two. The subsequent increase of the amount of CO_2 used is easy to handle, e.g. due to the possibility of recovering CO_2 by means of destillation having a comparatively low energy consumption and due to the fact that CO_2 is an easy to handle non toxic substance.

[0035] The inventive cleaning process utilises only a very small amount of toxic and/or flammable solvents, especially compared to known cleaning processes using halogenated and/or hydrocarbon containing solvents. Therefore, need and emission rate to the environment as well as content of solvent remaining on the goods to be cleaned are siginificantly improved, which means all these amounts are siginificantly reduced. The working conditions in general are therefore improved. Legislative demands like the German BimschV and the Californian Clean Air Act are easily satisfied.

[0036] The cleaning quality as a result of the inventive process is very good. The cleaned goods are essentially free of residues, which means essentially no solvents can be found on or in the goods after the cleaning process is finished.

[0037] Operating at the mentioned low temperatures, e.g. at a temperature between 10 and 40°C, reduces the risk for discolouration of delicate garments and other thermal degradation which might occur to some goods at high temperatures.

[0038] Embodiments of the present invention are described in greater detail below.

Example 1:

[0039] Garment or metal parts are cleaned by using perchloroethylene (PER). The goods to be cleaned are placed in a pressure-resistant vessel. Also other auxiliary components are adapted for operation under elevated pressure. First PER liquid is introduced into the cleaning vessel. The residues carrying PER liquid is then removed from the cleaning vessel. Pressurised CO_2 is introduced into the cleaning vessel forming the second cleaning bath. The CO_2 is used to dissolve solvent residues. Loaded with dissolved solvent the CO_2 is removed from the cleaning vessel and led to a recovery system. In the recovery vessel or system pure CO_2 is recovered, e.g. and preferably by means of destillation.

[0040] Both, the cleaning process and the solvent recovery, i.e. the separation of the solvent from the goods as well as the separation of the residues from the solvent, may be carried out more than once and in various sequences.

[0041] A very good cleaning quality is achieved and the cleaned goods are essentially free of the PER typical odour. The PER liquid used in the first cleaning bath as well as the PER liquid extracted by the help of CO2 out of the second cleaning bath is separated from residues such as contaminants, e.g. dirt or other substances which were cleaned off the goods and other extracted substances. In this way the unwanted residues like contaminants and dirt are collected in concentrated form. The separated solvents can be reused.

Example 2:

[0042] Example 2 is also an example for cleaning garments or metal parts. Instead of the use of PER isoparaffins (German abbreviation: KWL) are used. The other features of the cleaning process remain unchanged as described in example 1.

Example 3:

[0043] Goods to be cleaned with the help of PER or isoparaffins in the presence of CO2 already in the first cleaning bath.

[0044] The goods to be cleaned are placed in a pressure-resistant vessel. Also other auxiliary components are adapted for operation under elevated pressure. First PER or isoparaffin liquid is introduced into the cleaning vessel. CO_2 is already added as dense medium or solvent into the first cleaning bath. The concentration of CO_2 is advised to be preferably between 1 and 99,8%, more preferably between10 and 99%, even more preferably between 50 and 98% (percentage given on weight basis).

[0045] The residues carrying solvent mixture is then removed from the cleaning vessel.

[0046] Pressurised CO_2 is introduced into the cleaning vessel forming the second cleaning bath. The CO_2 is used to dissolve solvent residues. Loaded with dissolved solvent the CO_2 is removed from the cleaning vessel and led to a recovery system. In the recovery vessel or system pure CO_2 is recovered, e.g. and preferably by means of destillation.

[0047] The amount of PER or isoparaffins used is considerably smaller than in example 1 and 2. Subsequently cleaned goods are free of any solvent and any solvent odour.

[0048] All other features are similar to example 1.

Example 4:

[0049] Goods to be cleaned with the help of PER and isoparaffins in the presence of CO2 already in the first cleaning bath. All other features are similar to example 3.

Example 5:

[0050] Example 5 stresses that example 3 and 4 could also be limited to one cleaning bath, i.e. the first cleaning bath, and still achieve a very good cleaning quality.

Example 6:

[0051] In example 6 the cleaning process starts with a first cleaning bath containing CO2 in gaseous form and not containing any halogenated and/or hydrocarbons containing solvents in the first cleaning bath. One or more of this substances are used in subsequent cleaning bathes.

Example 7:

[0052] Example 7 is similar to example 6, but liquid CO2 is present in the first cleaning bath. This option may be very advantageous in order to get rid of a significant amount of dirt right at the beginning of the cleaning process.

[0053] In general, for all examples, it should be mentioned again that the amounts of different solvents present in the cleaning bathes can be chosen in the range of 0 to 100%. The amounts used differ in view of the cleaning ability and the recovery properties of the substances.

Claims

1. Process for cleaning goods comprising the following steps: a) placing the goods to be cleaned in a pressure-resistant cleaning vessel, b) introducing a cleaning solvent into the cleaning vessel, c) removing the residues carrying solvent from the cleaning vessel, d) separating the residues from the solvent, **characterised in that**, step b and step c are carried out at least twice, therefore leading at least to a first and second cleaning bath, using a halogenated and/or hydrocarbons containing solvent in one cleaning bath, and using a pressurised fluid containing solvent in another cleaning bath.

2. Process for cleaning goods comprising the following steps: a) placing the goods to be cleaned in a pressure-resistant cleaning vessel, b) introducing a cleaning solvent into the cleaning vessel, c) removing the residues carrying solvent from the cleaning vessel, d) separating the residues from the solvent, **characterised in that**, step b and step c are carried out at least once, therefore leading at least to one cleaning bath, using a halogenated and/or hydrocarbons containing solvent in combination with a pressurised fluid containing solvent in at least one cleaning bath.

3. Process according to claim 1 or 2, **characterised in that,** the pressurised fluid is liquid carbon dioxide and/or supercritical carbon dioxide.

4. Process according to any of claims 1 to 3, **characterised in that**, the goods to be cleaned are garments.

5. Process according to any of claims 1 to 4, **characterised in that,** the goods to be cleaned contain metal, plastic, stone and/or glass material.

6. Process according to any of claims 1 to 5, **characterised in that**, the goods to be cleaned are contaminated by chemical substances, organic residues and/or particles resting on the surface or within the structure of the goods.

7. Process according to any of claims 1 to 6, **characterised in that,** in at least one cleaning bath a mixture of a pressurised fluid with halogenated and/or hydrocarbons containing solvent is used.

8. Process according to any of claims 1 to 7, **characterised in that,** every cleaning bath is operated at an elevated pressure, i.e. a pressure at least above atmospheric pressure.

9. Process according to any of claims 1 to 8, **characterised in that,** the final cleaning bath, e.g. the second cleaning bath, is carried out using CO_2 in a concentration of at least 90% in weight of the whole solvent amount of the cleaning bath, preferably at least 95%, even more preferably at least 99%, the remainder beeing CO_2 or a detergent.

10. Process according to any of claims 1 to 9, **characterised in that**, the goods to be cleaned and/or the cleaning vessel are heated.

11. Process according to any of claims 1 to 10, **characterised in that,** a solvent recovery system is used showing a recovery rate of at least 98%, preferably of at least 99%.

12. Process according to claim 11, **characterised in that**, the solvent recovery system uses a vacuum pump to increase the solvent recovery rate.

13. Process according to any of claims 1 to 12, **characterised in that**, the final cleaning bath is heated to a temperature in the range of zero to 100°C, preferably not exceeding 40°C, even more preferably not exceeding 30°C.

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 07 01 7001

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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1 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	15 January 2008	van der Zee, Willem

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 7001

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The Hague	15 January 2008	van der Zee, Willem

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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